ADAPTIVE STREAMING DISCRIMINANT ANALYSIS

REGULARIZATION, ERROR RATE ESTIMATION, AND SEMI-SUPERVISED LEARNING

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"Trust in the LORD with all thine heart; and lean not unto thine own understanding. In all thy ways acknowledge him, and he shall direct thy paths. Be not wise in thine own eyes: fear the LORD, and depart from evil" (KJV Proverbs 3:5-7).

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Abstract: Streaming data will become one of the main areas of theoretical and practical interest in the coming years for the statistician. Business applications abound due to the competitive advantages that come from quickly extracting insights from data. In order to face streaming data head on, new statistical methods will need to be created, while existing ones and their corresponding implementations will need to be revised and made more adaptive to current trends, both new and revised methods also need to be computationally lean enough to rapidly process large amounts of high velocity data. Discriminant analysis is the standard algorithm for classification of random data. Several streaming versions of discriminant analysis exist, however, Anagnostopoulos et. al (2012) provide a variation that has its foundations in the adaptive filtering (Haykin (1996)) and weighted likelihood Hu and Zidek (2002) approaches. Their algorithm focuses on providing adaptive estimates of the parameters (mean, covariance matrix, along with prior probabilities for each group), which then provide adaptive classification boundaries flexibly modeling the data over time. This research seeks to expand on this algorithm by pursuing alternative estimation strategies as well as investigating ancillary items that are often overlooked when developing new methods such as error rate estimation and handling of missing data.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Overview

According to the International Data Corporation (IDC), "by 2025 more than a quarter of data created in the global datasphere will be real time in nature" (Reinsel, Gantz, and Rydning, 2017). Not only is data big, but it's fast and quickly fades in its importance, as the world constantly changes at an increasing pace. In today's society with advanced data technology, companies as well as individuals need to act on information quickly in order to obtain value and insight from it before the current trend has vanished. In certain domains, data analysts are now required to analyze "streaming data" in real time in order to obtain critical insights immediately. Typical examples of streaming data applications include the following, (1.) sensor data and Internet of things (IoT), (2.) telecommunications, (3.) social media, (4.) health care, (5.) marketing, and (6.) credit scoring. However, real time data analysis is not simply applicable to fast-paced technology domains, but also affects almost everyone in today's business world. For example, imagine you had opened a restaurant in December of 2019. You did this based on what were the then current market trends, customer segmentation analysis, and other various time series models predicting customer demand based on recent historical data within a short radius of your new restaurant's location. You analyzed the data and predicted you would be making real profits within 2 years if you ran the business according to the models and the data that you had analyzed. By the end of May 2020 , however, the world had completely changed. There was a significant and abrupt “concept drift” in the world, namely COVID-19, and all of your models and previous analyses were now rendered worthless, not to mention that you were now out of business. Clearly, streaming data analysis is applicable to anyone who requires data to make informed decisions quickly in real time.

Streaming data consists of indefinitely long, time-evolving sequences of data (Anagnostopoulos et al., 2012). New challenges come along with streaming data which include the following (Bifet et al., 2018): (1.) computational efficiency, (2.) scalability, and (3) nonstationarity, i.e., data-generating mechanisms governing the phenomena of interest may change over time. This last challenge has been coined concept drift (Widmer and Kubat, 1996) in the machine learning and data-mining communities. More so than the first two concerns, concept drift is the main analytical problem that has to be addressed by data analysts and engineers involved in procuring insights and models from streams of data (Anagnostopoulos et al., 2008a). If processes were always stationary, then life would be easy as analysts would simply need to use statistical models with large-sample properties like consistency (Serfling, 1980), and simply wait until enough data was analyzed so that the estimated model parameters were within some small epsilon of the true parameters. At that point data collection could be halted, and the model could be used indefinitely. Of course this is fantasy, models are rarely built only once, but rather are updated whenever their predictions/forecasts become less accurate. With the velocity of data continually increasing and trends/patterns appearing and disappearing quickly within certain applications, the typical workflow of building statistical models now has to be done on such a small time scale as to require either automation and/or new statistical models that are adaptive to changes in the data-generating mechanism.

Adapting to changes can be done either implicitly by the statistical model itself, or explicitly as a separate process (Ross et al., 2012). That is, the change is detected by an outside mechanism, which then informs the analyst to adapt and/or rebuild the model. There are various methods to handle such changes with corresponding advantages and disadvantages, depending on the focus of the analysis. The most obvious, and possibly, robust, method of handling changes over time is to analyze data within sliding or tumbling windows (Anagnostopoulos et al., 2012). A statistical model can be built in the usual "batch" sense within a window of time. That is, the batch or set of data is treated as static and a standard statistical model is built capturing some aspect of the data, e.g. expected value of a continuous response variable modeled as some function of the predictors. Residuals and measures of model quality can then be monitored over time, (Bifet et al., 2015a), and whenever quality indicators show decreasing model quality, then the model can be discarded and a new one can be built. Even though this approach is straightforward in that it does not require any real new methodology, it does require the analyst to specify a window size. Unfortunately,the size of the window may not be obvious, as the phenomena being studied may not be well understood. Additionally, the size of the window also presents trade-offs, which must be considered by the analyst (Bifet, 2010). Small windows are good for detecting drift quickly, especially abrupt drift, however they are generally poor for building accurate statistical models, as most methods and algorithms perform better with more data, thereby encouraging the analyst to pick a larger window. Furthermore, methods which can flexibly model nonlinear relationships may require lots of data. Lastly, this approach discards past information and incurs penalties for both lack of computational efficiency (since a new model must be rebuilt) and for inferential aspects of the model reaching some plateau, e.g. width of confidence interval maybe constant instead of decreasing with more data as sample sizes remain relatively constant across window sizes. Another approach which allows a modeler to circumvent the window size problem is to take what's known as an adaptive approach (Haykin, 1996). As opposed to continually rebuilding models, in this approach, a model is updated online in such a way that more recent observations are viewed as more important and older observations are forgotten over time. This works similarly to an exponentially weighted moving average (EWMA) chart in quality control applications (Montgomery, 1996), and is typically done through a weighting mechanism which is possibly adaptive and/or data-driven where it forgets information over time and pays more attention to more recent data.

Application to consumer credit

According to Pavlidis et al. (2012), consumer financial lending is an important part of the banking industry due to both the large amount of money lent to consumers and its overall impact on the global economy. The application of formal statistical methods has recently encouraged rapid growth in the industry. Credit scoring models, for instance, predict whether or not an applicant will default on a loan within a given time frame (Thomas, 2010). Linear methods such as logistic regression and discriminant analysis have been successfully applied to this problem due to their predictive and explanatory power (Pavlidis et al., 2012). Implementation of these static models, however, is not without problems as consumer lending is subject to concept drift when the underlying population changes due to changes in economic and/or other conditions (Pavlidis et al., 2012). Thus, credit scoring is an important application where streaming data classification methods can be utilized to improve upon existing static methods (Barddal et al., 2020). Due to its successful application to this problem, adaptive variants of discriminant analysis are an obvious modeling choice, and Adams et al. (2010) has already shown that temporally adaptive linear discriminant classifiers can outperform both static classifiers and those which are rebuilt periodically.

Despite the initial success in the application of streaming models to consumer credit scoring data (Adams et al. (2010), Barddal et al. (2020)), problems still exist that need to be addressed. First, consumer credit data is expanding in terms of the number of observations and the number of variables (Liu and Schumann, 2005). Compounding this problem, new additional sources of data are being used in predicting credit risk, for example, Djeundje et al. (2021) successfully demonstrate that adding behavioral and/or psychometric information to the typical credit applicant profile can provide additional predictive power. Thus, the ability for streaming discriminant-based classifiers to handle a large number of predictors will be imperative moving forward. One of the main statistical issues in discriminant analysis is the estimation of the covariance matrix and the computation of its inverse. For a large number of predictors, relative to the number of observations (small n, large p problem), the covariance matrix may become ill-conditioned, thereby increasing the possibility of numerical errors, or worse yet even singular. The large number of parameters relative to the number of observations can also lead to an unstable estimate of the covariance matrix due to lack of data. Additionally, from an implementation perspective, the computation of the inverse may simply take a prohibitively long time in the presence of high dimensions. Another common problem in the credit scoring modeling process is that only those individuals who are actually given a loan can add information to the model (Xiao et al., 2020). These rejected individuals could potentially provide additional useful information, and thus streaming classifiers could be enhanced by incorporating such data. The problem of incorporating those individuals into a credit scoring model is known as *reject inference* (Banasik and Crook, 2007). In order to do so, however, the streaming discriminant classifier will need to be able to handle data with missing class labels, as the applicant's true status as a good or bad credit risk is unknown. This is known as semi-supervised learning. Third, appropriately estimating the error rate in a non-static environment is crucial for gauging the streaming model's effectiveness. Current methods typically provide window-based estimates (Bifet et al., 2018) that fail to take into account that the complete model is actually a sequence of models changing over time. As the model is adaptive, the estimation of the error rate should also be adaptive and may require incorporation of certain aspects of the model and/or its related assumptions. For example, a typical error rate estimate used in streaming data analysis (Bifet et al. (2018)) is known as the interleaved estimate. Consider a typical streaming data scenario where an adaptive discriminant classifier is being used and updated with each new observation. First, the discriminant classifier is utilized to predict the class label of the incoming observation. Next, after the class label is observed, the classifier's parameters are updated along with the proportion of misclassifications. This approach computes the proportion of misclassifications in the *usual* way, that is, as the sample mean of the 0/1 Bernoulli random variables, however, these Bernoulli random variables are not necessarily identically distributed as the conditional error rate of the sample discriminant classifiers may not in general be identical, even under stationarity. The problem, of course, is even more drastic whenever a concept or population drift occurs. It seems more reasonable to use an approach that is adaptive in nature to estimate the error rate over time.

Anagnostopoulos et al. (2012) proposed an online, adaptive discriminant analysis algorithm. This proposal looks to modify certain aspects of this algorithm to address the above mentioned issues of high dimensionality, missing class labels, and error estimation of the current model. Chapter 2 contains a literature review of related work, and Chapter 3 describes the proposed work.

CHAPTER 2

LITERATURE REVIEW

2.1 Discriminant analysis and its adaptation to streaming data

Despite its simplicity, discriminant analysis remains a popular classification method (Hastie, Tibshirani, and Friedman, 2016). Research and investigation into discriminant analysis and other related methods is still ongoing, and, in fact, the number of research articles on the topic is simply staggering. It is a foundational tool, and without modification it provides the analyst with a classification model that is competitive in terms of accuracy and interpretability. At the very least, it can be used as a baseline to compare against more flexible, nonparametric methods such as neural networks. In its basic state without adornments, theoretical considerations include the assumption of multivariate normality of the predictors, and a common covariance matrix for linear discriminant analysis (LDA). In quadratic discriminant analysis, the assumption of a common covariance matrix among the groups is relaxed (McLachlan, 1992).

Discriminant analysis can be easily extended to an online algorithm since recursive update formulas readily exist for a mean vector, covariance matrix, and its inverse (Salmen, Schlipsing, and Igel, 2010). This straightforward approach, however, fails to adapt to concept drift, and thus parameter estimates may potentially be computed from heterogeneous data. Additionally, as n grows large the model parameter estimates become so heavily influenced by historical data, that the weight or influence of new observations goes to zero, resulting in a model that fails to capture new trends and patterns as they emerge. In order to adjust for concept drift, a windowed approach with an external drift detection method for online LDA\QDA would be a straightforward alternative, but as discussed previously this may not be optimal in terms of drift detection, due to window size selection and computational and statistical efficiency (Kuncheva and Žliobait (2009)). Alternatively, (Anagnostopoulos et al., 2012) provide an online learning algorithm for linear and quadratic discriminant analysis based on temporally adaptive forgetting factors. Forgetting factors have their origin in the adaptive filtering literature (Haykin (1996)). Their approach can be viewed as a continuous analogue to the sliding window approach. The adaptive factors are computed from the data, and provide a weighting mechanism that weights recent observations more heavily than older observations, while still accounting for the goodness of fit of the observation. This allows for a robust, continuous modeling of data in the presence of drift. This adaptive filtering approach has been successfully applied to credit scoring (Adams et al. (2010)). Alternative online, adaptive algorithms exist for discriminant analysis. Some of these are described in Anagnostopoulos et al. (2012), and include Kuncheva and Plumpton (2008) and Pavlidis et al. (2011) as well as more recent neural network based algorithms such as Hayes and Kanan (2019).

2.2 Regularization

A potential drawback of discriminant analysis (whether batch or online) is the fact that the inverse of the pooled covariance matrix for LDA and the multiple inverses, one for each group, for QDA must be computed (Orhan, Ang Li, and Erdogmus, 2012). This problem is exacerbated by the fact that in our current technological climate, high-velocity, big data tends to be the norm in commercial applications (Schifano et al., 2016). In general, the estimation of the covariance matrix is a fundamental concern in a variety of applications, for example, in functional genomics (Schafer and Strimmer, 2005),in numerical weather forecasting (Bickel and Levina, 2008) as well as in portfolio management for financial situations (Ledoit and Wolf, 2004). In these and similar applications, it is usually the case that the number of dimensions, p, relative to the number of observations, n, is large. It is precisely in these situations that the typical sample covariance matrix performs badly (Ledoit and Wolf, 2004). Often the matrix becomes ill-conditioned, and the sample eigenvalues diverge from their population counterparts (Fisher and Sun, 2011). Within the context of discriminant analysis, this presents a problem as one or more matrix inverses are required. Potential for numerical errors in computing the inverse increases as the condition number increases (Trefethen, 1997), and computations cease when the matrix is singular. A generalized inverse could be used, however, the estimate may be unreliable due to the relative lack of observations (Guo, Hastie, and Tibshirani, 2006). In addition to the computational aspect of the problem of inverting a large matrix, the statistical problem of estimating all the required parameters compounds the issue (Lancewicki, 2017). For the "small n, large p" problem there are various strategies one might implement to sidestep the issues. Some of these include imposing additional structure on the covariance matrix, and thereby reducing the number of parameters to estimate (Engel, Buydens, and Blanchet, 2017). If the underlying structure is not known and cannot be reasonably deduced from historical data and/or underlying mechanisms, then the method of regularization may be a possible alternative (Guo, Hastie, and Tibshirani, 2006). Regularization encourages sparsity and can be accomplished in a data-driven manner (Schafer and Strimmer (2005), Fisher and Sun (2011)). Within discriminant analysis, using regularized estimates in place of their ordinary sample counterparts can reduce bias and variability in the resulting discriminant functions (Guo, Hastie, and Tibshirani (2006)). Furthermore, it has been shown that regularized estimates improve the performance of discriminant models (Lancewicki and Aladjem (2014)).

Adaptive streaming algorithms are also not immune from the small n, large p problem. For example, the method proposed by (Anagnostopoulos et al. (2012)) involves adaptively weighting the observations which leads to an "effective sample size" which is essentially an estimate of the number of observations since the last concept drift occurred. Therefore any time a concept drift occurs, this small n, large p problem will arise. In light of the issues in estimating large covariance matrices for big data, researchers have utilized regularization of the covariance matrices within streaming variants of LDA and QDA. For example, Orhan, Ang Li, and Erdogmus (2012) provides a computationally efficient update formula for online regularized quadratic discriminant analysis. Hayes and Kanan (2019) use regularized estimates in their algorithm which combines a convolutional neural network with a streaming linear discriminant analysis model. Lancewicki (2017) provides efficient sequential update formulas for approximations of the regularized covariance matrix estimate, which could also be utilized in streaming quadratic analysis.

2.3 Semi-supervised classification

Semi-supervised classification is applicable to situations where the analyst has both labeled and unlabeled observations and would like to use all of the data in the model fitting process (Zhu, 2009). This is relevant in streaming analytics (Millan-Giraldo, Sanchez, and Traver, 2011) where there may exist a significant lag time between the arrival of the predictor information and its corresponding label. In credit scoring applications, many applicants are rejected and no class label is observed. The problem of incorporating those individuals into a credit scoring model is known as *reject inference* (Banasik and Crook, 2007). Much of the literature on streaming discriminant algorithms tend to ignore this aspect (Anagnostopoulos et al. (2012), Kuncheva and Plumpton (2008), Lancewicki and Aladjem (2014)). However, in practice, this issue is quite relevant. Some recent work on semi-supervised methods for discriminant analysis include the following work by Lee, Shin, and Park (2011) who developed a graph based implementation, Jiang et al. (2014) who implemented a sparse discriminant analysis used for facial recognition, Adeli et al. (2019) who implemented a robust, outlier resistant variant of semi-supervised discriminant analysis, and (Toher, Downey, and Murphy, 2011) who utilizes a Gaussian mixture EM based model.

2.4 Error rate estimation

In addition to building a model, some type of model evaluation is usually necessary. A standard measure of model evaluation for classification methods is the misclassification rate. Investigation into error rate estimation within the context of discriminant analysis has quite a long history (McLachlan, 1992). One of the oldest nonparametric estimators is the resubstitution estimate put forth by Smith (1946). This simple estimate is obtained by deploying the discriminant model on the observed training data that was utilized to fit the model. This estimator is known to have optimistic bias (Lachenbruch and Mickey, 1968). In order to correct for this bias, various nonparametric estimators have been introduced which usually involve some resampling mechanism in an attempt to reduce bias, and sometimes even variance as well. For example, bootstrap estimators like the 0.632 bootstrap (Efron, 1994) or jackknifed based estimators, along with cross-validation variants (Efron, 1982) are often used. Additionally those same or similar procedures can be used to obtain estimates of the variance and/or confidence intervals for the error rates (Efron, 1994).

Other developments in error rate estimation include those based on posterior probabilities (Fukunaga and Kessell, 1973; Glick, 1978; Hora and Wilcox, 1982a), which are more focused on reducing variance than bias (Glick, 1978). These types of estimators may be of interest in the streaming context since they can be used for unlabeled data. Typical methods for error rate estimation in the streaming context include utilizing a holdout sample, the interleaved approach, and the prequential approach (Bifet et al., 2015b). The interleaved approach updates the error rate over time by first predicting a new observation, and then determining whether or not it was predicted correctly. Afterwards, the observation will be used to update the model parameters. The prequential approach is similar, but incorporates a forgetting mechanism into the process, either via a sliding window or with some type of adaptive weighting scheme (Gama, Sebastião, and Rodrigues, 2009, Ross et al., 2012).

CHAPTER 3

METHODS

3.1 Overview

Statistical and machine learning methods for streaming data are becoming more popular as businesses and individuals attempt to capitalize on information more quickly. Discriminant analysis remains a popular tool across many applications, and streaming variants of the algorithm have already been used in practice. This research consists of addressing issues that arise when utilizing discriminant analysis models for streaming data. Specifically, issues of high-dimensionality, missing class labels, and estimation of the error rate were investigated.

3.2 High dimensionality

In the presence of high dimensions, estimation and inversion of the covariance matrix are fundamental concerns for discriminant analysis with streaming data. Often the matrix is ill-conditioned and inversion may be computationally intense. Additionally, the sample covariance matrix may not be a stable estimate, given the relative lack of observations. The first part of the research involves investigation into the improvement of model accuracy and general applicability of the streaming adaptive LDA\QDA algorithm proposed by Anagnostopoulos et al. (2012) by replacing the usual estimates of the covariance matrices with adaptive regularized covariance matrix estimates in an effort to mitigate these concerns. Additionally, sequential approximations to the inverses of the regularized covariance matrix (Lancewicki, 2017) will be considered, as this will be useful by decreasing the required computational time.

3.2.1 Online discriminant analysis

The outline presented here follows closely to that of Anagnostopoulos et al. (2012), specifically sections 2.1-2.4. Consider the problem of estimating the mean vector and covariance matrix from a sample of observations that originate from a multivariate normal distribution with a certain mean vector μ and covariance matrix Σ. In the traditional *batch* setting with t i.i.d. observations where $x_i \sim \mathcal{N}_p(\mu, \Sigma)$ for $i = 1, ..., t$, the usual maximum likelihood estimates of μ and Σ are as follows:

$$\hat{\mu}_t = \frac{1}{t}\sum_{i=1}^{t} x_i \tag{3.1}$$

$$\hat{\Sigma} = \frac{1}{t}\sum_{i=1}^{t} x_i x_i^T - \hat{\mu}_t \hat{\mu}_t^T. \tag{3.2}$$

To create a simple online algorithm to estimate μ and Σ, computations need to be performed sequentially, that is, the parameter estimates should be recursively updated as each new observation comes in. The online, recursive formulas for the sample mean vector and covariance matrix are as follows:

$$\begin{aligned} \hat{\mu}_t &= \left(1 - \frac{1}{t}\right)\hat{\mu}_{t-1} + \frac{1}{t}x_t, \quad \hat{\mu}_0 = 0 \\ \hat{\Sigma}_t &= \hat{\Pi}_t - \hat{\mu}_t \hat{\mu}_t^T, \end{aligned} \tag{3.3}$$

where

$$\hat{\Pi}_t = \left(1 - \frac{1}{t}\right)\hat{\Pi}_{t-1} + \frac{1}{t}x_t x_t^T, \quad \hat{\Pi}_0 = 0.$$

Next, consider the case where the mean vector and covariance matrix are allowed to vary with time, that is, $x_i \sim \mathcal{N}_p(\mu_i, \Sigma_i)$. To temporally adapt to possible changes in the parameters, Anagnostopoulos et al. (2012) smoothly down-weight the contribution of each observation to the likelihood function via *forgetting factors*, $\vec{\lambda} = (\lambda_1, \lambda_2, ..., \lambda_t)$ where $0 \leq \lambda_i \leq 1$ for $i = 1, ..., t$. In particular,

$$\begin{aligned} &\mathcal{L}^{(\vec{\lambda})}\left(x_{1:t}; \mu, \Sigma\right) \\ &\quad = \lambda_{t-1}\mathcal{L}^{(\vec{\lambda})}\left(x_{1:(t-1)}; \mu, \Sigma\right) + \mathcal{L}\left(x_t; \mu, \Sigma\right) \\ &\quad = \textstyle\sum_{i=1}^{t}\left(\prod_{j=i}^{t-1}\lambda_j\right)\mathcal{L}\left(x_i; \mu, \Sigma\right) \end{aligned} \tag{3.4}$$

where

$$x_{1:t} = (x_1, x_2, ..., x_t),$$

$$\mathcal{L}(x_i; \mu, \Sigma) = -\ln f(x_i, \mu, \Sigma),$$

and

$$f(x_i, \mu, \Sigma) = (2\pi)^{-p/2}\det(\Sigma)^{-\frac{1}{2}}\exp\{-\frac{1}{2}(x_i - \mu)^T\Sigma^{-1}(x_i - \mu)\}$$

The minimizers of the weighted negative log-likelihood function (3.4), are as follows.

$$\begin{aligned} \tilde{\mu}_t &= \sum_{i=1}^{t}\frac{w_i}{n_t}x_i \\ \tilde{\Pi}_t &= \sum_{1:t}^{t}\frac{w_i}{n_t}x_i x_i^T \\ \tilde{\Sigma}_t &= \tilde{\Pi}_t - \tilde{\mu}_t\tilde{\mu}_t^T \end{aligned} \tag{3.5}$$

where

$$w_i = \prod_{j=i}^{t-1}\lambda_j \ , \ w_t = 1, \text{ and } n_t = \sum_{i=1}^{t} w_i.$$

The weighted estimators can be recursively updated as follows:

$$\begin{aligned} &\tilde{\mu}_t = \left(1 - \frac{1}{n_t}\right)\tilde{\mu}_{t-1} + \frac{1}{n_t}x_t, \quad \tilde{\mu}_0 = \mathbf{0}, \\ &\tilde{\Pi}_t = \left(1 - \frac{1}{n_t}\right)\tilde{\Pi}_{t-1} + \frac{1}{n_t}x_t x_t^{\mathrm{T}}, \quad \tilde{\Pi}_0 = \mathbf{0}, \text{ and} \\ &\tilde{\Sigma}_t = \tilde{\Pi}_t - \tilde{\mu}_t\tilde{\mu}_t^{\mathrm{T}}, \end{aligned} \tag{3.6}$$

where the *effective sample size* may also be computed recursively as follows:

$$n_t = \lambda_{t-1} n_{t-1} + 1. \tag{3.7}$$

The *forgetting factors* can be sequentially computed in a data-driven manner by finding the λ that optimizes some empirical measure of performance. Anagnostopoulos et al. (2012) chose to minimize the statistically-based *one-step ahead negative log-likelihood*, as this objective function measures the fit of the parameter estimates at time t to the datapoint at time $t+1$. The *one-step ahead negative log-likelihood* is given below.

$$\begin{aligned} J_{t+1} &= L^{\vec{\lambda}}\left(x_{t+1}; \tilde{\mu}_t, \tilde{\Sigma}_t\right) \\ &= \frac{1}{2}\ln|\tilde{\Sigma}_t| + \frac{1}{2}\left(x_{t+1} - \tilde{\mu}_t\right)^T \tilde{\Sigma}_t^{-1}\left(x_{t+1} - \tilde{\mu}_t\right) \end{aligned} \tag{3.8}$$

To derive the computation of the λ_t's consider the fixed case where $\lambda_t = \lambda$ for all t. The derivative of the *one-step ahead negative log-likelihood* with respect to λ is given as follows:

$$\frac{\partial \mathcal{L}\left(x_{t+1}; \tilde{\mu}_t, \tilde{\Sigma}_i\right)}{\partial \lambda} = J'_{t+1} \tag{3.9}$$

where

$$J'_{t+1} = \frac{1}{2}\left(x_{t+1} - \tilde{\mu}_t\right)^T \left(-2\tilde{\Sigma}_t^{-1}\tilde{\mu}'_t + \left(\tilde{\Sigma}_t^{-1}\right)'\left(x_{t+1} - \tilde{\mu}_t\right)\right) + \frac{1}{2}\left(\ln\left|\tilde{\Sigma}_t\right|\right)', \tag{3.10}$$

$$\left(\tilde{\Sigma}_t^{-1}\right)' = -\tilde{\Sigma}_t^{-1}\tilde{\Sigma}'_t\tilde{\Sigma}_t^{-1}, \text{ and} \tag{3.11}$$

$$\left(\ln\left|\tilde{\Sigma}_t\right|\right)' = \operatorname{tr}\left(\tilde{\Sigma}_t^{-1}\tilde{\Sigma}'_t\right). \tag{3.12}$$

The fixed λ assumption yields the following *recursive gradient formulas*:

$$
\begin{aligned}
\tilde{\mu}'_t &= \left(1 - \frac{1}{n_t}\right) \tilde{\mu}'_{t-1} - \frac{n'_t}{n_t^2} \left(x_t - \tilde{\mu}_{t-1}\right), \\
\tilde{\Sigma}'_t &= \tilde{\Pi}'_t - \tilde{\mu}'_t \tilde{\mu}_t^T - \tilde{\mu}_t \left(\tilde{\mu}'_t\right)^T, \text{ and} \\
\tilde{n}'_t &= \lambda_{t-1} n'_{t-1} + n_{t-1},
\end{aligned}
\tag{3.13}
$$

where

$$
\tilde{\mu}'_0 = 0 \text{ and } \tilde{\Pi}'_0 = 0, \text{ and}
$$

$$
\tilde{\Pi}'_t = \left(1 - \frac{1}{n_t}\right) \tilde{\Pi}'_{t-1} - \frac{n'_t}{n_t^2} \left(x_t x_t^T - \tilde{\Pi}_{t-1}\right).
$$

The above derivations lead to a self-tuning algorithm via a gradient descent approach. The forgetting factors are updated as follows (where $\alpha \in [10^{-8}, 10^{-6}]$ is a step size):

$$
\lambda_{t+1} = \lambda_t - \alpha J'_{t+1}. \tag{3.14}
$$

The recursive gradient formulas were originally derived under the fixed λ case, however, in the case of self-tuning, the λ_t's change over time. J'_{t+1} can be seen as an approximate gradient in the case where the λ_t's vary. The above computations can be similarly derived for the multinomial distribution, which can be used for estimating the prior probabilities of group membership. The online, adaptive discriminant analysis algorithm can then be implemented via separate estimation algorithms, one for each group. For k groups, the quadratic discriminant analysis algorithm requires k copies of the adaptive multivariate normal estimation algorithm, and an additional k copies of the multinomial estimation algorithm. The predicted class label for an observation, x^*, is the one, c^*, which maximizes the posterior probability

$$
\hat{c}^* = \underset{j=1,\ldots,k}{\operatorname{argmin}} \left\{ \mathcal{L}\left(x^*; \tilde{\mu}_t^{(j)}, \tilde{\Sigma}_t^{(j)}\right) - \ln \tilde{p}_t^{(j)} \right\}. \tag{3.15}
$$

In order to estimate the pooled covariance matrix in the linear discriminant case, one additional copy of the adaptive multivariate normal estimation algorithm is utilized, but for the centered datapoints $x_t - \tilde{\mu}_t^j$ instead of x_t.

3.2.2 Covariance matrix regularization

In general, a regularized covariance matrix estimate, S^*, is a convex combination of the usual sample covariance matrix S and a positive definite, well-conditioned target matrix T.

$$S^* = \lambda T + (1-\lambda)S, \text{ where } \lambda \in (0,1) \tag{3.16}$$

The target matrix, T, ideally should be representative of the actual covariance matrix. However, in practice this may not be known. The choice of the target matrix is not crucial, however, (Schafer and Strimmer (2005)) as this shrinkage estimator will always be positive definite, well-conditioned, and non-singular for any dimension (Fisher and Sun, 2011). Fisher and Sun (2011) derive the following computationally inexpensive estimators for three different target matrices. They also show that these estimators are comparable to existing regularized estimates, show improvement for extremely high dimensions, and illustrate the usefulness of these estimators in discriminant analysis. The estimators are appropriate under the assumption of multivariate normality.

i) Average variance times the identity, $T = [tr(S)/p]I$

The optimal intensity, λ^*, is estimated as $\hat{\lambda}^* = \hat{\beta}^2/\hat{\delta}^2$ where,

$$\hat{\beta}^2 = \tfrac{1}{n}\hat{a}_2 + \tfrac{p}{n}\hat{a}_1^2,$$
$$\hat{\delta}^2 = \frac{n+1}{n}\hat{a}_2 + \frac{p-n}{n}\hat{a}_1^2$$

with

$$\hat{a}_1 = \operatorname{tr} S/p$$

and

$$\hat{a}_2 = \frac{n^2}{(n-1)(n+2)}\frac{1}{p}\left[\operatorname{tr} S^2 - \frac{1}{n}(\operatorname{tr} S)^2\right].$$

ii) Identity, $T = I$

The optimal intensity, λ^*, can be estimated with

$$\hat{\lambda}^* = \frac{\frac{1}{n}\hat{a}_2 + \frac{p}{n}\hat{a}_1^2}{\frac{n+1}{n}\hat{a}_2 + \frac{2}{n}\hat{a}_1^2 - 2\hat{a}_1 + 1}$$

where $\hat{a}_1$ and $\hat{a}_2$ are defined as above.

iii) $T = D_S = diag(S)$

$$\lambda^* = \frac{\hat{\beta}_D^2 + \hat{\gamma}_D^2}{\hat{\delta}_D^2}$$

where

$$\hat{\beta}_D^2 = \frac{1}{n}\left(\hat{a}_2 + p\hat{a}_1^2\right),$$
$$\hat{\gamma}_D^2 = -\frac{2}{n}\hat{a}_2^*,$$

and

$$\hat{\delta}_D^2 = \frac{n+1}{n}\hat{a}_2 + \frac{p}{n}\hat{a}_1^2 - \frac{n+2}{n}\hat{a}_2^*$$

for

$$\hat{a}_1^* = \operatorname{tr}\left(D_S\right)/p$$

and

$$\hat{a}_2^* = \frac{n}{n+2}\operatorname{tr}\left(D_S^2\right)/p.$$

3.2.3 Sequential approximations to the inverse of the regularized covariance matrix

Discriminant analysis requires computation of one or more matrix inverses. In a streaming environment, these inverses may be computationally prohibitive for a large number of predictor variables, therefore an approximation is desired in practice. Lancewicki (2017) provides two such approximations. In the equations below, let $d_{t+1} = x_{t+1} - \hat{\mu}_t$. Specifically, $\tilde{\Sigma}_1^{-1}(\lambda_{t+1})$, is an approximation of the inverse of the regularized covariance matrix estimate with regularization parameter λ_{t+1} at time $t+1$ which has the following form:

$$\tilde{\mathbf{\Sigma}}_1^{-1}\left(\lambda_{t+1}\right) = \tilde{\mathbf{G}}_t^{-1} - \alpha_t \tilde{\mathbf{G}}_t^{-1}\mathbf{F}_t\tilde{\mathbf{G}}_t^{-1} \qquad (3.17)$$

where

$$\tilde{\mathbf{G}}_t^{-1} = \frac{t}{t-1}\left(\tilde{\boldsymbol{\Sigma}}_1^{-1}(\lambda_t) - \frac{\tilde{\boldsymbol{\Sigma}}_1^{-1}(\lambda_t)\,\mathbf{d}_{t+1}\mathbf{d}_{t+1}^T\tilde{\boldsymbol{\Sigma}}_1^{-1}(\lambda_t)}{\frac{t^2-1}{t(1-\lambda_{t+1})} + \mathbf{d}_{t+1}^T\tilde{\boldsymbol{\Sigma}}_1^{-1}(\lambda_t)\,\mathbf{d}_{t+1}}\right), \tag{3.18}$$

and

$$\mathbf{F}_t = \frac{1}{(t+1)p}\lambda_{t+1}\left\|\mathbf{d}_{t+1}\right\|_F^2\mathbf{I} + \frac{t-1}{t}\left(\lambda_t - \lambda_{t+1}\right)(\mathbf{S_t} - \mathbf{T_t}), \tag{3.19}$$

with $\mathbf{S_t}$ and $\mathbf{T_t}$ the sample covariance matrix and target matrix estimates at time t, respectively. The α_t is selected to minimize the following squared error of the reconstruction (where $\|\cdot\|_F$ refers to the Frobenius norm, and is defined as $\|A\|_F = \sqrt{AA^T}$, where A is a real m by n matrix).

$$\alpha_t = \arg\min_{\alpha}\left\|\left(\tilde{\mathbf{G}}_t^{-1} - \alpha\tilde{\mathbf{G}}_t^{-1}\mathbf{F}_t\tilde{\mathbf{G}}_t^{-1}\right)\hat{\boldsymbol{\Sigma}}(\lambda_{t+1}) - \mathbf{I}\right\|_F^2. \tag{3.20}$$

The optimal α_t is then computed as follows

$$\alpha_t^* = \frac{\mathrm{Tr}\left(\tilde{\mathbf{G}}_t^{-1}\mathbf{F}_t\tilde{\mathbf{G}}_t^{-1}\hat{\boldsymbol{\Sigma}}(\lambda_{t+1})\left(\tilde{\mathbf{G}}_t^{-1}\hat{\boldsymbol{\Sigma}}(\lambda_{t+1}) - \mathbf{I}\right)\right)}{\left\|\tilde{\mathbf{G}}_t^{-1}\mathbf{F}_t\tilde{\mathbf{G}}_t^{-1}\hat{\boldsymbol{\Sigma}}(\lambda_{t+1})\right\|_F^2}. \tag{3.21}$$

The second approximation to the regularized inverse of the covariance matrix is derived by considering the case when $\lambda_t - \lambda_{t+1}$ is small and can be ignored. This allows us to drop the second term from $\mathbf{F}_t$. Thus,

$$\tilde{\mathbf{F}}_t = \frac{1}{(n+1)p}\lambda_{t+1}\left\|\mathbf{d}_{t+1}\right\|_F^2\mathbf{I}, \tag{3.22}$$

$$\tilde{\boldsymbol{\Sigma}}_2^{-1}(\lambda_{t+1}) = \tilde{\mathbf{G}}_t^{-1} - \alpha_t'\tilde{\mathbf{G}}_t^{-1}\overline{\mathbf{F}}_t\tilde{\mathbf{G}}_t^{-1}, \text{and} \tag{3.23}$$

$$\tilde{\mathbf{G}}_t^{-1} = \tfrac{t}{t-1}\left(\tilde{\boldsymbol{\Sigma}}_2^{-1}(\lambda_t) - \frac{\tilde{\Sigma}_t^{-1}(\lambda_t)\mathbf{d}_{t+1}\mathbf{d}_{t+1}^T\overline{\boldsymbol{\Sigma}}_2^{-1}(\lambda_t)}{\frac{t^2-1}{t(1-\lambda_{t+1})} + \mathbf{d}_{t+1}^T\boldsymbol{\Sigma}_2^{-1}(\lambda_t)\mathbf{d}_{t+1}}\right). \tag{3.24}$$

The optimal α_t' is then computed as follows

$$\alpha_t' = \frac{(n+1)p\,\mathrm{Tr}\left(\tilde{\mathbf{G}}_t^{-2}\hat{\boldsymbol{\Sigma}}(\lambda_{t+1})\left(\tilde{\mathbf{G}}_t^{-1}\hat{\boldsymbol{\Sigma}}(\lambda_{t+1}) - \mathbf{I}\right)\right)}{\lambda_{t+1}\left\|\mathbf{d}_{t+1}\right\|_F^2\left\|\tilde{\mathbf{G}}_t^{-2}\hat{\boldsymbol{\Sigma}}(\lambda_{t+1})\right\|_F^2}. \tag{3.25}$$

3.3 Presence of unobserved class labels

For many applications in streaming data the class label is not observed until much later, if at all. In credit scoring applications, rejected applicants will have no class label. In sensor networks, sensors may fail randomly (Hossain, Ahad, and Inoue, 2020), and thus not provide a class label. This research involves the investigation of the use of the EM algorithm to update the model when class labels are not available across various drift scenarios. This research investigates the extension of the work of (Toher, Downey, and Murphy, 2011) to the streaming case. The method is straightforward and a brief outline of it is given below.

Description of method for updating parameter estimates in the presence of missing class labels

i) Use posterior predicted probabilities from the model estimated at the previous time point to predict the current observation.

ii) Update all parameter estimates across all groups using posterior probabilities as weights. Contrast this to when the label is known, where the weight for the current observation is set to $\frac{1}{n_i}$ where n_i is the "effective sample size" for the i^{th} group. Instead, in the case where the label is unknown, the weight is $\frac{p_i}{n_i}$ for the i^{th} group across all groups, where p_i is the posterior probability for the i^{th} group of the current observation.

iii) Repeat (*i*) and (*ii*) until the estimated posterior probabilities converge

3.4 Error rate estimation

Error rate estimation is very important across many classification applications (risk of default, disease diagnosis, fault type prediction in sensor networks, etc.), and is a standard measure of overall model performance. The adaptive streaming discriminant analysis algorithm (Anagnostopoulos et al., 2012) produces a sequence of models evolving over time. At each time point it is necessary to obtain an estimate of the error rate conditioned on the current model. Standard error rate estimation methods tend to take a windowed approach; however, this typically involves aggregating over non-iid Bernoulli variables to compute an estimate of the error rate. For processes that are subject to drift, adaptive methods that do not assume stationarity may be preferred. Even if the process is stationary, the model is changing over time, and an adaptive approach may be warranted, especially in cases of small n. In addition to non-stationarity, estimation of the error rate must take computational efficiency into account, along with the fact that the entire historical dataset will not be available at a given time point due to the typical constraints of streaming data (e.g. data is not available to the system after updating the model). This rules out popular nonparametric resampling methods which are typically used in batch analyses to adjust for bias and reduce variance (see McLachlan, 1992). This research investigates the following methods for error rate estimation.

3.4.1 Adaptive D estimate

One of the oldest methods for estimating the conditional error rate for a linear discriminant analysis model is a parametric estimator introduced by Fisher (1936). For two groups and equal costs, it estimates the conditional error rate for the linear discriminant model as the optimal error rate using the sample Mahalanobis distance, $D = \sqrt{(\bar{x}_1 - \bar{x}_2)^T \hat{\Sigma}_p^{-1} (\bar{x}_1 - \bar{x}_2)}$, in place of the unknown population value. The D estimate of the error rate is given as follows:

$$\hat{P}_i^D = \Phi\left(\frac{-D}{2}\right) \text{ for } i = 1, 2, \tag{3.26}$$

where $\Phi(\cdot)$ is the standard normal cumulative distribution function. In the streaming context, the sample Mahalanobis distance can be replaced by its adaptive counterpart, that is, the sample estimates will simply be replaced with the adaptive estimates. This estimator can only be used in the case of two groups with equal covariance matrices.

3.4.2 Adaptive Resubstitution.

Another approach to estimating the conditional error rate is to utilize the resubstitution method originally suggested by Smith (1947). This method simply deploys the discriminant model on the training dataset and estimates the conditional error rate via the observed misclassification rate. This is well known to have optimistic bias, as the same data that was used to train the model is now also used to evaluate it. In the streaming paradigm the resubstitution method cannot be directly applied, since the entire historical dataset at any given time point is not available. Instead, since the streaming model is being updated at the occurrence of a new datapoint, the conditional error rate for a given model can be estimated utilizing an adaptive weighted likelihood approach.

When a datapoint is observed and ingested by the streaming model, parameter estimates and corresponding classification boundaries are updated. The model can then be used to predict the individual datapoint. This is in essence adaptive resubstitution. In the two group case, consider the conditional error rate, P_1, that is, the proportion of those cases that come from population 1, Π_1, but are instead classified as coming from population 2, Π_2. An estimate of P_1 can be formed as follows:

$$\hat{P}_1 = \frac{1}{n_1} \sum_{i=1}^{N} w_i \; I(\; \hat{r}(x_i;t) = 2 \mid X_i \in G_1 \;), \tag{3.27}$$

where $I(\cdot)$ is an indicator function, $\hat{r}(X_i;t)$ is the predicted class label of x_i based on the current discriminant model, and G_i is the i^{th} group. The weights, w_i, can be derived from the data using the one-step ahead negative log-likelihood approach for a binomial distribution, and for more than two groups a multinomial distribution can be utilized. Adaptive conditional error estimates can then be updated in real time using the sequential update formula found in Anagnostopoulos et al. (2012).

3.4.3 Adaptive Interleaved or Prequential MLE method

This is a slight variation of the adaptive resubstitution method above. Instead of first updating parameters and then obtaining a prediction, the order is reversed by obtaining a prediction and then updating the model. The adaptive multinomial

MLE approach can then be used to estimate error rates.

3.4.4 Adaptive Posterior Probability Estimate

Posterior probability estimates combine aspects of both the "plug-in" method (e.g. the "D" method) and the "counting" method (e.g. sample proportion) in order to achieve low bias and variance for the error rate of a sample discriminant function (Fukunaga and Kessell (1973); Glick (1978); Hora and Wilcox (1982b)). This estimator has the added benefit of not requiring the actual observed class labels. A posterior probability estimate of the total conditional error rate can be computed as follows:

$$\hat{e} = 1 - \frac{1}{N}\sum_{i=1}^{N} \max_{j \in J} P(j|X_i). \tag{3.28}$$

In the typical batch setting, this estimator is unbiased for the Bayes risk, and has been shown to be an adequate estimator of the error rate of the sample discriminant function (Glick, 1978, Hora and Wilcox, 1982a). To convert this to an adaptive estimator, the adaptive forgetting factor approach described in Bodenham (2014) can be used to estimate the mean of the maximum of the posterior probabilities. This adaptive approach by Bodenham (2014) is similiar to the estimation procedure in Anagnostopoulos et al. (2012). The difference is that no distributional assumption is made, and thus the one-step ahead negative log-likelihood is replaced with the sum of squares, for the loss function. The recursive algorithm for updating the mean is given below (Bodenham (2014)). In the formulas below, the λ's are the forgetting factors, x_t is a real valued observation at time t, $w_{t,\vec{\lambda}}$ is the *effective sample size*, $m_{t,\vec{\lambda}}$ is the weighted sum of the forgetting factors and the data, and $\bar{x}_{t,\vec{\lambda}}$ is the adaptive estimate of the mean. Specifically,

$$\begin{aligned} m_{t,\vec{\lambda}} &= \lambda_{t-1} m_{t-1,\vec{\lambda}} + x_t, \\ w_{t,\vec{\lambda}} &= \lambda_{t-1} w_{t-1,\vec{\lambda}} + 1, \text{ and} \\ \bar{x}_{t,\vec{\lambda}} &= \frac{m_{t,\vec{\lambda}}}{w_{t,\vec{\lambda}}}. \end{aligned} \tag{3.29}$$

Using the sum of squares loss function,

$$L_{t+1,\vec{\lambda}} = \left[\bar{x}_{t,\vec{\lambda}} - x_{t+1}\right]^2,$$

the gradient descent algorithm can be used to update the λ_t's. Specifically,

$$\lambda_{t+1} = \lambda_t - \eta \frac{\partial}{\partial \vec{\lambda}} L_{t+1,\vec{\lambda}}. \tag{3.30}$$

The value of η is a step-size parameter and is usually set to some *small* value [0.001, 0.1]. The specific value is not critical (Bodenham, 2014).

The loss function has derivative

$$\frac{\partial}{\partial \vec{\lambda}} L_{t+1,\vec{\lambda}} = 2\left[\bar{x}_{t,\vec{\lambda}} - x_{t+1}\right] \frac{\partial}{\partial \vec{\lambda}} \bar{x}_{t,\vec{\lambda}}$$

where,

$$\frac{\partial}{\partial \vec{\lambda}} \bar{x}_{t,\vec{\lambda}} = \frac{\partial}{\partial \vec{\lambda}} \left(\frac{m_{t,\vec{\lambda}}}{w_{t,\vec{\lambda}}}\right) = \frac{\Delta_{t,\vec{\lambda}} w_{t,\vec{\lambda}} - m_{t,\vec{\lambda}} \Omega_{t,\vec{\lambda}}}{\left(w_{t,\vec{\lambda}}\right)^2}, \tag{3.31}$$

$$\Omega_{t,\vec{\lambda}} = \lambda_{t-1}\Omega_{t-1,\vec{\lambda}} + w_{t-1,\vec{\lambda}}, \text{ and} \tag{3.32}$$

$$\Delta_{t,\vec{\lambda}} = \lambda_{t-1}\Delta_{t-1,\vec{\lambda}} + m_{t-1,\vec{\lambda}}. \tag{3.33}$$

3.4.5 Prequential Posterior Probability Estimate

This is a slight variation of the adaptive posterior probability estimate above. Instead of updating parameters first and then obtaining a posterior probability estimate, the order is reversed by obtaining the posterior probability estimate and then updating the model.

3.5 Summary

The current research involves investigation into issues arising out of the application of discriminant analysis to streaming data. Specifically, the issues of high dimensionality, missing class labels, and error rate estimation were addressed. Comprehensive simulation studies were performed to assess the proposed methods. T

CHAPTER 4

ALGORITHMIC, THEORETICAL, AND SIMULATION CONSIDERATIONS

4.1 Algorithm considerations

Gradient descent guides the online, adaptive estimation process. It attempts to determine how much to weight the historical data by minimizing the one-step ahead negative log-likelihood by using only information from the gradient to determine step size (Anagnostopoulos et al., 2012). In general, across many applications, the success of the gradient descent algorithm may depend heavily on the specification of α (Riedmiller and Braun, 1993). There is a large body of research that attempts to address the specification of α dynamically in online, sequential applications (Costa and Vazquez-Abad, 2006; Mahmood et al., 2012). Various momentum strategies attempt to adjust α over time, by either aggressively taking larger step sizes when sensing convergence upon the optimum or by pulling back and taking smaller step sizes in order to try and avoid oscillation. These strategies are not necessarily useful for the adaptive estimation scenario. In the case of online, adaptive estimation the gradient descent algorithm is used to determine how much weight to place on historical data when estimating the parameters. If the historical model fits the data well, then little to no movement of λ occurs, that is, λ approximately retains its current value. In the typical optimization scenario, the gradient having a norm approximately equal to zero, indicates the set of parameter estimates is close to the optimal solution. In the adaptive estimation case, there is something slightly different going on. The derivative of J'_t being close to zero means that the historical parameter estimates fit the new data point well. This should translate into weighting the historical estimates more heavily. This may not be the case, however, if the system has recently undergone an abrupt shift. In that case purging of historical information by means of decreasing λ has occurred and thus λ may now be small. If the historical estimates now fit the data well and thus J'_t is small, then the algorithm may become stuck or resistant to moving towards 1 as little to no movement of λ will take place and thus valuable historical information will be forgotten. This will produce an estimator which will fail to use all of the relevant information and may perform relatively poorly as compared to a simple stationary estimator. In order to combat this phenomenon, the following strategy, which will be referred to as *stationary momentum*, enables the algorithm to move λ closer to one when there is evidence indicating stationarity of the process. The proposed update rule is as follows.

$$\begin{aligned} \lambda_{t+1} &= \lambda_t - \alpha J'_{t+1} \\ \lambda^*_{t+1} &= (1-\gamma)\lambda_{t+1} + \gamma \end{aligned} \tag{4.1}$$

where,

$$\gamma = e^{-0.5z^2},\ z = (J'_{t+1} - \tilde{J'}_t)/\tilde{s}_{J'}$$

and, $\tilde{J'}_t$ and $\tilde{s}_{J'}$ are the adaptive estimates of the mean and standard deviation of J'. The value of γ provides a measure of how far away the process is from stationarity. In essence, γ can be viewed a *neighborhood* function which yields values close to one, if the derivative of the one-step ahead negative likelihood is close to zero and quickly decreases as J'_{t+1} moves away from zero indicating nonstationarity. This allows the algorithm to enlarge the window of observations that can contribute to the estimator which makes it more stable and less prone to erratic behavior especially when long periods of stationarity are to be expected.

An example of such a case is as follows. Consider one of the adaptive shrinkage estimators of the form, $S^* = (1-\tau)\tilde{\Sigma} + \tau T$ where $T = \text{diag}(\tilde{\Sigma})$. In this scenario, there are p = 50 variables and the process experiences an abrupt change at time point 500 in the covariance structure, specifically, the structure changes from from an identity matrix to a random Wishart matrix with scale equal to the identity matrix and degrees of freedom equal to 250.

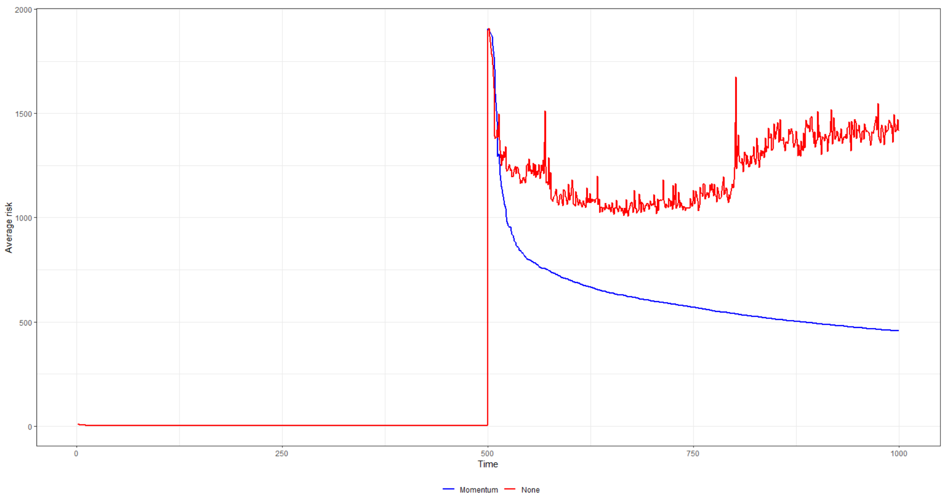


Figure 4.1: The average Frobenius norm over 10 simulations for an adaptive estimator with stationary momentum (in blue) and without (in red)

The above plot displays the average Frobenius norm over 10 simulations for an adaptive estimator that implements the above strategy with momentum (in blue), and one that does not implement the new strategy, that is, without momentum (red). Additionally, the plot of λ over time is also provided which illustrates how λ is able to quickly recover after the shift. Notice how the estimator which uses the new strategy is able to recover quickly from the abrupt shift and consistently provide a better quality estimator.

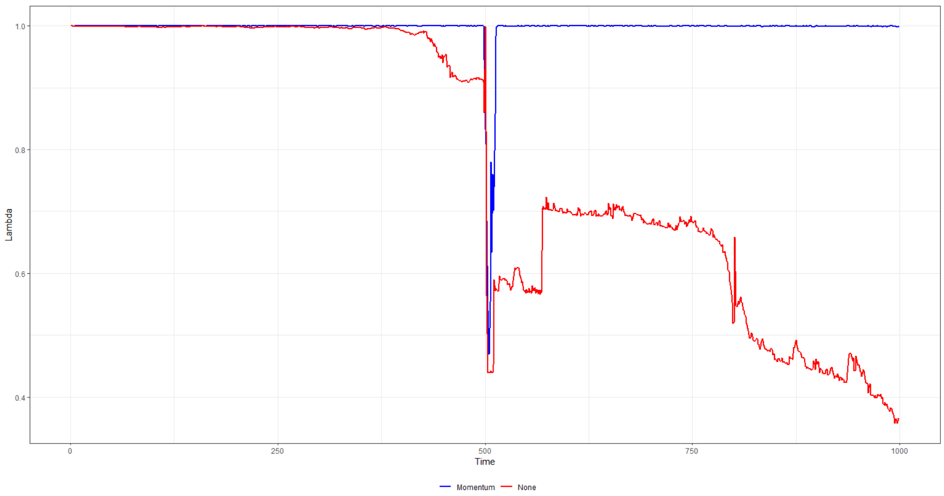


Figure 4.2: The average λ value over 10 simulations for an adaptive estimator with stationary momentum (in blue) and without (in red)

4.2 Adaptive Shrinkage Estimators

The proposed adaptive shrinkage estimators of the covariance matrix are an extension of the static adaptive estimators as proposed by Fisher and Sun (2011). The generalization to the adaptive case is accomplished by replacing the sample covariance matrix with its adaptive version along with each static entity of the *intensity parameter*, τ, with its corresponding adaptive counterpart as found in Anagnostopoulos et al. (2012). Additionally, in order to update the forgetting factor, λ_t, at each time point based on the one step ahead negative log-likelihood via the gradient descent algorithm, derivatives for each of the shrinkage covariance matrix estimates must be computed. The adaptive shrinkage estimator is given as follows

$$\tilde{\Sigma}^* = \tau T + (1-\tau)\tilde{\Sigma}, \text{ where } \tau \in (0,1)$$

where, $\tilde{\Sigma}$ is the adaptive estimator of Anagnostopoulos et al. (2012), T is the corresponding target matrix, and τ is the intensity parameter. The derivative of the adaptive shrinkage estimator with respect to the forgetting factor is as follows.

$$\begin{aligned}\tilde{\Sigma}^{*\prime} &= \left(\tau T + (1-\tau)\tilde{\Sigma}\right)' \\ &= \tau' T + \tau T' + \tilde{\Sigma}' - \tau'\tilde{\Sigma} - \tau\tilde{\Sigma}'\end{aligned}$$

T' and τ' differ for each target type and are given below.

4.2.1 Target = I

According to Fisher and Sun (2011), the optimal intensity, λ, in the case where the target matrix is the identity, $T = I$, is defined as,

$$\lambda = \frac{\frac{1}{n}\widehat{a}_2 + \frac{p}{n}\widehat{a}_1^2}{\frac{n+1}{n}\hat{a}_2 + \frac{p}{n}\hat{a}_1^2 - 2\hat{a}_1 + 1}$$

where,

$$\hat{a}_1 = \operatorname{tr}\tilde{\Sigma}/p$$

and

$$\hat{a}_2 = \frac{n^2}{(n-1)(n+2)} \frac{1}{p} \left[\operatorname{tr} \tilde{\Sigma}^2 - \frac{1}{n} (\operatorname{tr} \tilde{\Sigma})^2 \right].$$

The derivative of the adaptive, optimal intensity is given as,

$$\begin{aligned} \lambda' = & \left(\frac{n+1}{n} \hat{a}_2 + \frac{p}{n} \hat{a}_1^2 - 2\hat{a}_1 + 1 \right)^{-2} \\ & \left(\frac{-n'}{n^2} \hat{a}_2 + \frac{1}{n} \hat{a}_2' - \frac{n'p}{n^2} \hat{a}_1^2 + \frac{2p}{n} \hat{a}_1 \hat{a}_1' \frac{n+1}{n} \hat{a}_2 + \frac{p}{n} \hat{a}_1^2 - 2\hat{a}_1 + 1 \right. \\ & \left. - \frac{-n'}{n^2} \hat{a}_2 + \frac{n+1}{n} \hat{a}_2' - \frac{n'p}{n^2} \hat{a}_1^2 + \frac{2p}{n} \hat{a}_1 \hat{a}_1' - 2\hat{a}_1' \frac{1}{n} \hat{a}_2 + \frac{p}{n} \hat{a}_2 \right) \end{aligned}$$

The corresponding derivatives of $\hat{a}_1$ and $\hat{a}_2$ are given as follows.

$$\hat{a}_1' = \frac{1}{p} \cdot \operatorname{tr} \left(\tilde{\Sigma}' \right)$$

$$\begin{aligned} \hat{a}_2' = & \left[\operatorname{tr} \left(\tilde{\Sigma}^2 \right) - \frac{1}{n} \operatorname{tr} \left(\tilde{\Sigma} \right)^2 \right]^{-2} \\ & \left(\frac{2nn'(n-1)(n+2)p - n^2 p(2nn' + n')}{((n-1)(n+2)^2} \left[\operatorname{tr} \left(\tilde{\Sigma}^2 \right) - \frac{1}{n} \operatorname{tr} \left(\tilde{\Sigma} \right)^2 \right] \right. \\ & \left. - 2 \cdot \operatorname{tr} \left(\tilde{\Sigma}' \tilde{\Sigma} \right) + \frac{n'}{n^2} \operatorname{tr} \left(\tilde{\Sigma} \right)^2 - \frac{2}{n} \operatorname{tr} \left(\tilde{\Sigma}' \right) \frac{n^2}{(n-1)(n+2)p} \right) \end{aligned}$$

4.2.2 Target $= \mu I$

Recall, the optimal λ in this case is given as

$$\lambda = \frac{\frac{1}{n} \widehat{a}_2 + \frac{p}{n} \widehat{a}_1^2}{\frac{n+1}{n} \hat{a}_2 + \frac{p-n}{n} \hat{a}_1^2}$$

where,

$$\hat{a}_1 = \operatorname{tr} \tilde{\Sigma} / p$$

and

$$\hat{a}_2 = \frac{n^2}{(n-1)(n+2)}\frac{1}{p}\left[\operatorname{tr}\tilde{\Sigma}^2 - \frac{1}{n}(\operatorname{tr}\hat{\Sigma})^2\right].$$

The derivative of the adaptive, optimal intensity is given as,

$$\lambda' = \left(\frac{n+1}{n}\hat{a}_2 + \frac{p-n}{n}\hat{a}_1^2\right)^{-2}$$

$$\left(\frac{-n'}{n^2}\hat{a}_2 + \frac{1}{n}\hat{a}_2' - \frac{pn'}{n^2}\hat{a}_1^2 + \frac{2p}{n}\hat{a}_1\frac{n+1}{n}\hat{a}_2 + \frac{p-n}{n}\hat{a}_1^2\right.$$

$$\left. - -\frac{n'}{n^2}\hat{a}_2 + \frac{n+1}{n}\hat{a}_2' - \frac{n'p}{n^2}\hat{a}_1^2 + \frac{2(p-n)}{n}\hat{a}_1\hat{a}_1'\frac{1}{n}\hat{a}_2 + \frac{p}{n}\hat{a}_1^2\right)$$

4.2.3 Target = $\mathbf{D}_{\tilde{\Sigma}}$ =diag()

Recall, the optimal λ in this case is given as

$$\lambda^* = \frac{\hat{\beta}_D^2 + \hat{\gamma}_D^2}{\hat{\delta}_D^2}$$

where

$$\hat{\beta}_D^2 = \tfrac{1}{n}\left(\hat{a}_2 + p\hat{a}_1^2\right),$$
$$\hat{\gamma}_D^2 = -\tfrac{2}{n}\hat{a}_2^*,$$

and

$$\hat{\delta}_D^2 = \frac{n+1}{n}\hat{a}_2 + \frac{p}{n}\hat{a}_1^2 - \frac{n+2}{n}\hat{a}_2^*$$

for

$$\hat{a}_1 = \operatorname{tr}\left(D_{\tilde{\Sigma}}\right)/p$$

and

$$\hat{a}_2^* = \frac{n}{n+2}\operatorname{tr}\left(D_{\tilde{\Sigma}}^2\right)/p.$$

The corresponding derivatives of $\hat{a}_1^*$ and $\hat{a}_2^*$ are as follows.

$$\hat{a}_1^{*\prime} = \operatorname{tr}\left(D_{\tilde{\Sigma}'}\right)/p$$

$$\hat{a}_2^{*\prime} = \frac{2n'}{(n+2)^2} \operatorname{tr}\left(D_{\tilde{\Sigma}}^2\right)/p + \frac{2n}{n+2} \operatorname{tr}\left(D_{\tilde{\Sigma}'\Sigma}\right)$$

The derivative of the adaptive, optimal intensity is given as,

$$\lambda' = \left(\frac{n+1}{n}\hat{a}_2 + \frac{p}{n}\hat{a}_1^{*2} - \frac{n+1}{2}\hat{a}_2^*\right)^{-2}$$
$$\left(\frac{-n'}{n^2}\hat{a}_2 + \frac{1}{n}\hat{a}_2' - \frac{-pn'}{n^2}\hat{a}_1^{*2} + \frac{2p}{n}\hat{a}_1^{*\prime} + \frac{2n'}{n^2}\hat{a}_2^* - \frac{2}{n}\hat{a}_2^{*\prime}\frac{n+1}{n}\hat{a}_2 + \frac{p}{n}\hat{a}_1^{*2} - \frac{n+1}{2}\hat{a}_2^*\right.$$
$$\left. - \frac{n+1}{n}\hat{a}_2{}' - \frac{n'}{n^2}\hat{a}_2 - \frac{pn'}{n^2}\hat{a}_2^2 + \frac{2p}{n}\hat{a}_1^2 + \frac{2n'}{n^2}\hat{a}_2^* - \frac{n+2}{n}\hat{a}_2^*\frac{1}{n}\hat{a}_2 + \frac{p}{n}\hat{a}_1^{*2} - \frac{2}{n}\hat{a}_2^*\right)$$

4.3 Error Rate Estimator Theorems

4.3.1 The prequential estimator of the conditional error rate is asymptotically normal

For a sequence of linear or quadratic discriminant models, the corresponding sequence of conditional error rates, $\{\pi_t\}$, approaches the optimal error rate, π, as $t \to \infty$, see Rencher (1998). Let $X_i = 1$ if the i^{th} observation is classified incorrectly by the discriminant model and 0 otherwise, that is, $\{X_n\}$ is a sequence of Binomial random variables, that is, $X_i \sim Bin(1, \pi_i)$. The prequential error rate estimator, $\hat{p} = \frac{1}{t}\sum_{i=1}^{t} X_i$, typically used in streaming analytic applications is the cumulative error rate where the model is used to predict the observation's class label first and then the model's parameters are subsequently updated. This is also known as the test then train method (Bifet et al. (2018)). The asymptotic normality of the prequential error rate estimator can be established by the *Lindeberg-Feller* theorem. As the specific conditions of the theorem are typically difficult to verify, the conditions in a related corollary (sometimes referred to as *Liapounov's theorem*) are simpler to show. Specifically, to establish the result, one needs to show that $\sum_{i=1}^{n} \mathbb{E}|X_i - \mu_i|^v = o(B_n^v)$ as $n \to \infty$ for some $v > 2$ and where $B_n = \sum_{i=1}^{n} \sigma_i^2$. This result is well known, for example, see (Zou (2015)).

Let $v = 3$, then

$$\begin{aligned}\mathbb{E}|X_i - \mu_i|^3 &= |0 - \pi_i|^3(1 - \pi_i) + |1 - \pi_i|^3\pi_i \\ &= \pi_i^3(1 - \pi_i) + (1 - \pi_i)^3\pi_i \\ &\leq \pi_i(1 - \pi_i) + (1 - \pi_i)\pi_i \\ &= 2 \cdot \pi_i(1 - \pi_i)\end{aligned}$$

$$\begin{aligned}\sum_{i=1}^{n} \mathbb{E}|X_i - \mu_i|^3 &\leq 2\sum_{i=1}^{n} \pi_i(1 - \pi) \\ &= 2 \cdot B_n^2\end{aligned}$$

$$\frac{\sum_{i=1}^{n} \mathbb{E}|X_i - \mu_i|^3}{B_n^3} \leq \frac{2 \cdot B_n^2}{B_n^3} = \frac{2}{B_n} \to 0$$

Since,

$$B_n \to \infty$$

whenever,

$$0 < L \leq \pi_i \leq U < 1$$

As long as the conditional error rates of the sequence of models and the optimal error rates are bounded away from 0 and 1, the asymptotic normality of the prequential error rate estimator holds, that is, $\frac{1}{t}\sum_i X_i \sim AN\left(\frac{1}{t}\sum_i \pi_i, \frac{1}{t^2}\sum_i \pi_i(1 - \pi_i)\right)$. Furthermore, since $\pi_t \to \pi$, then $\frac{\frac{1}{t^2}\sum \pi(1-\pi)}{\frac{1}{t^2}\sum \pi_i(1-\pi_i)} \to 1$ as $t \to \infty$. Also, $\frac{\pi - \frac{1}{t}\sum \pi_i}{\frac{1}{t^2}\sum \pi_i(1-\pi_i)} \to 0$ since $\frac{1}{t}\sum \pi_i \to \pi$. Thus according to *Lemma A* in chapter 1 of Serfling (1980), $\hat{p} = \frac{1}{t}\sum X_i \sim AN\left(\pi, \frac{\pi(1-\pi)}{t}\right)$.

4.3.2 Consistency of the prequential error rate

Under stationarity, $\pi_t \to \pi$. This implies that $\mathbb{E}(\hat{p}) = \frac{1}{t}\sum_i \pi_i = \frac{1}{t} \cdot t\pi = \pi$ as $t \to \infty$. Similarly, $\mathbb{V}(\hat{p}) = \frac{1}{t^2}\sum_i \pi_i(1 - \pi_i) = \frac{\pi(1-\pi)}{t} \to 0$ as $t \to \infty$. Since $\hat{p}$ is asymptotically unbiased and its variance goes to 0 in the limit, it is MSE consistent and thus consistent (see Bain and Engelhardt (1992)).

4.3.3 Asymptotic Normality of the adaptive prequential estimator of the error rate under stationarity

The adaptive prequential error rate estimator can be written as $\tilde{p} = \frac{1}{n_t}\sum_i w_i X_i$ where w_i is the i^{th} adaptive weight and $n_t = \sum_i w_i$ (see equation 3.5). As before, let $X_i = 1$ if the i^{th} discriminant model classifies the i^{th} observation incorrectly and 0 otherwise and therefore $X_i \sim Bin(1, \pi_i)$. The expected value of the adaptive estimator is then given as $\mathbb{E}(\tilde{p}) = \frac{1}{n_t}\sum_i w_i \pi_i$. The variance is equal to $\mathbb{V}(\tilde{p}) = \frac{1}{n_t}\sum_i w_i^2 \pi_i(1-\pi_i)$. Similar to the static estimator, the asymptotic normality of $\tilde{p}$ is established by the *Lindeberg-Feller* theorem (Serfling (1980)). Let,$Y_i = \frac{t}{n_t} w_i X_i$. Note that $\mathbb{V}(Y_i) = \frac{t^2}{n_t^2} W_i^2 \cdot \mathbb{V}(x_i)$ and the expectation $\mu_i = \frac{t}{n_t} \cdot w_i \cdot \mu_i$.

$$\begin{aligned}
\mathbb{E}\left|Y_i - \mu_i\right|^3 &= \left|\frac{t}{n_t} w_i \pi_i\right|^3 (1-\pi_i) + \left|\frac{t}{n_t} w_i - \frac{t}{n_t} w_i \pi_i\right|^3 \pi_i \\
&= \left(\frac{t}{n_t} w_i\right)^3 \pi_i^3 (1-\pi_i) + \left(\frac{t}{n_t} w_i\right)^3 \pi_i (1-\pi_i)^3 \\
&\leq \left(\frac{t}{n_t} w_i\right)^3 \pi_i (1-\pi_i) + \left(\frac{t}{n_t} w_i\right)^3 \pi_i (1-\pi_i) \\
&= 2\left(\frac{t}{\eta_t} w_i\right)^3 \pi_i (1-\pi_i) \\
&\leq 2\frac{t^3}{n_t^3} w_i^2 \pi_i (1-\pi_i)
\end{aligned}$$

Thus,

$$\sum \mathbb{E}\left|y_i - \mu_i\right|^3 \leq 2\left(\frac{t}{n_t}\right)^3 \cdot \sum \pi_i(1-\pi i)$$

$$B_n^2 = \sum \mathbb{V}(y_i) = \frac{t^2}{n_t^2} \sum w_i^2 \pi_i (1-\pi_i)$$

$$\frac{\sum \mathbb{E}\left|y_i - \mu_i\right|^3}{B_n^3} \leq \frac{\left(\frac{t}{n_t}\right)^3 \sum w_i^2 \pi_i (1-\pi_i)}{\left[\frac{t^2}{n_t^2} \sum w_i^2 \pi_i (1-\pi_i)\right] B_n} = \frac{t/n_t}{B_n} \to 0$$

The above goes to 0 in the limit since under stationarity as $t/n_t \to 1$ and $B_n \to \infty$.

This satisfies the conditions for Liapounov's theorem, to hold and thus asymptotic normality of the adaptive estimator under stationarity has been established, that is, $\tilde{p} \sim AN\left(\frac{1}{n_t}\sum_i w_i\pi_i, \frac{1}{n_t^2}\sum_i w_i^2\pi_i(1-\pi_i\right)$. If the model (discriminant or otherwise) is asymptotically optimal, that is, $\pi_t \to \pi$ and additionally the adaptive weights go to unity, that is, $w_t \to 1$ as $t \to \infty$, then the conditions of *Lemma A* in Serfling (1980) have been satisfied, that is, $\frac{\frac{1}{n_t^2}\sum\pi(1-\pi)}{\frac{1}{n_t^2}\sum\pi_i(1-\pi_i)} \to 1$ and $\frac{\pi-\frac{1}{n_t}\sum w_i\pi_i}{\frac{1}{n_t^2}\sum\pi_i(1-\pi)} \to 0$ since $\frac{1}{n_t}\sum w_i\pi_i \to \frac{1}{n_t}\sum_i w_i\pi = \pi$ since $n_t = \sum_i w_i$ and $\pi_i \to \pi$. Thus, $\frac{1}{n_t}\sum_i w_iX_i \sim AN\left(\pi, \frac{\pi(1-\pi)}{n_t}\right)$.

4.3.4 Consistency of the Adaptive Error Rate Estimator

Under stationarity, the adaptive weights go to unity, that is, $w_t \to 1$ as $t \to \infty$. Additionally, if the model is asymptotically optimal, then $\pi_t \to \pi$. The expectation of the adaptive estimator, $\mathbb{E}(\tilde{p}) = \mathbb{E}\left(\frac{1}{n_t}\sum_i w_i\pi_i\right) = \pi$ since $n_t = \sum_i w_i$ and $\pi_i \to \pi$ as $t \to \infty$. The variance of the adaptive estimator is given as $\mathbb{V}(\tilde{p}) = \frac{1}{n_t^2}\sum_i w_i^2\pi_i(1-\pi_i) = \frac{1}{n_t^2}\left(\sum_i w_i^2\right)\pi(1-\pi) = \frac{n_t}{n_t^2}\pi(1-\pi) = \frac{1}{n_t}\pi(1-\pi) = 0$ in the limit. Thus, the adaptive estimator is MSE consistent and thus is consistent with respect to the optimal or Bayes error rate.

4.4 Design of Simulation Study For Evaluation of Adaptive Covariance Matrix Estimators

A simulation study was conducted in order to evaluate the adaptive shrinkage estimators of the covariance matrix for various dimensions and covariance structures including sparse structures. The adaptive estimators investigated were:

1. The adaptive covariance matrix estimate as put forth by Anagnostopoulos et al. (2012). Both the gradient descent and gradient descent with *stationary momentum* algorithms were used to adaptively estimate the covariance matrix.

2. Adaptive shrinkage estimator with target matrix, $T = I$.

3. Adaptive shrinkage estimator with target matrix, $T = \mu I$, where $\mu = \operatorname{tr}\tilde{\Sigma}/p$ and $\tilde{\Sigma}$ is the adaptive estimate from (1.).

4. Adaptive shrinkage estimator with target matrix, $T = diag(\tilde{\Sigma})$ where $\tilde{\Sigma}$ is the adaptive estimate from (1.)

For each of the shrinkage estimators (2.)-(4.), the gradient descent algorithm with *stationary momentum* was used for covariance estimation. The number of variables investigated included $p = 10$, 25, 50, 100, 250, 500, and 1000. Estimators were evaluated by simulated average loss $||\hat{\Sigma} - \Sigma||$ where $||\cdot||$ denotes the Frobenius norm which is defined for some real matrix $A_{m\times n}$, $||A||_F = \sqrt{\sum_{i=1}^{m}\sum_{j=1}^{n} a_{ij}^2}$.

4.4.1 Covariance Structures

For small $p = 10$, and 25, the covariance structures considered were:

1. Identity

2. First-order auto-regressive (AR1) with $\rho = 0.9$.

3. Compound symmetric with $\rho = 0.9$.

4. Random Wishart with degrees of freedom equal to $5p$ and scale matrix equal to the identity matrix.

For large $p > 25$, the following covariance structures were considered.

1. Identity

2. Block diagonal matrices where block sizes were varied such that sparsity levels of the overall matrix varied from 50% to 95%. The structures considered for each block were:

   (a) AR1 with $\rho = 0.9$.

   (b) CS with $\rho = 0.9$.

   (c) Random Wishart with degrees of freedom equal to $5p$ and scale matrix equal to the identity matrix.

4.4.2 Distribution of Data

Data was generated according to a multivariate normal distribution with one of the aforementioned covariance matrices with a mean vector equal to the zero vector, that is, $\mu = \mathbf{0}$. To test the robustness of the models to non-normal data, data was also generated according to a multivariate t-distribution with $v = 5$.

Multivariate normal data was generated using MATLAB's multivariate normal random data generator, *mvnrnd* (MATLAB (2020)). Additionally, multivariate t data was generated using the multivariate t random data generator, *MVT_RND* found in the *Toolkit on Econometrics and Economics Teaching* within the MATLAB File Exchange (Qian (2011)). In general, a random multivariate t vector can be generated by utilizing the following well known relationship among the multivariate normal, chi-square, and multivariate t distributions. According to Hoefert (2013), a p dimensional random vector, $\boldsymbol{x}$, from a multivariate t distribution with mean μ, degrees of freedom ν, and scale matrix Σ, can be constructed in the following manner. Let $\mathbf{x} = \boldsymbol{\mu} + \sqrt{\nu/u}\mathbf{Y}$, where Y and u are independent and distributed as $\mathcal{N}(0, \Sigma)$ and χ^2_ν respectively. The density of $\mathbf{x}$ is the multivariate t density given as

$$\frac{\Gamma[(\nu+p)/2]}{\Gamma(\nu/2)\nu^{p/2}\pi^{p/2}|\Sigma|^{1/2}}\left[1+\frac{1}{\nu}(\mathbf{x}-\mu)^T\mathbf{\Sigma}^{-1}(\mathbf{x}-\mu)\right]^{-(\nu+p)/2}$$

4.4.3 Types of Data Drift

Two types of drift were investigated, *abrupt*, and *gradual.* For the simulations involving covariance estimation only the covariance matrix was allowed to drift. For simulations involving discriminant analysis, both the mean vector and covariance matrix were allowed to drift. Prior probabilities were not allowed to drift and will be an area of future research.

As in Anagnostopoulos et al. (2012), gradual covariance drift was done using *piecewise convex covariance movement* (Anagnostopoulos et al. (2008b)). For all gradual drift simulations, the true covariance matrix at a given time $t \in$

$[t_{Start}, t_{End}]$, is defined as

$$\Sigma_t = \frac{t_{End} - t}{t_{End} - t_{Start}} \Sigma_{t_{Start}} + \frac{t - t_{Start}}{t_{End} - t_{Start}} \Sigma_{t_{End}}$$

Similarly, the mean vector at time t is defined as

$$\mu_t = \frac{t_{End} - t}{t_{End} - t_{Start}} \mu_{t_{Start}} + \frac{t - t_{Start}}{t_{End} - t_{Start}} \mu_{t_{End}}$$

For all abrupt drift scenarios, the covariance matrix and mean vector are swapped out for new parameters at a the midpoint of the simulation run.

4.4.4 Design of Simulation Study For Evaluation of Discriminant Analysis Models Based On Adaptive Covariance Matrix Estimators

In the case of two groups, the simulated distributions had an optimal error rate of 0.05, 0.1, and 0.25.

Multivariate Normal Data

According to Rencher (1998), for multivariate normal data, the optimal error rate for two groups with priors p_1 and p_2 is

$$p = p_1 \Phi \left[\frac{-\frac{1}{2}\Delta^2 + \ln(p2/p1)}{\Delta} \right] + p_2 \Phi \left[\frac{-\frac{1}{2}\Delta^2 - \ln(p2/p1)}{\Delta} \right] \tag{4.2}$$

where,

$$\Delta = \sqrt{(\mu_1 - \mu_2)^T \Sigma^{-1} (\mu_1 - \mu_2)} \tag{4.3}$$

The optimal error rate further simplifies with equal priors, as it can be easily computed as

$$p = \Phi(-0.5\sqrt{(\mu_1 - \mu_2)^T \Sigma^{-1} (\mu_1 - \mu_2)}). \tag{4.4}$$

After specifying a common covariance matrix, along with the priors p_1 and p_2, the mean vectors μ_1 and μ_2 were randomly generated in such a way as to ensure the specified optimal error rate was satisfied. This was done as follows. The

Mahalanobis distance between the two normal distributions was found such that the specified optimal error rate was satisfied (see 4.5). Next, a difference vector $\boldsymbol{d} = \mu_1 - \mu_2$ was randomly generated to satisfy the Mahalanobis distance (see 4.6). Specifically, a point on the multidimensional sphere centered at the origin with radius equal to the desired Mahalanobis distance was randomly generated (see Marsaglia (1972)) for details). Next, standardized mean vectors were computed as follows

$$\mu_1' = \boldsymbol{u} \odot \boldsymbol{z}$$

and

$$\mu_2' = (\boldsymbol{u} - \boldsymbol{1}) \odot \boldsymbol{z}$$

where $\boldsymbol{u}$ is a vector of independent uniform random variables on the interval [0,1]. Lastly, the mean vectors of the multivariate Gaussian distributions were computed as

$$\mu_1 = \Sigma^{-1/2}\mu_1'$$

and

$$\mu_2 = \Sigma^{-1/2}\mu_2'$$

where $\Sigma^{-1/2}$ is a symmetric square root matrix of the inverse covariance matrix Σ^{-1} (Rencher (1998)).

Multivariate Student t Data

In the case of linear discriminant analysis with two groups where the distribution for each group is a multivariate t distribution, simple, closed form expressions for the optimal error rates exist as well. This follows from the fact that if y is distributed according to a multivariate t distribution, that is, if $y \sim T_\nu(\mu, S)$ where S is a $p \times p$ positive definite scale matrix and where $S = \frac{\nu-2}{\nu} \cdot \Sigma$, then $\frac{\alpha' y - \alpha' \mu}{\sqrt{\alpha' S \alpha}} \sim t_\nu$, see (Paolella (2019a)) for details. The optimal error can be easily computed as

$$p = p_1 \boldsymbol{\Omega}_\nu \left[\frac{-\frac{1}{2}\Lambda^2 + \ln(p2/p1)}{\Lambda} \right] + p_2 \boldsymbol{\Omega}_\nu \left[\frac{-\frac{1}{2}\Lambda^2 - \ln(p2/p1)}{\Lambda} \right] \tag{4.5}$$

where,

$$\Lambda = \sqrt{\frac{\nu - 2}{\nu} \left(\mu_1 - \mu_2\right)^T \Sigma^{-1} \left(\mu_1 - \mu_2\right)} \tag{4.6}$$

and where $\boldsymbol{\Omega}_\nu$ is the cumulative distribution function for a Student's t distribution with ν degrees of freedom. For a given covariance matrix and optimal error rate, the mean vectors were randomly generated in a similar manner as before in the multivariate normal case.

Quadratic Discriminant Analysis

In general, unlike the linear case, the quadratic case does not have simple expressions for the optimal error rates (Rekabdar, Chinipardaz, and Mansouri (2017)). For the majority of the simulations, mean vectors and covariance matrices were simply randomly generated without regard to a specified optimal error rate. To investigate specified optimal error rates of 0.05, 0.1, and 0.25 it was necessary to randomly draw a single covariance matrix and assign this to both groups. This was done only in the case of $p = 100$ for a random Wishart matrix. Specifically the following simple distance based search procedure was utilized. For a specified optimal error rate, common covariance matrix, and priors, the Mahalanobis distance was calculated for the case where $\mu_1 = \mu_2$. Next, a search was performed to find the mean vectors μ_1 and μ_2 that approximately yield the desired optimal error rate. The optimal error rate for a given set of mean vectors was estimated by simulation, specifically by generating 100,000 observations in proportion to the prior probabilities and building a quadratic discrimination model and computing the error rate. By progressively increasing the Mahalanobis distance, the distributions were found that approximately yielded the specified optimal error rate.

4.4.5 Evaluation of Error Rate Estimator for Linear Discriminant Analysis with 2 Groups

According to McLachlan (1975) and Rencher (1998), the two misclassification probabilities in a two-group linear discriminant analysis with multivariate normal data are given as:

$$P_i = \Phi\left((-1)^i \frac{\left\{\boldsymbol{\mu}_i - \frac{1}{2}(\overline{\mathbf{x}}_1 + \overline{\mathbf{x}}_2)\right\}' \mathbf{S}^{-1}(\overline{\mathbf{x}}_1 - \overline{\mathbf{x}}_2) + \ln(p_2/p_1)}{\sqrt{(\overline{\mathbf{x}}_1 - \overline{\mathbf{x}}_2)' \mathbf{S}^{-1}\boldsymbol{\Sigma}\mathbf{S}^{-1}(\overline{\mathbf{x}}_1 - \overline{\mathbf{x}}_2)}}\right), \quad (i = 1, 2)$$

where Φ is the standard normal distribution function. Similarly, if the data is distributed according to a multivariate t-distribution and using the result from Paolella (2019a), about linear combinations of multivariate t random variables, then the two misclassification probabilities with multivariate t data are given as:

$$P_i = \Omega_\nu\left((-1)^i \cdot \sqrt{\frac{\nu}{\nu - 2}} \cdot \frac{\left\{\boldsymbol{\mu}_i - \frac{1}{2}(\overline{\mathbf{x}}_1 + \overline{\mathbf{x}}_2)\right\}' \mathbf{S}^{-1}(\overline{\mathbf{x}}_1 - \overline{\mathbf{x}}_2) + \ln(p_2/p_1)}{\sqrt{(\overline{\mathbf{x}}_1 - \overline{\mathbf{x}}_2)' \mathbf{S}^{-1}\boldsymbol{\Sigma}\mathbf{S}^{-1}(\overline{\mathbf{x}}_1 - \overline{\mathbf{x}}_2)}}\right), \quad (i = 1, 2)$$

where Ω_ν is the Student's t distribution function.

According to Rencher (1998), these conditional misclassification probabilities can be combined to compute the exact conditional error rate as $p_1 P_1 + p_2 P_2$ where p_1 and p_2 are the corresponding prior probabilities for each group. The adaptive error rate estimators investigated were as follows:

1. Adaptive D estimate
2. Adaptive Resubstitution
3. Adaptive Interleaved/Prequential
4. Adaptive Posterior Probability Estimate
5. Adaptive Prequential Posterior Probability Estimate

The error rate estimators were evaluated according to simulated MSE, variance, and bias in the case of two groups with equal priors.

4.4.6 Evaluation of Discriminant Models in the Presence of Missing Data

Missing class labels and its impact on classification accuracy and error rate estimator accuracy was investigated. Three levels of random missingness were investigated, 5%, 10%, and 25%.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Overview

Comprehensive simulation studies were carried out which investigated the performance of the proposed adaptive estimators in the context of covariance matrix estimation and linear and quadratic discriminant analysis. Results indicate that in general the adaptive shrinkage estimators tend to perform better under multivariate normality, and the advantage over the other adaptive estimators increases with increasing sparsity of the underlying covariance matrix. The only exception is that the shrinkage identity estimator performs poorly across most of the various scenarios excluding the case where the underlying covariance matrix is not the Wishart matrix.

5.2 Covariance Matrix Estimation

Simulation studies investigated the performance across the three main drift scenarios: no drift (stationary), abrupt drift, and gradual drift.

5.2.1 Stationary

For stationary data regimes, 5000 independent observations were sequentially generated from either a multivariate normal distribution (Rencher (1998)) or a multivariate t distribution with 5 degrees of freedom (Paolella (2019b)). The mean vector was set to the zero vector throughout the entirety of the simulation. The covariance matrix was set at the beginning of the simulation and did not vary.

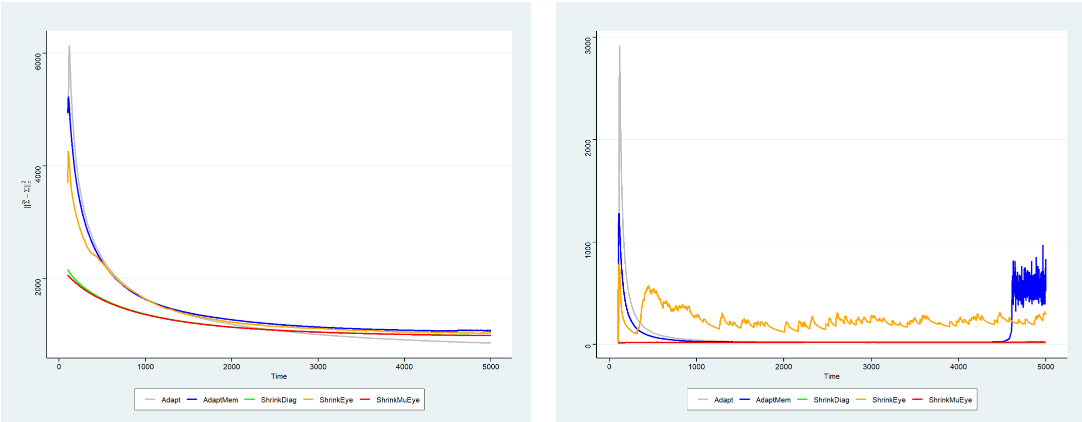
The following scenarios were considered for the specification of the covariance matrix,

- randomly sampled from a Wishart distribution with $5p$ degrees of freedom and scale matrix equal to the identity matrix,
- First-order autoregressive $\rho = 0.9$,
- Compound symmetric $\rho = 0.9$,
- Block diagonal structure

5.2.1.1 Wishart

Under a stationary multivariate normal distribution where the covariance matrix was randomly selected from a Wishart distribution with $df = 5p$ and scale matrix equal to the identity matrix, I_p, the estimators performed similarly across the various dimensions. In general, each estimator's loss profile resembles an approximate "L-shape" where the loss tends to be very high in the early stages of the simulation, but rapidly decreases as more data are observed. As expected (Ledoit and Wolf, 2004), the shrinkage estimators tend to have an advantage early on in the sequence when the dimensions are large relative to the number of observed time points. This advantage, however, diminishes and later disappears as more data are observed. This advantage is most apparent with the *shrinkage diagonal* and *shrinkage average variance* estimators. For a typical stationary example in this setting, see the trajectory plot below of the squared Frobenius norm for each estimator in the case of 100 dimensional multivariate normal data. Note that the *shrinkage diagonal* (red) and *shrinkage average variance* (green) estimators on average outperform the others for at least half of the simulation. The *shrinkage identity* estimator (yellow) initially has an advantage as compared to the non-shrinkage adaptive estimators, however, this quickly disappears.

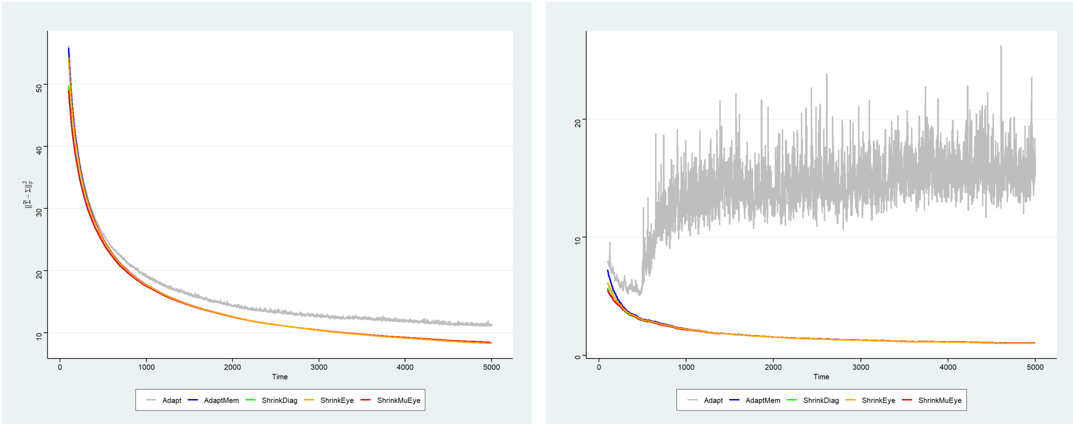
The standard deviation of loss over time is plotted below alongside the average loss. The graph reveals a similar decreasing trend as with the average loss for many of the estimators with a couple of notable exceptions. The *shrinkage identity* estimator exhibits significant more variability over time, and the *adaptive memory* estimator has large variability towards the end of the sequence.



(a) Average loss, Normal $p = 100$ (b) Standard deviation,Normal $p = 100$

Figure 5.1: Average loss and standard deviation for stationary multivariate normal data ($p = 100$) with Wishart covariance matrix

When the number of dimensions is small, e.g. when $p = 10$, the *adaptive* estimator performs noticeably worse in terms of average loss and appears to be slightly more unstable. This instability may be mitigated by considering alternative momentum settings and/or strategies. The current research did not address such issues. Even though the estimator performs worse in terms of average loss and variability, it still yields a downward trend in the loss. See plot below.The *adaptive estimator* seems to be slightly more unstable and more sensitive to possible changes in the data generating mechanism. This is highlighted in the plot of the standard deviation loss below.

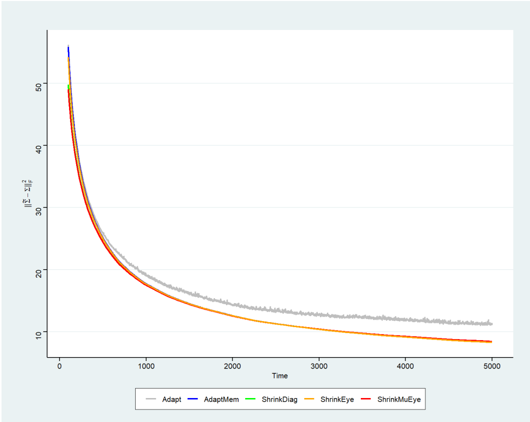


(a) Average loss, Normal $p = 10$ (b) Standard deviation,Normal $p = 10$

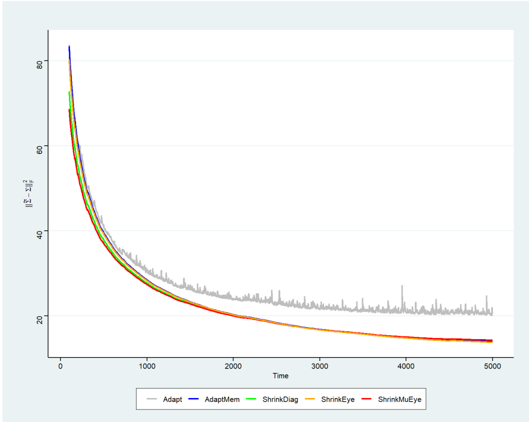
Figure 5.2: Average loss and standard deviation for stationary multivariate normal data ($p = 10$) with Wishart covariance matrix

Normal vs. MVT(5)

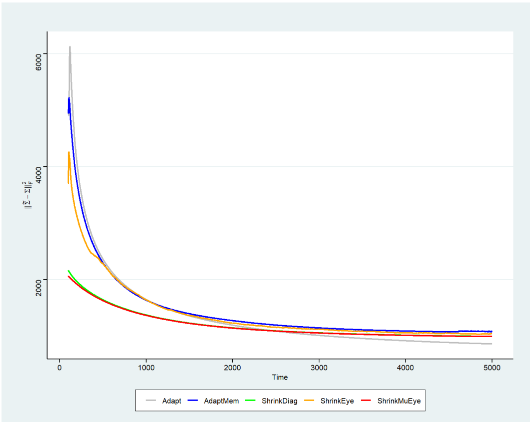
In the stationary case, similar results exist for both multivariate normal and multivariate t(5) data. The influence of the heavy tailed distribution on the estimators, however, does not go unnoticed. There appears to be a slightly greater benefit to the use of the *shrinkage diagonal* and *shrinkage average variance* estimators especially early in the sequence. The trajectories of the shrinkage estimators, however, appears to be slightly more rough and uneven. The *shrinkage identity* estimator's performance is affected most and performs slightly worse for $p \leq 100$ than the remaining estimators. This performance continues to degrade as p increases.



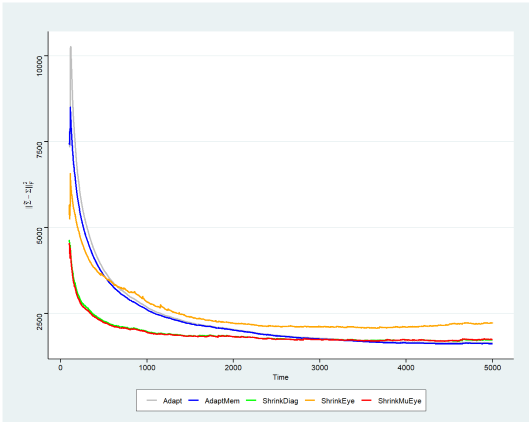
(a) Normal, $p = 10$



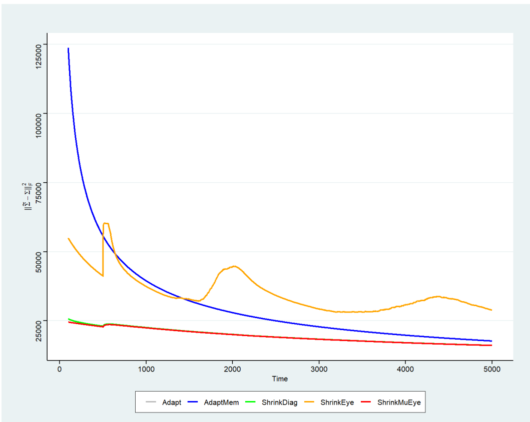
(b) MVT(5), $p = 10$



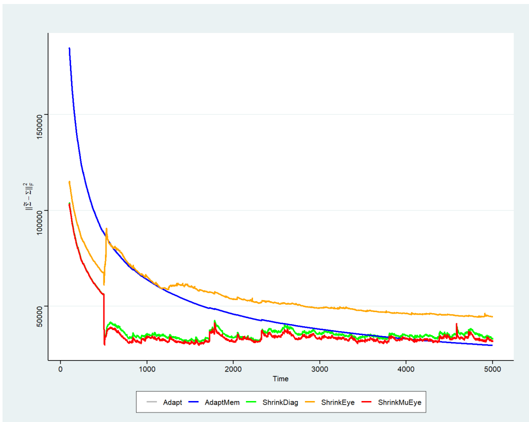
(c) Normal, $p = 100$



(d) MVT(5), $p = 100$

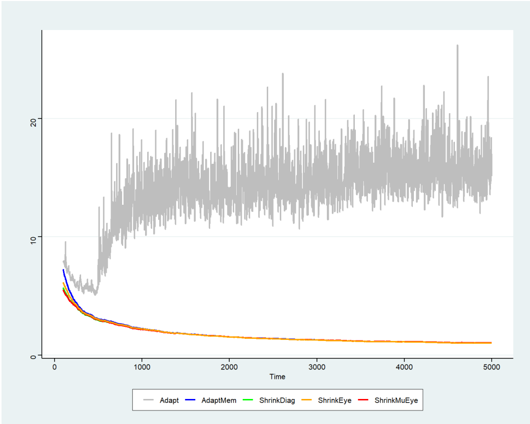


(e) Normal, $p = 500$

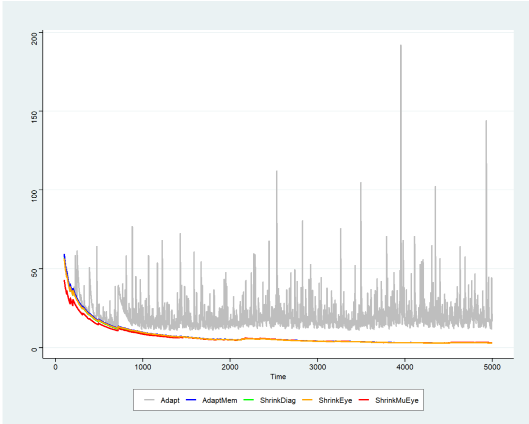


(f) MVT(5), $p = 500$

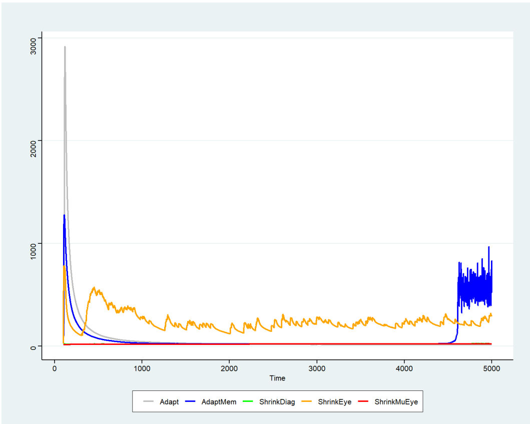
Figure 5.3: Average loss comparison between Normal and MVT(5) for Wishart covariance matrix.



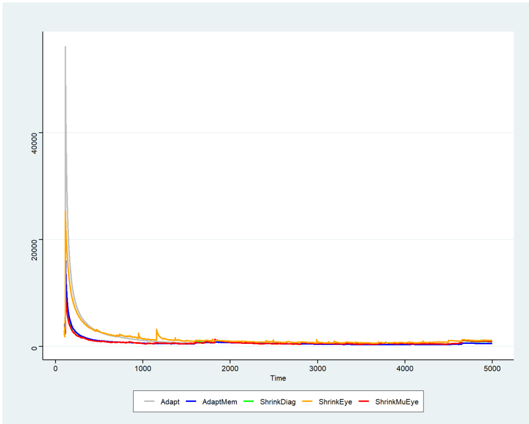
(a) Normal, $p = 10$



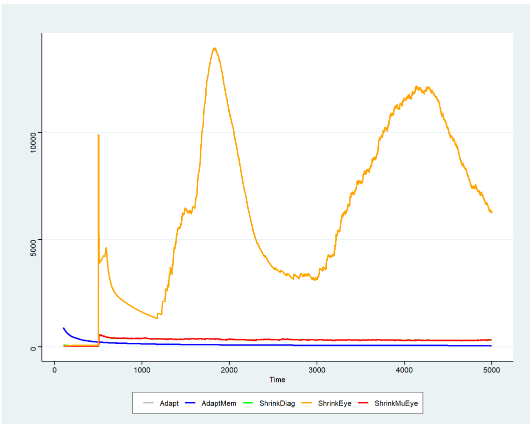
(b) MVT(5), $p = 10$



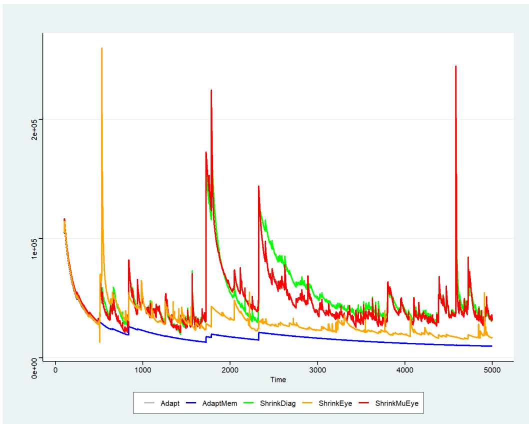
(c) Normal, $p = 100$



(d) MVT(5), $p = 100$

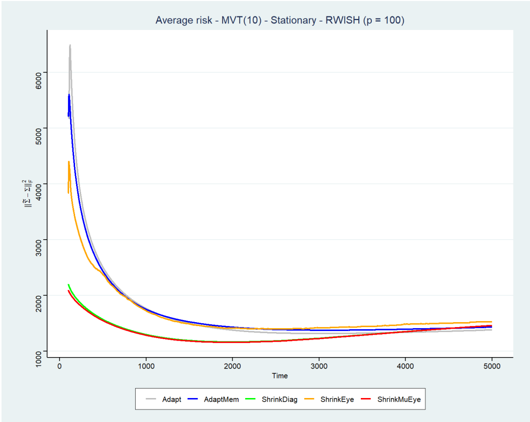


(e) Normal, $p = 500$

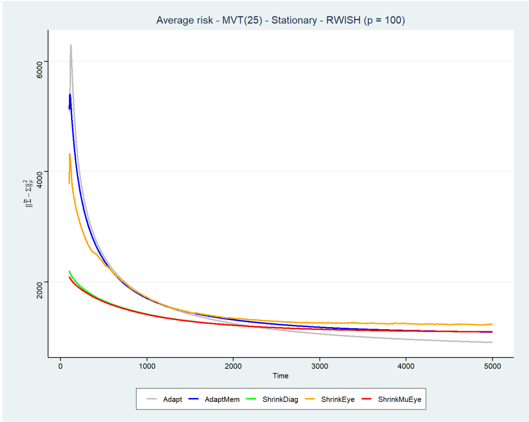


(f) MVT(5), $p = 500$

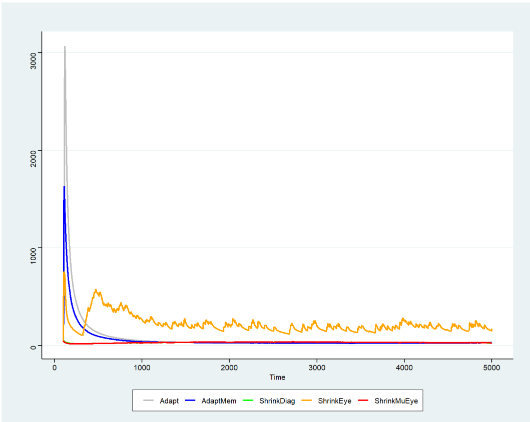
Figure 5.4: Standard deviation of loss comparison between Normal and MVT(5) for Wishart covariance matrix.



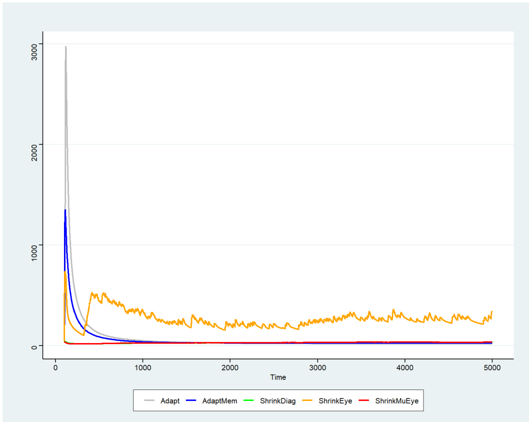
(a) MVT(10), $p = 100$



(b) MVT(25), $p = 100$



(c) Standard Deviation, MVT(10), $p = 100$



(d) Standard Deviation, MVT(25), $p = 100$

Figure 5.5: Average loss comparison between MVT(10) and MVT(25) for Wishart covariance matrix.

5.2.1.2 Compound Symmetric and Autoregressive Covariance Structures

In addition to a random Wishart matrix, two more covariance structures were considered. The *compound symmetric* and *auto-regressive* structures. Specifically, the compound symmetric covariance structure is as follows,

$$\Sigma = \begin{pmatrix} 1 & \rho & \cdots & \rho \\ \rho & 1 & \cdots & \rho \\ \vdots & \vdots & \ddots & \vdots \\ \rho & \rho & \cdots & 1 \end{pmatrix}_{p \times p} \tag{5.1}$$

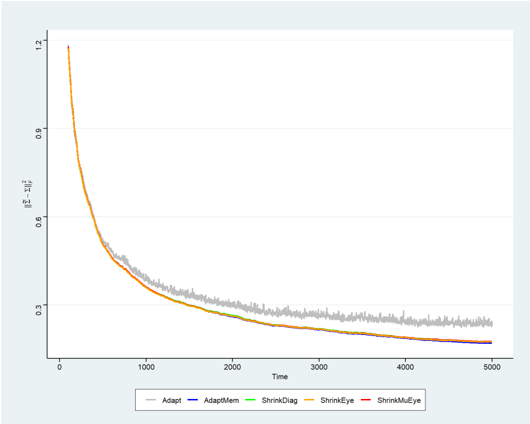
and the first-order autoregressive covariance structure is as follows,

$$\Sigma = \begin{pmatrix} 1 & \rho & \cdots & \rho^{p-1} \\ \rho & 1 & \cdots & \rho^{p-2} \\ \vdots & \vdots & \ddots & \vdots \\ \rho^{p-1} & \rho^{p-2} & \cdots & 1 \end{pmatrix}_{p \times p} \tag{5.2}$$

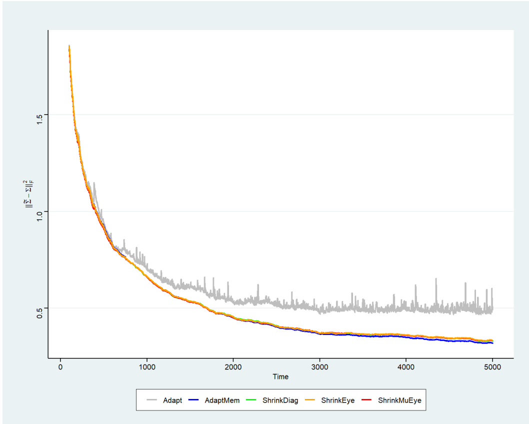
For simulations involving compound symmetric and AR(1) covariance structures, ρ was held constant at 0.9. For $p \leq 100$, all of the estimators performed well. The loss of each estimator appeared to be slowly converging toward 0, with the exception of $p = 10$ for the *adaptive* estimator. Trajectory plots for $p \leq 100$ for multivariate normal and multivariate t(5) for both the simulated average loss and its standard deviation are given below.

Normal vs. MVT(5)

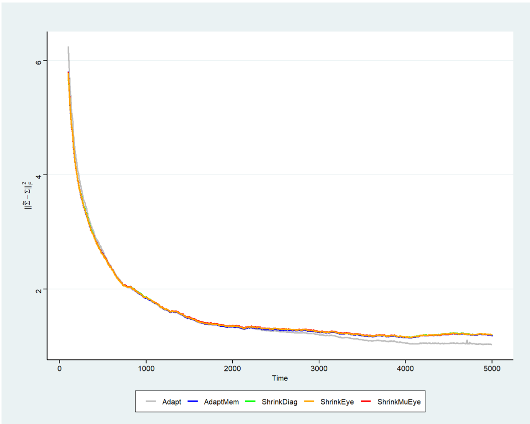
Compound Symmetry



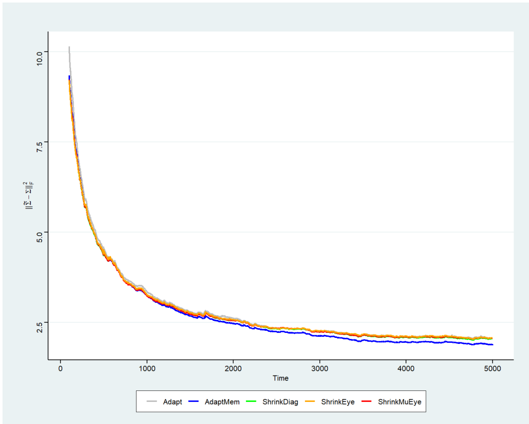
(a) Normal, $p = 10$



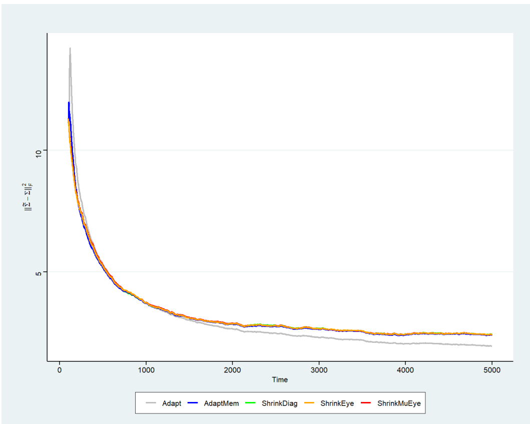
(b) MVT(5), $p = 10$



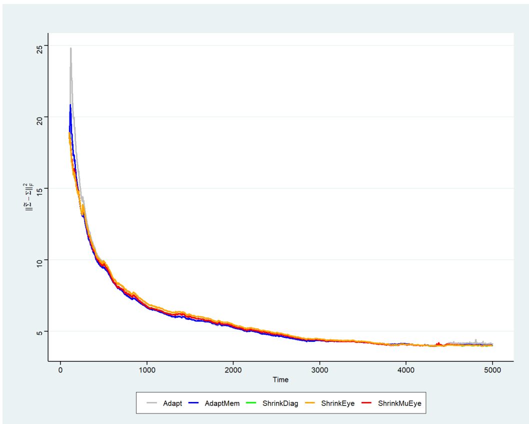
(c) Normal, $p = 50$



(d) MVT(5), $p = 50$

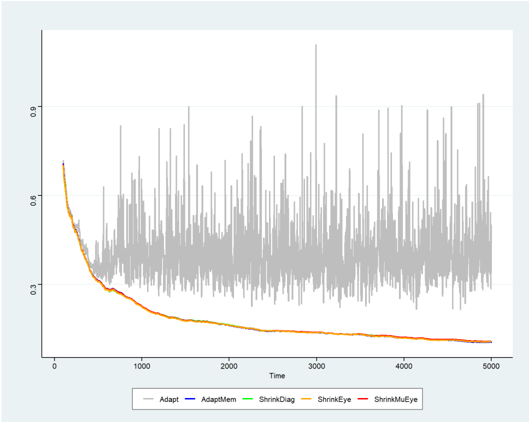


(e) Normal, $p = 100$

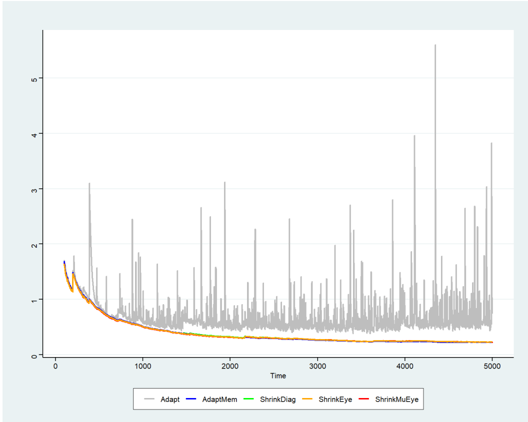


(f) MVT(5), $p = 100$

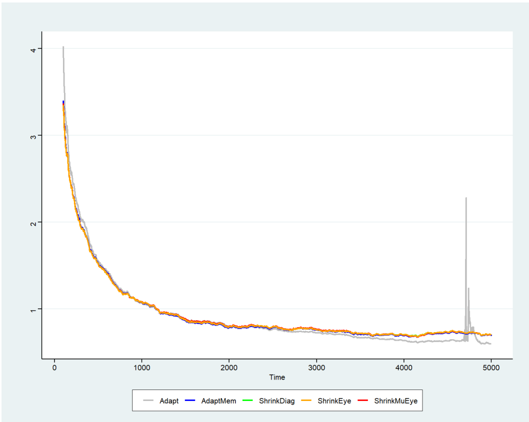
Figure 5.6: Average loss comparison between Normal and MVT(5) for CS covariance matrix ($p \leq 100$).



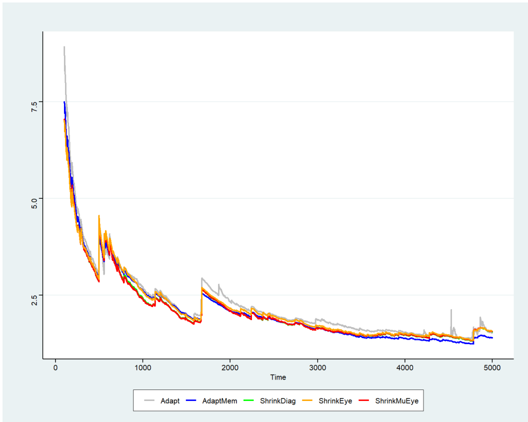
(a) Normal, $p = 10$



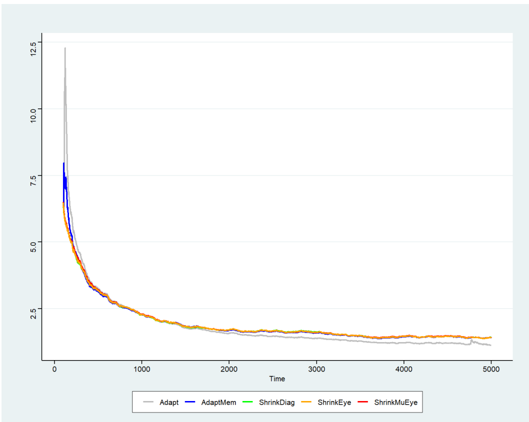
(b) MVT(5), $p = 10$



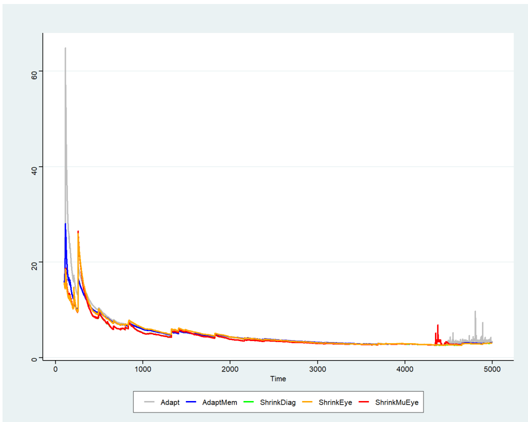
(c) Normal, $p = 50$



(d) MVT(5), $p = 50$



(e) Normal, $p = 100$

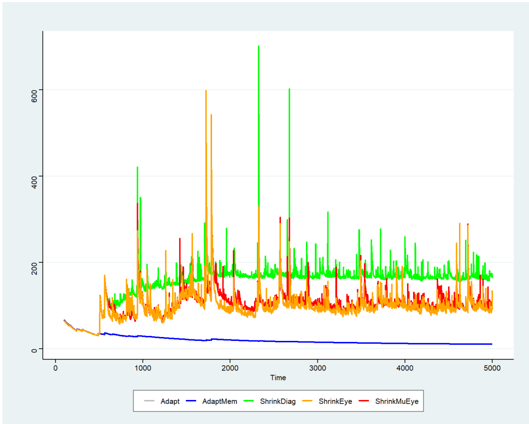


(f) MVT(5), $p = 100$

Figure 5.7: Standard deviation comparison between Normal and MVT(5) distributions for CS covariance matrix ($p \leq 100$).

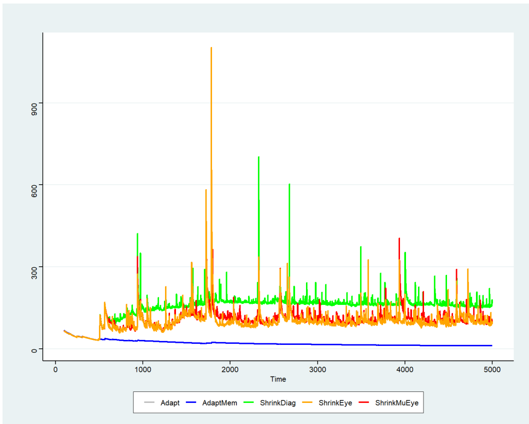
For large p, both *adaptive* estimators performed well whereas all of the shrinkage estimators suffered and performed much worse due to the complete lack of sparsity.

(a) Average loss, Normal $p = 500$



(b) Standard deviation, Normal $p = 500$

(c) Average loss, MVT(5) $p = 500$

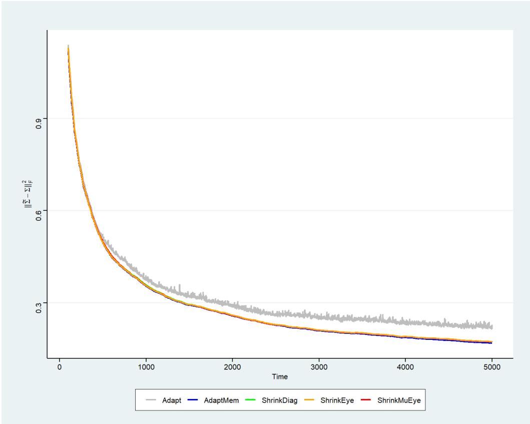


(d) Standard deviation, MVT(5) $p = 500$

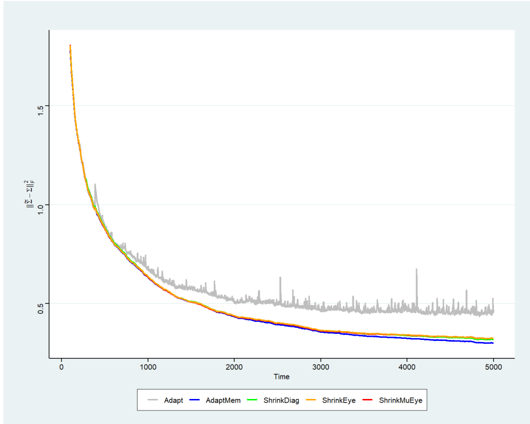
Figure 5.8: Average loss comparison between Normal and MVT(5) for CS covariance matrix ($p = 500$).

Autoregressive

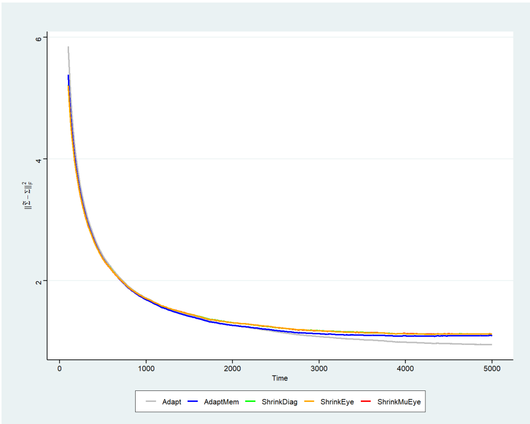
For the *autoregressive* case, the *adaptive* estimators tended to perform better than the *shrinkage* estimators even for large p. Under normality there was not much of a difference between the types of estimators, however, for the multivariate t(5) the discrepancy was much larger. See trajectory plots of loss below for $p \leq 100$.



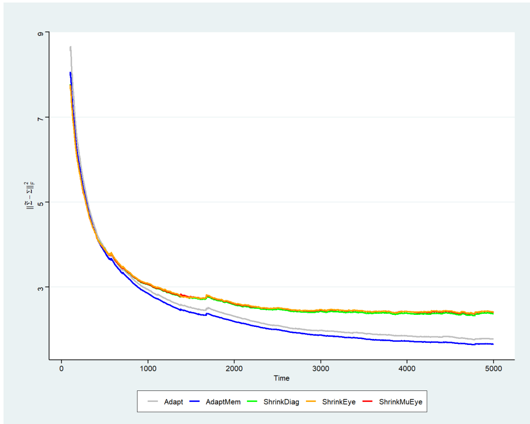
(a) Normal, $p = 10$



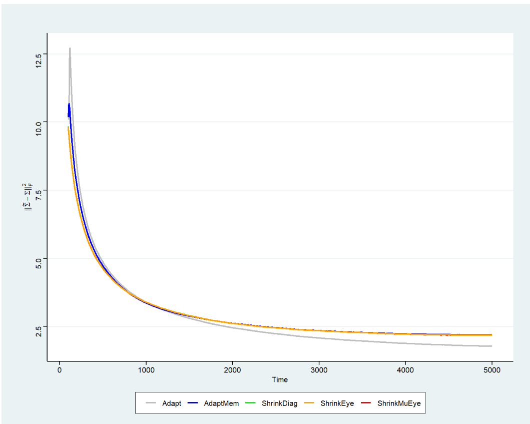
(b) MVT(5), $p = 10$



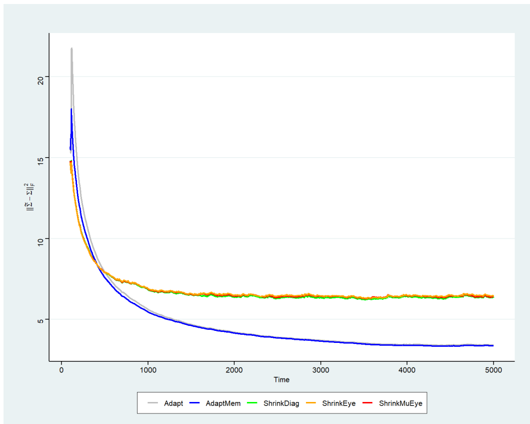
(c) Normal, $p = 50$



(d) MVT(5), $p = 50$



(e) Normal, $p = 100$



(f) MVT(5), $p = 100$

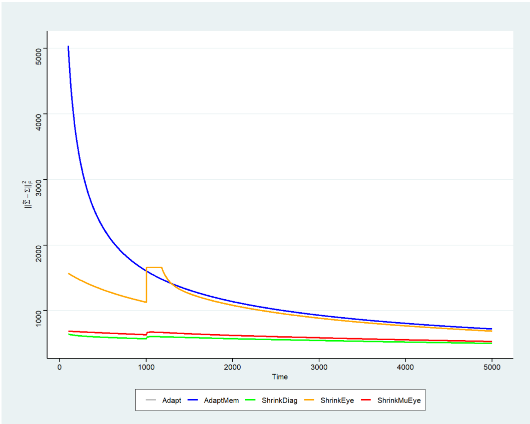
Figure 5.9: Comparision between Normal and MVT(5) for stationary AR(1) covariance matrix ($p <= 100$).

5.2.1.3 Block Covariance Structures

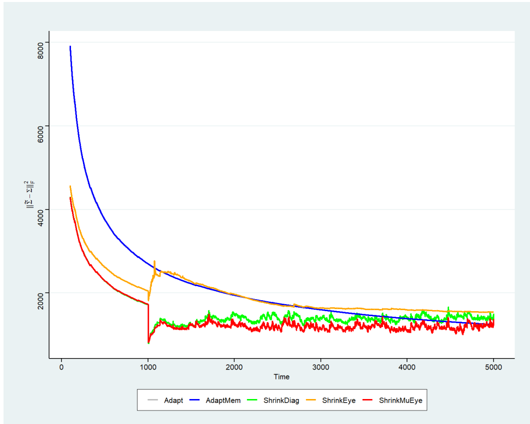
For stationary data, block matrices were investigated. The block structure considered is as follows

$$\Sigma = \begin{pmatrix} \Sigma_1 & 0 & \cdots & 0 \\ 0 & \Sigma_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \Sigma_r \end{pmatrix}_{p \times p} \tag{5.3}$$

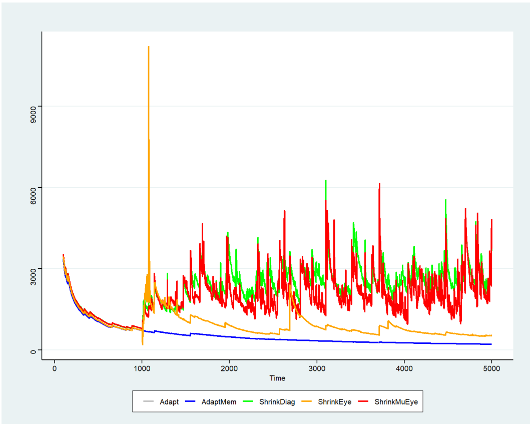
where, each Σ_i is a 10×10 matrix and $r = p/10$. Block CS, AR, and Wishart matrices were considered. The block CS and AR results are fairly consistent with the CS and AR stationary results. See below for the trajectory plots of the block Wishart matrices for $p = 1000$. The plots demonstrate that for multivariate normal data, the *shrinkage diagonal* and *shrinkage average variance* estimators have superior performance. The *shrinkage identity* estimator performs better in this scenario due to the sparseness of the block structure as it slightly outperforms the adaptive estimators. Under the multivariate t(5) distribution, the shrinkage estimators have a clear advantage early on the sequence, however, this advantage decreases as the sequence progresses.



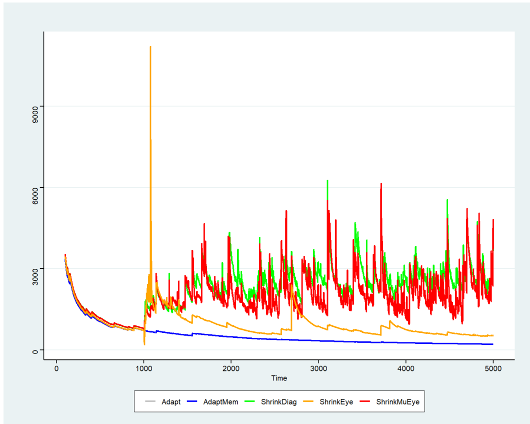
(a) Average loss, Normal $p = 1000$



(b) Average loss, MVT(5) $p = 1000$



(c) Standard deviation, Normal $p = 1000$



(d) Standard deviation, MVT(5) $p = 1000$

Figure 5.10: Comparision between Normal and MVT(5) for stationary block Wishart covariance matrix ($p = 1000$).

5.2.1.4 Summary of Stationary Covariance Estimation

- For Wishart matrices, *shrinkage diagonal* and *average variance* estimators performed better relative to the other estimators especially early in the sequence, however, this advantage eventually disappears approximately midway through the sequence. The *shrinkage identity* estimator did not provide any noticeable benefit beyond the adaptive estimators for normal data and performed worse in the multivariate t(5) case. The performance of the *shrinkage identity* degrades as the number of dimensions increases. In general, under the scenarios considered, it would be difficult to recommend the *shrinkage identity* estimator, although, in the block Wishart scenario, it was more stable and performed slightly better than the *adaptive* estimators. Future research may consider investigating how well the *shrinkage identity* estimator performs as sparsity increases along with investigating alternative momentum settings and strategies.

- AR(1) covariance structure under multivariate t(5) distributional regime, favors the non-shrinkage estimators. Performance degrades for the shrinkage estimators as the number of dimensions increase.

- CS covariance structure clearly favors the adaptive estimators. This is to be expected as the CS structure is a dense covariance matrix with no sparse structure.

- For small p, all estimators perform similarly and quite well for CS covariance structure, under both normal and multivariate t(5) distributions.

- For large p, the *shrinkage identity* performed poorly with the exception of the block Wishart case. The *shrinkage diagonal* and *shrinkage average variance* estimators appear to be the most robust across the different scenarios under multivariate normality, however, if the data exhibits non-normality consistent with the multivariate t(5) distribution, then the *adaptive* estimators may have a slight advantage.

Stationary Covariance Trajectories

Trajectories for stationary covariance matrix simulations are found in appendix B.

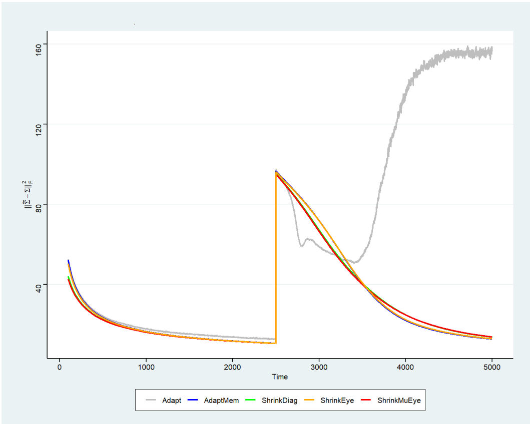
5.2.2 Abrupt Drift

For non-stationary data regimes under abrupt drift, 2500 independent observations were sequentially generated from either a multivariate normal distribution (Rencher (1998)) or a multivariate t distribution with 5 degrees of freedom (Paolella (2019b)). The covariance matrix was set at the beginning of the simulation. After the initial 2500 observations were generated, the covariance matrix was abruptly changed and the 2500 remaining observations were generated according to the new distribution. The mean vector was set to the zero vector throughout the entirety of the simulation. The following abrupt drift scenarios were considered.

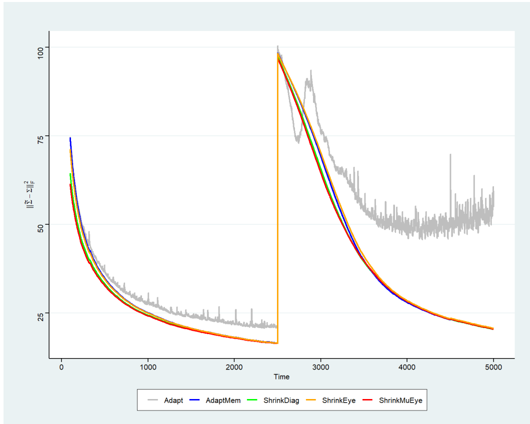
- Wishart to Wishart
- Block Wishart to Block Wishart
- Compound Symmetric to Autoregressive

5.2.2.1 Wishart to Wishart

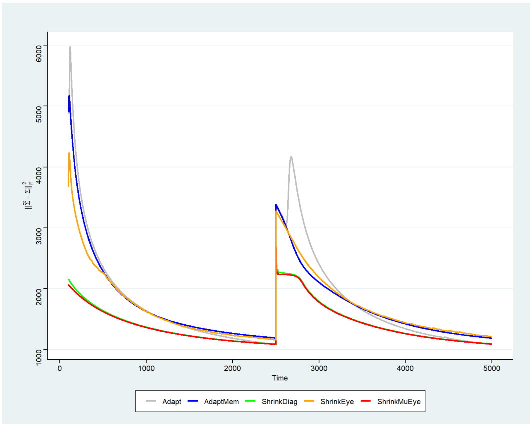
The plot below of the simulated average loss illustrates the advantages the *shrinkage diagonal* and *shrinkage average variance* estimators provide. Early in the sequence and immediately after a shift, the aforementioned shrinkage estimators provide significant savings in terms of average loss. Note that after the shift, the average loss of the *no-memory* adaptive estimator initially starts to decrease, but is followed by a subsequent increase. This is not present in the *adaptive remembering* variant of the estimator. Recall, the mechanics of the adaptive remembering estimator is specifically designed to avoid subsequent decreases in accuracy after a single abrupt shift. The *shrinkage identity* estimator, however, provides almost no advantage relative to the non-shrinkage adaptive estimators in this case and with few exceptions is much more variable than all the other estimators across the simulations. In fact as p increases, this estimator becomes more unstable. The *no-memory* adaptive estimator is also more variable than its *adaptive remembering* counterpart. This is consistent across many of the abrupt drift scenarios. See the corresponding plot of the standard deviation below.



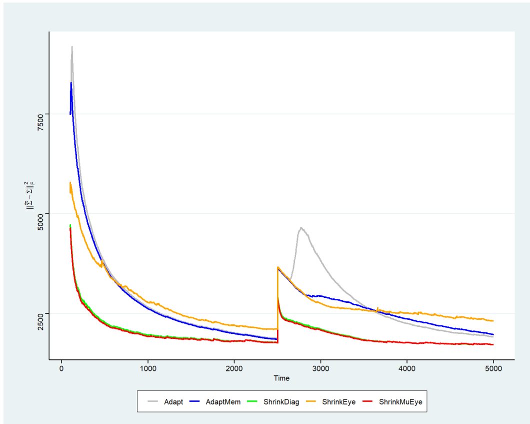
(a) Normal, $p = 10$



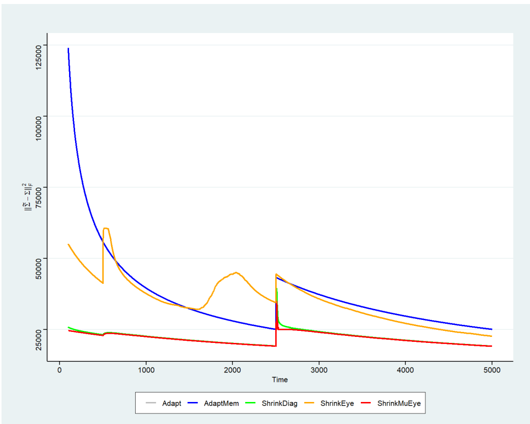
(b) MVT(5), $p = 10$



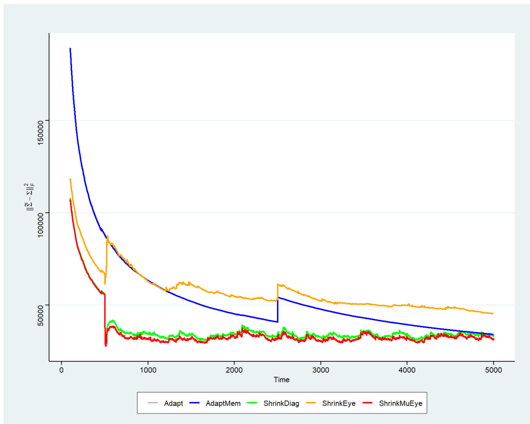
(c) Normal, $p = 100$



(d) MVT(5), $p = 100$

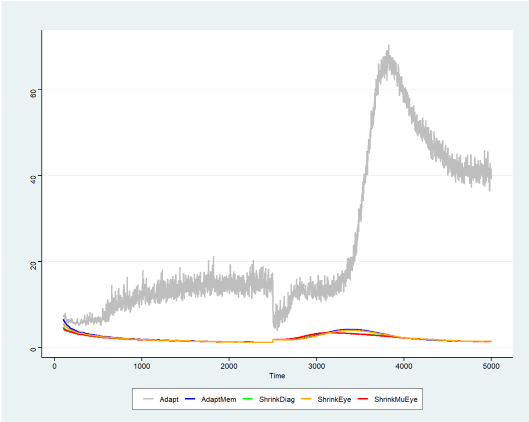


(e) Normal, $p = 500$

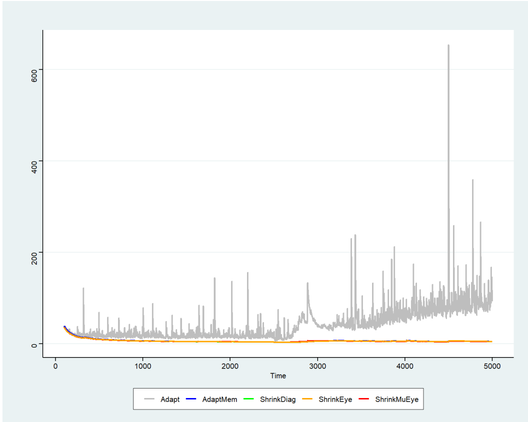


(f) MVT(5), $p = 500$

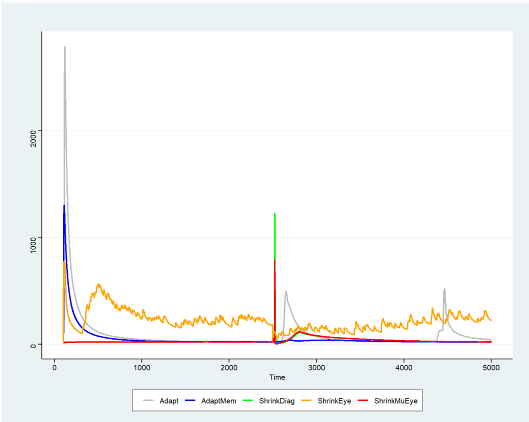
Figure 5.11: Average loss comparision between Normal and MVT(5) under abrupt change (Wishart to Wishart).



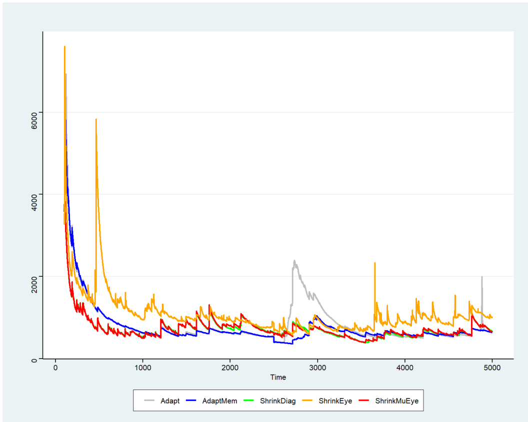
(a) Normal, $p = 10$



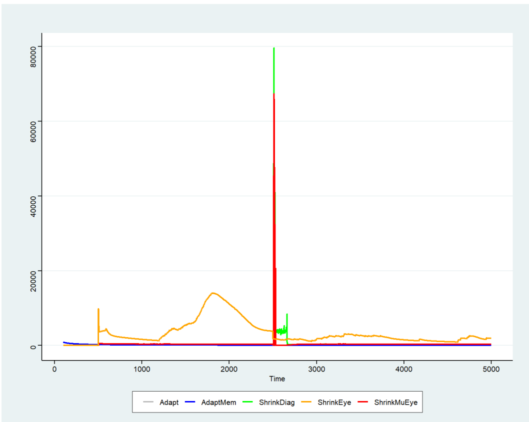
(b) MVT(5), $p = 10$



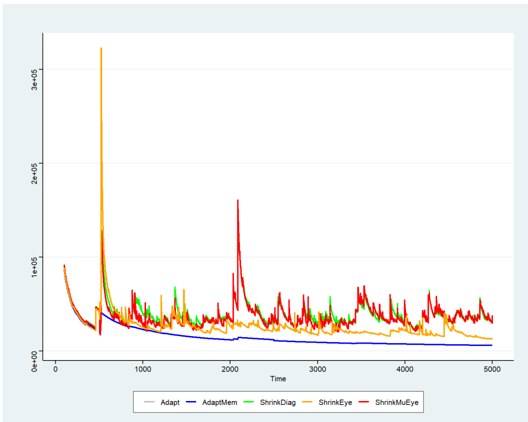
(c) Normal, $p = 100$



(d) MVT(5), $p = 100$



(e) Normal, $p = 500$

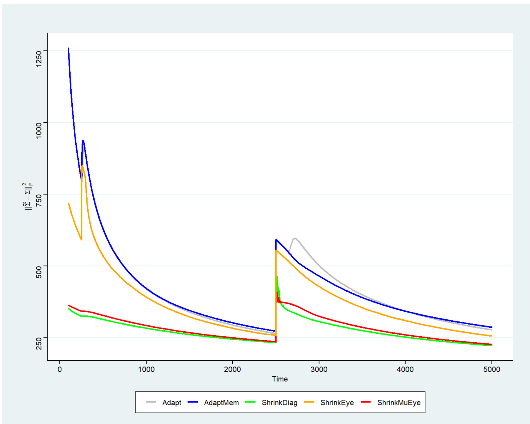


(f) MVT(5), $p = 500$

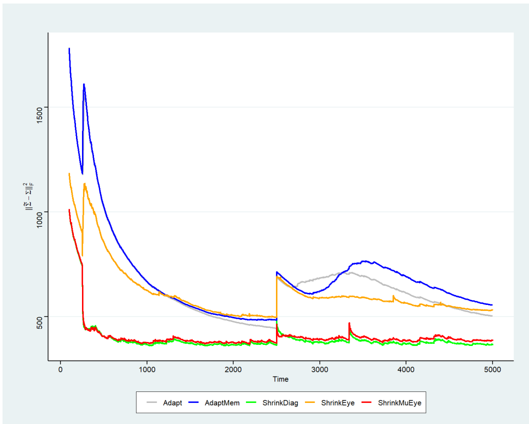
Figure 5.12: Standard deviation comparison between Normal and MVT(5) for abrupt change (Wishart to Wishart).

5.2.2.2 Block Wishart to Block Wishart

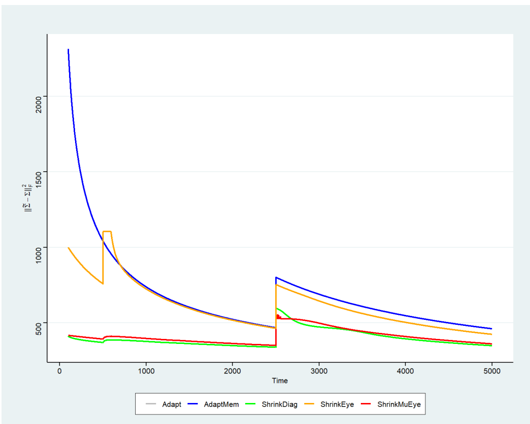
For $p = 250$ and 500, a sparse block Wishart structure under abrupt drift was investigated. The covariance matrix was specified as a sparse block matrix consisting of 25 and 50 blocks respectively of size 10×10 where each block was a randomly sampled Wishart matrix with $5p$ degrees of freedom and a scale matrix equal to the identity matrix. Under normality, the *shrinkage identity* estimator showed improvement and actually performed slightly better than the *adaptive* estimators. Under normality, however, the *shrinkage diagonal* and *shrinkage average* estimators were superior in terms of average loss. Under the multivariate t(5) distribution, however, the *shrinkage diagonal* and *shrinkage average variance* showed increasing average loss in the later stages of the sequence.



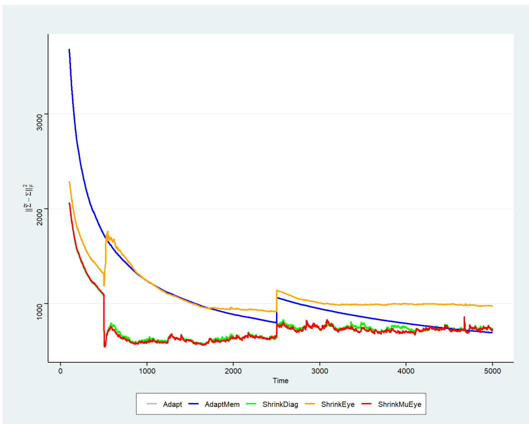
(a) Normal, $p = 250$



(b) MVT(5), $p = 250$

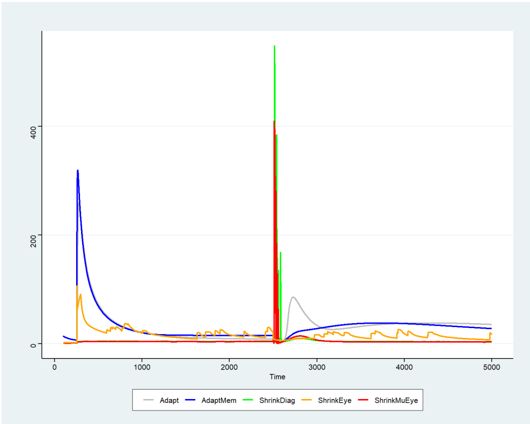


(c) Normal, $p = 500$

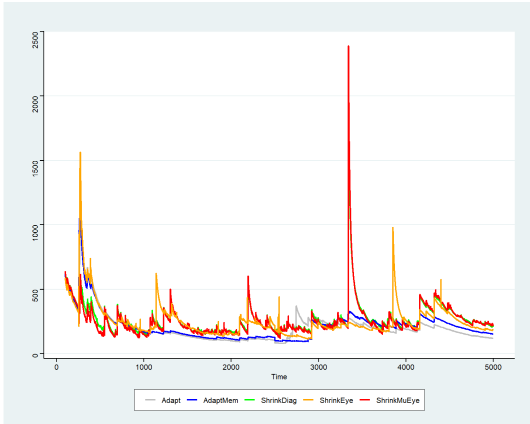


(d) MVT(5), $p = 500$

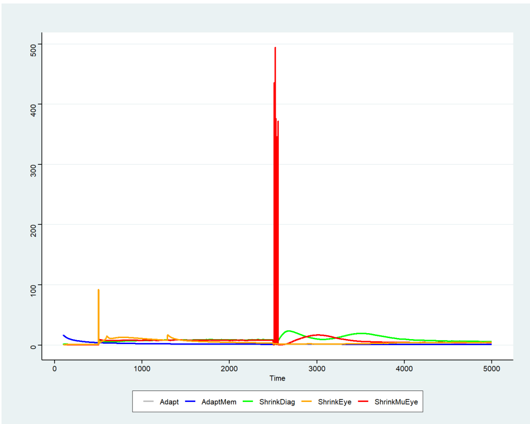
Figure 5.13: Simulated average loss comparison between Normal and MVT(5) for abrupt change (Block Wishart to Block Wishart).



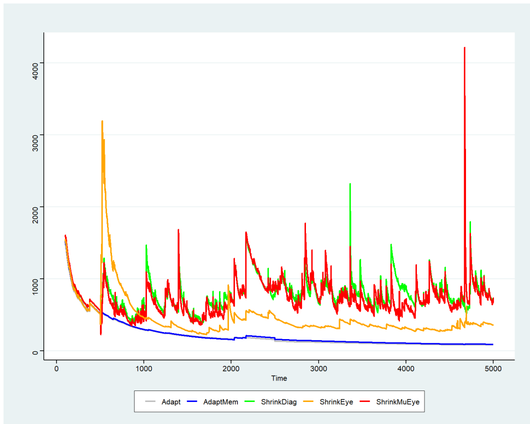
(a) Normal, $p = 250$



(b) MVT(5), $p = 250$



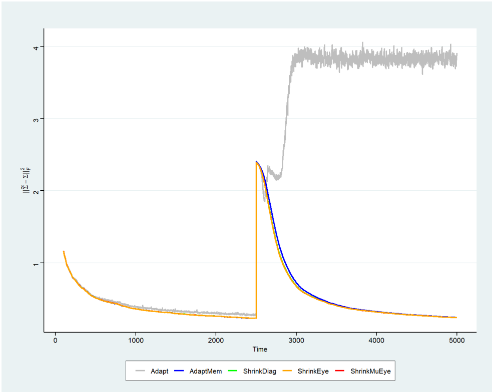
(c) Normal, $p = 500$



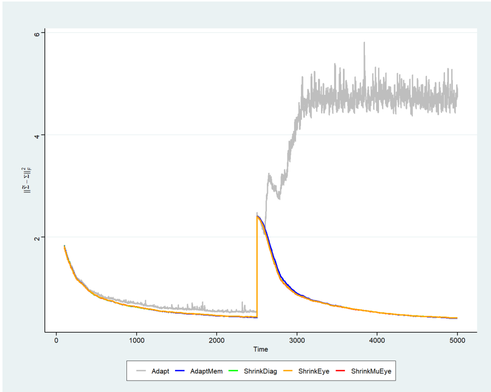
(d) MVT(5), $p = 500$

Figure 5.14: Simulated standard deviation of loss comparison between Normal and MVT(5) for abrupt change (Block Wishart to Block Wishart).

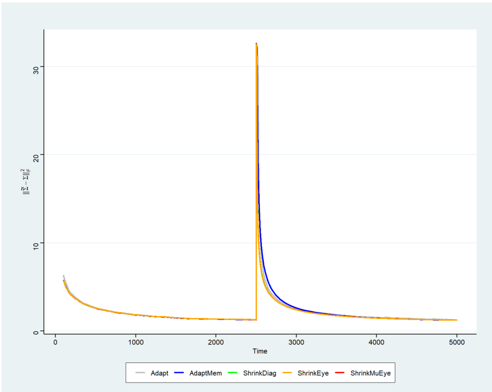
5.2.2.3 CS to AR



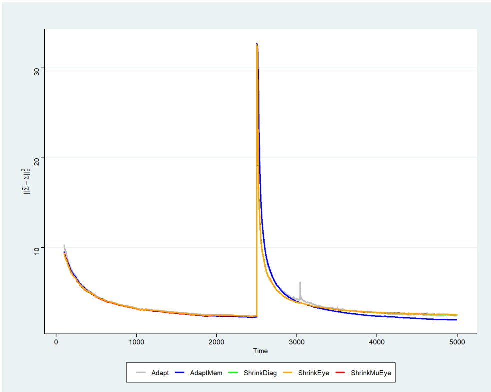
(a) Normal, $p = 10$



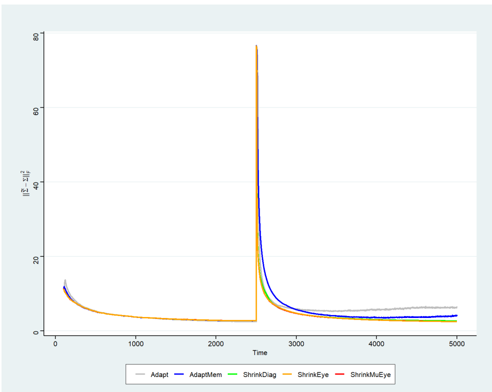
(b) mvt(5), $p = 10$



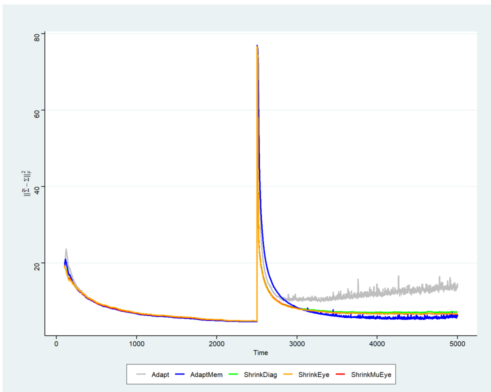
(c) Normal, $p = 50$



(d) mvt(5), $p = 50$



(e) Normal, $p = 100$



(f) mvt(5), $p = 100$

Figure 5.15: Average loss comparision between Normal and MVT(5) for abrupt change (CS to AR).

5.2.2.4 Abrupt Drift Covariance Estimation Summary

Many of the results from the stationary Wishart case transfer to the abrupt case as might be expected. The *adaptive estimator* performs poorly for small p, with large average loss and standard deviation. The remaining estimators perform well. When $p = 100$, the *shrinkage* estimators along with the *adaptive memory* estimator are superior in terms of average loss. They tend to adjust quickly to the abrupt change. For large number of dimensions, $p \geq 500$, the *shrinkage diagonal* and *shrinkage average variance* estimators dominate the others in terms of average loss at the cost of a slightly increased standard deviation for both normal and t(5) distributions.

The block Wishart results are similar to the Wishart results, with the exception that the *shrinkage identity* estimator performs much better in this scenario. Also the advantage of the *shrinkage diagonal* and *shrinkage average variance* is slightly more prominent.

Abrupt Drift Covariance Trajectories

Trajectories for abrupt drift covariance matrix simulations are found in appendix C.

5.2.3 Gradual Drift

For non-stationary data regimes under gradual drift, 5000 independent observations were sequentially generated from either a multivariate normal distribution(Rencher (1998)) or a multivariate t distribution with 5 degrees of freedom (Paolella(2019)). The mean vector was set to the zero vector throughout the entirety of the simulation. The covariance matrix was set to an initial start matrix and gradually shifted to an end matrix via the method of *piecewise convex covariance movement* (Anagnostopoulos et al. (2008b)). For any given time point, $t \in [t_{Start}, t_{End}]$, the covariance matrix is defined as

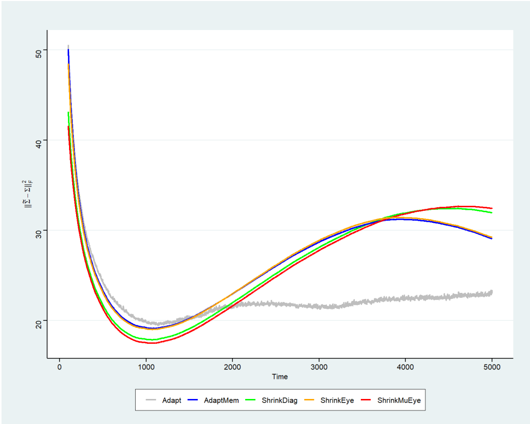
$$\Sigma_t = \frac{t_{End} - t}{t_{End} - t_{Start}} \Sigma_{t_{Start}} + \frac{t - t_{Start}}{t_{End} - t_{Start}} \Sigma_{t_{End}}$$

The following gradual drift scenarios were considered.

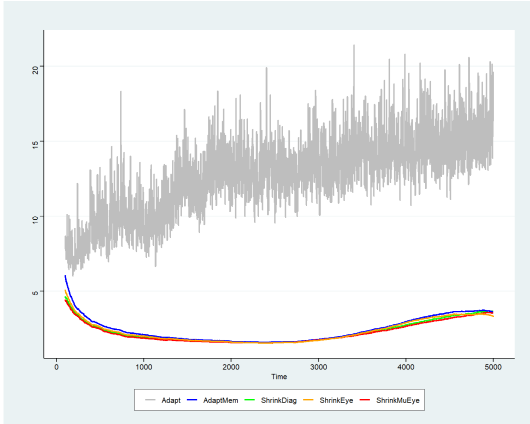
- Wishart to Wishart
- Block Wishart to Block Wishart
- Compound Symmetric to Autoregressive

5.2.3.1 Wishart to Wishart

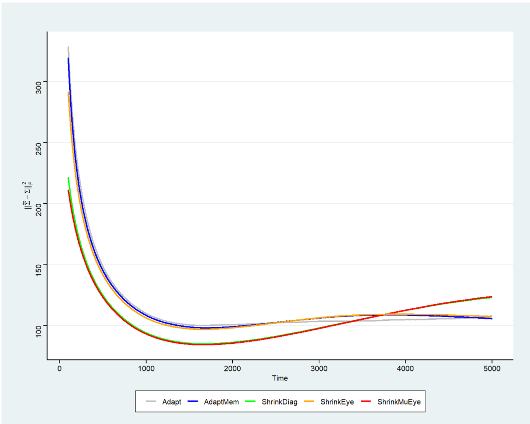
The plot below reveals that the shrinkage estimators have a slight advantage over the *adaptive* estimators which increases as p increases, similar to what was seen before in the abrupt drift case. The *shrinkage identity* estimator performs much better under multivariate normality in the gradual drift case as compared to the abrupt drift case, although, it still fails to perform much better than the *adaptive* estimators and exhibits a very large standard deviation. In the $p = 10$ case, the *adaptive* estimator performs very well in terms of average loss, unlike the abrupt drift case. For $p = 500$, only a block Wishart matrix scenario was considered.



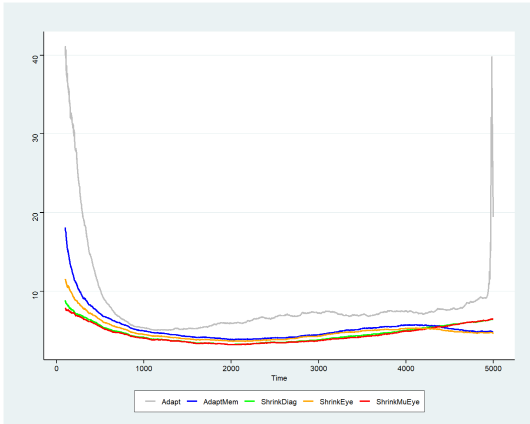
(a) Average loss, $p = 10$



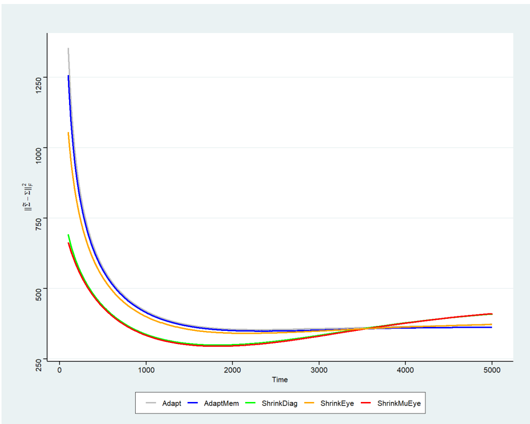
(b) Standard deviation, $p = 10$



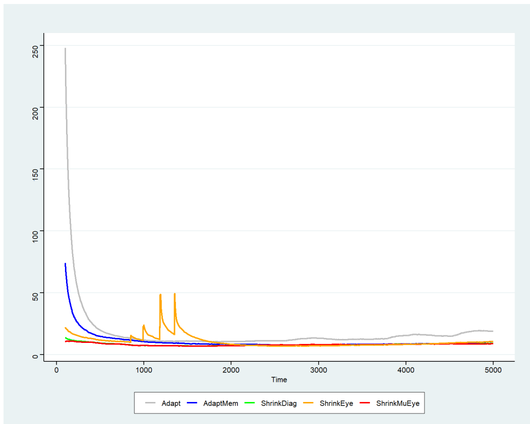
(c) Average loss, $p = 50$



(d) Standard deviation, $p = 50$

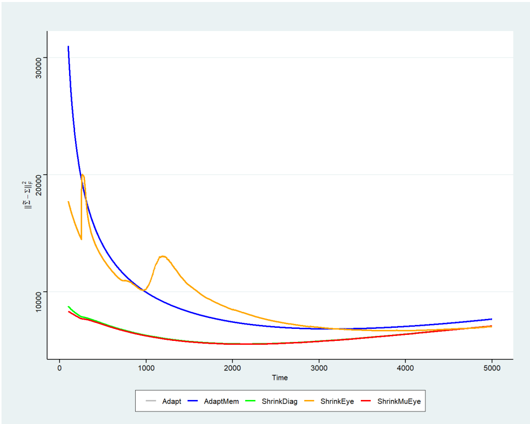


(e) Average loss, $p = 100$

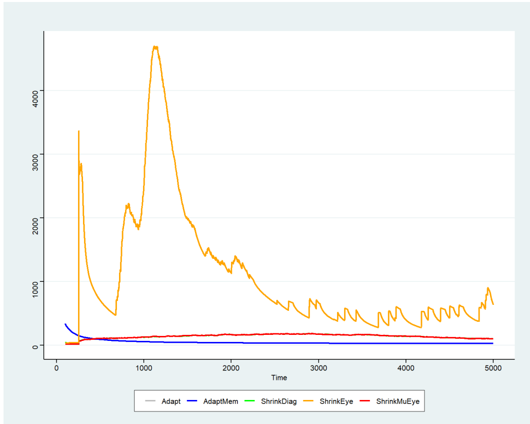


(f) Standard deviation, $p = 100$

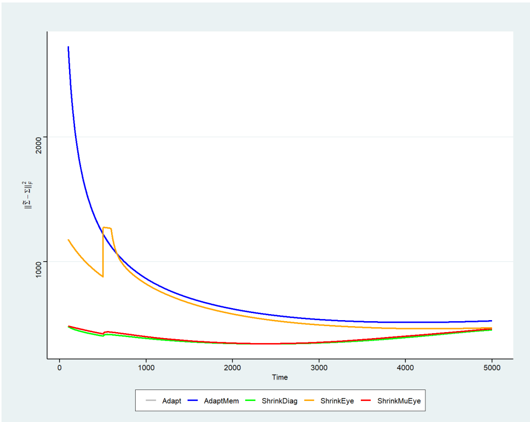
Figure 5.16: Simulated average loss and standard deviation for gradual change (Wishart to Wishart) under normality.



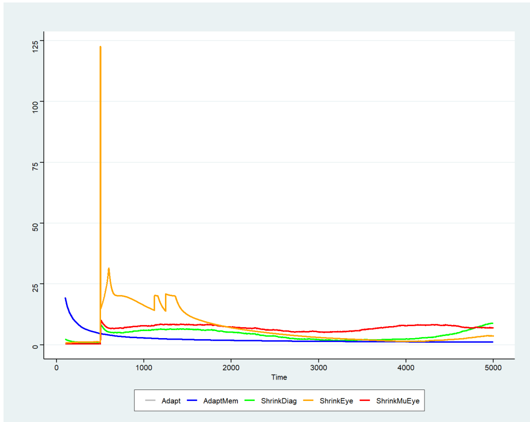
(a) Average loss, $p = 250$



(b) Standard deviation, $p = 250$



(c) Average loss, $p = 500$

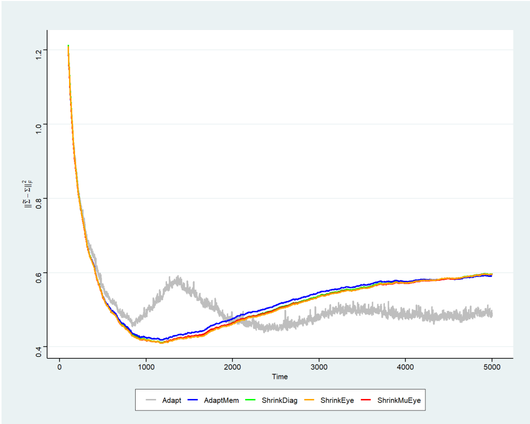


(d) Standard deviation, $p = 500$

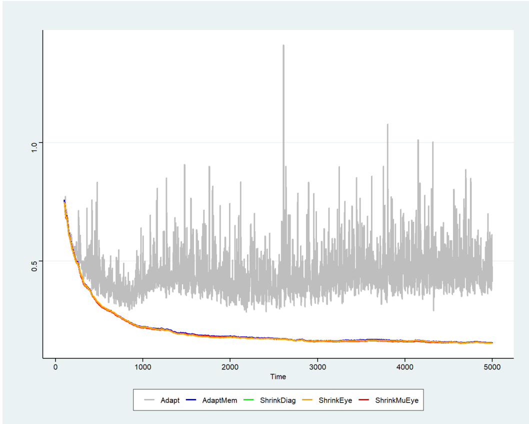
Figure 5.17: Simulated average loss and standard deviation for gradual change (block Wishart to block Wishart) under normality.

5.2.3.2 CS to AR under Normality

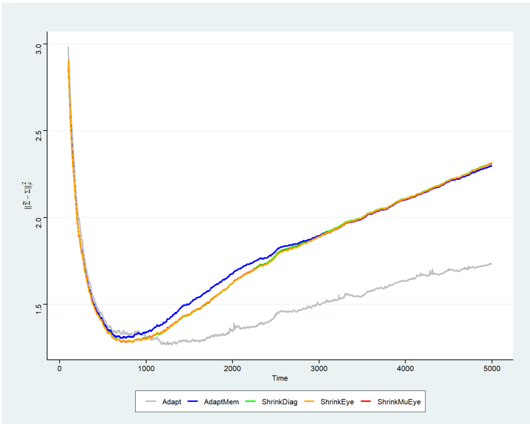
Under normality for $p < 100$, the *adaptive* estimator is the preferred estimator. It has consistently lower simulated risk with comparable standard deviation. However, for larger p, the *adaptivemem* estimator performs better and the shrinkage estimators tend to perform the best including the *shrinkage identity* estimator. This is the unique case where the *shrinkage identity* estimator may be among the set of preferred estimators.



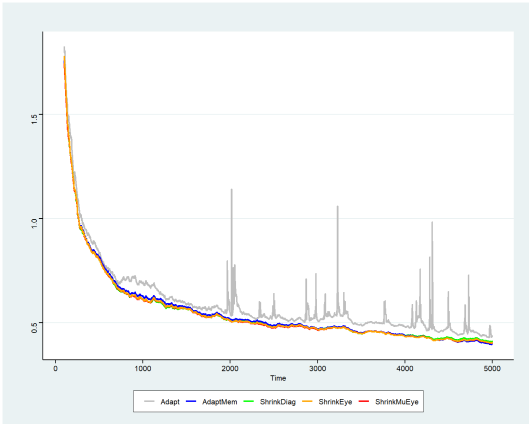
(a) Average loss, $p = 10$



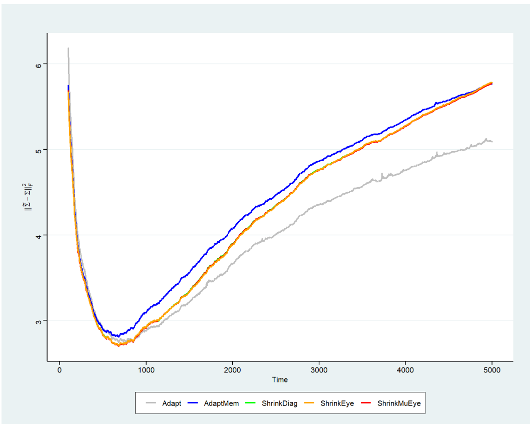
(b) Standard deviation, $p = 10$



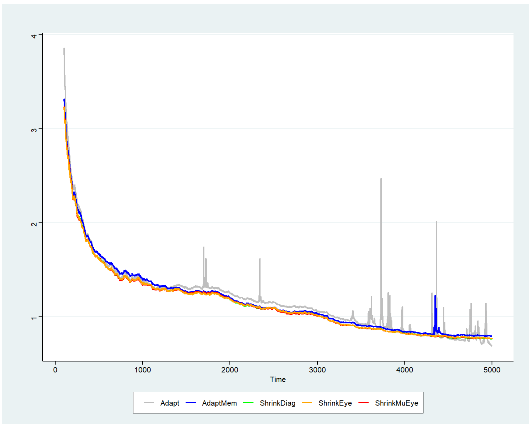
(c) Average loss, $p = 25$



(d) Standard deviation, $p = 25$

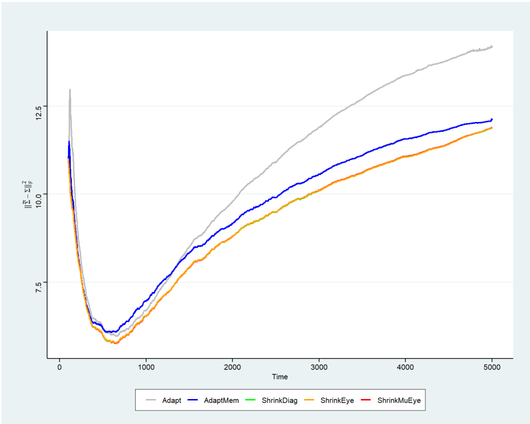


(e) Average loss, $p = 50$

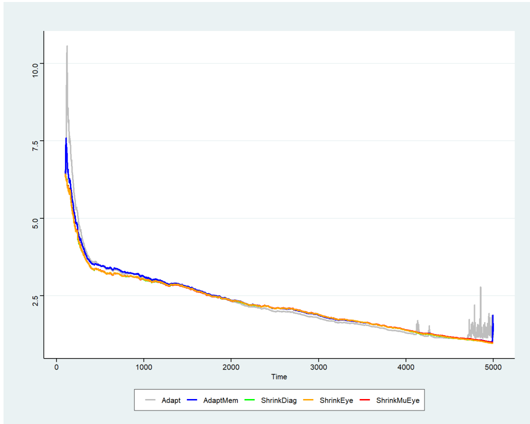


(f) Standard deviation, $p = 50$

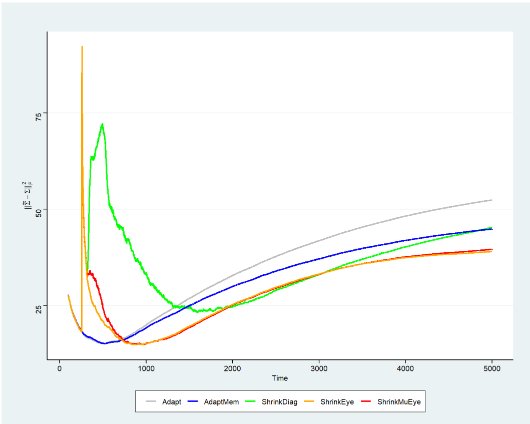
Figure 5.18: Simulated average loss and standard deviation for gradual change (CS to AR) under normality.



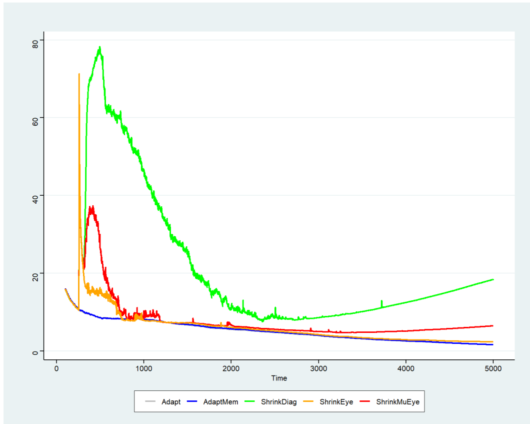
(a) Average loss, $p = 100$



(b) Standard deviation, $p = 100$



(c) Average loss, $p = 250$

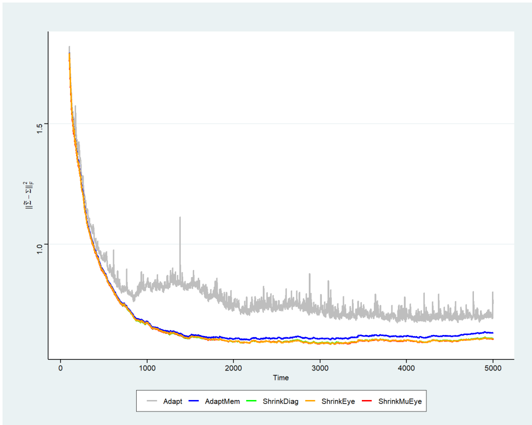


(d) Standard deviation, $p = 250$

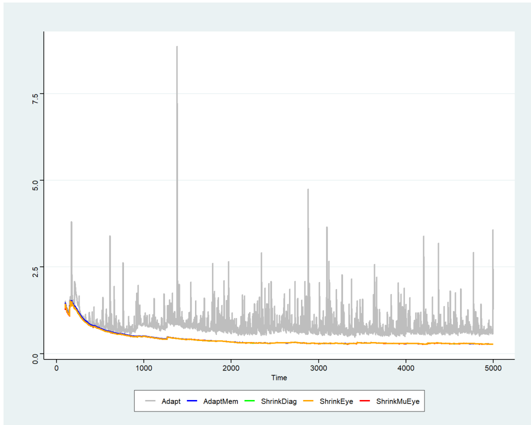
Figure 5.19: Simulated average loss and standard deviation for gradual change (CS to AR) under normality.

5.2.3.3 CS to AR under Multivariate t(5)

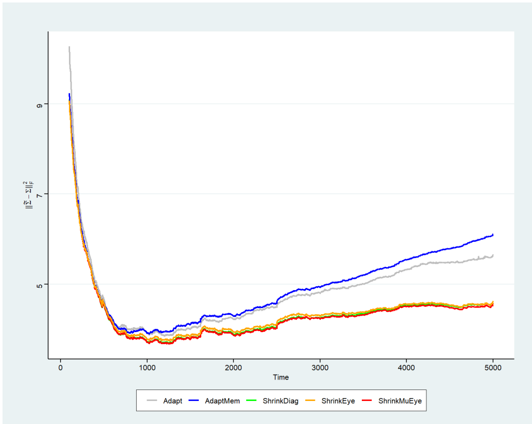
Under multivariate t(5), all of the *shrinkage* estimators perform better than their adaptive counterparts. The advantage increases with p.



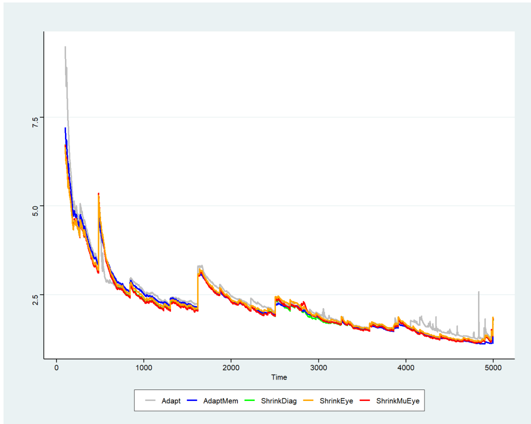
(a) Average loss, $p = 10$



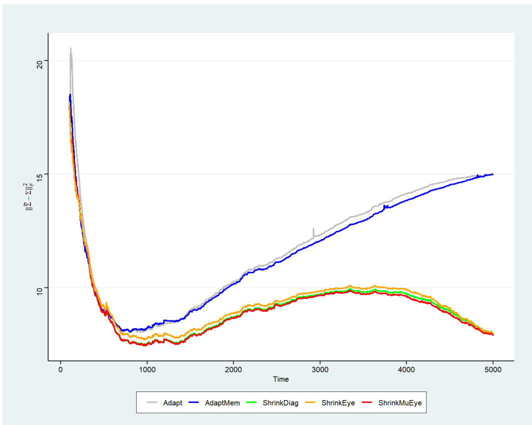
(b) Standard deviation, $p = 10$



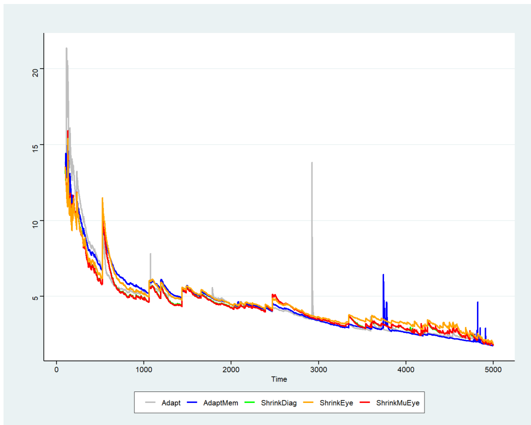
(c) Average loss, $p = 50$



(d) Standard deviation, $p = 50$



(e) Average loss, $p = 100$



(f) Standard deviation, $p = 100$

Figure 5.20: Simulated average loss and standard deviation for gradual change (CS to AR) under multivariate t(5).

5.2.3.4 Gradual Drift Summary

The main results of the gradual drift simulations are given below.

1. The *shrinkage identity* estimator performs well in the CS to AR case under multivariate normality. This is the unique scenario where the estimator can be recommended for use.

2. Across the various scenarios and especially for large p, the *shrinkage diagonal* and *shrinkage average variance* estimators performed consistently the best.

Gradual Drift Covariance Trajectories

Trajectories for gradual drift covariance matrix simulations are found in appendix D.

5.3 Linear Discriminant Analysis

Evaluation of the estimators and their corresponding LDA models over time was done by considering the theoretical conditional error rate of each model. This can can be calculated exactly at each time point in the case of linear discriminant analysis with two groups. According to McLachlan (1975), the two misclassification probabilities in a two-group linear discriminant analysis are given as:

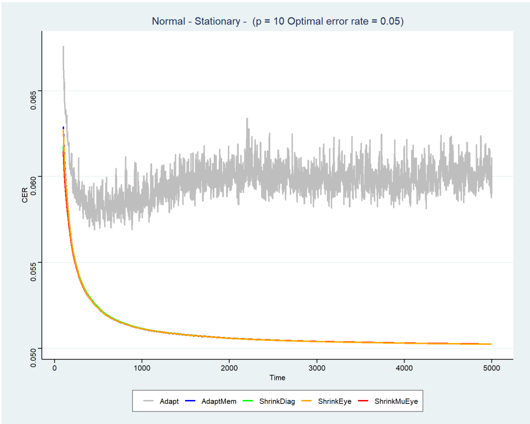
$$P_i = \Phi\left((-1)^i \frac{\boldsymbol{\mu}_i - \frac{1}{2}\left(\overline{\mathbf{x}}_1 + \overline{\mathbf{x}}_2\right)' \mathbf{S}^{-1}\left(\overline{\mathbf{x}}_1 - \overline{\mathbf{x}}_2\right)}{\sqrt{\left(\overline{\mathbf{x}}_1 - \overline{\mathbf{x}}_2\right)' \mathbf{S}^{-1}\boldsymbol{\Sigma}\mathbf{S}^{-1}\left(\overline{\mathbf{x}}_1 - \overline{\mathbf{x}}_2\right)}}\right), \quad (i = 1, 2)$$

where Φ is the standard normal distribution function. According to Rencher (1998), these misclassification probabilities can be combined to compute the exact conditional error rate as $\pi_1 P_1 + \pi_2 P_2$ where π_1 and π_2 are the corresponding prior probabilities for each group.

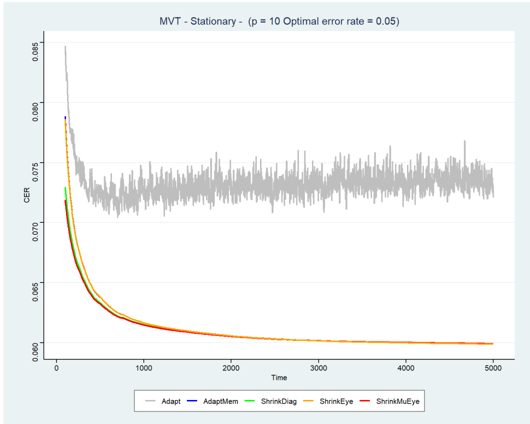
5.3.1 Stationarity

In the stationary case, most of the simulations focused on the Wishart scenario, that is, covariance matrices were randomly sampled from a Wishart distribution with $5p$ degrees of freedom and a scale matrix equal to the identity matrix. Mean vectors were randomly selected such that a 5% optimal error rate was satisfied (see section 4.4.4). Both multivariate normal and multivariate t(5) (Paolella (2019b)) distributions were investigated. As to be expected (Ledoit and Wolf (2004)), the performance of two of the three shrinkage estimators, specifically, *shrinkage diagonal* and *shrinkage average variance*, were superior under multivariate normality, however, results tended to vary in the case of the multivariate t(5) distribution. Results associated with the shrinkage estimators even deteriorated with increasing dimension in the case of multivariate t(5) data. The *shrinkage identity* estimator's performance drastically deteriorated with increasing dimensions in the Wishart case for both multivariate normal and multivariate t(5) distributions. The *adaptive* estimator performs well for all cases except one, where $p = 10$. In this case the *adaptive estimator* performs poorly both in terms of the conditional error rate and in terms of stability. This instability may be mitigated by considering alternative momentum settings and/or strategies. The current research did not address such issues.

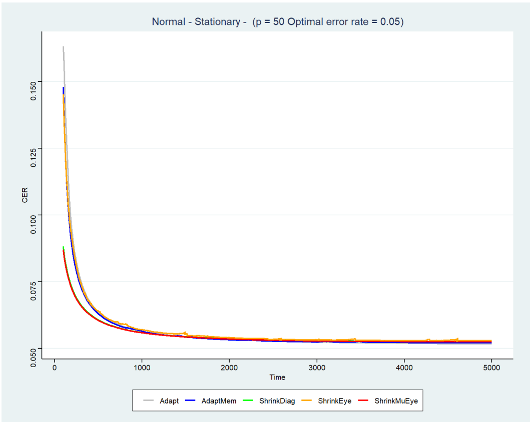
The following graphs display the conditional error rate (CER) trajectories for stationary LDA models for each estimator. Notice in the case of $p = 10$, the adaptive estimator performs very poorly. As the dimensions increase, the shrinkage estimators, excluding the *shrinkage identity* estimator, have slight but noticeably smaller conditional error rates near the beginning of the sequence. This is to be expected especially in the case of multivariate normal data, where the shrinkage estimators have been designed to perform well in those circumstances. Once the dimensions increase beyond $p = 100$, the performance of the *shrinkage* estimators progressively worsens in the case of multivariate t(5) data. The error rate for the *average variance* and *shrinkage diagonal* estimators actually increase over time and thus are not converging to the optimal error rate. This is in contrast to the multivariate normal scenario where all of the estimators display behavior consistent with convergence to the optimal error rate. The standard deviations also become progressively more unstable for the *average variance* and *shrinkage diagonal* estimators as the dimensions increase under the multivariate t(5) data scenario.



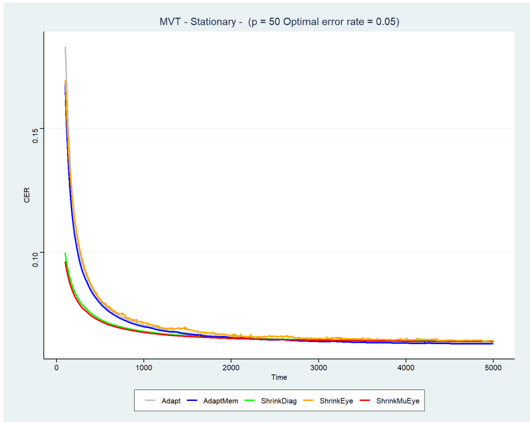
(a) Normal, $p = 10$



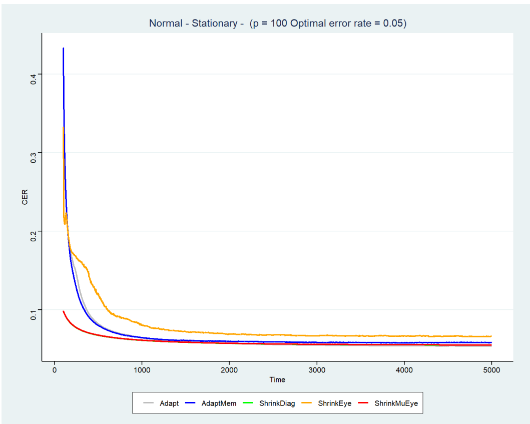
(b) MVT(5), $p = 10$



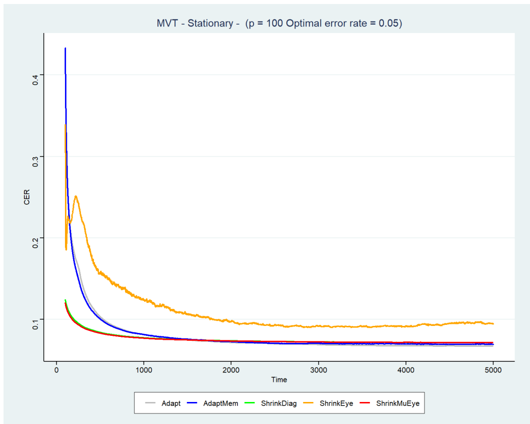
(c) Normal, $p = 50$



(d) MVT(5), $p = 50$

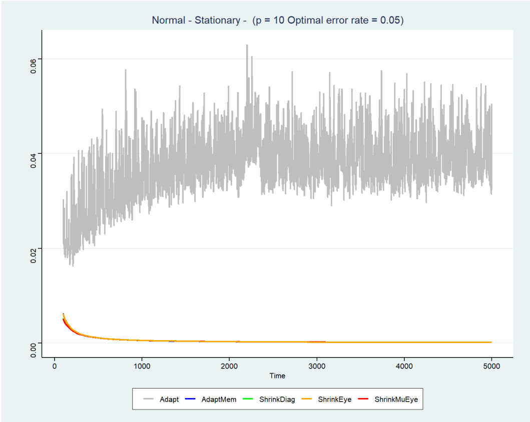


(e) Normal, $p = 100$

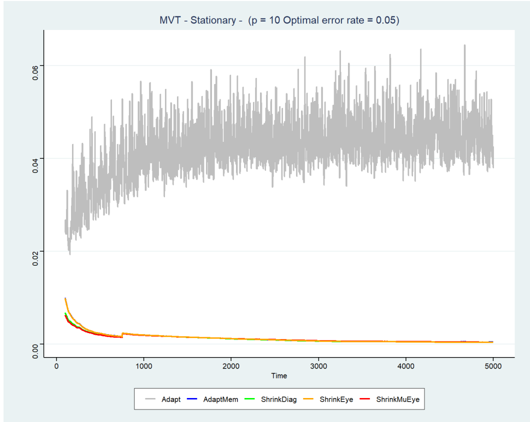


(f) MVT(5), $p = 100$

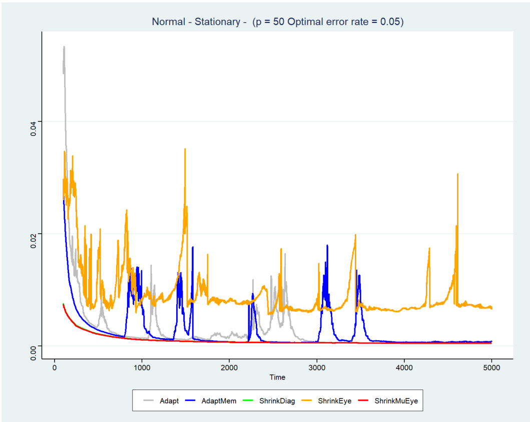
Figure 5.21: CER comparison among the stationary Wishart LDA models under both Normal and MVT(5) distributions for $p = 10, 50,$ and 100.



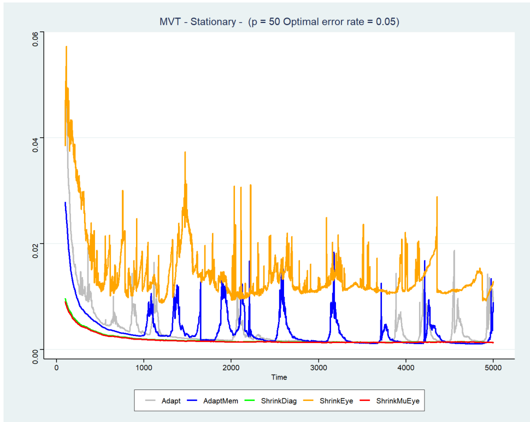
(a) Normal, $p = 10$



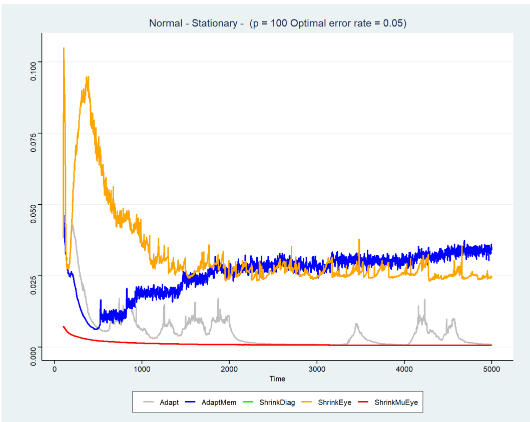
(b) MVT(5), $p = 10$



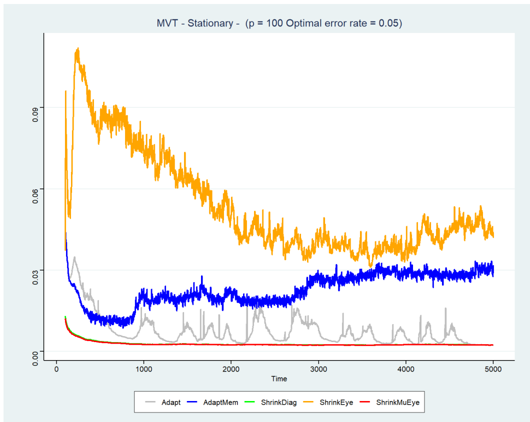
(c) Normal, $p = 50$



(d) MVT(5), $p = 50$

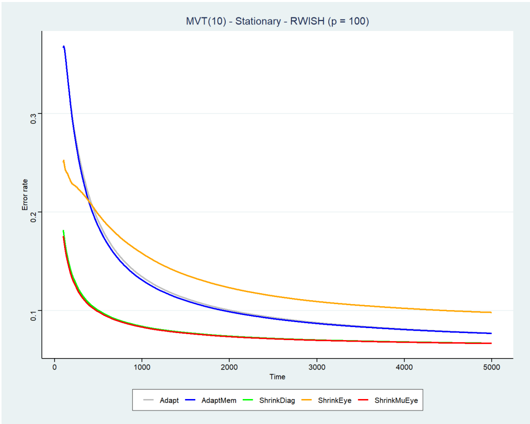


(e) Normal, $p = 100$

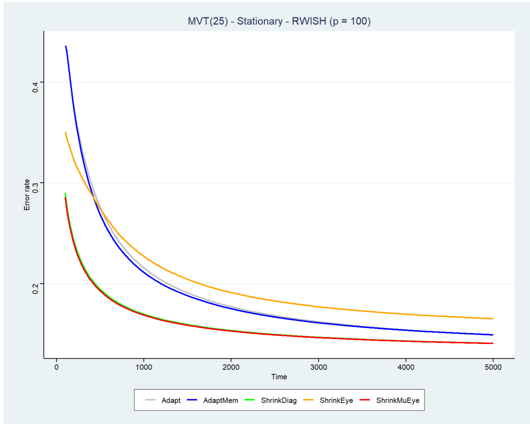


(f) MVT(5), $p = 100$

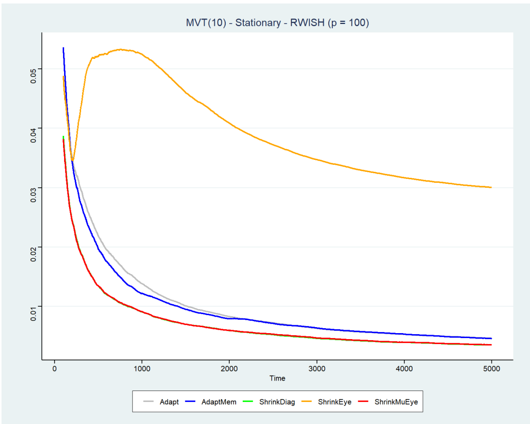
Figure 5.22: Standard deviation of CER comparison among the stationary Wishart LDA models under both Normal and MVT(5) distributions for $p = 10, 50$, and 100.



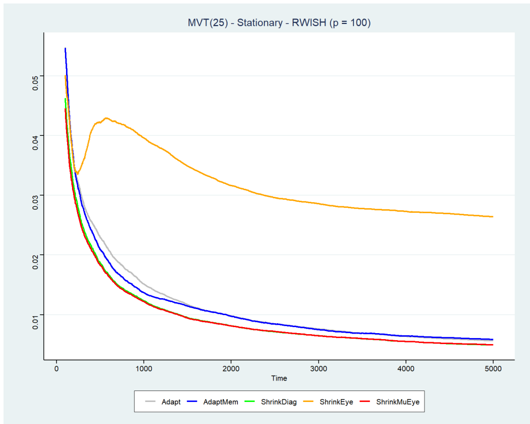
(a) Average CER MVT(10), $p = 100$



(b) Average CER MVT(25), $p = 100$

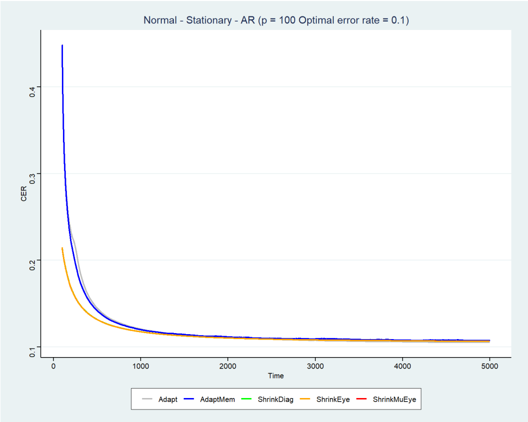


(c) Standard deviation MVT(10), $p = 100$

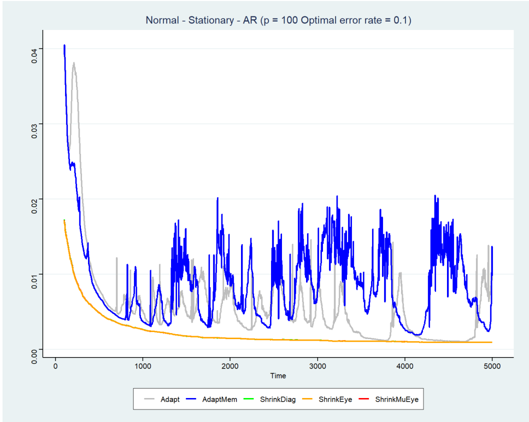


(d) Standard deviation MVT(25), $p = 100$

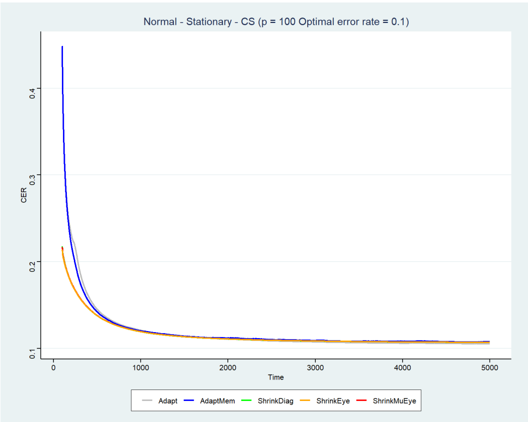
Figure 5.23: Comparison among the stationary Wishart LDA models under both MVT(10) and MVT(25) distributions for $p = 100$.



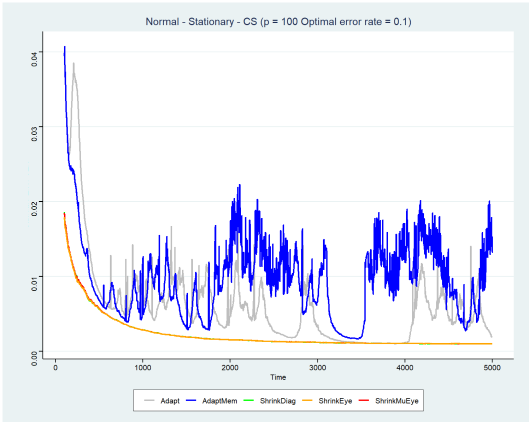
(a) AR $p = 100$



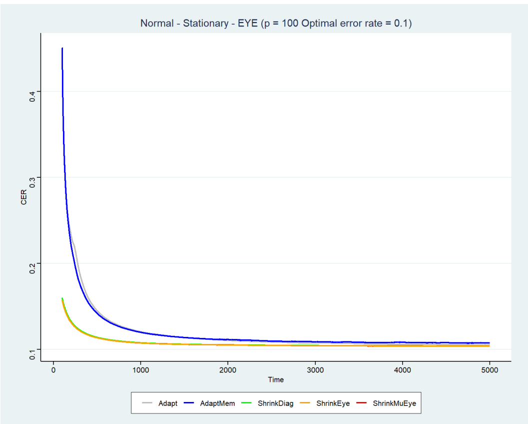
(b) Standard deviation AR $p = 100$



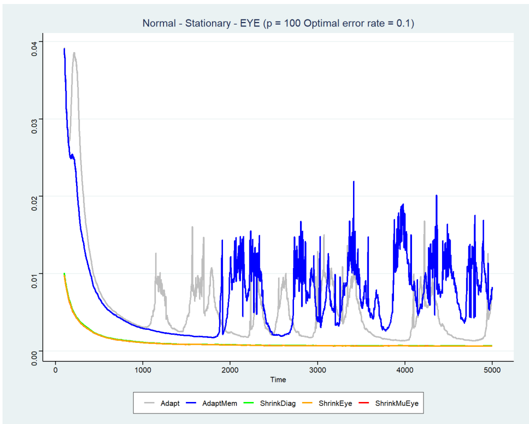
(c) CS $p = 100$



(d) Standard deviation CS, $p = 100$

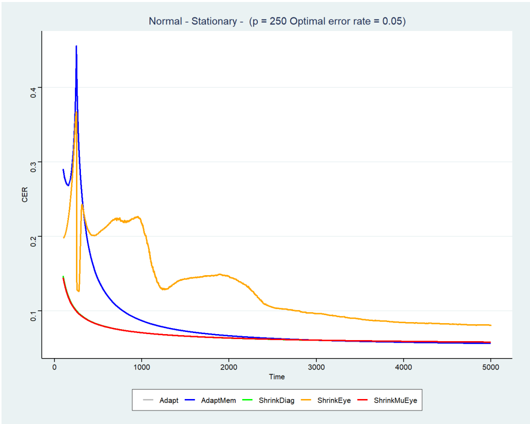


(e) Identity $p = 100$

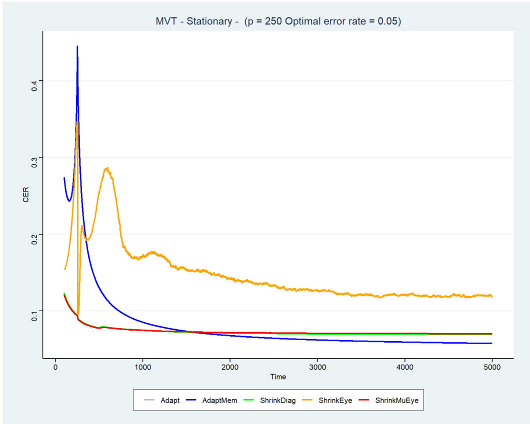


(f) Standard deviation Identity, $p = 100$

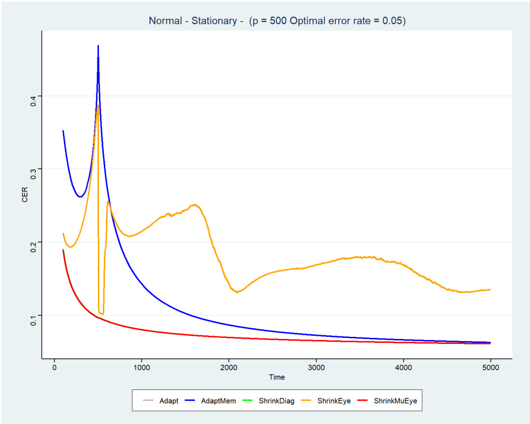
Figure 5.24: CER comparison among LDA models under normality with various covariance matrices for $p = 100$.



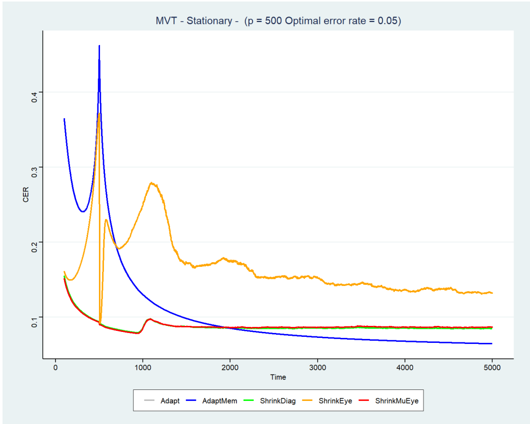
(a) Normal, $p = 250$



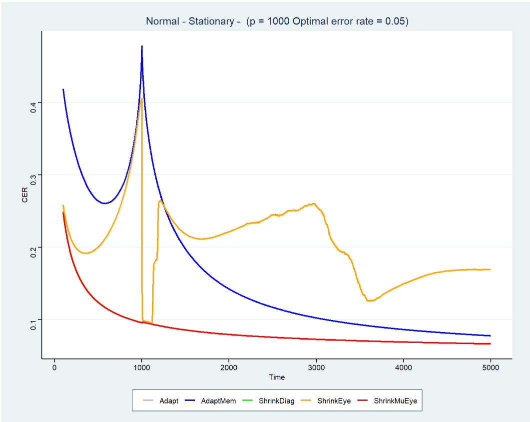
(b) MVT(5), $p = 250$



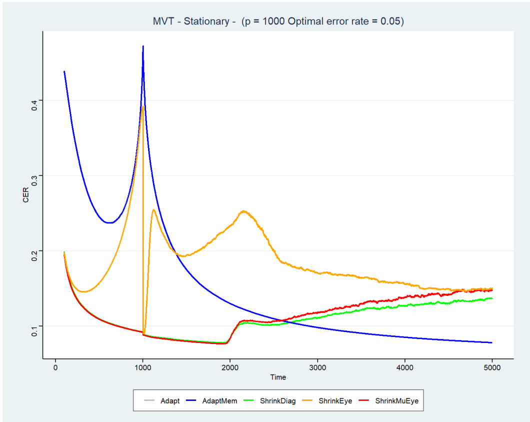
(c) Normal, $p = 500$



(d) MVT(5), $p = 500$

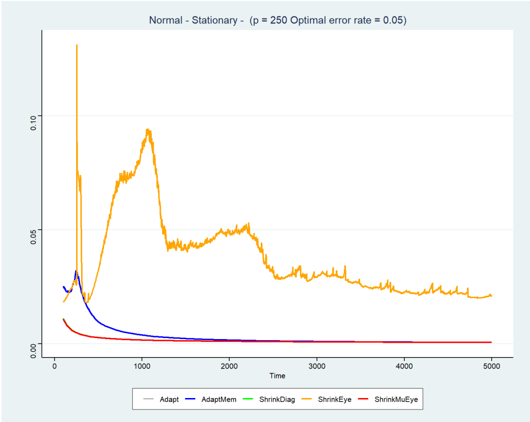


(e) Normal, $p = 1000$

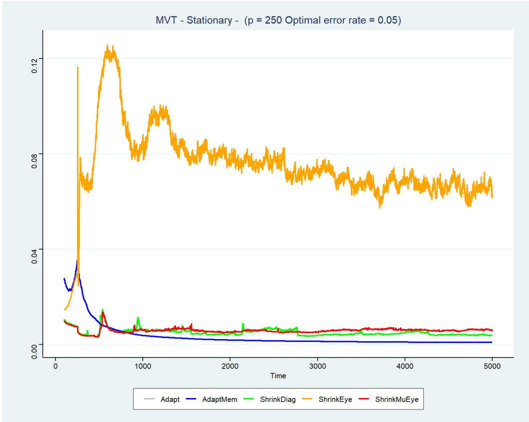


(f) MVT(5), $p = 1000$

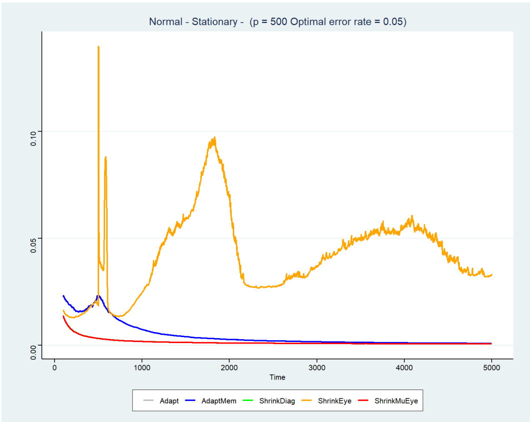
Figure 5.25: CER comparison among the stationary Wishart LDA models under both Normal and MVT(5) distributions for $p = 250, 50$, and 1000.



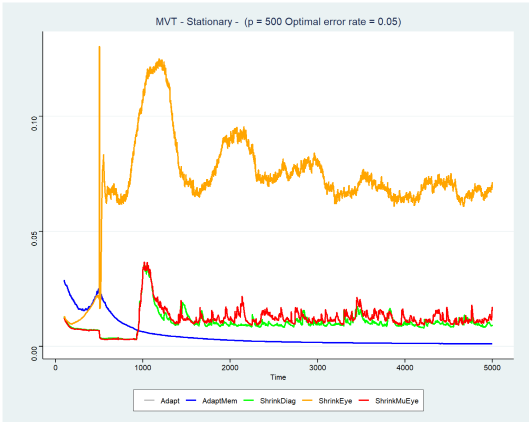
(a) Normal, $p = 250$



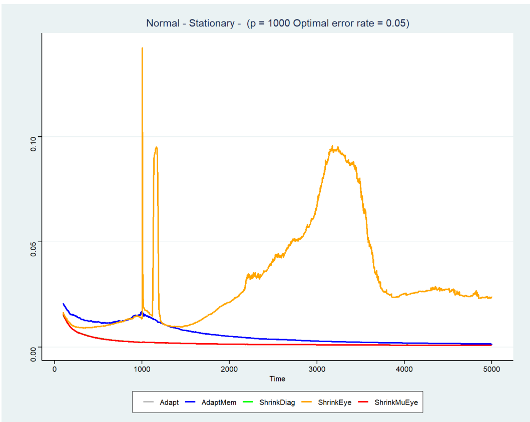
(b) MVT(5), $p = 250$



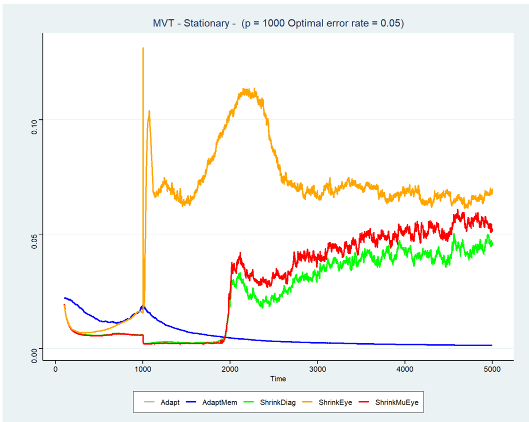
(c) Normal, $p = 500$



(d) MVT(5), $p = 500$



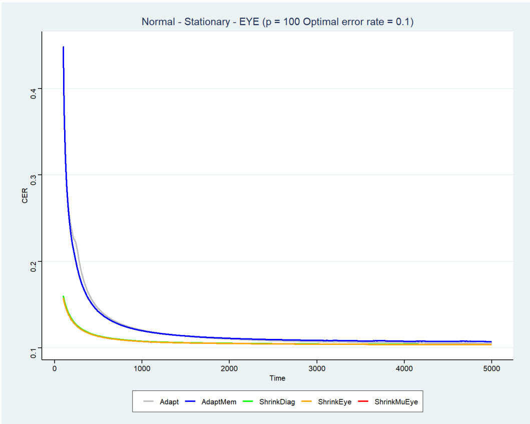
(e) Normal, $p = 1000$



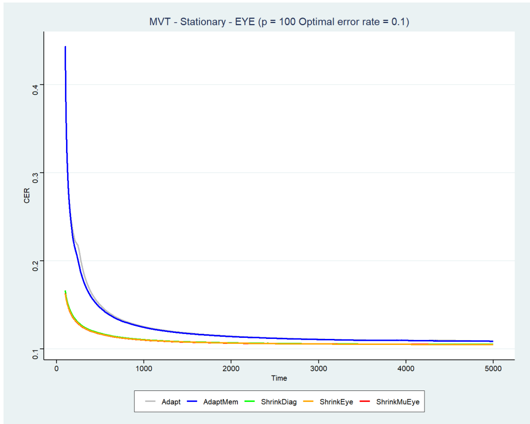
(f) MVT(5), $p = 1000$

Figure 5.26: Standard deviation of CER comparison among the stationary Wishart LDA models under both Normal and MVT(5) distributions for $p = 250, 500,$ and 1000.

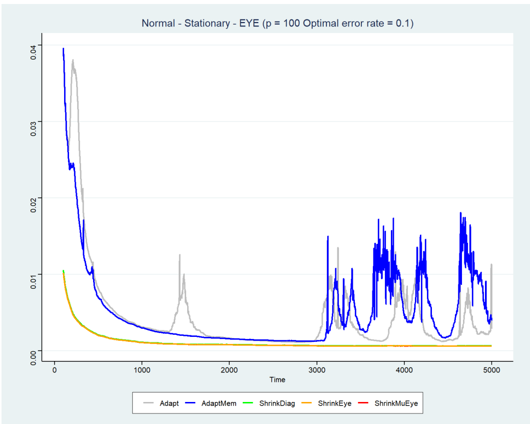
The *adaptive* and *adaptivemem* estimators do well under the various scenarios. The *shrinkage diagonal* and *shrinkage average variance* estimators perform the best in the multivariate normal case across all dimensions. They both do well in the case of multivariate t(5) for $p \leq 100$, however, as the dimensions increase, both estimators deteriorate in terms accuracy. The only setting investigated that the *shrinkage identity* performed well was not surprisingly when the covariance was set to the identity. See graphs below for both CER and standard deviation when $\Sigma = I$ and $p = 100$.



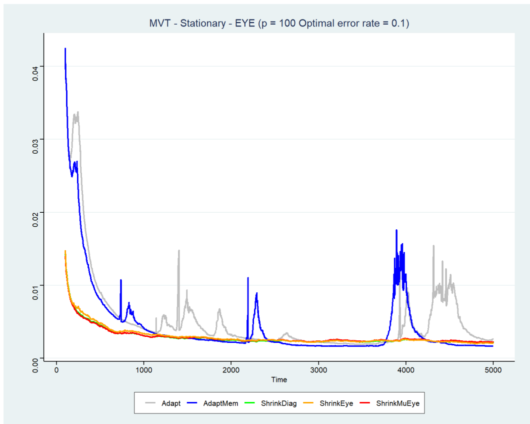
(a) Normal, $p = 100$



(b) MVT(5), $p = 100$



(c) Standard deviation Normal, $p = 100$



(d) Standard deviation MVT(5), $p = 100$

Figure 5.27: CER comparison among the stationary identity LDA models under both Normal and MVT(5) distributions for $p = 100$.

LDA Stationary Trajectories

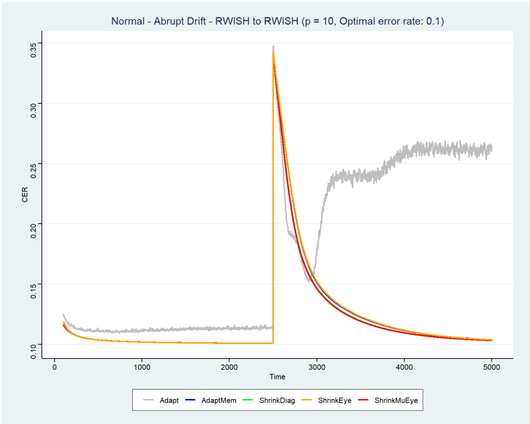
Trajectories for both multivariate normal and multivariate t(5) data for LDA stationary scenarios are reported in tables C1 to C18 in appendix C.

LDA Stationary Summary

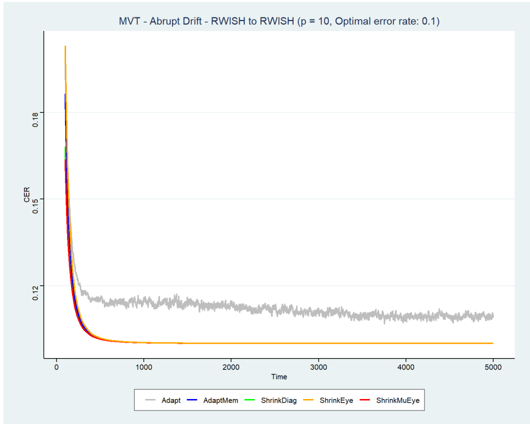
Under multivariate normality, the *shrinkage diagonal* and *shrinkage average* *variance* LDA models are superior in terms of the conditional error rate. The advantage increases as p increases. Contrary to this, the *shrinkage identity* LDA model becomes more unstable as p increases. Its performance deteriorates and its use cannot be recommended for the situations considered here excluding the case where $\Sigma = I$. Except for the *shrinkage identity* model, all other models appear to be asymptotically optimal as the conditional error rate converges towards the optimal error rate of 5%. For multivariate t(5) data, all of the models perform similarly for $p \leq 100$. For $p \geq 250$, the performance of the *shrinkage diagonal* and *shrinkage average variance* LDA models wanes and slowly worsens whereas the *adaptive* estimators continually improve. In the case of multivariate t(5) stationary data, the *adaptive* and *adaptivemem* are the only estimators that can be recommended.

5.3.2 Abrupt Drift

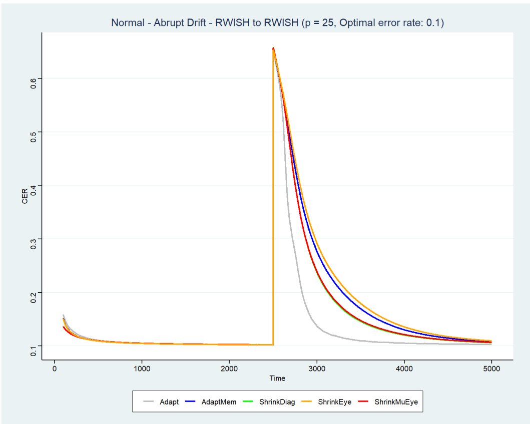
For non-stationary data regimes under abrupt drift, 2500 independent observations were sequentially generated from either a multivariate normal distribution (Rencher (1998)) or a multivariate t distribution with 5 degrees of freedom (Paolella (2019b)). The mean vector was randomly generated to ensure a specified optimum error rate (see 4.4.4). For most of the simulations only two scenarios were considered for the covariance matrix. For $p \leq 500$, the covariance matrix was randomly sampled from a Wishart distribution with $5p$ degrees of freedom with a scale matrix equal to the identity matrix. For $p \geq 250$, a block covariance matrix was also considered where each individual block was a 10×10 randomly sampled Wishart matrix with 50 degrees of freedom and a scale matrix equal to the identity matrix. For the case of $p = 100$ and equal priors, CS, AR, and identity matrices were also considered for the covariance matrix. After the initial 2500 observations were generated, the covariance matrix and mean vectors were abruptly changed and the 2500 remaining observations were generated according to the new distribution. Under multivariate normality and regardless of priors, the *shrinkage diagonal* and *shrinkage average variance* LDA models perform very well relative to the other estimators, and their performance improves as the dimensions increase. In terms of the conditional error rate, CER, these estimators produce very competitive discriminant models. In contrast, the performance of the *shrinkage identity* LDA model drastically deteriorates in the case of increasing dimensions. It is also extremely unstable in the initial stationary period prior to the abrupt drift especially in the case of equal priors and moderately unbalanced priors. In the scenarios considered, it would be difficult to justify its use as it performs extremely poorly. However, its use may be justified in settings where the covariance matrix is sparse as its performance slightly improves in the Block Wishart scenario. Future research could investigate its performance under increasing sparsity. Both *adaptive* estimators perform similarly with a slight edge to the *adaptive* estimator with the exception of $p = 10$. Most of the results in the Wishart scenario carry-over to the case of the block Wishart covariance matrix with the exception of the slight improvement in the *shrinkage identity* LDA model. In the block Wishart case, the *shrinkage identity* estimator's performance improves but still exhibits instability especially early in the sequence. For the multivariate t(5) scenario with equal priors for both Wishart and block Wishart matrices, the *average variance* and *shrinkage diagonal* estimators perform better initially but the performance seems to plateau after a certain point, whereas the *adaptive* and *adaptivemem* start off slowly but gradually perform better than the shrinkage estimators. This pattern disappears as the priors become more unequal. In the case of 70/30 unequal priors, the the *average variance* and *shrinkage diagonal* estimators dominate the others. For 90/10 unequal priors, the dominance is still present but to a much lesser degree.



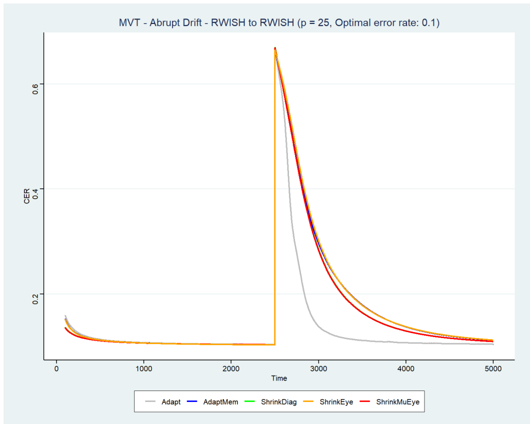
(a) Normal, $p = 10$



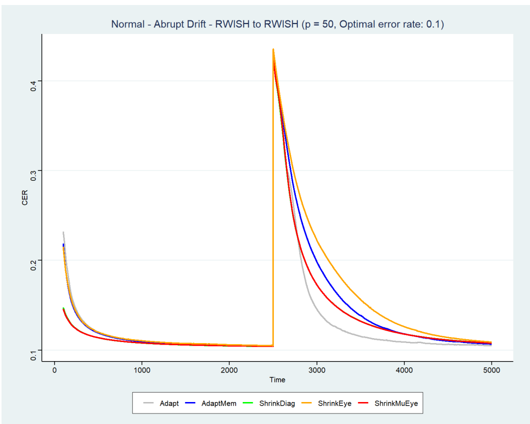
(b) MVT(5), $p = 10$



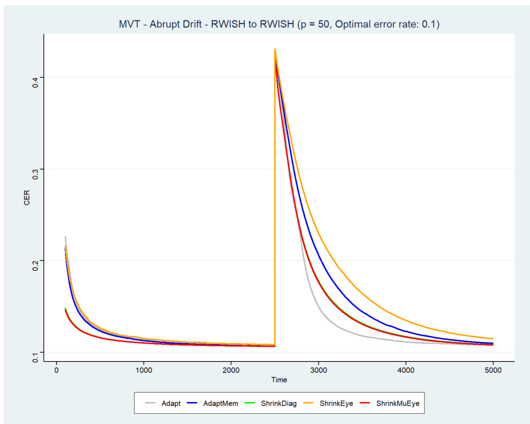
(c) Normal, $p = 25$



(d) MVT(5), $p = 25$

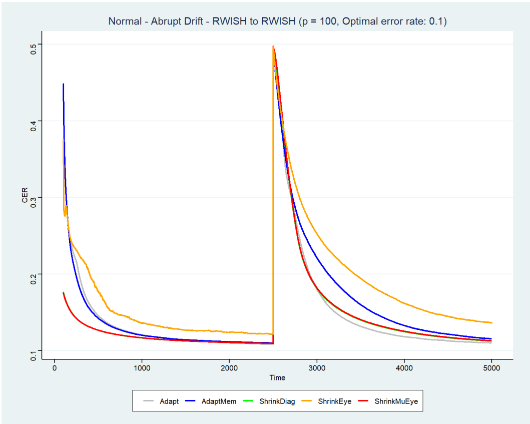


(e) Normal, $p = 50$

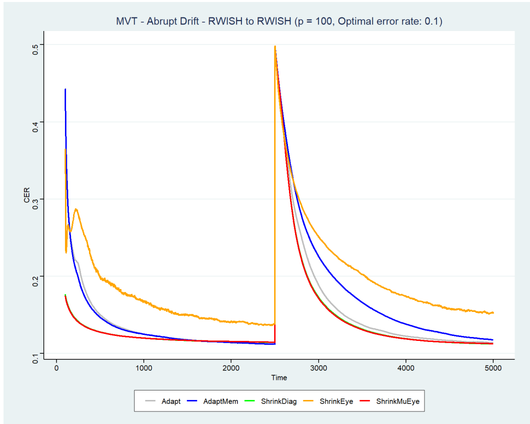


(f) MVT(5), $p = 50$

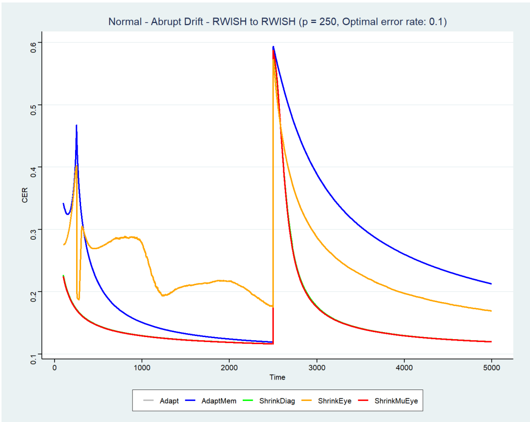
Figure 5.28: Abrupt shift CER comparison among the Wishart LDA models for both Normal and MVT(5) distributions with equal priors for $p = 10, 25$, and 50.



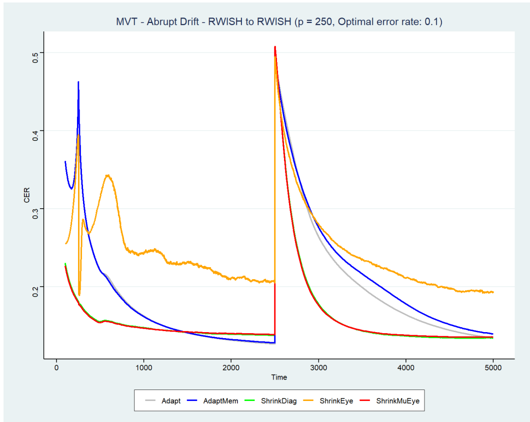
(a) Normal, $p = 100$



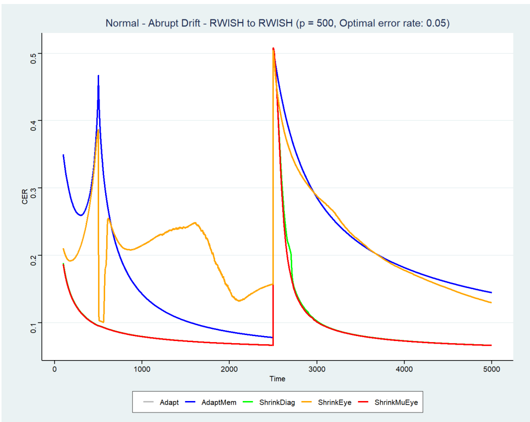
(b) MVT(5), $p = 100$



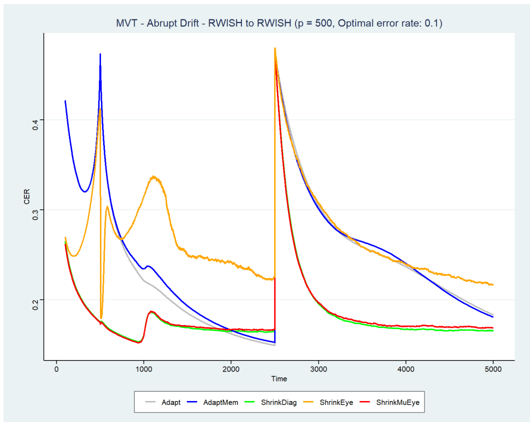
(c) Normal, $p = 250$



(d) MVT(5), $p = 250$

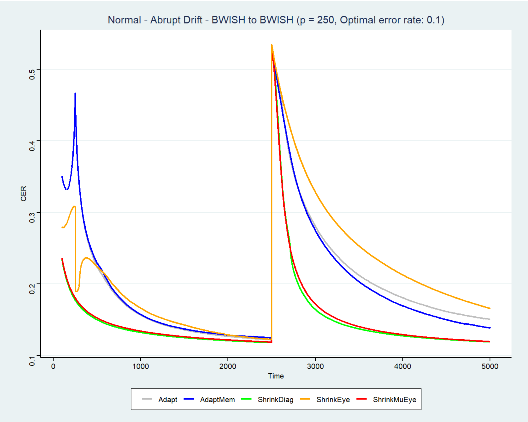


(e) Normal, $p = 500$

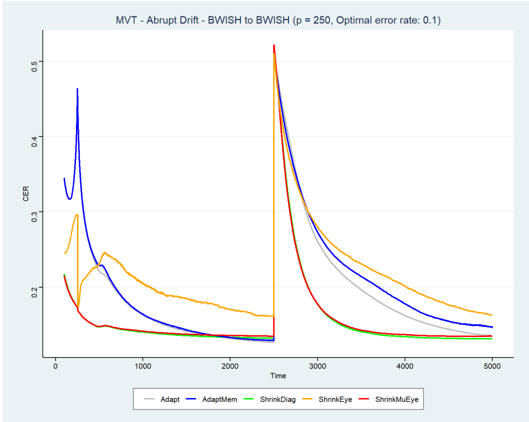


(f) MVT(5), $p = 500$

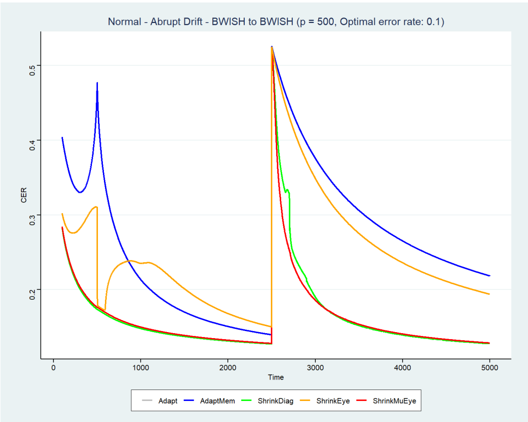
Figure 5.29: Abrupt shift CER comparison among the Wishart LDA models for both Normal and MVT(5) distributions for $p = 100, 250$, and 500.



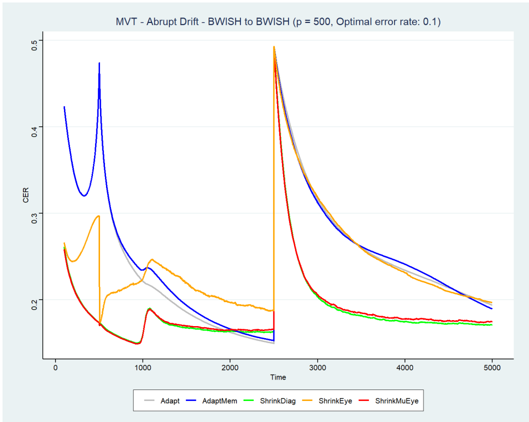
(a) Normal, $p = 250$



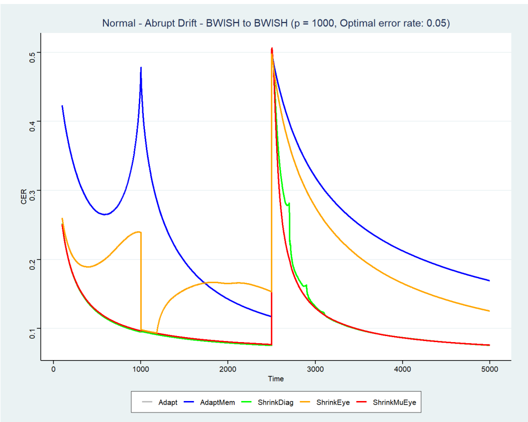
(b) MVT(5), $p = 250$



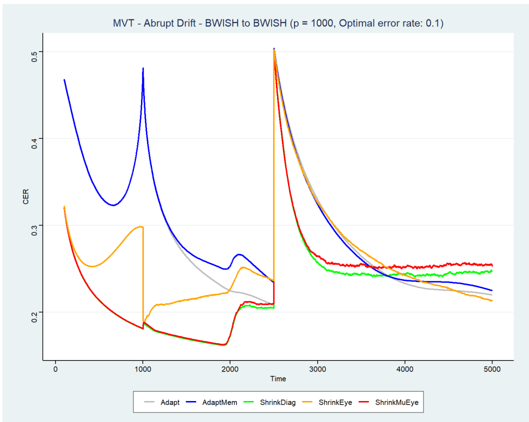
(c) Normal, $p = 500$



(d) MVT(5), $p = 500$

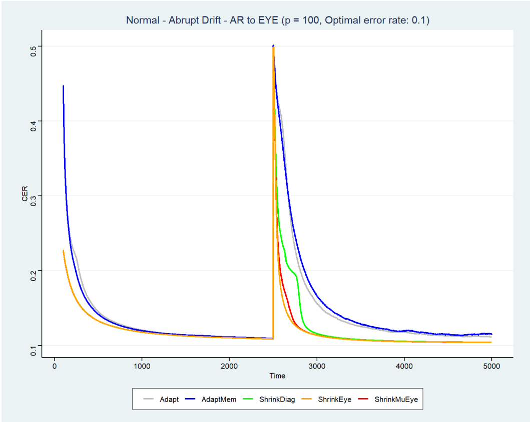


(e) Normal, $p = 1000$

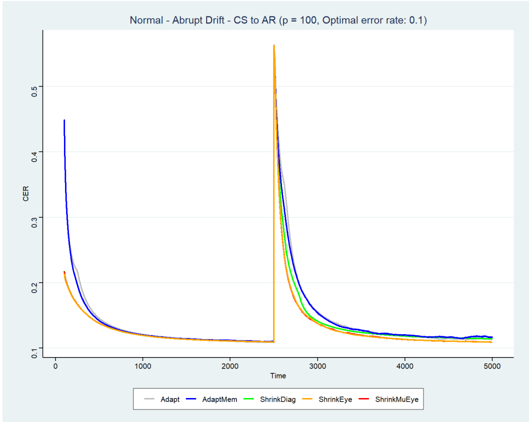


(f) MVT(5), $p = 1000$

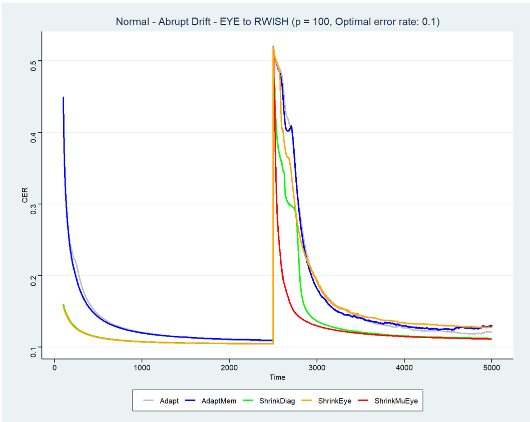
Figure 5.30: Abrupt shift CER comparison among the Block Wishart LDA models for both Normal and MVT(5) distributions with equal priors for $p = 250$, and 500.



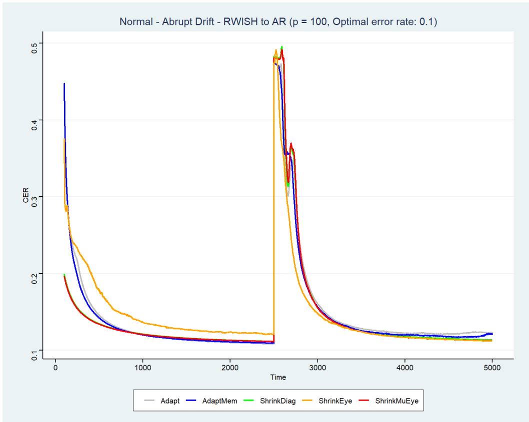
(a) AR,Identity $p = 100$



(b) CS,AR $p = 100$



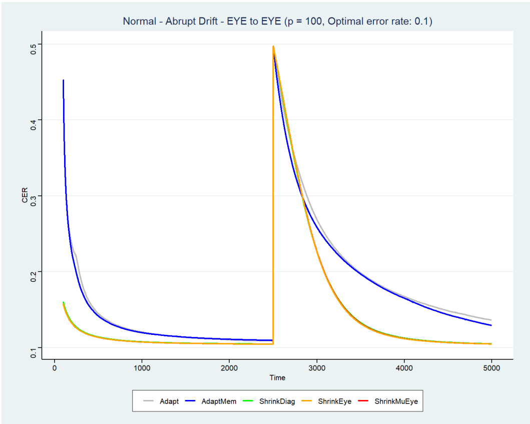
(c) Identity, RWISH $p = 100$



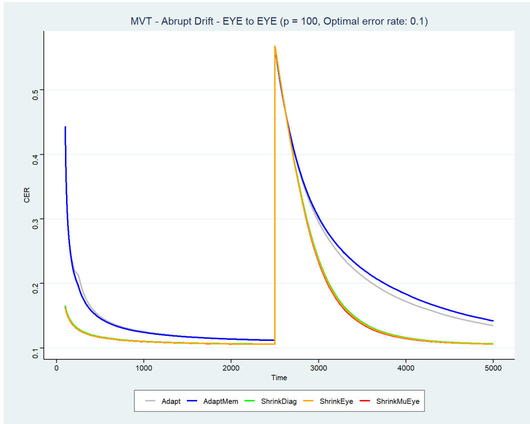
(d) RWISH, AR $p = 100$

Figure 5.31: Abrupt shift CER comparison among the Block Wishart LDA models for both Normal and MVT(5) distributions with equal priors for $p = 250$, and 500.

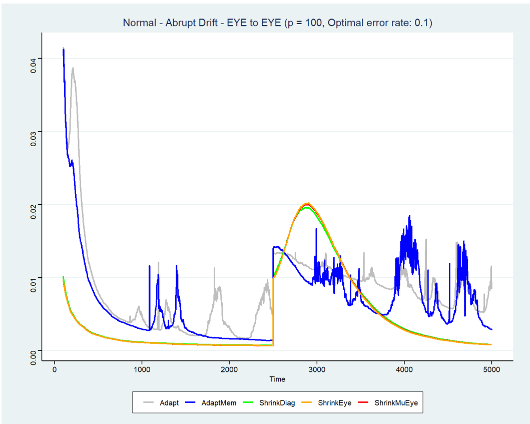
One additional scenario was considered namely the case where the common covariance matrix was to the identity matrix. The results are shown below. In this case all of the estimators perform will with all of the shrinkage estimators performing very well.



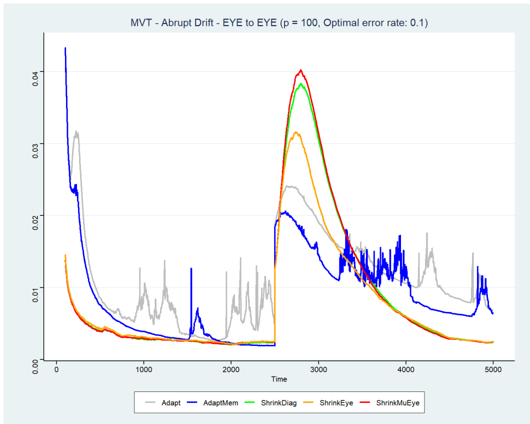
(a) Normal, $p = 100$



(b) MVT(5), $p = 100$

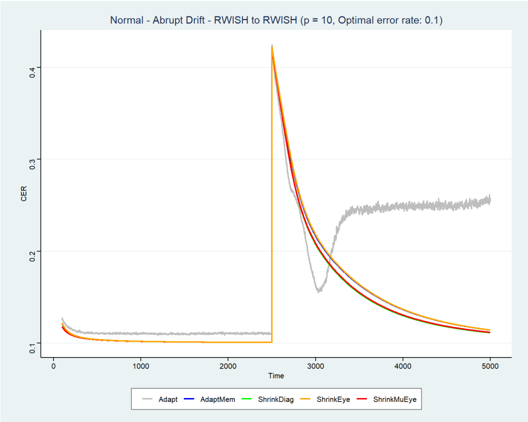


(c) Standard deviation Normal, $p = 100$

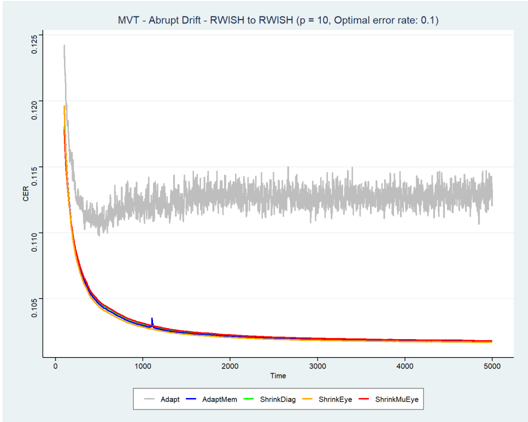


(d) Standard deviation MVT(5), $p = 100$

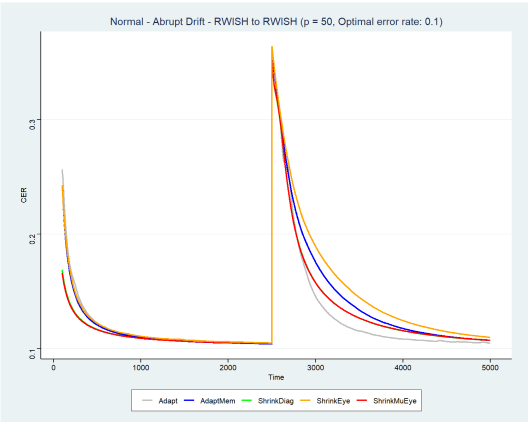
Figure 5.32: Comparison among the abrupt identity LDA models under both Normal and MVT(5) distributions for $p = 100$.



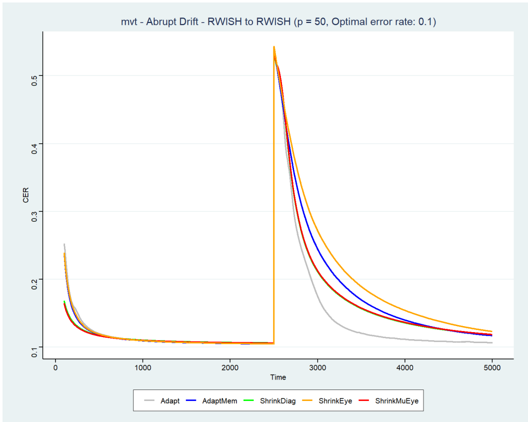
(a) Normal, $p = 10$



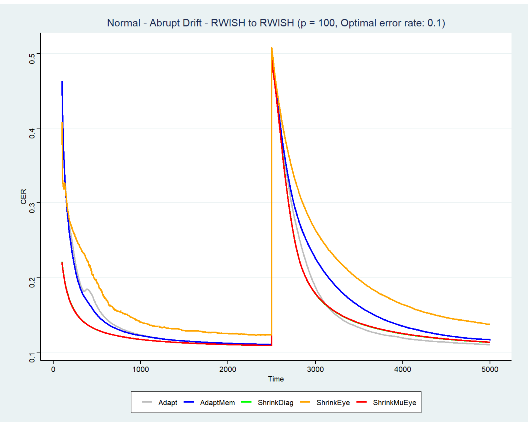
(b) MVT(5), $p = 10$



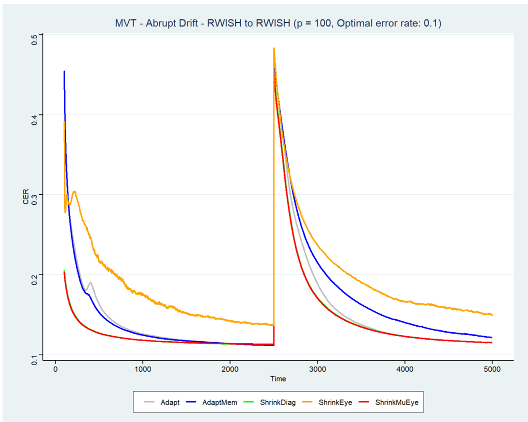
(c) Normal, $p = 50$



(d) MVT(5), $p = 50$

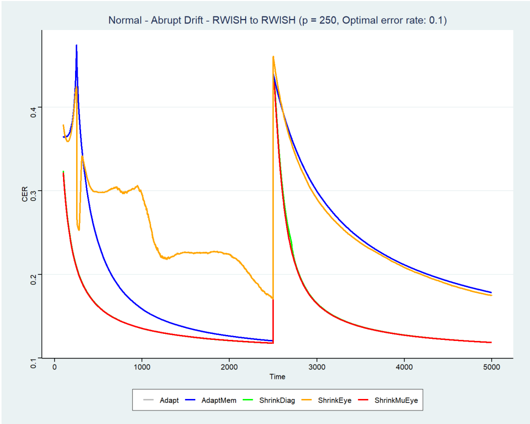


(e) Normal, $p = 100$

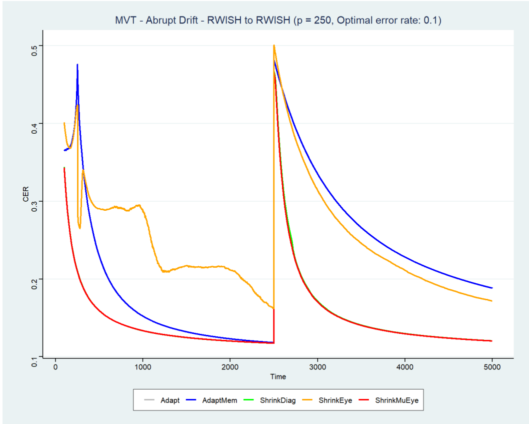


(f) MVT(5), $p = 100$

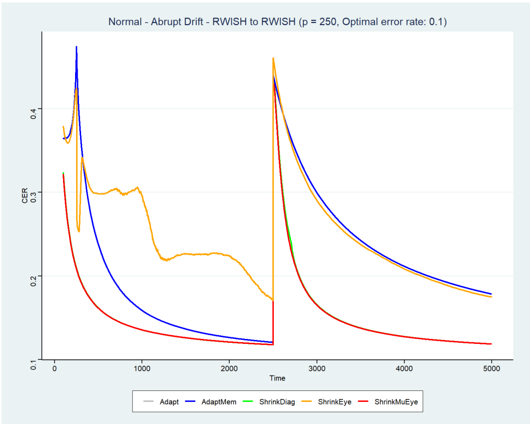
Figure 5.33: Abrupt shift CER comparison among the Wishart LDA models for both Normal and MVT(5) distributions with 70/30 priors for $p = 10, 50$, and 100.



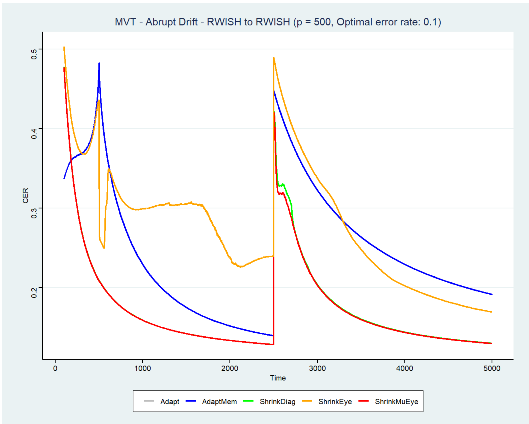
(a) Normal, $p = 250$



(b) MVT(5), $p = 250$

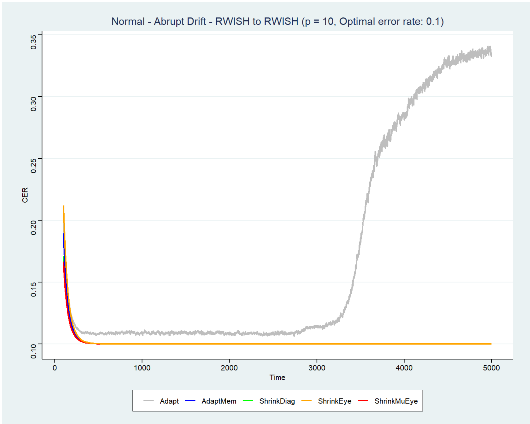


(c) Normal, $p = 500$

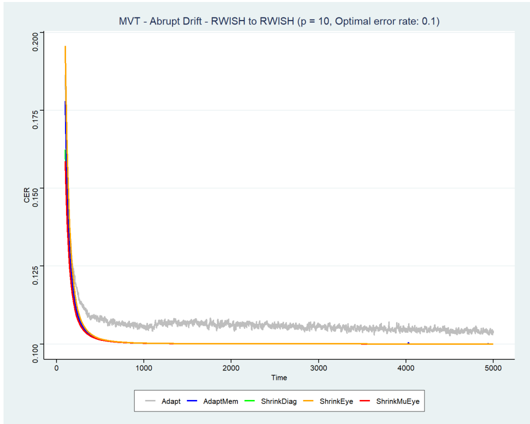


(d) MVT(5), $p = 500$

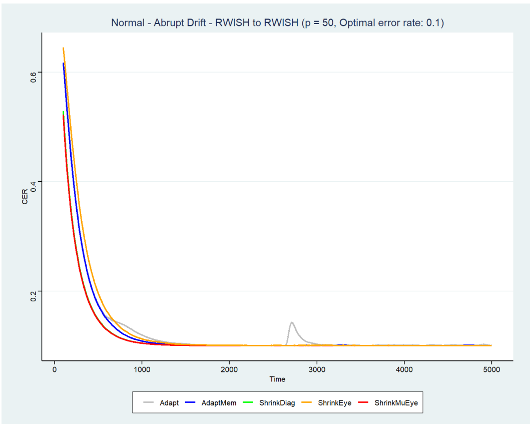
Figure 5.34: Abrupt shift CER comparison among the Wishart LDA models for both Normal and MVT(5) distributions with 70/30 priors for $p = 250$, and 500.



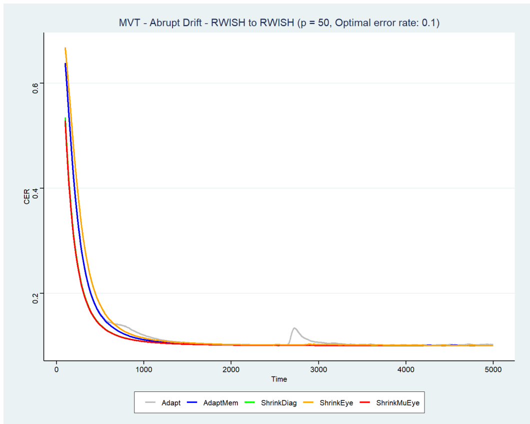
(a) Normal, $p = 10$



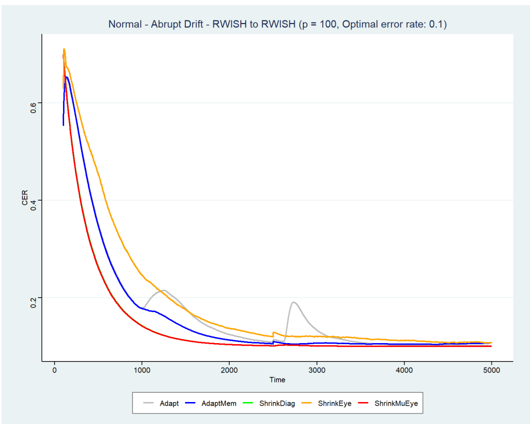
(b) MVT(5), $p = 10$



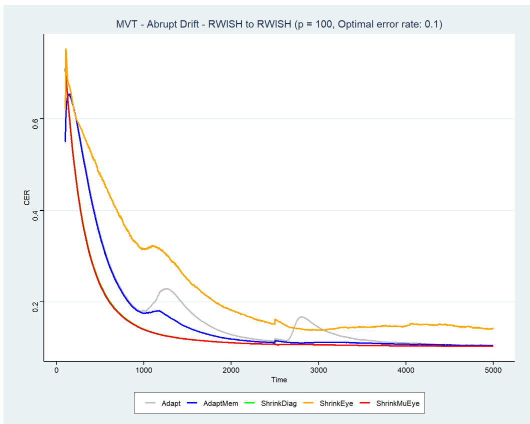
(c) Normal, $p = 50$



(d) MVT(5), $p = 50$



(e) Normal, $p = 100$

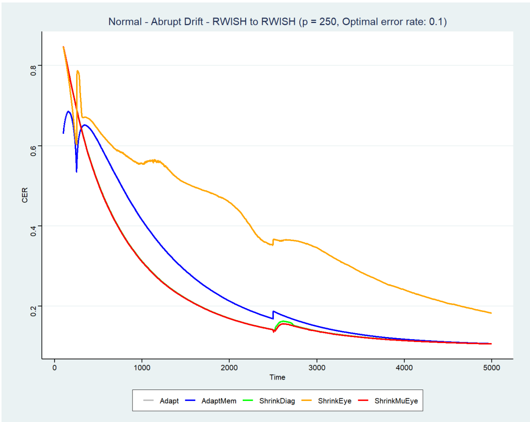


(f) MVT(5), $p = 100$

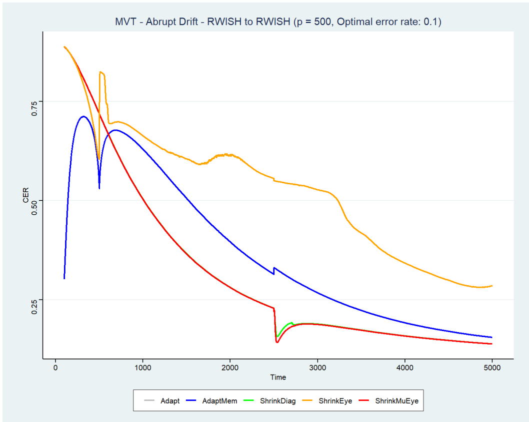
Figure 5.35: Abrupt shift CER comparison among the Wishart LDA models for both Normal and MVT(5) distributions with 90/10 priors for $p = 10, 50$ and 100.

(a) Normal, $p = 250$

(b) MVT(5), $p = 250$



(c) Normal, $p = 500$



(d) MVT(5), $p = 500$

Figure 5.36: Abrupt shift CER comparison among the Wishart LDA models for both Normal and MVT(5) distributions with 90/10 priors for $p = 250$ and 500

LDA Abrupt Drift Trajectories

Comprehensive simulation results including trajectories for both multivariate normal and multivariate t(5) data for the LDA abrupt drift scenarios are reported in tables from D1 through D40 in appendix D.

LDA Abrupt Drift Summary

The *shrinkage diagonal* and *shrinkage average variance* LDA models can be recommended across all dimensions, but especially for $p \geq 250$. The two models consistently had lower conditional error rates across the different priors and distributions considered. The standard deviations of the conditional error rates for the *shrinkage diagonal* and *shrinkage average variance* are also quite competitive with the other models. For small p the *adaptive* estimators did well.

For $p = 10$, the *adaptive memory* LDA model outperforms the *adaptive* LDA model. For larger p and equal and moderately unequal priors the *adaptive* estimators revealed a quadratic relationship with respect to the conditional error rate as they would experience an initial decrease and then a subsequent increase until $n \approx p$ at which point the conditional error rate would decrease again until the time of abrupt drift. This pattern was not evident for the *shrinkage diagonal* and *shrinage average variance* LDA models as their trajectories were monotonically decreasing until the abrupt drift time point. Excluding the case where $\Sigma = I$, the *shrinkage identity* LDA model cannot be recommended for the scenarios considered.

5.3.3 Gradual Drift

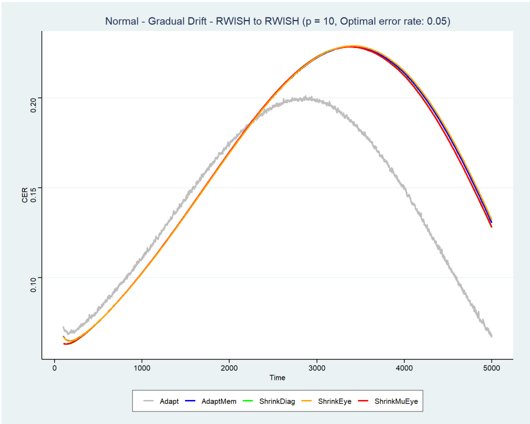
For non-stationary data regimes under gradual drift, data was simulated according to the method of *piecewise convex covariance movement* utilized in Anagnostopoulos et al. (2012). More specifically, for most of the simulations a common covariance matrix was randomly selected either from a Wishart distribution with $5p$ degrees and scale matrix equal to the identity matrix or was a randomly selected block matrix such that each block was a randomly selected 10×10 matrix from a Wishart distribution with 50 degrees of freedom and a scale matrix, I_{10}. For the case of $p = 100$ and equal priors, CS, AR, and identity matrices were also considered for the covariance matrix. The two mean vectors were then randomly selected such that an optimal error rate was satisfied. This first of parameters were the the *start* parameters. This process was repeated to generate the *end* parameters. At a given time point, t, during the simulation, the common population covariance matrix was set to

$$\Sigma_t = \frac{t_{End} - t}{t_{End} - t_{Start}} \Sigma_{t_{Start}} + \frac{t - t_{Start}}{t_{End} - t_{Start}} \Sigma_{t_{End}}$$

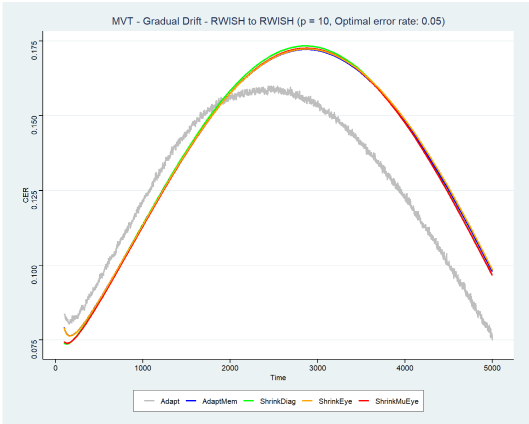
Similarly, the mean vector at time t was defined as

$$\mu_t = \frac{t_{End} - t}{t_{End} - t_{Start}} \mu_{t_{Start}} + \frac{t - t_{Start}}{t_{End} - t_{Start}} \mu_{t_{End}}$$

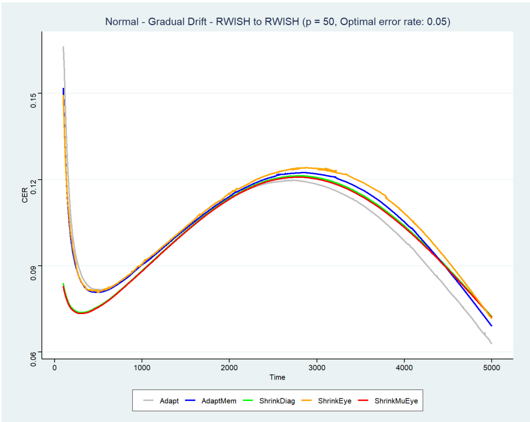
Under multivariate normality, the *average variance* and the *shrinkage diagonal* estimator perform the best



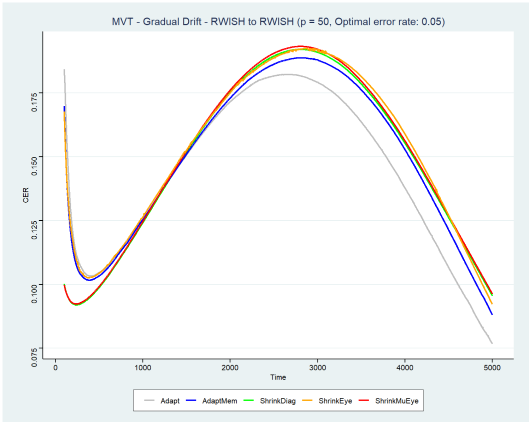
(a) Normal, $p = 10$



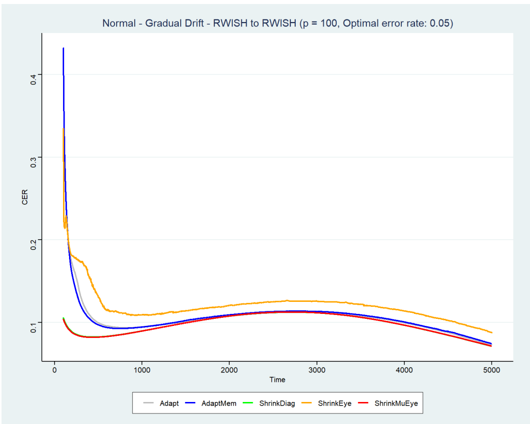
(b) MVT(5), $p = 10$



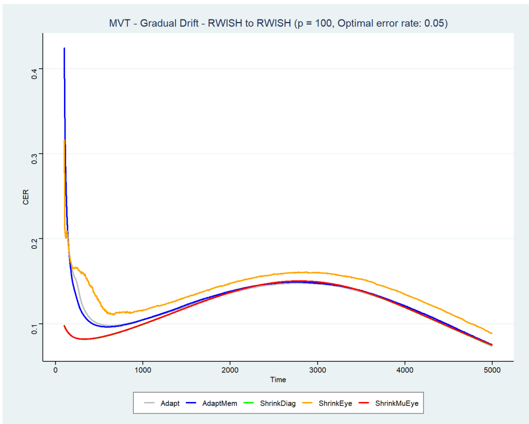
(c) Normal, $p = 50$



(d) MVT(5), $p = 50$

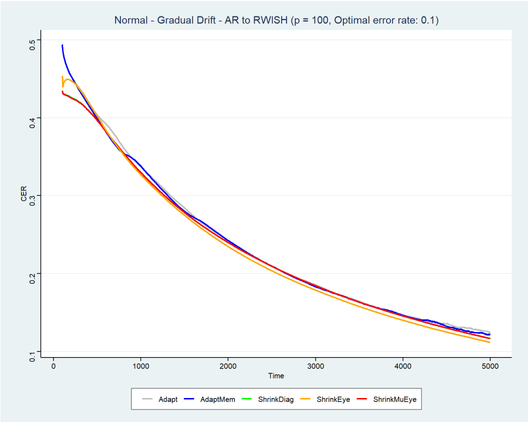


(e) Normal, $p = 100$

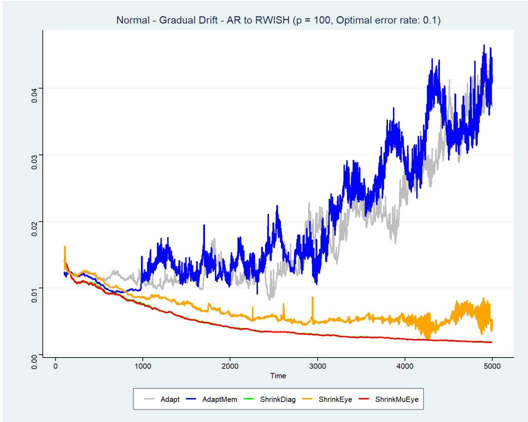


(f) MVT(5), $p = 100$

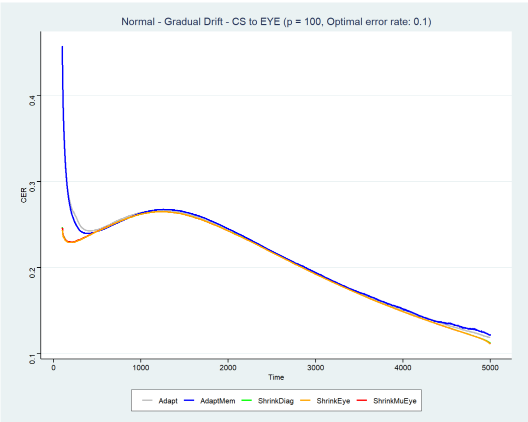
Figure 5.37: CER comparision between Normal and MVT(5) for gradual drift (Wishart to Wishart) LDA models.



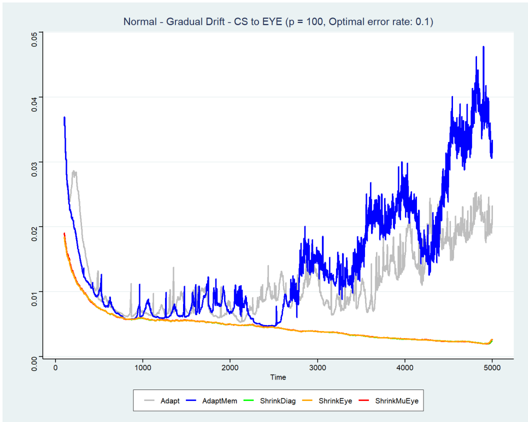
(a) AR,RWISH, $p = 100$



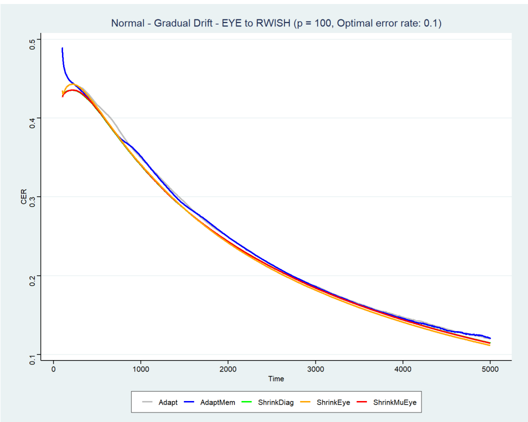
(b) SE AR,RWISH, $p = 100$



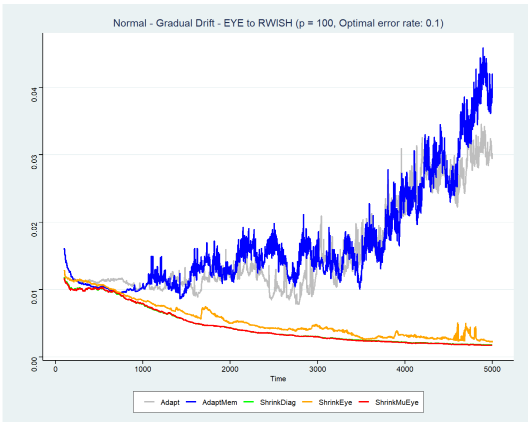
(c) CS,EYE, $p = 100$



(d) SE CS,EYE, $p = 100$

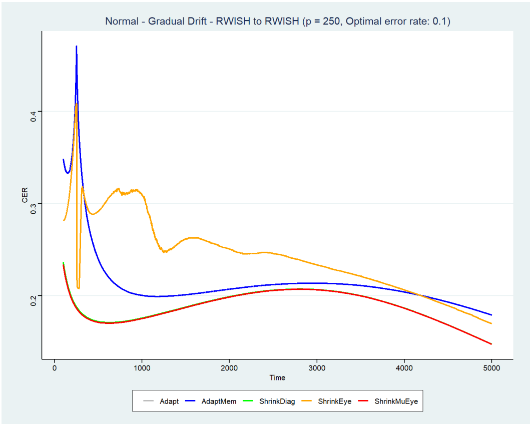


(e) EYE,RWISH, $p = 100$

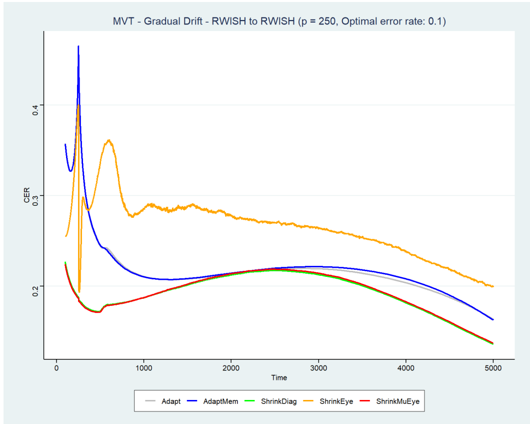


(f) SE EYE,RWISH, $p = 100$

Figure 5.38: CER comparision between LDA models with various covariance matrices under normality.

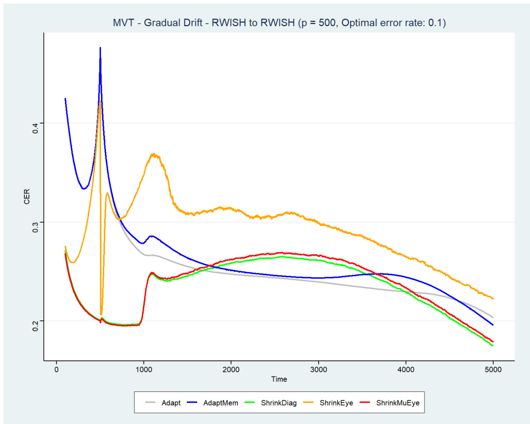


(a) Normal, (RWISH) $p = 250$

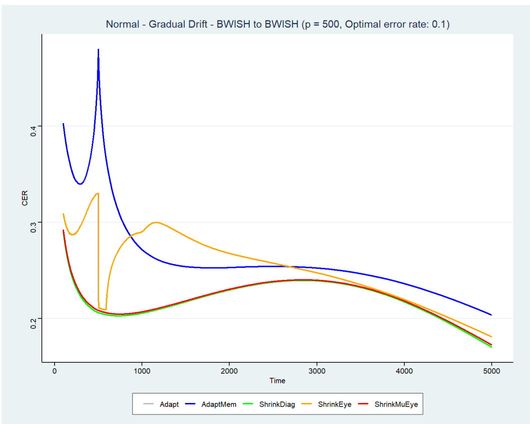


(b) MVT(5), (RWISH) $p = 250$

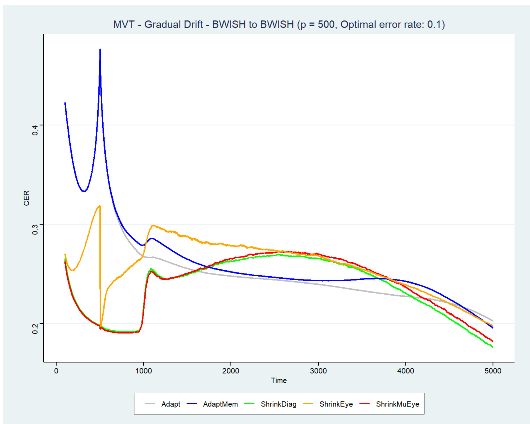
(c) Normal, (RWISH) $p = 500$



(d) MVT(5), (RWISH) $p = 500$



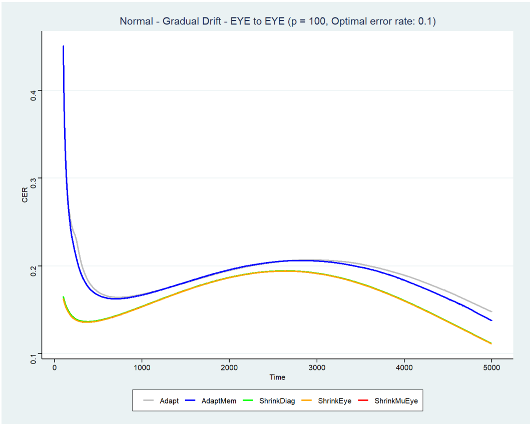
(e) Normal (BWISH), $p = 500$



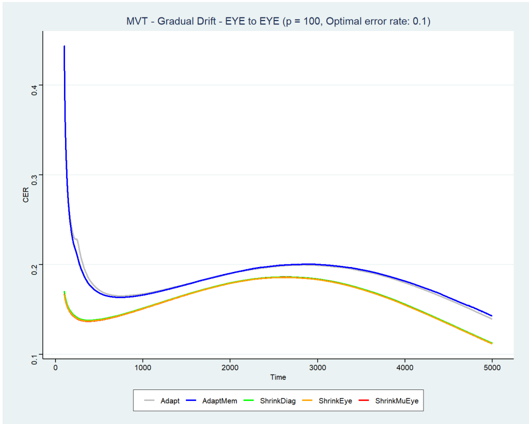
(f) MVT(5) (BWISH), $p = 500$

Figure 5.39: CER comparision between Normal and MVT(5) for gradual drift (Wishart to Wishart) LDA models with equal priors.

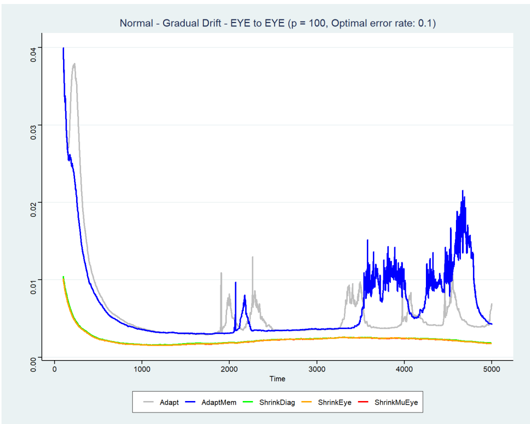
For $p = 100$, one additonal case was considered, namely where the covariance was held constant $\Sigma = I$ for the entire simulation. The results are below and just as in the abrupt and stationary cases, the shrinkage estimators are superior in terms of performance including the *shrinkage identity*.



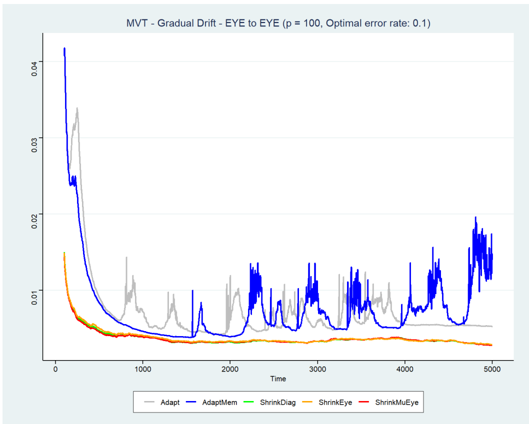
(a) Normal, $p = 100$



(b) MVT(5), $p = 100$



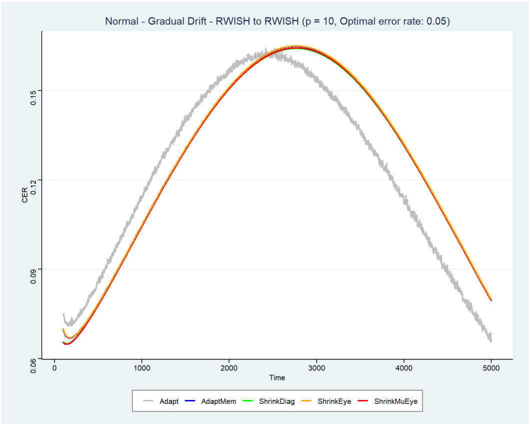
(c) Standard deviation Normal, $p = 100$



(d) Standard deviation MVT(5), $p = 100$

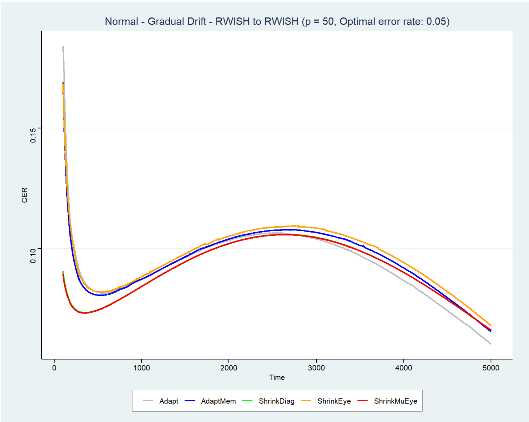
Figure 5.40: CER comparison among the gradual identity LDA models under both Normal and MVT(5) distributions for $p = 100$.

The following graphs display the Wishart results for the case of moderately unbalanced priors (70/30).

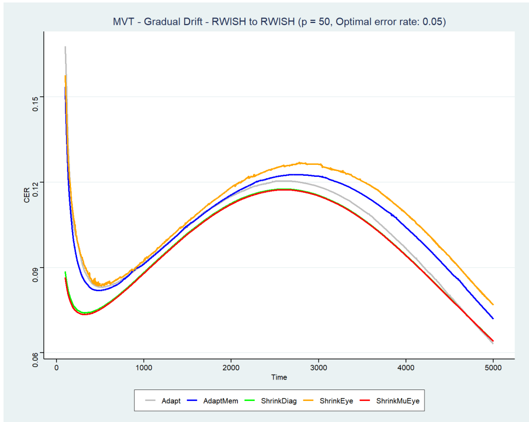


(a) Normal, $p = 10$

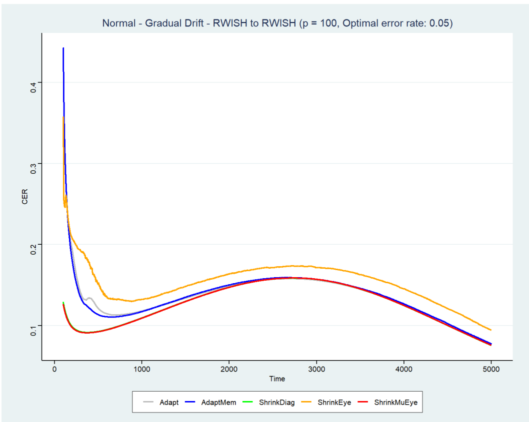
(b) MVT(5), $p = 10$



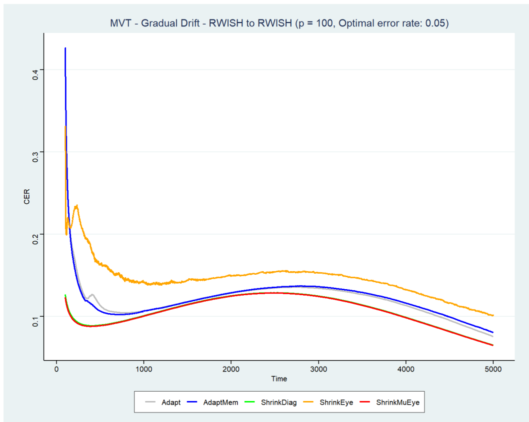
(c) Normal, $p = 50$



(d) MVT(5), $p = 50$

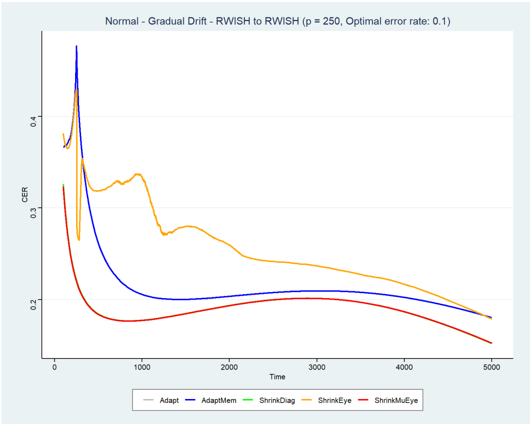


(e) Normal, $p = 100$

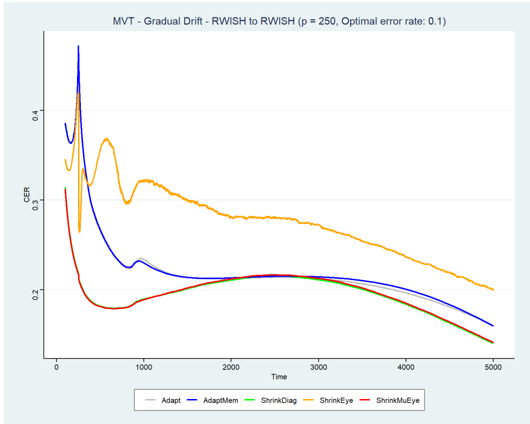


(f) MVT(5), $p = 100$

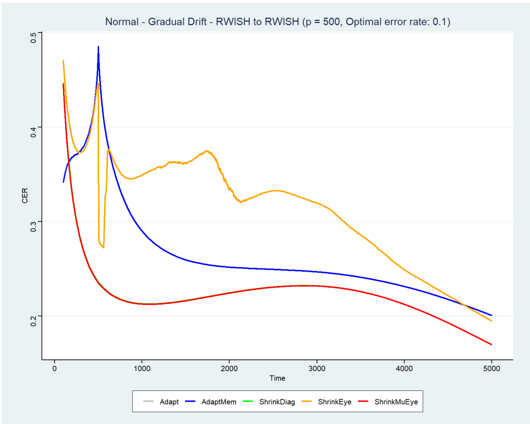
Figure 5.41: CER comparision between Normal and MVT(5) for gradual drift (Wishart to Wishart) LDA models for 70/30 priors.



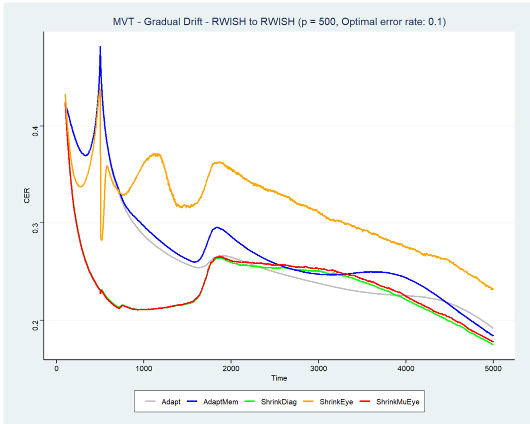
(a) Normal, $p = 250$



(b) MVT(5), $p = 250$



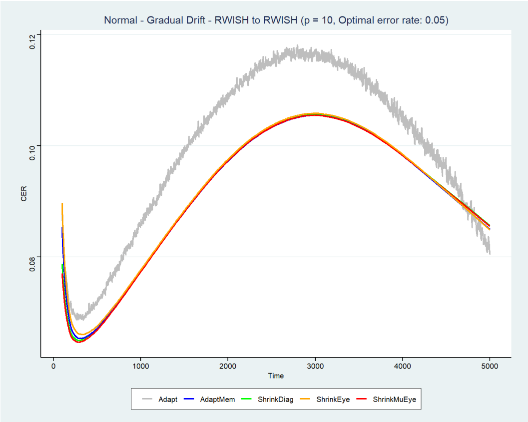
(c) Normal, $p = 500$



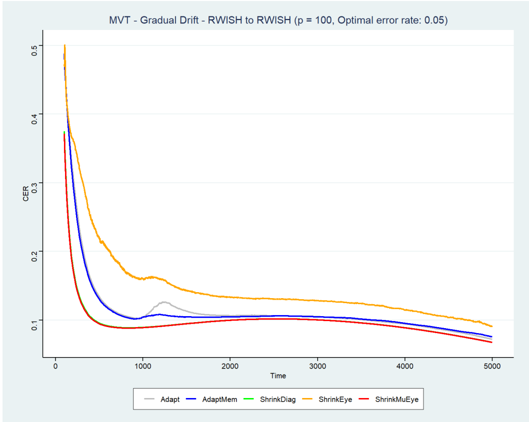
(d) MVT(5), $p = 500$

Figure 5.42: CER comparision between Normal and MVT(5) for gradual drift (Wishart to Wishart) LDA models for 70/30 priors.

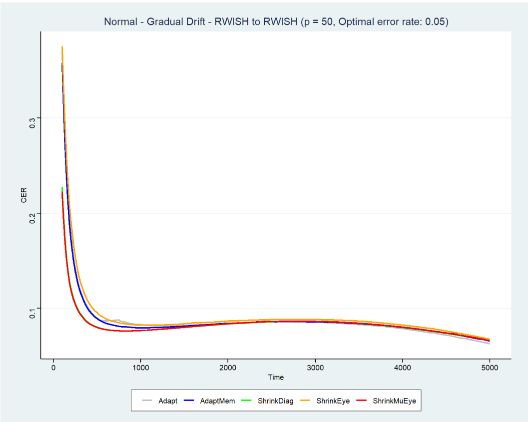
Lastly, the highly unbalanced prior case (90/10) is shown below.



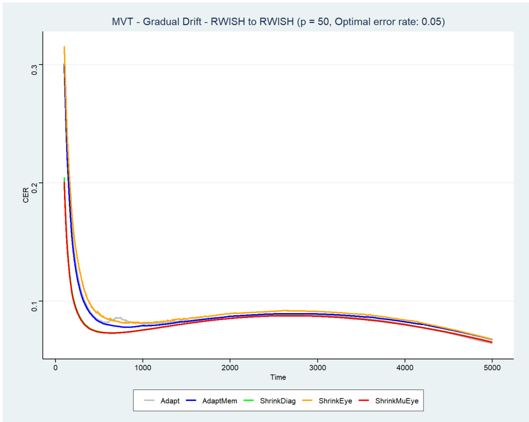
(a) Normal, $p = 10$



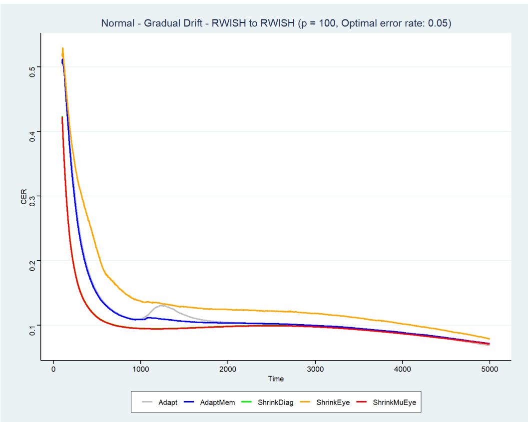
(b) MVT(5), $p = 10$



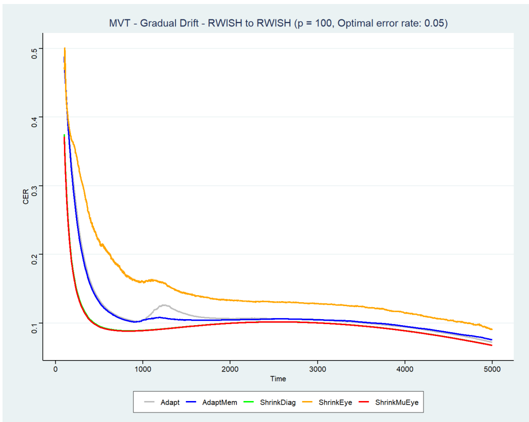
(c) Normal, $p = 50$



(d) MVT(5), $p = 50$

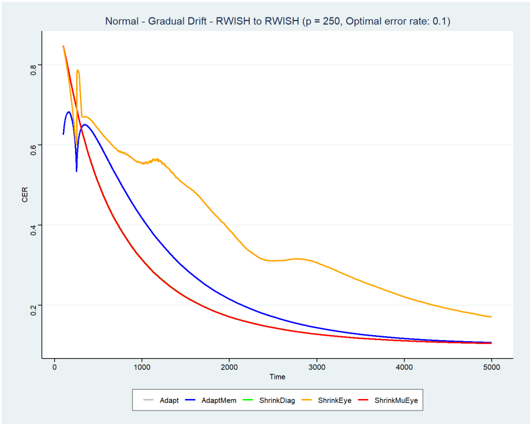


(e) Normal, $p = 100$

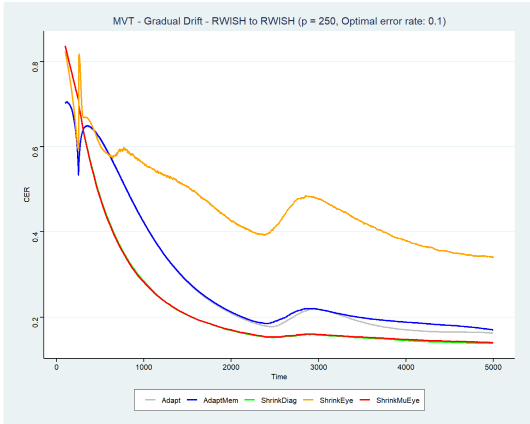


(f) MVT(5), $p = 100$

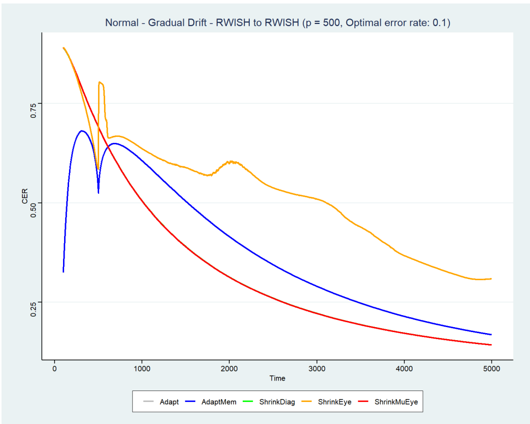
Figure 5.43: CER comparision between Normal and MVT(5) for gradual drift (Wishart to Wishart) LDA models for 90/10 priors.



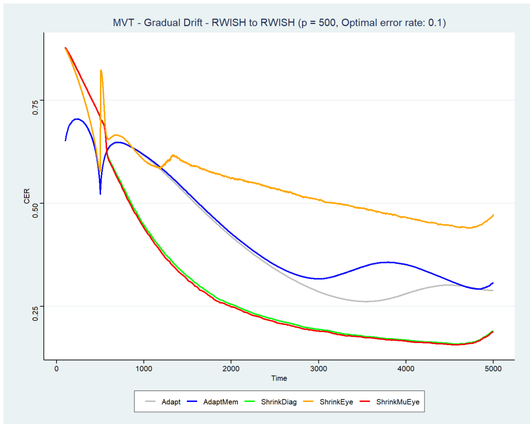
(a) Normal, $p = 250$



(b) MVT(5), $p = 250$



(c) Normal, $p = 500$



(d) MVT(5), $p = 500$

Figure 5.44: CER comparision between Normal and MVT(5) for gradual drift (Wishart to Wishart) LDA models for 90/10 priors.

LDA Gradual Drift Trajectories

Trajectories for both multivariate normal and multivariate t(5) data for LDA gradual drift scenarios are reported in appendix G.

LDA Gradual Drift Summary

The LDA Gradual results are consistent the LDA Abrupt results. The *shrinkage diagonal* and *shrinkage average* estimators outperform all other estimators for large p. The *shrinkage identity* estimator is unstable, however, for the block Wishart matrices, does appear to be slightly more stable and in the case of $\Sigma = I$ appears to be a very good model. This suggests that the *shrinkage identity* estimator's performance increases as the common covariance matrix approaches the identity.

5.4 Error rate estimators for LDA with 2 groups

In addition to model building, error rate estimation is vitally important in adaptive streaming contexts for monitoring model quality over time. Such monitoring is useful in cases of both static and adaptive models. For this investigation, the following error rate estimators were examined. For more details see section 3.4.

1. **Adaptive D estimate** The static D estimate is one of the oldest methods for estimating the conditional error rate for a linear discriminant analysis model. It is a parametric estimator introduced by Fisher (1936). It is defined as follows:

$$\hat{P}_i^D = \Phi\left(\frac{-D}{2}\right) \text{ for } i = 1, 2, \tag{5.4}$$

   where $\Phi(\cdot)$ is the standard normal cumulative distribution function and $D = \sqrt{(\bar{x}_1 - \bar{x}_2)^T \hat{\Sigma}_p^{-1} (\bar{x}_1 - \bar{x}_2)}$. For this investigation, the static sample estimates will be replaced with their adaptive counterparts.

2. **Adaptive Resubstitution.** This method combines the resubstitution method as originally suggested by Smith (1947) with the adaptive estimation described in Anagnostopoulos et al. (2012) which is also used to adaptively estimate priors in the streaming LDA context.

3. **Adaptive Interleaved/Prequential MLE method** This is a slight variation of the adaptive resubstitution method above. Instead of first updating parameters and then obtaining a prediction, the order is reversed by obtaining a prediction and then updating the model. The adaptive multinomial MLE approach can then be used to estimate error rates.

4. **Adaptive Posterior Probability Estimate** This method adaptively estimates the posterior probability estimate (Fukunaga and Kessell (1973), Glick (1978), and Hora and Wilcox (1982b)) by the method of Bodenham (2014).

5. **Prequential Posterior Probability Estimate** This is a slight variation of the adaptive posterior probability estimate above. Instead of updating parameters first and then obtaining a posterior probability estimate, the

order is reversed by obtaining the posterior probability estimate and then updating the model.

Covariance matrices were randomly sampled from a Wishart distribution with $5p$ degrees of freedom and a scale matrix equal to the identity matrix. The number of predictors was held constant at $p = 100$. Data was generated according to a multivariate normal distribution. In addition, the D error estimate was evaluated under departures of normality. Stationary, abrupt, and gradual drift were considered.

5.4.1 LDA Stationary

In the context of stationary multivariate normal data with a common Wishart covariance matrix, the conditional error rate for each of the LDA models has the typical "L-shape" as present in the average loss profiles of the adaptive covariance matrix estimates. The conditional error rate for each of the LDA models appears to be converging toward the specified optimal rate by the end of the simulation. Both variants of the adaptive LDA models are very similar in terms of model quality. The *shrinkage identity* model performs slightly worse than the others, while the *shrinkage diagonal* and *shrinkage average variance* produce models with smaller conditional error rates throughout the entire simulation run. This is consistent throughout most of the stationary scenarios considered.

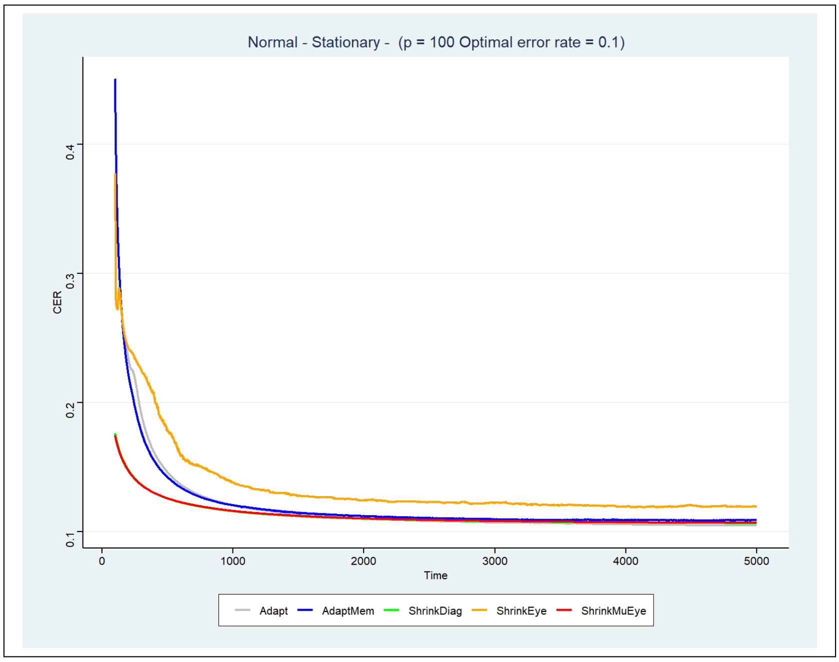
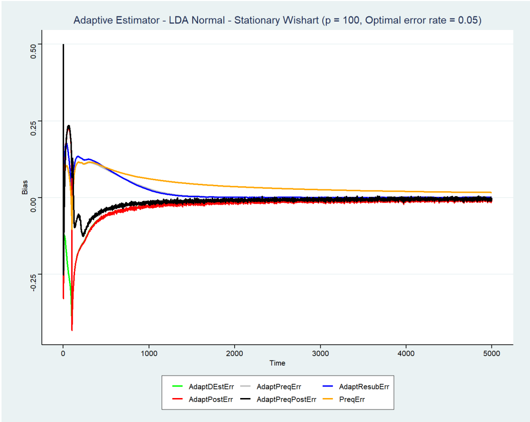
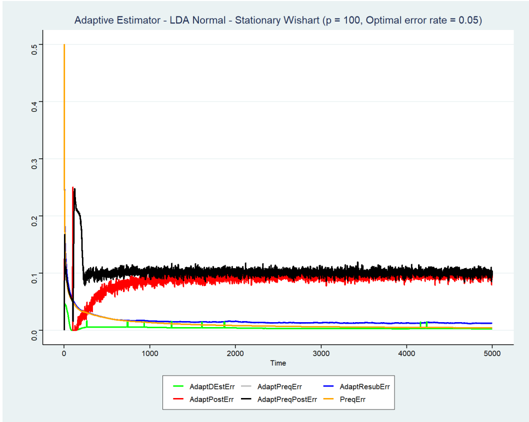


Figure 5.45: Conditional error rate for stationary multivariate normal data with $p = 100$.

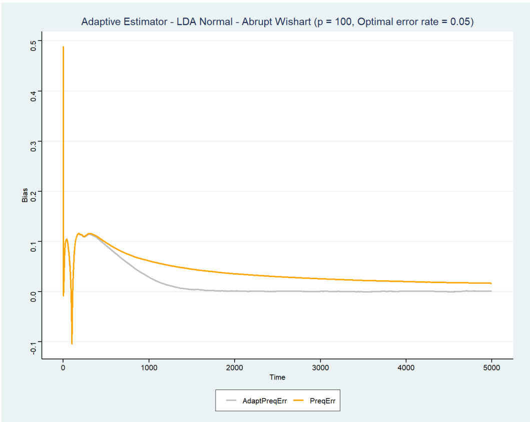
In this case, the conditional error rate profiles are similar across all estimators. The subsequent error rate estimators should then behave similarly across the different models. For simplicity of exposition, therefore, consider the *adaptive* LDA model and its associated error rate estimators. For the above stationary case, the conditional error rate estimators for the *adaptive* LDA model are plotted below.



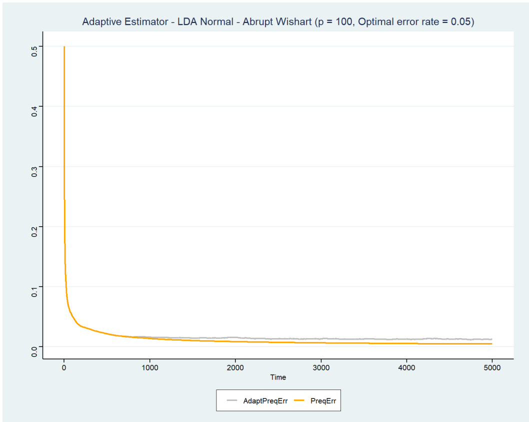
(a) Bias



(b) Standard deviation



(c) Bias of prequential estimators



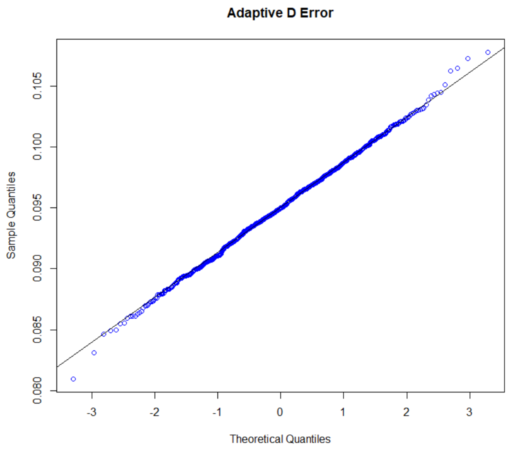
(d) Standard deviation of prequential estimators

Figure 5.46: Comparison of CER estimators under normality with $p = 100$.

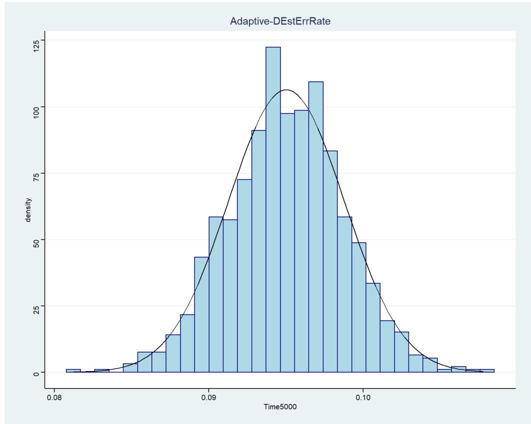
Most of the estimators perform well and tend to have relatively small bias which decreases over time. The *adaptive posterior* and *adaptive prequential posterior* seem to have a slight edge in terms bias over the others with the *adaptive prequential posterior* having the best bias trajectory. However, the standard deviations of these estimators tend to be quite large relative to the other estimators. This is consistent with the bias-variance trade-off (Hastie, Tibshirani, and Friedman (2016)) principle. Excluding the posterior probability based estimators, the remaining adaptive estimators have simulated average bias and standard deviation both approaching zero as the sequence progresses indicating possible consistency of each estimator.

A typical error rate estimator used in sequential estimation is the *prequential* estimator (Bifet et al. (2018)). The *adaptive prequential* estimator outperforms the standard prequential estimator in terms of bias, see plot below. Not only does the adaptive prequential estimator outperform the standard prequential estimator in terms of bias, but its standard deviation is almost as small and appears to be converging toward zero. The results suggest that the adaptive prequential estimator is a good candidate for use in real world applications involving sequential predictive modeling.

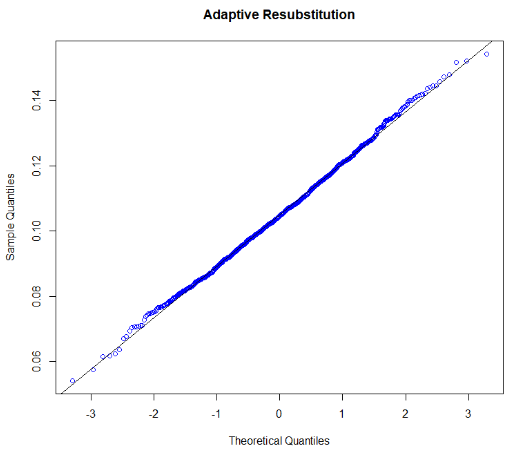
For large n, the distributions for the adaptive D estimate, resubstitution estimate, and adaptive prequential estimate appear approximately normal. See qq-plots and histograms below for simulated error rate distributions at time point $t = 5000$. In contrast, the posterior based estimates are highly positively skewed.



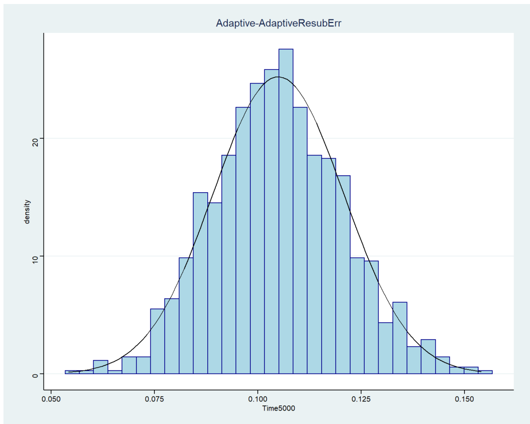
(a) D Estimate QQPlot



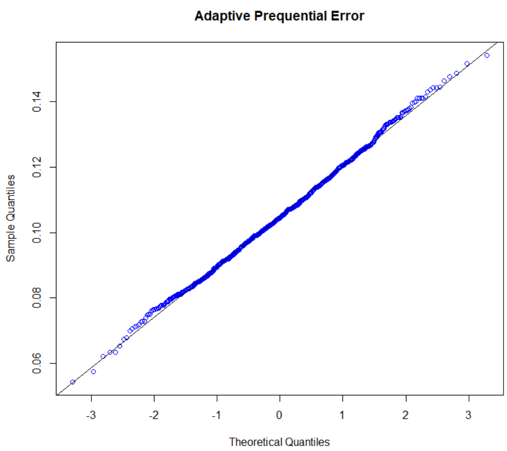
(b) D Estimate Histogram



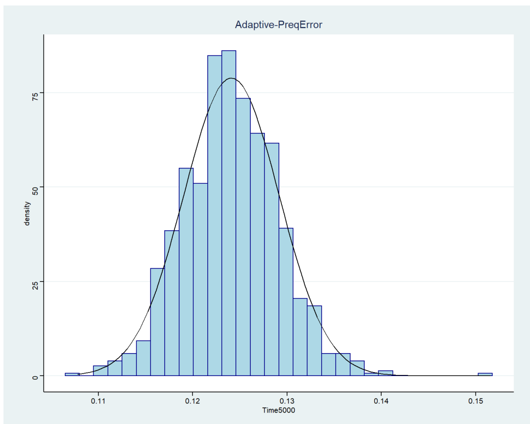
(c) Resubstitution QQPlot



(d) Resubstitution Histogram

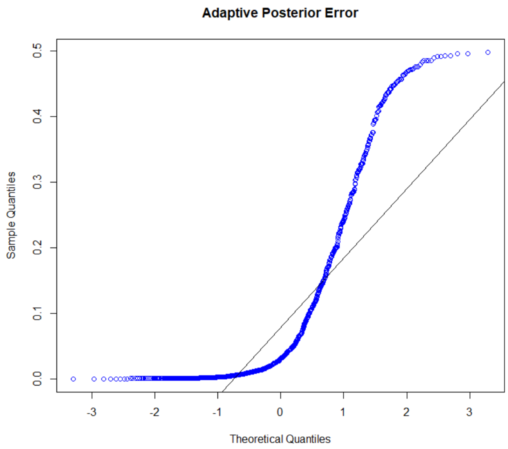


(e) Prequential QQPlot

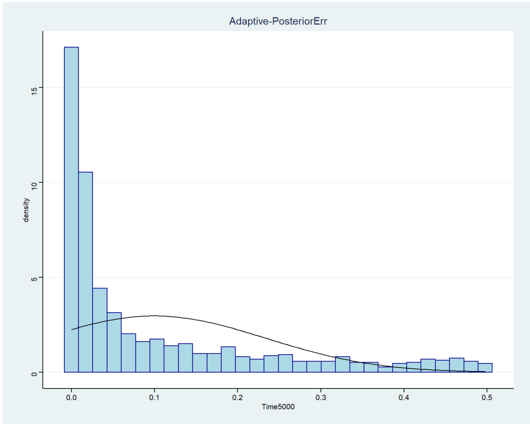


(f) Prequential Histogram

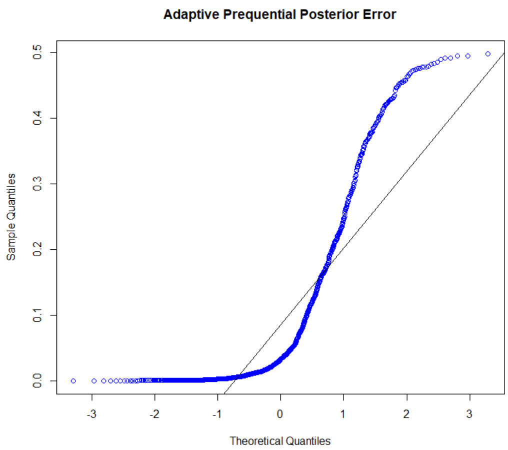
Figure 5.47: Simulated distributions for error rate estimators at time $t = 5000$.



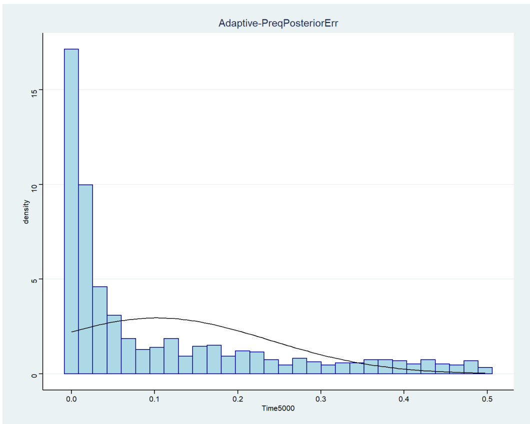
(a) Posterior estimate QQ Plot



(b) Posterior estimate Histogram



(c) Prequential posterior estimate QQ plot

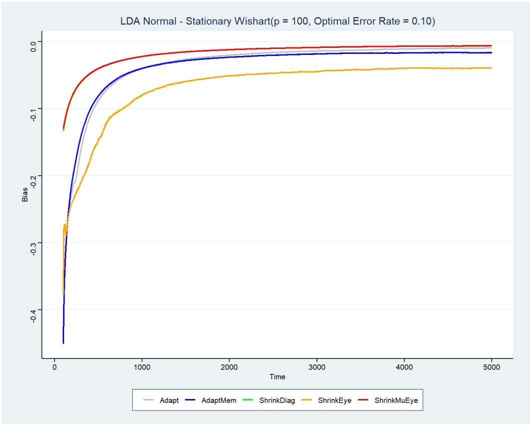


(d) Prequential posterior estimate histogram

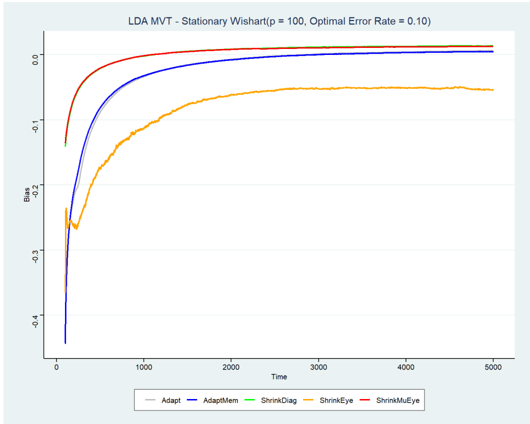
Figure 5.48: Simulated distributions for posterior based error rate estimators at time $t = 5000$.

Adaptive D Estimate

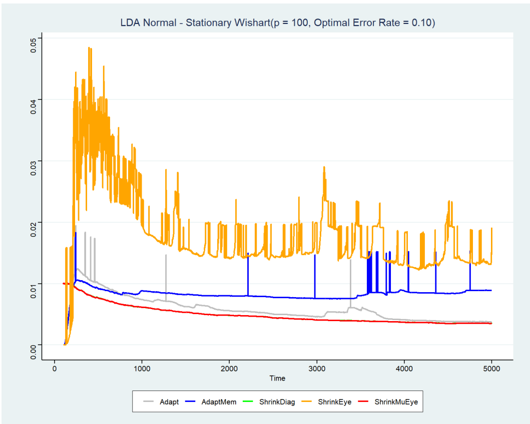
For the adaptive D estimate of the error estimate, comparisons were made across all of the different estimating methods. Additionally, comparisons were also made under both normality and MVT(5) distributions. See the graphs below.



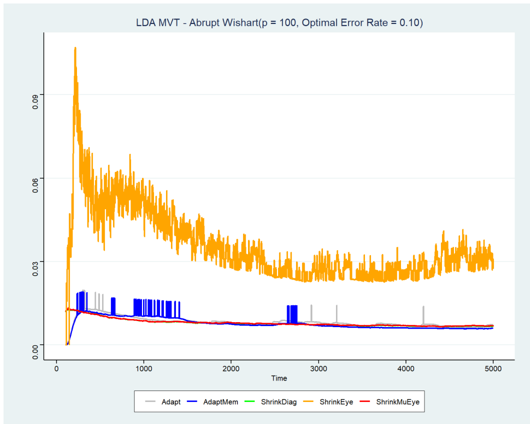
(a) Bias Normal, $p = 100$



(b) Bias MVT(5), $p = 100$



(c) Standard deviation Normal, $p = 100$



(d) Standard deviation MVT(5), $p = 100$

Figure 5.49: Comparision between Normal and MVT(5) stationary Wishart LDA models.

Under normality, the *shrinkage average variance* and *shrinkage diagonal* estimates perform the best. They provide a clear advantage over the methods especially early in the sequence. However as the sequence progresses, the performance of the *adaptive* and *adaptivemem* estimators improve. Tables for error rate estimators under stationarity can be found in appendix H.

5.4.1.1 Summary

1. The adaptive prequential error rate estimate outperforms the standard prequential estimate and should be considered whenever accurate estimation of the conditional error rate is needed.

2. The adaptive resubstitution estimator should also be considered as it's bias

and standard deviation are very competitive relative to the other estimators.

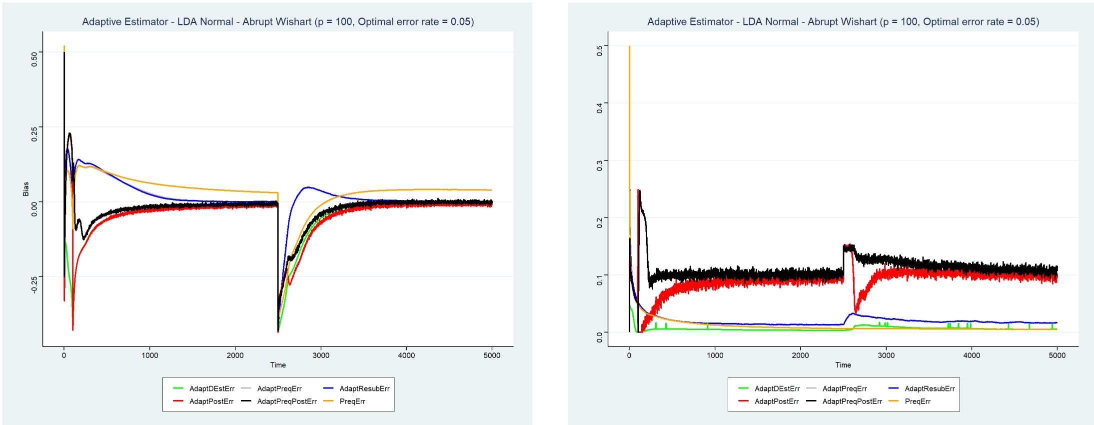
3. The error rate estimators based on the posterior probabilities have small bias but may have excessive standard deviations. Excluding the posterior based estimates, the adaptive estimates have approximately normal distributions for large n.

4. The *shrinkage average variance* and *shrinkage diagonal* D error estimates are preferable under normality, whereas the *adaptive* and *adaptivemem* D error estimates are preferable under MVT(5).

5.4.2 LDA Abrupt

As in previous simulations, for non-stationary data regimes under abrupt drift, 2500 independent observations were sequentially generated from a multivariate normal distribution. The mean vector was randomly generated to ensure a specified optimum error rate. The covariance matrix was randomly sampled from a Wishart distribution with $5p$ degrees of freedom with a scale matrix equal to the identity matrix. After the initial 2500 observations were generated, the covariance matrix and mean vectors were abruptly changed and the 2500 remaining observations were generated according to the new distribution. The number of dimensions was held constant at 100.

As in the stationary case, the conditional error rate profiles are fairly similar across all estimators. The subsequent error rate estimators should then behave similarly across the different models. For simplicity of exposition, therefore, consider the *adaptive* LDA model and its associated error rate estimators. Similar to the stationary case most of the adaptive estimators have relatively low bias especially when considered against the prequential error rate estimator. Additionally the *adaptive resubstitution* error estimator rebounds quickly after the abrupt regime change at $t = 2501$.

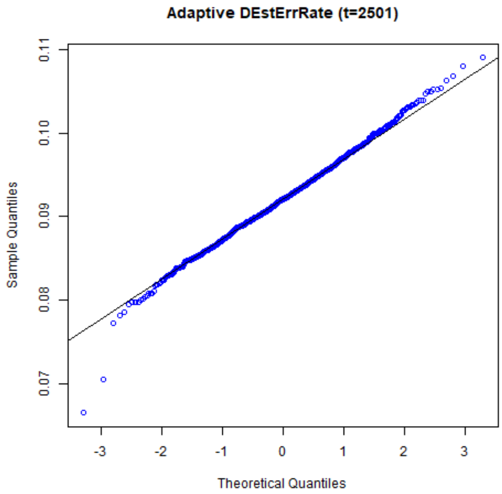


(a) Bias of error rate estimators

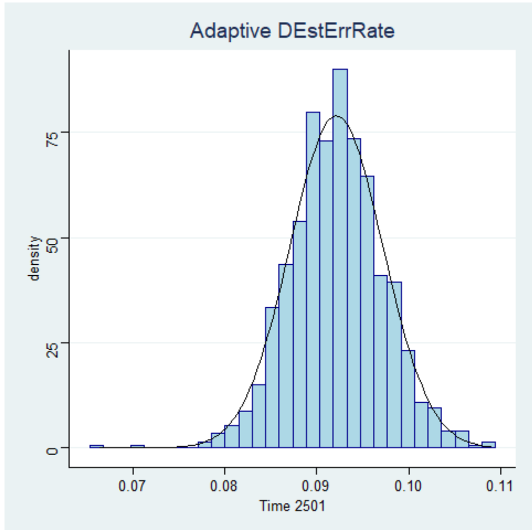
(b) Standard deviation of error rate estimators

Figure 5.50: Bias and standard deviation of error rate estimators under abrupt drift

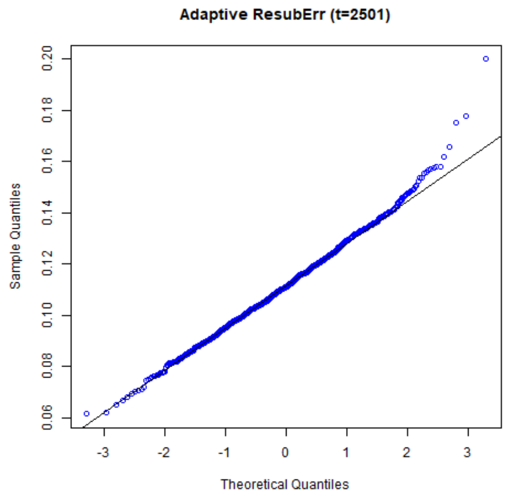
At the time of the abrupt change, the distributions for the adaptive D estimate, resubstitution estimate, and adaptive prequential estimate appear approximately normal. See qq-plots and histograms below for simulated error rate distributions at time point t= 2501. In contrast, the posterior based estimates are highly positively skewed. This same pattern exists (not displayed) for large n as well which is also consistent with the stationary case.



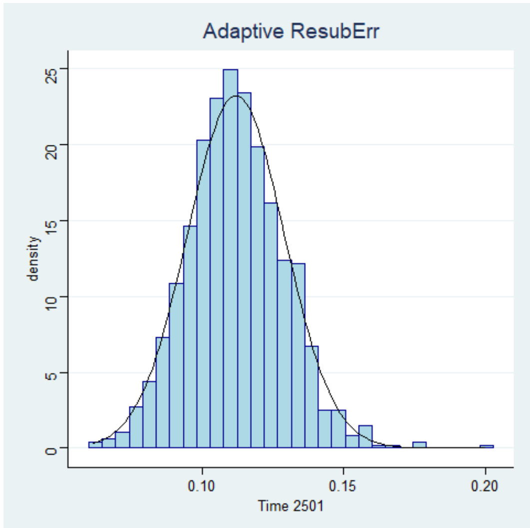
(a) D estimate QQPlot



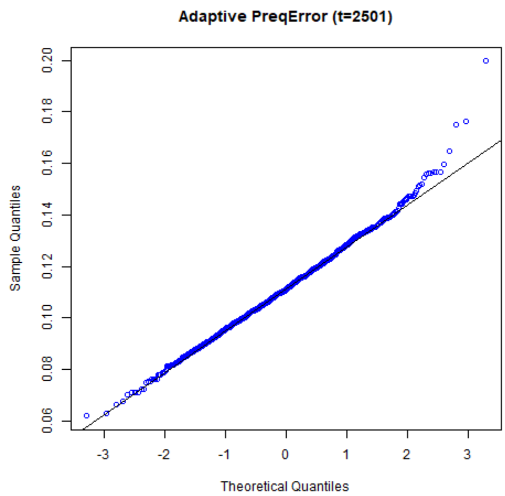
(b) D estimate histogram



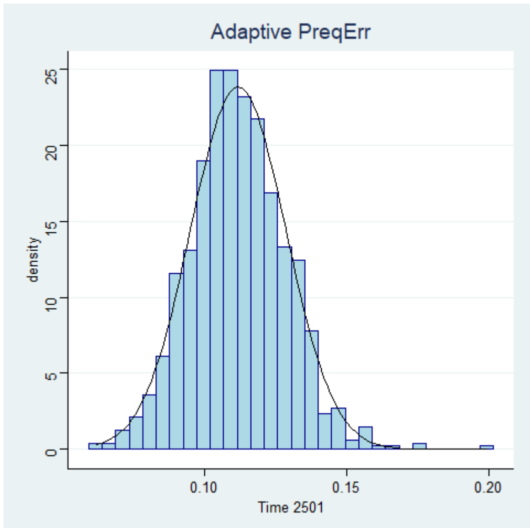
(c) Resubstitution QQPlot



(d) Resubstitution histogram

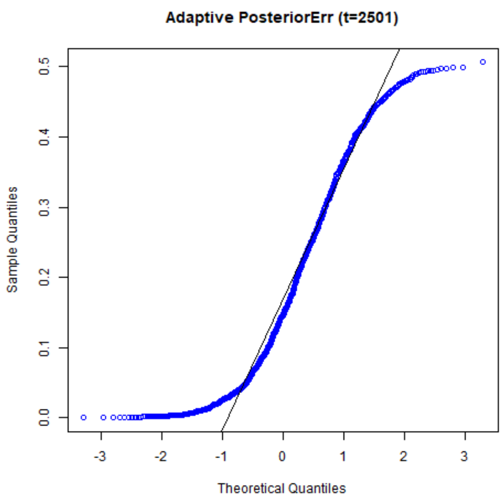


(e) Prequential QQPlot

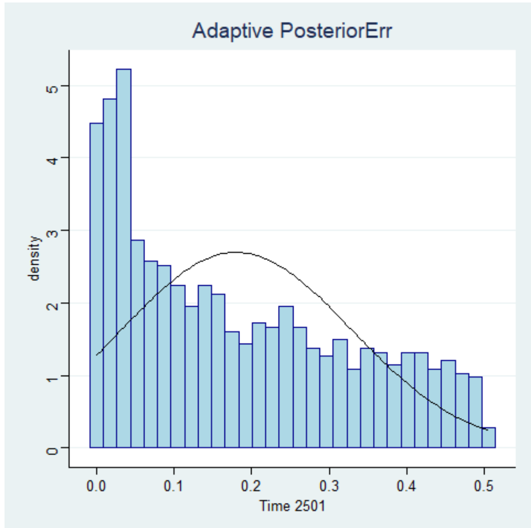


(f) Prequential histogram

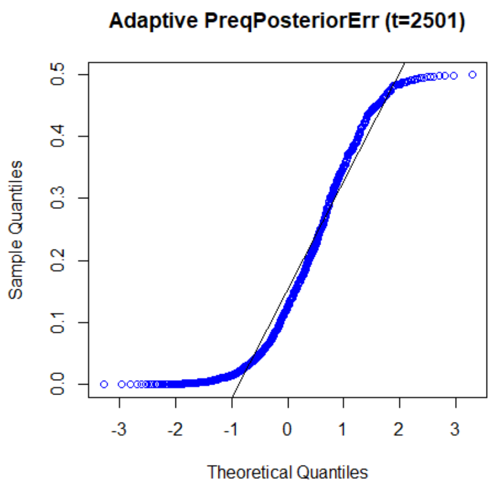
Figure 5.51: Simulated distributions for error rate estimators at time $t = 2501$.



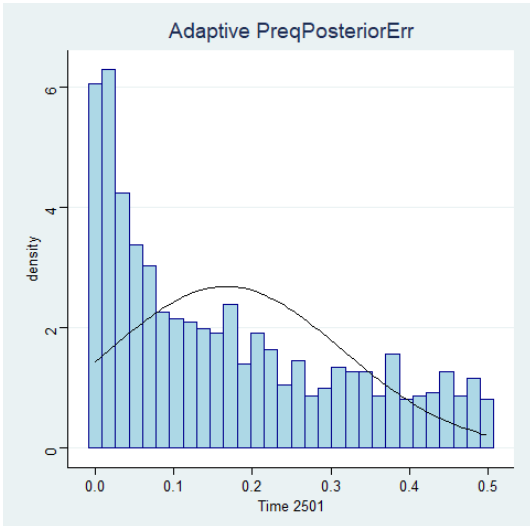
(a) Posterior error estimate QQPlot



(b) Posterior error estimate histogram



(c) Prequential posterior error QQPlot

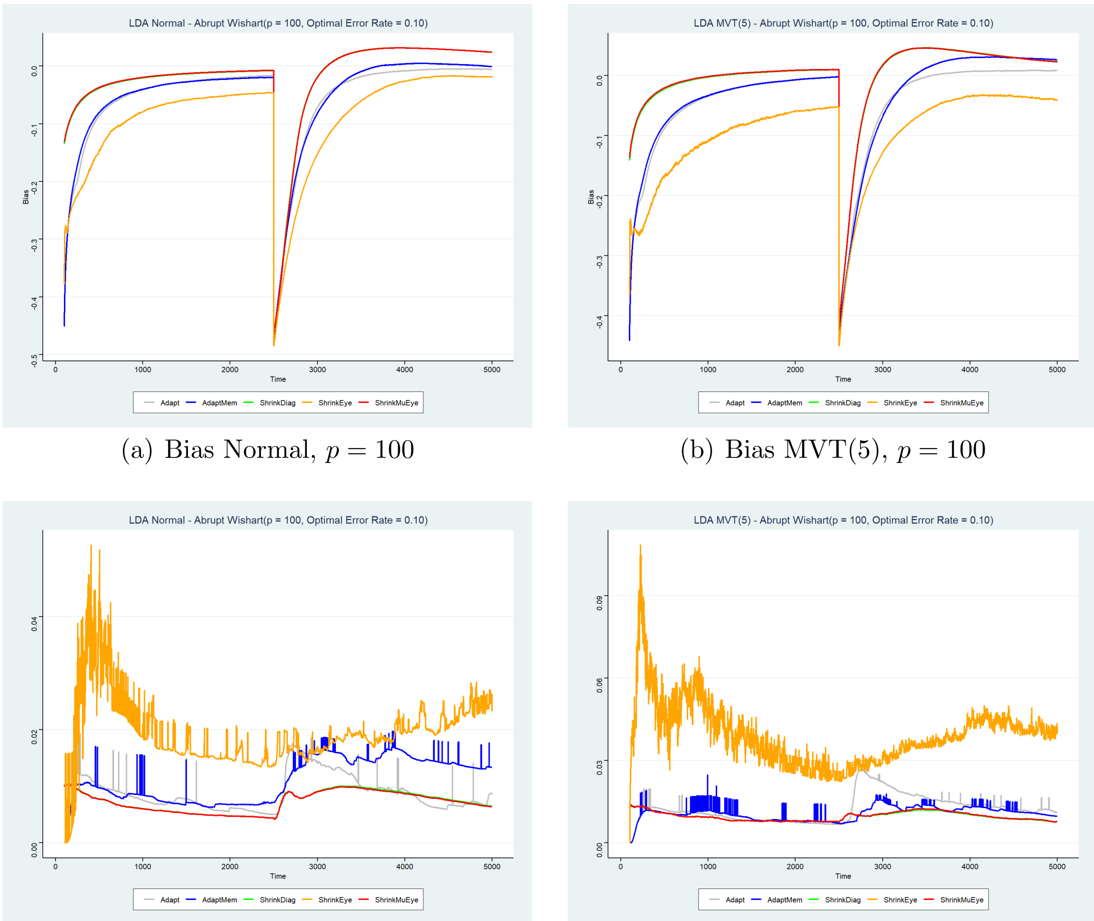


(d) Prequential posterior error Histogram

Figure 5.52: Simulated distributions for error rate estimators at time $t = 2501$.

Adaptive D Estimate

The *shrinkage average variance* and *shrinkage diagonal* D error estimates have an early advantage, however, after the shift, the bias of the estimators switches from negative to positive and the change is so pronounced that the *adaptive* and *adaptivemem* estimators eventually outperform the shrinkage estimators. This is consistent for normality and MVT(5) scenarios. The standard deviations are also much smaller for the *shrinkage average variance* and *shrinkage diagonal* estimators.



(a) Bias Normal, $p = 100$

(b) Bias MVT(5), $p = 100$

(c) Standard deviation Normal, $p = 100$

(d) Standard deviation MVT(5), $p = 100$

Figure 5.53: Comparision between Normal and MVT(5) stationary Wishart LDA models.

Similar to the stationary case, the estimators based on the posterior probabilities have rather large standard deviations relative to the other estimators.

Optimal error rate change from 5% to 25%

Another example of interest is when the separation and subsequent optimal error rate between the two populations undergoes a dramatic change. Consider the case where the optimal error rate changes from 5% to 25%. The plot of the conditional error rate over time across the different estimators is given below. The models perform similarly well with the *adaptive estimator* performing the best after the shift.

Figure 5.54: CER

The trajectory of the bias is given below. The *adaptive resubstitution* and *adaptive prequential* estimators perform very well prior to the drift but then have the quickest rebounds after the shift.

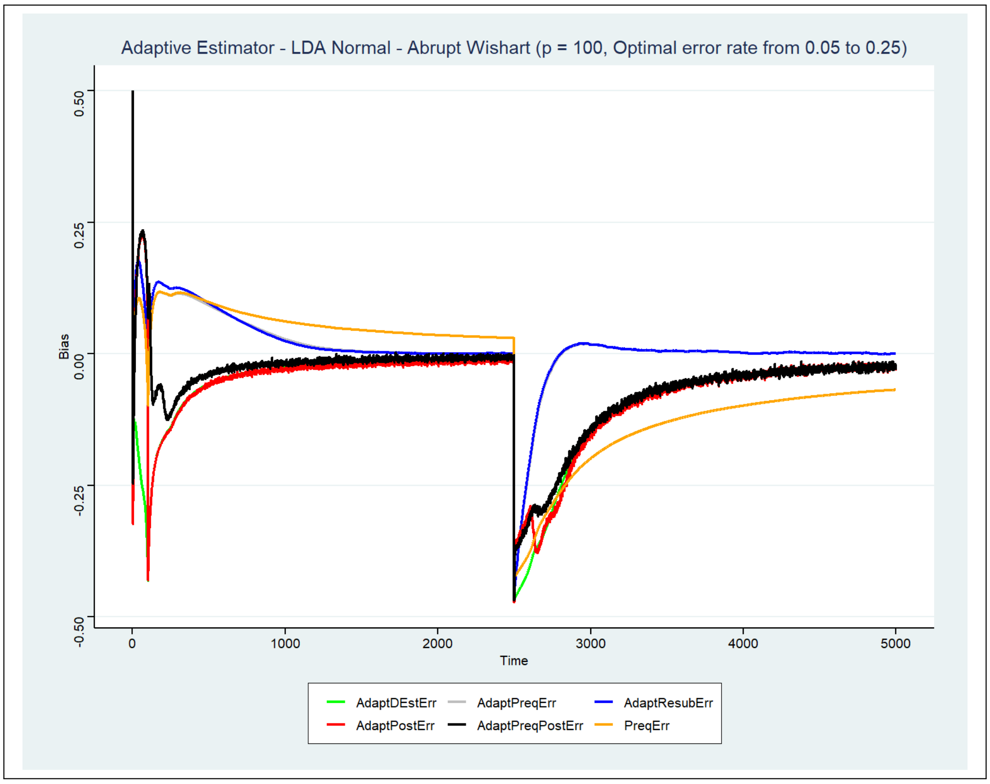
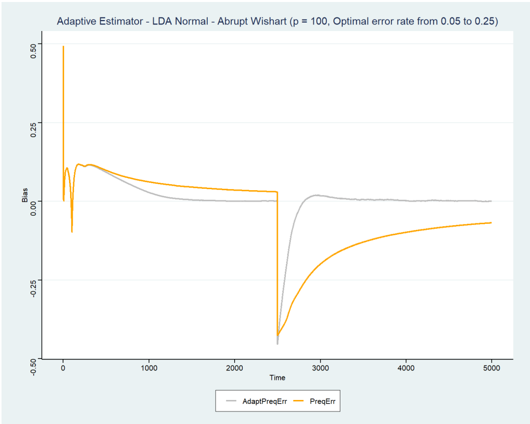
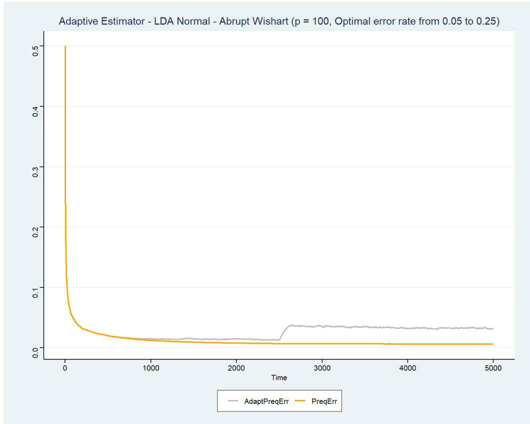


Figure 5.55: CER

The *adaptive prequential* estimate of the conditional error rate provides a more accurate estimate than the static prequential estimate for most of the observed time points. Additionally, the standard deviation of the estimate of the adaptive estimator is comparable to the static. This trend is fairly stable across many of the simulation scenarios investigated.



(a) Bias of error rate estimators



(b) Standard deviation of error rate estimators

Figure 5.56: Simulated bias and standard deviation of prequential estimators under abrupt drift

Tables for error rate estimators under abrupt drift can be found in appendix I.

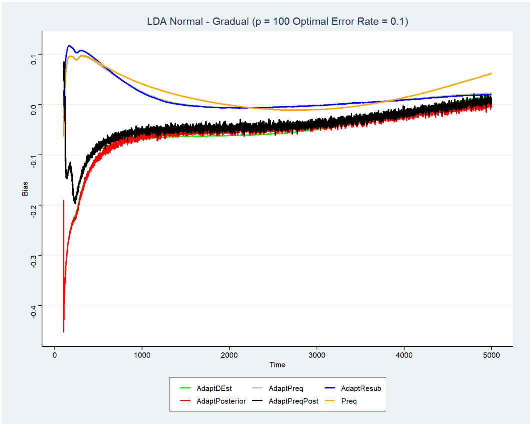
5.4.2.1 Summary

- Adaptive prequential estimate of CER is preferable to the standard prequential estimate (smaller bias and comparable standard deviation)
- If multivariate normality assumptions are satisfied the adaptive D estimate performs very well and is a good estimate of CER.
- The *adaptive* and *adaptivemem* D error estimates outperform the shrinkage D error estimates.
- The distributions of the adaptive D, prequential, and resubstitution error rate estimators are approximately normal for large n.
- The *adaptive resubstitution* error estimate performs the best immediately after the drift. It adapts the quickest to the shift.

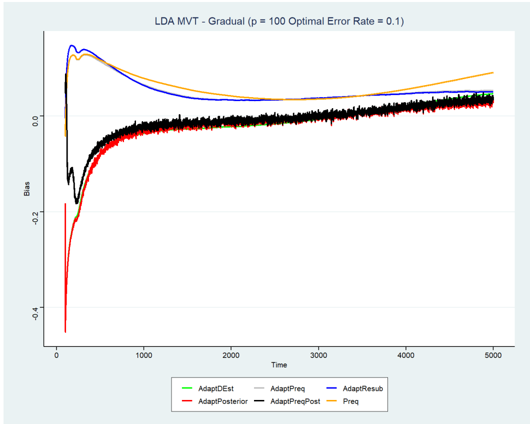
5.4.3 LDA Gradual

For non-stationary data regimes under gradual drift, data was simulated according to the method of *piecewise convex covariance movement* utilized in Anagnostopoulos et al. (2012). More specifically, a common covariance matrix was randomly selected either from a Wishart distribution with $5p$ degrees and scale matrix equal to the identity matrix or was a randomly selected block matrix such that each block was a randomly selected 10×10 matrix from a Wishart distribution with 50 degrees of freedom and a scale matrix, I_{10}. The two mean vectors were then randomly selected such that an optimal error rate was satisfied. This first of parameters were the the *start* parameters. This process was repeated to generate the *end* parameters.

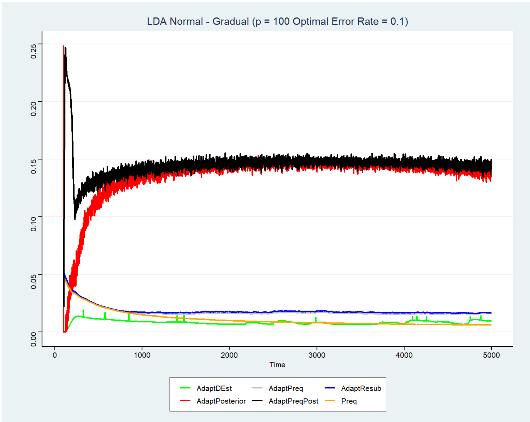
As in the stationary and abrupt cases, the conditional error rate profiles are fairly similar across all estimators. The subsequent error rate estimators should then behave similarly across the different models. For simplicity of exposition, therefore, consider the adaptive LDA model and its associated error rate estimators. In the case of normality, the resubstitution, prequential, and adaptive prequential bias trajectories are closer to zero across the entire sequence than the posterior based estimates. This however changes under MVT(5) data. Similar to the stationary and abrupt cases, the posterior based estimates have large standard deviation trajectories relative to the other estimators.



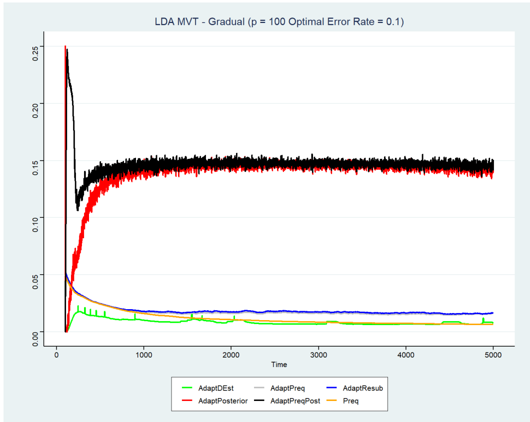
(a) Bias Normal, $p = 100$



(b) Bias MVT(5), $p = 100$



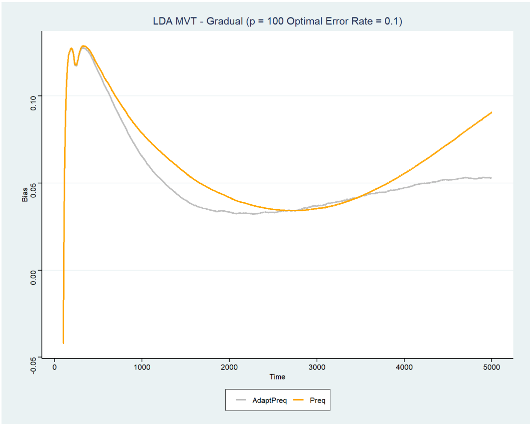
(c) Standard deviation Normal, $p = 100$



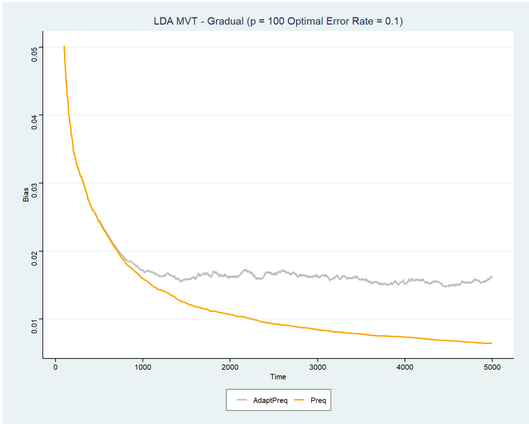
(d) Standard deviation MVT(5), $p = 100$

Figure 5.57: Simulated bias and standard deviation of error rate estimators under gradual drift

The adaptive prequential estimator has slightly smaller simulated bias across the sequence than the standard prequential estimator. It begins to separate itself more towards the end of the sequence. The advantage in bias is bought at the expense of a larger standard deviation. See trajectories below.



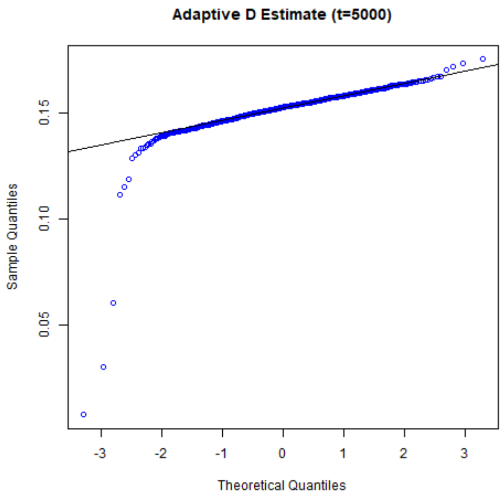
(a) Bias Normal, $p = 100$



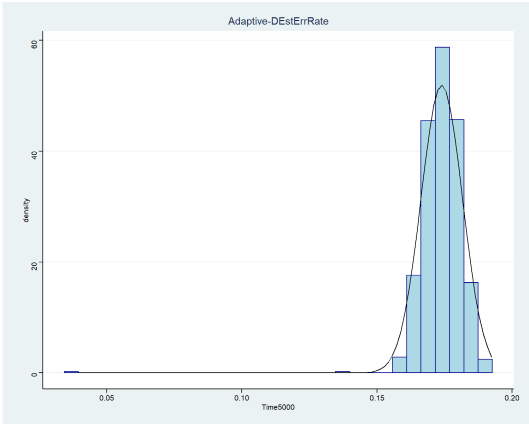
(b) Standard deviation Normal, $p = 100$

Figure 5.58: Simulated bias and standard deviation of prequential estimators under gradual drift

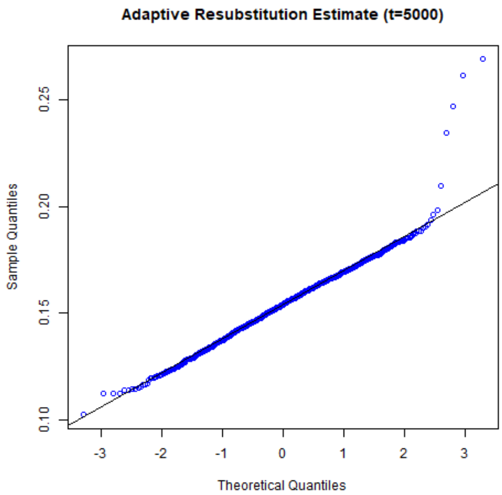
The distributions for the adaptive D estimate, resubstitution estimate, and adaptive prequential estimate appear approximately normal, however, there are some notable extreme outlying values present in all of the simulated distributions. See qq-plots and histograms below for simulated error rate distributions at time point t= 5000. In contrast, the posterior based estimates are highly positively skewed. This same pattern exists (not displayed) for large n as well which is also consistent with the stationary and abrupt cases.



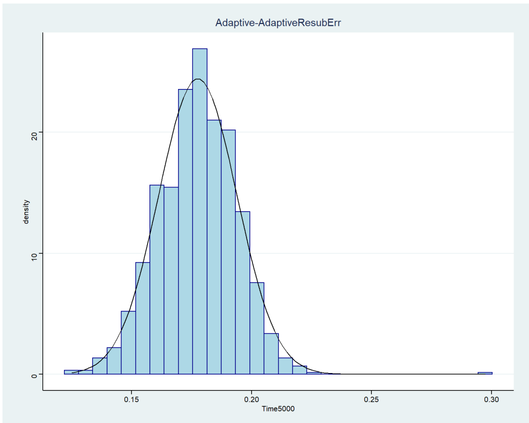
(a) D estimate QQ plot



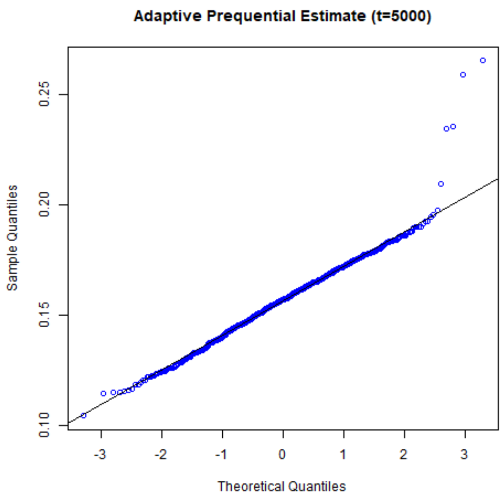
(b) D estimate histogram



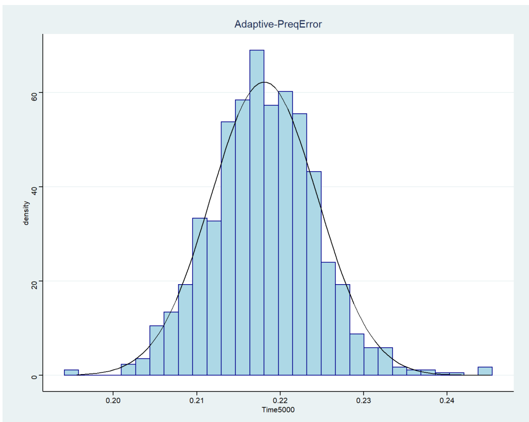
(c) Resubstitution QQ plot



(d) Resubstitution histogram

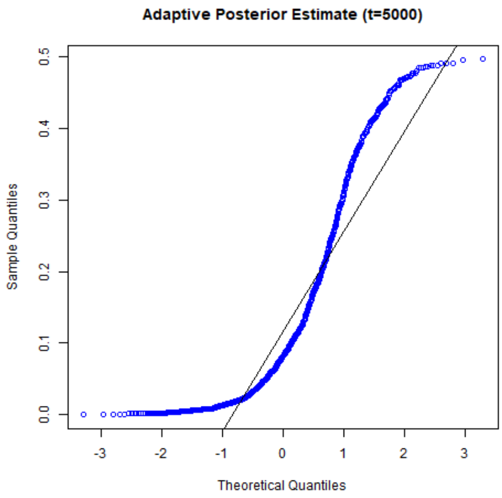


(e) Prequential QQ plot

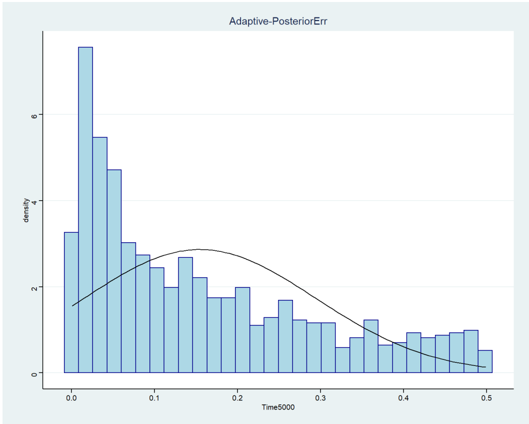


(f) Prequential histogram

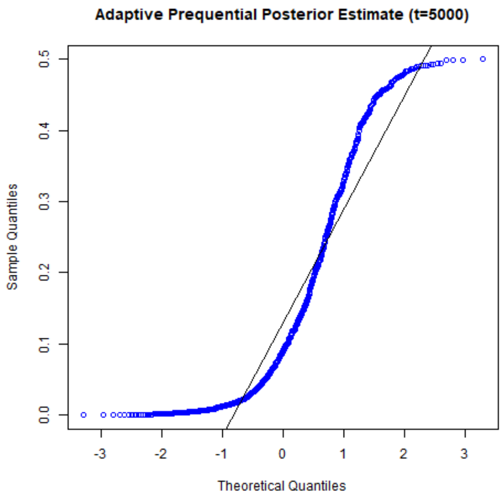
Figure 5.59: Simulated distributions for error rate estimators at time $t = 5000$



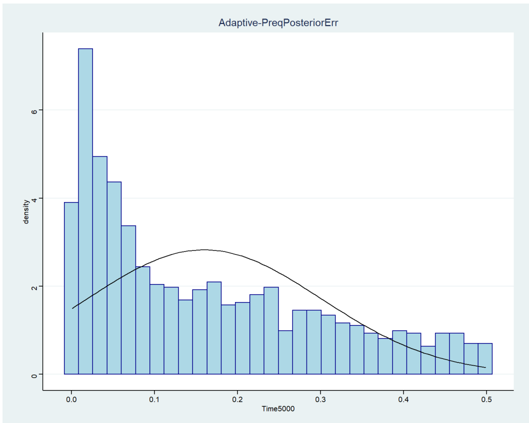
(a) Posterior error estimate QQ plot



(b) Posterior error estimate histogram



(c) Prequential posterior error QQ plot

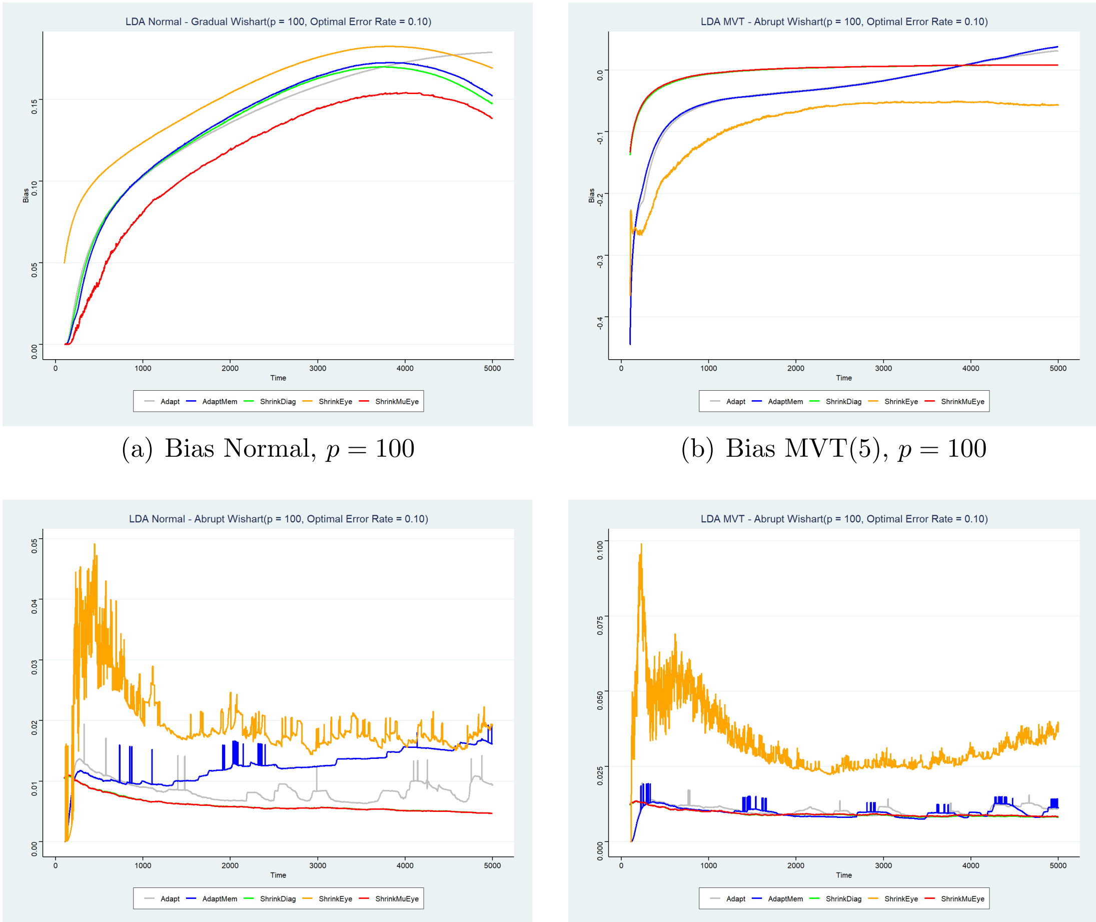


(d) Prequential posterior error histogram

Figure 5.60: Simulated distributions for error rate estimates at time $t = 5000$

Adaptive D Estimate

Under the gradual drift scenario, the adaptive D estimate did not perform as well as in the stationary and abrupt cases. The bias tended to be high across all estimator types. The *shrinkage average variance* estimator has the lowest bias,and it also has the smallest standard deviation.



(a) Bias Normal, $p = 100$

(b) Bias MVT(5), $p = 100$

(c) Standard deviation Normal, $p = 100$

(d) Standard deviation MVT(5), $p = 100$

Figure 5.61: Bias and standard deviation comparisons of D error estimates under both normality and MVT(5)

Tables for error rate estimators under gradual drift can be found in appendix J.

5.4.3.1 Summary

1. Adaptive prequential estimate of CER is preferable to the standard prequential estimate (smaller bias and comparable standard deviation)

2. The adaptive D estimate performs very poorly under gradual drift and may not be good estimate of CER.

3. The distributions of the adaptive D, prequential, and resubstitution error rate estimators are approximately normal for large n, and the posterior based

distribution are positively skewed.

5.5 Missing class labels

In the context of streaming data, missing class labels is a common situation as for many streaming applications the label will be delayed or absent (Millan-Giraldo, Sanchez, and Traver, 2011). For example, in credit scoring applications, rejected applicants will have no class label and in sensor networks, sensors may fail randomly (Hossain, Ahad, and Inoue, 2020), and thus not provide a class label. The following is a brief description of the method investigated.

Description of method for updating parameter estimates in the presence of missing class labels

i) Use posterior predicted probabilities from the model estimated at the previous time point to predict the current observation.

ii) Update all parameter estimates across all groups using posterior probabilities as weights. Contrast this to when the label is known, where the weight for the current observation is set to $\frac{1}{n_i}$ where n_i is the "effective sample size" for the i^{th} group. Instead, in the case where the label is unknown, the weight is $\frac{p_i}{n_i}$ for the i^{th} group across all groups, where p_i is the posterior probability for the i^{th} group of the current observation.

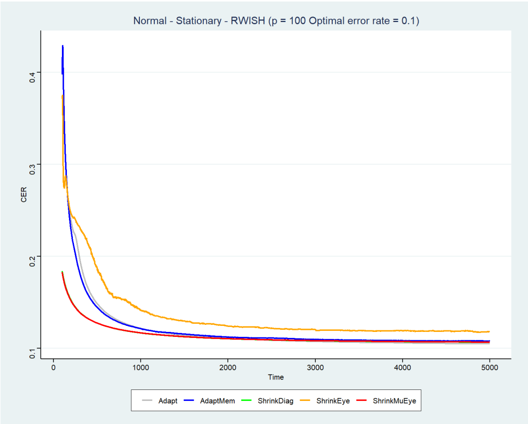
iii) Repeat (*i*) and (*ii*) until the estimated posterior probabilities converge

This method was investigated in both linear and quadratic discriminant analysis settings for three levels of random missingness in the class labels, specifically, 5%, 10%, and 25%.

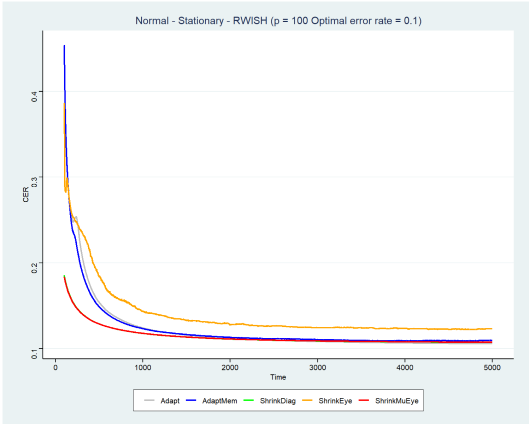
5.5.1 LDA

For the case of linear discriminant analysis, both the semi-supervised algorithm (as described above) and the standard streaming algorithms (observations with missing data were ignored) were evaluated. In the case of stationary multivariate normal data, the methods yielded very similar conditional error rate trajectories. See plots below.

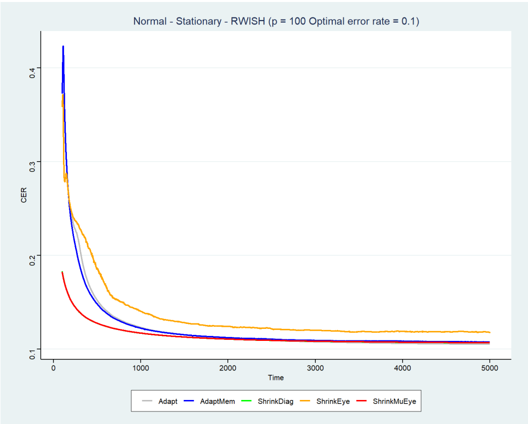
5.5.1.1 Stationary



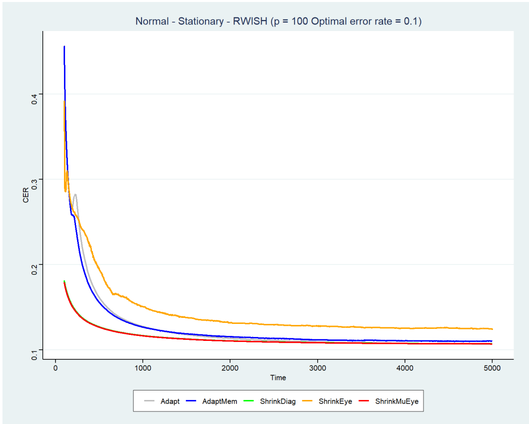
(a) Normal 5%, $p = 100$



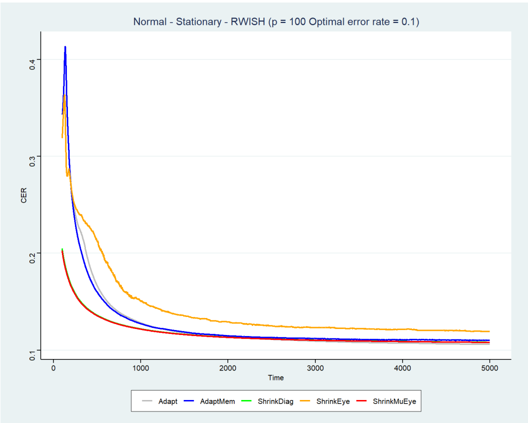
(b) Normal 5% - semisupervised, $p = 100$



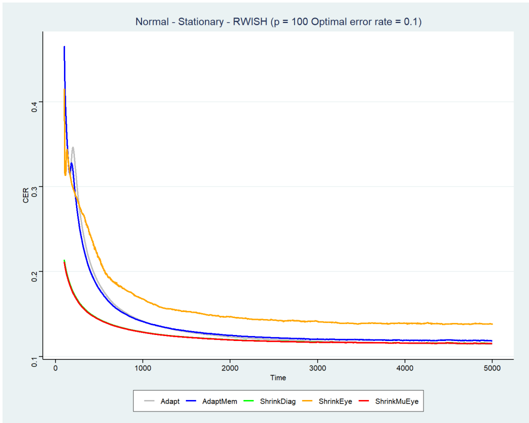
(c) Normal 10%, $p = 100$



(d) Normal 10% - semisupervised, $p = 100$



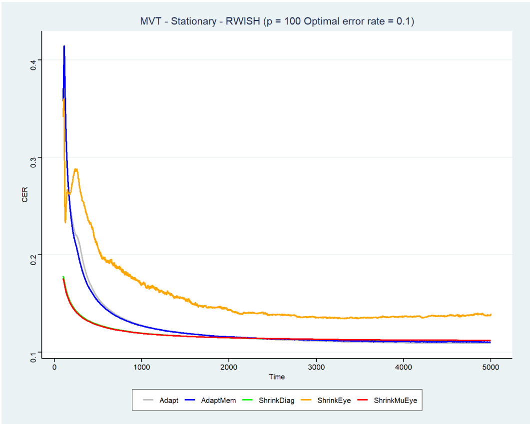
(e) Normal 25%, $p = 100$



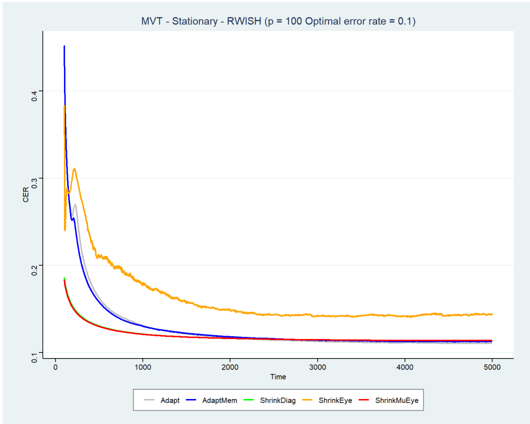
(f) Normal 25% - semisupervised, $p = 100$

Figure 5.62: CER missing data simulations under stationarity and normality

Results were consistent for other dimensions as well along with non-normal data. See results for MVT(5) data.



(a) MVT 10%, $p = 100$

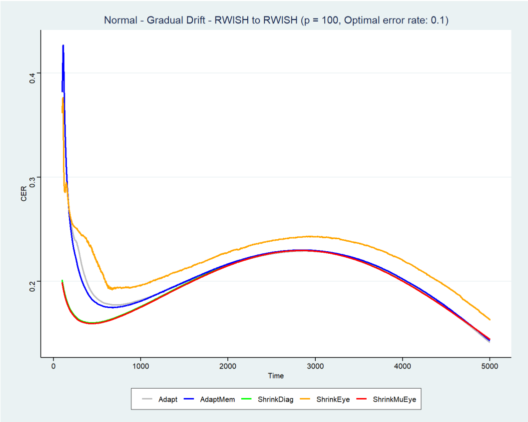


(b) MVT 10% - semisupervised, $p = 100$

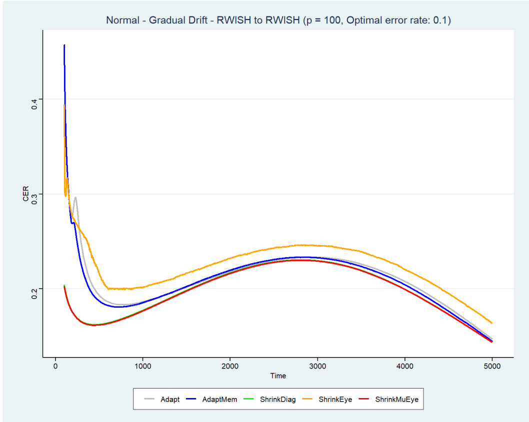
Figure 5.63: CER missing data simulations under non-normality and stationarity

5.5.1.2 Gradual

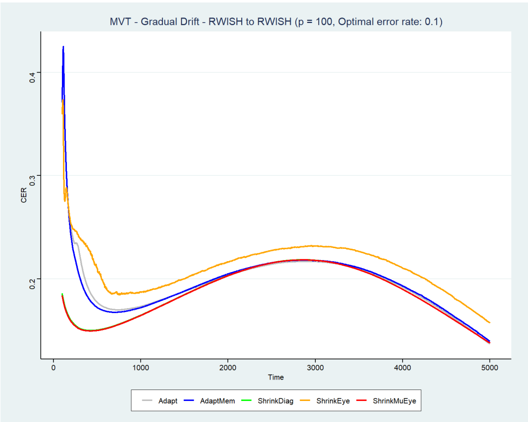
Results in the gradual drift setting were consistent for both semi-supervised and the standard algorithms, with a slight edge given to the standard algorithms.



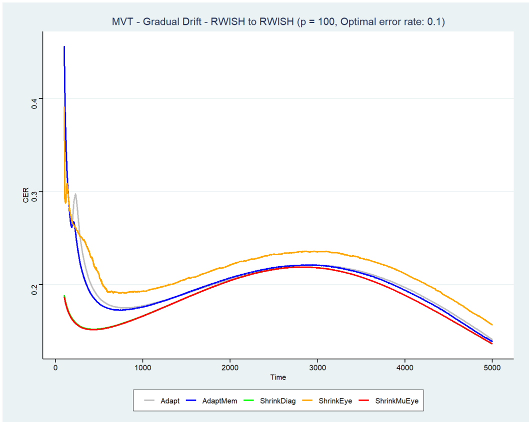
(a) Normal 10%, $p = 100$



(b) Normal 10% - semisupervised, $p = 100$



(c) MVT 10%, $p = 100$

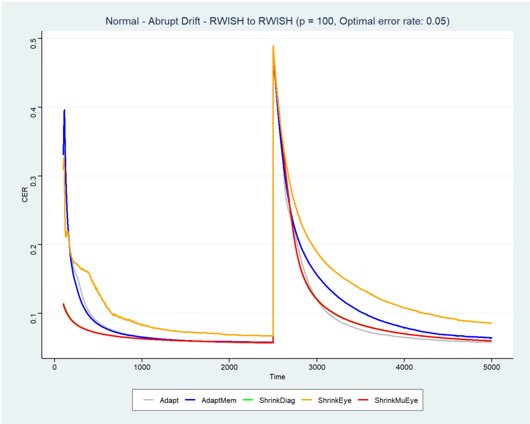


(d) MVT 10% - semisupervised, $p = 100$

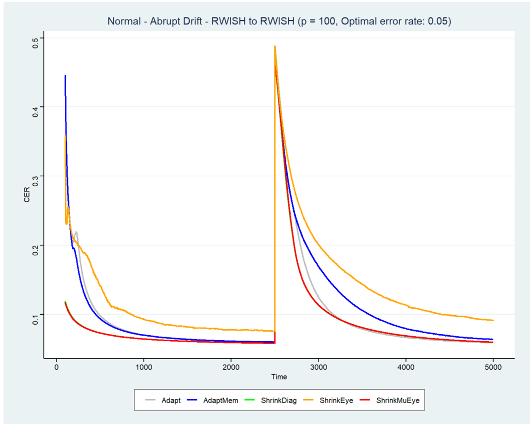
Figure 5.64: CER missing data simulations

5.5.1.3 Abrupt

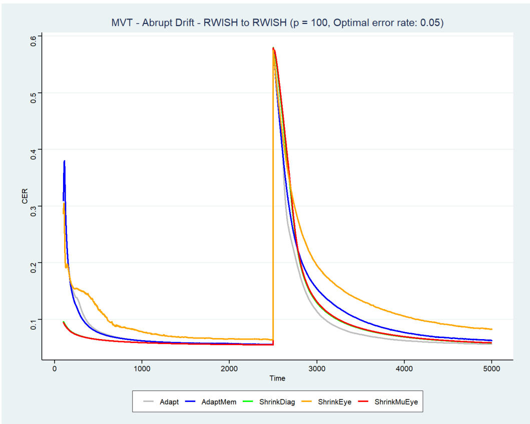
Results in the abrupt drift setting were consistent for both semi-supervised and the standard algorithms, with a slight edge given to the standard algorithms.



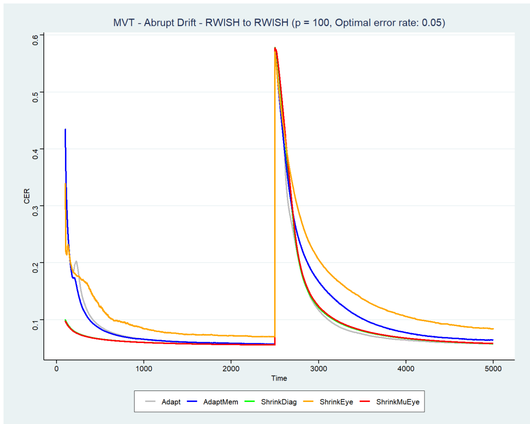
(a) Normal 10%, $p = 100$



(b) Normal 10% - semisupervised, $p = 100$



(c) MVT 10%, $p = 100$

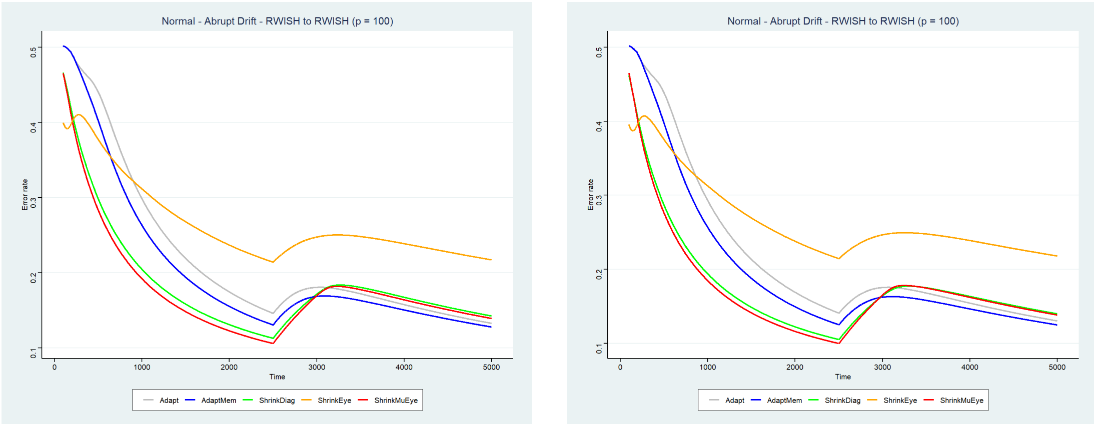


(d) MVT 10% - semisupervised, $p = 100$

Figure 5.65: CER missing data simulations

5.5.2 QDA

The results for missing data in the quadratic discriminant case was similar to that of linear discriminant analysis. The graphs comparing the multivariate normal data for 10% missing data for $p = 100$ is shown below.



(a) Normal 10%, $p = 100$

(b) Normal 10% - semisupervised, $p = 100$

Figure 5.66: CER missing data simulations

5.5.2.1 Summary of Missing Data Investigation

1. Results were consistent for both semisupervised and standard implementations of the adaptive streaming algorithms.

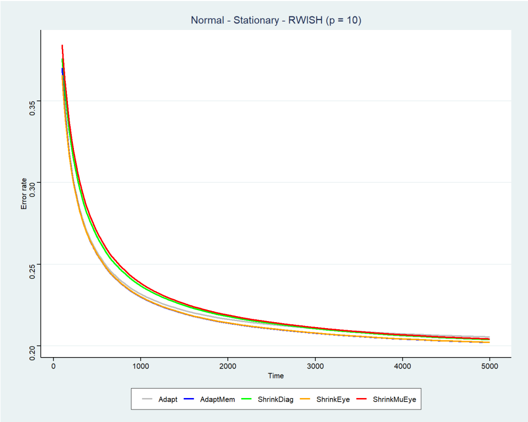
2. Future research should investigate other missing data scenarios, for example, missing not at random.

5.6 Quadratic Discriminant Analysis

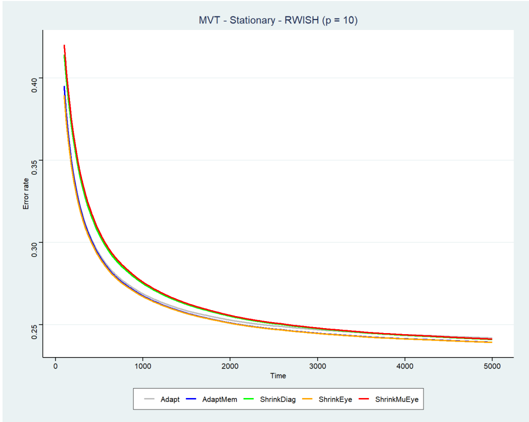
In the quadratic discriminant case, models were evaluated according to the average error rate across the simulations.

5.6.1 Stationary

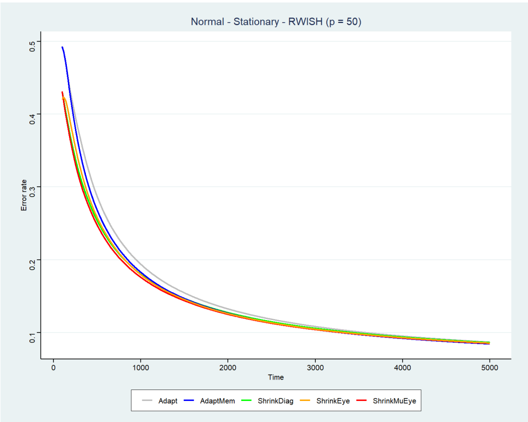
Most of the simulations in the stationary case focused on the Wishart scenario, that is, covariance matrices were randomly sampled from a Wishart distribution with $5p$ degrees of freedom and a scale matrix equal to the identity matrix. Elements of the mean vectors were uniform on the interval (0,1). Both multivariate normal and multivariate t(5) (Paolella (2019b)) distributions were investigated. In the multivariate normal case, the *shrinkage diagonal* and *average variance* have superior performance across all dimensions. Their advantages increase as the dimensions increase. The *shrinkage identity* estimator performs well in both the multivariate normal and multivariate t(5) settings up until $p = 50$. Its performance degenerates beginning at $p = 100$. In the multivariate t(5) setting, both the *shrinakge diagonal* and *average variance* estimators perform well up to $p = 100$, but then performance falls off for $p = 250$ and $p = 500$ where both the estimators display an initial decreasing trend, but soon falter and display either a static trend in the case of $p = 250$ or a slow upward trend in the case of $p = 500$.



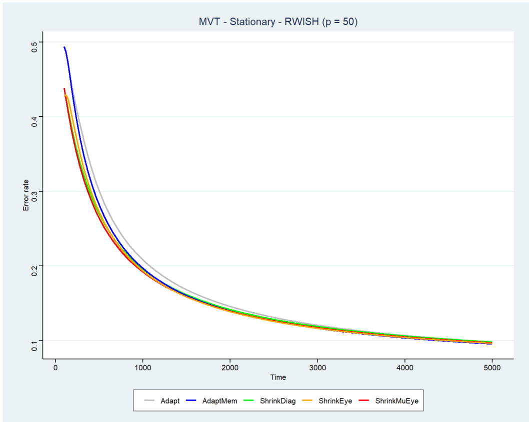
(a) Normal, (RWISH) $p = 10$



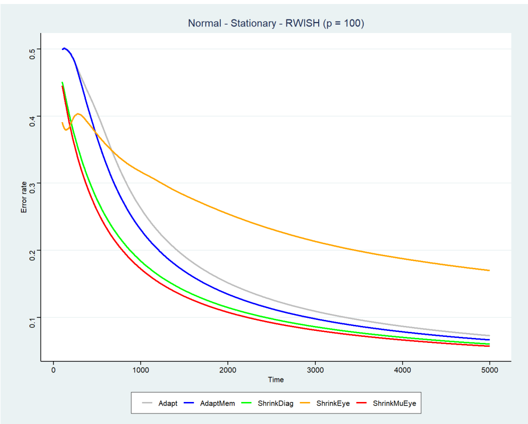
(b) MVT(5), (RWISH) $p = 10$



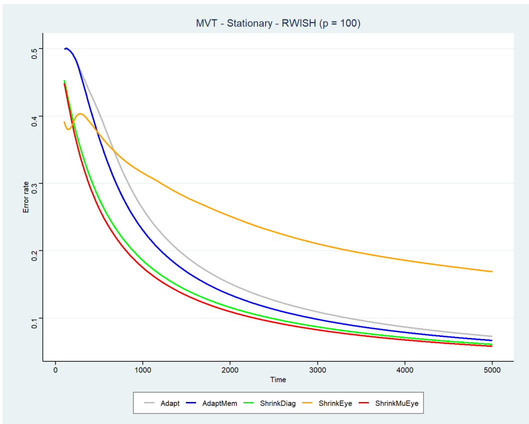
(c) Normal, (RWISH) $p = 50$



(d) MVT(5), (RWISH) $p = 50$

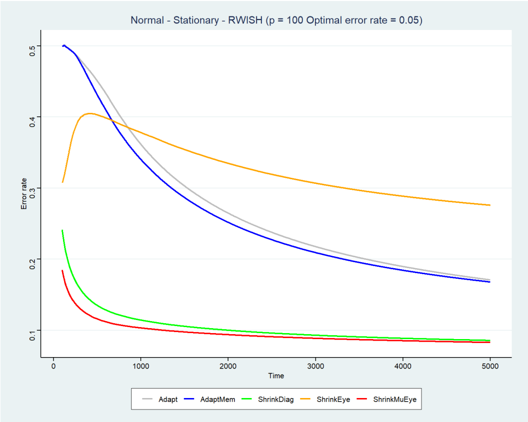


(e) Normal (RWISH), $p = 100$

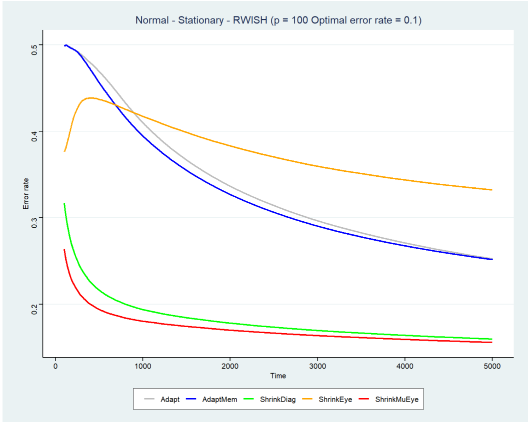


(f) MVT(5) (RWISH), $p = 100$

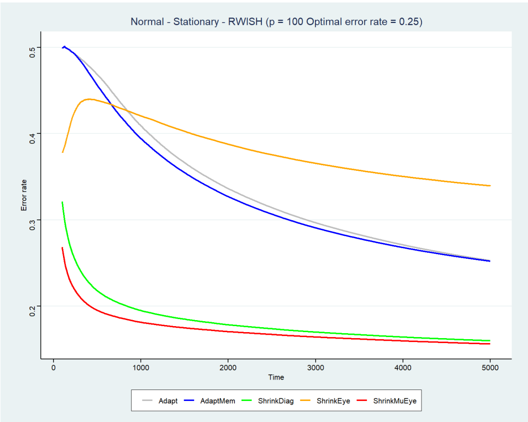
Figure 5.67: Comparision between Normal and MVT(5) for stationary (Wishart to Wishart) QDA models.



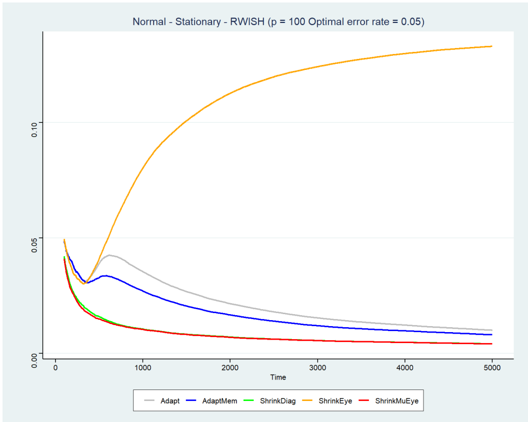
(a) 5% error rate



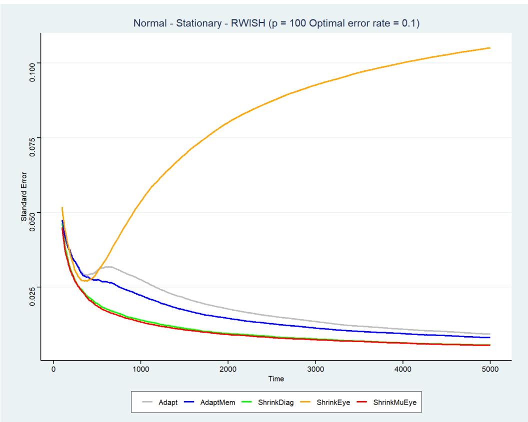
(b) Standard deviation 5% error rate



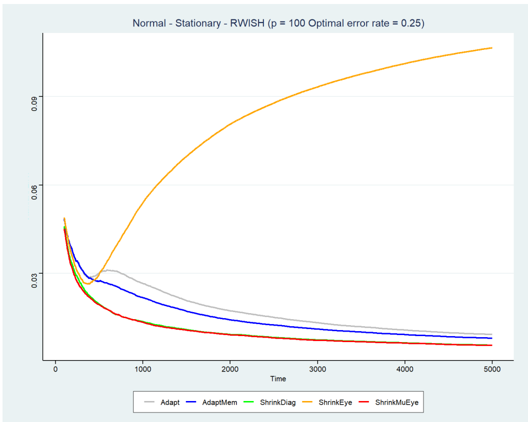
(c) 10 % error rate



(d) Standard deviation 10% error rate

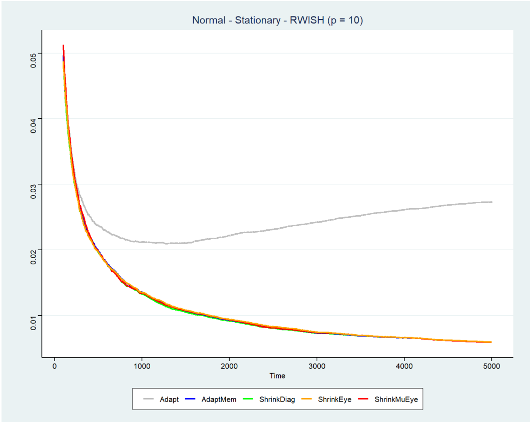


(e) 25 % error rate

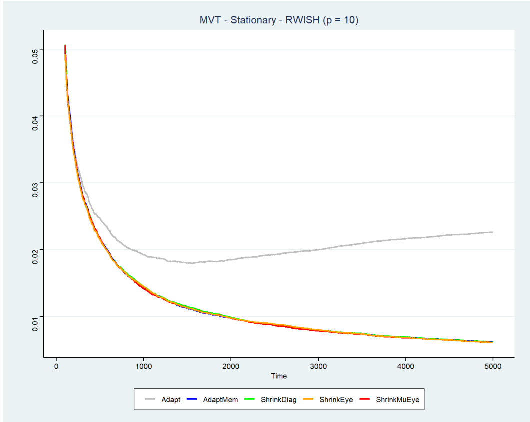


(f) Standard deviation 25 % error rate

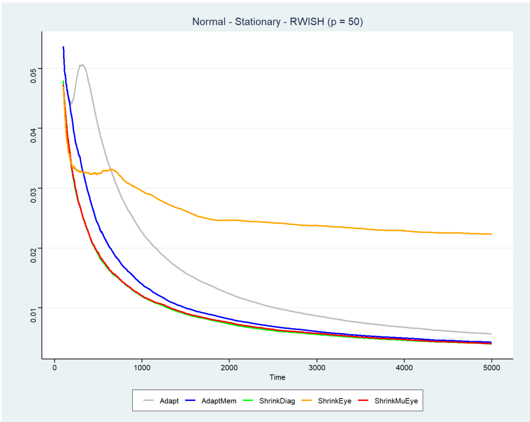
Figure 5.68: Comparison of QDA models under normality with $p = 100$ for various optimal error rates.



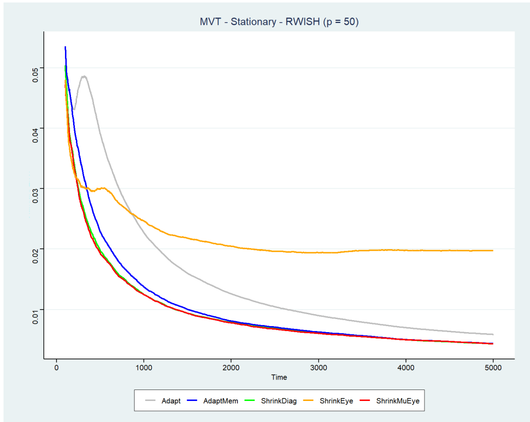
(a) Normal, (RWISH) $p = 10$



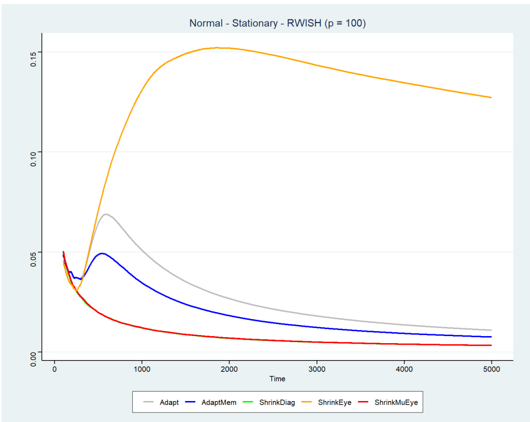
(b) MVT(5), (RWISH) $p = 10$



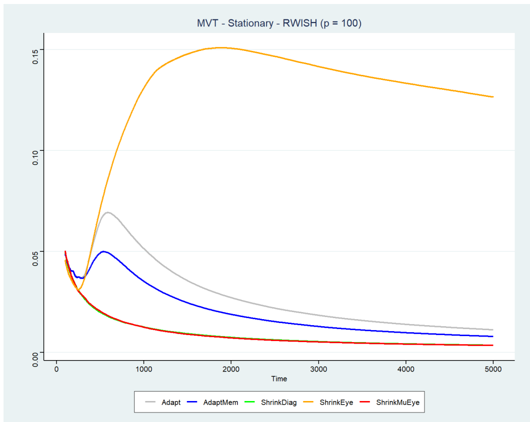
(c) Normal, (RWISH) $p = 50$



(d) MVT(5), (RWISH) $p = 50$

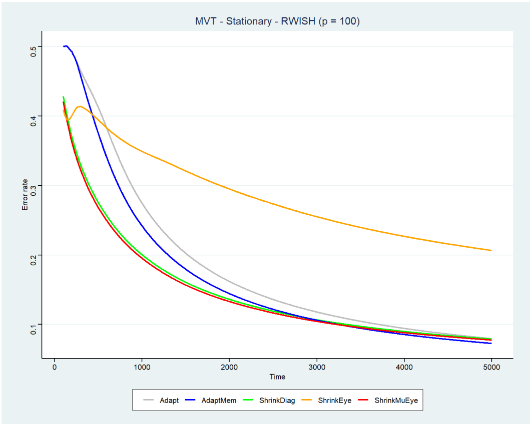


(e) Normal (RWISH), $p = 100$

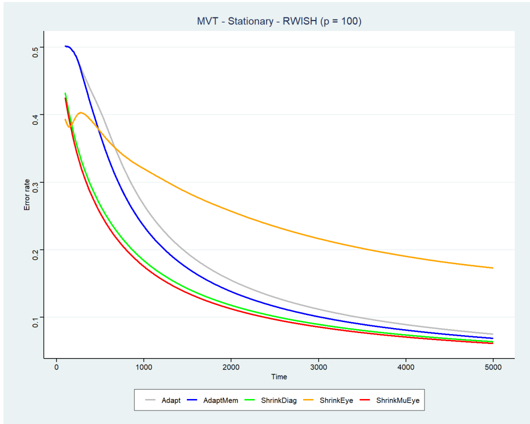


(f) MVT(5) (RWISH), $p = 100$

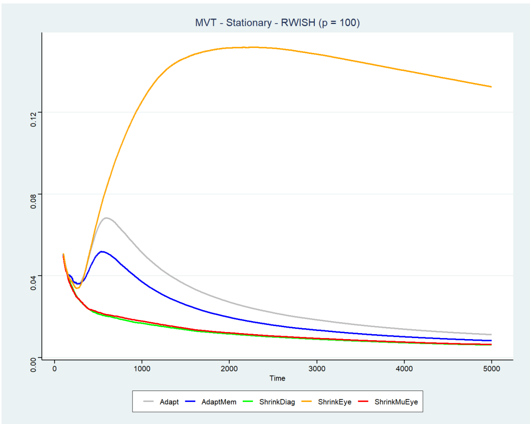
Figure 5.69: Standard deviation comparision between Normal and MVT(5) for stationary (Wishart to Wishart) QDA models.



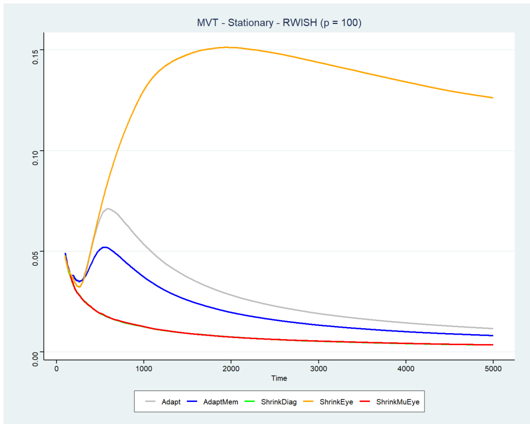
(a) MVT(10), $p = 100$



(b) MVT(25), $p = 100$

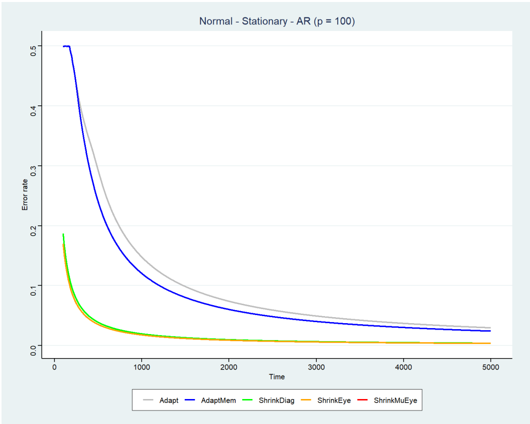


(c) Standard deviation MVT(10), $p = 100$

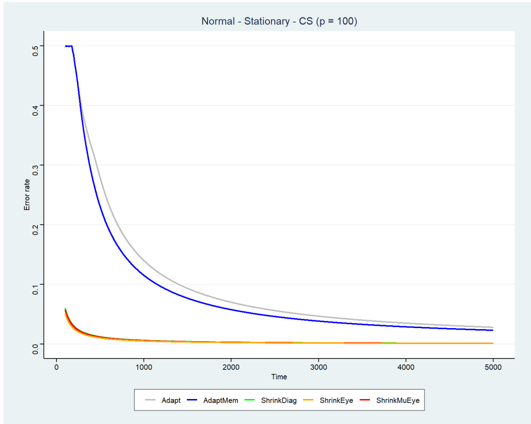


(d) Standard deviation MVT(25), $p = 100$

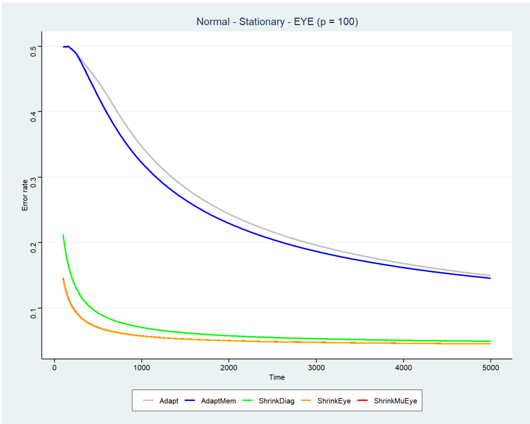
Figure 5.70: Comparision between Normal and MVT(5) for stationary (Wishart to Wishart) QDA models.



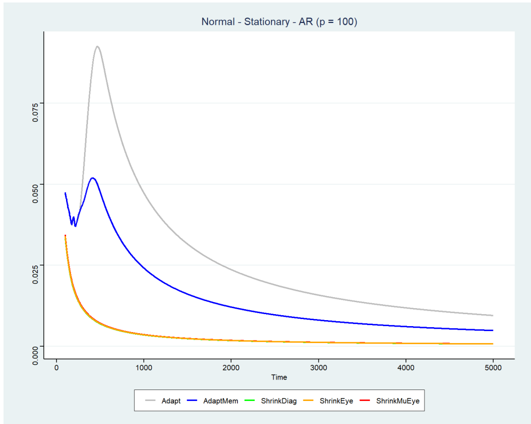
(a) AR $p = 100$



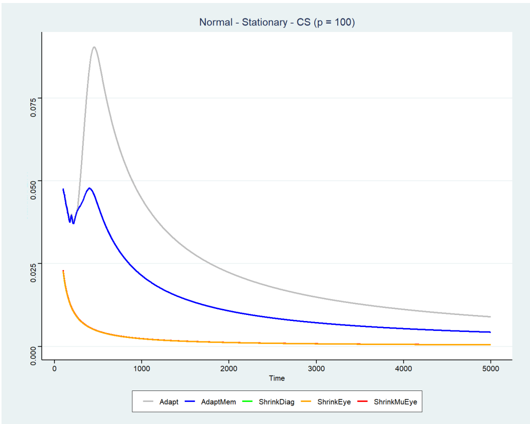
(b) Standard deviation AR $p = 100$



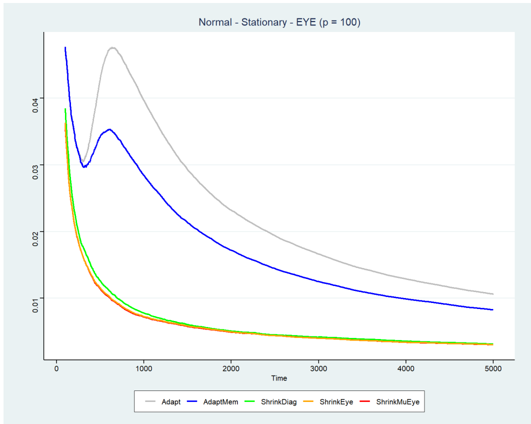
(c) CS $p = 100$



(d) Standard deviation CS $p = 100$

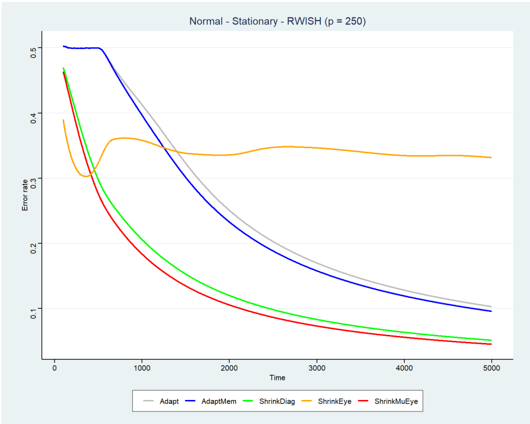


(e) EYE $p = 100$



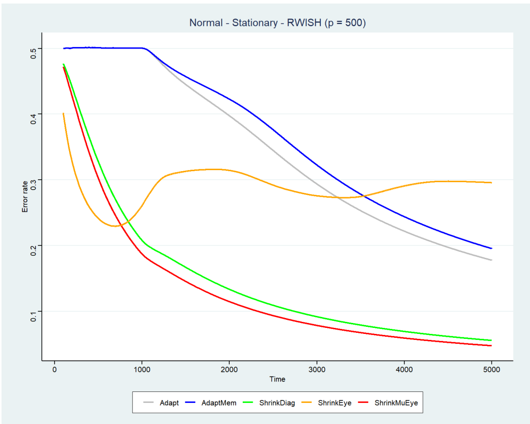
(f) Standard deviation EYE $p = 100$

Figure 5.71: Comparision of stationary QDA models for various covariance matrices.



(a) Normal, (RWISH) $p = 250$

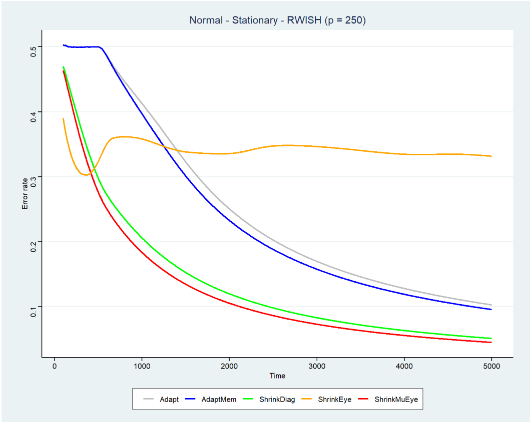
(b) MVT(5), (RWISH) $p = 250$



(c) Normal, (RWISH) $p = 500$

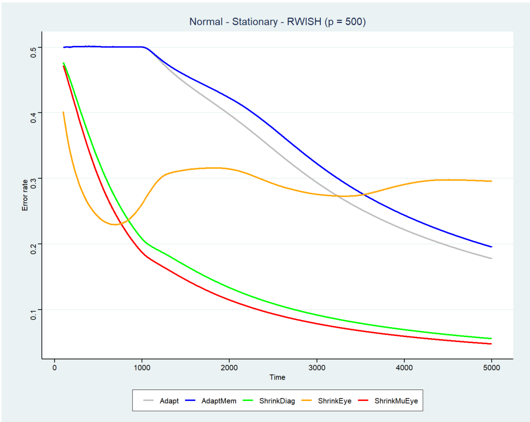
(d) MVT(5), (RWISH) $p = 500$

Figure 5.72: Conditional error rate comparision between Normal and MVT(5) for stationary (Wishart to Wishart) QDA models.

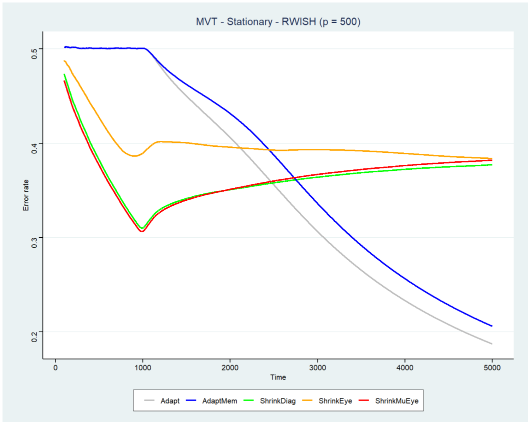


(a) Normal, (RWISH) $p = 250$

(b) MVT(5), (RWISH) $p = 250$



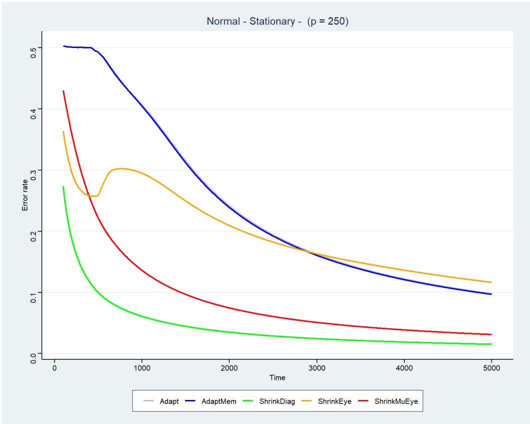
(c) Normal, (RWISH) $p = 500$



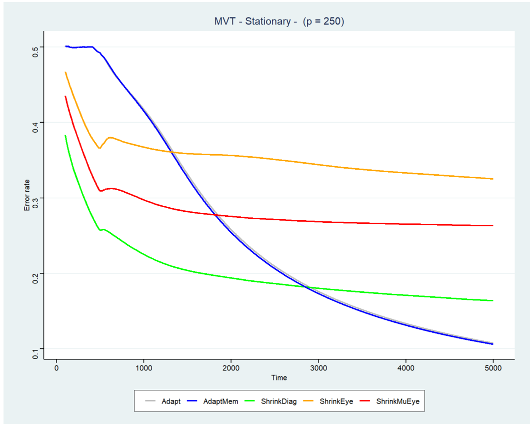
(d) MVT(5), (RWISH) $p = 500$

Figure 5.73: Error rate comparision between Normal and MVT(5) for stationary (Wishart to Wishart) QDA models.

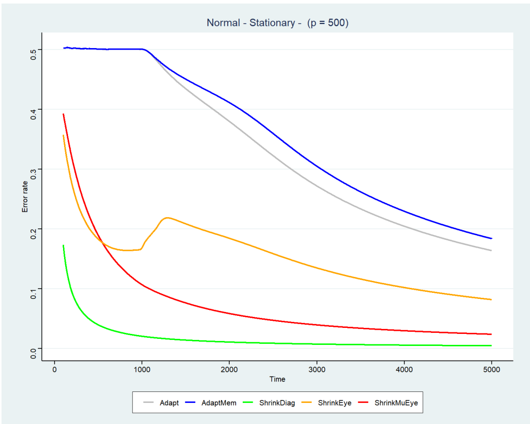
In the blocked Wishart case, the performance of the estimators is similar to that of the Wishart case, however, due to the sparseness of the covariance matrices, the advantages of the shrinkage estimators are more pronounced. The *shrinkage diagonal* matrix is the clear winner in this case. On the other hand in the multivariate t(5) scenario, the adaptive estimators perform better although they do not overtake the *shrinkage diagonal* estimator until much later in the sequence.



(a) Normal, (BWISH) $p = 250$



(b) MVT(5), (BWISH) $p = 250$



(c) Normal, (BWISH) $p = 500$

(d) MVT(5), (BWISH) $p = 500$

Figure 5.74: Error rate comparision between Normal and MVT(5) for stationary (Wishart to Wishart) QDA models.

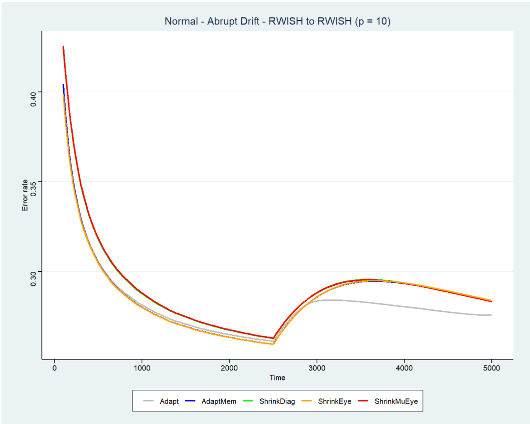
QDA Stationary Trajectories Comprehensive simulation results including trajectories for both multivariate normal and multivariate t(5) data for the QDA stationary scenarios are reported in appendix N.

QDA Stationary Summary

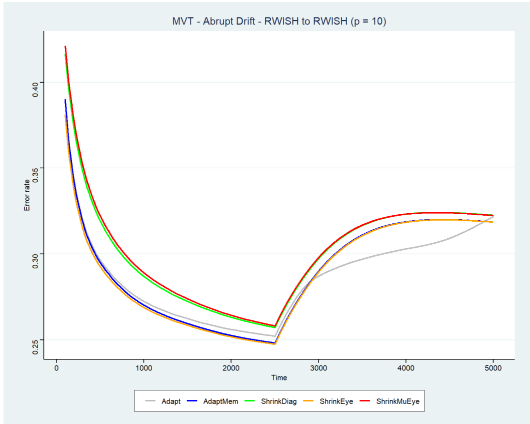
In the multivariate normal case, the *shrinkage diagonal* estimator is the clear favorite, followed closely by the *average variance* estimator. In the multivariate t(5) case, the adaptive estimators should be used. The *shrinkage identity* estimator cannot be recommended for use in the scenarios investigated.

5.6.2 Abrupt Drift

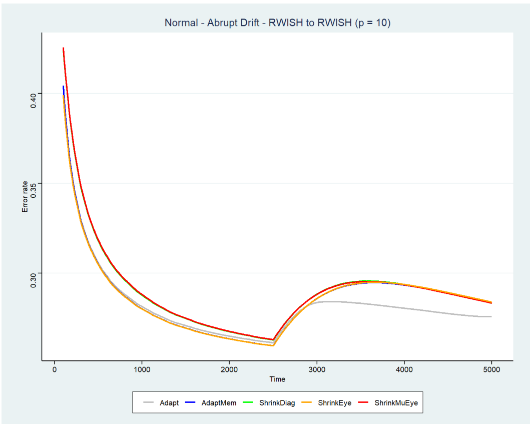
In the case of an abrupt drift, a single disturbance or shift was introduced into the sequence of observations. All simulations consisted of 5000 time points where the first 2500 observations were generated according to a specific distribution while the last 2500 observations were generated according to a different distribution. Most of the simulations focused on the Wishart to Wishart abrupt case. Similar to the stationary case, the *shrinkage diagonal* and *average variance* displayed superior performance in the multivariate normal case. In the multivariate t(5) scenario, the *adaptive* estimators eventually overtake the shrinkage estimators.



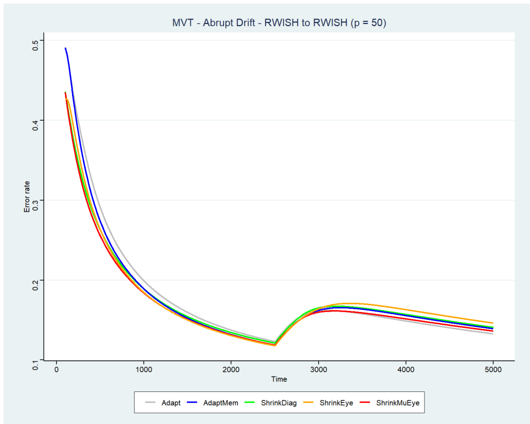
(a) Normal, (RWISH) $p = 10$



(b) MVT(5), (RWISH) $p = 10$

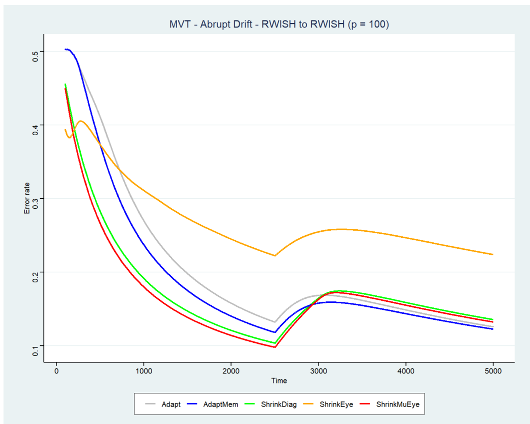


(c) Normal, (RWISH) $p = 50$



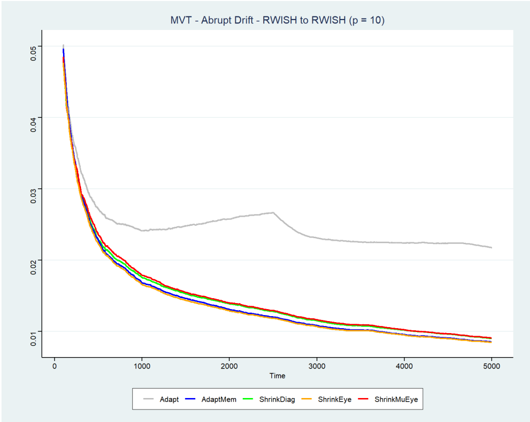
(d) MVT(5), (RWISH) $p = 50$

(e) Normal (RWISH), $p = 100$

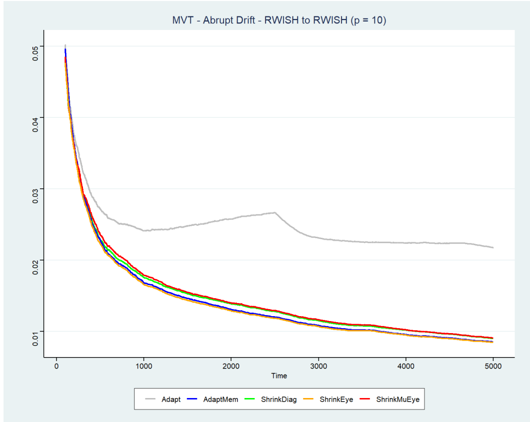


(f) MVT(5) (RWISH), $p = 100$

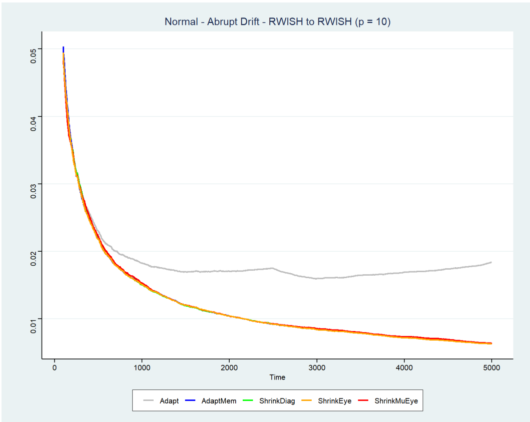
Figure 5.75: Comparision between Normal and MVT(5) for Abrupt Drift (Wishart to Wishart) QDA models.



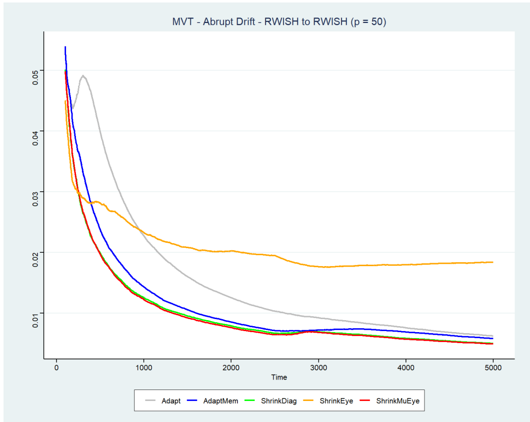
(a) Normal, (RWISH) $p = 10$



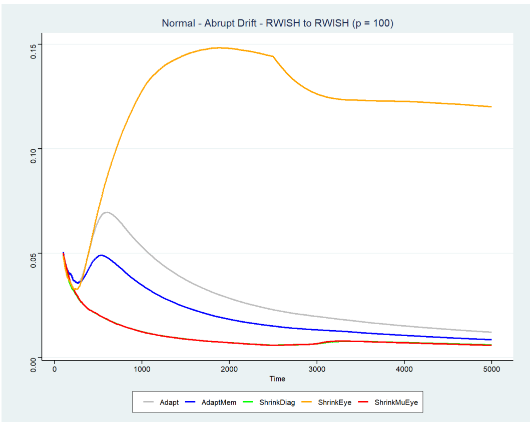
(b) MVT(5), (RWISH) $p = 10$



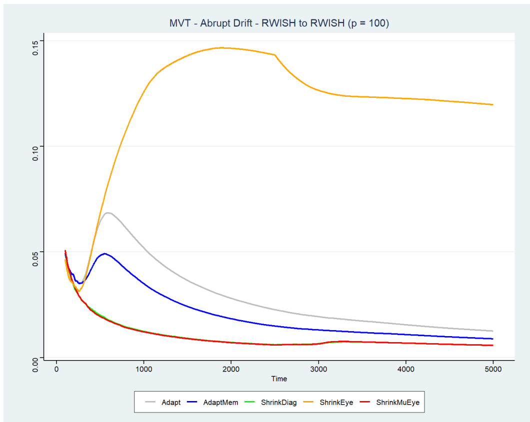
(c) Normal, (RWISH) $p = 50$



(d) MVT(5), (RWISH) $p = 50$

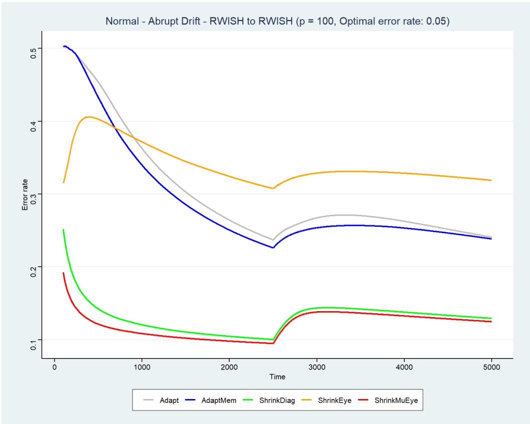


(e) Normal (RWISH), $p = 100$

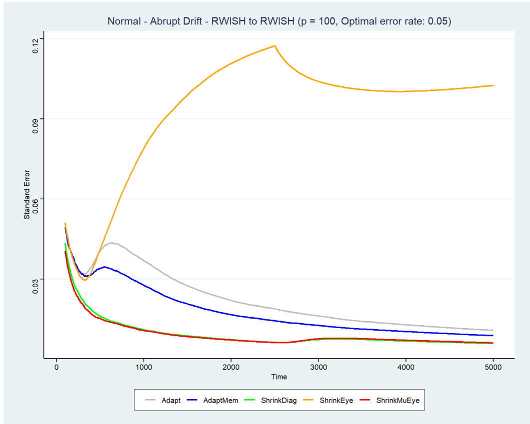


(f) MVT(5) (RWISH), $p = 100$

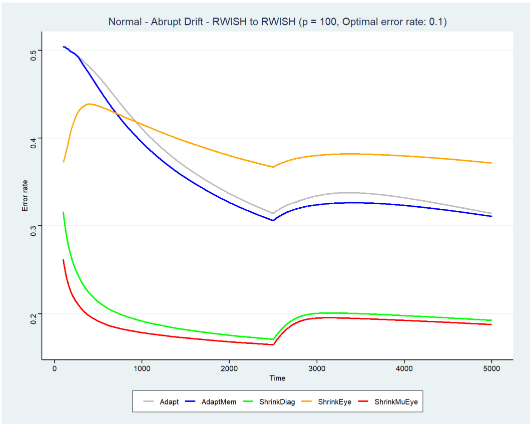
Figure 5.76: Standard deviation of CER comparision between Normal and MVT(5) for Abrupt Drift (Wishart to Wishart) QDA models.



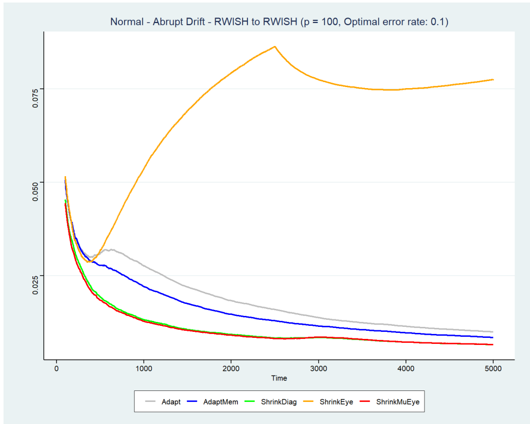
(a) 5 % error rate



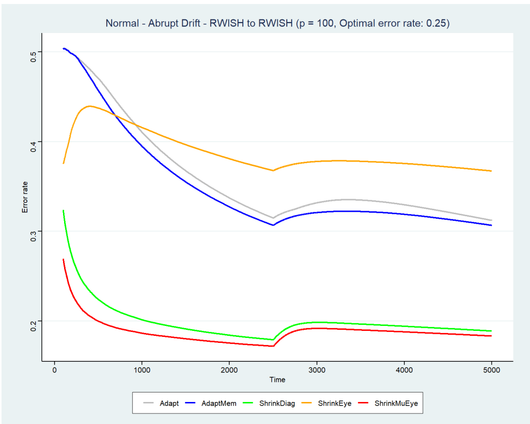
(b) Standard deviation 5% error rate



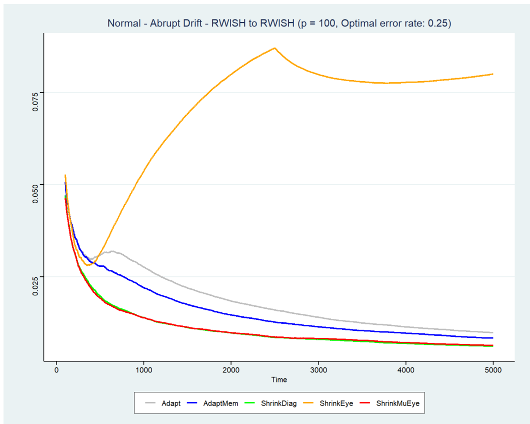
(c) 10 % error rate



(d) Standard deviation 10 % error rate

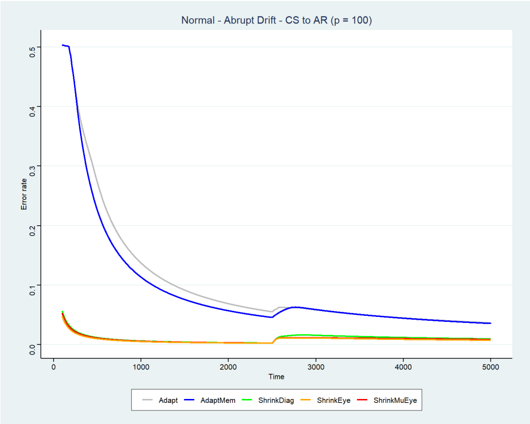


(e) 25 % error rate

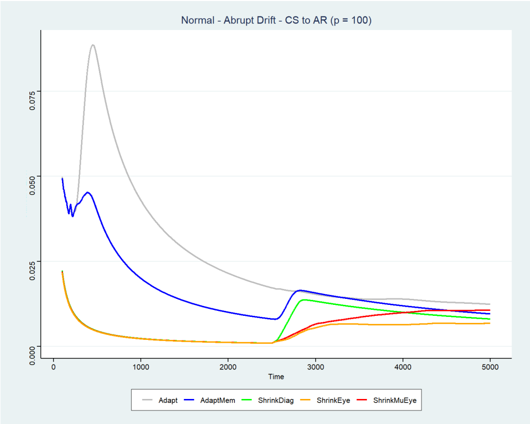


(f) Standard deviation 25 % error rate

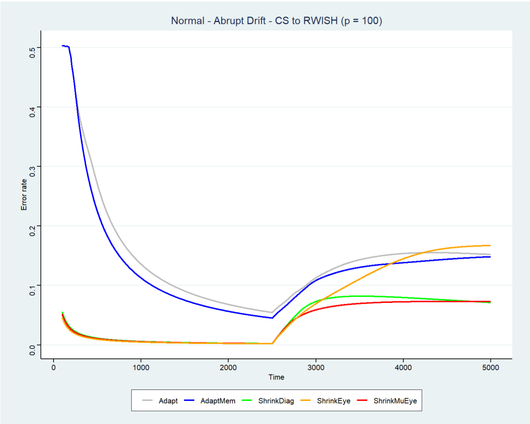
Figure 5.77: Comparison of abrupt drift QDA models under normality for $p = 100$ for various optimal error rates.



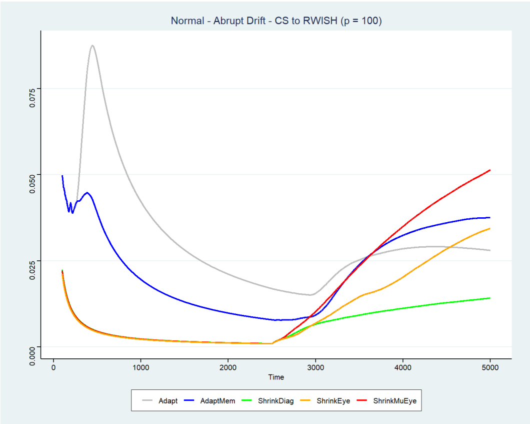
(a) CS,AR



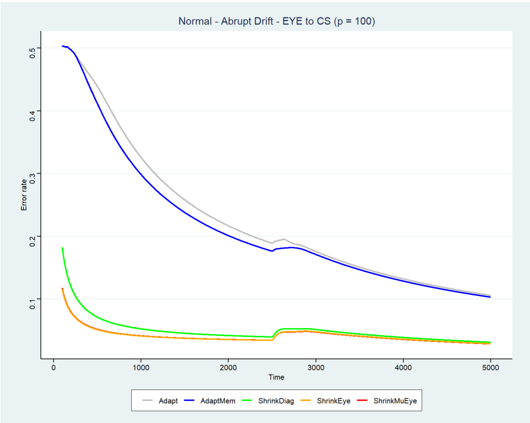
(b) Standard deviation CS, AR



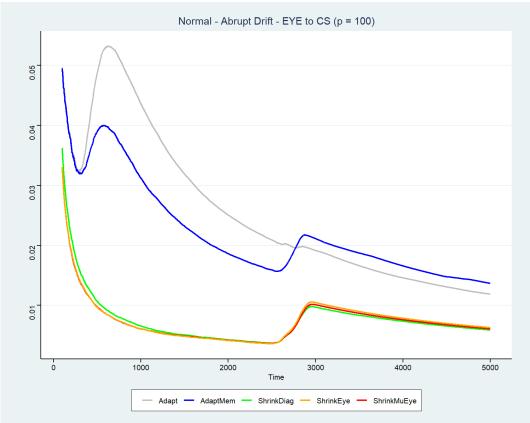
(c) CS,RWISH



(d) Standard deviation CS,RWISH



(e) EYE,CS



(f) Standard deviation EYE,CS

Figure 5.78: Comparison of abrupt drift QDA models for various covariance structures ($p = 100$) under normality.

(a) Normal, (RWISH) $p = 250$

(b) MVT(5), (RWISH) $p = 250$

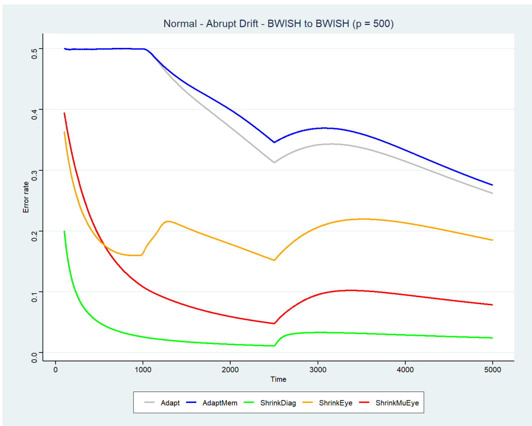
(c) Normal, (RWISH) $p = 500$

(d) MVT(5), (RWISH) $p = 500$

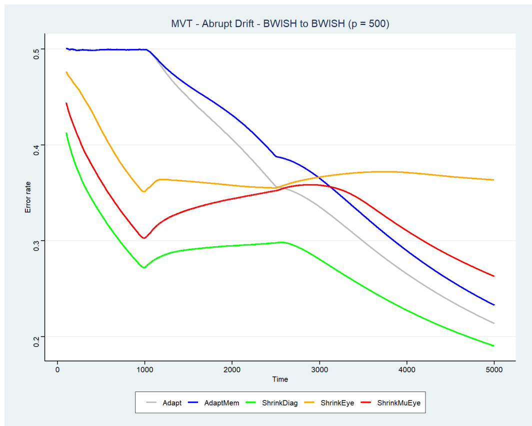
Figure 5.79: Comparision between Normal and MVT(5) for Abrupt Drift (Wishart to Wishart) QDA models.

(a) Normal, (BWISH) $p = 250$

(b) MVT(5), (BWISH) $p = 250$



(c) Normal, (BWISH) $p = 500$



(d) MVT(5), (BWISH) $p = 500$

Figure 5.80: Comparision between Normal and MVT(5) for Abrupt Drift (Wishart to Wishart) QDA models.

QDA Abrupt Drift Trajectories Comprehensive simulation results including trajectories for both multivariate normal and multivariate t(5) data for the QDA abrupt drift scenarios are reported in appendix O.

QDA Abrupt Drift Summary

In the multivariate normal case, the *shrinkage diagonal* estimator is the clear favorite, followed closely by the *average variance* estimator. In the multivariate t(5) case, the adaptive estimators should be used. The *shrinkage identity* estimator cannot be recommended for use in the scenarios investigated. Results are consistent across different priors as well.

5.6.3 Gradual Drift

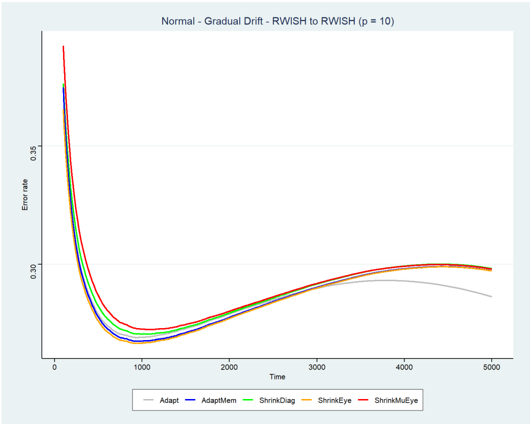
For non-stationary data regimes under gradual drift, data was simulated according to the method of *piecewise convex covariance movement* utilized in Anagnostopoulos et al. (2012). For each group a covariance matrix was randomly selected either from a Wishart distribution with $5p$ degrees and scale matrix equal to the identity matrix or was a randomly selected block matrix such that each block was a randomly selected 10×10 matrix from a Wishart distribution with 50 degrees of freedom and a scale matrix, I_{10}. The two mean vectors were then randomly selected such that each element was randomly selected from a uniform distribution on the interval (0,1). This first of these parameters were the the *start* parameters. This process was repeated to generate the *end* parameters. At a given time point, t, during the simulation, for each group the population covariance matrix was set to

$$\Sigma_t = \frac{t_{End} - t}{t_{End} - t_{Start}} \Sigma_{t_{Start}} + \frac{t - t_{Start}}{t_{End} - t_{Start}} \Sigma_{t_{End}}$$

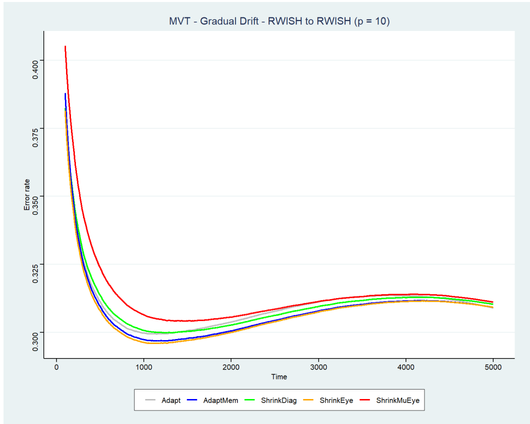
Similarly, the mean vector at time t was defined as

$$\mu_t = \frac{t_{End} - t}{t_{End} - t_{Start}} \mu_{t_{Start}} + \frac{t - t_{Start}}{t_{End} - t_{Start}} \mu_{t_{End}}$$

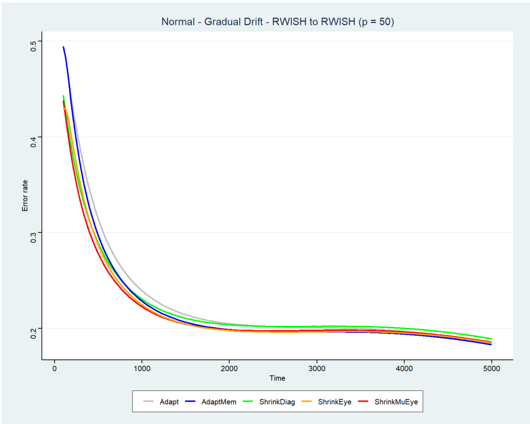
Under multivariate normality and for $p \leq 100$, the *shrinkage diagonal* and *average variance* estimates perform the best in terms of the average error rate. For MVT(5) data, this is not the case. The *shrinkage diagonal* and *average variance* estimators show an initial improvement over the adaptive estimators, however, this is not sustained over the entire course of the simulation. The *adaptive* and *adaptive-mem* estimators, eventually perform much better than the shrinkage estimators. Similar results are seen in the case of block Wishart covariance structures.



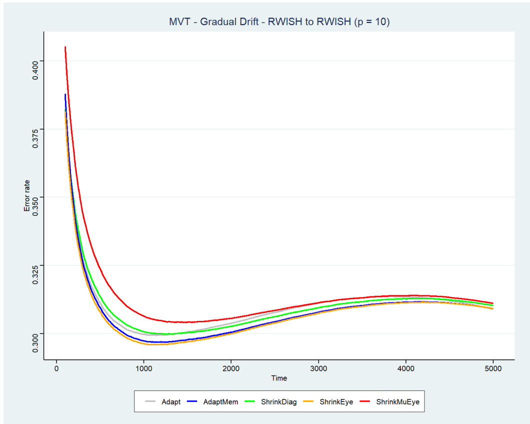
(a) Normal, (RWISH) $p = 10$



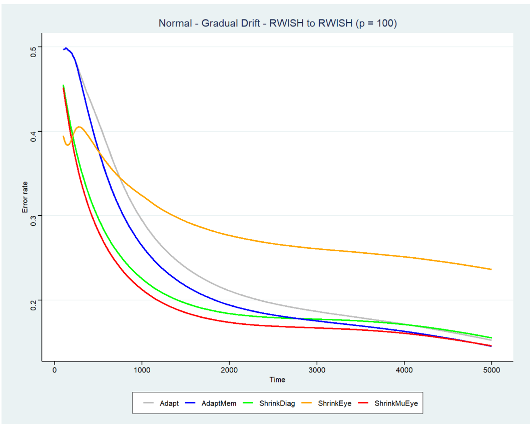
(b) MVT(5), (RWISH) $p = 10$



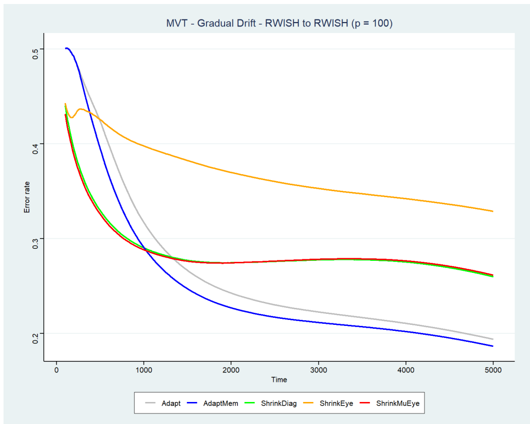
(c) Normal, (RWISH) $p = 50$



(d) MVT(5), (RWISH) $p = 50$

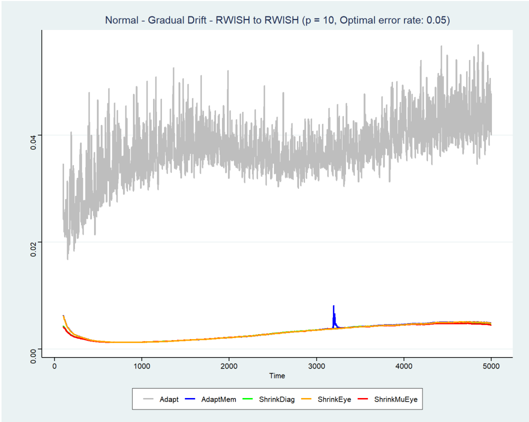


(e) Normal (RWISH), $p = 100$

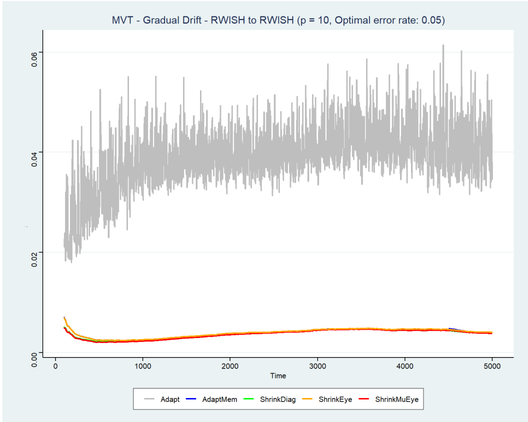


(f) MVT(5) (RWISH), $p = 100$

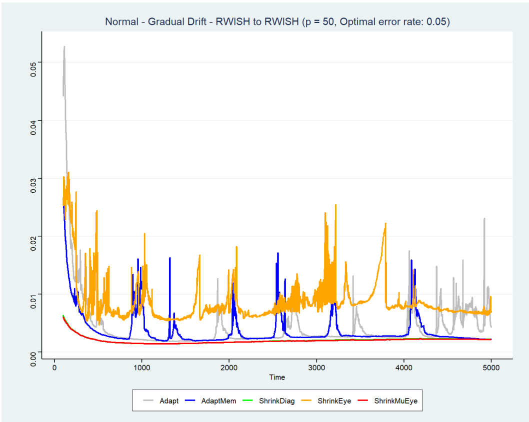
Figure 5.81: Comparision between Normal and MVT(5) for Abrupt Drift (Wishart to Wishart) QDA models.



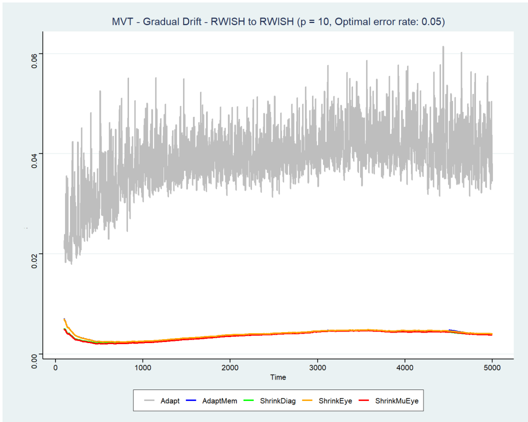
(a) Normal, (RWISH) $p = 10$



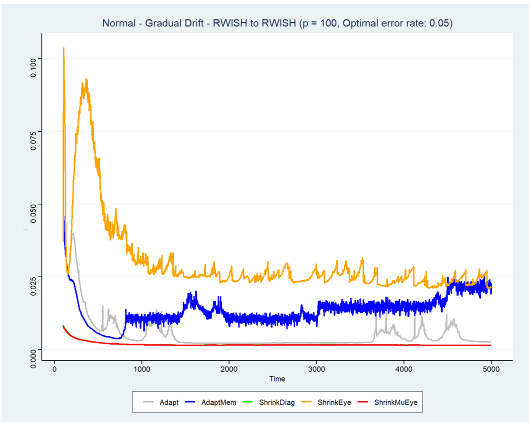
(b) MVT(5), (RWISH) $p = 10$



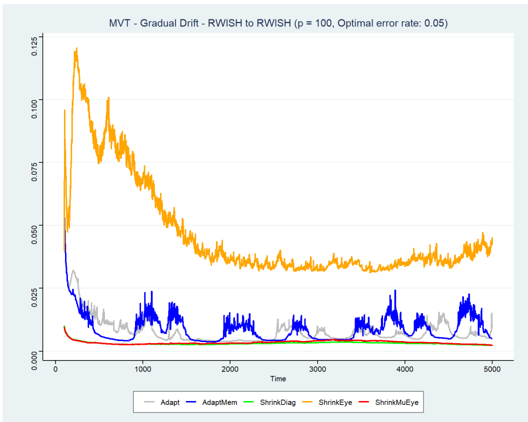
(c) Normal, (RWISH) $p = 50$



(d) MVT(5), (RWISH) $p = 50$

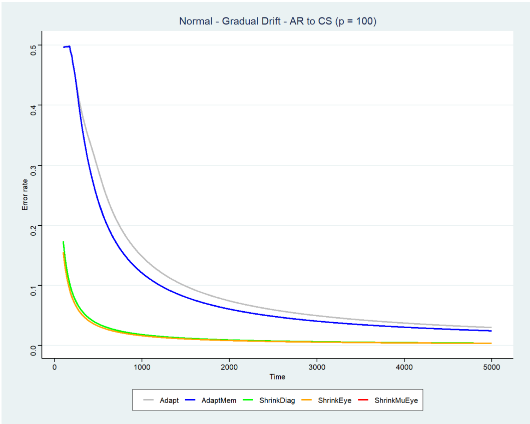


(e) Normal (RWISH), $p = 100$

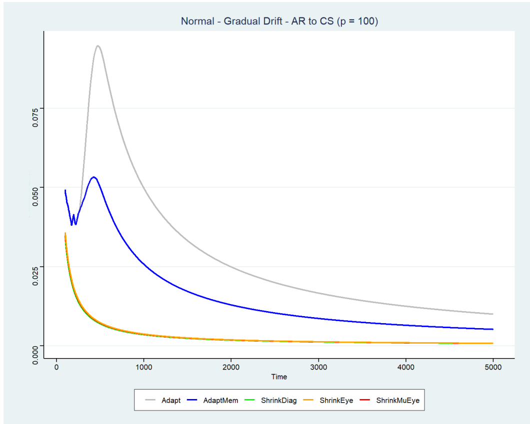


(f) MVT(5) (RWISH), $p = 100$

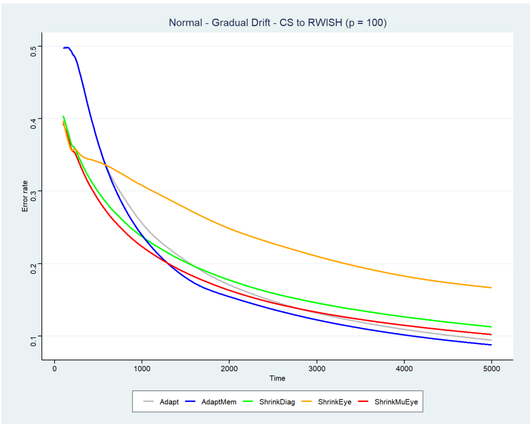
Figure 5.82: Standard deviation comparision between Normal and MVT(5) for Abrupt Drift (Wishart to Wishart) QDA models.



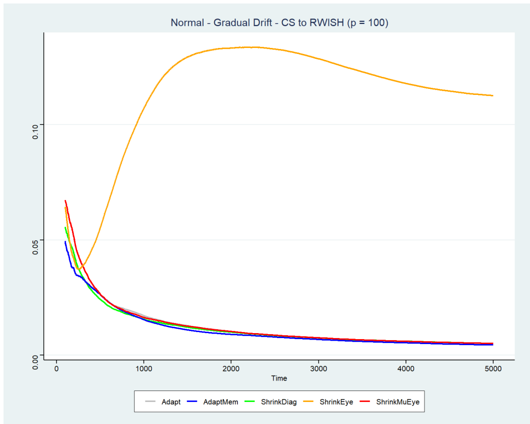
(a) AR,CS



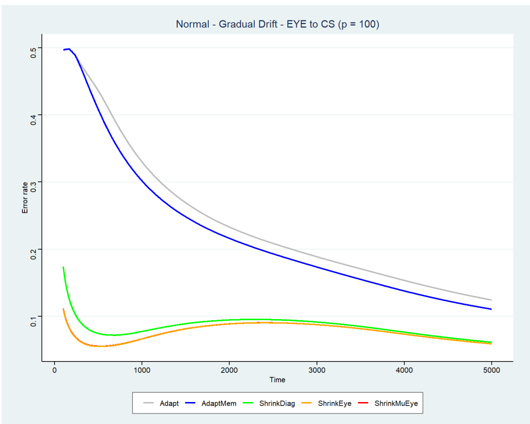
(b) SE AR,CS



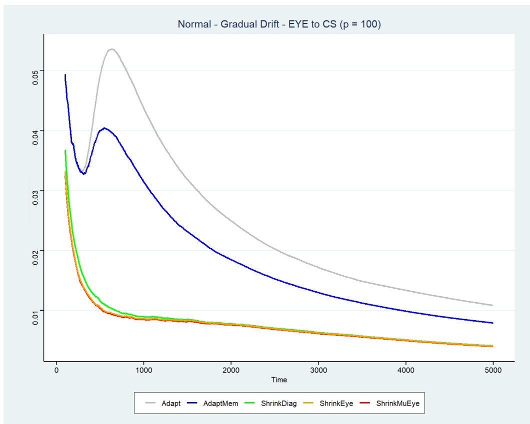
(c) CS,RWISH



(d) SE CS,RWISH

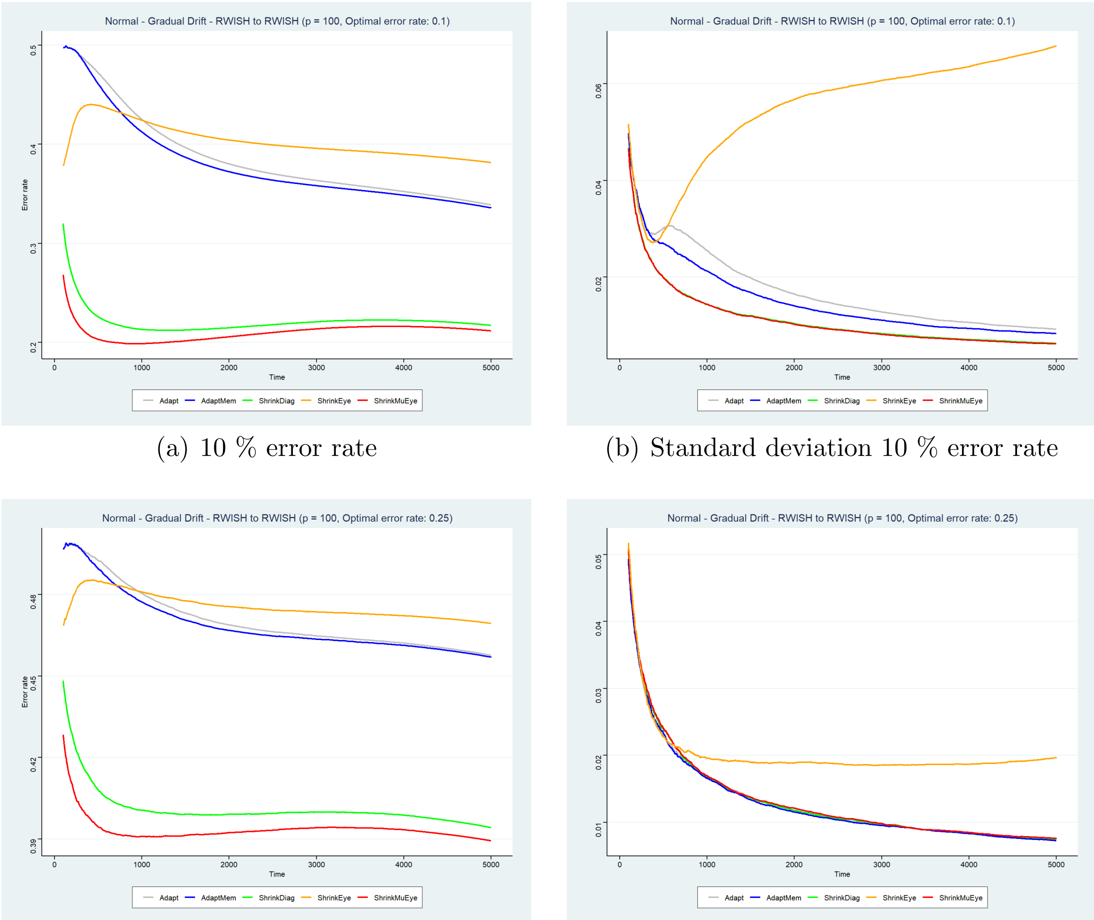


(e) EYE, CS



(f) SE EYE, CS

Figure 5.83: Comparison of gradual drift QDA models for various covariance matrices for $p = 100$.



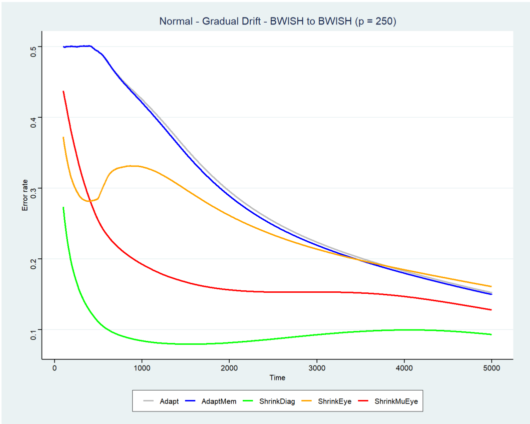
(a) 10 % error rate

(b) Standard deviation 10 % error rate

(c) 25 % error rate

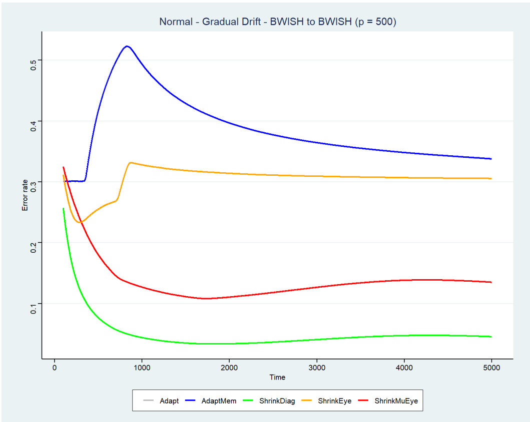
(d) Standard deviation 25% error rate

Figure 5.84: Comparison of gradual drift QDA models for optimal error rates of 10% and 25% error rates for $p = 100$.

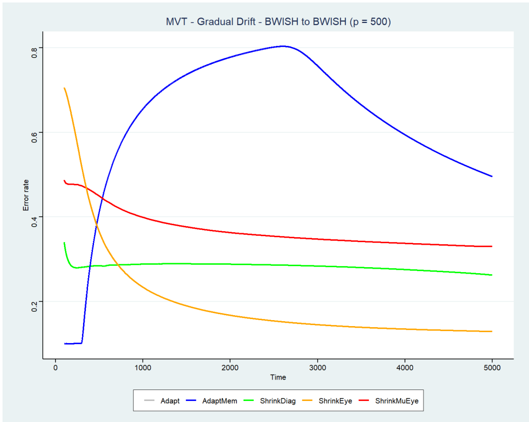


(a) Normal, (BWISH) $p = 250$

(b) MVT(5), (BWISH) $p = 250$



(c) Normal, (BWISH) $p = 500$



(d) MVT(5), (BWISH) $p = 500$

Figure 5.85: Comparision between Normal and MVT(5) for Gradual Drift (Wishart to Wishart) QDA models.

QDA Gradual Drift Trajectories Comprehensive simulation results including trajectories for both multivariate normal and multivariate t(5) data for the QDA gradual drift scenarios are reported in appendix P.

QDA Gradual Drift Summary

The results are similar to that in the abrupt QDA scenario. In the multivariate normal case, the *shrinkage diagonal* and *average variance* estimators are the clear favorites. In the multivariate t(5) case, the adaptive estimators should be used. For most of the scenarios investigated, the *shrinkage identity* estimator cannot be recommended.

CHAPTER 6

CONCLUDING REMARKS

6.1 Summary

In the current analytics environment with advanced data analysis tools, data analysts and statisticians need to quickly extract information from data in order to obtain value and insight from it before the ephemeral trend vanishes. Those who can act on the trend quickly are those who will profit from it. The demand to decrease the time between data collection and model building and thus prediction and insight has statisticians and analysts analyzing "streaming data" in real time in order to obtain critical insights immediately. Examples of streaming data abound and include the following, (1.) sensor data and Internet of things (IoT), (2.) telecommunications, (3.) social media, (4.) health care, (5.) marketing, and (6.) credit scoring. The current direction in data analytics (Reinsel, Gantz,and Rydning, 2017) is to move away from pulling historical data from databases into statistical software packages in order to build static models with a brief shelf life, but rather have an adaptive modelling algorithm sit in the stream of data ingesting new data updating model parameters and thus providing up to date predictions based on the most recent data in real time.

Analyzing data in real time creates new challenges for the statistician to solve. One main challenge to overcome is the fact that in many settings the data generating mechanism is not assumed to be stationary, but rather evolving or drifting over time. This phenomenon is typically referred to as concept drift and new statistical algorithms designed to handle streaming data will specifically need to account for this. In addition, as data technologies continue to advance, more and more data will be collected. New streaming algorithms will not only need to account for evolving data, but also the high dimensionality of the data.

To address these and other streaming analytic issues, statisticians will not only need to create new algorithms, but legacy algorithms will need to be re-engineered and updated to be useful in the streaming context. One such legacy algorithm in the context of classification is discriminant analysis. Despite the simplicity of the method, discriminant analysis is still the standard choice among many for different applications. At the very least it typically serves as a baseline measure to improve upon. Adaptive variants of discriminant analysis are an obvious modeling choice in the streaming context, and Adams et al. (2010) has already shown that temporally adaptive linear discriminant classifiers can outperform both static classifiers and those which are rebuilt periodically. Anagnostopolous et al (2012) provide an adaptive online algorithm based on temporally adaptive forgetting factors. Their approach can be seen as a continuous analogue to the windowed approach. Their approach uniquely combines results from adaptive filter theory and weighted likelihood theory (Haykin, 1996).

A potential drawback of using discriminant analysis in the streaming context is that it requires estimates of the inverse covariance matrix either pooled for linear discriminant analysis or one for each group in quadratic discriminant analysis. As the dimensions increase potential pitfalls include numerical errors as well as statistical estimation problems in light of the small n, large p setting especially early in the sequence. Regularization provides a potential road out of the problem and has been used successfully in the streaming context, for example, see Orhan, AngLi, and Erdogmus (2012). Lastly, all of the problems and issues that arise in modeling building get carried over to the streaming context. For example, issues of missing data are especially common in the streaming context along with providing measures of classification accuracy in real time. The proposed research attempts to address issues of high dimensionality, missing class labels, and error rate estimation in the case of streaming discriminant analysis.

6.2 Future Directions

The proposed sequential estimation technique has been shown through simulation to provide more accurate estimation of the covariance matrix along with providing more accurate linear and quadratic discriminant models than their non-shrinkage counterparts under the assumption of multivariate normality. This accuracy and improvement, however, does not in general extend to the non-normal case investigated. Future research should look at ways to extend the adaptive approach to non-normal, heavier tailed distributions for a more robust sequential estimation algorithm. Additionally, adaptive error rate estimators (Anagnostopoulos et al., 2012, Bodenham, 2014) were shown to be more accurate than the current prequential estimator that is typically available in software packages and thus commonly used in applications. Future research should focus on taking the adaptive point estimates and expanding them into interval estimates. The missing data approach investigated failed to show any increase in accuracy, in fact, it was demonstrated that the proposed method was no better than simply ignoring those data points with missing class labels. Future research should look towards creating new and better missing data methods including missing class labels but also extending to missing data problems in general e.g. missing at random, missing completely at random etc. Lastly, the proposed momentum adjustment provided a method for rebounding from abrupt drifts and shifts in the data, however, more research can be done on this topic alone as the gradient descent algorithm has been modified to handle sequential estimation new momentum strategies need to be considered.

6.3 Conclusions

Streaming data is becoming ubiquitous as data technology advances. Opportunities will continue to increase for statisticians and data analysts to analyze data in real time. Estimation and prediction algorithms will need to be developed to address the demand to act on information quickly and accurately. The proposed estimation technique helps address issues of high-dimensional estimation in a streaming environment by uniquely combining shrinkage estimation techniques

(Fisher and Sun, 2011) with sequential algorithms (Anagnostopoulos et al., 2012). The proposed procedures are an attractive solution especially in streaming applications where multivariate normal data can be assumed.

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APPENDIX LIST OF ABBREVIATIONS AND NOTATIONS

Adapt - Adaptive estimator

AdaptMem - Adaptive estimator with adaptive remembering

ShrinkDiag - Adaptive shrinkage diagonal estimator

ShrinkEye - Adaptive shrinkage identity estimator

ShrinkMuEye - Adaptive shrinkage average variance estimator

RWISH - Random Wishart matrix

BWISH - Block matrix consisting of blocks of random Wishart matrices

MVT - Multivariate t distribution

AR - autoregressive covariance structure

CS - compound symmetric covariance structure

EYE - identity matrix

AdaptPreq - adaptive prequential error rate estimator

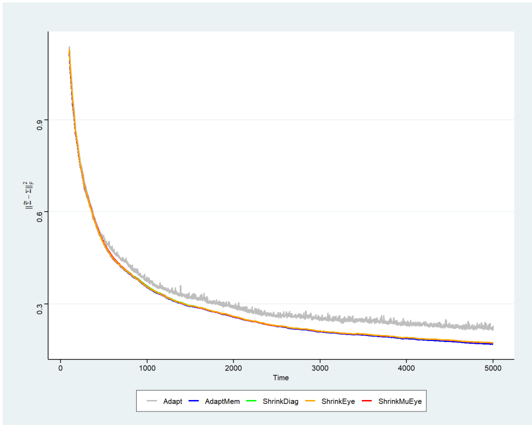
AdaptResub - adaptive resubstitution error rate estimator

AdaptiveDEst - adaptive D error rate estimator

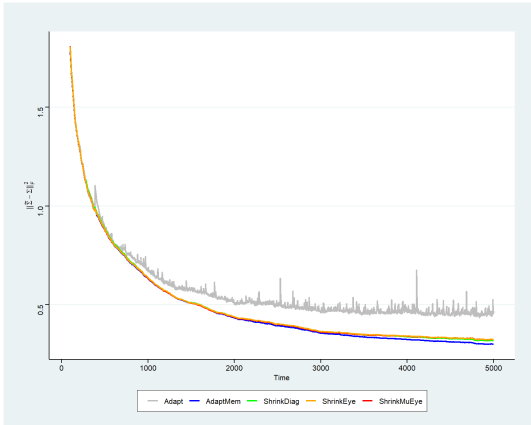
AdaptPosterior - adaptive posterior error rate estimator

Preq - static prequential error rate estimator

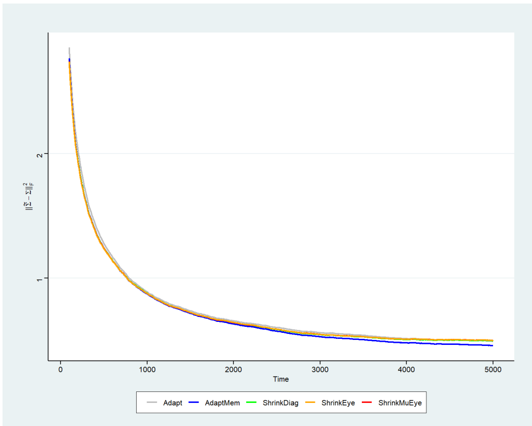
APPENDIX B: STATIONARY COVARIANCE SIMULATION



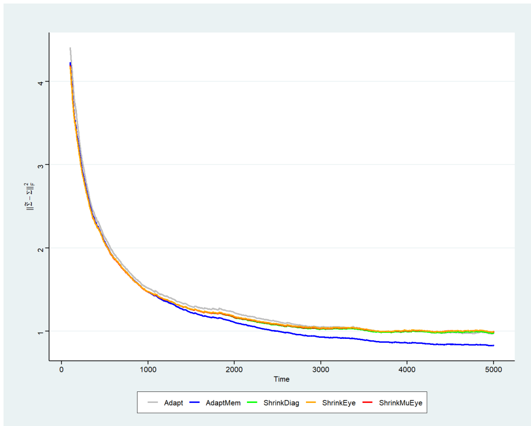
(a) Normal, $p = 10$



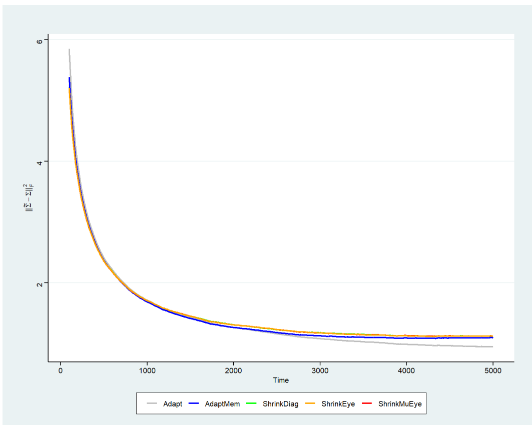
(b) mvt(5), $p = 10$



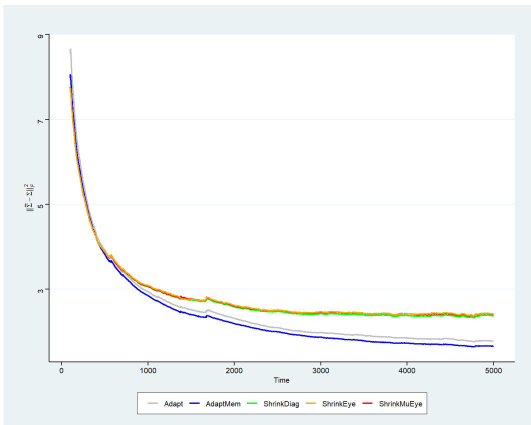
(c) Normal, $p = 25$



(d) mvt(5), $p = 25$

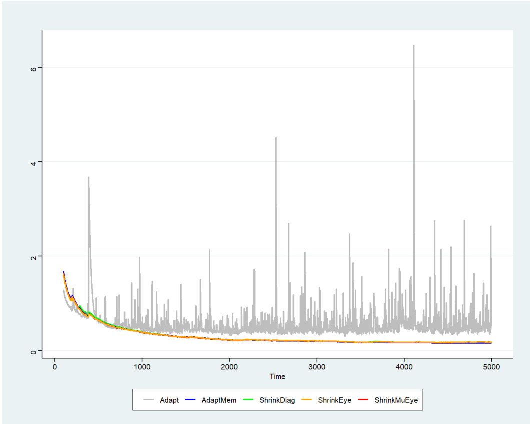


(e) Normal, $p = 50$

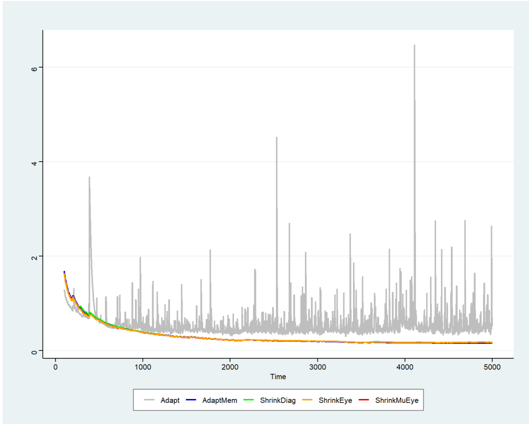


(f) mvt(5), $p = 50$

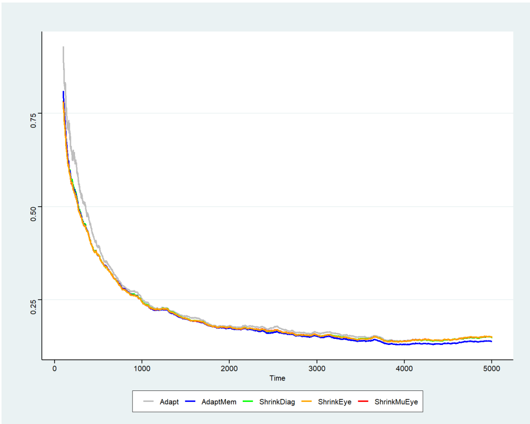
Figure B.0.1: Average loss comparison between Normal and mvt(5) for stationary AR(1) covariance matrix ($p \leq 50$).



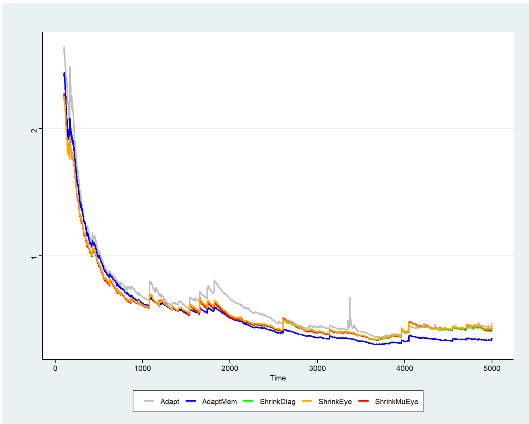
(a) Normal, $p = 10$



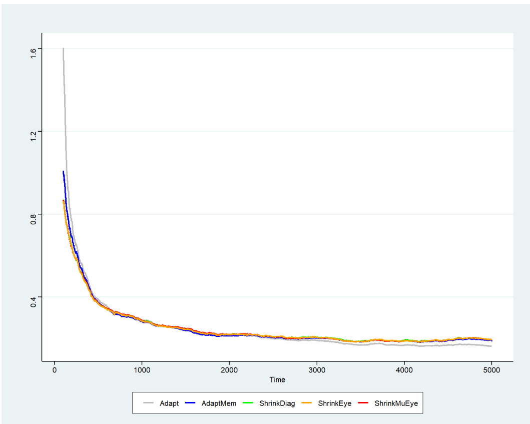
(b) mvt(5), $p = 10$



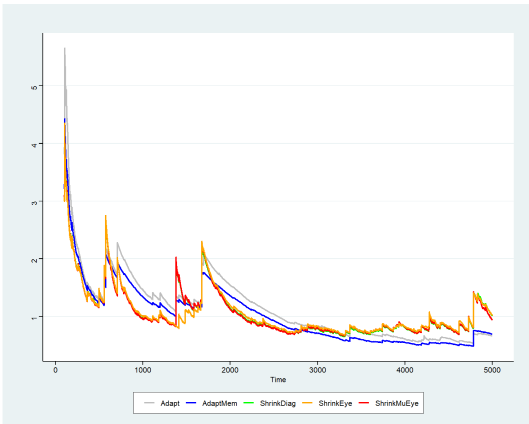
(c) Normal, $p = 25$



(d) mvt(5), $p = 25$

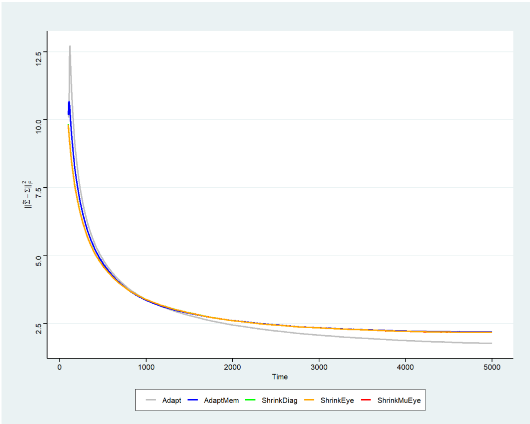


(e) Normal, $p = 50$

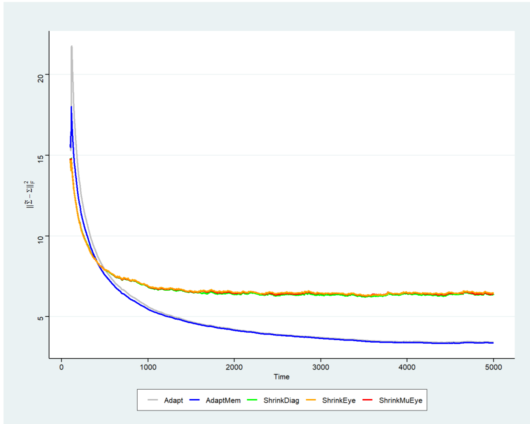


(f) mvt(5), $p = 50$

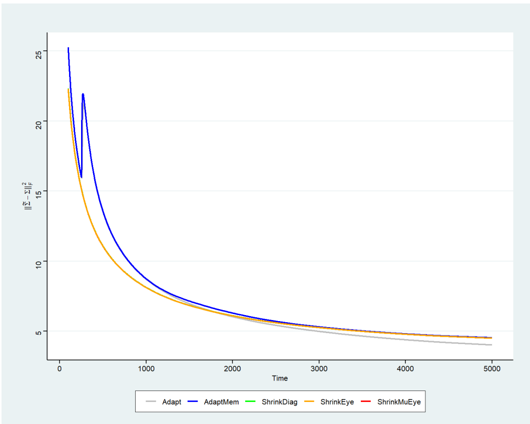
Figure B.0.2: Standard deviation of loss comparison between Normal and mvt(5) for stationary AR(1) covariance matrix ($p \leq 50$).



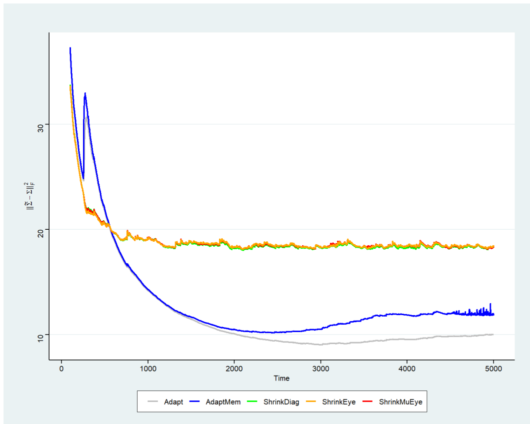
(a) Normal, $p = 100$



(b) mvt(5), $p = 100$

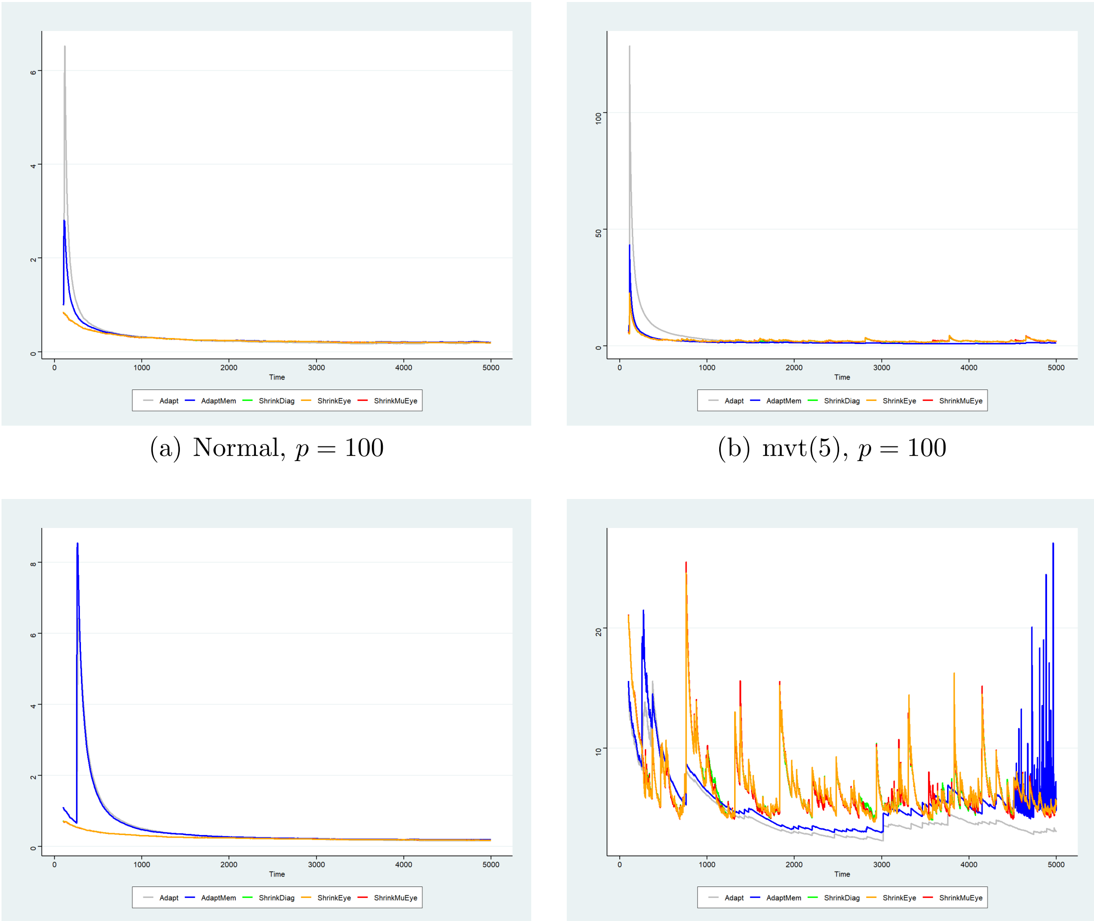


(c) Normal, $p = 250$



(d) mvt(5), $p = 250$

Figure B.0.3: Average loss comparison between Normal and mvt(5) for stationary AR(1) covariance matrix ($100 \leq p \leq 1000$).



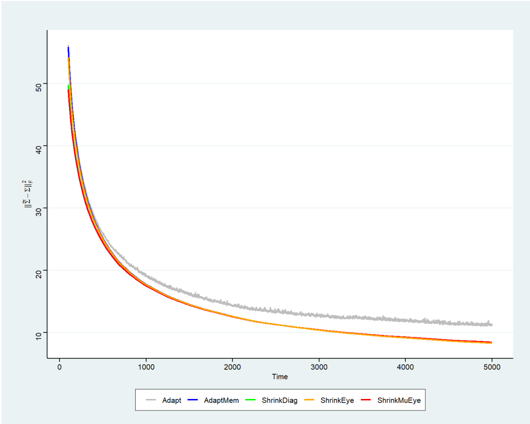
(a) Normal, $p = 100$

(b) mvt(5), $p = 100$

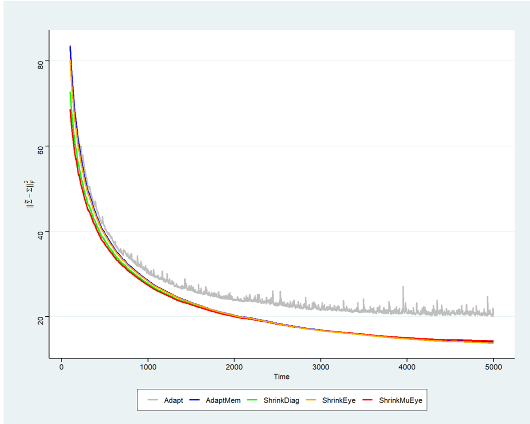
(c) Normal, $p = 250$

(d) mvt(5), $p = 250$

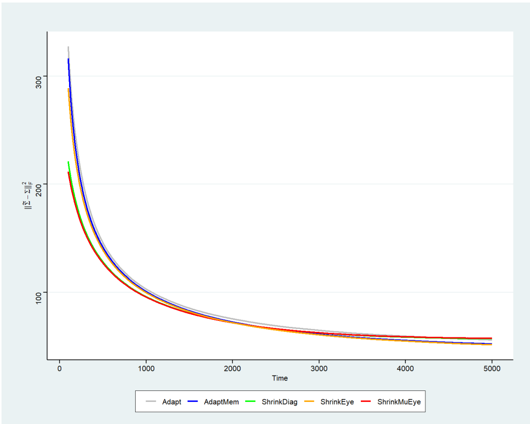
Figure B.0.4: Standard deviation of loss comparison between Normal and mvt(5) for stationary AR(1) covariance matrix ($100 \leq p \leq 1000$).



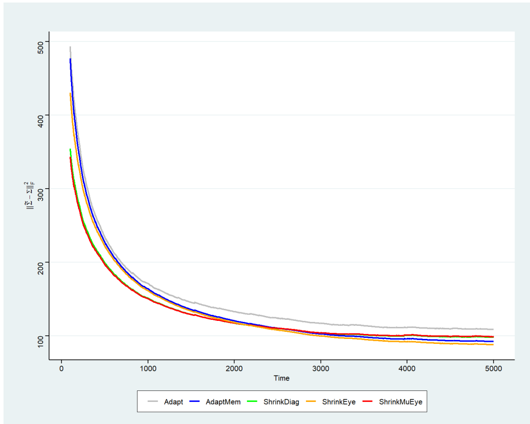
(a) Normal, $p = 10$



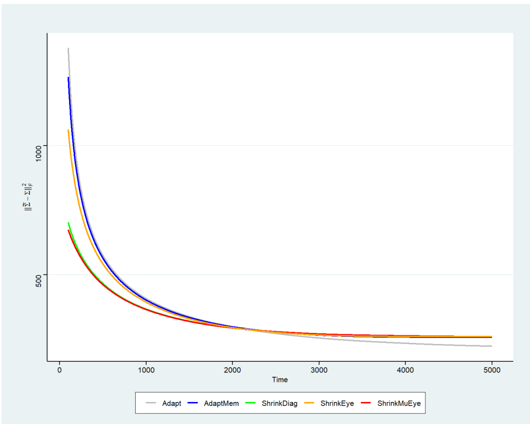
(b) mvt(5), $p = 10$



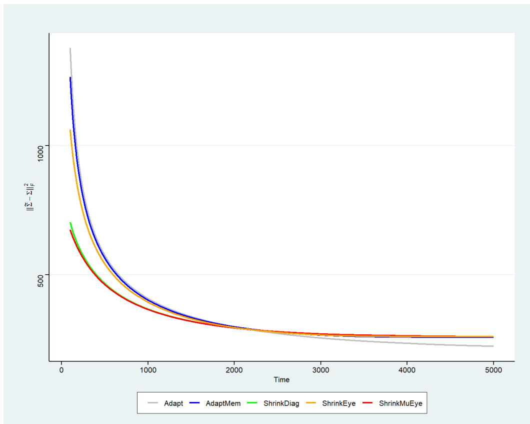
(c) Normal, $p = 25$



(d) mvt(5), $p = 25$

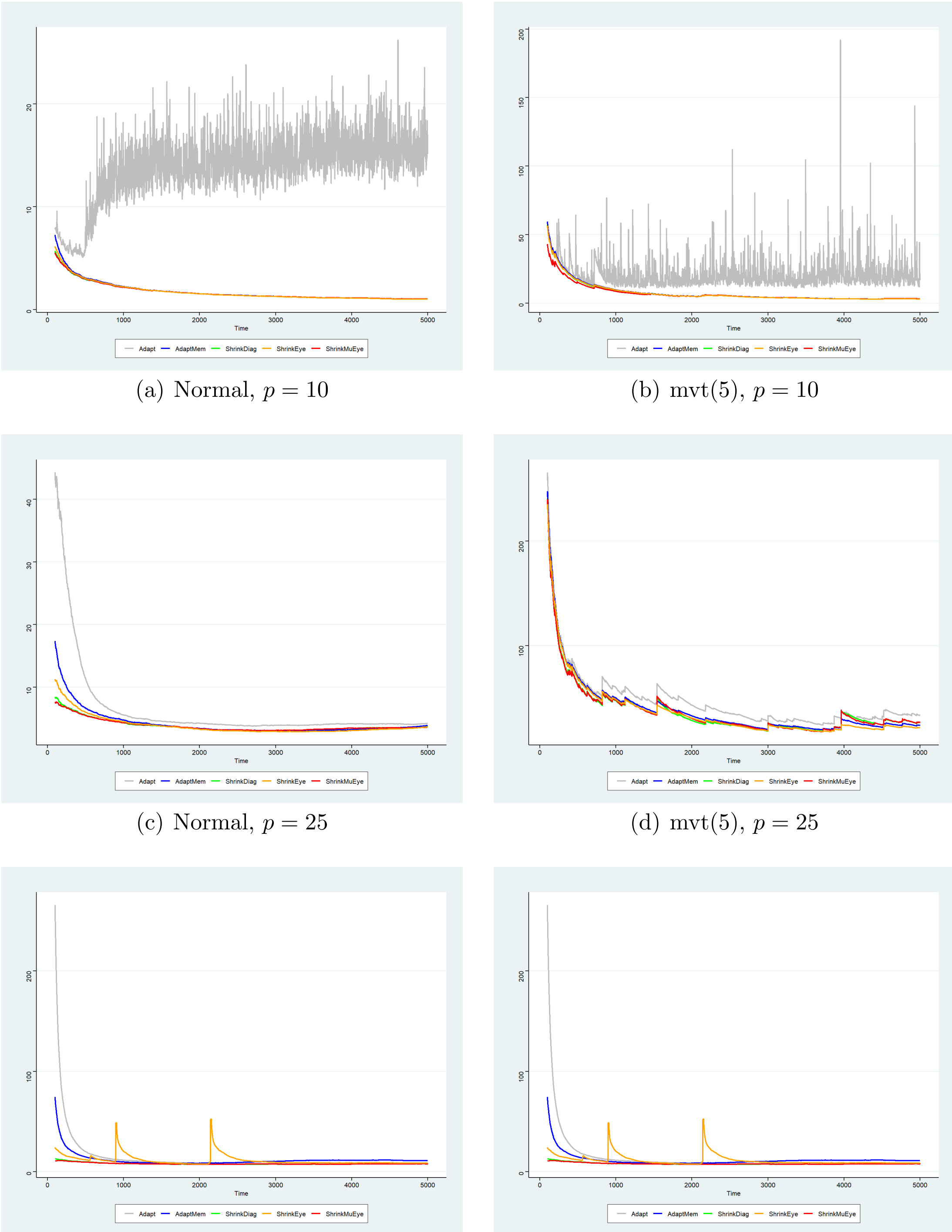


(e) Normal, $p = 50$



(f) mvt(5), $p = 50$

Figure B.0.5: Average loss comparison between Normal and mvt(5) for stationary Wishart covariance matrix ($p \leq 50$).



(a) Normal, $p = 10$

(b) mvt(5), $p = 10$

(c) Normal, $p = 25$

(d) mvt(5), $p = 25$

(e) Normal, $p = 50$

(f) mvt(5), $p = 50$

Figure B.0.6: Standard deviation of loss comparison between Normal and mvt(5) for stationary Wishart covariance matrix ($p \leq 50$).

Table B.1: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Stationary, Distribution:MVT(5), Cov:AR, p: 100). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	21.5255	21.5368	19.4515	19.3463	19.3653
	(10.4937)	(10.5116)	(9.23)	(9.2169)	(9.2017)
100	15.7324	15.7301	14.8635	14.8181	14.8221
	(6.6999)	(6.7024)	(6.0582)	(6.0483)	(6.0453)
500	7.9772	7.591	7.92	7.911	7.9198
	(6.4138)	(2.6491)	(2.7184)	(2.7664)	(2.7106)
1000	5.6543	5.4629	6.8376	6.88	6.8623
	(2.6865)	(1.5114)	(1.8316)	(1.8468)	(1.8201)
1500	4.7061	4.6307	6.5397	6.6122	6.5817
	(1.7324)	(1.3443)	(1.9141)	(1.9118)	(1.9102)
2000	4.2154	4.1663	6.3754	6.477	6.4298
	(1.4319)	(1.3529)	(1.7832)	(1.8243)	(1.7482)
2500	3.9026	3.8659	6.3152	6.4061	6.3696
	(1.1851)	(1.1681)	(1.8558)	(1.8553)	(1.8501)
3000	3.6998	3.6639	6.3417	6.462	6.3969
	(1.0791)	(1.0719)	(1.7333)	(1.853)	(1.705)
3500	3.5343	3.4818	6.238	6.3451	6.3087
	(0.8677)	(0.8308)	(1.4253)	(1.449)	(1.4441)
4000	3.4459	3.4009	6.4159	6.5091	6.4712
	(0.8834)	(0.8624)	(2.0739)	(2.0798)	(2.0363)
4500	3.4174	3.3606	6.3798	6.488	6.4457
	(0.9349)	(0.88)	(2.0468)	(2.0062)	(2.0541)
5000	3.4117	3.3651	6.3483	6.4572	6.4172
	(1.1806)	(1.1752)	(1.8192)	(1.9392)	(1.8185)

Table B.2: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Stationary, Distribution:Normal, Cov:AR, p:100). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	21.5398	21.5288	19.4492	19.3498	19.3753
	(10.498)	(10.4878)	(9.2295)	(9.2168)	(9.2156)
100	15.7539	15.7059	14.8585	14.8171	14.8157
	(6.7029)	(6.6444)	(6.0598)	(6.0482)	(6.0491)
500	7.936	7.6362	7.9185	7.9102	7.9147
	(6.3621)	(2.7144)	(2.7185)	(2.7654)	(2.7099)
1000	5.6222	5.4891	6.8388	6.8785	6.8614
	(2.668)	(1.5362)	(1.8315)	(1.8471)	(1.8201)
1500	4.6916	4.6362	6.5382	6.6123	6.5855
	(1.7286)	(1.3508)	(1.9139)	(1.9116)	(1.9126)
2000	4.2005	4.1568	6.3798	6.4829	6.4286
	(1.4183)	(1.3017)	(1.7934)	(1.8281)	(1.7486)
2500	3.8938	3.8597	6.3162	6.4202	6.3717
	(1.1832)	(1.149)	(1.8557)	(1.9094)	(1.8495)
3000	3.7083	3.6494	6.3382	6.4613	6.4028
	(1.0914)	(1.0597)	(1.7325)	(1.8696)	(1.7146)
3500	3.5343	3.4743	6.2391	6.3468	6.308
	(0.8715)	(0.825)	(1.4261)	(1.4491)	(1.4445)
4000	3.447	3.4002	6.4177	6.5111	6.4719
	(0.8825)	(0.865)	(2.0519)	(2.0791)	(2.0356)
4500	3.4187	3.3569	6.3778	6.485	6.4445
	(0.9449)	(0.8662)	(2.0467)	(2.0043)	(2.0545)
5000	3.4138	3.3585	6.3467	6.4618	6.4145
	(1.1754)	(1.1617)	(1.8195)	(1.9432)	(1.8195)

Table B.3: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Stationary, Distribution:MVT, Cov1:AR, p:10). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	2.4388	2.4492	2.438	2.4263	2.4402
	(2.9398)	(2.9467)	(2.8399)	(2.8124)	(2.8255)
100	1.8101	1.8006	1.8103	1.7941	1.8039
	(1.7036)	(1.699)	(1.6511)	(1.6349)	(1.6444)
500	0.9091	0.8834	0.877	0.8788	0.8819
	(0.6648)	(0.6785)	(0.6426)	(0.6363)	(0.6436)
1000	0.6809	0.6373	0.6361	0.6316	0.634
	(0.4978)	(0.4004)	(0.3862)	(0.3788)	(0.3848)
1500	0.5763	0.5088	0.5088	0.5071	0.5083
	(0.4406)	(0.2883)	(0.2804)	(0.2769)	(0.2778)
2000	0.5119	0.4367	0.4345	0.4375	0.4378
	(0.3819)	(0.2287)	(0.2203)	(0.2234)	(0.2224)
2500	0.5016	0.3973	0.3985	0.4031	0.403
	(0.4065)	(0.2129)	(0.2123)	(0.218)	(0.2177)
3000	0.4655	0.3558	0.3609	0.3633	0.3632
	(0.399)	(0.193)	(0.1954)	(0.1996)	(0.1991)
3500	0.4711	0.3368	0.3457	0.3497	0.3504
	(0.5434)	(0.1697)	(0.1711)	(0.1726)	(0.1747)
4000	0.4604	0.3242	0.3354	0.3401	0.3397
	(0.4724)	(0.167)	(0.1717)	(0.1751)	(0.1745)
4500	0.4436	0.3136	0.3273	0.3314	0.3313
	(0.3802)	(0.1623)	(0.1703)	(0.1714)	(0.1715)
5000	0.4563	0.3025	0.3182	0.3221	0.3221
	(0.5209)	(0.1594)	(0.1696)	(0.1726)	(0.1728)

Table B.4: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Stationary, Distribution:Normal, Cov1:AR, p:10). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	2.4346	2.4418	2.4378	2.4231	2.4431
	(2.939)	(2.9423)	(2.8387)	(2.8142)	(2.8252)
100	1.8124	1.7996	1.7954	1.8034	1.8034
	(1.7071)	(1.699)	(1.6506)	(1.6401)	(1.6434)
500	0.9068	0.882	0.8834	0.8815	0.8801
	(0.6662)	(0.6517)	(0.6721)	(0.6475)	(0.6432)
1000	0.6783	0.6355	0.6378	0.6361	0.6341
	(0.495)	(0.3919)	(0.3944)	(0.3892)	(0.3846)
1500	0.5772	0.5084	0.5104	0.5093	0.5076
	(0.4421)	(0.2878)	(0.2871)	(0.2798)	(0.2776)
2000	0.5106	0.4355	0.4364	0.4377	0.4375
	(0.392)	(0.2271)	(0.2243)	(0.2242)	(0.2223)
2500	0.4984	0.3966	0.3993	0.4032	0.4026
	(0.4286)	(0.2117)	(0.215)	(0.2186)	(0.2177)
3000	0.4633	0.356	0.3609	0.3633	0.3625
	(0.3901)	(0.1929)	(0.1951)	(0.1995)	(0.1992)
3500	0.47	0.3381	0.3477	0.3465	0.3499
	(0.5456)	(0.1697)	(0.1721)	(0.1742)	(0.1742)
4000	0.4617	0.3253	0.3366	0.3372	0.3398
	(0.4827)	(0.1666)	(0.172)	(0.1743)	(0.1743)
4500	0.4448	0.3133	0.3267	0.3298	0.3315
	(0.3929)	(0.1607)	(0.1692)	(0.1717)	(0.1717)
5000	0.4607	0.302	0.3189	0.3208	0.3223
	(0.5446)	(0.1582)	(0.1703)	(0.172)	(0.1727)

Table B.5: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: Normal, Cov: AR, p: 250). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	50.6324	50.8128	40.8167	40.5818	40.5924
	(20.2292)	(20.8712)	(17.7342)	(17.301)	(17.2885)
100	37.831	37.4786	32.856	32.7055	32.7104
	(16.7046)	(14.9907)	(14.4697)	(14.3218)	(14.3212)
500	21.7407	22.1345	20.5346	20.5293	20.5182
	(9.3272)	(9.9759)	(7.3368)	(7.457)	(7.3883)
1000	14.149	14.3586	18.7179	18.7619	18.7833
	(6.021)	(6.4946)	(7.8296)	(7.7301)	(7.9402)
1500	11.4403	11.6789	18.5441	18.6479	18.6351
	(4.3094)	(4.9107)	(7.1529)	(7.535)	(7.1612)
2000	10.0694	10.4543	18.4525	18.5763	18.5961
	(3.1143)	(3.4408)	(6.5719)	(6.7225)	(6.8342)
2500	9.3947	10.2569	18.3148	18.3879	18.3473
	(2.8606)	(3.92)	(5.5996)	(5.5813)	(5.5295)
3000	9.0279	10.5286	18.1096	18.2469	18.2238
	(2.3762)	(3.2791)	(4.546)	(4.492)	(4.4702)
3500	9.3084	11.4396	18.635	18.7302	18.7403
	(3.7618)	(4.869)	(7.1785)	(7.0889)	(7.104)
4000	9.5229	11.8213	18.2836	18.3933	18.3691
	(3.8294)	(5.0874)	(5.626)	(5.5707)	(5.633)
4500	9.8269	11.9101	18.3571	18.4898	18.4635
	(3.5048)	(4.7886)	(5.2258)	(5.3235)	(5.1697)
5000	9.9743	12.089	18.5423	18.604	18.5651
	(3.0281)	(6.5208)	(6.2722)	(6.1907)	(6.1647)

Table B.6: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: MVT(5), Cov: AR, p: 500). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	101.4504	101.4183	73.3715	73.1582	73.2886
	(51.3348)	(51.368)	(47.0831)	(47.1436)	(47.164)
100	75.2013	75.079	60.2991	60.0393	60.1035
	(38.2627)	(38.1744)	(36.2923)	(36.1755)	(36.1832)
500	35.841	35.8686	33.2959	33.366	33.4089
	(11.6495)	(11.6997)	(10.7812)	(11.0557)	(11.0615)
1000	25.9095	25.9175	36.3177	36.3735	36.3294
	(9.4506)	(9.4543)	(15.7807)	(14.6706)	(15.3125)
1500	21.2237	21.2256	35.8434	36.1896	35.8495
	(6.2455)	(6.2477)	(9.5682)	(10.6392)	(9.4727)
2000	18.5656	18.5627	37.2625	37.1513	37.2044
	(7.1788)	(7.1796)	(33.1054)	(30.8067)	(31.8684)
2500	16.7894	16.7902	36.4278	36.6064	36.4345
	(8.5671)	(8.5677)	(23.4698)	(22.0697)	(22.2885)
3000	15.3661	15.3697	35.91	36.1696	35.9762
	(7.1018)	(7.1018)	(9.6066)	(10.1786)	(9.7139)
3500	14.2168	14.2221	36.0694	36.074	36.0472
	(6.0342)	(6.0342)	(10.7557)	(9.8999)	(10.0846)
4000	13.305	13.3111	36.4169	36.5837	36.4896
	(5.2433)	(5.2439)	(10.5854)	(10.1334)	(10.1503)
4500	12.5337	12.5427	36.0995	36.2774	35.994
	(4.6412)	(4.6431)	(9.549)	(10.3334)	(9.1736)
5000	11.926	11.9349	36.0034	35.7624	35.7205
	(4.2351)	(4.237)	(10.0091)	(8.8577)	(9.2251)

Table B.7: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: Normal, Cov: AR, p: 500). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	101.4774	101.5607	73.501	73.2053	73.1459
	(51.409)	(51.4971)	(47.176)	(47.1457)	(47.1132)
100	75.1188	75.2173	60.2781	60.0825	60.1211
	(38.1935)	(38.3315)	(36.1907)	(36.1877)	(36.2574)
500	35.8224	35.773	33.2183	33.383	33.3612
	(11.655)	(11.4054)	(10.7018)	(11.0565)	(11.0169)
1000	25.9026	25.8857	36.3909	36.3572	36.3337
	(9.4484)	(9.3902)	(15.8853)	(14.6726)	(15.3019)
1500	21.216	21.2004	35.784	36.1966	35.767
	(6.2455)	(6.2165)	(9.3786)	(10.6695)	(9.4139)
2000	18.5569	18.5485	37.3622	37.1409	37.2185
	(7.1796)	(7.1691)	(33.0782)	(30.8014)	(31.8726)
2500	16.7888	16.777	36.4656	36.6267	36.5041
	(8.5674)	(8.5624)	(23.4406)	(22.1109)	(22.3335)
3000	15.3661	15.3558	35.9879	36.2113	35.9199
	(7.102)	(7.0989)	(9.5711)	(10.1824)	(9.686)
3500	14.2175	14.2111	36.3266	36.0701	36.0692
	(6.0344)	(6.033)	(18.2727)	(9.8873)	(10.2389)
4000	13.3071	13.3033	36.398	36.5964	36.3392
	(5.2438)	(5.2459)	(10.4998)	(10.1346)	(9.9124)
4500	12.5395	12.5367	36.2512	36.1287	36.232
	(4.6431)	(4.645)	(10.4329)	(9.5118)	(12.0173)
5000	11.9318	11.9279	35.8359	35.6607	35.8802
	(4.2373)	(4.238)	(9.8391)	(8.6665)	(10.2372)

Table B.8: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: MVT(5), Cov: AR, p: 50). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	10.9931	11.0924	10.5534	10.4197	10.4977
	(5.6316)	(5.8187)	(5.2107)	(5.0727)	(5.1841)
100	8.7012	8.1185	7.8186	7.7888	7.7944
	(4.0258)	(3.3249)	(3.1462)	(3.1227)	(3.1356)
500	3.9426	3.854	3.9046	3.9216	3.9102
	(1.4467)	(1.3719)	(1.455)	(1.4651)	(1.4664)
1000	2.951	2.855	3.0565	3.0907	3.0703
	(1.4657)	(1.3472)	(0.9643)	(1.0481)	(0.9623)
1500	2.5107	2.4109	2.7471	2.7876	2.7679
	(1.2899)	(1.2253)	(1.3147)	(1.361)	(1.3285)
2000	2.301	2.1866	2.582	2.6088	2.6025
	(1.5314)	(1.3588)	(1.1373)	(1.1891)	(1.1208)
2500	2.0886	1.9934	2.4787	2.5162	2.5052
	(1.0397)	(0.9296)	(0.8155)	(0.8523)	(0.8113)
3000	1.9769	1.8717	2.4259	2.4704	2.4552
	(0.8301)	(0.712)	(0.7843)	(0.8354)	(0.7887)
3500	1.913	1.7842	2.3968	2.4494	2.4322
	(0.7563)	(0.5996)	(0.7259)	(0.7641)	(0.7404)
4000	1.84	1.7297	2.3841	2.4181	2.42
	(0.6084)	(0.5515)	(0.8043)	(0.799)	(0.8133)
4500	1.8176	1.6923	2.3792	2.4301	2.4215
	(0.6025)	(0.5291)	(0.7812)	(0.8251)	(0.7964)
5000	1.7623	1.6535	2.3705	2.4075	2.4036
	(0.6548)	(0.6926)	(1.0048)	(1.0127)	(0.9318)

Table B.9: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: Normal, Cov: AR, p: 50). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	11.0178	11.0781	10.542	10.4529	10.4408
	(5.7256)	(5.783)	(5.2101)	(5.1036)	(5.0734)
100	8.6763	8.1078	7.8107	7.7691	7.7801
	(3.9551)	(3.333)	(3.147)	(3.0771)	(3.0943)
500	3.9389	3.8486	3.9024	3.9094	3.9076
	(1.4437)	(1.3622)	(1.4542)	(1.4627)	(1.4836)
1000	2.9391	2.8519	3.0606	3.0852	3.0594
	(1.4645)	(1.3421)	(0.97)	(0.9977)	(0.9515)
1500	2.4945	2.4035	2.7529	2.7807	2.7367
	(1.0897)	(1.223)	(1.3174)	(1.3462)	(1.0736)
2000	2.3004	2.1866	2.5818	2.6187	2.6133
	(1.4868)	(1.3596)	(1.1375)	(1.1914)	(1.1156)
2500	2.0836	1.9915	2.4783	2.5184	2.5079
	(1.0083)	(0.9303)	(0.8159)	(0.8403)	(0.8066)
3000	1.9733	1.8652	2.4229	2.4674	2.4593
	(0.8036)	(0.7052)	(0.7785)	(0.824)	(0.7957)
3500	1.905	1.7812	2.3954	2.4349	2.4281
	(0.7421)	(0.5966)	(0.7247)	(0.7468)	(0.7356)
4000	1.8482	1.7247	2.3796	2.423	2.4114
	(0.6086)	(0.5485)	(0.8034)	(0.8178)	(0.8026)
4500	1.8246	1.6917	2.381	2.4246	2.4093
	(0.6092)	(0.5301)	(0.7849)	(0.811)	(0.7829)
5000	1.7713	1.6534	2.367	2.4056	2.4021
	(0.6604)	(0.6922)	(1.0036)	(1.0175)	(0.9292)

Table B.10: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Stationary, Distribution:Normal, Cov:CS, p: 100). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	24.7542	24.6521	24.7714	24.7294	24.7012
	(20.4346)	(20.2353)	(19.7438)	(19.7096)	(19.6152)
100	18.9768	18.8845	19.0654	19.0102	18.8925
	(16.2978)	(16.2542)	(15.9637)	(15.9346)	(15.9023)
500	9.9008	9.5196	9.7317	9.9113	9.7161
	(10.366)	(9.9072)	(9.2774)	(10.107)	(9.3286)
1000	6.801	6.6953	6.7462	6.95	6.7772
	(6.1282)	(6.0514)	(5.1814)	(6.2376)	(5.1728)
1500	5.873	5.825	6.0375	6.1812	6.0191
	(5.24)	(5.2447)	(5.4255)	(5.7828)	(5.4285)
2000	5.2349	5.226	5.3258	5.4647	5.342
	(4.2063)	(4.2396)	(3.8372)	(4.3197)	(3.8423)
2500	4.7577	4.7438	4.8134	4.9024	4.8478
	(3.6349)	(3.7113)	(3.4993)	(3.7214)	(3.5101)
3000	4.4205	4.3436	4.4045	4.4484	4.4168
	(3.1065)	(3.1038)	(2.9501)	(3.0672)	(2.952)
3500	4.2862	4.2219	4.2526	4.2904	4.2663
	(2.8383)	(2.8328)	(2.7692)	(2.8028)	(2.788)
4000	4.0823	4.0443	4.0727	4.081	4.093
	(2.8387)	(2.8239)	(2.8359)	(2.8739)	(2.8538)
4500	4.1278	4.0582	4.0406	4.0442	4.0721
	(2.8048)	(2.7256)	(2.661)	(2.6847)	(2.7795)
5000	4.1247	4.0556	4.0156	4.0268	4.0264
	(3.1279)	(3.0758)	(3.0077)	(3.0314)	(3.0228)

Table B.11: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Stationary, Distribution:MVT(5), Cov:CS, p: 10). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	2.4581	2.4412	2.479	2.3959	2.4736
	(2.6691)	(2.6755)	(2.5931)	(1.6356)	(2.5864)
100	1.8601	1.8392	1.8616	1.8378	1.8641
	(1.7018)	(1.6978)	(1.6532)	(1.3542)	(1.6454)
500	0.9356	0.919	0.9203	0.9139	0.9212
	(0.8456)	(0.8285)	(0.8186)	(0.7922)	(0.8137)
1000	0.6974	0.6629	0.6606	0.6614	0.6615
	(0.5753)	(0.5124)	(0.5037)	(0.4964)	(0.5024)
1500	0.5873	0.5359	0.5361	0.5358	0.5319
	(0.438)	(0.3874)	(0.3837)	(0.3708)	(0.3679)
2000	0.5158	0.4519	0.4538	0.453	0.4538
	(0.4545)	(0.3243)	(0.3237)	(0.3171)	(0.3174)
2500	0.4977	0.4052	0.4061	0.4046	0.4074
	(0.4203)	(0.2967)	(0.3012)	(0.2964)	(0.2989)
3000	0.4727	0.3674	0.3686	0.369	0.3692
	(0.4191)	(0.2647)	(0.2666)	(0.2677)	(0.2664)
3500	0.4771	0.3535	0.3643	0.3607	0.366
	(0.4243)	(0.2344)	(0.2371)	(0.238)	(0.2374)
4000	0.4886	0.3462	0.3566	0.355	0.3594
	(0.5528)	(0.2373)	(0.2418)	(0.2434)	(0.242)
4500	0.4753	0.3311	0.3435	0.3452	0.3444
	(0.5465)	(0.23)	(0.2352)	(0.2383)	(0.236)
5000	0.4778	0.3192	0.3314	0.333	0.3333
	(0.5517)	(0.2242)	(0.226)	(0.228)	(0.2272)

Table B.12: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Stationary, Distribution:Normal, Cov:CS, p: 10). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	2.4726	2.4457	2.4764	2.4496	2.4707
	(2.6946)	(2.6747)	(2.5935)	(2.5566)	(2.5839)
100	1.8723	1.8581	1.8633	1.8567	1.8573
	(1.7111)	(1.6941)	(1.6536)	(1.6368)	(1.6526)
500	0.9412	0.919	0.9206	0.9216	0.9212
	(0.8555)	(0.829)	(0.8157)	(0.822)	(0.8152)
1000	0.698	0.6618	0.6619	0.6643	0.6595
	(0.5689)	(0.5126)	(0.5036)	(0.5058)	(0.4979)
1500	0.6052	0.5363	0.5334	0.5359	0.5318
	(0.6004)	(0.3868)	(0.3678)	(0.3748)	(0.3659)
2000	0.5314	0.4536	0.4541	0.4519	0.4523
	(0.5061)	(0.3249)	(0.3164)	(0.3173)	(0.3145)
2500	0.508	0.4051	0.4066	0.4061	0.4072
	(0.4687)	(0.2976)	(0.2981)	(0.2996)	(0.2989)
3000	0.4789	0.3652	0.3692	0.37	0.3712
	(0.4905)	(0.2643)	(0.268)	(0.2676)	(0.2686)
3500	0.4866	0.3562	0.365	0.3604	0.365
	(0.491)	(0.2353)	(0.238)	(0.2384)	(0.2389)
4000	0.4853	0.3476	0.3573	0.357	0.3573
	(0.5359)	(0.2347)	(0.2409)	(0.2441)	(0.2423)
4500	0.4651	0.3306	0.3425	0.344	0.3428
	(0.4481)	(0.2273)	(0.2353)	(0.2379)	(0.236)
5000	0.4854	0.3174	0.3312	0.333	0.3325
	(0.7973)	(0.2172)	(0.2258)	(0.228)	(0.2268)

Table B.13: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: Normal, Cov: CS, p: 250). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	63.0853	63.2166	63.2855	63.294	63.3319
	(63.218)	(63.2593)	(61.1501)	(61.1231)	(61.1893)
100	46.8418	46.8993	46.9127	47.0033	46.922
	(40.0806)	(40.1013)	(39.3251)	(39.2901)	(39.3142)
500	23.5968	23.5372	42.3922	39.0869	38.2943
	(16.9282)	(17.4379)	(40.4842)	(31.4679)	(30.3578)
1000	16.7576	16.7645	37.8508	36.9281	35.178
	(11.7987)	(11.9266)	(35.5174)	(25.1039)	(24.9977)
1500	13.7346	13.8638	33.3689	35.5012	31.7812
	(13.1522)	(13.9556)	(33.4803)	(26.4625)	(21.6251)
2000	12.1578	12.5373	30.153	38.0389	32.1176
	(10.7101)	(11.4935)	(38.7373)	(43.3872)	(38.7022)
2500	11.5765	12.3419	25.5319	40.4741	29.2323
	(10.3038)	(11.3121)	(29.3716)	(42.9027)	(25.9676)
3000	11.3944	12.7162	27.0281	40.3294	31.0976
	(8.937)	(9.9184)	(37.2244)	(40.1421)	(39.2926)
3500	11.2349	13.1305	26.466	35.2688	27.7993
	(8.2185)	(9.7768)	(42.9608)	(35.9272)	(35.2859)
4000	11.7047	14.2865	25.0543	34.2497	26.1428
	(8.7194)	(11.0236)	(41.3423)	(29.6127)	(30.253)
4500	12.2784	14.672	24.3909	34.9671	24.6715
	(9.9497)	(11.954)	(41.8248)	(36.3583)	(32.2867)
5000	12.7399	14.7194	21.9238	35.3834	24.5995
	(10.4105)	(11.8924)	(39.3048)	(43.7326)	(47.5813)

Table B.14: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: MVT(5), Cov: CS, p: 25). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	6.4126	6.3097	6.3339	6.3183	6.3498
	(6.653)	(5.3392)	(5.2251)	(5.2003)	(5.1535)
100	4.7409	4.5998	4.6173	4.6059	4.6091
	(4.1993)	(3.645)	(3.5956)	(3.5901)	(3.5684)
500	2.3183	2.232	2.2421	2.2391	2.2347
	(1.7015)	(1.6378)	(1.5942)	(1.6099)	(1.5851)
1000	1.6404	1.5934	1.6011	1.6005	1.5932
	(1.1098)	(1.1081)	(1.103)	(1.1087)	(1.0792)
1500	1.3793	1.3154	1.3332	1.3363	1.3327
	(1.0202)	(0.9565)	(0.9718)	(0.9752)	(0.9669)
2000	1.2776	1.1713	1.2019	1.2066	1.2004
	(0.9261)	(0.7914)	(0.7969)	(0.8041)	(0.7919)
2500	1.1711	1.0566	1.1013	1.1022	1.0981
	(0.8249)	(0.7212)	(0.7411)	(0.7494)	(0.743)
3000	1.1425	0.9992	1.0489	1.0473	1.045
	(0.8327)	(0.6748)	(0.7105)	(0.7102)	(0.7006)
3500	1.106	0.9602	1.0133	1.0155	1.0124
	(0.751)	(0.637)	(0.6617)	(0.6661)	(0.6614)
4000	1.0843	0.9357	0.9972	1.001	1.0033
	(0.7675)	(0.6596)	(0.7168)	(0.7198)	(0.7212)
4500	1.0768	0.9312	1.0036	1.0055	1.0027
	(0.7953)	(0.6946)	(0.7535)	(0.763)	(0.7572)
5000	1.0748	0.9162	0.995	0.9975	0.9987
	(0.8434)	(0.6872)	(0.7464)	(0.7508)	(0.751)

Table B.15: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: Normal, Cov: CS, p: 25). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	6.2735	6.4271	6.4496	6.3029	6.4011
	(4.9977)	(6.8234)	(6.7137)	(5.1294)	(5.3167)
100	4.6939	4.6179	4.6761	4.6042	4.6308
	(3.6362)	(4.206)	(4.1833)	(3.5722)	(3.6296)
500	2.3159	2.2657	2.2444	2.2473	2.2371
	(1.69)	(1.6959)	(1.6286)	(1.612)	(1.6549)
1000	1.6585	1.5939	1.6051	1.6055	1.5978
	(1.1399)	(1.1199)	(1.109)	(1.1141)	(1.1152)
1500	1.383	1.3156	1.3358	1.341	1.3499
	(1.0271)	(0.9529)	(0.9716)	(0.9767)	(1.0133)
2000	1.2836	1.1845	1.1956	1.2089	1.2177
	(0.9278)	(0.7971)	(0.7917)	(0.8074)	(0.8467)
2500	1.1691	1.0646	1.0948	1.1033	1.104
	(0.8256)	(0.7172)	(0.7401)	(0.7497)	(0.7539)
3000	1.147	1.0049	1.0463	1.0511	1.0463
	(0.839)	(0.6766)	(0.7053)	(0.7116)	(0.7056)
3500	1.11	0.9677	1.0142	1.0209	1.0162
	(0.7553)	(0.6501)	(0.6594)	(0.6677)	(0.6629)
4000	1.0924	0.9384	1.001	1.0037	1.0053
	(0.7739)	(0.6617)	(0.7235)	(0.7199)	(0.7202)
4500	1.0778	0.9304	1.0057	1.011	1.0108
	(0.7985)	(0.7079)	(0.7546)	(0.764)	(0.7602)
5000	1.0765	0.9155	0.9895	0.9987	1.0009
	(0.8438)	(0.6923)	(0.7454)	(0.7509)	(0.7568)

Table B.16: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: MVT, Cov: CS, p: 500). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	120.3212	120.2556	120.7074	120.8784	120.7994
	(93.2201)	(93.0909)	(89.9401)	(89.9709)	(89.9125)
100	88.5822	88.326	88.5966	88.7537	88.6691
	(66.4621)	(66.0985)	(64.9245)	(65.1994)	(64.8893)
500	44.3914	44.334	44.3643	44.3381	44.4264
	(35.1383)	(35.0718)	(34.9451)	(34.9201)	(34.9559)
1000	31.7496	31.7864	150.5225	105.115	106.1727
	(29.044)	(28.9916)	(149.5966)	(111.5807)	(113.0681)
1500	26.1235	26.154	202.9704	155.3792	150.4674
	(21.6455)	(21.6384)	(158.0896)	(126.4856)	(126.7527)
2000	23.2624	23.3035	206.329	107.8317	116.6623
	(20.3948)	(20.3648)	(169.4468)	(92.2741)	(105.2508)
2500	20.6803	20.7241	193.8943	113.3676	114.3509
	(17.115)	(17.1106)	(170.1859)	(108.5032)	(113.1484)
3000	19.2337	19.2619	182.0683	110.671	107.9962
	(15.2609)	(15.2308)	(174.0569)	(89.0459)	(96.734)
3500	17.8326	17.8413	158.3137	108.0894	100.3446
	(13.5801)	(13.551)	(162.811)	(137.0786)	(99.7587)
4000	16.6866	16.6905	157.45	111.3217	108.3528
	(12.1861)	(12.1758)	(303.8474)	(157.7998)	(132.1399)
4500	15.3638	15.3799	136.0237	98.5089	102.4877
	(11.2855)	(11.2843)	(160.5496)	(91.1061)	(126.3839)
5000	14.6756	14.6811	131.3012	107.5612	100.1432
	(10.5289)	(10.5422)	(175.2724)	(100.6893)	(98.6153)

Table B.17: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: Normal, Cov: CS, p: 500). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	120.5722	120.1881	120.8256	120.5395	120.7889
	(93.1813)	(93.1674)	(89.9458)	(89.9162)	(89.9644)
100	88.7246	88.3243	88.7701	88.4443	88.5904
	(66.4384)	(66.1209)	(65.157)	(64.8657)	(64.8536)
500	44.3825	44.3497	44.523	44.2706	44.3914
	(35.1299)	(35.1444)	(34.9597)	(34.8709)	(34.9474)
1000	31.8298	31.8052	150.0935	105.1308	105.9443
	(29.0759)	(29.0439)	(149.1399)	(111.5952)	(112.8622)
1500	26.1884	26.1582	206.8307	152.5396	146.1853
	(21.6682)	(21.654)	(159.3001)	(121.7528)	(116.6872)
2000	23.3432	23.3138	201.0015	106.7662	114.3403
	(20.3963)	(20.387)	(172.23)	(90.3521)	(104.2282)
2500	20.7319	20.7235	191.5536	112.7888	115.793
	(17.1165)	(17.114)	(170.0984)	(102.6712)	(113.1983)
3000	19.2743	19.2773	180.7304	105.9405	114.3644
	(15.2529)	(15.2518)	(165.9401)	(86.9019)	(105.2471)
3500	17.8764	17.8556	170.1102	106.971	110.7457
	(13.577)	(13.5847)	(180.9422)	(134.1699)	(146.3119)
4000	16.7113	16.7082	165.2805	108.752	105.9652
	(12.1833)	(12.1828)	(239.1037)	(112.2783)	(103.0645)
4500	15.3754	15.4159	155.0891	102.7871	104.4394
	(11.2898)	(11.3018)	(184.042)	(95.5204)	(116.2042)
5000	14.6893	14.7267	137.5127	105.826	99.9495
	(10.5383)	(10.555)	(166.052)	(135.5597)	(99.7792)

Table B.18: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: MVT(5), Cov: CS, p: 50). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	12.2385	12.193	12.2198	12.1379	12.2055
	(10.0966)	(10.0836)	(9.7382)	(9.5405)	(9.6901)
100	10.266	9.4268	9.2767	9.305	9.2983
	(9.0731)	(7.6389)	(7.1499)	(7.1877)	(7.2504)
500	4.5491	4.4848	4.4576	4.566	4.465
	(4.3392)	(4.128)	(4.407)	(4.5152)	(4.4118)
1000	3.3265	3.2185	3.2337	3.3253	3.2588
	(2.6868)	(2.6074)	(2.4005)	(2.729)	(2.4842)
1500	2.7908	2.671	2.7281	2.7684	2.7187
	(1.9961)	(1.9809)	(1.8869)	(2.0195)	(1.8817)
2000	2.6002	2.4508	2.5481	2.6167	2.5599
	(2.3312)	(2.0835)	(2.0973)	(2.2015)	(2.11)
2500	2.3098	2.22	2.3357	2.357	2.3168
	(1.9403)	(1.8513)	(1.8937)	(1.9793)	(1.8872)
3000	2.2296	2.1105	2.2436	2.2693	2.2442
	(1.833)	(1.6352)	(1.631)	(1.7009)	(1.6458)
3500	2.1501	1.9982	2.1425	2.154	2.1484
	(1.6)	(1.4218)	(1.4817)	(1.5096)	(1.4886)
4000	2.1083	1.9508	2.0905	2.1028	2.0937
	(1.5391)	(1.3853)	(1.4678)	(1.4787)	(1.4746)
4500	2.0786	1.9528	2.0829	2.0894	2.0774
	(1.4118)	(1.3377)	(1.4412)	(1.4394)	(1.4277)
5000	2.0417	1.8917	2.0451	2.0332	2.0444
	(1.7003)	(1.4057)	(1.5516)	(1.5063)	(1.5275)

Table B.19: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: Normal, Cov: CS, p: 50). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	12.2024	12.2204	12.1202	12.2169	12.1443
	(10.0894)	(10.0807)	(9.5742)	(9.7157)	(9.5656)
100	10.2297	9.4273	9.3029	9.2985	9.2934
	(9.092)	(7.6095)	(7.3516)	(7.1681)	(7.2269)
500	4.5734	4.4706	4.4996	4.4955	4.4809
	(4.3458)	(4.125)	(4.4349)	(4.4871)	(4.4349)
1000	3.3424	3.225	3.2666	3.271	3.2405
	(2.6701)	(2.6082)	(2.5042)	(2.5986)	(2.3908)
1500	2.8005	2.6653	2.7035	2.7673	2.7139
	(1.999)	(1.9839)	(1.8814)	(1.9939)	(1.9048)
2000	2.6053	2.4745	2.5695	2.574	2.543
	(2.3382)	(2.1004)	(2.1296)	(2.1783)	(2.1017)
2500	2.3421	2.2305	2.3348	2.3411	2.3131
	(1.9797)	(1.8558)	(1.894)	(1.9684)	(1.8808)
3000	2.2484	2.1243	2.2553	2.2606	2.2376
	(1.8507)	(1.6458)	(1.6477)	(1.6911)	(1.6277)
3500	2.1672	2.0064	2.153	2.152	2.1737
	(1.6178)	(1.4243)	(1.4925)	(1.5027)	(1.5192)
4000	2.1133	1.9602	2.0895	2.1074	2.1098
	(1.5422)	(1.3875)	(1.4767)	(1.4893)	(1.496)
4500	2.1096	1.9642	2.0825	2.0946	2.1007
	(1.4798)	(1.3235)	(1.4366)	(1.4426)	(1.4404)
5000	2.0318	1.8827	2.0345	2.0564	2.0431
	(1.4558)	(1.3648)	(1.52)	(1.55)	(1.5438)

Table B.20: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: Normal, Cov: RWISH, p: 100). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	10044.9965	10083.6969	5663.3434	6847.4774	5524.0269
	(3568.4594)	(3657.2901)	(3505.9003)	(3226.0164)	(3522.421)
100	7633.0376	7659.4954	4765.9468	5853.788	4690.9003
	(4404.4688)	(4424.9292)	(4444.4674)	(4284.6242)	(4451.587)
500	3812.0745	3712.1677	2314.4848	3380.3129	2257.3703
	(1386.4984)	(1397.5561)	(789.6372)	(1290.7946)	(748.9715)
1000	2684.1115	2645.3702	1989.5991	2500.0489	1962.9169
	(872.1066)	(799.0427)	(723.034)	(788.3769)	(700.6425)
1500	2278.8972	2262.8564	1946.4159	2246.2805	1925.7647
	(860.2051)	(880.79)	(1304.6455)	(947.9947)	(1351.9421)
2000	2013.3461	1999.8803	1812.4718	2165.4689	1803.2405
	(563.9229)	(597.5172)	(574.5897)	(681.6064)	(579.2322)
2500	1867.5794	1868.6982	1779.2029	2196.2099	1776.8126
	(528.5684)	(818.5844)	(579.7253)	(696.2455)	(614.72)
3000	1784.3738	1804.0951	1774.1884	2226.622	1773.0515
	(467.8679)	(1420.0204)	(629.8486)	(722.3185)	(639.2088)
3500	1757.3879	1731.071	1798.5439	2299.7352	1801.3951
	(937.9398)	(905.1069)	(1501.5146)	(2064.6622)	(1521.1109)
4000	1699.8067	1676.2043	1735.8406	2265.0656	1734.0282
	(714.2736)	(725.6333)	(766.5278)	(1204.8091)	(767.0355)
4500	1673.2413	1654.661	1715.1355	2246.692	1717.2876
	(632.3223)	(744.6464)	(642.4197)	(1084.7477)	(651.7005)
5000	1651.6106	1626.596	1735.7541	2240.1553	1727.8889
	(575.0335)	(618.4906)	(925.3335)	(988.1759)	(855.1775)

Table B.21: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Stationary, Dist:MVT(5), Cov: RWISH, p: 100). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	10266.5945	10297.9984	5933.0655	7070.491	5770.0617
	(4476.4208)	(4504.7861)	(4474.6974)	(4096.9593)	(4448.8094)
100	7460.8123	7460.7446	4637.6649	5671.2542	4543.9155
	(2792.0492)	(2794.7247)	(2845.5843)	(2567.2935)	(2833.5453)
500	3745.9257	3576.734	2258.5285	3534.6807	2216.3255
	(3174.6537)	(1184.6958)	(1054.4632)	(3058.9002)	(1046.3781)
1000	2662.0955	2589.13	1967.0108	2827.1966	1941.8843
	(1278.2623)	(641.4964)	(606.1526)	(1649.3461)	(590.8494)
1500	2214.3441	2180.3864	1847.0071	2368.6805	1830.4949
	(744.6638)	(525.3998)	(604.7957)	(1089.7153)	(608.9461)
2000	2010.0365	1987.2919	1816.7622	2197.456	1810.4402
	(775.2382)	(719.749)	(778.3)	(1261.1834)	(785.0474)
2500	1840.3983	1824.6306	1731.9848	2085.9566	1729.2717
	(539.179)	(540.9006)	(479.6409)	(882.1622)	(477.2177)
3000	1756.5585	1732.767	1729.3045	2052.4529	1724.4256
	(455.5343)	(461.6215)	(643.8526)	(670.2883)	(673.3104)
3500	1685.4807	1659.6463	1697.8694	2039.4806	1703.6494
	(377.7942)	(363.6401)	(486.3183)	(652.3331)	(503.9547)
4000	1643.2688	1620.7995	1710.5448	2097.9954	1710.8921
	(398.2881)	(375.8844)	(537.337)	(796.5428)	(568.3307)
4500	1626.8175	1601.8564	1699.2809	2126.4913	1698.6252
	(415.1253)	(380.431)	(532.352)	(798.4894)	(548.2017)
5000	1619.4238	1595.8424	1702.7292	2180.9274	1703.0788
	(519.6261)	(512.2256)	(722.1361)	(1504.376)	(769.792)

Table B.22: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: Normal, Cov: RWISH, p: 100). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	10394.1856	10394.2351	6000.9502	7171.1603	5855.5472
	(4557.24)	(4556.823)	(4509.9615)	(4187.1664)	(4519.2091)
100	7533.3709	7524.6839	4688.1566	5751.0295	4604.7573
	(2751.963)	(2750.4772)	(2775.6254)	(2527.0261)	(2781.6353)
500	3783.5364	3616.5375	2321.9117	3601.7284	2277.4549
	(3096.301)	(1159.6791)	(1067.9546)	(3078.2055)	(1060.4102)
1000	2686.977	2615.1938	2012.9334	2868.6552	1985.7369
	(1252.8744)	(635.4396)	(657.2772)	(1580.4612)	(638.3823)
1500	2237.722	2205.1424	1892.9191	2437.2949	1873.6847
	(735.8771)	(526.7812)	(611.1275)	(1164.1167)	(602.9196)
2000	2030.8733	2009.5794	1847.1984	2207.3527	1839.8287
	(803.2029)	(750.4672)	(807.5611)	(951.5333)	(832.4905)
2500	1861.9622	1846.7434	1778.6738	2075.4032	1774.0424
	(564.92)	(566.6106)	(540.0941)	(750.358)	(552.0215)
3000	1777.6327	1753.8434	1765.0782	2065.7216	1764.1978
	(472.1933)	(475.3804)	(685.3059)	(694.4008)	(692.9762)
3500	1704.5517	1679.0015	1726.621	2076.9981	1724.3389
	(388.0905)	(373.5366)	(481.9299)	(707.6339)	(468.4284)
4000	1662.6847	1639.5401	1745.4915	2123.3159	1750.685
	(428.0958)	(400.2352)	(604.5779)	(854.0183)	(658.7249)
4500	1645.4275	1619.4337	1738.4485	2169.3339	1745.3028
	(425.7102)	(390.9557)	(618.3375)	(839.8048)	(643.821)
5000	1639.726	1616.6353	1746.04	2239.3442	1752.0212
	(554.4306)	(546.2439)	(870.7929)	(1162.946)	(902.3484)

Table B.23: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Stationary, Distribution:MVT(5), Cov:RWISH, p: 10). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	117.9619	117.8544	97.5343	109.832	90.7475
	(77.3523)	(76.86)	(71.8774)	(70.7498)	(70.742)
100	88.522	88.2778	77.4185	84.7461	74.1365
	(51.8718)	(52.0177)	(48.8165)	(48.5374)	(48.4372)
500	44.1447	42.0389	40.3787	41.6444	39.835
	(29.7017)	(17.1068)	(16.265)	(16.6039)	(16.0688)
1000	32.4955	30.1183	29.4578	30.0225	29.2313
	(17.6834)	(9.4475)	(8.95)	(9.3005)	(8.7944)
1500	28.2805	24.675	24.3415	24.5678	24.2402
	(19.9483)	(6.794)	(6.7923)	(6.6206)	(6.7276)
2000	25.4128	21.5235	21.338	21.4212	21.2533
	(16.5368)	(5.7034)	(5.7365)	(5.5384)	(5.6906)
2500	24.0548	19.5356	19.5949	19.5166	19.5377
	(14.2785)	(5.6768)	(6.3623)	(6.0346)	(6.3397)
3000	22.9101	17.8476	17.9153	17.7584	17.8803
	(13.0612)	(4.5741)	(4.9538)	(4.7708)	(4.9286)
3500	23.6134	16.7972	16.989	16.7364	16.9553
	(43.0506)	(4.1215)	(4.3644)	(4.2139)	(4.324)
4000	21.8523	15.8224	16.0666	15.732	16.0517
	(14.1677)	(3.4717)	(3.6065)	(3.502)	(3.5851)
4500	21.4913	15.1958	15.5167	15.0703	15.5289
	(12.7289)	(3.3779)	(3.4586)	(3.2791)	(3.4364)
5000	21.6589	14.8859	15.2382	14.6834	15.2919
	(16.147)	(3.5066)	(3.5928)	(3.2892)	(3.6085)

Table B.24: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Stationary, Distribution:Normal, Cov:RWISH, p:10). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	108.489	108.5304	87.2709	101.0085	80.5845
	(102.2461)	(102.2348)	(98.0778)	(97.1092)	(97.6378)
100	80.8671	80.3935	68.7743	77.2939	65.259
	(59.9631)	(59.7628)	(57.6308)	(57.3517)	(57.4837)
500	39.6865	38.0485	35.9686	37.6661	35.4191
	(24.6488)	(17.4929)	(16.7242)	(17.0112)	(16.5756)
1000	29.2709	27.3029	26.3764	27.1401	26.1494
	(15.4478)	(9.0618)	(8.4653)	(8.8754)	(8.3348)
1500	25.2667	22.3817	21.8649	22.2301	21.6425
	(15.6753)	(6.5646)	(6.2045)	(6.1612)	(5.7908)
2000	22.962	19.5296	19.2153	19.4156	19.0491
	(13.9275)	(5.3669)	(5.1888)	(5.0941)	(4.9937)
2500	21.9322	17.7301	17.5325	17.6	17.4309
	(13.4273)	(5.2642)	(5.2324)	(5.04)	(5.1441)
3000	20.8021	16.1563	16.0469	16.0343	15.9804
	(12.2936)	(4.1147)	(4.0193)	(3.9574)	(3.96)
3500	21.526	15.2042	15.1694	15.0782	15.127
	(44.3038)	(3.6912)	(3.5815)	(3.578)	(3.5281)
4000	19.8984	14.3547	14.3833	14.1978	14.3703
	(13.7393)	(3.1474)	(3.0805)	(3.0253)	(3.0522)
4500	19.469	13.7476	13.8437	13.5654	13.8621
	(11.3076)	(2.9041)	(2.8428)	(2.7467)	(2.8242)
5000	19.7599	13.4294	13.6038	13.2087	13.6246
	(16.1385)	(2.9446)	(2.997)	(2.7573)	(2.9778)

Table B.25: Average squared Frobenius norm, $||\tilde{\Sigma}-\Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: MVT(5), Cov: RWISH, p: 250). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	63302.8608	63156.3759	33382.3046	37706.6851	32962.3263
	(30935.9085)	(30875.9741)	(30868.6381)	(29743.5234)	(30911.7619)
100	47441.1897	47368.61	27502.6763	31925.6856	27250.1838
	(28119.4217)	(28119.6025)	(28803.0125)	(27915.5905)	(28822.5133)
500	22499.3521	22462.8603	10835.933	21938.1384	10460.9521
	(8563.081)	(8531.8292)	(10052.1856)	(12255.8789)	(10078.2709)
1000	16294.4195	16273.308	10154.468	18934.5319	9860.3927
	(6975.3975)	(6960.8343)	(8517.6803)	(10953.3517)	(8057.7652)
1500	13374.0851	13360.7526	9959.982	17161.4531	9844.7075
	(4924.0714)	(4917.7636)	(7608.2765)	(9464.6803)	(7734.239)
2000	11656.3071	11648.6247	9773.1175	15695.0705	9637.9509
	(4166.3834)	(4163.5785)	(7755.8912)	(6977.6119)	(8144.4729)
2500	10441.1368	10435.9259	9842.9098	14898.4508	9591.387
	(3402.2079)	(3400.9889)	(6880.6147)	(6622.3183)	(6354.0238)
3000	9484.5774	9481.6181	9295.6024	14382.81	9081.6973
	(2805.0984)	(2803.8663)	(4410.1731)	(6585.2716)	(4344.5148)
3500	8789.4522	8787.4551	9843.6252	14272.2285	9667.049
	(2386.2526)	(2385.2862)	(6055.8567)	(5818.9319)	(6358.1448)
4000	8220.7581	8217.0667	9676.5312	14050.6226	9424.6443
	(2077.7679)	(2077.17)	(5576.0455)	(6298.7155)	(5067.0672)
4500	7765.9095	7765.0159	9541.5542	14704.2385	9284.4201
	(1888.7094)	(1888.7281)	(4984.1481)	(11813.3315)	(4981.4818)
5000	7356.2638	7352.6899	9501.3269	13913.9584	9136.5832
	(1675.5882)	(1674.4546)	(5729.2274)	(4954.9159)	(5228.9852)

Table B.26: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: Normal, Cov: RWISH, p: 250). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	62278.7519	62206.7184	32611.7963	37016.711	32334.0623
	(23653.7558)	(23540.1283)	(23598.1429)	(22285.5002)	(23708.5595)
100	45964.7064	45947.5097	26090.9949	30563.7621	25895.2247
	(18424.8338)	(18416.0872)	(19102.607)	(17985.0204)	(19131.5525)
500	22320.4233	22316.6702	10709.8273	22023.4713	10286.073
	(7189.5702)	(7189.3861)	(8862.4204)	(12070.4113)	(8688.1181)
1000	16010.9664	16006.0102	9870.1455	18650.2588	9658.1907
	(6062.1063)	(6060.4253)	(7168.6662)	(11622.8111)	(7763.0671)
1500	13142.2461	13144.6787	9859.9081	17015.8495	9755.3012
	(4317.9741)	(4318.1922)	(8173.3051)	(10556.3182)	(8685.7401)
2000	11445.0342	11442.8747	9807.8854	16117.2455	9714.1421
	(3280.0867)	(3279.5739)	(6495.0872)	(9828.0594)	(7009.4226)
2500	10270.2161	10268.5237	9718.1002	15116.3921	9626.0387
	(2742.9981)	(2742.4288)	(6197.2766)	(9793.5491)	(6590.2245)
3000	9361.1927	9359.6823	9332.5898	14070.0765	9107.3336
	(2285.8477)	(2285.7686)	(4149.2981)	(5274.7391)	(3765.5796)
3500	8735.3636	8733.3706	9638.7124	14073.6298	9499.3859
	(2440.0518)	(2439.6966)	(5532.8223)	(6270.7104)	(5898.3103)
4000	8207.5022	8206.0724	9529.9122	14161.3321	9327.8966
	(2304.6344)	(2304.1091)	(5903.0099)	(7998.4036)	(5843.3236)
4500	7765.9209	7764.5178	9730.718	14756.2629	9482.2905
	(2078.7534)	(2078.4614)	(5997.9383)	(9525.1466)	(5630.0364)
5000	7372.2236	7370.6479	9689.788	14653.9174	9322.9748
	(1875.0253)	(1874.9257)	(6579.582)	(8533.7035)	(5734.7554)

Table B.27: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: MVT(5), Cov: RWISH, p: 25). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	662.9393	660.3169	452.5283	551.1765	431.6741
	(363.5373)	(376.3957)	(346.4776)	(332.5655)	(355.9637)
100	487.7703	474.7311	352.7747	426.1459	340.2997
	(215.0706)	(205.8395)	(188.1468)	(186.0995)	(189.214)
500	234.1265	227.4636	200.009	221.4485	196.9233
	(72.7619)	(69.4546)	(62.0943)	(66.9813)	(59.5963)
1000	170.4291	163.3781	151.1834	160.7908	149.705
	(53.1797)	(45.5037)	(42.3488)	(43.9585)	(41.9018)
1500	144.5219	135.1265	128.8114	132.9651	128.1696
	(41.6587)	(34.5808)	(32.2689)	(33.0437)	(32.0674)
2000	132.2127	119.9009	117.0876	117.5	116.7373
	(41.5771)	(31.1468)	(27.1025)	(29.14)	(27.004)
2500	123.8689	110.3411	110.1999	107.5058	110.0945
	(35.6876)	(26.5016)	(25.6349)	(24.3271)	(25.8984)
3000	116.2732	102.0163	103.6938	99.1928	103.764
	(28.0171)	(19.7076)	(19.012)	(18.0493)	(19.2955)
3500	112.8654	97.9291	101.2736	94.8329	101.5665
	(27.1474)	(22.7102)	(21.9655)	(21.2617)	(22.0119)
4000	110.2277	95.259	100.2852	91.5679	100.7403
	(33.855)	(28.4139)	(35.4985)	(23.8018)	(36.1906)
4500	108.0457	92.2822	98.0312	88.4431	98.6509
	(27.0484)	(21.4781)	(23.6481)	(19.0134)	(23.8896)
5000	108.316	91.7567	98.1537	87.3537	98.9209
	(33.6551)	(24.3531)	(27.2303)	(21.3452)	(27.5809)

Table B.28: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Distribution: Normal, Cov: RWISH, p: 25). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	661.667	654.7299	450.0869	550.0553	424.1537
	(378.0677)	(378.6575)	(367.0854)	(349.3185)	(362.0655)
100	489.3155	471.6523	350.5412	425.2125	335.4447
	(243.9343)	(213.1542)	(204.5964)	(199.6944)	(200.8427)
500	233.5619	227.5516	199.762	221.5921	196.0348
	(72.9683)	(71.3437)	(64.202)	(69.069)	(62.5725)
1000	170.0038	163.3425	150.7673	160.7689	148.8603
	(55.9142)	(47.9885)	(45.0588)	(46.3762)	(44.7591)
1500	144.3362	135.1358	128.5869	132.9681	127.597
	(43.1396)	(35.9064)	(34.0412)	(34.3526)	(33.8718)
2000	131.5632	119.3936	116.3662	117.0794	115.6996
	(39.28)	(29.8161)	(26.2885)	(28.0327)	(26.347)
2500	123.1716	109.779	109.2452	107.0169	108.7861
	(34.4065)	(25.06)	(24.0723)	(23.3405)	(23.9573)
3000	115.8569	101.5791	102.7218	98.6922	102.4017
	(27.7256)	(18.9069)	(18.0685)	(17.3946)	(17.8603)
3500	112.4943	97.4434	100.0676	94.0979	99.9772
	(25.7895)	(19.4433)	(17.6088)	(17.6455)	(17.6139)
4000	110.377	95.1554	99.3491	91.1553	99.5006
	(32.5454)	(25.8151)	(31.35)	(21.037)	(31.9571)
4500	108.5409	92.3596	97.3596	88.1989	97.5525
	(29.1996)	(20.4403)	(21.4556)	(17.2224)	(21.3502)
5000	108.0577	91.4812	97.4643	87.0355	97.6566
	(33.4632)	(23.8374)	(27.4363)	(20.6964)	(27.6173)

Table B.29: Average squared Frobenius norm, $||\tilde{\Sigma}-\Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: MVT(5), Cov: RWISH, p: 500). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	250065.0758	250355.9736	128224.6052	138650.8141	127935.3834
	(113639.1895)	(113873.1547)	(114095.7611)	(111068.0129)	(114565.1051)
100	185752.638	185893.822	103379.0896	114555.6798	102795.5786
	(105868.3635)	(105884.758)	(108826.6983)	(106559.7191)	(108406.5551)
500	88409.1456	88421.5627	56258.2648	67404.386	56129.86
	(30522.0109)	(30516.4197)	(32608.002)	(30519.6946)	(32667.5746)
1000	63946.3191	63950.8216	35290.9267	65539.4846	34057.555
	(23051.1778)	(23049.5587)	(49396.5016)	(50305.291)	(50139.7663)
1500	52369.7385	52372.1857	32500.6109	60301.432	30738.2388
	(15271.8955)	(15270.6319)	(32336.1744)	(29221.8091)	(28066.2855)
2000	45785.1123	45792.9458	33681.7845	53798.7737	31872.8778
	(17638.5254)	(17636.1739)	(54755.4939)	(33792.3225)	(59489.4493)
2500	41393.0457	41392.3533	36829.3347	51635.8982	34169.3842
	(19903.3354)	(19903.3447)	(89902.6099)	(27404.808)	(66974.7588)
3000	37897.9203	37897.4171	36130.5741	49030.1097	33358.1092
	(16537.8643)	(16537.8858)	(50333.4897)	(23403.276)	(37585.6507)
3500	35110.9146	35112.1716	33994.5387	47548.6075	32090.2093
	(14068.4487)	(14068.357)	(40054.1154)	(22527.4671)	(34589.3495)
4000	32847.3217	32852.7047	34696.9914	46165.2106	32996.5566
	(12222.541)	(12223.0772)	(39958.505)	(19416.9949)	(37526.2431)
4500	30966.6202	30971.861	34546.1762	45529.9982	33162.2412
	(10817.6309)	(10818.1284)	(39744.3712)	(18849.5625)	(36030.7458)
5000	29430.532	29435.6444	33021.9196	44495.7624	31808.1044
	(9783.9951)	(9784.2882)	(32472.3787)	(16836.0242)	(31818.9681)

Table B.30: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: Normal, Cov: RWISH, p: 500). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	249307.4479	249647.2413	127913.068	139684.8389	127210.3189
	(112469.7536)	(112474.131)	(113126.6364)	(111218.2124)	(113313.9898)
100	185504.6695	185963.3304	103445.2483	115272.7765	102929.6957
	(107664.8552)	(107769.0414)	(110699.6485)	(108683.4127)	(110756.4559)
500	88399.5087	88398.6912	56247.4854	67171.3657	56162.2507
	(30750.0687)	(30718.0128)	(32747.3214)	(29362.8342)	(32857.4158)
1000	63883.839	63922.939	34787.5765	64609.7814	33964.0517
	(22562.872)	(22566.0654)	(45996.5587)	(38623.6251)	(45688.7982)
1500	52313.1385	52341.2282	31024.3517	59926.1369	30483.5155
	(14965.3971)	(14968.2461)	(22950.0956)	(27981.6791)	(26502.5347)
2000	45730.1227	45749.7918	33847.8978	53861.3411	30658.9651
	(17317.0823)	(17317.07)	(59043.5408)	(26278.5038)	(27964.9362)
2500	41360.9598	41379.3231	36874.9077	51998.5679	35278.1441
	(20296.0738)	(20294.7225)	(100442.0055)	(31225.9969)	(102100.9843)
3000	37871.8925	37884.5385	36595.6649	49910.994	33375.5462
	(16865.3781)	(16863.8402)	(53293.1287)	(29542.6669)	(49796.0074)
3500	35087.1097	35088.7369	34817.2809	47895.1512	32365.7181
	(14351.5644)	(14351.5632)	(45587.6298)	(22982.215)	(42519.7273)
4000	32822.61	32813.8667	34067.2517	47819.1578	32394.4966
	(12470.9262)	(12468.4572)	(35116.6871)	(27968.8409)	(35846.3557)
4500	30946.19	30921.0897	35701.0429	46475.4846	32579.2502
	(11035.6152)	(11029.9553)	(45851.1748)	(20400.2967)	(34771.4941)
5000	29411.4097	29389.2963	33151.0698	46605.0361	31435.863
	(9973.2537)	(9968.2014)	(33674.2282)	(26992.8476)	(31811.2121)

Table B.31: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: MVT(5), Cov: RWISH, p: 50). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	2492.4139	2494.6209	1525.2277	1896.0245	1466.4551
	(1047.0824)	(1046.9951)	(1006.4261)	(917.9602)	(1011.2444)
100	1990.1008	1841.0244	1171.9577	1493.9299	1134.9664
	(805.9122)	(622.3314)	(561.8793)	(515.0455)	(563.67)
500	897.6686	874.0864	679.6131	828.9152	668.184
	(269.9932)	(233.1706)	(220.5428)	(228.1727)	(223.6039)
1000	664.6561	642.8173	545.7564	620.9532	540.5829
	(336.46)	(282.6182)	(279.174)	(261.2239)	(280.7853)
1500	566.6916	543.3515	494.4334	523.1624	495.1735
	(256.6921)	(234.591)	(234.221)	(216.2171)	(261.8641)
2000	515.7816	490.945	472.4991	474.9814	471.152
	(285.9454)	(261.8395)	(307.962)	(262.5596)	(306.6002)
2500	470.6121	448.508	449.4922	431.4811	447.9185
	(198.9481)	(179.6686)	(207.4338)	(174.0692)	(205.8654)
3000	444.1603	419.3432	432.6519	403.6264	431.4596
	(147.0972)	(124.8936)	(142.3199)	(123.366)	(139.5489)
3500	427.2291	399.2073	419.7839	386.7958	418.7702
	(126.614)	(96.1602)	(94.1032)	(100.3763)	(92.6426)
4000	413.0014	385.6903	415.4217	376.3481	415.939
	(95.6255)	(82.7644)	(106.5213)	(81.7208)	(106.2168)
4500	404.6638	375.7	410.6861	369.7776	410.309
	(97.7083)	(77.0201)	(93.5329)	(76.3202)	(90.0707)
5000	398.972	370.7603	409.4079	366.7354	410.4988
	(113.1644)	(124.6673)	(121.8288)	(105.645)	(123.7351)

Table B.32: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift: Stationary, Dist: Normal, Cov: RWISH, p: 50). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	2554.0497	2554.2143	1566.1473	1946.3662	1510.4441
	(1052.1606)	(1049.9749)	(1011.3183)	(914.758)	(1008.3499)
100	2041.6159	1888.151	1209.8449	1535.2657	1171.1442
	(821.4456)	(617.529)	(557.0222)	(506.8315)	(551.1054)
500	918.2637	899.3623	704.9183	852.0787	690.4839
	(267.9989)	(257.0105)	(243.2402)	(245.3277)	(234.9604)
1000	679.4705	659.4401	563.4663	637.5301	555.3301
	(320.3899)	(276.4404)	(258.864)	(257.7015)	(193.3529)
1500	579.8096	556.4186	509.9351	537.3052	510.4452
	(251.9999)	(234.1856)	(228.555)	(215.5843)	(273.0201)
2000	527.2547	502.4737	485.2877	483.1446	485.8106
	(278.5877)	(257.399)	(294.2619)	(244.948)	(303.4145)
2500	482.6263	460.3232	463.1112	441.6829	463.6212
	(197.6698)	(179.674)	(201.1976)	(171.9161)	(206.3734)
3000	455.6726	430.3998	447.1297	413.67	447.1247
	(147.0976)	(125.6243)	(145.9913)	(125.5179)	(148.2375)
3500	439.2452	410.4124	434.4605	397.3016	434.2586
	(134.3405)	(102.2311)	(104.4661)	(106.6666)	(104.259)
4000	424.6864	396.2729	428.7371	386.8468	430.0039
	(100.382)	(85.9426)	(105.9205)	(86.0888)	(107.8799)
4500	416.7031	386.3125	425.3192	380.7257	427.0107
	(103.7532)	(81.5003)	(100.3976)	(82.4557)	(104.5816)
5000	410.574	381.871	427.5903	377.6723	430.6077
	(114.7984)	(125.3018)	(190.5446)	(108.0398)	(194.182)

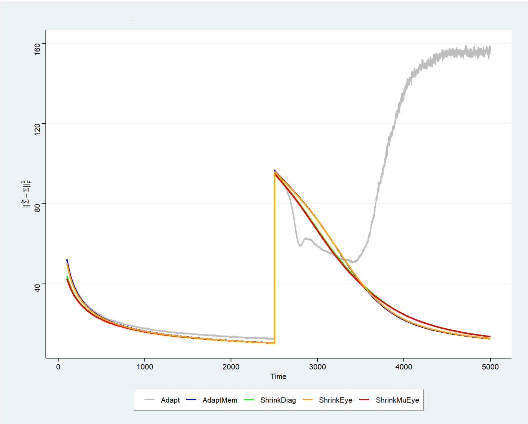
Table B.33: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points Drift:None, Distribution: MVT(10), Cov:RWISH. The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	7447.7523	7441.7246	2466.8662	4509.2714	2248.4216
	(412.9504)	(408.3377)	(104.4702)	(66.6773)	(91.8895)
100	5305.8875	5301.7492	2206.1259	3859.9116	2095.5446
	(216.5226)	(216.4704)	(51.2845)	(48.3636)	(43.9528)
500	2506.2215	2436.1281	1568.7999	2376.6209	1547.4671
	(130.1695)	(93.8366)	(20.1078)	(529.2878)	(19.7282)
1000	1764.863	1749.3688	1295.057	1722.6897	1283.409
	(48.112)	(36.8491)	(25.5053)	(262.3845)	(25.9487)
1500	1494.9442	1522.2328	1188.1368	1487.3156	1179.2332
	(31.1906)	(30.3113)	(32.3303)	(236.6443)	(32.4656)
2000	1374.1153	1427.1312	1161.1061	1408.3363	1153.9984
	(24.4421)	(28.3807)	(32.4596)	(213.6969)	(33.0148)
2500	1324.1208	1385.1249	1180.016	1395.5697	1174.209
	(22.1246)	(25.7525)	(33.2517)	(154.5835)	(33.1475)
3000	1312.3049	1372.8088	1227.1331	1416.2289	1222.2103
	(23.0359)	(24.0452)	(32.6163)	(203.2394)	(33.095)
3500	1318.7544	1376.9961	1285.8704	1438.2649	1283.539
	(23.2113)	(23.0414)	(30.7137)	(184.701)	(31.2105)
4000	1333.0547	1389.7423	1347.3171	1480.8206	1345.5267
	(24.3323)	(24.2714)	(29.7822)	(249.5909)	(30.3995)
4500	1353.6214	1407.0475	1403.9545	1496.5517	1403.9081
	(27.1218)	(25.8766)	(27.0335)	(155.9747)	(27.2145)
5000	1380.1847	1428.7386	1454.4556	1523.7364	1455.4567
	(33.6739)	(26.6396)	(25.7614)	(172.6259)	(26.0792)

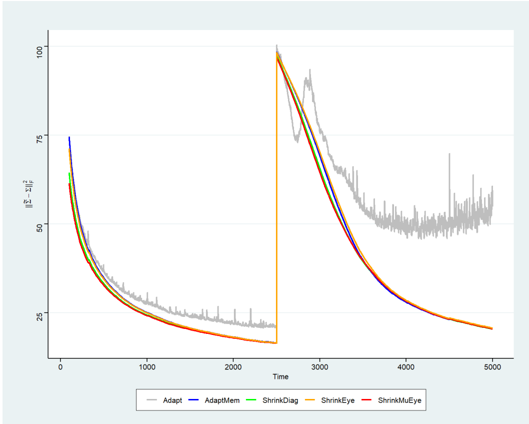
Table B.34: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points Drift:None, Distribution: MVT (25), Cov:RWISH. The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	7366.7918	7365.5855	2449.7961	4454.5599	2235.4258
	(434.1675)	(429.936)	(105.8577)	(67.0041)	(91.0131)
100	5229.5386	5229.637	2203.4993	3814.9103	2098.0527
	(220.1964)	(219.1898)	(49.0707)	(45.1221)	(40.6452)
500	2469.3941	2399.5581	1657.6691	2332.7524	1641.7642
	(124.8359)	(88.1608)	(19.5065)	(441.9363)	(19.5082)
1000	1718.4139	1702.7019	1414.3643	1723.2652	1408.7384
	(48.8937)	(37.1726)	(24.3484)	(346.4047)	(24.5273)
1500	1413.3201	1444.5535	1287.36	1446.0868	1284.641
	(31.4053)	(28.8286)	(26.358)	(204.9814)	(26.5537)
2000	1242.9993	1312.1525	1213.9677	1339.2545	1212.7456
	(24.4653)	(26.4595)	(27.5129)	(214.6091)	(27.7815)
2500	1132.6223	1229.6666	1167.6174	1285.5144	1167.526
	(21.263)	(25.8083)	(29.076)	(219.0297)	(29.7301)
3000	1055.6556	1175.8024	1138.5081	1253.9038	1139.0906
	(19.541)	(25.0867)	(30.7212)	(231.7873)	(31.473)
3500	999.6576	1139.5494	1120.3259	1248.0331	1121.5786
	(18.4716)	(23.6995)	(34.0982)	(280.0639)	(34.8443)
4000	957.6314	1115.909	1107.9956	1243.332	1109.0506
	(18.0755)	(24.9675)	(34.1198)	(276.4589)	(34.2642)
4500	925.7402	1100.452	1098.7405	1224.9606	1100.0514
	(17.9478)	(24.2559)	(33.1923)	(230.8536)	(33.2338)
5000	900.5105	1089.256	1092.2773	1235.2562	1093.7747
	(18.1022)	(24.8482)	(33.7602)	(335.7334)	(34.0772)

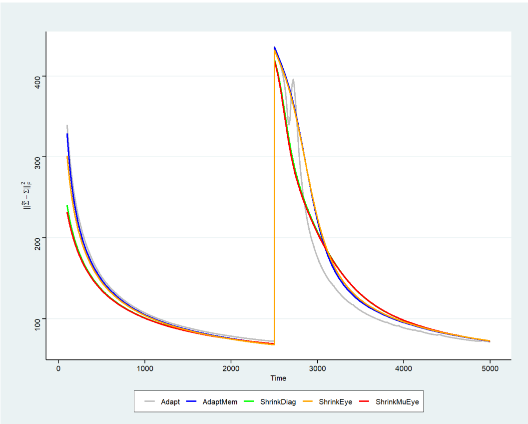
APPENDIX C: ABRUPT DRIFT COVARIANCE SIMULATION



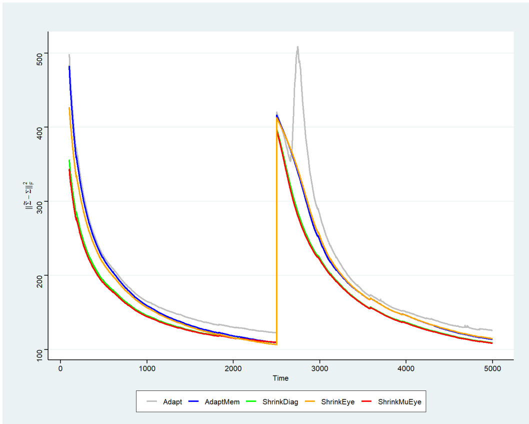
(a) Normal, $p = 10$



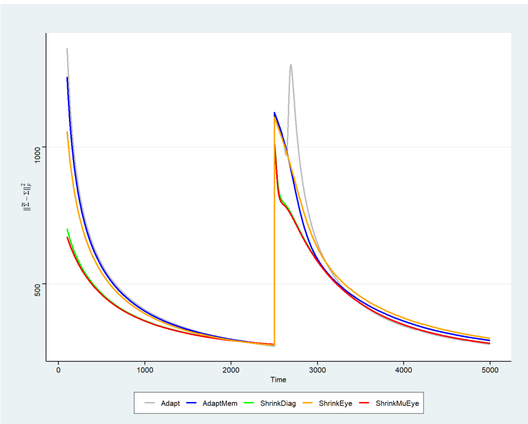
(b) mvt(5), $p = 10$



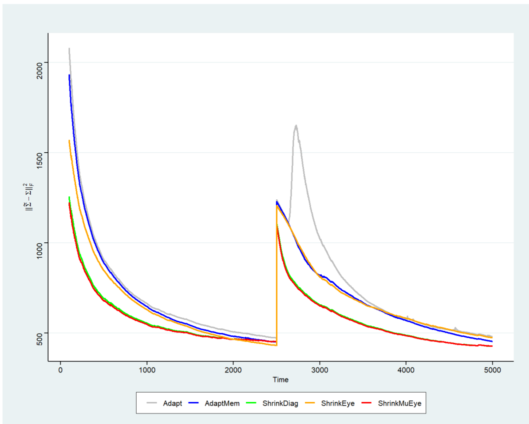
(c) Normal, $p = 25$



(d) mvt(5), $p = 25$

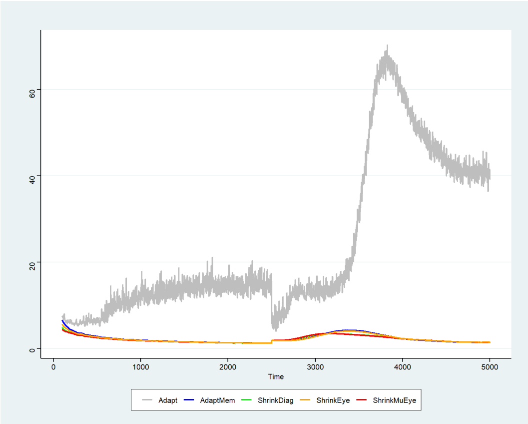


(e) Normal, $p = 50$

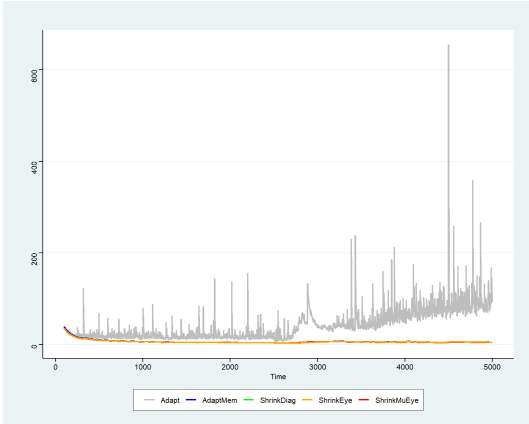


(f) mvt(5), $p = 50$

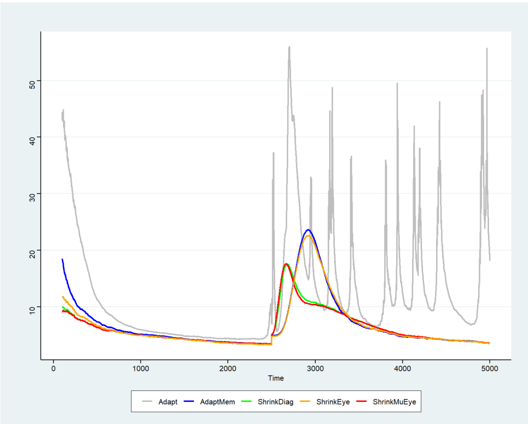
Figure C.0.1: Average loss comparison between Normal and mvt(5) for abrupt drift for Wishart covariance matrices ($p \leq 50$).



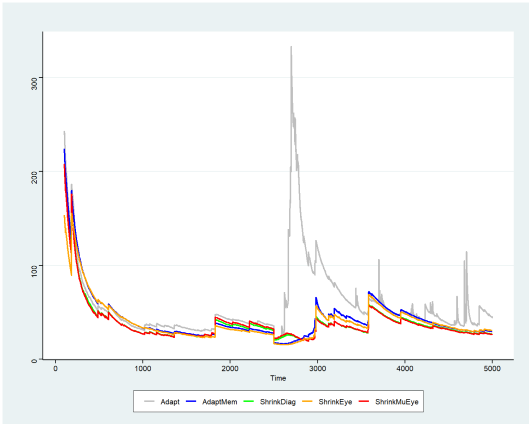
(a) Normal, $p = 10$



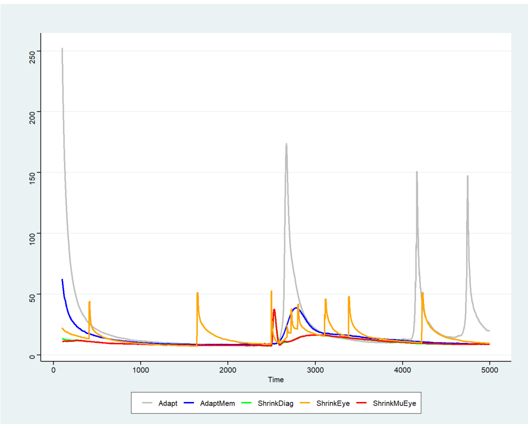
(b) mvt(5), $p = 10$



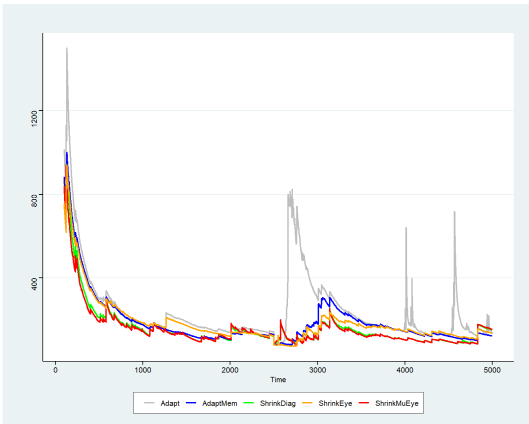
(c) Normal, $p = 25$



(d) mvt(5), $p = 25$

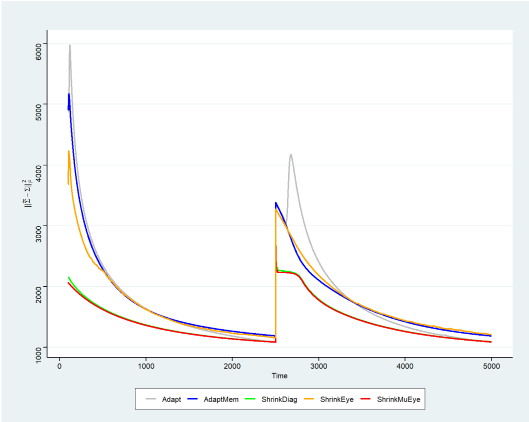


(e) Normal, $p = 50$

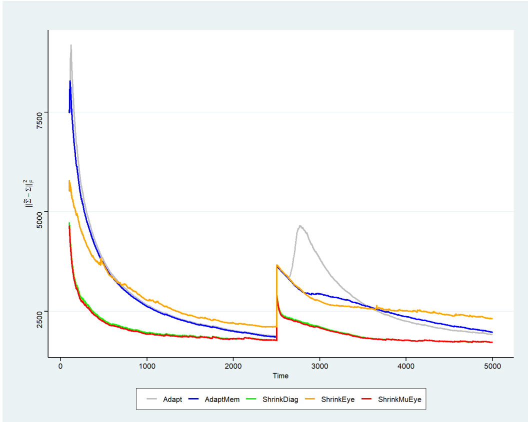


(f) mvt(5), $p = 50$

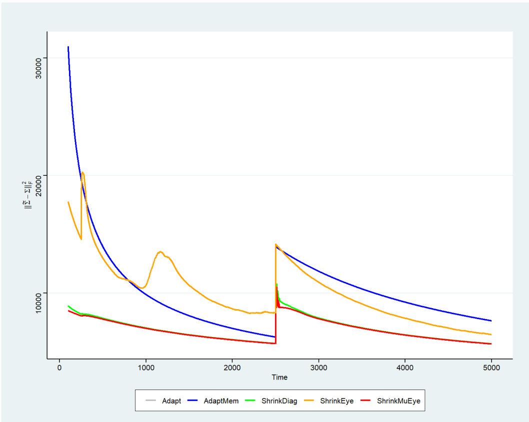
Figure C.0.2: Standard deviation loss comparison between Normal and mvt(5) for abrupt drift for Wishart covariance matrices ($p \leq 50$).



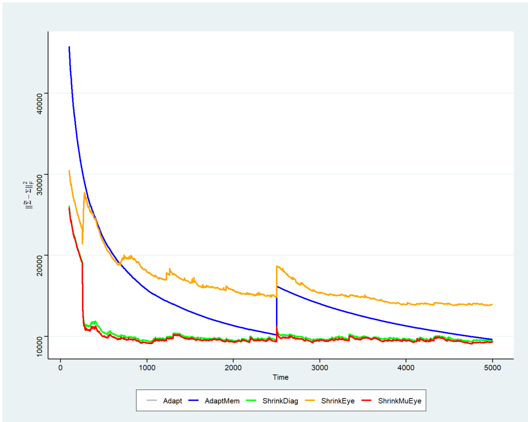
(a) Normal, $p = 100$



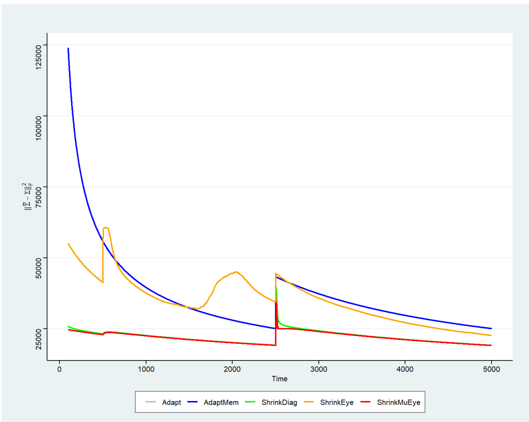
(b) mvt(5), $p = 100$



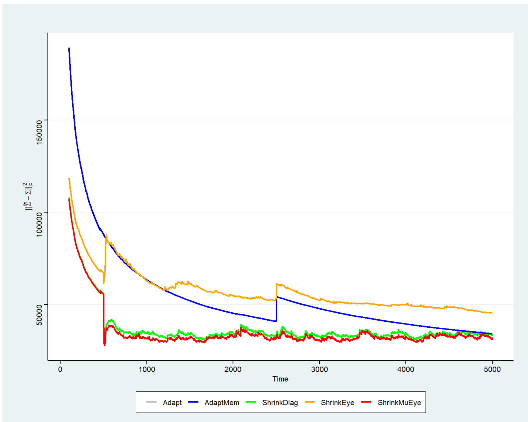
(c) Normal, $p = 250$



(d) mvt(5), $p = 250$

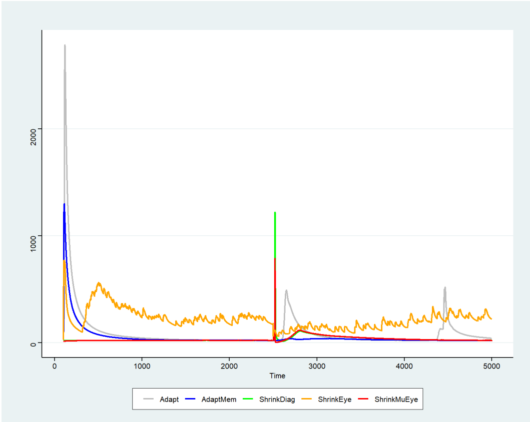


(e) Normal, $p = 500$

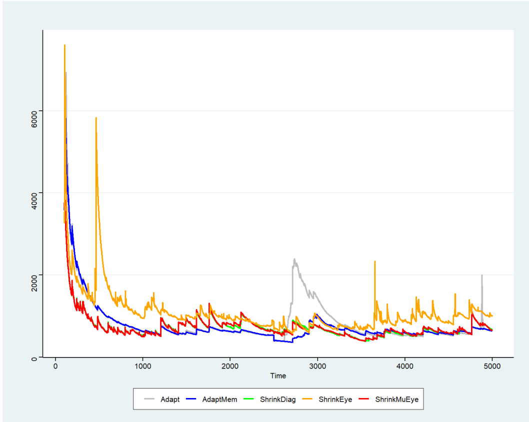


(f) mvt(5), $p = 500$

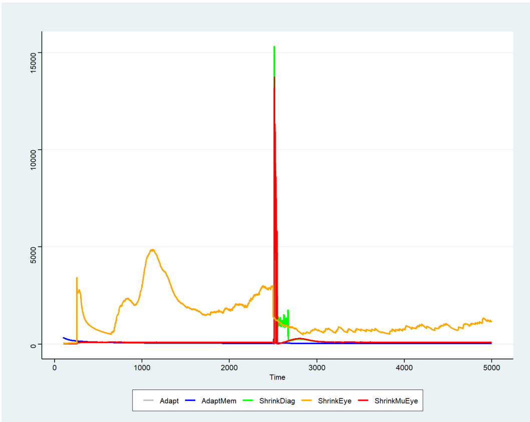
Figure C.0.3: Average loss comparison between Normal and mvt(5) for abrupt drift for Wishart covariance matrices ($100 \leq p \leq 500$).



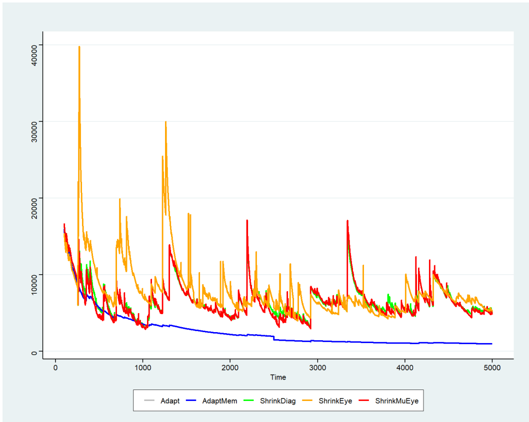
(a) Normal, $p = 100$



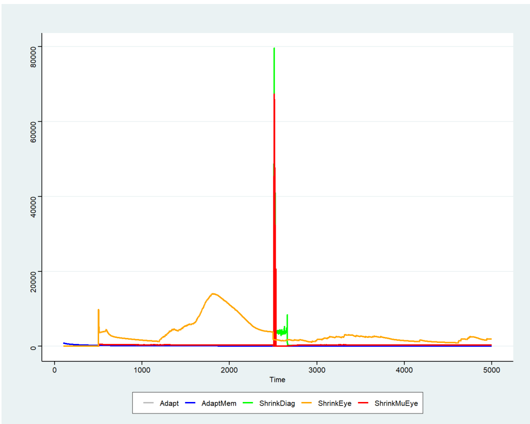
(b) mvt(5), $p = 100$



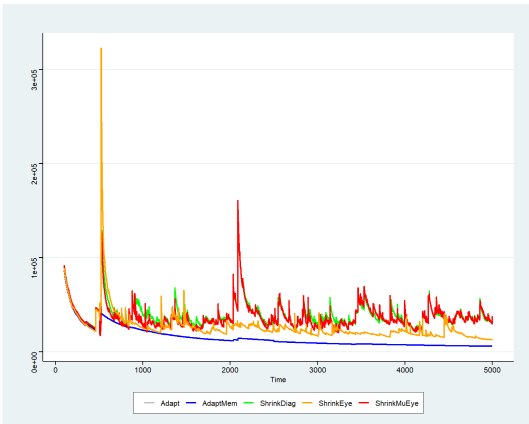
(c) Normal, $p = 250$



(d) mvt(5), $p = 250$



(e) Normal, $p = 500$



(f) mvt(5), $p = 500$

Figure C.0.4: Average loss comparison between Normal and mvt(5) for abrupt drift for Wishart covariance matrices ($100 \leq p \leq 500$).

Table C.1: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:MVT, Cov1:BCS, Cov2:BAR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	21.3205	21.3008	18.985	18.9021	18.9245
	(11.9692)	(12.0013)	(10.8188)	(10.8163)	(10.8151)
100	15.8396	15.8361	14.7912	14.7531	14.7627
	(7.7927)	(7.8203)	(7.2231)	(7.2139)	(7.2137)
500	7.9332	7.7589	8.1278	8.1199	8.1266
	(3.0226)	(3.1626)	(2.8818)	(3.0119)	(2.8732)
1000	5.5907	5.5094	7.4434	7.4867	7.4654
	(1.5764)	(1.6597)	(1.8574)	(1.8239)	(1.8428)
1500	4.6792	4.6305	7.4581	7.5374	7.5
	(1.3233)	(1.3042)	(2.7446)	(2.795)	(2.761)
2000	4.2218	4.1743	7.4265	7.4978	7.469
	(1.5189)	(1.5705)	(2.4919)	(2.492)	(2.4884)
2500	3.9212	3.8646	7.3348	7.4027	7.3717
	(1.3024)	(1.2705)	(2.012)	(2.0306)	(2.0094)
3000	8.172	6.9582	7.2637	7.2439	7.2412
	(5.6137)	(2.6301)	(2.0195)	(2.0052)	(1.9849)
3500	6.2723	5.1812	6.462	6.47	6.4681
	(5.4572)	(1.5246)	(1.3083)	(1.3087)	(1.2987)
4000	5.8409	4.4318	6.3259	6.3534	6.3357
	(6.9268)	(1.6966)	(1.9619)	(1.9541)	(1.954)
4500	6.3388	4.1078	6.2632	6.3077	6.2812
	(12.1388)	(2.8821)	(1.749)	(1.7997)	(1.7479)
5000	6.6784	3.9015	6.2917	6.3252	6.2995
	(18.8897)	(2.4727)	(2.3525)	(2.3801)	(2.2252)

Table C.2: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:Normal, Cov1:BCS, Cov2:BAR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	14.513	14.5239	13.0832	13.0188	13.025
	(1.3402)	(1.3402)	(0.8043)	(0.7945)	(0.7956)
100	10.2924	10.3043	9.7379	9.7136	9.718
	(0.8832)	(0.8885)	(0.681)	(0.6774)	(0.6781)
500	4.8497	4.7188	4.6202	4.6158	4.6165
	(0.4589)	(0.4215)	(0.3684)	(0.3678)	(0.3678)
1000	3.3799	3.3577	3.4252	3.4246	3.424
	(0.2901)	(0.2799)	(0.2676)	(0.2682)	(0.267)
1500	2.773	2.851	2.9199	2.9196	2.9201
	(0.2282)	(0.2333)	(0.2293)	(0.2292)	(0.2298)
2000	2.4313	2.5928	2.6417	2.6415	2.6421
	(0.1898)	(0.2004)	(0.1978)	(0.1976)	(0.1975)
2500	2.2252	2.4501	2.4938	2.4921	2.4925
	(0.1774)	(0.1994)	(0.1949)	(0.195)	(0.1947)
3000	5.0532	4.259	4.3885	4.3867	4.3836
	(2.9666)	(0.2912)	(0.264)	(0.2624)	(0.2621)
3500	4.0358	3.1911	3.2044	3.2012	3.2013
	(4.6799)	(0.1858)	(0.1732)	(0.1725)	(0.1737)
4000	3.6511	2.7391	2.7113	2.7065	2.7064
	(5.4308)	(0.1618)	(0.15)	(0.1494)	(0.1495)
4500	3.6119	2.6596	2.4543	2.4489	2.4487
	(5.9507)	(2.3308)	(0.1368)	(0.1364)	(0.1364)
5000	3.7483	2.5186	2.2975	2.2917	2.2921
	(7.0638)	(2.1216)	(0.1315)	(0.1305)	(0.1312)

Table C.3: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:MVT, Cov1:BWISH, Cov2:BAR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	5066.6973	5063.3859	2689.534	2893.345	2679.6187
	(2799.6118)	(2799.3774)	(2830.2747)	(2767.2006)	(2828.4285)
100	3748.4739	3750.0386	2130.8462	2344.8827	2130.515
	(1735.8483)	(1736.2551)	(1824.9777)	(1762.5458)	(1822.5731)
500	1737.5039	1737.4288	1105.6585	1328.1433	1116.3949
	(849.349)	(849.2856)	(881.2592)	(854.3377)	(883.304)
1000	1250.6696	1250.3808	694.0974	1259.2829	660.7033
	(458.1219)	(457.8054)	(765.6084)	(502.9574)	(575.2788)
1500	1027.4177	1027.4323	664.3278	1033.435	667.4016
	(311.5619)	(311.2916)	(667.6051)	(388.6113)	(593.4526)
2000	893.2503	892.8635	669.1582	951.5075	661.6106
	(235.6377)	(235.2811)	(610.3402)	(371.2382)	(540.5149)
2500	805.752	805.3712	635.003	912.9126	647.3341
	(236.3415)	(236.2227)	(502.1093)	(535.5073)	(482.6814)
3000	1218.8063	1218.5962	33.5359	33.9707	34.2337
	(167.5669)	(167.5391)	(10.2378)	(10.1443)	(21.2195)
3500	1044.7489	1044.5685	31.8666	32.5327	31.4917
	(143.6325)	(143.6088)	(12.6484)	(18.773)	(12.146)
4000	914.1973	914.0395	31.1315	31.2331	30.396
	(125.6825)	(125.6618)	(16.0748)	(15.7436)	(15.3976)
4500	812.6473	812.5069	30.012	30.2986	29.6938
	(111.7187)	(111.7004)	(8.9111)	(10.0482)	(9.0694)
5000	731.406	731.2795	29.7275	29.6441	29.4692
	(100.5508)	(100.5344)	(9.117)	(9.9756)	(9.6128)

Table C.4: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:MVT, Cov1:BWISH, Cov2:BWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	1037.2349	1033.7872	589.628	709.9608	584.2198
	(566.7452)	(561.4447)	(563.4453)	(535.002)	(561.5695)
100	762.8008	761.2503	469.7507	581.0415	470.2989
	(364.9272)	(363.5748)	(372.8364)	(349.1816)	(371.0739)
500	380.0584	370.95	223.3941	334.3483	231.0484
	(125.7217)	(125.0109)	(92.796)	(112.6886)	(90.1837)
1000	267.3261	263.5112	190.3012	252.562	198.5661
	(62.4827)	(64.2462)	(51.1287)	(77.7323)	(50.2609)
1500	226.1235	223.7938	184.5132	219.0751	192.5025
	(67.9213)	(62.8696)	(94.1107)	(98.7367)	(90.3861)
2000	203.5658	201.031	178.0592	201.4403	185.7731
	(63.8968)	(63.2334)	(81.4788)	(73.0416)	(77.5683)
2500	188.8311	185.9862	171.8104	196.177	179.986
	(53.9786)	(51.5772)	(53.207)	(63.7145)	(52.6278)
3000	383.4229	302.0864	212.8525	276.9265	215.2918
	(141.2639)	(109.4751)	(78.7826)	(97.0697)	(80.1112)
3500	268.5708	269.8323	184.7161	260.322	187.2983
	(59.64)	(58.8197)	(42.6273)	(59.1891)	(42.8723)
4000	223.3791	237.6632	174.8424	246.1166	178.6477
	(50.247)	(59.8146)	(51.4558)	(74.2496)	(53.9457)
4500	202.0855	213.4983	171.1525	234.6626	175.0616
	(52.4329)	(55.1565)	(53.4845)	(78.608)	(54.5697)
5000	190.1712	196.3583	171.742	222.7536	175.4832
	(63.7549)	(67.9694)	(101.2443)	(97.6601)	(102.0687)

Table C.5: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:Normal, Cov1:BWISH, Cov2:BWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	698.992	699.0069	228.7916	431.5435	227.8945
	(17.8566)	(17.8654)	(4.0643)	(2.3229)	(1.3162)
100	496.6608	496.7007	208.7405	368.1683	216.5662
	(9.7743)	(9.7608)	(2.2705)	(2.6892)	(1.4044)
500	233.5764	227.3121	159.0808	208.1431	165.3945
	(11.2706)	(7.3748)	(1.7571)	(2.764)	(1.8079)
1000	162.5726	161.4193	132.8609	153.0305	135.9207
	(4.093)	(2.8279)	(1.7248)	(1.7841)	(1.7338)
1500	133.8172	137.539	118.7343	130.1671	120.2807
	(2.5573)	(2.2274)	(1.814)	(1.5378)	(1.7563)
2000	117.5714	125.3812	110.358	119.076	111.078
	(2.0595)	(2.14)	(1.7927)	(1.7591)	(1.7049)
2500	107.0708	117.7778	105.0299	112.8669	105.2176
	(1.7463)	(2.0178)	(1.9066)	(1.996)	(1.7637)
3000	235.6223	209.4995	172.6471	212.6657	173.6073
	(5.9127)	(3.8144)	(9.5714)	(2.9283)	(8.0457)
3500	161.2927	163.9259	139.1449	163.8423	140.5122
	(2.6067)	(2.9011)	(4.8973)	(2.4568)	(4.8337)
4000	131.0421	138.7176	122.3331	139.1658	123.1996
	(1.8817)	(2.2417)	(3.0702)	(2.1966)	(3.1423)
4500	115.3564	124.3066	112.3705	124.3594	112.7313
	(1.8673)	(1.9562)	(2.3387)	(2.0241)	(2.2917)
5000	105.8884	115.8042	106.4979	115.1982	106.4434
	(8.8181)	(1.8928)	(2.1765)	(1.9824)	(2.0217)

Table C.6: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:MVT, Cov1:BWISH, Cov2:BWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	2462.6101	2457.3116	1305.8045	1474.2006	1299.0502
	(1037.2256)	(1035.7906)	(1043.7984)	(990.7568)	(1042.8069)
100	1792.3806	1789.4402	1015.5463	1189.0731	1017.3161
	(619.3171)	(623.1294)	(646.0549)	(595.4855)	(646.3156)
500	1026.5519	1029.0134	408.4809	857.8576	407.8418
	(372.5823)	(353.678)	(219.1618)	(360.2051)	(174.0071)
1000	666.722	668.2819	369.085	627.0991	377.1868
	(174.4291)	(170.9228)	(169.3078)	(183.0344)	(154.1201)
1500	542.6504	550.947	376.1331	561.5044	388.3886
	(136.4486)	(146.6506)	(235.6493)	(215.064)	(239.0624)
2000	476.4353	495.415	365.8166	505.8842	376.5414
	(100.4126)	(114.783)	(169.4242)	(156.621)	(157.9086)
2500	443.8937	484.1165	364.4935	497.9443	374.9226
	(104.5969)	(125.7625)	(173.7155)	(214.9689)	(169.1689)
3000	684.2375	621.2537	379.5787	590.4123	393.9975
	(268.8511)	(233.4051)	(260.761)	(237.5982)	(249.589)
3500	694.4973	765.592	387.0607	593.1697	404.0218
	(224.1607)	(278.7739)	(327.2101)	(210.7518)	(315.4946)
4000	612.6117	690.5843	368.3385	564.2521	383.468
	(190.4424)	(230.3309)	(221.2934)	(257.4485)	(208.2127)
4500	548.6607	611.3051	380.7981	551.3447	400.6683
	(186.5528)	(232.3509)	(359.5897)	(314.1104)	(366.4524)
5000	503.7208	555.8462	366.52	531.1808	386.3882
	(118.8793)	(151.8335)	(209.7543)	(182.4771)	(216.8209)

Table C.7: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:Normal, Cov1:BWISH, Cov2:BWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	1781.4354	1781.5742	376.6058	787.265	370.1683
	(25.4494)	(25.3945)	(3.7197)	(1.1527)	(0.803)
100	1266.6238	1266.6845	352.0613	721.2572	362.3212
	(14.0233)	(14.0103)	(1.8988)	(1.4489)	(0.7267)
500	628.8353	630.3622	313.1769	535.507	327.2511
	(72.7677)	(69.1217)	(4.1512)	(24.4594)	(3.6668)
1000	420.8377	421.6486	282.5533	391.3793	291.8112
	(20.8456)	(19.9985)	(3.9377)	(19.5786)	(3.625)
1500	339.1402	344.5373	260.4418	322.4144	266.7341
	(11.4589)	(15.2023)	(3.9815)	(9.8491)	(3.5964)
2000	293.6021	301.3401	244.4525	282.3216	248.7132
	(9.041)	(14.6894)	(3.8671)	(16.4969)	(3.385)
2500	263.6453	272.0711	232.1379	257.3475	235.1569
	(8.3139)	(14.9431)	(4.1703)	(21.263)	(3.5732)
3000	501.6557	464.6649	305.5506	428.3208	324.366
	(33.5417)	(27.5764)	(5.7009)	(16.1514)	(6.6694)
3500	399.1444	389.4284	274.1298	353.9441	285.5016
	(31.617)	(36.9859)	(3.7951)	(11.1359)	(3.2099)
4000	342.0433	341.717	251.2583	308.7255	259.0287
	(37.2324)	(36.8453)	(3.5598)	(18.2039)	(2.948)
4500	303.8593	309.6426	234.5877	277.5876	240.099
	(37.5101)	(32.4614)	(3.4624)	(11.7038)	(3.0025)
5000	276.6182	285.6521	221.7485	255.5962	225.6946
	(35.1136)	(27.4872)	(3.5043)	(16.689)	(2.9427)

Table C.8: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:MVT, Cov1:BWISH, Cov2:BWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	4908.4959	4908.0009	2518.4642	2725.4305	2511.7829
	(2101.4802)	(2102.3673)	(2127.3449)	(2063.6368)	(2132.1265)
100	3703.8431	3703.436	2073.5949	2293.5138	2070.6986
	(1524.7495)	(1525.8869)	(1605.701)	(1546.3385)	(1606.0816)
500	1725.3697	1729.6066	1088.0618	1312.2087	1095.7426
	(513.905)	(521.6776)	(563.6027)	(516.5615)	(564.0312)
1000	1236.4386	1240.615	628.4128	1240.7402	599.7892
	(293.6281)	(298.5056)	(692.7968)	(464.3386)	(502.87)
1500	1019.8891	1019.665	617.8966	1007.6415	612.1392
	(216.6823)	(208.7621)	(580.6811)	(280.1017)	(562.631)
2000	884.2628	884.3687	649.6038	943.9985	638.4652
	(163.1502)	(157.976)	(769.2305)	(503.6302)	(749.6845)
2500	794.3051	797.7318	643.467	911.0185	656.7909
	(158.7966)	(181.8937)	(815.2456)	(485.9257)	(893.179)
3000	941.328	943.9842	725.7227	1004.6673	728.3907
	(120.0737)	(138.2025)	(662.8615)	(329.9105)	(690.0509)
3500	855.242	857.6523	784.8817	984.1238	744.5776
	(106.7115)	(120.9075)	(910.5359)	(364.8661)	(748.7295)
4000	787.0716	789.1926	742.5267	996.4853	699.4278
	(95.5105)	(107.2983)	(850.851)	(325.0605)	(652.236)
4500	732.7408	734.1974	738.2255	990.2631	719.8865
	(86.2457)	(95.3666)	(711.5143)	(291.1991)	(604.094)
5000	688.9822	690.2906	725.7063	971.342	717.1259
	(83.232)	(90.7997)	(685.0976)	(356.0774)	(696.9995)

Table C.9: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:Normal, Cov1:BWISH, Cov2:BWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	3270.0572	3270.1763	440.2034	1049.4159	419.89
	(33.0567)	(33.1556)	(3.6616)	(0.5005)	(0.4417)
100	2324.5008	2324.5846	410.7593	1000.127	416.3312
	(16.7162)	(16.8007)	(1.9208)	(0.6335)	(0.3028)
500	1043.8417	1043.8543	369.2466	759.7146	392.0453
	(3.9163)	(3.9163)	(0.567)	(1.0461)	(0.4639)
1000	738.4588	738.4807	376.317	724.77	396.1484
	(2.3338)	(2.3372)	(7.2778)	(10.7893)	(7.6383)
1500	603.0526	603.0591	361.4704	595.0319	378.09
	(1.7279)	(1.7308)	(8.638)	(7.3268)	(8.1547)
2000	522.3121	522.3138	348.5492	516.9821	362.7401
	(1.4202)	(1.4256)	(8.6672)	(4.4603)	(7.7831)
2500	467.1909	467.1948	337.7236	463.39	349.534
	(1.2707)	(1.267)	(8.4638)	(3.2668)	(7.9471)
3000	689.0066	689.0117	472.0355	644.7141	497.6696
	(1.3963)	(1.3954)	(10.1175)	(1.841)	(16.6228)
3500	607.9965	607.9996	437.3023	561.4716	443.3297
	(1.2507)	(1.2487)	(19.4159)	(2.346)	(6.0213)
4000	546.8222	546.8255	393.6014	502.6828	408.6632
	(1.1245)	(1.1243)	(9.7121)	(3.7801)	(4.4057)
4500	498.8923	498.8965	367.8851	457.9612	381.7921
	(1.0347)	(1.0339)	(6.5028)	(4.1177)	(4.1205)
5000	460.2383	460.2442	348.0679	423.3349	360.161
	(0.9362)	(0.935)	(5.6415)	(4.5172)	(4.0964)

Table C.10: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:MVT, Cov1:CS, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	26.27	26.5871	26.4469	26.49	26.3903
	(29.7291)	(30.5646)	(29.6298)	(29.5992)	(29.6172)
100	19.1424	19.2855	19.3467	19.2956	19.2349
	(18.3846)	(18.7506)	(18.381)	(18.3534)	(18.327)
500	9.6955	9.4491	9.5153	9.6825	9.5084
	(7.0741)	(6.8913)	(6.8264)	(6.9162)	(6.8042)
1000	6.8718	6.7282	6.88	6.9866	6.8986
	(4.7185)	(4.6165)	(4.4912)	(4.7489)	(4.492)
1500	5.7498	5.6891	5.8832	5.9682	5.8598
	(3.935)	(3.8646)	(3.9632)	(4.0695)	(3.9225)
2000	4.9658	4.9703	5.1596	5.1946	5.1392
	(3.4352)	(3.4661)	(3.6342)	(3.7273)	(3.621)
2500	4.6371	4.6311	4.8118	4.833	4.847
	(3.5287)	(3.3805)	(3.5328)	(3.5694)	(3.5663)
3000	10.8066	8.4074	8.246	8.0594	8.1199
	(14.1159)	(3.5957)	(2.3106)	(2.2311)	(2.2571)
3500	10.5116	6.0013	7.2087	6.9822	6.9274
	(14.6627)	(3.3698)	(1.7487)	(1.6341)	(1.5268)
4000	12.7095	5.6455	7.1371	6.8117	6.7856
	(28.52)	(6.6859)	(2.9268)	(2.5266)	(2.5394)
4500	13.209	5.5067	7.1207	6.6976	6.6707
	(22.0623)	(7.5507)	(2.7003)	(1.8646)	(1.9108)
5000	14.6989	6.0741	7.1339	6.6686	6.5959
	(26.2734)	(10.9251)	(3.1521)	(2.7444)	(2.5711)

Table C.11: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:Normal, Cov1:CS, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	16.4306	16.4907	16.3291	16.2159	16.3418
	(9.7265)	(9.7715)	(9.6346)	(9.5747)	(9.6381)
100	11.3419	11.4131	11.3826	11.3459	11.3739
	(6.5969)	(6.5716)	(6.573)	(6.5608)	(6.571)
500	5.3576	5.1974	5.2161	5.2275	5.2166
	(3.3497)	(3.2175)	(3.2365)	(3.2319)	(3.2363)
1000	3.7338	3.7084	3.7393	3.7469	3.7421
	(2.2712)	(2.2368)	(2.2547)	(2.2569)	(2.2552)
1500	3.0487	3.1511	3.1547	3.1589	3.1659
	(1.8078)	(1.8619)	(1.8677)	(1.8608)	(1.8709)
2000	2.6445	2.8255	2.8494	2.8491	2.8565
	(1.5815)	(1.6911)	(1.7022)	(1.7055)	(1.7025)
2500	2.4521	2.7136	2.7384	2.7506	2.7399
	(1.4762)	(1.6517)	(1.6633)	(1.6712)	(1.6643)
3000	5.864	5.705	4.7171	4.7558	4.6891
	(5.7358)	(2.2208)	(0.4818)	(0.751)	(0.5724)
3500	5.2909	4.0431	3.4955	3.424	3.4208
	(7.6815)	(3.9745)	(0.4362)	(0.3989)	(0.5143)
4000	5.7441	3.6269	3.0119	2.892	2.9374
	(9.7221)	(5.1736)	(0.4385)	(0.2884)	(0.8768)
4500	6.2018	3.6414	2.8042	2.6284	2.6483
	(10.6514)	(5.9154)	(0.6368)	(0.2815)	(0.5312)
5000	6.3808	3.9472	2.666	2.4827	2.4754
	(11.3098)	(6.9324)	(0.6141)	(0.4832)	(0.2591)

Table C.12: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:MVT, Cov1:CS, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	2.4356	2.4243	2.4312	2.4201	2.4214
	(1.8571)	(1.8496)	(1.8136)	(1.7608)	(1.7646)
100	1.8578	1.8352	1.8405	1.8302	1.8241
	(1.4773)	(1.465)	(1.4556)	(1.4308)	(1.4295)
500	0.8947	0.8594	0.8549	0.86	0.8586
	(0.6623)	(0.5777)	(0.566)	(0.5741)	(0.5737)
1000	0.6997	0.6304	0.6277	0.6311	0.6331
	(0.6191)	(0.432)	(0.4282)	(0.4341)	(0.432)
1500	0.6115	0.5173	0.5188	0.5225	0.5225
	(0.8193)	(0.3466)	(0.3479)	(0.3515)	(0.3498)
2000	0.5422	0.4564	0.4605	0.4624	0.4614
	(0.5217)	(0.2998)	(0.3017)	(0.3041)	(0.3042)
2500	0.5333	0.4253	0.4325	0.4342	0.434
	(0.4892)	(0.2849)	(0.2895)	(0.2919)	(0.2918)
3000	4.1258	0.898	0.8753	0.8742	0.8707
	(3.368)	(0.4889)	(0.4676)	(0.4675)	(0.4637)
3500	4.5081	0.6558	0.6538	0.6524	0.6487
	(3.1112)	(0.4499)	(0.4474)	(0.4484)	(0.4403)
4000	4.6438	0.5248	0.5267	0.5262	0.5247
	(3.4355)	(0.3286)	(0.3252)	(0.3269)	(0.322)
4500	4.8851	0.4502	0.4529	0.452	0.4523
	(5.918)	(0.267)	(0.2631)	(0.2641)	(0.2618)
5000	4.9111	0.408	0.4125	0.4151	0.4144
	(4.5703)	(0.2282)	(0.2261)	(0.2287)	(0.2263)

Table C.13: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:Normal, Cov1:CS, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	1.616	1.6084	1.6194	1.6175	1.6173
	(0.9827)	(0.9795)	(0.9577)	(0.9539)	(0.9577)
100	1.174	1.169	1.1709	1.1685	1.1719
	(0.7211)	(0.7084)	(0.707)	(0.7023)	(0.7067)
500	0.5256	0.5154	0.5162	0.5147	0.5161
	(0.3365)	(0.3177)	(0.3157)	(0.3141)	(0.3161)
1000	0.3875	0.3618	0.3622	0.3612	0.3621
	(0.3585)	(0.2282)	(0.2289)	(0.2291)	(0.23)
1500	0.3291	0.297	0.2977	0.2964	0.297
	(0.3512)	(0.1807)	(0.1807)	(0.1797)	(0.1804)
2000	0.3006	0.2597	0.2605	0.26	0.26
	(0.3805)	(0.1637)	(0.1631)	(0.1618)	(0.1626)
2500	0.2788	0.2302	0.2306	0.2305	0.2305
	(0.3991)	(0.1451)	(0.1455)	(0.145)	(0.145)
3000	3.8292	0.7231	0.677	0.6722	0.6724
	(1.8273)	(0.2608)	(0.2491)	(0.2474)	(0.2467)
3500	3.743	0.4188	0.4086	0.4065	0.4071
	(1.6896)	(0.1738)	(0.17)	(0.1687)	(0.1691)
4000	3.867	0.3229	0.3183	0.318	0.3172
	(2.0612)	(0.1474)	(0.1442)	(0.1437)	(0.1438)
4500	3.8848	0.2754	0.2728	0.2721	0.2722
	(1.8665)	(0.1262)	(0.1247)	(0.1239)	(0.1243)
5000	3.9084	0.2428	0.2412	0.24	0.2408
	(1.8977)	(0.1085)	(0.1074)	(0.107)	(0.1072)

Table C.14: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:MVT, Cov1:CS, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	6.3825	6.3237	6.3162	6.3552	6.2982
	(5.617)	(5.5199)	(5.2855)	(5.3431)	(5.274)
100	4.74	4.5891	4.6328	4.6177	4.5914
	(3.545)	(3.524)	(3.5498)	(3.4419)	(3.4075)
500	2.1805	2.1493	2.147	2.1479	2.1452
	(1.4142)	(1.3534)	(1.336)	(1.333)	(1.3263)
1000	1.6461	1.582	1.595	1.5892	1.5924
	(1.0574)	(1.0081)	(1.0162)	(1.0224)	(1.0123)
1500	1.3761	1.294	1.3148	1.3178	1.3175
	(0.8948)	(0.8367)	(0.8473)	(0.854)	(0.8461)
2000	1.2564	1.1474	1.1736	1.1756	1.1758
	(0.7955)	(0.703)	(0.7188)	(0.7194)	(0.7191)
2500	1.1633	1.0478	1.0824	1.0889	1.0903
	(0.8526)	(0.7232)	(0.7574)	(0.762)	(0.7617)
3000	2.2052	2.114	2.0681	2.0709	2.0678
	(1.0777)	(1.0377)	(0.9982)	(1.021)	(1.0095)
3500	1.6008	1.4913	1.4917	1.4992	1.4976
	(0.7622)	(0.6565)	(0.6355)	(0.6444)	(0.6374)
4000	1.3592	1.2325	1.2695	1.2786	1.2791
	(0.586)	(0.4969)	(0.4896)	(0.4975)	(0.4956)
4500	1.2226	1.0727	1.1372	1.1456	1.1458
	(0.6628)	(0.3902)	(0.4021)	(0.4084)	(0.4047)
5000	1.1341	0.9693	1.0643	1.0733	1.0728
	(0.5782)	(0.3624)	(0.3956)	(0.4031)	(0.399)

Table C.15: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:Normal, Cov1:CS, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	4.0849	4.0243	4.0161	4.0212	4.0213
	(2.4426)	(2.3603)	(2.3529)	(2.369)	(2.3688)
100	2.9599	2.8717	2.8726	2.8616	2.8794
	(1.7811)	(1.6671)	(1.6666)	(1.6607)	(1.6785)
500	1.3106	1.2811	1.2841	1.2787	1.2796
	(0.7682)	(0.7467)	(0.7461)	(0.7432)	(0.7423)
1000	0.9037	0.889	0.8895	0.8903	0.8961
	(0.5506)	(0.5313)	(0.5294)	(0.53)	(0.5327)
1500	0.7476	0.7264	0.7295	0.7308	0.7345
	(0.4464)	(0.43)	(0.4313)	(0.4297)	(0.4316)
2000	0.6737	0.6401	0.6494	0.6518	0.6485
	(0.4214)	(0.399)	(0.4026)	(0.4028)	(0.4043)
2500	0.6194	0.59	0.5974	0.5975	0.599
	(0.376)	(0.3583)	(0.3609)	(0.3626)	(0.3625)
3000	1.3307	1.4776	1.3085	1.3051	1.3085
	(0.4716)	(0.4959)	(0.4134)	(0.4092)	(0.4123)
3500	0.9269	0.9585	0.9078	0.9082	0.905
	(0.2743)	(0.2961)	(0.2626)	(0.2616)	(0.2589)
4000	0.7634	0.7595	0.7367	0.7379	0.7354
	(0.227)	(0.2377)	(0.2201)	(0.2198)	(0.218)
4500	0.6737	0.6543	0.6423	0.6424	0.6417
	(0.2178)	(0.1986)	(0.1904)	(0.1906)	(0.189)
5000	0.6108	0.5833	0.5798	0.5813	0.5796
	(0.1885)	(0.1662)	(0.1623)	(0.1631)	(0.1629)

Table C.16: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:MVT, Cov1:CS, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	13.2379	13.2417	13.2099	13.2369	13.2314
	(11.7886)	(11.8014)	(11.3731)	(11.3395)	(11.3463)
100	10.342	9.6032	9.4671	9.4315	9.483
	(8.7602)	(8.1137)	(7.7879)	(7.7328)	(7.8012)
500	4.6247	4.5859	4.5105	4.5642	4.5187
	(3.5827)	(3.7199)	(3.1342)	(3.2397)	(3.1331)
1000	3.2875	3.2239	3.2287	3.2497	3.221
	(2.6923)	(2.6451)	(2.6002)	(2.688)	(2.6035)
1500	2.8149	2.7182	2.7437	2.7856	2.7471
	(2.1388)	(2.0555)	(1.896)	(2.0409)	(1.8895)
2000	2.5464	2.4052	2.4812	2.5044	2.4843
	(1.8349)	(1.7224)	(1.7439)	(1.7892)	(1.7502)
2500	2.4304	2.2911	2.3961	2.4107	2.3988
	(1.8897)	(1.7806)	(1.8177)	(1.8518)	(1.8185)
3000	4.2744	4.0125	3.9118	3.9235	3.9211
	(2.3973)	(1.4563)	(1.2849)	(1.3287)	(1.3161)
3500	3.227	2.8967	3.1133	3.1337	3.1205
	(2.0961)	(1.1491)	(0.9657)	(0.9859)	(0.9635)
4000	2.8099	2.3775	2.7596	2.7843	2.7778
	(2.1197)	(0.748)	(0.7158)	(0.7324)	(0.7747)
4500	2.5871	2.1327	2.6397	2.6509	2.6566
	(2.3991)	(0.7477)	(0.9079)	(0.9045)	(0.9178)
5000	2.4151	1.9628	2.5458	2.5672	2.5633
	(1.7241)	(0.6756)	(0.8186)	(0.8575)	(0.8377)

Table C.17: Average squared Frobenius norm, $||\tilde{\Sigma}-\Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:Normal, Cov1:CS, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	8.2728	8.2778	8.2673	8.2506	8.256
	(4.9125)	(4.9243)	(4.846)	(4.8417)	(4.8426)
100	6.2963	5.7526	5.7499	5.7403	5.7515
	(3.8949)	(3.3544)	(3.346)	(3.3435)	(3.3493)
500	2.6419	2.5871	2.5909	2.5966	2.5918
	(1.5575)	(1.5094)	(1.51)	(1.5076)	(1.5097)
1000	1.8367	1.8093	1.8261	1.8232	1.8251
	(1.0986)	(1.0752)	(1.075)	(1.0777)	(1.0756)
1500	1.5004	1.4777	1.492	1.4998	1.493
	(0.8554)	(0.8437)	(0.8511)	(0.859)	(0.8511)
2000	1.3308	1.3303	1.351	1.348	1.3509
	(0.7777)	(0.7702)	(0.7817)	(0.791)	(0.7822)
2500	1.2468	1.2653	1.283	1.2878	1.2829
	(0.7595)	(0.7652)	(0.7821)	(0.7872)	(0.7819)
3000	2.5351	2.5984	2.3925	2.3912	2.3996
	(0.962)	(0.5777)	(0.3834)	(0.3825)	(0.4793)
3500	1.8292	1.774	1.72	1.7321	1.7235
	(0.6377)	(0.3627)	(0.2793)	(0.5141)	(0.2944)
4000	1.5433	1.4777	1.4384	1.4373	1.4371
	(1.1668)	(1.2449)	(0.252)	(0.2839)	(0.2585)
4500	1.3671	1.2998	1.303	1.3076	1.3043
	(0.6278)	(0.6661)	(0.2239)	(0.3329)	(0.2557)
5000	1.2605	1.2231	1.2281	1.2286	1.239
	(0.9847)	(0.7195)	(0.2086)	(0.2732)	(0.4586)

Table C.18: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:Normal, Cov1:RWISH, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	175061.8441	175059.7792	27107.1099	57845.5572	24697.6865
	(1743.1497)	(1751.4796)	(163.5963)	(29.6912)	(26.2366)
100	124397.8872	124395.7268	25663.629	54975.6096	24450.2095
	(891.8193)	(891.9703)	(81.6248)	(38.2166)	(17.8389)
500	55853.0413	55852.4489	22995.0212	41284.3816	22766.1286
	(223.1271)	(223.4285)	(31.4053)	(59.6208)	(27.7862)
1000	39516.1551	39515.9329	22468.4511	37544.9694	22360.6727
	(134.2243)	(134.5878)	(356.5726)	(1632.0523)	(362.3433)
1500	32269.3218	32269.2327	21126.7856	33151.3801	21058.6829
	(98.5554)	(98.6671)	(329.2876)	(6547.7373)	(333.1014)
2000	27947.4836	27947.6466	20013.0267	44375.1029	19959.4456
	(80.2861)	(80.4023)	(332.5533)	(11343.4108)	(333.3393)
2500	24997.8719	24998.3567	19093.007	34046.1477	19055.7405
	(69.7788)	(69.9834)	(327.1416)	(3728.8315)	(331.8217)
3000	55022.6823	55022.9786	25.3326	24.3454	25.253
	(92.8708)	(92.9167)	(1.1818)	(8.2909)	(0.5307)
3500	47164.2966	47164.5506	17.0257	16.5961	16.965
	(79.6122)	(79.6526)	(1.0451)	(2.237)	(1.8447)
4000	41270.0899	41270.3124	13.8	13.5188	13.9022
	(69.6656)	(69.7015)	(0.5209)	(1.0345)	(2.2208)
4500	36685.4571	36685.6548	12.0497	11.8653	12.2444
	(61.9286)	(61.961)	(0.5625)	(1.3462)	(2.7768)
5000	33017.5902	33017.7681	10.9087	10.7595	11.0018
	(55.7397)	(55.7691)	(0.8454)	(1.413)	(1.991)

Table C.19: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:MVT, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	10317.3495	10307.8267	5910.0688	7082.4583	5767.4041
	(5664.3417)	(5669.8345)	(5632.2275)	(5357.1458)	(5619.2395)
100	7591.4289	7587.7833	4714.5006	5791.7312	4634.731
	(3610.1376)	(3611.0322)	(3682.617)	(3456.921)	(3677.7061)
500	3779.6304	3688.3151	2287.5129	3667.6294	2244.6911
	(1206.8662)	(1201.853)	(862.7147)	(3386.3545)	(855.0775)
1000	2662.1014	2625.8861	1964.684	2783.3419	1930.6837
	(612.295)	(629.1548)	(531.46)	(951.7714)	(509.9502)
1500	2249.4419	2226.5983	1896.1718	2405.939	1876.9005
	(651.1645)	(610.1113)	(918.4395)	(1024.1239)	(934.0124)
2000	2023.5162	2004.4317	1816.6569	2213.0677	1818.8476
	(622.089)	(628.4471)	(732.2188)	(961.4591)	(808.0873)
2500	1877.8852	1853.772	1775.5988	2112.8855	1769.042
	(541.4339)	(527.6468)	(633.8443)	(861.7504)	(618.8755)
3000	3826.7983	2942.0674	2112.5139	2761.3338	2090.2831
	(1437.7676)	(1014.9642)	(748.6989)	(986.9923)	(755.2841)
3500	2697.4724	2657.0645	1847.6223	2591.821	1835.5179
	(584.9631)	(554.5723)	(413.2539)	(708.611)	(413.3384)
4000	2255.291	2369.9921	1777.428	2521.5859	1778.2458
	(533.4425)	(590.5334)	(593.6863)	(911.2462)	(620.4699)
4500	2036.494	2144.4441	1737.3711	2411.4842	1739.1678
	(539.9933)	(566.1993)	(576.6062)	(884.0571)	(586.1423)
5000	1914.2748	1974.1339	1723.2398	2316.6228	1720.6367
	(634.7383)	(635.6663)	(669.8471)	(1004.8764)	(646.4355)

Table C.20: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:Normal, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	7034.2524	7035.835	2368.2692	4353.104	2164.3143
	(175.641)	(176.3208)	(34.1736)	(23.4785)	(12.8207)
100	5000.5085	5001.599	2165.5302	3711.144	2066.8862
	(99.5725)	(99.7579)	(20.4979)	(26.9751)	(13.3363)
500	2350.5615	2287.7613	1638.7321	2261.4124	1622.9865
	(114.3059)	(74.9038)	(19.6733)	(550.6848)	(19.4817)
1000	1635.7853	1624.0271	1366.6247	1623.2767	1360.4432
	(42.0044)	(28.8903)	(19.0055)	(259.5495)	(19.1872)
1500	1346.5606	1384.2281	1223.4651	1359.658	1219.6515
	(25.5508)	(21.9608)	(20.0612)	(225.071)	(20.3101)
2000	1183.2947	1262.1637	1137.8445	1228.2761	1135.2556
	(20.6363)	(21.2809)	(20.1642)	(173.9289)	(20.2508)
2500	1077.7974	1185.6746	1085.0309	1155.7805	1082.8117
	(16.9009)	(19.8513)	(20.0292)	(179.0317)	(20.1727)
3000	2402.5523	2102.188	1788.4321	2184.0504	1776.8875
	(68.1415)	(35.0447)	(76.8464)	(151.2347)	(79.2568)
3500	1647.659	1672.0321	1440.0726	1683.2227	1434.194
	(27.3468)	(29.8431)	(45.6556)	(131.996)	(46.2476)
4000	1338.3068	1419.2156	1260.9137	1434.5172	1256.9754
	(20.2141)	(23.3537)	(30.5202)	(150.0466)	(30.7949)
4500	1182.8154	1271.4106	1155.354	1301.2067	1152.1866
	(222.2552)	(19.8102)	(23.1638)	(253.6585)	(23.048)
5000	1078.562	1184.2223	1088.9352	1204.0462	1086.4561
	(39.7663)	(19.1877)	(20.654)	(219.2036)	(20.5611)

Table C.21: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:MVT, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	101.0321	100.8108	81.4122	92.773	75.3761
	(53.7754)	(53.2487)	(48.5159)	(45.6311)	(47.0772)
100	75.0991	74.8624	64.67	71.5276	61.6594
	(39.6833)	(39.3637)	(37.2375)	(36.0404)	(36.4099)
500	37.274	34.8491	33.2157	34.5066	32.7595
	(33.0262)	(10.0613)	(9.4766)	(9.5855)	(9.2798)
1000	27.9291	25.0293	24.3488	24.9355	24.168
	(20.9502)	(6.0948)	(5.6917)	(5.85)	(5.6211)
1500	23.9267	20.6614	20.2962	20.6445	20.2405
	(15.7626)	(4.5747)	(4.544)	(4.6029)	(4.7131)
2000	21.7707	18.1076	17.8758	18.0879	17.8674
	(13.9991)	(4.3048)	(4.1948)	(4.2421)	(4.3604)
2500	20.6889	16.4933	16.3627	16.4472	16.3825
	(11.9628)	(4.1387)	(4.117)	(4.0069)	(4.1778)
3000	75.8501	69.2922	65.7153	70.2926	64.6246
	(37.8586)	(5.8666)	(6.2097)	(5.4991)	(6.2622)
3500	54.1149	39.824	39.4421	41.0106	39.6638
	(40.1138)	(6.4169)	(5.6867)	(5.9895)	(5.5734)
4000	49.6373	27.9255	28.0476	28.4372	28.2198
	(69.831)	(5.5071)	(5.0364)	(5.1854)	(4.7232)
4500	65.6347	23.2442	23.1944	23.5099	23.2738
	(550.3706)	(6.3023)	(5.8902)	(6.4503)	(5.8091)
5000	54.8714	20.4972	20.3439	20.6275	20.3962
	(92.9503)	(4.9378)	(4.5721)	(4.8391)	(4.5268)

Table C.22: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:Normal, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	73.7733	73.7202	56.4073	68.924	52.6893
	(9.7139)	(9.3935)	(6.222)	(6.8336)	(5.103)
100	52.739	52.5555	44.2809	50.7199	42.8723
	(7.0759)	(6.6073)	(4.8677)	(5.5858)	(4.4397)
500	24.3171	23.5503	22.5465	23.3503	22.4135
	(7.1821)	(2.7744)	(2.4726)	(2.6556)	(2.4823)
1000	17.883	16.5508	16.2038	16.4661	16.1666
	(12.8941)	(1.8931)	(1.8052)	(1.8514)	(1.7888)
1500	15.546	13.5966	13.4234	13.548	13.3906
	(16.73)	(1.5506)	(1.4896)	(1.5249)	(1.4925)
2000	13.7171	11.8286	11.7341	11.7959	11.7181
	(13.9342)	(1.3023)	(1.2698)	(1.2852)	(1.2786)
2500	12.8132	10.6508	10.5979	10.6146	10.5886
	(15.4519)	(1.1905)	(1.1821)	(1.1847)	(1.1878)
3000	58.8469	71.9391	67.2214	71.8626	66.5912
	(11.5291)	(2.8282)	(3.1492)	(2.7351)	(3.2269)
3500	54.1472	40.6111	40.6397	40.9017	40.1246
	(30.6202)	(4.0864)	(3.1264)	(3.8872)	(3.0718)
4000	134.3897	22.1912	24.9383	22.5397	24.8914
	(58.6521)	(2.2631)	(2.2428)	(2.2828)	(2.2286)
4500	154.8719	15.6649	17.4222	15.8744	17.5115
	(41.4386)	(1.5818)	(1.6384)	(1.6335)	(1.6446)
5000	156.4418	12.7634	13.7373	12.8843	13.8019
	(40.4433)	(1.3848)	(1.4081)	(1.4267)	(1.3916)

Table C.23: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:MVT, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	63223.0573	63259.6479	33668.8531	37925.122	33271.5354
	(27241.5968)	(27242.0661)	(27366.6697)	(26046.5161)	(27412.2353)
100	45954.269	45978.6798	26165.595	30579.2003	25979.0503
	(16123.7655)	(16120.6983)	(16792.0859)	(15527.9003)	(16848.5045)
500	22080.9794	22062.7321	10549.6644	21563.775	10056.0571
	(5693.7798)	(5690.6244)	(5719.423)	(8874.7213)	(4731.6113)
1000	15772.6613	15768.8861	9493.6696	18004.4109	9229.001
	(3563.7406)	(3563.2878)	(3499.8127)	(7171.3975)	(3347.7684)
1500	13072.5864	13066.8673	9958.5167	16634.3826	9760.3982
	(2955.8335)	(2956.616)	(7774.4434)	(8171.4613)	(7875.7574)
2000	11332.0812	11329.189	9485.9831	15655.2231	9329.0484
	(2192.7417)	(2193.9738)	(4438.3762)	(6974.0319)	(4257.9465)
2500	10178.6003	10176.2333	9559.0005	14825.5036	9330.035
	(1942.7304)	(1942.8661)	(4993.7995)	(6393.1142)	(4308.6889)
3000	14023.036	14022.0612	9693.7936	15406.4015	9548.7273
	(1354.1852)	(1354.4344)	(7529.8867)	(6301.669)	(7838.4329)
3500	12469.2361	12467.6965	9968.175	14893.2735	9806.3447
	(1185.0702)	(1185.7615)	(7405.0213)	(6078.1134)	(7622.5774)
4000	11291.6732	11286.933	9617.1912	13902.4741	9438.0047
	(1068.1686)	(1062.7044)	(5284.8436)	(5086.0578)	(5192.121)
4500	10382.4085	10376.994	9822.4134	14019.5029	9539.6397
	(1084.9722)	(1080.2776)	(7783.6805)	(7399.6533)	(7335.6671)
5000	9613.3655	9608.299	9545.0905	13894.5374	9297.9473
	(964.3095)	(959.6895)	(5022.3908)	(5202.9746)	(4810.8486)

Table C.24: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:Normal, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	43813.6907	43810.4773	9517.6685	19463.5225	8679.1307
	(626.3614)	(631.5351)	(78.6386)	(26.4727)	(19.0876)
100	31149.501	31147.8466	8929.0852	17817.4795	8511.0982
	(333.2629)	(335.0068)	(43.1232)	(35.0414)	(16.0671)
500	13984.5037	13984.5781	7865.5951	13004.0256	7791.0843
	(93.1566)	(93.0895)	(89.6849)	(709.5099)	(89.8933)
1000	9892.7226	9892.7945	7038.5934	10686.6511	7003.5598
	(58.7112)	(58.6865)	(90.2463)	(3012.103)	(91.0642)
1500	8079.9714	8080.0079	6449.8202	10666.3521	6429.5918
	(44.0788)	(44.1476)	(86.0473)	(1913.6357)	(86.4617)
2000	6998.4825	6998.5822	6034.4825	8665.4902	6018.7264
	(38.378)	(38.4031)	(87.9704)	(1779.9306)	(87.8278)
2500	6259.7996	6259.8265	5713.2298	8337.609	5701.7754
	(32.7534)	(32.7625)	(91.0227)	(2987.6428)	(91.6036)
3000	11861.3393	11861.1886	7880.1025	10929.5585	7817.9106
	(36.6707)	(36.7035)	(132.0397)	(724.4972)	(138.0016)
3500	10359.6665	10359.5446	7045.9527	9079.4021	7017.2476
	(33.0008)	(32.9092)	(95.1569)	(694.5452)	(95.968)
4000	9231.3953	9231.2824	6445.9731	7858.2494	6427.8049
	(30.759)	(30.7193)	(86.2086)	(756.5579)	(86.9688)
4500	8350.5892	8350.5079	6016.7147	7031.3058	6002.0911
	(28.8656)	(28.8133)	(90.2418)	(980.6108)	(89.0212)
5000	7643.3896	7643.2541	5684.4138	6462.0178	5672.6379
	(27.1366)	(27.1145)	(84.4844)	(1133.6703)	(82.9898)

Table C.25: Average squared Frobenius norm, $||\tilde{\Sigma}-\Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:MVT, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	680.1838	666.2592	453.4981	554.0221	428.8451
	(347.1203)	(330.9044)	(309.0988)	(286.0811)	(312.6016)
100	498.0259	482.81	354.6278	426.6683	342.045
	(240.769)	(223.3356)	(206.5794)	(150.2126)	(207.0529)
500	225.7948	221.9461	192.5695	215.4758	189.6034
	(55.4253)	(61.7326)	(49.5631)	(61.9813)	(49.0051)
1000	164.9337	159.2795	145.8401	156.6727	144.4842
	(31.27)	(33.1606)	(26.9705)	(33.3242)	(26.8488)
1500	142.481	132.8409	126.0471	130.6422	125.4402
	(32.8745)	(27.2442)	(25.9564)	(25.8528)	(26.279)
2000	130.0616	118.328	115.6099	115.8614	115.404
	(42.1069)	(33.9777)	(35.9564)	(31.5418)	(38.106)
2500	122.5696	109.1432	109.3578	106.4298	109.6048
	(35.3468)	(27.4915)	(30.3272)	(25.708)	(31.939)
3000	282.1286	247.6769	223.1731	253.1047	221.1396
	(118.8921)	(58.9059)	(43.1764)	(53.9948)	(41.6791)
3500	179.1203	173.4908	161.5187	173.6869	160.8841
	(50.5092)	(38.5726)	(30.0652)	(35.368)	(30.2302)
4000	150.7841	146.03	136.4727	146.0133	135.6078
	(49.3847)	(50.391)	(42.8188)	(48.1264)	(41.8793)
4500	133.5843	125.5988	119.3573	126.4969	118.6762
	(37.6723)	(33.9241)	(31.9222)	(34.4006)	(31.3401)
5000	125.8867	113.6567	108.8878	114.6428	108.4546
	(44.957)	(29.435)	(26.6558)	(30.368)	(26.1693)

Table C.26: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:Normal, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	473.7929	465.476	288.7891	396.9566	269.1039
	(67.9869)	(32.9709)	(13.1317)	(14.9501)	(10.4482)
100	340.9443	330.5883	240.7291	302.8078	232.341
	(42.1451)	(18.4394)	(9.9249)	(11.6562)	(9.0374)
500	152.0418	148.1835	136.1803	145.4576	135.2902
	(11.3363)	(7.3316)	(6.3384)	(6.6579)	(6.33)
1000	107.4507	105.1884	101.1695	104.2208	100.8661
	(5.9675)	(5.1253)	(4.9996)	(4.9416)	(5.0064)
1500	88.9743	86.5609	84.8151	85.8385	84.683
	(4.8292)	(4.3155)	(4.2657)	(4.229)	(4.2749)
2000	78.4723	75.6173	75.1274	74.9437	75.0976
	(4.4178)	(3.7597)	(3.6486)	(3.598)	(3.6499)
2500	72.2382	68.5489	68.9605	67.9085	69.0382
	(10.7182)	(3.4196)	(3.3876)	(3.2821)	(3.3907)
3000	175.885	221.5642	207.5235	224.6927	205.9461
	(13.6434)	(21.4509)	(10.7681)	(20.6857)	(10.3854)
3500	110.229	121.3202	130.3528	123.4196	130.5017
	(9.8999)	(6.8644)	(7.5371)	(7.0509)	(7.4835)
4000	88.8554	95.355	98.0468	96.1595	98.1868
	(12.4115)	(4.7108)	(4.9777)	(4.8084)	(5.0259)
4500	77.8948	81.3929	82.0931	81.8113	82.1413
	(14.1754)	(4.1385)	(4.1029)	(4.171)	(4.1627)
5000	71.2294	72.4224	72.5516	72.7006	72.5619
	(18.1242)	(3.5715)	(3.5132)	(3.5579)	(3.5909)

Table C.27: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:MVT, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	256853.8302	257007.1176	137195.3455	146624.6554	135951.8472
	(140303.3868)	(140263.0894)	(142652.0416)	(138510.6982)	(141957.9593)
100	190096.8665	190210.228	108542.8148	119147.8355	107743.3757
	(87933.8208)	(87895.5337)	(92707.968)	(89529.027)	(92524.0644)
500	88074.7488	88158.3348	56107.8602	67180.8802	55737.1629
	(41886.5162)	(42089.3219)	(43773.353)	(41751.0328)	(43520.9786)
1000	63357.4927	63395.294	34449.404	62866.8151	31716.7614
	(22700.1805)	(22783.7982)	(39255.5406)	(24764.785)	(27766.4256)
1500	52024.3989	52051.0348	34064.1586	61212.7217	31959.5475
	(15390.7421)	(15433.2229)	(33003.0786)	(30034.5826)	(31164.9206)
2000	45216.902	45265.506	34542.9677	54700.6763	32674.9674
	(11651.4959)	(11683.9043)	(33824.8851)	(26317.0485)	(32569.9563)
2500	40795.8881	40835.2352	33198.9828	53083.4268	31654.8962
	(11815.021)	(11829.7748)	(30383.7798)	(26500.8683)	(29917.8296)
3000	47724.5661	47752.7579	32652.1889	52316.6324	30652.2943
	(9024.1681)	(9031.3484)	(29203.342)	(16956.1593)	(25960.2858)
3500	43043.0187	43066.0451	35932.8529	50392.9738	35398.6261
	(8034.6809)	(8037.9265)	(49509.3648)	(19366.3858)	(53871.7972)
4000	39416.5187	39435.8886	34303.1165	49918.5618	32289.1984
	(7217.7247)	(7220.4835)	(44247.5492)	(22026.3895)	(46079.4023)
4500	36474.8989	36490.7293	34044.8034	48557.543	32702.9017
	(6370.7172)	(6372.4907)	(31588.1606)	(24904.1016)	(32444.3143)
5000	34093.7351	34103.3949	33519.0128	45421.4128	31793.8292
	(5716.6472)	(5717.293)	(34742.2746)	(13231.8615)	(35477.9537)

Table C.28: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:Normal, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	175291.9905	175292.0939	27256.2267	57971.2594	24852.1495
	(1767.5562)	(1773.9092)	(160.1724)	(28.8864)	(24.9967)
100	124578.2686	124575.6491	25809.959	55090.4567	24600.7904
	(889.2683)	(890.5859)	(81.4529)	(38.1959)	(18.7544)
500	55932.521	55932.6128	23119.7446	41355.5109	22890.0899
	(225.0111)	(224.7793)	(31.407)	(58.8353)	(27.2267)
1000	39571.8837	39572.1738	22584.3353	37654.967	22474.4348
	(133.8479)	(133.2687)	(353.2354)	(1622.1423)	(363.1175)
1500	32315.6911	32316.0376	21202.1065	32553.2751	21129.473
	(102.1161)	(101.9878)	(350.2954)	(5514.094)	(347.2892)
2000	27988.444	27989.0493	20083.8101	44446.5897	20031.0025
	(80.5426)	(80.4527)	(321.3412)	(11175.2247)	(313.9856)
2500	25034.1439	25034.6473	19150.8517	34410.7447	19108.9632
	(70.0994)	(70.2196)	(327.7792)	(3776.4677)	(336.2471)
3000	37296.3009	37296.5461	24211.489	35784.746	24001.3002
	(73.6189)	(73.7769)	(351.183)	(1834.805)	(353.1866)
3500	32950.6901	32950.9673	22538.788	30803.4837	22436.8789
	(65.2835)	(65.478)	(336.2345)	(2752.769)	(340.1365)
4000	29667.1099	29667.3376	21173.8724	27126.6222	21111.6848
	(58.8953)	(59.0325)	(354.7236)	(1494.7502)	(348.047)
4500	27091.6726	27091.8586	20065.7069	24487.7324	20023.6404
	(54.2089)	(54.3952)	(333.1391)	(1001.683)	(337.9607)
5000	25014.4604	25014.6151	19109.8055	22600.1166	19077.1005
	(50.7484)	(50.8321)	(317.5652)	(1883.2816)	(316.6856)

Table C.29: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:MVT, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	2622.0871	2613.7886	1640.0858	2000.7405	1578.0996
	(1469.2106)	(1459.8944)	(1428.061)	(1321.756)	(1405.4458)
100	2094.5289	1944.4959	1264.8555	1576.8899	1231.0503
	(1036.3375)	(896.1888)	(854.7047)	(764.7826)	(851.0597)
500	908.8987	891.3805	693.3674	848.7954	681.4436
	(299.5008)	(284.8534)	(210.2631)	(281.9737)	(192.7582)
1000	664.8325	647.7207	556.2229	630.4871	549.6967
	(178.5474)	(176.264)	(150.2886)	(184.4866)	(146.1782)
1500	568.634	544.0054	501.0676	531.364	497.6151
	(190.3507)	(132.4178)	(124.1174)	(172.5547)	(122.6247)
2000	507.6758	482.7947	466.8082	465.9742	465.9729
	(139.6957)	(106.4925)	(104.0091)	(121.262)	(110.1172)
2500	473.949	450.9592	453.6138	432.1212	453.3242
	(141.679)	(128.934)	(119.5346)	(122.7607)	(121.061)
3000	1023.733	818.837	656.5449	811.8082	651.4089
	(300.8687)	(182.5503)	(106.7622)	(129.8598)	(108.5747)
3500	696.9137	669.5456	551.4771	664.5197	546.7662
	(197.6334)	(191.227)	(135.1895)	(173.2223)	(127.9056)
4000	580.2484	570.0319	488.1301	582.3741	485.9651
	(169.2142)	(143.2459)	(104.3542)	(144.51)	(103.5759)
4500	517.8319	501.1312	446.4724	519.8143	446.1942
	(129.1267)	(121.9967)	(95.6054)	(132.2615)	(96.6405)
5000	481.8615	454.4822	427.9373	474.9398	428.4625
	(136.3712)	(123.0491)	(151.4664)	(136.602)	(153.923)

Table C.30: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:Normal, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	1759.6366	1759.2793	794.6661	1312.524	728.3961
	(67.1443)	(66.8041)	(19.5342)	(19.249)	(10.8681)
100	1369.2544	1262.1204	702.8381	1061.1749	672.6077
	(257.6265)	(63.0914)	(13.4559)	(22.3209)	(10.9834)
500	573.5722	562.9145	464.8234	540.8438	461.124
	(20.9699)	(15.5243)	(10.3178)	(17.667)	(10.3383)
1000	406.0166	400.278	365.7336	391.4911	364.3746
	(11.5585)	(10.0519)	(8.823)	(9.4055)	(8.8101)
1500	335.9347	332.9135	319.0693	327.5263	318.4284
	(9.3191)	(8.5767)	(7.8488)	(7.5285)	(7.9475)
2000	296.5158	296.8295	293.0731	293.8678	292.7589
	(8.5664)	(8.4937)	(7.8596)	(12.3037)	(7.9107)
2500	271.7544	276.4796	278.6816	276.994	278.4798
	(8.4097)	(9.1703)	(7.3976)	(52.7151)	(7.4418)
3000	647.9179	590.3745	584.1762	631.8735	582.1492
	(21.657)	(20.4435)	(16.204)	(17.1898)	(16.1947)
3500	426.7439	437.4638	428.641	453.1691	428.4995
	(11.5348)	(14.9938)	(13.0028)	(18.9701)	(13.2207)
4000	345.5884	363.6621	350.66	375.0549	350.5815
	(12.8319)	(11.8202)	(10.1145)	(11.1217)	(10.4082)
4500	303.9755	319.8169	307.789	329.7262	307.62
	(15.0923)	(9.6513)	(8.7666)	(14.2646)	(8.9363)
5000	278.4051	292.9543	282.6831	300.8446	282.4658
	(19.9877)	(8.8225)	(8.7611)	(9.4992)	(8.786)

Table C.31: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Abrupt, Distribution:Normal, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	7035.7992	7035.3081	2368.2552	4353.2159	2164.3261
	(175.5323)	(176.3551)	(34.2619)	(23.7771)	(12.8384)
100	5000.9762	5000.8778	2165.6039	3711.4614	2066.8588
	(99.7849)	(99.5906)	(20.5361)	(27.0512)	(13.276)
500	2349.3829	2287.4631	1638.5703	2259.66	1622.9618
	(113.295)	(74.6906)	(19.5052)	(549.3545)	(19.4957)
1000	1635.6103	1624.0735	1366.5971	1625.8119	1360.4855
	(41.7111)	(28.9021)	(18.9841)	(274.0527)	(19.1734)
1500	1346.3843	1384.203	1223.3277	1362.3777	1219.7357
	(25.529)	(21.9486)	(20.1176)	(233.8927)	(20.29)
2000	1182.9848	1262.0917	1137.7015	1226.815	1135.3146
	(20.4955)	(21.21)	(20.1334)	(162.641)	(20.2292)
2500	1077.5321	1185.6743	1085.0007	1154.5763	1082.7779
	(16.8148)	(19.8398)	(19.9315)	(175.3018)	(20.0899)
3000	2403.1658	2102.123	1788.3992	2184.9243	1776.7744
	(68.0785)	(34.9284)	(76.9545)	(158.7674)	(79.0995)
3500	1647.986	1671.9488	1439.9946	1682.8543	1434.1635
	(27.2531)	(29.7835)	(45.5543)	(127.7363)	(46.0983)
4000	1338.2967	1419.1129	1260.7779	1434.6261	1256.9534
	(20.1793)	(23.3702)	(30.4108)	(149.588)	(30.6744)
4500	1182.7903	1271.3511	1155.2672	1299.8722	1152.2458
	(222.2684)	(19.7577)	(23.2009)	(247.9966)	(22.9891)
5000	1078.5392	1184.1666	1089.039	1202.1218	1086.4696
	(39.9305)	(19.1012)	(20.6872)	(213.3707)	(20.5825)

APPENDIX D: GRADUAL DRIFT COVARIANCE SIMULATION

Table D.1: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:MVT, Cov1:BWISH, Cov2:BWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	614331954.7966	609715920.3318	597701148.4319	599216602.3855	601720402.9847
	(10113027150.3833)	(10112850264.9608)	(9908219983.5923)	(9905690303.1593)	(9905895166.1854)
100	1325134731.7938	1322562224.3473	788084460.0221	825950458.3258	792325527.2015
	(19495307348.9823)	(19495372438.1987)	(10093669990.3874)	(10156605997.1224)	(10092349791.3699)
500	9532185044.058	9509609210.9322	9385311379.5066	9412995466.3003	9397372754.097
	(148261418486.177)	(148261241074.1)	(147936601049.015)	(147932607149.667)	(147933055458)
1000	17996317478.5002	17989237616.6584	240012641.8445	1879019710.8728	1752682232.376
	(383197947748.541)	(383198142766.162)	(2605423895.2472)	(29482027184.7714)	(33609538027.7829)
1500	13326418667.5844	13288167045.5909	607149000.7473	4419296381.5614	1385421143.275
	(256531971930.687)	(256531658085.552)	(12711444505.0143)	(75924529373.029)	(13871851315.3228)
2000	45745249982.8337	45520023704.6459	235016892.8354	29285339218.7074	767519900.7741
	(1130572436387.34)	(1130564108859.59)	(3682786787.6735)	(834946512191.831)	(6569980517.5098)
2500	40259671718.7961	39941876549.3604	276513872.0485	21857458433.1431	1592897267.3437
	(907431459065.973)	(907423281933.827)	(3716710340.4637)	(473181671153.807)	(24433994896.1587)
3000	42219108611.1427	41770076503.6284	37684642334.3371	38329902146.3815	18068011881.8175
	(783619685278.052)	(783603542756.703)	(1153227294140.7)	(719786939392.505)	(487254903709.225)
3500	36660361654.3016	36274741713.4398	842241543.3772	25839623624.6632	927532572.1025
	(671738325068.601)	(671724795571.355)	(19923750474.2944)	(465792997661.013)	(11440818639.259)
4000	32507153238.6352	32136723849.2753	982315673.4894	16693615124.0252	1203202892.2427
	(587784615423.405)	(587773889644.477)	(14976898298.0668)	(289955022041.925)	(10907068904.2031)
4500	57830444128.137	57501307415.9218	4806552148.9061	390420026658.593	10409185415.4028
	(945736984109.06)	(945741792312.769)	(85901079123.4954)	(10098891997872.4)	(274148717868.996)
5000	61312273339.3276	61015410797.5292	27526759817.5595	276189061281.962	858347624.9021
	(893857154658.556)	(893864384078.551)	(836917146310.224)	(7460210847547.07)	(6226445749.927)

Table D.2: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:Normal, Cov1:BWISH, Cov2:BWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	3860.3327	3860.2775	516.7017	1239.0745	490.3096
	(38.5324)	(38.1901)	(4.4095)	(0.5249)	(0.5351)
100	2741.3521	2741.3668	477.9259	1177.7145	481.1175
	(19.7081)	(19.5427)	(2.3307)	(0.704)	(0.3423)
500	1225.0965	1225.0937	401.3295	878.9144	418.9822
	(4.605)	(4.6122)	(0.6696)	(1.1512)	(0.3986)
1000	863.8521	863.8517	382.3701	820.4395	395.9502
	(2.757)	(2.7578)	(6.0326)	(16.2144)	(7.8215)
1500	707.1376	707.1376	355.1631	666.8742	362.1375
	(2.1181)	(2.1146)	(6.4335)	(12.344)	(8.2736)
2000	619.0174	619.0121	341.0464	578.3757	343.9539
	(1.7468)	(1.7551)	(5.1487)	(7.0021)	(7.2579)
2500	565.5345	565.5273	337.903	523.7352	339.8699
	(1.5393)	(1.5445)	(3.5097)	(4.5525)	(6.0204)
3000	533.4767	533.4744	345.4353	490.5898	349.6862
	(1.3697)	(1.3782)	(2.1493)	(2.9682)	(5.2789)
3500	516.4074	516.4052	362.6647	470.777	371.3502
	(1.2537)	(1.2617)	(1.9781)	(2.0425)	(6.1504)
4000	510.4642	510.4632	388.8407	460.8454	399.5854
	(1.1634)	(1.1701)	(2.352)	(1.36)	(7.802)
4500	513.17	513.1673	421.0612	460.5851	428.3747
	(1.1025)	(1.1083)	(4.2141)	(2.1382)	(7.9416)
5000	522.5835	522.5799	450.236	467.1179	459.826
	(1.0377)	(1.0407)	(8.8371)	(3.6236)	(6.8145)

Table D.3: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:MVT, Cov1:CS, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	14472765.1944	14471925.2641	14181446.5842	14738770.6012	14175035.8744
	(415367314.0946)	(415367342.3021)	(407073116.1073)	(407399886.5285)	(406900986.589)
100	7638872.9913	7637173.5151	7559244.2268	7855066.9678	7557545.0064
	(209938078.3994)	(209938134.6681)	(207862007.8741)	(208073832.8992)	(207818487.1975)
500	3265541.3231	17190496.0515	893514.4084	6013591.6594	948765.8667
	(52051209.0372)	(478433870.7633)	(6667521.3612)	(127097923.839)	(6446164.0565)
1000	12086205.0598	17107024.7068	35311585.8166	64411487.7382	3790369.4942
	(198923704.2742)	(261826731.2321)	(880331618.6203)	(1725689890.2297)	(57165842.6108)
1500	7997139.9838	8446235.4582	15689874.3812	40989429.4187	3457029.0471
	(90210050.6185)	(76253325.3043)	(403828040.5946)	(952561024.8728)	(26958665.0803)
2000	13880988.759	7516550.5478	9290221.3383	24328312.5346	8227014.1309
	(228103274.3357)	(54882541.0228)	(247345603.9996)	(395464637.3097)	(141401387.0038)
2500	23575516.8245	8451319.149	1408368.0312	27849305.9892	4169620.4766
	(653515153.6714)	(103497770.0831)	(15695831.2039)	(433446248.9707)	(41667371.7163)
3000	9713060.8668	5674344.2974	6685595.6781	22243584.0298	4054544.6612
	(216829629.3407)	(44883060.8736)	(138234272.5301)	(327060450.2402)	(37169096.1016)
3500	11782101.4607	10475501.7832	6334221.3462	18550919.2484	9987180.8258
	(247257520.152)	(154928842.306)	(177609972.1278)	(194667293.4525)	(153740597.4811)
4000	183540785.3597	295603085.6614	1009786.3165	491581298.9462	7640566.72
	(5593135494.9456)	(9015642192.5648)	(13249320.7692)	(14973447593.9774)	(64531984.7227)
4500	10284271.7181	247896867.2761	1249763.3817	311049289.2163	4436510.4917
	(221832188.7616)	(6664783787.2428)	(14249697.2992)	(9175563010.6587)	(32562452.3498)
5000	27607781.603	23539800297.3957	5491354.0372	261803619.3502	14413017.572
	(407576917.7003)	(739220497241.328)	(138916521.439)	(6578728036.9923)	(172211745.0815)

Table D.4: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:Normal, Cov1:CS, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	16.0639	16.0511	16.0444	16.0192	16.0097
	(9.6748)	(9.6855)	(9.4435)	(9.4225)	(9.4334)
100	11.1317	11.0969	11.0697	11.0478	11.0521
	(6.635)	(6.5918)	(6.5089)	(6.4874)	(6.4901)
500	6.2279	6.188	5.9937	6.0043	5.9979
	(3.4918)	(3.4801)	(3.3254)	(3.32)	(3.3289)
1000	6.7049	6.9718	6.5363	6.5438	6.5351
	(3.0962)	(3.1152)	(3.0202)	(3.0287)	(3.0298)
1500	8.5013	8.3356	7.9148	7.9215	7.9114
	(2.7834)	(2.7965)	(2.756)	(2.764)	(2.7529)
2000	9.79	9.1652	8.7952	8.7945	8.7986
	(2.3146)	(2.3491)	(2.329)	(2.3381)	(2.3297)
2500	10.9098	9.9022	9.4814	9.4872	9.4868
	(1.9907)	(2.0868)	(2.0863)	(2.0851)	(2.0915)
3000	11.8928	10.5616	10.099	10.1009	10.1093
	(1.7704)	(1.8633)	(1.8792)	(1.879)	(1.8861)
3500	12.7074	11.1061	10.614	10.6054	10.6164
	(1.5572)	(1.6328)	(1.6391)	(1.6398)	(1.6389)
4000	13.3685	11.5639	11.0694	11.055	11.0677
	(1.2965)	(1.3908)	(1.3787)	(1.3833)	(1.3936)
4500	13.808	11.8422	11.425	11.4175	11.4272
	(1.1277)	(1.1624)	(1.1457)	(1.1522)	(1.1686)
5000	14.1819	12.1192	11.8847	11.8908	11.8952
	(1.2549)	(1.3414)	(0.9592)	(0.9579)	(0.987)

Table D.5: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:MVT, Cov1:CS, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	972145.8541	791608.097	483048.4734	736007.9418	151556.9193
	(27681138.5747)	(22331175.3021)	(13820191.3529)	(21647686.0061)	(3381978.4212)
100	608633.8717	547463.2677	262362.2299	532916.4183	157727.0794
	(11948443.5102)	(10635369.9936)	(6379101.3955)	(10588285.8688)	(2222387.0168)
500	380603151.0808	79739718.202	47131676.7409	79076783.8919	45009274.8219
	(11699339357.1526)	(1941713843.5603)	(1356667612.754)	(1928823201.6197)	(1399063835.0406)
1000	12938468.482	30292839.4745	6341968.9266	30823651.9299	1553658.4729
	(326061459.2347)	(650437592.8158)	(111827707.5473)	(649950008.3969)	(23203143.0369)
1500	7080172.2662	20734580.5776	4070586.5293	12704539.2434	3264699.7916
	(141015967.7787)	(394296051.6364)	(59597924.4371)	(180602109.7281)	(54703002.6266)
2000	8130657.5422	11728753.471	1844661.4561	6548155.7571	2629841.9202
	(185547098.4772)	(208440449.8182)	(19882571.957)	(74581358.7486)	(29398023.7003)
2500	466919.97	7293571.59	1109989.5243	4057861.3505	1746783.2267
	(5950230.585)	(123352926.4997)	(9535245.622)	(43840614.0978)	(15484531.3381)
3000	647322.4418	5035567.3606	838973.7966	2729321.3272	1093201.8488
	(11795123.4679)	(79845379.2894)	(6978559.8247)	(30205189.9098)	(8496881.2305)
3500	1851557.8747	3599061.0544	893661.4941	2295008.9911	1194481.672
	(25587663.0529)	(46780262.863)	(7909453.7371)	(23256509.3158)	(9864770.9976)
4000	22671399.4459	6381952.1086	4817206.6752	5364247.1729	4857792.2758
	(689634936.1496)	(108856696.7701)	(122234566.5539)	(96299195.9431)	(119790177.7569)
4500	1261076.3606	4187196.6468	4279551.0416	1835067470.0454	4333618.8278
	(26714995.971)	(56650701.0197)	(94907748.6627)	(57937353489.761)	(93483726.419)
5000	1394835.1542	3481572.9164	3730656.7344	1057443823.3789	4114928.2023
	(29132835.5958)	(39354019.3716)	(76044078.1784)	(33361278907.6267)	(76319943.6945)

Table D.6: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:Normal, Cov1:CS, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	1.6853	1.6856	1.7049	1.7004	1.6959
	(1.0306)	(1.0309)	(1.015)	(1.0182)	(1.0122)
100	1.2154	1.2128	1.2223	1.219	1.2158
	(0.7693)	(0.7672)	(0.7601)	(0.7578)	(0.7576)
500	0.5646	0.5368	0.5369	0.5355	0.5343
	(0.493)	(0.321)	(0.3196)	(0.3218)	(0.3177)
1000	0.4984	0.4253	0.4197	0.4186	0.4177
	(0.5299)	(0.2234)	(0.2207)	(0.2218)	(0.2198)
1500	0.5468	0.4375	0.4281	0.425	0.4284
	(0.411)	(0.1945)	(0.1921)	(0.1893)	(0.1918)
2000	0.4662	0.4761	0.465	0.4617	0.4644
	(0.3534)	(0.183)	(0.1805)	(0.1795)	(0.1812)
2500	0.4479	0.5114	0.5009	0.4973	0.4995
	(0.367)	(0.1724)	(0.1707)	(0.1706)	(0.1705)
3000	0.4866	0.5463	0.5371	0.5346	0.5349
	(0.4446)	(0.1635)	(0.1618)	(0.1626)	(0.1616)
3500	0.5012	0.5664	0.5599	0.5575	0.5575
	(0.4908)	(0.1665)	(0.1625)	(0.164)	(0.1622)
4000	0.4811	0.576	0.5735	0.5725	0.5715
	(0.4222)	(0.1623)	(0.1593)	(0.1617)	(0.1596)
4500	0.481	0.5834	0.5846	0.5849	0.5831
	(0.4312)	(0.1583)	(0.157)	(0.1569)	(0.1562)
5000	0.4863	0.5912	0.5962	0.5956	0.5955
	(0.4366)	(0.154)	(0.1537)	(0.1528)	(0.153)

Table D.7: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:MVT, Cov1:CS, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	226244195.0201	226299324.2055	221715054.2832	221677173.3371	221676626.727
	(7015932379.7718)	(7015930750.3731)	(6875420928.0039)	(6872863160.3219)	(6872888062.8179)
100	120461241.5896	120766298.6535	119292976.6621	119294179.9662	119293776.9216
	(3547404947.563)	(3547405482.2831)	(3512219434.4134)	(3511580048.685)	(3511583059.6317)
500	30033889.9363	23078397.8156	195625729.7806	2439765.6804	290057249.7201
	(550806382.0241)	(535118069.9438)	(5165335200.5822)	(28920141.7766)	(7277926175.1651)
1000	150848840.7873	2249823838.0128	6529086.0028	1271766040.8554	125772797.9903
	(3939894107.0988)	(70612577881.8972)	(97014022.8546)	(40006864919.7356)	(3616864491.4564)
1500	19633998.3233	8380074943.1479	4238604.2367	596512150.1684	5401837.8882
	(211185573.6678)	(246753046433.264)	(40185849.7684)	(13409084623.2414)	(39483684.3287)
2000	92839880.2907	5598672062.9881	7750372.6741	474091575.5083	43048035.2435
	(2330554580.5428)	(165544966288.205)	(78641378.6995)	(7180455313.5153)	(999997522.5244)
2500	59137551.1861	663307823.9252	2131848.2621	666074511.9517	13355004.6665
	(1177353415.5257)	(13678542055.9314)	(20551308.5196)	(14625710991.8091)	(172182997.4721)
3000	28714441.209	373705044.8751	2373964.2254	323048543.227	15535798.901
	(563787555.5032)	(7163720386.1915)	(26228116.8)	(5883278145.624)	(276854958.629)
3500	99779659.9377	451927669.4258	8703354.6469	333894071.7575	24549241.7924
	(1795163949.6409)	(8228013132.761)	(149931646.4979)	(5398799958.1154)	(401982011.1924)
4000	7223244.6117	4718093444.7599	3883547.9975	5568308300.7189	17134508.0133
	(132063780.1817)	(141380255667.74)	(57494971.7811)	(169702375306.418)	(245123209.6433)
4500	7077678.9125	3200560963.0192	18223000.5503	3471020883.7098	20926411.9211
	(148117972.1386)	(94790127028.249)	(475782225.489)	(100997172531.657)	(381378782.9457)
5000	27067653.9544	1617118380.5054	2376294.5811	2371540697.0588	8248720.492
	(580985575.3731)	(49369118494.4708)	(30885419.3327)	(69402633501.6586)	(133876523.4702)

Table D.8: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:Normal, Cov1:CS, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	40.7724	40.8187	40.7176	40.6847	40.6618
	(23.1943)	(23.1994)	(22.7399)	(22.7492)	(22.7423)
100	27.9413	27.9946	27.8658	27.9121	27.8875
	(16.3104)	(16.3181)	(16.1519)	(16.1635)	(16.1754)
500	15.038	15.1078	71.6034	20.8638	24.6003
	(8.6743)	(8.6155)	(77.8844)	(14.9932)	(26.498)
1000	19.8845	19.0986	33.2862	14.9825	15.2093
	(8.1183)	(8.1433)	(46.299)	(7.8522)	(10.3802)
1500	26.7985	24.9011	24.4079	19.5547	19.2303
	(6.7196)	(6.8238)	(25.3507)	(7.2458)	(7.2918)
2000	32.7705	29.902	24.6321	25.1924	25.116
	(5.5852)	(5.7185)	(11.1074)	(6.0845)	(6.7659)
2500	37.6934	33.8612	28.9464	29.6447	29.4386
	(4.7531)	(4.8875)	(9.1506)	(5.136)	(5.6015)
3000	41.7728	37.0432	32.9854	33.0914	33.0453
	(3.9722)	(4.0886)	(8.6036)	(4.2683)	(5.0478)
3500	45.325	39.7719	36.9612	35.7651	35.7866
	(3.1345)	(3.2007)	(10.1641)	(3.429)	(4.8115)
4000	48.1796	41.8455	40.1823	37.357	37.5396
	(2.5595)	(2.6115)	(12.5024)	(2.901)	(5.1351)
4500	50.4984	43.5164	42.8496	38.2727	38.6452
	(2.091)	(2.1089)	(15.2856)	(2.5689)	(5.7513)
5000	52.3594	44.7983	45.2338	38.9748	39.5561
	(1.6217)	(1.6311)	(18.444)	(2.3826)	(6.4927)

Table D.9: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:MVT, Cov1:CS, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	2622224.9653	3586775.2653	5498756.9639	4569780.7312	5194634.635
	(66862642.7812)	(96793889.9149)	(157582107.9598)	(128394121.8985)	(156466722.3156)
100	331223.2602	475628.6708	2780151.419	1298217.1295	2640602.4436
	(7283495.8274)	(8526725.4391)	(80034540.9566)	(30482832.3114)	(79823553.8014)
500	10289282.8912	7321136.9743	6632563.7438	6782411.0241	6050830.8787
	(200846067.5005)	(106720245.0732)	(129170152.2903)	(98489424.5767)	(130938623.0228)
1000	1220833.2765	14105430.9189	1889972.0438	14902527.0016	4044825.133
	(16313765.7415)	(332444772.9206)	(24709848.8526)	(361399293.7362)	(56594513.7219)
1500	919917.5088	33492193.9783	1182712.0556	36796006.7843	1926019.9412
	(17147706.1941)	(828266046.4017)	(11098904.2851)	(899091317.641)	(19432526.9949)
2000	4600274.4706	38055575.436	12528154.0334	40035026.0073	3562122.9703
	(123821315.4416)	(703260700.596)	(327148795.8783)	(732456726.9243)	(57310865.8313)
2500	1469063241.3769	315091351.6486	271662272.4584	429860569.2635	4355819.0352
	(46348949571.6419)	(9283245580.6283)	(8392031816.2363)	(12892462832.5291)	(54519618.3805)
3000	14615253.5434	259491019.5517	59914715.4719	321287156.1517	12652455.6097
	(325836691.7805)	(7318036990.763)	(1815476838.2714)	(9369157596.1786)	(205442162.6506)
3500	3195433.2771	261023460.3448	15843651.8484	301839851.2505	89693203.7835
	(53878510.8913)	(6233071241.9396)	(445855596.3275)	(7524426615.0232)	(2613762944.4469)
4000	221121112.7216	244774924.5462	119192580.7562	264438266.8072	86985057.108
	(5967147794.5052)	(5289577378.7846)	(3490696513.7739)	(5934766476.2896)	(1903130393.902)
4500	2718136.8054	177797800.3757	5796714.0897	171504232.6873	45822100.3001
	(29980232.2925)	(3948473987.2226)	(114117961.3632)	(3723065333.3507)	(1318357590.317)
5000	3764599.5878	105475347.8676	2425963.1719	62620589.7487	36895590.495
	(87025975.0057)	(2525566587.553)	(28064733.9929)	(905347483.0602)	(1055744976.6937)

Table D.10: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:Normal, Cov1:CS, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	4.2009	4.1132	4.0839	4.0869	4.0958
	(2.4924)	(2.4011)	(2.3675)	(2.3624)	(2.3397)
100	2.9988	2.9155	2.9051	2.9172	2.9083
	(1.8485)	(1.7858)	(1.7836)	(1.8028)	(1.7655)
500	1.4363	1.4069	1.3975	1.393	1.3951
	(0.8345)	(0.8142)	(0.8027)	(0.8021)	(0.8046)
1000	1.3123	1.3386	1.3032	1.3	1.3018
	(0.6894)	(0.6281)	(0.614)	(0.6148)	(0.6129)
1500	1.2859	1.502	1.4389	1.44	1.4407
	(0.5871)	(0.5746)	(0.5663)	(0.5661)	(0.5659)
2000	1.348	1.6763	1.6203	1.6207	1.6218
	(0.5487)	(0.5178)	(0.5099)	(0.51)	(0.5092)
2500	1.4393	1.809	1.7857	1.777	1.7774
	(0.5347)	(0.49)	(0.4864)	(0.4826)	(0.4789)
3000	1.498	1.8938	1.8938	1.888	1.8874
	(0.5118)	(0.4713)	(0.4703)	(0.4688)	(0.4666)
3500	1.551	1.9949	2.0025	2.0005	1.9973
	(0.4902)	(0.4532)	(0.4483)	(0.4497)	(0.4501)
4000	1.6336	2.1027	2.1085	2.1078	2.1049
	(0.4807)	(0.4381)	(0.4396)	(0.435)	(0.4343)
4500	1.6973	2.2057	2.2133	2.2127	2.2107
	(0.5228)	(0.4226)	(0.428)	(0.4225)	(0.4228)
5000	1.7299	2.2985	2.3144	2.314	2.3128
	(0.4339)	(0.3976)	(0.4116)	(0.406)	(0.4051)

Table D.11: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:MVT, Cov1:CS, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	1734381.3065	1731538.6507	1700233.2395	1696239.9001	3115410.5069
	(44367275.7976)	(44366197.6052)	(43574550.7868)	(43461476.1915)	(61957242.4262)
100	2417595.9146	2461973.9095	1408145.0461	2156487.4182	1726266.6341
	(52838854.3454)	(52373796.8512)	(25785879.5786)	(48438582.3829)	(31394601.2708)
500	14263729.3195	19110745.9265	634703.7861	19923202.494	1087104.0123
	(408559640.77)	(538682222.2013)	(6089599.6413)	(565979492.1859)	(11446874.0809)
1000	10361846.4329	280598631.8179	20856024.8763	422947926.0489	4629634.8896
	(208490002.5794)	(8682067035.6642)	(621408022.8385)	(12563102237.7383)	(96501552.8995)
1500	1736880.0449	98380261.3532	71008504.0659	295766685.6281	1632048.9174
	(23492454.0103)	(2761280556.524)	(1899613523.7912)	(7356799484.5307)	(12589088.9443)
2000	19198729.8016	58498341.1523	49093236.1469	135949583.13	9492759.5722
	(350799501.6876)	(1524663518.509)	(1169923842.0014)	(2967028575.8506)	(163806345.5337)
2500	4040150.735	38519925.0907	35612480.9575	81763798.5117	3835735.8228
	(39455453.8967)	(963079653.4582)	(822749697.2174)	(1651417377.2947)	(43927843.1899)
3000	2064348.7359	25746469.6614	2913807.1846	50156858.8275	2593403.1657
	(32271320.189)	(651801390.6469)	(65291181.3469)	(992215638.0843)	(23395627.8084)
3500	42263987.9785	45650955.5515	1752995.9787	403374448.0299	2601649.6215
	(1279596702.4956)	(786009830.6437)	(32367130.9685)	(11390057314.948)	(34351400.3021)
4000	19001684.6409	44544516.0382	1316336.8462	44659517.7642	5700480.1025
	(356011598.626)	(634479706.3365)	(19758517.0085)	(599233311.3605)	(80055386.0736)
4500	43533782.5551	65051498.1946	11521918.9525	65478034.0012	15856686.9689
	(1294898592.4158)	(1109390380.7898)	(328734194.2652)	(1099595592.8596)	(311150283.98)
5000	14766040.7263	48368301.7625	12763601.0666	56878168.6207	10562547.5728
	(260528022.6236)	(726809438.2929)	(370990211.3119)	(887386104.3229)	(122123490.0066)

Table D.12: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:Normal, Cov1:CS, Cov2:AR). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	7.9363	7.9664	7.9816	7.9847	7.9749
	(4.7142)	(4.7143)	(4.602)	(4.585)	(4.599)
100	6.2468	5.7796	5.722	5.713	5.7227
	(3.8753)	(3.3081)	(3.2213)	(3.2151)	(3.2277)
500	2.8984	2.8953	2.8348	2.8311	2.8273
	(1.657)	(1.6612)	(1.6166)	(1.6097)	(1.612)
1000	2.877	3.0915	2.9163	2.9213	2.913
	(1.3673)	(1.3931)	(1.3396)	(1.345)	(1.3387)
1500	3.2167	3.5619	3.3412	3.3336	3.3365
	(1.3076)	(1.2635)	(1.2536)	(1.2467)	(1.2521)
2000	3.6662	4.0785	3.8984	3.8865	3.8944
	(1.2498)	(1.1984)	(1.1822)	(1.1831)	(1.1849)
2500	4.0087	4.4692	4.3482	4.3406	4.3439
	(1.1512)	(1.0946)	(1.0859)	(1.0914)	(1.0845)
3000	4.3528	4.862	4.7632	4.7603	4.7568
	(1.0502)	(1.0245)	(1.0048)	(1.007)	(1.002)
3500	4.5697	5.1132	5.0267	5.0289	5.0214
	(0.9192)	(0.9039)	(0.8777)	(0.8795)	(0.8781)
4000	4.7562	5.3458	5.2731	5.2778	5.2711
	(0.8356)	(0.8369)	(0.8197)	(0.8172)	(0.8174)
4500	4.9532	5.5757	5.5338	5.5391	5.5321
	(0.7748)	(0.8023)	(0.7779)	(0.7859)	(0.7816)
5000	5.0932	5.7696	5.7748	5.7847	5.7712
	(0.6845)	(0.7923)	(0.7644)	(0.7671)	(0.7671)

Table D.13: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:MVT, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	2376992237.373	2376992777.8024	2331914354.3815	2523747924.6618	2328836458.311
	(32253370442.4674)	(32253370404.2632)	(31635323806.7166)	(32127623091.1974)	(31595292064.3146)
100	1461851555.2176	1465960045.3261	1447781267.7985	1546680367.885	1439500381.4404
	(16872432453.5655)	(16873056586.1062)	(16712084105.3467)	(16962927664.5763)	(16701573623.4984)
500	10622073825.7546	12091183200.1964	3501041862.3322	12346555735.1922	1235141197.0967
	(243839441180.421)	(289604853977.591)	(103259827795.114)	(296859048743.275)	(14711841746.3399)
1000	3758214815.5561	21378831061.2004	4368002940.0509	21915066469.5707	5359299508.6999
	(62616292087.4155)	(405746307248.458)	(88080142742.6764)	(415771863653.048)	(66046995202.1056)
1500	4892259325.2721	16512301211.9526	2065171546.2156	15592683836.5421	3223903373.7332
	(59224041950.613)	(261567554373.733)	(35549852132.891)	(246045738899.841)	(31200730687.3495)
2000	6019530451.573	14545802160.788	2365841122.9386	13664189326.9469	4642649039.3613
	(94162039076.0053)	(195218739796.566)	(45178144431.8836)	(164121818245.371)	(55857180649.6851)
2500	5770040477.3628	7737025831.6234	1063511998.7452	13120503615.9148	8123105799.5013
	(139639044448.419)	(96388310579.8992)	(19142861094.9225)	(160916899457.742)	(204427654558.133)
3000	9203174252.1135	6172829080.7219	2415927449.8674	9228112610.8081	5691589939.5213
	(259184087977.223)	(69220186811.0851)	(55947853206.4499)	(95511635615.8398)	(109399319125.842)
3500	5906708406.366	15326500415.4414	3512284055.433	9106552853.4021	6781798084.0231
	(166769019861.745)	(324919516664.424)	(92118811503.8805)	(83403511919.6651)	(102890422068.451)
4000	4279255000.0768	10135036368.7136	1291474736.7437	110004211837.013	27396489962.5276
	(61355743047.9405)	(150647256253.967)	(18228528792.6435)	(3194209304164.06)	(771633266733.066)
4500	122603028606.117	28594268000.4933	2796805480.2487	106905626101.022	16112974077.6767
	(3816828515062.27)	(646580344847.996)	(78508790072.0816)	(2574306175518.1)	(317158909688.832)
5000	13364324931.0214	31405111422.0696	4938382904.4487	326815331269.213	14078301067.7401
	(219830405164.962)	(527401078756.557)	(73247164926.0077)	(9257727614819.61)	(233514732667.186)

Table D.14: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:Normal, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	6940.7187	6942.0616	2285.6187	4284.3868	2077.5754
	(174.1004)	(175.0487)	(35.3562)	(23.7574)	(14.283)
100	4933.3343	4933.6358	2073.6825	3652.0463	1969.3632
	(99.6723)	(99.9939)	(20.6545)	(25.7409)	(12.7129)
500	2327.1089	2261.5662	1496.4883	2188.5801	1476.2033
	(112.6498)	(72.2967)	(18.1565)	(438.5293)	(18.3136)
1000	1644.1678	1632.5299	1224.3141	1590.0407	1213.0545
	(39.5725)	(27.6925)	(21.5138)	(240.1508)	(21.7615)
1500	1398.3186	1428.7487	1120.8212	1374.1194	1112.5216
	(23.5445)	(21.66)	(24.4592)	(193.2749)	(25.0622)
2000	1292.4953	1348.7529	1110.4044	1290.486	1103.432
	(18.7158)	(20.2355)	(30.0078)	(135.1419)	(30.1783)
2500	1254.0157	1319.4256	1147.716	1276.1613	1142.9064
	(17.9591)	(19.0838)	(29.945)	(190.0147)	(30.1029)
3000	1248.7336	1314.1852	1207.4746	1280.2785	1204.6459
	(18.1982)	(19.5103)	(32.3475)	(112.938)	(32.3499)
3500	1257.3521	1320.7609	1269.104	1302.7298	1267.1497
	(20.5654)	(20.7356)	(29.5739)	(106.5872)	(29.0261)
4000	1271.9463	1332.0375	1328.9969	1333.9098	1328.7871
	(20.1314)	(20.6263)	(26.6718)	(120.3404)	(26.6605)
4500	1289.0295	1345.7035	1383.8424	1364.6617	1384.1461
	(23.4744)	(21.1672)	(24.0389)	(133.693)	(23.6452)
5000	1310.3765	1361.7621	1430.4916	1407.1754	1431.7201
	(34.6976)	(21.2995)	(21.2907)	(217.5003)	(20.8744)

Table D.15: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:MVT, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	3021594.9214	3424147.1388	2476417.6662	3284697.4662	2446480.3334
	(59954978.1495)	(58300601.5089)	(36455171.6441)	(53631621.881)	(32340854.5189)
100	13443979.9648	9835250.8949	4320640.2152	9727200.7971	4022650.3009
	(250031367.8772)	(201085030.5083)	(52688886.1025)	(198829937.4311)	(41062798.8578)
500	7236954795.3742	7124537368.375	4389847433.2798	7078844102.8385	193361704.3318
	(213836846966.992)	(178040898428.787)	(95158271220.1977)	(176872548629.941)	(4274408343.9398)
1000	115311097.7645	2840611708.3695	1576275990.2782	3384998596.3561	428482545.3373
	(2058752796.6856)	(63224746095.764)	(28337461230.2029)	(72686676156.3825)	(9001578751.8248)
1500	298329192.8697	1663930747.9068	475783090.6086	2311627648.0664	526693463.7263
	(6424487878.3917)	(31852292781.0356)	(7227651746.2716)	(45685734970.7758)	(8138417871.5302)
2000	11579819687.5788	2543650800.7662	1761230713.0636	3024689772.1682	1283574612.157
	(291688798947.655)	(44632459171.5354)	(33338236169.564)	(47679493405.0014)	(30141134352.3899)
2500	4079712858.3751	2309186956.1441	1819209116.0078	2165633511.136	1427442818.0371
	(114035747921.231)	(35883535423.0956)	(28967758092.9964)	(33837332776.0684)	(27807015218.4015)
3000	263729435.2647	1372347151.4179	1091627677.776	1130757817.5423	869364204.7517
	(5408771031.9901)	(19879883751.7997)	(16448862807.5225)	(17086167401.851)	(17129890416.4012)
3500	95154308.7041	868040273.0766	824583332.3198	883400367.9236	860021292.6293
	(1938581467.7423)	(12716902508.7739)	(11729096123.3347)	(12580137643.3468)	(14089116458.8556)
4000	229404149.4501	709596364.7957	593910533.9904	739412492.5078	714059020.7248
	(5334575731.4268)	(9661671169.2917)	(9295177075.3383)	(9562425797.7975)	(10926117880.217)
4500	6806936272.2793	2144266133.1499	1716427033.9524	2303872852.4515	1344698435.1035
	(186273593939.342)	(43955080240.063)	(33759934770.5613)	(48179715379.3763)	(30885160543.6163)
5000	78306951.1526	1932588735.1514	1675117351.7432	1920182276.9774	984800853.5929
	(1207377894.6708)	(36141410678.4067)	(29423228180.71)	(38390809429.052)	(19419446101.1394)

Table D.16: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:Normal, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	71.2708	70.9851	55.8736	66.6204	52.285
	(9.7137)	(9.0754)	(6.4233)	(6.8944)	(5.7039)
100	50.7875	50.3652	43.3497	48.7262	41.7615
	(7.5031)	(6.1366)	(4.6749)	(5.1393)	(4.4469)
500	24.2898	23.3218	21.7112	23.0951	21.322
	(10.0423)	(2.7894)	(2.5719)	(2.6258)	(2.4846)
1000	19.8202	19.1942	17.8991	19.0594	17.5142
	(9.0043)	(2.1079)	(1.9331)	(2.0051)	(1.877)
1500	20.2392	20.1887	19.0701	20.1232	18.695
	(12.0275)	(1.8)	(1.7164)	(1.7445)	(1.6886)
2000	21.5253	22.9542	21.9788	22.9731	21.6145
	(12.6714)	(1.6465)	(1.5845)	(1.596)	(1.5669)
2500	21.5192	26.0132	25.1778	26.1221	24.8221
	(9.5505)	(1.6119)	(1.5766)	(1.5661)	(1.562)
3000	21.4834	28.6716	28.0922	28.8642	27.7547
	(13.1479)	(1.777)	(1.7678)	(1.7198)	(1.7407)
3500	22.0827	30.5218	30.4282	30.7551	30.1594
	(15.2431)	(2.2746)	(2.1736)	(2.2104)	(2.1333)
4000	22.343	31.1697	31.8963	31.3661	31.8077
	(13.7717)	(2.9744)	(2.7492)	(2.9032)	(2.6592)
4500	22.6638	30.5421	32.3791	30.6803	32.5446
	(15.6048)	(3.5635)	(3.317)	(3.4051)	(3.1804)
5000	23.2172	29.043	31.915	29.1852	32.3926
	(17.8976)	(3.613)	(3.6556)	(3.3446)	(3.5498)

Table D.17: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:MVT, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	1157925883797.66	1157878643123.39	1134918015984.93	1134262480788.66	1134298342030.34
	(36493915810998.6)	(36493917277880)	(35770427594243)	(35749739098337.2)	(35749867426924.4)
100	592536418403.142	592516080949.673	586694559797.547	586526520281.312	584907440051.728
	(18433522161588.2)	(18433522799384.3)	(18252531094501.4)	(18247362991290)	(18247361801171.3)
500	1369845192231.58	1369840690723.43	991275028966.892	112817256006.79	1228392057818.73
	(30957336920945.6)	(30957337119927.2)	(24902764823346.9)	(1668091046692.83)	(30672084201232.6)
1000	1724124593703.99	1724140369989.17	2691859682.0304	2189841726980.79	491140956403.557
	(35767400430860.7)	(35767399677529.3)	(36184974917.7659)	(67288378895667.9)	(14868251611289.5)
1500	3268154163821.52	3268206874816.18	3564287650.5262	4821377796607.77	9943163592.0612
	(61699367287563.3)	(61699364509102.8)	(41568376616.7664)	(93454143150255.7)	(74138474414.0105)
2000	2711245298303.42	2711281265996.94	2938007559.3828	3432054477245.76	373187603753.37
	(46620054009275.9)	(46620051927488.1)	(27076383515.2829)	(60449271236738.9)	(10116325453943)
2500	3844818674597	3844845529931.69	1508120198.3109	4217383627657.46	5075471309698.2
	(66011739655247.9)	(66011738094849.3)	(11300035280.5223)	(78477265757405.1)	(152928000576353)
3000	3209183545883.19	3209192890732.95	1039276366.7915	2630965630419.6	3123640363121.21
	(55013280749722.5)	(55013280206350.1)	(7426536052.8425)	(49586177969232)	(97927830882695.9)
3500	2901942364217.24	2901947406043.68	8665460552.5574	1755696178991.68	2304090158121.24
	(47340983152616.4)	(47340982844884.8)	(203008139199.444)	(29617923331871.8)	(72054989986627.4)
4000	5174784049681.68	5174788445806.78	6719942437.643	10838501887521.5	1808572117723.3
	(92758455554385.2)	(92758455309529.5)	(149396770359.852)	(329881639612930)	(56952837551116.5)
4500	4650294331461.62	4650299341390.46	336641792573.077	6002799515082.28	13122906486.3373
	(82465078295138.6)	(82465078012917.9)	(10418111385279.2)	(176566441832379)	(137742133878.759)
5000	4186694077518.9	4186698588902.77	6495071002.5886	269545912605.831	6529952630.0549
	(74220145258031.9)	(74220145003813.6)	(113762620721.879)	(4226702471355.12)	(47537368016.969)

Table D.18: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:Normal, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	43794.6815	43794.7897	9445.5319	19450.7105	8605.3494
	(638.9131)	(638.4085)	(81.9073)	(27.0657)	(19.2701)
100	31143.2159	31143.1396	8779.7797	17781.8363	8357.978
	(345.0278)	(344.9019)	(44.8281)	(33.765)	(15.4291)
500	14004.3007	14004.4196	7309.3574	12855.5133	7224.8682
	(91.9184)	(91.8974)	(106.2462)	(706.144)	(105.7756)
1000	9977.2592	9977.3632	6294.2052	10237.9822	6249.109
	(57.1889)	(57.1568)	(127.969)	(2486.3142)	(128.9503)
1500	8296.5045	8296.5824	5766.5608	10549.5323	5735.1041
	(43.885)	(43.9272)	(148.303)	(1979.5395)	(150.6433)
2000	7433.9427	7434.0372	5576.3543	8483.2023	5553.4982
	(38.4603)	(38.4256)	(166.2166)	(1131.5338)	(166.3464)
2500	7001.0423	7001.1398	5601.4913	7472.8266	5582.5665
	(34.8676)	(34.8775)	(179.2542)	(666.3163)	(178.9941)
3000	6841.7242	6841.8537	5790.2312	6969.6304	5774.9098
	(32.018)	(32.0026)	(175.4209)	(668.2993)	(175.6891)
3500	6874.6963	6874.7243	6065.3617	6732.6311	6056.1578
	(29.9039)	(29.8888)	(163.4775)	(406.5316)	(165.7734)
4000	7047.6049	7047.6367	6390.7157	6697.0029	6382.2805
	(28.6936)	(28.6708)	(142.1292)	(396.6467)	(143.3767)
4500	7323.5724	7323.6337	6741.2089	6808.7175	6735.9426
	(27.5285)	(27.536)	(117.4029)	(433.8664)	(118.9763)
5000	7676.7159	7676.7747	7083.9038	7024.5842	7080.9811
	(26.6297)	(26.6509)	(101.9787)	(634.948)	(100.5156)

Table D.19: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:MVT, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	318580910.0032	2850848152.0312	164291996.1055	203381795.8592	163520120.0238
	(6645472132.934)	(86964365175.0918)	(4089119175.608)	(3777615578.8502)	(4072257025.7708)
100	125814790.18	468308234.6239	92616404.5865	91964973.4557	91619427.7775
	(2969231846.0166)	(13284115845.7441)	(2087487592.9725)	(1488261545.0673)	(2082523393.8119)
500	1904491240.8426	1388212171.3366	862627743.0739	629511390.065	871070219.2544
	(43611272904.5645)	(24290162291.4368)	(17769213328.2429)	(9307518158.4591)	(18032302114.6208)
1000	263252015.9281	3018900738.1861	1137388577.8713	1473395393.8618	936682387.7143
	(2978954366.999)	(75777841714.2041)	(14527495894.2676)	(18377429763.0566)	(13195978665.4836)
1500	7488133105.9301	13420624073.6557	6625487002.1132	11366200599.4924	1282644571.6774
	(222477989311.959)	(372618715286.897)	(152547227349.97)	(291017401025.063)	(19116613557.158)
2000	175067902.5721	8770976197.8511	1423669302.2731	7004265335.5701	881406049.5777
	(2092044622.9839)	(227562345257.198)	(24872292715.3959)	(168932475207.897)	(11781782168.7321)
2500	434476860.6879	13791422483.9757	867431110.7597	4702720528.9703	371950442.0671
	(8783031065.549)	(291718733796.756)	(14472030514.8513)	(117547227073.286)	(4131551574.7124)
3000	664335628.2633	11767938629.7652	565613255.5118	3785492054.6779	622253529.1604
	(10492212830.1385)	(218887511412.629)	(5507932192.8136)	(83751220578.9439)	(7120845801.0514)
3500	579487185.5095	15059341600.622	465167627.8967	2898086227.9242	394958906.9464
	(15103007365.7064)	(261173548904.275)	(4504617549.1915)	(62156668018.0943)	(4012822836.3671)
4000	173094273.1019	14296909940.0598	306076051.9361	2296304440.923	326113818.1783
	(1970690867.6088)	(217176741122.801)	(2854000059.8536)	(49041740097.6008)	(2733795488.2507)
4500	549460665.485	12019487256.3179	480343818.4759	2033831090.7118	344233555.2999
	(13756608115.3238)	(179861179922.406)	(6131953581.545)	(38841955859.6853)	(4234973565.8902)
5000	421212303.0128	9250925865.64	4592262016.5407	7507912328.3157	1969063378.8018
	(8140458264.0704)	(137550984810.397)	(104499522098.079)	(160903553873.442)	(32829051516.0422)

Table D.20: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:Normal, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	459.4684	452.0279	265.4394	383.4596	243.1407
	(66.3861)	(29.945)	(11.6965)	(13.1515)	(8.3197)
100	330.2376	320.896	222.062	292.8128	211.7376
	(40.9876)	(18.2453)	(8.8398)	(11.6189)	(7.8273)
500	148.4028	145.1216	124.7533	141.6106	123.2709
	(10.232)	(7.1606)	(5.6833)	(6.4202)	(5.5203)
1000	109.9458	108.3258	93.9613	106.2652	93.0977
	(5.3523)	(4.9689)	(4.1275)	(4.5237)	(4.0355)
1500	100.4061	98.6627	85.3137	97.2006	84.5985
	(5.2511)	(4.2489)	(3.544)	(3.9222)	(3.5231)
2000	100.4833	98.776	85.9871	97.9665	85.3933
	(5.9245)	(3.8547)	(3.2038)	(3.6326)	(3.1883)
2500	102.0174	102.2638	90.9255	102.0408	90.4952
	(6.7182)	(4.0766)	(3.5019)	(3.8447)	(3.4629)
3000	103.2939	106.0155	97.7901	106.1866	97.5342
	(7.2193)	(4.4733)	(3.8168)	(4.3103)	(3.7119)
3500	103.5772	108.2036	105.1801	108.5799	105.0828
	(7.0575)	(5.2558)	(4.3837)	(4.9424)	(4.2013)
4000	104.7419	108.5275	112.3587	109.1898	112.3885
	(7.5306)	(5.7064)	(5.0152)	(5.2748)	(4.9168)
4500	105.4703	107.2885	118.4301	108.4494	118.7314
	(7.6351)	(5.2285)	(5.72)	(4.9246)	(5.6142)
5000	107.4081	105.5517	122.9275	107.23	123.5341
	(19.4166)	(4.8128)	(6.4437)	(4.6676)	(6.4815)

Table D.21: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:MVT, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	3107501204.948	3105349942.7317	3053408121.2451	3042138242.0718	3044376268.682
	(95525238378.8603)	(95525277981.5231)	(93861980835.2276)	(93577335185.8995)	(93579013938.1865)
100	1473053201.4958	1669649345.1841	1699101572.93	1553696460.791	1666825341.5906
	(37866863300.5673)	(45159211601.0837)	(47937775452.9045)	(41784254445.9024)	(47812847071.3388)
500	9331265545.1886	11721592544.251	442313929.7451	11504934171.6521	831947337.1692
	(278888881259.895)	(346620722234.506)	(6596504725.9395)	(336813529821.54)	(10900002660.227)
1000	1570870539.3893	79094276311.0714	2013651177.0382	92767941472.6992	39811706651.9981
	(21565088160.8083)	(2278395698503.88)	(44076204337.6972)	(2710278748705.97)	(1188384243055.83)
1500	814005278.3936	42789908372.9923	6629672170.702	42368664616.5566	2441312849.0402
	(12378988991.097)	(1002796487038.57)	(175110099203.047)	(937941526861.96)	(40388841861.5032)
2000	4092697715.957	26933750123.1525	5428925291.6124	17744531145.0567	2495863327.4536
	(79688253653.1718)	(611154911530.343)	(111414621282.337)	(292437919657.643)	(31813485323.7344)
2500	1259484914.9694	18438159036.9934	3979924808.0837	10910652982.8761	1669305519.0841
	(12984770872.9378)	(413994220950.615)	(79718110042.1136)	(157092713620.318)	(16986261728.0324)
3000	285166483.3865	13366670127.6949	3265897809.8448	6437594413.8805	2270353005.858
	(2292867961.7706)	(293160588466.429)	(63486285971.2298)	(83415719732.7836)	(47333733717.7591)
3500	140881909977.899	19559986990.3376	30509712240.7204	49994867653.7423	7737932645.0162
	(4187404545564.42)	(326313606996.836)	(767689188285.758)	(1360759001716.71)	(139870380458.026)
4000	17383601796.368	15466509803.177	14749452179.3127	35238918982.2524	5640790388.3688
	(419901484851.169)	(217224882490.551)	(232584266940.419)	(805650960900.332)	(82807623963.3433)
4500	73469176970.5741	20582819484.2437	5400014908.7778	32105961414.466	5631963462.3253
	(2202803895216.23)	(349987933029.97)	(71730794184.9841)	(613125185007.391)	(94667402696.0879)
5000	2728305864.9431	18719072352.8916	9376201200.6336	26603657800.9323	7593029101.952
	(65996383137.1025)	(285997003603.097)	(173203975431.549)	(452539546613.6)	(180243952088.311)

Table D.22: Average squared Frobenius norm, $||\tilde{\Sigma} - \Sigma||_F^2$, for each covariance estimator type for 1,000 simulations for a selected number of time points (Drift:Gradual, Distribution:Normal, Cov1:RWISH, Cov2:RWISH). The standard deviation of the loss is provided in parentheses.

Time	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	1761.5464	1761.4296	790.0812	1313.5061	726.8807
	(70.1342)	(69.7595)	(20.2983)	(18.5758)	(11.272)
100	1361.1009	1263.6752	692.9851	1058.8993	664.923
	(251.5622)	(75.3631)	(14.0539)	(22.2157)	(10.5927)
500	575.2967	565.8151	438.343	539.1218	433.6622
	(19.816)	(14.7146)	(9.2823)	(11.7319)	(9.0998)
1000	419.5173	414.5578	337.0023	400.2892	333.3963
	(11.7545)	(10.4462)	(7.2443)	(24.0834)	(7.2671)
1500	369.9142	365.4589	303.3255	354.0938	299.4579
	(10.9542)	(8.8311)	(7.0118)	(16.7581)	(6.8354)
2000	354.4173	350.0435	299.5441	340.8504	295.6739
	(10.4766)	(8.2155)	(7.2092)	(8.2474)	(7.1465)
2500	353.4998	348.5028	312.0966	341.9954	308.4671
	(11.1049)	(7.7868)	(7.7425)	(6.8842)	(7.7071)
3000	356.966	351.6391	333.0618	348.4375	330.3803
	(13.2279)	(7.8036)	(7.7921)	(7.0417)	(7.9182)
3500	360.3885	356.2264	356.5972	356.3338	354.8631
	(12.4261)	(8.2637)	(7.8533)	(7.6611)	(7.8911)
4000	364.4204	359.3725	377.5596	362.9571	376.7772
	(15.3021)	(8.5741)	(8.5018)	(8.2639)	(8.3862)
4500	367.3608	360.7536	395.4464	367.5326	395.5657
	(14.8294)	(9.2274)	(8.8673)	(9.3016)	(8.7482)
5000	372.7193	362.1856	408.8696	371.78	410.0629
	(18.7819)	(10.4402)	(9.0922)	(10.5234)	(8.8234)

APPENDIX E: STATIONARY LDA SIMULATION

Table E.1: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 10) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.078	0.0821	0.0781	0.0658	0.0774	0.0638
	(0.0147)	(0.0243)	(0.015)	(0.0086)	(0.0146)	(0.0075)
100	0.0642	0.069	0.0643	0.0599	0.0641	0.0591
	(0.0075)	(0.0205)	(0.0076)	(0.0051)	(0.0075)	(0.0047)
500	0.0532	0.0599	0.0532	0.0529	0.0532	0.0528
	(0.0016)	(0.0308)	(0.0016)	(0.0014)	(0.0016)	(0.0014)
1000	0.0517	0.0598	0.0517	0.0516	0.0517	0.0515
	(0.0014)	(0.0298)	(0.0014)	(0.0014)	(0.0014)	(0.0014)
1500	0.0512	0.0607	0.0512	0.0511	0.0512	0.0511
	(0.0011)	(0.0372)	(0.0011)	(0.001)	(0.0011)	(0.001)
2000	0.0509	0.0615	0.0509	0.0509	0.0509	0.0509
	(9e-04)	(0.0411)	(8e-04)	(8e-04)	(8e-04)	(8e-04)
2500	0.0507	0.0604	0.0507	0.0507	0.0507	0.0507
	(7e-04)	(0.0366)	(6e-04)	(6e-04)	(6e-04)	(7e-04)
3000	0.0506	0.0608	0.0506	0.0506	0.0506	0.0506
	(6e-04)	(0.0343)	(4e-04)	(4e-04)	(4e-04)	(5e-04)
3500	0.0505	0.061	0.0506	0.0506	0.0505	0.0506
	(5e-04)	(0.0376)	(4e-04)	(3e-04)	(4e-04)	(4e-04)
4000	0.0505	0.0606	0.0505	0.0505	0.0505	0.0505
	(4e-04)	(0.0328)	(3e-04)	(3e-04)	(3e-04)	(4e-04)
4500	0.0504	0.0604	0.0505	0.0505	0.0505	0.0505
	(4e-04)	(0.0323)	(3e-04)	(3e-04)	(3e-04)	(3e-04)
5000	0.0504	0.0606	0.0504	0.0504	0.0504	0.0504
	(3e-04)	(0.0325)	(3e-04)	(2e-04)	(2e-04)	(3e-04)

Table E.2: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 10) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.0781	0.0821	0.0783	0.0721	0.0777	0.0714
	(0.0143)	(0.027)	(0.0143)	(0.0097)	(0.0141)	(0.0096)
100	0.063	0.0682	0.063	0.0619	0.0629	0.0616
	(0.0062)	(0.0385)	(0.0063)	(0.0052)	(0.0062)	(0.0051)
500	0.0524	0.0582	0.0523	0.0524	0.0523	0.0523
	(0.0011)	(0.0333)	(0.0011)	(0.0011)	(0.0011)	(0.0011)
1000	0.0511	0.059	0.0511	0.0512	0.0511	0.0511
	(5e-04)	(0.0459)	(5e-04)	(5e-04)	(5e-04)	(5e-04)
1500	0.0508	0.0598	0.0508	0.0508	0.0508	0.0508
	(4e-04)	(0.0355)	(4e-04)	(4e-04)	(4e-04)	(4e-04)
2000	0.0506	0.0599	0.0506	0.0506	0.0506	0.0506
	(3e-04)	(0.0363)	(3e-04)	(3e-04)	(3e-04)	(3e-04)
2500	0.0505	0.0599	0.0505	0.0505	0.0505	0.0505
	(2e-04)	(0.0387)	(2e-04)	(2e-04)	(2e-04)	(2e-04)
3000	0.0504	0.0596	0.0504	0.0504	0.0504	0.0504
	(2e-04)	(0.0386)	(2e-04)	(2e-04)	(2e-04)	(2e-04)
3500	0.0503	0.0605	0.0503	0.0504	0.0503	0.0504
	(1e-04)	(0.0468)	(2e-04)	(2e-04)	(1e-04)	(2e-04)
4000	0.0503	0.0612	0.0503	0.0503	0.0503	0.0503
	(1e-04)	(0.0482)	(1e-04)	(1e-04)	(1e-04)	(1e-04)
4500	0.0503	0.0595	0.0503	0.0503	0.0503	0.0503
	(1e-04)	(0.0355)	(1e-04)	(1e-04)	(1e-04)	(1e-04)
5000	0.0502	0.0604	0.0502	0.0503	0.0502	0.0503
	(1e-04)	(0.0486)	(1e-04)	(1e-04)	(1e-04)	(1e-04)

Table E.3: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 25) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1329	0.1391	0.1355	0.0822	0.131	0.078
	(0.0295)	(0.0359)	(0.0322)	(0.011)	(0.0291)	(0.0097)
100	0.0852	0.092	0.086	0.0703	0.0852	0.0683
	(0.0121)	(0.02)	(0.0129)	(0.0065)	(0.0132)	(0.006)
500	0.0575	0.0584	0.0576	0.0566	0.0577	0.0563
	(0.0026)	(0.003)	(0.0026)	(0.0022)	(0.0045)	(0.002)
1000	0.054	0.0544	0.054	0.0538	0.0541	0.0537
	(0.0014)	(0.0015)	(0.0013)	(0.0012)	(0.0029)	(0.0011)
1500	0.0527	0.0532	0.0528	0.0528	0.0528	0.0527
	(9e-04)	(0.0015)	(9e-04)	(9e-04)	(0.0017)	(9e-04)
2000	0.0521	0.0526	0.0522	0.0523	0.0522	0.0523
	(7e-04)	(0.001)	(7e-04)	(8e-04)	(0.0015)	(7e-04)
2500	0.0517	0.0522	0.0518	0.052	0.0518	0.052
	(6e-04)	(8e-04)	(6e-04)	(7e-04)	(0.0015)	(7e-04)
3000	0.0514	0.052	0.0516	0.0519	0.0516	0.0518
	(5e-04)	(8e-04)	(6e-04)	(7e-04)	(0.0015)	(6e-04)
3500	0.0512	0.0519	0.0515	0.0518	0.0515	0.0517
	(4e-04)	(0.001)	(5e-04)	(7e-04)	(0.0016)	(6e-04)
4000	0.0511	0.0519	0.0514	0.0517	0.0514	0.0516
	(4e-04)	(0.0014)	(7e-04)	(6e-04)	(0.0015)	(6e-04)
4500	0.051	0.0518	0.0514	0.0516	0.0513	0.0516
	(4e-04)	(9e-04)	(6e-04)	(6e-04)	(0.0017)	(6e-04)
5000	0.0509	0.0522	0.0513	0.0516	0.0513	0.0516
	(3e-04)	(0.0088)	(6e-04)	(7e-04)	(0.0018)	(7e-04)

Table E.4: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 25) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1486	0.1542	0.1507	0.0879	0.1459	0.0875
	(0.0355)	(0.0415)	(0.037)	(0.011)	(0.0343)	(0.0103)
100	0.0877	0.0944	0.0882	0.0724	0.0874	0.0729
	(0.0126)	(0.0217)	(0.013)	(0.0062)	(0.0125)	(0.0063)
500	0.0562	0.057	0.0562	0.0557	0.0562	0.0559
	(0.0018)	(0.0026)	(0.0018)	(0.0016)	(0.0018)	(0.0017)
1000	0.053	0.0532	0.053	0.053	0.053	0.053
	(9e-04)	(0.0013)	(9e-04)	(8e-04)	(9e-04)	(8e-04)
1500	0.052	0.0522	0.052	0.0521	0.052	0.0521
	(6e-04)	(8e-04)	(6e-04)	(6e-04)	(6e-04)	(6e-04)
2000	0.0515	0.0519	0.0515	0.0516	0.0515	0.0516
	(4e-04)	(0.0072)	(4e-04)	(5e-04)	(4e-04)	(5e-04)
2500	0.0512	0.0514	0.0513	0.0514	0.0512	0.0514
	(3e-04)	(9e-04)	(4e-04)	(4e-04)	(4e-04)	(4e-04)
3000	0.051	0.0513	0.0511	0.0512	0.051	0.0512
	(3e-04)	(0.0015)	(3e-04)	(3e-04)	(3e-04)	(3e-04)
3500	0.0508	0.0511	0.0509	0.0511	0.0509	0.0511
	(2e-04)	(0.0011)	(3e-04)	(3e-04)	(3e-04)	(3e-04)
4000	0.0507	0.0511	0.0508	0.051	0.0508	0.051
	(2e-04)	(0.0032)	(2e-04)	(3e-04)	(2e-04)	(3e-04)
4500	0.0507	0.0509	0.0508	0.051	0.0508	0.051
	(2e-04)	(5e-04)	(2e-04)	(3e-04)	(2e-04)	(3e-04)
5000	0.0506	0.0509	0.0507	0.0509	0.0507	0.051
	(2e-04)	(4e-04)	(2e-04)	(3e-04)	(2e-04)	(3e-04)

Table E.5: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 50) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3355	0.3355	0.3348	0.0976	0.274	0.0933
	(0.066)	(0.0656)	(0.0658)	(0.0127)	(0.0502)	(0.0113)
100	0.1303	0.15	0.1359	0.0789	0.1405	0.0774
	(0.0201)	(0.0418)	(0.0254)	(0.007)	(0.0502)	(0.0066)
500	0.0642	0.0654	0.0645	0.0603	0.0668	0.0601
	(0.0033)	(0.0043)	(0.0033)	(0.0022)	(0.0171)	(0.0022)
1000	0.0576	0.0582	0.0577	0.0567	0.0592	0.0567
	(0.0018)	(0.0025)	(0.0018)	(0.0014)	(0.0099)	(0.0014)
1500	0.0552	0.0559	0.0555	0.0554	0.0573	0.0554
	(0.0012)	(0.003)	(0.0013)	(0.0012)	(0.0133)	(0.0012)
2000	0.054	0.0547	0.0549	0.0548	0.0566	0.0548
	(0.001)	(0.0013)	(0.0118)	(0.0011)	(0.0173)	(0.0012)
2500	0.0533	0.0541	0.0538	0.0544	0.0561	0.0544
	(8e-04)	(0.0013)	(0.0011)	(0.0011)	(0.0168)	(0.0011)
3000	0.0528	0.0537	0.0535	0.0541	0.0555	0.0542
	(7e-04)	(0.001)	(0.0035)	(0.0011)	(0.0154)	(0.0011)
3500	0.0524	0.0534	0.0531	0.0539	0.0553	0.054
	(6e-04)	(0.001)	(9e-04)	(0.0011)	(0.0218)	(0.0011)
4000	0.0522	0.0535	0.0529	0.0538	0.0546	0.0539
	(6e-04)	(0.0081)	(8e-04)	(0.0011)	(0.0112)	(0.0011)
4500	0.0519	0.0531	0.0528	0.0538	0.0545	0.0538
	(5e-04)	(0.0011)	(0.0017)	(0.0011)	(0.0109)	(0.0011)
5000	0.0518	0.053	0.0527	0.0538	0.0543	0.0538
	(5e-04)	(0.0012)	(8e-04)	(0.0011)	(0.0106)	(0.0011)

Table E.6: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 50) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3609	0.3605	0.3607	0.1148	0.3003	0.1119
	(0.0617)	(0.0614)	(0.0616)	(0.0141)	(0.0488)	(0.0131)
100	0.1446	0.1638	0.1494	0.0884	0.1465	0.0872
	(0.0226)	(0.0473)	(0.0274)	(0.0076)	(0.0263)	(0.0074)
500	0.0629	0.0637	0.063	0.0607	0.064	0.0606
	(0.0028)	(0.0037)	(0.0028)	(0.0021)	(0.0167)	(0.0021)
1000	0.0561	0.0565	0.0565	0.056	0.057	0.0559
	(0.0012)	(0.0014)	(0.0069)	(0.0011)	(0.0085)	(0.0011)
1500	0.054	0.0543	0.0543	0.0544	0.0554	0.0543
	(8e-04)	(0.0011)	(0.0027)	(8e-04)	(0.0214)	(8e-04)
2000	0.053	0.0534	0.0533	0.0536	0.0541	0.0535
	(6e-04)	(0.0015)	(7e-04)	(7e-04)	(0.0083)	(7e-04)
2500	0.0524	0.053	0.0527	0.0531	0.0534	0.0531
	(5e-04)	(0.0066)	(7e-04)	(6e-04)	(0.0063)	(6e-04)
3000	0.052	0.0523	0.0525	0.0529	0.0533	0.0528
	(4e-04)	(7e-04)	(8e-04)	(6e-04)	(0.0081)	(6e-04)
3500	0.0517	0.0521	0.0526	0.0527	0.0531	0.0527
	(3e-04)	(5e-04)	(0.0078)	(5e-04)	(0.0073)	(5e-04)
4000	0.0515	0.0519	0.0522	0.0526	0.053	0.0526
	(3e-04)	(4e-04)	(6e-04)	(5e-04)	(0.0067)	(5e-04)
4500	0.0513	0.0518	0.0522	0.0526	0.0531	0.0526
	(3e-04)	(4e-04)	(7e-04)	(5e-04)	(0.0092)	(5e-04)
5000	0.0512	0.0517	0.0522	0.0526	0.0529	0.0525
	(2e-04)	(4e-04)	(8e-04)	(5e-04)	(0.0069)	(5e-04)

Table E.7: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 100) under stationarity, for a EYE covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3366	0.3367	0.3368	0.203	0.1959	0.1965
	(0.0372)	(0.0372)	(0.0372)	(0.0218)	(0.0212)	(0.021)
100	0.4169	0.4167	0.4167	0.1664	0.1631	0.1635
	(0.0413)	(0.0413)	(0.0413)	(0.0146)	(0.0148)	(0.0141)
500	0.1434	0.1496	0.1467	0.1176	0.1169	0.1167
	(0.0076)	(0.009)	(0.008)	(0.0045)	(0.0047)	(0.0043)
1000	0.1231	0.1251	0.1243	0.1103	0.11	0.1098
	(0.0035)	(0.004)	(0.0041)	(0.0031)	(0.0034)	(0.0031)
1500	0.1161	0.1179	0.1173	0.1078	0.1076	0.1075
	(0.0025)	(0.0074)	(0.0028)	(0.0027)	(0.0029)	(0.0028)
2000	0.1125	0.1141	0.1138	0.1066	0.1064	0.1063
	(0.0019)	(0.0032)	(0.0022)	(0.0025)	(0.0026)	(0.0026)
2500	0.1102	0.112	0.1118	0.106	0.1057	0.1057
	(0.0016)	(0.0023)	(0.0022)	(0.0024)	(0.0025)	(0.0025)
3000	0.1087	0.1107	0.1105	0.1056	0.1053	0.1054
	(0.0013)	(0.0022)	(0.0017)	(0.0023)	(0.0023)	(0.0024)
3500	0.1075	0.1098	0.1096	0.1052	0.105	0.105
	(0.0012)	(0.0019)	(0.0017)	(0.0022)	(0.0023)	(0.0023)
4000	0.1067	0.1095	0.1095	0.1053	0.105	0.1051
	(0.0011)	(0.007)	(0.0104)	(0.0026)	(0.0026)	(0.0027)
4500	0.1061	0.1095	0.1088	0.105	0.1048	0.1049
	(0.001)	(0.0103)	(0.0019)	(0.0022)	(0.0022)	(0.0023)
5000	0.1055	0.1087	0.1085	0.1049	0.1045	0.1047
	(9e-04)	(0.0026)	(0.0017)	(0.0021)	(0.0021)	(0.0022)

Table E.8: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 100) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.2657	0.2658	0.2655	0.1259	0.1649	0.1187
	(0.04)	(0.04)	(0.0399)	(0.0163)	(0.0247)	(0.0144)
100	0.3807	0.3808	0.3807	0.0991	0.3085	0.0959
	(0.0519)	(0.0519)	(0.0518)	(0.0106)	(0.0423)	(0.0098)
500	0.0777	0.0822	0.0801	0.0677	0.1295	0.067
	(0.0046)	(0.0101)	(0.0107)	(0.0027)	(0.0796)	(0.0025)
1000	0.0641	0.0658	0.0661	0.0629	0.1022	0.0625
	(0.0024)	(0.0091)	(0.0197)	(0.0019)	(0.0682)	(0.0018)
1500	0.0598	0.0611	0.062	0.0611	0.0882	0.0609
	(0.0016)	(0.0081)	(0.0212)	(0.0019)	(0.0621)	(0.0019)
2000	0.0576	0.0587	0.0599	0.0601	0.0796	0.06
	(0.0013)	(0.0036)	(0.0219)	(0.0018)	(0.047)	(0.0017)
2500	0.0562	0.0575	0.0583	0.0596	0.0766	0.0595
	(0.001)	(0.0032)	(0.0176)	(0.0018)	(0.042)	(0.0018)
3000	0.0552	0.0569	0.0587	0.0592	0.0746	0.0592
	(9e-04)	(0.0066)	(0.0277)	(0.0017)	(0.0381)	(0.0017)
3500	0.0545	0.0562	0.0582	0.0589	0.0741	0.0589
	(8e-04)	(0.0052)	(0.0265)	(0.0017)	(0.0312)	(0.0016)
4000	0.054	0.0559	0.058	0.0588	0.0745	0.0588
	(7e-04)	(0.0038)	(0.0262)	(0.0018)	(0.0362)	(0.0018)
4500	0.0536	0.0558	0.0577	0.0586	0.0776	0.0587
	(6e-04)	(0.0065)	(0.0265)	(0.0018)	(0.0421)	(0.0018)
5000	0.0533	0.0554	0.058	0.0585	0.0773	0.0585
	(6e-04)	(0.0017)	(0.0293)	(0.0017)	(0.0396)	(0.0017)

Table E.9: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under stationarity, for a EYE covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3346	0.3347	0.3345	0.2048	0.1995	0.1995
	(0.035)	(0.0351)	(0.0348)	(0.019)	(0.018)	(0.0181)
100	0.4272	0.4269	0.4271	0.1607	0.1582	0.1581
	(0.04)	(0.0396)	(0.0397)	(0.0107)	(0.0103)	(0.0103)
500	0.1396	0.1455	0.1421	0.1138	0.1133	0.1133
	(0.0059)	(0.0082)	(0.007)	(0.0021)	(0.002)	(0.002)
1000	0.1189	0.1204	0.1197	0.1075	0.1072	0.1072
	(0.0029)	(0.0031)	(0.003)	(0.0011)	(0.0011)	(0.0011)
1500	0.1124	0.1136	0.1136	0.1058	0.1056	0.1056
	(0.0019)	(0.007)	(0.002)	(9e-04)	(8e-04)	(8e-04)
2000	0.1092	0.1101	0.1109	0.1051	0.1049	0.1049
	(0.0014)	(0.0017)	(0.0016)	(8e-04)	(8e-04)	(8e-04)
2500	0.1074	0.1082	0.1094	0.1047	0.1045	0.1045
	(0.001)	(0.0012)	(0.0013)	(7e-04)	(7e-04)	(7e-04)
3000	0.1061	0.1071	0.1085	0.1043	0.1041	0.1041
	(9e-04)	(0.0018)	(0.0013)	(7e-04)	(6e-04)	(6e-04)
3500	0.1053	0.1063	0.1079	0.1041	0.1039	0.1039
	(7e-04)	(0.0021)	(0.0028)	(7e-04)	(6e-04)	(6e-04)
4000	0.1046	0.1058	0.1075	0.1039	0.1037	0.1037
	(6e-04)	(0.0065)	(0.0048)	(7e-04)	(6e-04)	(6e-04)
4500	0.1041	0.1052	0.1071	0.1037	0.1036	0.1036
	(6e-04)	(0.0014)	(0.0019)	(6e-04)	(6e-04)	(6e-04)
5000	0.1037	0.105	0.1071	0.1037	0.1035	0.1035
	(5e-04)	(0.0029)	(0.0043)	(6e-04)	(6e-04)	(6e-04)

Table E.10: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.2678	0.2679	0.2679	0.1308	0.202	0.1293
	(0.0377)	(0.0378)	(0.0378)	(0.0149)	(0.0314)	(0.0146)
100	0.4009	0.4007	0.4008	0.099	0.3334	0.0988
	(0.0486)	(0.0484)	(0.0488)	(0.0074)	(0.039)	(0.0074)
500	0.0779	0.0819	0.0799	0.0672	0.1192	0.0675
	(0.0044)	(0.0065)	(0.0067)	(0.0022)	(0.0681)	(0.0022)
1000	0.0627	0.0639	0.0642	0.0608	0.0803	0.0609
	(0.0018)	(0.0062)	(0.0175)	(0.0013)	(0.0364)	(0.0013)
1500	0.0582	0.0593	0.0607	0.0583	0.0717	0.0584
	(0.0012)	(0.0108)	(0.0226)	(0.001)	(0.0266)	(0.001)
2000	0.0561	0.0571	0.0594	0.057	0.0687	0.057
	(9e-04)	(0.0084)	(0.0251)	(8e-04)	(0.0243)	(8e-04)
2500	0.0548	0.0555	0.0588	0.0562	0.0675	0.0562
	(7e-04)	(0.001)	(0.0283)	(8e-04)	(0.026)	(8e-04)
3000	0.054	0.0547	0.0582	0.0557	0.0667	0.0557
	(6e-04)	(8e-04)	(0.0285)	(7e-04)	(0.0246)	(7e-04)
3500	0.0534	0.0543	0.0579	0.0553	0.0664	0.0554
	(5e-04)	(0.005)	(0.0293)	(6e-04)	(0.0264)	(6e-04)
4000	0.053	0.0538	0.0578	0.0551	0.0665	0.0551
	(4e-04)	(7e-04)	(0.0309)	(6e-04)	(0.0263)	(6e-04)
4500	0.0526	0.0537	0.0581	0.055	0.0662	0.055
	(4e-04)	(0.0052)	(0.033)	(6e-04)	(0.0249)	(6e-04)
5000	0.0524	0.0533	0.0581	0.0548	0.0659	0.0549
	(3e-04)	(9e-04)	(0.0347)	(6e-04)	(0.0245)	(6e-04)

Table E.11: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under stationarity, for a covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.2716	0.2718	0.2721	0.1532	0.1497	0.1523
	(0.0387)	(0.038)	(0.0385)	(0.0211)	(0.0204)	(0.0211)
100	0.3993	0.3984	0.3992	0.1394	0.1356	0.1387
	(0.0477)	(0.0476)	(0.0477)	(0.0158)	(0.0146)	(0.0156)
500	0.0778	0.0818	0.0796	0.076	0.0761	0.0762
	(0.0046)	(0.0061)	(0.0053)	(0.0042)	(0.0042)	(0.0042)
1000	0.0627	0.0637	0.0633	0.0627	0.0627	0.0627
	(0.0019)	(0.0021)	(0.002)	(0.0019)	(0.0019)	(0.0019)
1500	0.0583	0.0589	0.0592	0.0588	0.0588	0.0588
	(0.0013)	(0.0014)	(0.0014)	(0.0013)	(0.0013)	(0.0013)
2000	0.0561	0.0567	0.0573	0.0571	0.0571	0.0571
	(9e-04)	(0.0011)	(0.0012)	(0.0011)	(0.0011)	(0.0011)
2500	0.0548	0.0555	0.0563	0.0561	0.0562	0.0562
	(8e-04)	(0.001)	(0.001)	(9e-04)	(9e-04)	(9e-04)
3000	0.054	0.0548	0.0558	0.0556	0.0556	0.0556
	(7e-04)	(0.001)	(0.001)	(8e-04)	(8e-04)	(8e-04)
3500	0.0534	0.0543	0.0554	0.0551	0.0552	0.0552
	(6e-04)	(0.0019)	(0.0011)	(8e-04)	(8e-04)	(8e-04)
4000	0.053	0.054	0.0551	0.0549	0.0549	0.0549
	(5e-04)	(0.0014)	(0.0011)	(7e-04)	(7e-04)	(7e-04)
4500	0.0527	0.0542	0.0557	0.0547	0.0547	0.0547
	(5e-04)	(0.0108)	(0.0165)	(7e-04)	(7e-04)	(7e-04)
5000	0.0524	0.0556	0.0564	0.0546	0.0546	0.0546
	(5e-04)	(0.0226)	(0.0235)	(7e-04)	(7e-04)	(7e-04)

Table E.12: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 250) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3692	0.3691	0.3691	0.1642	0.1678	0.1586
	(0.0398)	(0.0395)	(0.0396)	(0.0216)	(0.0221)	(0.0212)
100	0.2749	0.2748	0.2749	0.1238	0.1533	0.1212
	(0.0277)	(0.0277)	(0.0276)	(0.0107)	(0.0146)	(0.01)
500	0.1302	0.1302	0.1302	0.0781	0.2542	0.0775
	(0.0091)	(0.0091)	(0.0091)	(0.0046)	(0.1062)	(0.0039)
1000	0.0852	0.0852	0.0852	0.0748	0.1734	0.0747
	(0.0037)	(0.0037)	(0.0037)	(0.0063)	(0.0872)	(0.0061)
1500	0.0733	0.0733	0.0733	0.0722	0.1538	0.0728
	(0.0024)	(0.0024)	(0.0024)	(0.0055)	(0.0805)	(0.0068)
2000	0.0677	0.0677	0.0677	0.0709	0.1421	0.0716
	(0.0018)	(0.0018)	(0.0018)	(0.0046)	(0.0759)	(0.0051)
2500	0.0643	0.0643	0.0643	0.0705	0.1337	0.0712
	(0.0014)	(0.0014)	(0.0014)	(0.0066)	(0.0779)	(0.0053)
3000	0.062	0.0621	0.0621	0.0698	0.1268	0.0707
	(0.0012)	(0.0012)	(0.0012)	(0.0038)	(0.0751)	(0.0051)
3500	0.0605	0.0605	0.0605	0.07	0.1212	0.0707
	(0.0011)	(0.0011)	(0.0011)	(0.0063)	(0.067)	(0.0062)
4000	0.0593	0.0593	0.0593	0.0696	0.1211	0.0705
	(9e-04)	(9e-04)	(9e-04)	(0.0047)	(0.0699)	(0.0061)
4500	0.0583	0.0583	0.0583	0.0692	0.1186	0.0701
	(8e-04)	(8e-04)	(8e-04)	(0.0039)	(0.0661)	(0.006)
5000	0.0576	0.0576	0.0576	0.0693	0.1184	0.0702
	(8e-04)	(8e-04)	(8e-04)	(0.0039)	(0.0634)	(0.0059)

Table E.13: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3658	0.3658	0.3659	0.2066	0.2239	0.2024
	(0.0329)	(0.0329)	(0.0331)	(0.0218)	(0.0241)	(0.0215)
100	0.2912	0.2911	0.2912	0.1474	0.1978	0.1452
	(0.0254)	(0.0254)	(0.0253)	(0.0112)	(0.0185)	(0.011)
500	0.1424	0.1424	0.1424	0.0817	0.2037	0.0815
	(0.0097)	(0.0097)	(0.0097)	(0.0027)	(0.032)	(0.0027)
1000	0.0868	0.0868	0.0868	0.0705	0.2165	0.0705
	(0.0038)	(0.0038)	(0.0038)	(0.0016)	(0.085)	(0.0016)
1500	0.0727	0.0727	0.0727	0.0659	0.1428	0.066
	(0.0022)	(0.0022)	(0.0022)	(0.0012)	(0.0421)	(0.0012)
2000	0.0664	0.0664	0.0664	0.0633	0.1463	0.0634
	(0.0016)	(0.0016)	(0.0016)	(0.001)	(0.0493)	(0.001)
2500	0.0628	0.0628	0.0628	0.0616	0.1048	0.0617
	(0.0012)	(0.0012)	(0.0012)	(9e-04)	(0.0318)	(9e-04)
3000	0.0605	0.0605	0.0605	0.0604	0.0964	0.0605
	(0.001)	(0.001)	(0.001)	(8e-04)	(0.0293)	(8e-04)
3500	0.0589	0.0589	0.0589	0.0595	0.089	0.0596
	(8e-04)	(8e-04)	(8e-04)	(7e-04)	(0.0263)	(7e-04)
4000	0.0577	0.0577	0.0577	0.0588	0.0843	0.0589
	(7e-04)	(7e-04)	(7e-04)	(6e-04)	(0.0228)	(6e-04)
4500	0.0568	0.0568	0.0568	0.0583	0.0824	0.0583
	(6e-04)	(6e-04)	(6e-04)	(6e-04)	(0.0224)	(6e-04)
5000	0.0561	0.0561	0.0561	0.0578	0.0808	0.0579
	(5e-04)	(5e-04)	(5e-04)	(6e-04)	(0.021)	(6e-04)

Table E.14: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4441	0.4443	0.444	0.2191	0.2148	0.2125
	(0.0318)	(0.0317)	(0.0317)	(0.0347)	(0.0347)	(0.0352)
100	0.3667	0.3667	0.3666	0.1559	0.1616	0.1523
	(0.0289)	(0.0289)	(0.0291)	(0.013)	(0.0132)	(0.0124)
500	0.444	0.4441	0.4439	0.0937	0.3717	0.0931
	(0.0243)	(0.0242)	(0.0242)	(0.0069)	(0.0209)	(0.0068)
1000	0.13	0.13	0.13	0.0865	0.2496	0.0858
	(0.0063)	(0.0063)	(0.0063)	(0.0326)	(0.106)	(0.033)
1500	0.098	0.098	0.098	0.0873	0.1728	0.0874
	(0.0038)	(0.0038)	(0.0038)	(0.0147)	(0.0724)	(0.0118)
2000	0.0851	0.085	0.085	0.0853	0.175	0.086
	(0.0026)	(0.0026)	(0.0026)	(0.0096)	(0.0906)	(0.0119)
2500	0.0778	0.0778	0.0778	0.0849	0.1529	0.0861
	(0.002)	(0.002)	(0.002)	(0.009)	(0.0746)	(0.0117)
3000	0.0732	0.0732	0.0732	0.0851	0.1524	0.0861
	(0.0017)	(0.0017)	(0.0017)	(0.0095)	(0.0794)	(0.011)
3500	0.07	0.07	0.07	0.0859	0.1453	0.0876
	(0.0014)	(0.0014)	(0.0014)	(0.0141)	(0.0719)	(0.017)
4000	0.0676	0.0676	0.0676	0.0851	0.1367	0.0865
	(0.0013)	(0.0013)	(0.0013)	(0.0097)	(0.0653)	(0.0118)
4500	0.0658	0.0658	0.0658	0.0847	0.1387	0.0862
	(0.0011)	(0.0011)	(0.0011)	(0.0091)	(0.0736)	(0.011)
5000	0.0643	0.0643	0.0643	0.0848	0.1325	0.087
	(0.001)	(0.001)	(0.001)	(0.0093)	(0.0699)	(0.017)

Table E.15: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4443	0.4438	0.4439	0.219	0.2145	0.2126
	(0.0317)	(0.0317)	(0.0319)	(0.0345)	(0.0348)	(0.0351)
100	0.3668	0.3666	0.3666	0.1559	0.1614	0.1524
	(0.029)	(0.0291)	(0.0289)	(0.013)	(0.0132)	(0.0125)
500	0.4441	0.4441	0.4439	0.0937	0.3719	0.0932
	(0.0243)	(0.0243)	(0.0243)	(0.0069)	(0.021)	(0.0068)
1000	0.1301	0.13	0.13	0.0864	0.2492	0.0858
	(0.0063)	(0.0063)	(0.0063)	(0.0326)	(0.1058)	(0.033)
1500	0.0981	0.098	0.098	0.0872	0.1729	0.0873
	(0.0038)	(0.0038)	(0.0038)	(0.0147)	(0.0727)	(0.0117)
2000	0.085	0.0851	0.085	0.0852	0.1744	0.086
	(0.0026)	(0.0026)	(0.0026)	(0.0096)	(0.0905)	(0.0119)
2500	0.0778	0.0778	0.0778	0.085	0.153	0.086
	(0.002)	(0.002)	(0.002)	(0.01)	(0.0748)	(0.0105)
3000	0.0732	0.0732	0.0732	0.0852	0.1523	0.0861
	(0.0017)	(0.0017)	(0.0017)	(0.0095)	(0.0797)	(0.0109)
3500	0.07	0.07	0.07	0.086	0.1456	0.0876
	(0.0014)	(0.0014)	(0.0014)	(0.0141)	(0.0725)	(0.017)
4000	0.0676	0.0676	0.0676	0.085	0.1351	0.0866
	(0.0013)	(0.0013)	(0.0013)	(0.0089)	(0.063)	(0.0118)
4500	0.0658	0.0658	0.0658	0.0848	0.1382	0.0862
	(0.0011)	(0.0011)	(0.0011)	(0.0092)	(0.0732)	(0.0109)
5000	0.0643	0.0643	0.0643	0.0848	0.1323	0.087
	(0.001)	(0.001)	(0.001)	(0.0093)	(0.0699)	(0.017)

Table E.16: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4294	0.4295	0.4295	0.263	0.2692	0.2596
	(0.0291)	(0.0293)	(0.0292)	(0.0269)	(0.0285)	(0.0274)
100	0.3539	0.354	0.3541	0.1916	0.2129	0.1897
	(0.0232)	(0.0232)	(0.0232)	(0.0139)	(0.0166)	(0.0139)
500	0.4528	0.4528	0.4529	0.0969	0.3875	0.0966
	(0.0221)	(0.0222)	(0.0221)	(0.0032)	(0.0186)	(0.0032)
1000	0.1431	0.1431	0.1431	0.0802	0.2151	0.0801
	(0.0074)	(0.0074)	(0.0074)	(0.0018)	(0.0247)	(0.0018)
1500	0.1025	0.1026	0.1025	0.0734	0.2438	0.0733
	(0.004)	(0.004)	(0.004)	(0.0013)	(0.0592)	(0.0013)
2000	0.0866	0.0866	0.0866	0.0695	0.1435	0.0695
	(0.0027)	(0.0027)	(0.0027)	(0.0011)	(0.0705)	(0.0011)
2500	0.0779	0.0779	0.0779	0.067	0.1587	0.067
	(0.002)	(0.002)	(0.002)	(0.001)	(0.0277)	(0.001)
3000	0.0725	0.0725	0.0725	0.0652	0.1689	0.0651
	(0.0016)	(0.0016)	(0.0016)	(8e-04)	(0.0369)	(8e-04)
3500	0.0689	0.0689	0.0689	0.0638	0.1797	0.0638
	(0.0013)	(0.0013)	(0.0013)	(8e-04)	(0.0497)	(8e-04)
4000	0.0662	0.0662	0.0662	0.0626	0.1688	0.0626
	(0.0011)	(0.0011)	(0.0011)	(7e-04)	(0.0548)	(7e-04)
4500	0.0643	0.0643	0.0643	0.0617	0.1349	0.0617
	(0.001)	(0.001)	(0.001)	(7e-04)	(0.0386)	(7e-04)
5000	0.0627	0.0627	0.0627	0.061	0.1353	0.061
	(9e-04)	(9e-04)	(9e-04)	(6e-04)	(0.0328)	(6e-04)

Table E.17: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 1000) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4794	0.4794	0.4794	0.2824	0.2784	0.2779
	(0.0206)	(0.0206)	(0.0206)	(0.0454)	(0.0475)	(0.0477)
100	0.4402	0.4401	0.4401	0.1998	0.199	0.1968
	(0.0222)	(0.0222)	(0.0221)	(0.0191)	(0.0193)	(0.0197)
500	0.2453	0.2453	0.2452	0.1096	0.1573	0.109
	(0.0123)	(0.0123)	(0.0123)	(0.0057)	(0.0076)	(0.0056)
1000	0.4589	0.4589	0.4588	0.092	0.3921	0.0917
	(0.0188)	(0.0188)	(0.0188)	(0.006)	(0.0158)	(0.0059)
1500	0.1749	0.1749	0.1749	0.0805	0.1943	0.0795
	(0.0074)	(0.0074)	(0.0075)	(0.0025)	(0.0649)	(0.0023)
2000	0.1299	0.1299	0.1299	0.0842	0.2336	0.0841
	(0.0047)	(0.0047)	(0.0047)	(0.0216)	(0.1026)	(0.0254)
2500	0.1096	0.1096	0.1096	0.1018	0.2	0.1062
	(0.0032)	(0.0032)	(0.0032)	(0.0231)	(0.0861)	(0.0306)
3000	0.0979	0.0979	0.0979	0.1109	0.1701	0.1185
	(0.0025)	(0.0025)	(0.0025)	(0.0338)	(0.066)	(0.0414)
3500	0.0903	0.0903	0.0903	0.1216	0.1643	0.1298
	(0.0021)	(0.0021)	(0.0021)	(0.0402)	(0.0704)	(0.0483)
4000	0.0849	0.0849	0.0849	0.1265	0.1559	0.1382
	(0.0018)	(0.0018)	(0.0018)	(0.0418)	(0.0685)	(0.051)
4500	0.0808	0.0808	0.0808	0.1306	0.1495	0.1426
	(0.0016)	(0.0016)	(0.0016)	(0.04)	(0.068)	(0.0508)
5000	0.0777	0.0777	0.0777	0.136	0.1499	0.1475
	(0.0014)	(0.0014)	(0.0014)	(0.0456)	(0.0682)	(0.0512)

Table E.18: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 1000) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4745	0.4745	0.4745	0.3258	0.3275	0.3235
	(0.0224)	(0.0224)	(0.0224)	(0.0312)	(0.0326)	(0.0324)
100	0.4194	0.4197	0.4196	0.2509	0.2596	0.2492
	(0.021)	(0.021)	(0.0209)	(0.0159)	(0.0168)	(0.0161)
500	0.2642	0.2642	0.2642	0.1246	0.2005	0.1243
	(0.0121)	(0.0121)	(0.0121)	(0.0042)	(0.0097)	(0.0042)
1000	0.4668	0.4669	0.4668	0.0961	0.4052	0.096
	(0.0166)	(0.0166)	(0.0166)	(0.0022)	(0.0135)	(0.0022)
1500	0.1979	0.1978	0.1979	0.086	0.2186	0.086
	(0.0079)	(0.0079)	(0.0079)	(0.0017)	(0.0101)	(0.0017)
2000	0.1426	0.1426	0.1426	0.0797	0.2215	0.0797
	(0.0051)	(0.0051)	(0.0051)	(0.0013)	(0.0212)	(0.0013)
2500	0.1173	0.1173	0.1172	0.0758	0.2443	0.0758
	(0.0037)	(0.0037)	(0.0037)	(0.0012)	(0.0412)	(0.0012)
3000	0.1025	0.1025	0.1025	0.073	0.257	0.073
	(0.0028)	(0.0028)	(0.0028)	(0.0011)	(0.0667)	(0.0011)
3500	0.0931	0.0931	0.0931	0.0709	0.1455	0.071
	(0.0023)	(0.0023)	(0.0023)	(0.001)	(0.0753)	(0.001)
4000	0.0865	0.0865	0.0865	0.0693	0.1498	0.0693
	(0.0019)	(0.0019)	(0.0019)	(9e-04)	(0.0255)	(9e-04)
4500	0.0816	0.0816	0.0816	0.0679	0.1675	0.0679
	(0.0017)	(0.0017)	(0.0017)	(8e-04)	(0.0275)	(8e-04)
5000	0.0779	0.0779	0.0779	0.0668	0.1695	0.0668
	(0.0014)	(0.0014)	(0.0014)	(8e-04)	(0.0237)	(8e-04)

Table E.19: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt(10) data (p = 100) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4379	0.4382	0.4379	0.2469	0.2532	0.2372
	(0.0779)	(0.0778)	(0.0779)	(0.0579)	(0.06)	(0.0562)
100	0.3665	0.3667	0.3665	0.1823	0.2491	0.1763
	(0.0541)	(0.0541)	(0.0542)	(0.039)	(0.0487)	(0.0384)
500	0.1815	0.1911	0.1855	0.1003	0.1978	0.0989
	(0.0177)	(0.0219)	(0.0197)	(0.0134)	(0.0522)	(0.0134)
1000	0.1286	0.1344	0.131	0.0839	0.1582	0.0832
	(0.011)	(0.0138)	(0.0122)	(0.0091)	(0.0524)	(0.0091)
1500	0.108	0.1124	0.1101	0.0775	0.1361	0.077
	(0.0083)	(0.0101)	(0.0095)	(0.007)	(0.046)	(0.007)
2000	0.0968	0.1003	0.0987	0.0738	0.1231	0.0734
	(0.0068)	(0.0083)	(0.0079)	(0.0059)	(0.0408)	(0.0059)
2500	0.0898	0.0928	0.0916	0.0716	0.1147	0.0712
	(0.0059)	(0.0072)	(0.0072)	(0.0053)	(0.0372)	(0.0053)
3000	0.085	0.0876	0.0868	0.07	0.1091	0.0697
	(0.0052)	(0.0063)	(0.0064)	(0.0046)	(0.0347)	(0.0047)
3500	0.0815	0.0839	0.0833	0.0689	0.1051	0.0686
	(0.0047)	(0.0057)	(0.0058)	(0.0042)	(0.033)	(0.0043)
4000	0.0788	0.081	0.0806	0.068	0.1022	0.0678
	(0.0044)	(0.0053)	(0.0053)	(0.0039)	(0.0317)	(0.004)
4500	0.0765	0.0787	0.0784	0.0673	0.0997	0.0671
	(0.0041)	(0.0049)	(0.0049)	(0.0037)	(0.0307)	(0.0037)
5000	0.0748	0.0768	0.0767	0.0667	0.098	0.0665
	(0.0039)	(0.0046)	(0.0046)	(0.0035)	(0.03)	(0.0035)

Table E.20: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt(25) data (p = 100) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.494	0.4943	0.4943	0.3473	0.3544	0.341
	(0.0805)	(0.0804)	(0.0804)	(0.0681)	(0.069)	(0.0657)
100	0.4357	0.4359	0.436	0.2905	0.3482	0.2865
	(0.0547)	(0.0549)	(0.0548)	(0.0466)	(0.0505)	(0.0449)
500	0.2645	0.2758	0.2687	0.1944	0.2744	0.1929
	(0.02)	(0.023)	(0.0209)	(0.0187)	(0.0422)	(0.0183)
1000	0.2083	0.2157	0.2111	0.1696	0.2271	0.1687
	(0.0132)	(0.0151)	(0.0137)	(0.0124)	(0.0396)	(0.0122)
1500	0.1855	0.1908	0.188	0.1593	0.2043	0.1586
	(0.0103)	(0.0117)	(0.0115)	(0.0095)	(0.0349)	(0.0095)
2000	0.1727	0.177	0.1751	0.1533	0.1911	0.1529
	(0.0087)	(0.0098)	(0.0097)	(0.0081)	(0.0316)	(0.0081)
2500	0.1644	0.1681	0.1667	0.1494	0.1827	0.149
	(0.0077)	(0.0084)	(0.0084)	(0.0071)	(0.0296)	(0.0072)
3000	0.1587	0.162	0.161	0.1466	0.1769	0.1463
	(0.0068)	(0.0076)	(0.0075)	(0.0065)	(0.0286)	(0.0065)
3500	0.1544	0.1575	0.1568	0.1445	0.1728	0.1443
	(0.0063)	(0.0069)	(0.0069)	(0.006)	(0.0278)	(0.006)
4000	0.151	0.1539	0.1536	0.1429	0.1695	0.1427
	(0.0058)	(0.0064)	(0.0064)	(0.0055)	(0.0273)	(0.0055)
4500	0.1484	0.1511	0.1511	0.1417	0.1671	0.1415
	(0.0054)	(0.006)	(0.0061)	(0.0052)	(0.0269)	(0.0052)
5000	0.1463	0.1488	0.149	0.1406	0.1651	0.1405
	(0.0052)	(0.0056)	(0.0058)	(0.0049)	(0.0264)	(0.0049)

Table E.21: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under stationarity, for a AR covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4092	0.409	0.4088	0.3662	0.3627	0.3632
	(0.0736)	(0.074)	(0.0734)	(0.067)	(0.0675)	(0.0673)
100	0.3762	0.3764	0.3761	0.306	0.304	0.3043
	(0.0508)	(0.051)	(0.0506)	(0.0444)	(0.0448)	(0.0452)
500	0.2312	0.2419	0.2355	0.1861	0.1858	0.1858
	(0.0186)	(0.0213)	(0.0196)	(0.0166)	(0.0167)	(0.0167)
1000	0.1793	0.1861	0.1821	0.1547	0.1546	0.1545
	(0.0122)	(0.0136)	(0.0127)	(0.0113)	(0.0113)	(0.0114)
1500	0.158	0.163	0.1603	0.1414	0.1413	0.1413
	(0.0095)	(0.0106)	(0.0101)	(0.0089)	(0.009)	(0.009)
2000	0.1461	0.1502	0.1483	0.1339	0.1338	0.1338
	(0.0079)	(0.0087)	(0.0087)	(0.0074)	(0.0075)	(0.0075)
2500	0.1385	0.142	0.1407	0.1289	0.1288	0.1288
	(0.0073)	(0.0077)	(0.0078)	(0.0066)	(0.0067)	(0.0067)
3000	0.1333	0.1363	0.1355	0.1255	0.1254	0.1254
	(0.0065)	(0.007)	(0.0071)	(0.006)	(0.006)	(0.006)
3500	0.1294	0.1322	0.1317	0.1229	0.1228	0.1228
	(0.0059)	(0.0064)	(0.0068)	(0.0055)	(0.0055)	(0.0055)
4000	0.1264	0.1289	0.1288	0.1209	0.1209	0.1209
	(0.0055)	(0.0059)	(0.0064)	(0.0051)	(0.0051)	(0.0051)
4500	0.1239	0.1263	0.1264	0.1194	0.1193	0.1193
	(0.0051)	(0.0055)	(0.006)	(0.0047)	(0.0047)	(0.0048)
5000	0.122	0.1243	0.1246	0.1182	0.1181	0.1181
	(0.0048)	(0.0051)	(0.0058)	(0.0045)	(0.0044)	(0.0045)

Table E.22: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under stationarity, for a EYE covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4904 (0.0814)	0.49 (0.0815)	0.49 (0.0815)	0.3128 (0.061)	0.3061 (0.0598)	0.3052 (0.0603)
100	0.424 (0.0542)	0.4236 (0.0542)	0.4236 (0.0543)	0.249 (0.0411)	0.2434 (0.0409)	0.2428 (0.041)
500	0.2407 (0.0185)	0.2512 (0.0217)	0.2449 (0.0196)	0.1514 (0.0159)	0.1496 (0.0159)	0.1495 (0.0159)
1000	0.1837 (0.0122)	0.1903 (0.0139)	0.1864 (0.0126)	0.1306 (0.0106)	0.1294 (0.0106)	0.1293 (0.0106)
1500	0.1611 (0.0095)	0.1659 (0.0105)	0.1633 (0.0096)	0.1228 (0.0086)	0.1219 (0.0086)	0.1218 (0.0086)
2000	0.1484 (0.0081)	0.1522 (0.0089)	0.1503 (0.0083)	0.1183 (0.0074)	0.1176 (0.0075)	0.1175 (0.0075)
2500	0.1403 (0.007)	0.1436 (0.0077)	0.1423 (0.0074)	0.1156 (0.0065)	0.115 (0.0065)	0.1149 (0.0065)
3000	0.1347 (0.0061)	0.1376 (0.0067)	0.1367 (0.0066)	0.1137 (0.0058)	0.1132 (0.0058)	0.1131 (0.0058)
3500	0.1305 (0.0056)	0.1332 (0.0063)	0.1326 (0.0063)	0.1122 (0.0054)	0.1117 (0.0054)	0.1117 (0.0054)
4000	0.1272 (0.0052)	0.1297 (0.0058)	0.1295 (0.0059)	0.1111 (0.005)	0.1107 (0.0049)	0.1107 (0.005)
4500	0.1247 (0.0049)	0.127 (0.0054)	0.127 (0.0056)	0.1103 (0.0047)	0.1099 (0.0047)	0.1099 (0.0048)
5000	0.1226 (0.0046)	0.1249 (0.0051)	0.1251 (0.0053)	0.1096 (0.0044)	0.1093 (0.0045)	0.1092 (0.0045)

Table E.23: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under stationarity, for a CS covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4698	0.4697	0.4695	0.3323	0.3312	0.3318
	(0.0772)	(0.0773)	(0.0772)	(0.062)	(0.0612)	(0.0621)
100	0.4127	0.4125	0.4123	0.2805	0.2782	0.2799
	(0.0521)	(0.0523)	(0.052)	(0.0443)	(0.0436)	(0.0445)
500	0.2388	0.2494	0.2433	0.1871	0.1866	0.1872
	(0.0191)	(0.0222)	(0.0202)	(0.0177)	(0.0176)	(0.0178)
1000	0.1826	0.1893	0.1854	0.1565	0.1563	0.1566
	(0.0119)	(0.0139)	(0.0128)	(0.0114)	(0.0114)	(0.0115)
1500	0.1599	0.1649	0.1623	0.1425	0.1425	0.1428
	(0.0092)	(0.0105)	(0.0098)	(0.0087)	(0.0087)	(0.0087)
2000	0.1477	0.1517	0.1499	0.1349	0.1348	0.135
	(0.0077)	(0.0089)	(0.0084)	(0.0074)	(0.0074)	(0.0074)
2500	0.1399	0.1433	0.1421	0.1299	0.1299	0.13
	(0.0067)	(0.0077)	(0.0078)	(0.0065)	(0.0065)	(0.0065)
3000	0.1345	0.1375	0.1368	0.1265	0.1264	0.1265
	(0.0061)	(0.0068)	(0.0073)	(0.0059)	(0.0059)	(0.0059)
3500	0.1304	0.1331	0.1327	0.1238	0.1238	0.1239
	(0.0055)	(0.0062)	(0.0068)	(0.0053)	(0.0053)	(0.0053)
4000	0.1271	0.1296	0.1295	0.1217	0.1216	0.1217
	(0.0051)	(0.0058)	(0.0067)	(0.005)	(0.005)	(0.005)
4500	0.1246	0.1269	0.1271	0.12	0.12	0.1201
	(0.0048)	(0.0054)	(0.0067)	(0.0047)	(0.0047)	(0.0047)
5000	0.1225	0.1248	0.1252	0.1187	0.1187	0.1188
	(0.0046)	(0.0051)	(0.0064)	(0.0045)	(0.0045)	(0.0045)

APPENDIX F: ABRUPT DRIFT LDA SIMULATION

Table F.1: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 10) under abrupt drift (priors: Equal) where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1441	0.1477	0.1442	0.1312	0.1435	0.1291
	(0.023)	(0.0293)	(0.023)	(0.0151)	(0.0228)	(0.0138)
100	0.1232	0.1276	0.1232	0.1191	0.1229	0.1184
	(0.0118)	(0.0241)	(0.0118)	(0.0094)	(0.0117)	(0.0089)
500	0.1055	0.1132	0.1055	0.1052	0.1055	0.1052
	(0.0028)	(0.0407)	(0.0028)	(0.0025)	(0.0027)	(0.0025)
1000	0.1029	0.1121	0.1029	0.1028	0.1029	0.1028
	(0.0015)	(0.0376)	(0.0015)	(0.0014)	(0.0014)	(0.0014)
1500	0.102	0.1114	0.102	0.102	0.102	0.102
	(0.0011)	(0.0348)	(0.0011)	(0.001)	(0.001)	(0.001)
2000	0.1015	0.1115	0.1015	0.1015	0.1015	0.1015
	(8e-04)	(0.0337)	(0.0019)	(7e-04)	(7e-04)	(7e-04)
2500	0.1012	0.1113	0.1012	0.1012	0.1012	0.1012
	(8e-04)	(0.0346)	(8e-04)	(7e-04)	(7e-04)	(7e-04)
3000	0.101	0.111	0.1011	0.1011	0.101	0.1011
	(7e-04)	(0.0338)	(7e-04)	(6e-04)	(6e-04)	(6e-04)
3500	0.1009	0.1113	0.1009	0.1009	0.1009	0.1009
	(7e-04)	(0.0349)	(7e-04)	(5e-04)	(5e-04)	(5e-04)
4000	0.1008	0.1127	0.1008	0.1009	0.1008	0.1009
	(6e-04)	(0.0461)	(7e-04)	(5e-04)	(5e-04)	(5e-04)
4500	0.1007	0.1128	0.1008	0.1008	0.1008	0.1008
	(6e-04)	(0.0458)	(6e-04)	(5e-04)	(4e-04)	(5e-04)
5000	0.1006	0.1127	0.1007	0.1008	0.1007	0.1008
	(5e-04)	(0.0438)	(7e-04)	(5e-04)	(4e-04)	(5e-04)

Table F.2: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 10) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.0815	0.0873	0.0817	0.0677	0.0808	0.0667
	(0.015)	(0.0335)	(0.0152)	(0.0076)	(0.0146)	(0.0066)
100	0.0674	0.0728	0.0676	0.0633	0.0673	0.0633
	(0.0063)	(0.0285)	(0.0064)	(0.0043)	(0.0063)	(0.0041)
500	0.0755	0.0816	0.0755	0.0754	0.0755	0.0754
	(0.0014)	(0.0259)	(0.0014)	(0.0014)	(0.0014)	(0.0013)
1000	0.1026	0.1114	0.1026	0.1027	0.1026	0.1028
	(0.0013)	(0.0392)	(0.0013)	(0.0013)	(0.0013)	(0.0013)
1500	0.1353	0.1429	0.1352	0.1355	0.1352	0.1355
	(0.0016)	(0.033)	(0.0016)	(0.0016)	(0.0016)	(0.0016)
2000	0.1704	0.1749	0.1696	0.1702	0.1696	0.1702
	(0.0022)	(0.038)	(0.0021)	(0.0022)	(0.0021)	(0.0021)
2500	0.204	0.1958	0.2009	0.2016	0.2009	0.2015
	(0.0029)	(0.0377)	(0.0028)	(0.0029)	(0.0028)	(0.0029)
3000	0.2312	0.1989	0.2225	0.223	0.2227	0.2229
	(0.0036)	(0.0348)	(0.0035)	(0.0035)	(0.0035)	(0.0035)
3500	0.2482	0.1816	0.2282	0.228	0.2287	0.2279
	(0.0042)	(0.0367)	(0.0042)	(0.0042)	(0.0041)	(0.0041)
4000	0.2529	0.1503	0.2139	0.2126	0.2149	0.2124
	(0.0046)	(0.0462)	(0.0046)	(0.0045)	(0.0045)	(0.0045)
4500	0.2458	0.108	0.1797	0.1771	0.1811	0.177
	(0.0047)	(0.0434)	(0.005)	(0.0048)	(0.005)	(0.0047)
5000	0.229	0.0681	0.1305	0.1278	0.1321	0.1281
	(0.0048)	(0.0477)	(0.0049)	(0.0046)	(0.0048)	(0.0045)

Table F.3: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 10) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.0846	0.0887	0.0845	0.0758	0.0848	0.0736
	(0.0185)	(0.0306)	(0.0182)	(0.0121)	(0.0184)	(0.0108)
100	0.0706	0.0747	0.0707	0.0679	0.0708	0.0672
	(0.008)	(0.0202)	(0.008)	(0.0065)	(0.008)	(0.0062)
500	0.0855	0.0914	0.0855	0.0851	0.0855	0.0851
	(0.0024)	(0.0241)	(0.0024)	(0.0022)	(0.0024)	(0.0022)
1000	0.1291	0.1371	0.1291	0.1289	0.129	0.1289
	(0.0019)	(0.0321)	(0.0019)	(0.0019)	(0.0019)	(0.0019)
1500	0.1866	0.1947	0.1864	0.1862	0.1863	0.1864
	(0.0023)	(0.0355)	(0.0023)	(0.0022)	(0.0023)	(0.0022)
2000	0.2505	0.2539	0.2493	0.2491	0.2494	0.2493
	(0.0034)	(0.0352)	(0.0034)	(0.0033)	(0.0034)	(0.0033)
2500	0.3079	0.2888	0.3026	0.302	0.3032	0.3022
	(0.0052)	(0.034)	(0.0052)	(0.0052)	(0.0052)	(0.0052)
3000	0.3449	0.2763	0.3279	0.3266	0.3291	0.3267
	(0.0073)	(0.0276)	(0.0074)	(0.0074)	(0.0074)	(0.0074)
3500	0.3528	0.2234	0.3147	0.3129	0.316	0.3128
	(0.0086)	(0.0375)	(0.0081)	(0.008)	(0.0081)	(0.008)
4000	0.3341	0.154	0.2746	0.2732	0.2757	0.273
	(0.0079)	(0.0341)	(0.0076)	(0.0076)	(0.0076)	(0.0076)
4500	0.3015	0.1009	0.2186	0.2172	0.2194	0.2169
	(0.0064)	(0.0356)	(0.0101)	(0.0102)	(0.0101)	(0.0103)
5000	0.2646	0.0648	0.1488	0.1466	0.1494	0.146
	(0.0073)	(0.0397)	(0.0102)	(0.0104)	(0.0103)	(0.0104)

Table F.4: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 10) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.0875	0.0921	0.0873	0.0728	0.0881	0.0711
	(0.0196)	(0.031)	(0.0195)	(0.0108)	(0.0198)	(0.0093)
100	0.0702	0.0749	0.07	0.0659	0.0704	0.0655
	(0.0078)	(0.0267)	(0.0077)	(0.0054)	(0.008)	(0.0049)
500	0.0786	0.0867	0.0786	0.0781	0.0786	0.078
	(0.0015)	(0.0455)	(0.0016)	(0.0013)	(0.0015)	(0.0013)
1000	0.105	0.1146	0.1049	0.1046	0.1049	0.1044
	(0.0016)	(0.0388)	(0.0015)	(0.0014)	(0.0016)	(0.0014)
1500	0.1312	0.1397	0.1306	0.1302	0.1306	0.1301
	(0.002)	(0.04)	(0.0019)	(0.0018)	(0.0019)	(0.0018)
2000	0.1531	0.1564	0.1512	0.1507	0.1512	0.1507
	(0.0025)	(0.0415)	(0.0024)	(0.0024)	(0.0024)	(0.0023)
2500	0.1683	0.1628	0.1631	0.1625	0.1632	0.1626
	(0.0029)	(0.0485)	(0.0027)	(0.0027)	(0.0028)	(0.0027)
3000	0.1751	0.1541	0.1635	0.1628	0.1636	0.163
	(0.0032)	(0.0446)	(0.003)	(0.0029)	(0.003)	(0.0029)
3500	0.1735	0.1358	0.1521	0.1516	0.1524	0.1519
	(0.0035)	(0.0428)	(0.0032)	(0.0031)	(0.0032)	(0.0031)
4000	0.1645	0.1134	0.1318	0.1314	0.132	0.1316
	(0.0036)	(0.0456)	(0.0032)	(0.003)	(0.0031)	(0.003)
4500	0.15	0.0891	0.1063	0.1061	0.1066	0.1061
	(0.0036)	(0.0463)	(0.003)	(0.0028)	(0.003)	(0.0028)
5000	0.1321	0.0661	0.0795	0.0795	0.0798	0.0794
	(0.0036)	(0.045)	(0.0027)	(0.0026)	(0.0026)	(0.0025)

Table F.5: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 10) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1394	0.1442	0.139	0.1185	0.1469	0.1106
	(0.1058)	(0.1115)	(0.1049)	(0.0985)	(0.1087)	(0.0925)
100	0.0788	0.0834	0.0787	0.0729	0.0815	0.0715
	(0.0255)	(0.0391)	(0.0254)	(0.021)	(0.0277)	(0.0203)
500	0.0675	0.0738	0.0675	0.0674	0.0675	0.0672
	(0.0026)	(0.034)	(0.0026)	(0.0027)	(0.0026)	(0.0026)
1000	0.0808	0.0879	0.0808	0.0807	0.0807	0.0806
	(0.0016)	(0.0332)	(0.0016)	(0.0016)	(0.0015)	(0.0016)
1500	0.0937	0.1017	0.0936	0.0934	0.0936	0.0934
	(0.0012)	(0.0395)	(0.0012)	(0.0011)	(0.0012)	(0.0011)
2000	0.1033	0.1111	0.103	0.1027	0.1031	0.1028
	(0.0015)	(0.042)	(0.0015)	(0.0014)	(0.0015)	(0.0014)
2500	0.1088	0.1154	0.1078	0.1074	0.108	0.1076
	(0.002)	(0.0422)	(0.0018)	(0.0017)	(0.0019)	(0.0018)
3000	0.1105	0.1159	0.1084	0.108	0.1086	0.1082
	(0.0022)	(0.0444)	(0.0019)	(0.0018)	(0.002)	(0.0018)
3500	0.1096	0.1124	0.1061	0.1058	0.1063	0.106
	(0.002)	(0.0447)	(0.0015)	(0.0014)	(0.0016)	(0.0015)
4000	0.1073	0.1058	0.1024	0.1024	0.1026	0.1024
	(0.0015)	(0.0373)	(0.001)	(0.001)	(0.0011)	(0.001)
4500	0.1044	0.0955	0.0977	0.0978	0.0977	0.0978
	(0.0011)	(0.0305)	(0.0013)	(0.0012)	(0.0013)	(0.0012)
5000	0.1012	0.0787	0.0907	0.091	0.0906	0.0911
	(9e-04)	(0.0299)	(0.0024)	(0.0022)	(0.0024)	(0.0022)

Table F.6: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 10) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1543	0.1579	0.1544	0.1248	0.1665	0.12
	(0.0882)	(0.0925)	(0.0886)	(0.0703)	(0.094)	(0.0675)
100	0.0851	0.0889	0.0856	0.0789	0.09	0.0772
	(0.0231)	(0.0349)	(0.0282)	(0.0194)	(0.0305)	(0.0184)
500	0.0672	0.0715	0.0672	0.0671	0.0676	0.0669
	(0.0036)	(0.0262)	(0.0037)	(0.0036)	(0.0039)	(0.0035)
1000	0.0775	0.0857	0.0775	0.0775	0.0777	0.0774
	(0.0031)	(0.0385)	(0.0031)	(0.0031)	(0.0032)	(0.0031)
1500	0.0882	0.0988	0.0881	0.0883	0.0884	0.0882
	(0.0033)	(0.0471)	(0.0033)	(0.0033)	(0.0034)	(0.0033)
2000	0.0975	0.1083	0.0973	0.0975	0.0976	0.0973
	(0.0037)	(0.0501)	(0.0037)	(0.0037)	(0.0037)	(0.0037)
2500	0.1039	0.115	0.1033	0.1035	0.1037	0.1033
	(0.0039)	(0.0552)	(0.0038)	(0.0038)	(0.0039)	(0.0038)
3000	0.107	0.1171	0.1055	0.1056	0.1058	0.1055
	(0.004)	(0.0599)	(0.0038)	(0.0038)	(0.0039)	(0.0038)
3500	0.1066	0.1123	0.1034	0.1034	0.1037	0.1033
	(0.0036)	(0.0561)	(0.0032)	(0.0032)	(0.0033)	(0.0032)
4000	0.1036	0.1049	0.0982	0.0983	0.0985	0.0983
	(0.003)	(0.0558)	(0.0024)	(0.0024)	(0.0025)	(0.0024)
4500	0.099	0.0954	0.0917	0.092	0.0918	0.092
	(0.0023)	(0.0505)	(0.0017)	(0.0017)	(0.0018)	(0.0017)
5000	0.0935	0.0811	0.085	0.0857	0.0849	0.0855
	(0.0019)	(0.0455)	(0.0019)	(0.0018)	(0.0019)	(0.0018)

Table F.7: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 25) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1517	0.1586	0.1546	0.0947	0.149	0.0921
	(0.0336)	(0.0399)	(0.0354)	(0.0126)	(0.0326)	(0.0116)
100	0.0947	0.1024	0.0955	0.0802	0.0945	0.0794
	(0.0127)	(0.0236)	(0.0132)	(0.0072)	(0.0126)	(0.0067)
500	0.0913	0.0925	0.0914	0.0904	0.0913	0.0903
	(0.0023)	(0.0033)	(0.0024)	(0.0021)	(0.0023)	(0.002)
1000	0.1297	0.1299	0.1297	0.1292	0.1297	0.1292
	(0.0019)	(0.0028)	(0.0019)	(0.0017)	(0.0018)	(0.0017)
1500	0.1742	0.1731	0.1737	0.1734	0.1738	0.1734
	(0.0023)	(0.0027)	(0.0024)	(0.0022)	(0.0024)	(0.0022)
2000	0.2172	0.2093	0.2147	0.2141	0.2151	0.2141
	(0.0031)	(0.0036)	(0.0031)	(0.0029)	(0.0031)	(0.0029)
2500	0.2518	0.2243	0.2428	0.2414	0.2445	0.2414
	(0.004)	(0.0061)	(0.0042)	(0.004)	(0.0041)	(0.0039)
3000	0.2723	0.2159	0.2493	0.2461	0.2529	0.2461
	(0.0048)	(0.0061)	(0.0051)	(0.0048)	(0.0049)	(0.0048)
3500	0.2757	0.1833	0.2288	0.2239	0.2339	0.2238
	(0.0054)	(0.0067)	(0.006)	(0.0056)	(0.0056)	(0.0057)
4000	0.2624	0.1356	0.1853	0.1808	0.1903	0.1807
	(0.0057)	(0.0073)	(0.0058)	(0.0053)	(0.0055)	(0.0052)
4500	0.236	0.0917	0.1311	0.1297	0.1345	0.1296
	(0.0058)	(0.0056)	(0.0048)	(0.0044)	(0.0047)	(0.0043)
5000	0.2016	0.0572	0.081	0.0831	0.0827	0.0831
	(0.0056)	(0.0021)	(0.0033)	(0.003)	(0.0034)	(0.003)

Table F.8: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 25) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1664	0.1725	0.169	0.0886	0.1658	0.0851
	(0.044)	(0.0491)	(0.0455)	(0.0153)	(0.0437)	(0.014)
100	0.096	0.1034	0.0966	0.0735	0.097	0.0721
	(0.0151)	(0.0244)	(0.0157)	(0.007)	(0.0155)	(0.0065)
500	0.0745	0.0755	0.0745	0.0728	0.0746	0.0727
	(0.0024)	(0.0032)	(0.0025)	(0.0019)	(0.0025)	(0.0018)
1000	0.0893	0.0895	0.0892	0.0886	0.0892	0.0886
	(0.0016)	(0.0029)	(0.0016)	(0.0014)	(0.0016)	(0.0013)
1500	0.1059	0.1052	0.1056	0.1054	0.1056	0.1054
	(0.0018)	(0.0029)	(0.0018)	(0.0016)	(0.0018)	(0.0016)
2000	0.121	0.1182	0.1198	0.12	0.12	0.1201
	(0.002)	(0.0023)	(0.002)	(0.0018)	(0.002)	(0.0018)
2500	0.1328	0.1255	0.1297	0.1302	0.13	0.1303
	(0.0023)	(0.0025)	(0.0022)	(0.0021)	(0.0022)	(0.0021)
3000	0.14	0.1248	0.133	0.1339	0.1337	0.1341
	(0.0026)	(0.0072)	(0.0026)	(0.0024)	(0.0025)	(0.0024)
3500	0.1418	0.115	0.1286	0.1295	0.1297	0.1298
	(0.0027)	(0.0028)	(0.0027)	(0.0026)	(0.0026)	(0.0026)
4000	0.1384	0.0999	0.1169	0.1174	0.1186	0.1178
	(0.0029)	(0.0033)	(0.003)	(0.0026)	(0.0028)	(0.0026)
4500	0.1306	0.0812	0.0995	0.0996	0.1016	0.1
	(0.003)	(0.0041)	(0.003)	(0.0025)	(0.0027)	(0.0025)
5000	0.1195	0.0608	0.0785	0.0786	0.0805	0.0791
	(0.003)	(0.0122)	(0.0029)	(0.0023)	(0.0025)	(0.0023)

Table F.9: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 25) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3742	0.3808	0.3771	0.248	0.3907	0.2413
	(0.1375)	(0.136)	(0.1368)	(0.1264)	(0.1397)	(0.1257)
100	0.1746	0.1866	0.176	0.1248	0.1915	0.1218
	(0.0584)	(0.0668)	(0.0588)	(0.0422)	(0.0631)	(0.0408)
500	0.0728	0.0739	0.0728	0.0706	0.0743	0.0704
	(0.0057)	(0.0073)	(0.0057)	(0.0049)	(0.0062)	(0.0048)
1000	0.0763	0.0768	0.0763	0.0755	0.077	0.0754
	(0.0032)	(0.0075)	(0.0032)	(0.0029)	(0.0034)	(0.0029)
1500	0.0835	0.0834	0.0833	0.0829	0.084	0.0828
	(0.0029)	(0.0033)	(0.0029)	(0.0028)	(0.0031)	(0.0027)
2000	0.0901	0.0896	0.0897	0.0895	0.0904	0.0894
	(0.003)	(0.0091)	(0.003)	(0.0029)	(0.0031)	(0.0028)
2500	0.0952	0.0928	0.0941	0.0941	0.0948	0.0939
	(0.0031)	(0.0036)	(0.0031)	(0.003)	(0.0033)	(0.003)
3000	0.098	0.0933	0.0955	0.0958	0.0963	0.0955
	(0.0031)	(0.0044)	(0.0031)	(0.003)	(0.0032)	(0.0029)
3500	0.0984	0.0905	0.0937	0.0943	0.0945	0.0941
	(0.003)	(0.0084)	(0.0028)	(0.0027)	(0.003)	(0.0026)
4000	0.0966	0.0843	0.0887	0.0898	0.0894	0.0896
	(0.0028)	(0.0036)	(0.0025)	(0.0023)	(0.0027)	(0.0022)
4500	0.0928	0.0758	0.0811	0.0828	0.0814	0.0827
	(0.0024)	(0.0109)	(0.002)	(0.0018)	(0.0022)	(0.0018)
5000	0.0875	0.064	0.0716	0.0742	0.0716	0.0742
	(0.0021)	(0.0106)	(0.0018)	(0.0017)	(0.0019)	(0.0017)

Table F.10: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 50) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.338	0.3379	0.3373	0.098	0.2747	0.0946
	(0.0655)	(0.0655)	(0.0651)	(0.0127)	(0.0504)	(0.0114)
100	0.1374	0.1574	0.1435	0.0828	0.1455	0.0819
	(0.021)	(0.0437)	(0.0263)	(0.0075)	(0.0404)	(0.0072)
500	0.0867	0.088	0.0871	0.0809	0.0895	0.081
	(0.0039)	(0.0043)	(0.0041)	(0.0026)	(0.017)	(0.0025)
1000	0.1028	0.1035	0.1032	0.1004	0.1052	0.1006
	(0.0027)	(0.0071)	(0.0063)	(0.0022)	(0.0161)	(0.0022)
1500	0.1237	0.1234	0.1234	0.1223	0.1266	0.1226
	(0.0029)	(0.0033)	(0.003)	(0.0024)	(0.0286)	(0.0024)
2000	0.1437	0.1408	0.1419	0.141	0.145	0.1415
	(0.0034)	(0.0055)	(0.0038)	(0.0028)	(0.0183)	(0.0028)
2500	0.159	0.1498	0.1534	0.1513	0.1573	0.1519
	(0.0041)	(0.0044)	(0.0041)	(0.0036)	(0.0169)	(0.0037)
3000	0.167	0.1481	0.1548	0.1499	0.1609	0.1505
	(0.0046)	(0.0064)	(0.0046)	(0.0043)	(0.0142)	(0.0044)
3500	0.1672	0.1356	0.1457	0.1374	0.1537	0.1377
	(0.0049)	(0.0073)	(0.005)	(0.0049)	(0.0145)	(0.0049)
4000	0.16	0.114	0.1275	0.1169	0.1372	0.1169
	(0.005)	(0.0048)	(0.0061)	(0.0047)	(0.018)	(0.0048)
4500	0.147	0.0894	0.1038	0.0936	0.1133	0.0935
	(0.0048)	(0.0066)	(0.0044)	(0.0042)	(0.0117)	(0.0043)
5000	0.1308	0.0661	0.0795	0.0714	0.0873	0.0713
	(0.0046)	(0.0078)	(0.0042)	(0.0035)	(0.0162)	(0.0035)

Table F.11: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 50) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3619	0.3619	0.3624	0.1038	0.3025	0.1012
	(0.0616)	(0.0617)	(0.0622)	(0.0119)	(0.051)	(0.0111)
100	0.1492	0.1671	0.1532	0.0842	0.1507	0.0831
	(0.0233)	(0.0429)	(0.0266)	(0.0064)	(0.0268)	(0.0062)
500	0.0806	0.0817	0.0807	0.0758	0.0808	0.0756
	(0.0032)	(0.0064)	(0.0033)	(0.002)	(0.0057)	(0.002)
1000	0.09	0.0903	0.0905	0.0883	0.0907	0.0881
	(0.002)	(0.0021)	(0.0121)	(0.0014)	(0.009)	(0.0014)
1500	0.1032	0.1029	0.103	0.1021	0.1036	0.1019
	(0.0019)	(0.0019)	(0.0021)	(0.0015)	(0.0059)	(0.0015)
2000	0.1154	0.1135	0.1142	0.1135	0.1149	0.1132
	(0.0021)	(0.0025)	(0.0029)	(0.0017)	(0.0074)	(0.0017)
2500	0.1246	0.119	0.121	0.1202	0.1222	0.1198
	(0.0024)	(0.0025)	(0.0026)	(0.0019)	(0.0068)	(0.0018)
3000	0.1296	0.1184	0.122	0.1207	0.1239	0.1202
	(0.0026)	(0.0027)	(0.0025)	(0.002)	(0.0092)	(0.0019)
3500	0.1302	0.1115	0.1167	0.1149	0.1193	0.1144
	(0.0028)	(0.0043)	(0.0027)	(0.0021)	(0.0084)	(0.002)
4000	0.1264	0.0987	0.1052	0.1039	0.1082	0.1034
	(0.0029)	(0.0026)	(0.0028)	(0.0022)	(0.0075)	(0.0022)
4500	0.1186	0.0816	0.0885	0.0891	0.0915	0.0887
	(0.003)	(0.0034)	(0.0026)	(0.0023)	(0.0075)	(0.0022)
5000	0.108	0.0628	0.069	0.0722	0.0715	0.072
	(0.0029)	(0.0044)	(0.0021)	(0.0022)	(0.0068)	(0.0021)

Table F.12: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 50) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3541	0.3539	0.3543	0.121	0.2969	0.116
	(0.0723)	(0.0724)	(0.0723)	(0.0291)	(0.0634)	(0.0285)
100	0.1488	0.1688	0.155	0.0888	0.1589	0.0867
	(0.0261)	(0.0491)	(0.0322)	(0.0102)	(0.0455)	(0.0096)
500	0.0816	0.0831	0.0819	0.0757	0.0838	0.0753
	(0.0038)	(0.0045)	(0.0039)	(0.0025)	(0.011)	(0.0025)
1000	0.091	0.0915	0.0913	0.0882	0.0923	0.0879
	(0.0026)	(0.0028)	(0.0044)	(0.0021)	(0.0108)	(0.002)
1500	0.1048	0.1045	0.1048	0.102	0.1061	0.1018
	(0.0027)	(0.0029)	(0.0083)	(0.0023)	(0.0093)	(0.0022)
2000	0.1172	0.1151	0.1156	0.1125	0.1182	0.1122
	(0.003)	(0.0057)	(0.0029)	(0.0023)	(0.0181)	(0.0023)
2500	0.1263	0.1203	0.1218	0.1174	0.1249	0.1171
	(0.0033)	(0.0071)	(0.0032)	(0.0025)	(0.0115)	(0.0025)
3000	0.1306	0.1184	0.1221	0.1154	0.1263	0.1152
	(0.0035)	(0.0035)	(0.0076)	(0.0027)	(0.0186)	(0.0027)
3500	0.1301	0.1103	0.1158	0.1071	0.1203	0.107
	(0.0037)	(0.004)	(0.0035)	(0.0029)	(0.0115)	(0.0029)
4000	0.1251	0.0966	0.1041	0.0942	0.109	0.0941
	(0.0037)	(0.007)	(0.0038)	(0.0028)	(0.0121)	(0.0028)
4500	0.1166	0.08	0.0887	0.0792	0.0938	0.0792
	(0.0036)	(0.0041)	(0.0033)	(0.0026)	(0.0139)	(0.0026)
5000	0.106	0.0631	0.0718	0.064	0.0768	0.064
	(0.0034)	(0.0038)	(0.003)	(0.0024)	(0.0183)	(0.0024)

Table F.13: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 50) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3766	0.3765	0.3762	0.1274	0.3288	0.1238
	(0.0721)	(0.0722)	(0.0719)	(0.0257)	(0.0635)	(0.0249)
100	0.1653	0.1851	0.1705	0.0912	0.17	0.09
	(0.0306)	(0.0509)	(0.0343)	(0.0108)	(0.0343)	(0.0103)
500	0.0805	0.0818	0.0807	0.0745	0.082	0.0744
	(0.0037)	(0.0043)	(0.0038)	(0.0022)	(0.0092)	(0.0022)
1000	0.087	0.0872	0.0873	0.0843	0.0883	0.0842
	(0.0021)	(0.0028)	(0.0061)	(0.0015)	(0.0091)	(0.0015)
1500	0.0969	0.0964	0.0965	0.0945	0.0978	0.0945
	(0.0019)	(0.002)	(0.002)	(0.0014)	(0.0099)	(0.0014)
2000	0.1051	0.1034	0.1039	0.1021	0.1051	0.102
	(0.0021)	(0.0025)	(0.0021)	(0.0016)	(0.0082)	(0.0015)
2500	0.1104	0.1064	0.1075	0.1056	0.1088	0.1055
	(0.0023)	(0.0074)	(0.0023)	(0.0017)	(0.0069)	(0.0017)
3000	0.1122	0.1039	0.1066	0.1046	0.1084	0.1045
	(0.0024)	(0.0024)	(0.0024)	(0.0018)	(0.013)	(0.0018)
3500	0.1107	0.097	0.1012	0.0991	0.1031	0.099
	(0.0025)	(0.003)	(0.0026)	(0.0019)	(0.0067)	(0.0018)
4000	0.1061	0.0867	0.0919	0.0901	0.0942	0.09
	(0.0025)	(0.0023)	(0.0024)	(0.0018)	(0.0062)	(0.0017)
4500	0.0991	0.0742	0.0795	0.0786	0.0821	0.0787
	(0.0024)	(0.002)	(0.0022)	(0.0018)	(0.0063)	(0.0017)
5000	0.0904	0.0603	0.0655	0.0659	0.068	0.0661
	(0.0023)	(0.002)	(0.002)	(0.0016)	(0.0063)	(0.0016)

Table F.14: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 50) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.485	0.4843	0.485	0.4223	0.4839	0.4177
	(0.1229)	(0.1221)	(0.1227)	(0.2002)	(0.1327)	(0.2042)
100	0.2982	0.3178	0.3041	0.2068	0.3181	0.2028
	(0.1)	(0.1052)	(0.1014)	(0.1056)	(0.1051)	(0.1058)
500	0.0823	0.0839	0.0827	0.0741	0.0895	0.0738
	(0.0077)	(0.0152)	(0.0081)	(0.0051)	(0.0277)	(0.0049)
1000	0.0781	0.0809	0.0791	0.0756	0.0816	0.0755
	(0.003)	(0.0078)	(0.0148)	(0.0022)	(0.0131)	(0.0022)
1500	0.0826	0.0834	0.0827	0.0811	0.0848	0.081
	(0.0021)	(0.0054)	(0.0028)	(0.0018)	(0.0107)	(0.0017)
2000	0.0873	0.0868	0.0871	0.0853	0.0893	0.0853
	(0.0019)	(0.0021)	(0.0102)	(0.0015)	(0.0153)	(0.0015)
2500	0.0905	0.0887	0.0891	0.0875	0.0913	0.0874
	(0.0018)	(0.0033)	(0.0019)	(0.0015)	(0.0089)	(0.0015)
3000	0.0919	0.0884	0.089	0.0872	0.0912	0.0871
	(0.0018)	(0.0102)	(0.0018)	(0.0015)	(0.0084)	(0.0015)
3500	0.0916	0.0855	0.0868	0.0847	0.0888	0.0846
	(0.0019)	(0.0051)	(0.002)	(0.0016)	(0.0092)	(0.0016)
4000	0.0897	0.0806	0.0824	0.0801	0.084	0.0799
	(0.002)	(0.0086)	(0.0021)	(0.0019)	(0.009)	(0.0018)
4500	0.0863	0.073	0.0759	0.0735	0.0766	0.0733
	(0.0021)	(0.0053)	(0.0024)	(0.0021)	(0.0059)	(0.002)
5000	0.0818	0.0637	0.0674	0.0652	0.0676	0.0651
	(0.0022)	(0.0089)	(0.0023)	(0.0023)	(0.0058)	(0.0021)

Table F.15: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 50) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.522	0.5214	0.5219	0.4376	0.5284	0.4293
	(0.1114)	(0.1113)	(0.1119)	(0.1658)	(0.1191)	(0.1671)
100	0.3557	0.3711	0.3608	0.2298	0.3779	0.2247
	(0.0967)	(0.0993)	(0.0973)	(0.0818)	(0.0991)	(0.0812)
500	0.089	0.0897	0.0892	0.0801	0.0954	0.0799
	(0.0103)	(0.0107)	(0.0104)	(0.0078)	(0.0184)	(0.0077)
1000	0.0791	0.0828	0.0794	0.0765	0.0822	0.0765
	(0.0045)	(0.0169)	(0.0051)	(0.0038)	(0.0097)	(0.0038)
1500	0.081	0.0818	0.0811	0.0798	0.0836	0.0799
	(0.0034)	(0.004)	(0.0034)	(0.003)	(0.0095)	(0.003)
2000	0.0841	0.084	0.084	0.0834	0.0865	0.0836
	(0.0029)	(0.0044)	(0.0068)	(0.0028)	(0.0116)	(0.0028)
2500	0.0864	0.0857	0.0859	0.0857	0.088	0.086
	(0.0025)	(0.0082)	(0.0076)	(0.0026)	(0.0077)	(0.0026)
3000	0.0874	0.0854	0.0856	0.0858	0.0881	0.0862
	(0.0023)	(0.0087)	(0.0026)	(0.0024)	(0.0082)	(0.0025)
3500	0.0872	0.0827	0.0838	0.0838	0.0864	0.0842
	(0.0022)	(0.003)	(0.0024)	(0.0022)	(0.0092)	(0.0022)
4000	0.0857	0.0785	0.0799	0.0797	0.0823	0.0801
	(0.0021)	(0.0071)	(0.0025)	(0.0019)	(0.0076)	(0.002)
4500	0.0828	0.0717	0.0739	0.0736	0.0761	0.0739
	(0.002)	(0.01)	(0.0077)	(0.0018)	(0.0103)	(0.0018)
5000	0.0789	0.0624	0.0654	0.0658	0.0674	0.0661
	(0.0018)	(0.0085)	(0.0041)	(0.0016)	(0.0104)	(0.0016)

Table F.16: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 100) under gradual drift (priors: Equal), where the covariance matrix drifts from EYE to EYE. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3368	0.3367	0.3368	0.2042	0.1977	0.1984
	(0.0386)	(0.0385)	(0.0385)	(0.0221)	(0.0213)	(0.0212)
100	0.4182	0.4185	0.4182	0.1709	0.1676	0.1679
	(0.0423)	(0.0422)	(0.0422)	(0.0151)	(0.015)	(0.0144)
500	0.1653	0.1718	0.1687	0.1389	0.1382	0.138
	(0.0074)	(0.0091)	(0.0084)	(0.0047)	(0.005)	(0.0046)
1000	0.1651	0.1674	0.1663	0.1515	0.1511	0.151
	(0.0044)	(0.0072)	(0.0046)	(0.0039)	(0.0041)	(0.0039)
1500	0.1772	0.1782	0.1779	0.1669	0.1665	0.1665
	(0.0037)	(0.0049)	(0.0039)	(0.0031)	(0.0033)	(0.0032)
2000	0.1905	0.1904	0.1903	0.1796	0.1792	0.1793
	(0.0037)	(0.0118)	(0.0039)	(0.0032)	(0.0033)	(0.0033)
2500	0.2012	0.1978	0.1985	0.1859	0.1855	0.1855
	(0.0041)	(0.006)	(0.0052)	(0.0033)	(0.0034)	(0.0033)
3000	0.2073	0.1991	0.2002	0.184	0.1834	0.1835
	(0.0045)	(0.0061)	(0.009)	(0.0033)	(0.0033)	(0.0033)
3500	0.2076	0.193	0.1943	0.1733	0.1726	0.1726
	(0.0048)	(0.0056)	(0.0072)	(0.0035)	(0.0035)	(0.0035)
4000	0.2019	0.1799	0.1817	0.1559	0.1551	0.1552
	(0.0051)	(0.0055)	(0.0061)	(0.0036)	(0.0035)	(0.0036)
4500	0.1906	0.1611	0.1635	0.1346	0.1339	0.1339
	(0.0051)	(0.0053)	(0.0063)	(0.0033)	(0.0034)	(0.0034)
5000	0.175	0.1394	0.1429	0.1125	0.1119	0.1118
	(0.0051)	(0.0053)	(0.0143)	(0.0028)	(0.0029)	(0.0028)

Table F.17: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 100) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.2627	0.2625	0.2627	0.1234	0.1669	0.119
	(0.0388)	(0.0389)	(0.0387)	(0.0161)	(0.0265)	(0.0151)
100	0.3809	0.3812	0.3813	0.0998	0.3115	0.0981
	(0.05)	(0.0498)	(0.05)	(0.0101)	(0.0402)	(0.0096)
500	0.1015	0.1067	0.1041	0.0861	0.1548	0.086
	(0.0056)	(0.0119)	(0.0065)	(0.0032)	(0.075)	(0.0032)
1000	0.1091	0.1111	0.1104	0.1025	0.1455	0.1025
	(0.0035)	(0.0096)	(0.0102)	(0.0027)	(0.0671)	(0.0028)
1500	0.1258	0.1262	0.1264	0.1212	0.1495	0.1211
	(0.0033)	(0.0044)	(0.0064)	(0.0027)	(0.0416)	(0.0031)
2000	0.1425	0.1407	0.1414	0.1366	0.1607	0.1365
	(0.0036)	(0.0039)	(0.0095)	(0.0029)	(0.0366)	(0.0033)
2500	0.1554	0.1494	0.1502	0.1438	0.1692	0.1436
	(0.0041)	(0.0046)	(0.0042)	(0.0031)	(0.0345)	(0.0036)
3000	0.162	0.1497	0.1508	0.1405	0.1704	0.1403
	(0.0046)	(0.0072)	(0.0048)	(0.0034)	(0.0321)	(0.0043)
3500	0.1615	0.1406	0.143	0.1272	0.1636	0.127
	(0.0049)	(0.0078)	(0.0101)	(0.0034)	(0.0336)	(0.0043)
4000	0.1537	0.1228	0.1268	0.1073	0.1474	0.1072
	(0.0049)	(0.0068)	(0.0076)	(0.0031)	(0.0337)	(0.0037)
4500	0.1406	0.1005	0.1059	0.0857	0.1243	0.0856
	(0.0048)	(0.01)	(0.0049)	(0.0028)	(0.0349)	(0.003)
5000	0.1242	0.0767	0.0835	0.0655	0.1028	0.0655
	(0.0043)	(0.0101)	(0.005)	(0.0023)	(0.043)	(0.0024)

Table F.18: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under gradual drift (priors: Equal), where the covariance matrix drifts from EYE to EYE. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3374	0.3374	0.3373	0.2077	0.2024	0.2026
	(0.0357)	(0.0359)	(0.0356)	(0.0187)	(0.018)	(0.018)
100	0.4286	0.4286	0.4287	0.1658	0.1632	0.1632
	(0.0381)	(0.0381)	(0.0379)	(0.0105)	(0.0102)	(0.0102)
500	0.1641	0.1703	0.1667	0.1378	0.1373	0.1373
	(0.0065)	(0.0085)	(0.0074)	(0.0024)	(0.0024)	(0.0024)
1000	0.166	0.1676	0.1668	0.1539	0.1535	0.1535
	(0.0034)	(0.0037)	(0.0036)	(0.0016)	(0.0016)	(0.0016)
1500	0.1805	0.1809	0.1813	0.1725	0.1722	0.1722
	(0.0029)	(0.0031)	(0.0031)	(0.0017)	(0.0017)	(0.0017)
2000	0.1957	0.1949	0.1955	0.1869	0.1866	0.1866
	(0.0029)	(0.0079)	(0.0031)	(0.0019)	(0.0019)	(0.0019)
2500	0.2076	0.204	0.2043	0.1939	0.1936	0.1936
	(0.0032)	(0.0036)	(0.0034)	(0.0023)	(0.0022)	(0.0022)
3000	0.2143	0.2067	0.2055	0.1916	0.1913	0.1913
	(0.0036)	(0.0036)	(0.0036)	(0.0024)	(0.0024)	(0.0024)
3500	0.2149	0.202	0.1985	0.1799	0.1795	0.1795
	(0.0038)	(0.0093)	(0.0053)	(0.0025)	(0.0025)	(0.0025)
4000	0.2092	0.1894	0.1837	0.1605	0.1601	0.1601
	(0.004)	(0.0052)	(0.0097)	(0.0025)	(0.0024)	(0.0024)
4500	0.1977	0.1706	0.1626	0.1367	0.1362	0.1362
	(0.0041)	(0.0066)	(0.0103)	(0.0023)	(0.0022)	(0.0022)
5000	0.1817	0.1477	0.1377	0.1116	0.1112	0.1112
	(0.0041)	(0.0069)	(0.0043)	(0.0018)	(0.0018)	(0.0018)

Table F.19: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.2787	0.2786	0.2787	0.1405	0.2056	0.1365
	(0.0374)	(0.0373)	(0.0374)	(0.016)	(0.0286)	(0.0151)
100	0.3983	0.3985	0.3982	0.106	0.3351	0.1044
	(0.0444)	(0.0445)	(0.0445)	(0.0085)	(0.0369)	(0.0081)
500	0.0951	0.0996	0.0971	0.0822	0.1312	0.082
	(0.0049)	(0.0068)	(0.0056)	(0.0024)	(0.0615)	(0.0024)
1000	0.0933	0.0943	0.0942	0.0895	0.1089	0.0894
	(0.0026)	(0.0032)	(0.012)	(0.0017)	(0.0303)	(0.0017)
1500	0.1006	0.1009	0.1021	0.0993	0.1138	0.0993
	(0.0021)	(0.0024)	(0.0152)	(0.0015)	(0.025)	(0.0015)
2000	0.1081	0.1075	0.1089	0.1075	0.1204	0.1075
	(0.0021)	(0.0022)	(0.0096)	(0.0016)	(0.0254)	(0.0016)
2500	0.1137	0.1114	0.1129	0.1119	0.1248	0.112
	(0.0023)	(0.0023)	(0.0113)	(0.0016)	(0.0247)	(0.0016)
3000	0.1164	0.1116	0.1129	0.1114	0.1253	0.1115
	(0.0024)	(0.0023)	(0.0109)	(0.0016)	(0.0256)	(0.0016)
3500	0.1162	0.1076	0.1089	0.106	0.1219	0.106
	(0.0024)	(0.0024)	(0.0154)	(0.0016)	(0.0284)	(0.0016)
4000	0.1131	0.0994	0.1004	0.0964	0.1137	0.0965
	(0.0025)	(0.0036)	(0.0155)	(0.0015)	(0.0242)	(0.0015)
4500	0.1075	0.0875	0.089	0.0844	0.1023	0.0844
	(0.0026)	(0.007)	(0.0224)	(0.0015)	(0.0222)	(0.0015)
5000	0.1	0.0726	0.0741	0.0709	0.0876	0.0711
	(0.0025)	(0.0028)	(0.0228)	(0.0014)	(0.0216)	(0.0014)

Table F.20: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 100) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3197	0.3193	0.3195	0.1917	0.2327	0.1846
	(0.0569)	(0.0569)	(0.0567)	(0.0517)	(0.0547)	(0.0516)
100	0.3952	0.3954	0.3953	0.1274	0.3309	0.124
	(0.0566)	(0.0568)	(0.057)	(0.0193)	(0.0477)	(0.0187)
500	0.102	0.1135	0.1065	0.0891	0.163	0.0885
	(0.0061)	(0.0192)	(0.0102)	(0.0036)	(0.076)	(0.0035)
1000	0.1044	0.1063	0.1064	0.1006	0.1413	0.1003
	(0.0036)	(0.0047)	(0.0199)	(0.003)	(0.068)	(0.0031)
1500	0.1168	0.1177	0.1176	0.1144	0.1442	0.1141
	(0.0031)	(0.009)	(0.0067)	(0.0029)	(0.0505)	(0.0029)
2000	0.1293	0.1284	0.1286	0.1248	0.1495	0.1246
	(0.0032)	(0.0074)	(0.0033)	(0.0029)	(0.0364)	(0.0042)
2500	0.1386	0.1345	0.1352	0.1285	0.1541	0.1282
	(0.0035)	(0.0065)	(0.0036)	(0.0029)	(0.0314)	(0.004)
3000	0.143	0.134	0.136	0.1245	0.1529	0.1241
	(0.0038)	(0.0044)	(0.0115)	(0.0028)	(0.028)	(0.0034)
3500	0.1419	0.1265	0.129	0.1137	0.1448	0.1133
	(0.0039)	(0.0061)	(0.0112)	(0.0029)	(0.0261)	(0.0029)
4000	0.1358	0.1131	0.116	0.0987	0.1324	0.0983
	(0.004)	(0.0103)	(0.0044)	(0.0029)	(0.0301)	(0.0028)
4500	0.1255	0.0952	0.0992	0.0817	0.1162	0.0813
	(0.0039)	(0.0107)	(0.0093)	(0.0028)	(0.0339)	(0.0028)
5000	0.1124	0.0753	0.0802	0.0647	0.1007	0.0645
	(0.0037)	(0.0091)	(0.0069)	(0.0023)	(0.0442)	(0.0023)

Table F.21: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3109	0.311	0.311	0.2081	0.2818	0.204
	(0.0501)	(0.0502)	(0.0501)	(0.0481)	(0.0585)	(0.048)
100	0.4127	0.4126	0.4127	0.1318	0.3594	0.1302
	(0.0513)	(0.0511)	(0.0512)	(0.0175)	(0.0457)	(0.0171)
500	0.1015	0.1128	0.1054	0.0873	0.1425	0.087
	(0.0058)	(0.0169)	(0.0122)	(0.003)	(0.0679)	(0.003)
1000	0.1011	0.1027	0.1031	0.0962	0.1179	0.0959
	(0.0031)	(0.0036)	(0.0189)	(0.002)	(0.0288)	(0.0019)
1500	0.1114	0.1118	0.113	0.1086	0.1254	0.1082
	(0.0024)	(0.003)	(0.0183)	(0.0017)	(0.0233)	(0.0016)
2000	0.1218	0.1208	0.1224	0.1189	0.1345	0.1185
	(0.0024)	(0.003)	(0.0161)	(0.0017)	(0.0249)	(0.0017)
2500	0.1293	0.1264	0.1277	0.1246	0.1395	0.1242
	(0.0025)	(0.0096)	(0.0156)	(0.0018)	(0.0236)	(0.0018)
3000	0.1327	0.1259	0.1274	0.1243	0.1403	0.1239
	(0.0026)	(0.0041)	(0.0164)	(0.0019)	(0.0253)	(0.0018)
3500	0.1319	0.1201	0.122	0.1177	0.1347	0.1175
	(0.0028)	(0.0112)	(0.0247)	(0.0019)	(0.0232)	(0.0019)
4000	0.1269	0.1077	0.1098	0.106	0.1233	0.106
	(0.0028)	(0.0061)	(0.023)	(0.0019)	(0.0233)	(0.0019)
4500	0.1184	0.0912	0.0946	0.0908	0.107	0.091
	(0.0028)	(0.0045)	(0.0301)	(0.0018)	(0.0221)	(0.0018)
5000	0.1073	0.0721	0.0768	0.0741	0.0887	0.0743
	(0.0027)	(0.0028)	(0.0367)	(0.0016)	(0.0236)	(0.0016)

Table F.22: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 100) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5598	0.5606	0.5595	0.6076	0.6095	0.606
	(0.156)	(0.1562)	(0.1559)	(0.1866)	(0.1619)	(0.1898)
100	0.4855	0.4861	0.4854	0.3785	0.4751	0.3751
	(0.0821)	(0.0822)	(0.082)	(0.1503)	(0.0907)	(0.1519)
500	0.1277	0.1345	0.1308	0.0958	0.2206	0.0949
	(0.0164)	(0.0254)	(0.0177)	(0.0103)	(0.0935)	(0.0102)
1000	0.0985	0.1043	0.1042	0.0892	0.1602	0.0889
	(0.0063)	(0.0277)	(0.0329)	(0.0044)	(0.0778)	(0.0043)
1500	0.099	0.113	0.1046	0.0947	0.1433	0.0946
	(0.0039)	(0.0261)	(0.0191)	(0.0031)	(0.0497)	(0.0032)
2000	0.1031	0.1063	0.1045	0.0997	0.133	0.0996
	(0.0032)	(0.0063)	(0.0047)	(0.003)	(0.0333)	(0.003)
2500	0.1062	0.1061	0.1058	0.1016	0.1305	0.1015
	(0.0028)	(0.0057)	(0.0108)	(0.0023)	(0.0291)	(0.0024)
3000	0.1074	0.1051	0.1046	0.1002	0.1282	0.1001
	(0.0027)	(0.0133)	(0.003)	(0.002)	(0.0275)	(0.002)
3500	0.1065	0.1005	0.1014	0.0958	0.1242	0.0957
	(0.0025)	(0.0053)	(0.0071)	(0.0018)	(0.034)	(0.0017)
4000	0.1036	0.0943	0.0951	0.0887	0.1148	0.0886
	(0.0023)	(0.0132)	(0.0052)	(0.0018)	(0.0316)	(0.0018)
4500	0.0992	0.0846	0.0862	0.0792	0.1034	0.0791
	(0.0022)	(0.0129)	(0.003)	(0.0021)	(0.0324)	(0.0021)
5000	0.0935	0.072	0.0756	0.0675	0.0913	0.0673
	(0.0022)	(0.0095)	(0.0153)	(0.0026)	(0.039)	(0.0026)

Table F.23: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5516	0.5517	0.5517	0.669	0.6994	0.6692
	(0.1352)	(0.1366)	(0.1353)	(0.1497)	(0.1225)	(0.1506)
100	0.5138	0.5146	0.5138	0.4276	0.5209	0.4256
	(0.0741)	(0.0742)	(0.0739)	(0.1199)	(0.0777)	(0.12)
500	0.1459	0.151	0.1482	0.1129	0.2168	0.1123
	(0.0186)	(0.0225)	(0.0192)	(0.0127)	(0.0823)	(0.0126)
1000	0.1047	0.1095	0.1084	0.0949	0.1369	0.0945
	(0.0082)	(0.0289)	(0.0235)	(0.0062)	(0.0377)	(0.0061)
1500	0.0997	0.1158	0.1058	0.0954	0.1281	0.095
	(0.0056)	(0.0326)	(0.0237)	(0.0046)	(0.0316)	(0.0045)
2000	0.1001	0.1039	0.1033	0.098	0.1239	0.0976
	(0.0045)	(0.0082)	(0.021)	(0.0041)	(0.0287)	(0.004)
2500	0.1005	0.1008	0.102	0.0992	0.1219	0.0988
	(0.004)	(0.0049)	(0.0203)	(0.0037)	(0.0288)	(0.0037)
3000	0.0997	0.0974	0.0993	0.0975	0.1182	0.0972
	(0.0035)	(0.0038)	(0.0219)	(0.0034)	(0.027)	(0.0033)
3500	0.0974	0.0927	0.0946	0.0931	0.1108	0.0928
	(0.0031)	(0.0032)	(0.0199)	(0.0028)	(0.0227)	(0.0028)
4000	0.0937	0.0867	0.0881	0.0867	0.1016	0.0866
	(0.0026)	(0.0124)	(0.0192)	(0.0021)	(0.0207)	(0.0021)
4500	0.0889	0.0789	0.0804	0.0791	0.0913	0.079
	(0.0022)	(0.0155)	(0.0269)	(0.0016)	(0.0225)	(0.0016)
5000	0.0832	0.0684	0.0711	0.0706	0.0785	0.0705
	(0.0019)	(0.0081)	(0.0277)	(0.0015)	(0.0166)	(0.0015)

Table F.24: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 250) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4271	0.427	0.4271	0.2777	0.2796	0.2725
	(0.0307)	(0.0307)	(0.0308)	(0.0249)	(0.0254)	(0.0251)
100	0.3582	0.3583	0.3582	0.2277	0.255	0.2248
	(0.0259)	(0.0259)	(0.0258)	(0.0153)	(0.0184)	(0.015)
500	0.2332	0.2447	0.2454	0.1727	0.3357	0.1719
	(0.0115)	(0.0184)	(0.0172)	(0.0102)	(0.0771)	(0.0102)
1000	0.2012	0.2107	0.2104	0.1873	0.2855	0.1874
	(0.006)	(0.0086)	(0.0076)	(0.0087)	(0.0665)	(0.009)
1500	0.2042	0.2081	0.2084	0.2015	0.2883	0.2024
	(0.0046)	(0.0053)	(0.0052)	(0.0091)	(0.0637)	(0.0103)
2000	0.2124	0.2138	0.2144	0.2125	0.2779	0.2138
	(0.0043)	(0.0049)	(0.0046)	(0.0094)	(0.0577)	(0.0103)
2500	0.2196	0.2186	0.2199	0.2173	0.2703	0.2188
	(0.0044)	(0.0047)	(0.0048)	(0.0102)	(0.048)	(0.0119)
3000	0.2231	0.2193	0.2215	0.2128	0.2639	0.2144
	(0.0047)	(0.005)	(0.0059)	(0.0086)	(0.0452)	(0.011)
3500	0.2218	0.2143	0.218	0.2006	0.2547	0.2021
	(0.0049)	(0.0054)	(0.007)	(0.0094)	(0.0439)	(0.0103)
4000	0.2153	0.2039	0.2081	0.1816	0.238	0.1829
	(0.0052)	(0.0063)	(0.0079)	(0.0076)	(0.0438)	(0.0089)
4500	0.2039	0.1876	0.1901	0.1595	0.2187	0.1607
	(0.0051)	(0.0066)	(0.0079)	(0.0079)	(0.0459)	(0.0093)
5000	0.1885	0.1635	0.1627	0.136	0.2001	0.1371
	(0.0051)	(0.0075)	(0.0088)	(0.0073)	(0.0559)	(0.0098)

Table F.25: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4058	0.4059	0.406	0.2928	0.3066	0.2885
	(0.0276)	(0.0276)	(0.0276)	(0.0215)	(0.0227)	(0.0212)
100	0.3496	0.3495	0.3495	0.2374	0.282	0.2347
	(0.0236)	(0.0236)	(0.0235)	(0.0137)	(0.0189)	(0.0135)
500	0.2399	0.2399	0.2399	0.172	0.292	0.1712
	(0.0114)	(0.0114)	(0.0114)	(0.0042)	(0.0275)	(0.0042)
1000	0.2004	0.2004	0.2004	0.1758	0.3095	0.1753
	(0.0054)	(0.0054)	(0.0054)	(0.0027)	(0.0621)	(0.0027)
1500	0.2011	0.2011	0.2011	0.1877	0.2619	0.1873
	(0.004)	(0.004)	(0.004)	(0.0024)	(0.0334)	(0.0024)
2000	0.2072	0.2072	0.2072	0.199	0.2507	0.1986
	(0.0037)	(0.0037)	(0.0037)	(0.0024)	(0.0312)	(0.0024)
2500	0.2121	0.2121	0.2121	0.206	0.2458	0.2057
	(0.0037)	(0.0037)	(0.0037)	(0.0026)	(0.0212)	(0.0026)
3000	0.2137	0.2136	0.2137	0.2067	0.2336	0.2065
	(0.0038)	(0.0038)	(0.0038)	(0.0027)	(0.0189)	(0.0027)
3500	0.2111	0.2111	0.2111	0.2001	0.2213	0.1999
	(0.0038)	(0.0038)	(0.0038)	(0.0027)	(0.0206)	(0.0027)
4000	0.2041	0.2041	0.2041	0.1866	0.2064	0.1865
	(0.0039)	(0.0039)	(0.0039)	(0.0027)	(0.0201)	(0.0027)
4500	0.1931	0.1931	0.1932	0.1684	0.1893	0.1683
	(0.0039)	(0.0039)	(0.0039)	(0.0026)	(0.0214)	(0.0026)
5000	0.1791	0.1791	0.1791	0.1475	0.1698	0.1474
	(0.0038)	(0.0038)	(0.0038)	(0.0024)	(0.0231)	(0.0024)

Table F.26: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 250) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4242	0.4239	0.4239	0.4252	0.4299	0.4235
	(0.0573)	(0.0572)	(0.0573)	(0.0908)	(0.0884)	(0.0929)
100	0.3866	0.3865	0.3863	0.315	0.3462	0.3131
	(0.0381)	(0.0381)	(0.0379)	(0.0487)	(0.0459)	(0.0491)
500	0.2549	0.2662	0.267	0.1816	0.3551	0.181
	(0.014)	(0.0206)	(0.0202)	(0.0087)	(0.0716)	(0.0088)
1000	0.2078	0.2337	0.2298	0.1894	0.3205	0.1887
	(0.0073)	(0.033)	(0.0266)	(0.0209)	(0.0679)	(0.0194)
1500	0.2047	0.2135	0.2135	0.2011	0.2999	0.2018
	(0.0052)	(0.0091)	(0.008)	(0.0109)	(0.0577)	(0.011)
2000	0.2094	0.2124	0.213	0.2105	0.2812	0.2118
	(0.0045)	(0.0057)	(0.0053)	(0.0095)	(0.0543)	(0.0107)
2500	0.2142	0.2137	0.2148	0.2148	0.2792	0.2164
	(0.0044)	(0.0048)	(0.005)	(0.0093)	(0.0543)	(0.0112)
3000	0.2161	0.2121	0.2141	0.2109	0.2723	0.2124
	(0.0045)	(0.0049)	(0.0058)	(0.0081)	(0.0485)	(0.009)
3500	0.214	0.2064	0.2099	0.2002	0.2537	0.2017
	(0.0045)	(0.0052)	(0.0069)	(0.0078)	(0.0413)	(0.0088)
4000	0.2077	0.1962	0.2003	0.1836	0.2364	0.1848
	(0.0047)	(0.0061)	(0.0078)	(0.008)	(0.0438)	(0.0097)
4500	0.197	0.1806	0.1831	0.1626	0.2189	0.1639
	(0.0046)	(0.0064)	(0.0077)	(0.0071)	(0.0467)	(0.0087)
5000	0.183	0.1591	0.1594	0.1399	0.2002	0.141
	(0.0046)	(0.0069)	(0.0078)	(0.0067)	(0.0503)	(0.0075)

Table F.27: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3454	0.3454	0.3454	0.4464	0.4686	0.445
	(0.0308)	(0.0307)	(0.0307)	(0.0728)	(0.0724)	(0.0739)
100	0.3661	0.3661	0.3661	0.3276	0.3823	0.3249
	(0.0299)	(0.0299)	(0.0299)	(0.0369)	(0.0394)	(0.0368)
500	0.2621	0.2622	0.2621	0.1843	0.3187	0.184
	(0.0145)	(0.0145)	(0.0145)	(0.0068)	(0.0284)	(0.0067)
1000	0.2057	0.2057	0.2057	0.1773	0.3339	0.1772
	(0.0067)	(0.0067)	(0.0067)	(0.0039)	(0.0585)	(0.0039)
1500	0.2	0.2	0.2	0.1846	0.2799	0.1845
	(0.0049)	(0.0049)	(0.0049)	(0.0032)	(0.0352)	(0.0032)
2000	0.2034	0.2034	0.2034	0.1934	0.2596	0.1933
	(0.0043)	(0.0043)	(0.0043)	(0.0028)	(0.0341)	(0.0029)
2500	0.2076	0.2076	0.2075	0.1997	0.2415	0.1996
	(0.004)	(0.004)	(0.004)	(0.0028)	(0.0214)	(0.0028)
3000	0.2094	0.2094	0.2094	0.2012	0.2367	0.2012
	(0.0039)	(0.0039)	(0.0039)	(0.0028)	(0.0219)	(0.0028)
3500	0.2078	0.2079	0.2078	0.1969	0.2274	0.1969
	(0.0039)	(0.0039)	(0.0039)	(0.0029)	(0.0192)	(0.0029)
4000	0.2023	0.2023	0.2023	0.1865	0.2166	0.1867
	(0.0039)	(0.0039)	(0.0039)	(0.0029)	(0.0209)	(0.0028)
4500	0.1929	0.1929	0.1929	0.171	0.1993	0.1713
	(0.0039)	(0.0039)	(0.0039)	(0.0028)	(0.0191)	(0.0027)
5000	0.1802	0.1802	0.1802	0.152	0.1787	0.1524
	(0.0038)	(0.0038)	(0.0038)	(0.0026)	(0.0188)	(0.0026)

Table F.28: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 250) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.6266	0.6271	0.626	0.8677	0.8676	0.8704
	(0.1801)	(0.1801)	(0.1805)	(0.0625)	(0.0568)	(0.057)
100	0.7023	0.7023	0.7022	0.8364	0.8256	0.8378
	(0.0815)	(0.0812)	(0.0816)	(0.0395)	(0.0366)	(0.0393)
500	0.6144	0.6174	0.6197	0.4832	0.6047	0.4803
	(0.0318)	(0.0326)	(0.0315)	(0.0695)	(0.055)	(0.0708)
1000	0.4097	0.4215	0.4224	0.285	0.5608	0.2822
	(0.0332)	(0.0347)	(0.0342)	(0.0462)	(0.0457)	(0.0444)
1500	0.2738	0.2819	0.2838	0.2047	0.5071	0.205
	(0.0255)	(0.0272)	(0.0267)	(0.0304)	(0.0603)	(0.0321)
2000	0.2021	0.2089	0.2121	0.1683	0.4268	0.1698
	(0.0173)	(0.0188)	(0.0194)	(0.0213)	(0.0863)	(0.0232)
2500	0.1637	0.1783	0.19	0.1522	0.4121	0.1532
	(0.0119)	(0.0428)	(0.0585)	(0.0342)	(0.111)	(0.0335)
3000	0.1421	0.2183	0.218	0.1578	0.4784	0.1589
	(0.0082)	(0.1033)	(0.0846)	(0.0519)	(0.1053)	(0.0517)
3500	0.1292	0.1882	0.1984	0.1515	0.4237	0.1531
	(0.0061)	(0.0635)	(0.053)	(0.0328)	(0.0877)	(0.034)
4000	0.1208	0.17	0.1879	0.145	0.3794	0.1472
	(0.0045)	(0.041)	(0.0399)	(0.0292)	(0.0828)	(0.0292)
4500	0.1155	0.165	0.1805	0.1407	0.3527	0.1431
	(0.0034)	(0.031)	(0.0313)	(0.0246)	(0.0829)	(0.0253)
5000	0.1117	0.1622	0.17	0.138	0.3397	0.14
	(0.0026)	(0.0284)	(0.0277)	(0.0233)	(0.0891)	(0.0236)

Table F.29: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3551	0.3547	0.3547	0.883	0.8843	0.8837
	(0.1573)	(0.1566)	(0.1566)	(0.0589)	(0.0582)	(0.0587)
100	0.623	0.6227	0.623	0.8477	0.8471	0.8483
	(0.0781)	(0.0783)	(0.078)	(0.0373)	(0.0325)	(0.037)
500	0.608	0.6079	0.608	0.5068	0.6397	0.5057
	(0.0274)	(0.0275)	(0.0275)	(0.0393)	(0.0243)	(0.0393)
1000	0.4173	0.4172	0.4173	0.3145	0.5549	0.3137
	(0.0271)	(0.0272)	(0.0271)	(0.0275)	(0.0514)	(0.0274)
1500	0.2903	0.2902	0.2903	0.2211	0.4993	0.2205
	(0.0244)	(0.0244)	(0.0244)	(0.0207)	(0.0729)	(0.0206)
2000	0.2151	0.2151	0.2151	0.1712	0.3874	0.1709
	(0.0181)	(0.0182)	(0.0181)	(0.0148)	(0.0712)	(0.0147)
2500	0.1709	0.171	0.1709	0.144	0.3108	0.1438
	(0.014)	(0.014)	(0.0139)	(0.0106)	(0.0635)	(0.0105)
3000	0.1437	0.1438	0.1437	0.1275	0.3059	0.1273
	(0.0106)	(0.0106)	(0.0106)	(0.0078)	(0.0815)	(0.0077)
3500	0.1269	0.127	0.1269	0.1173	0.2606	0.1172
	(0.0077)	(0.0077)	(0.0077)	(0.0057)	(0.0636)	(0.0056)
4000	0.1167	0.1167	0.1167	0.1111	0.2207	0.111
	(0.0056)	(0.0056)	(0.0056)	(0.0042)	(0.0479)	(0.0041)
4500	0.1103	0.1103	0.1103	0.107	0.1911	0.107
	(0.0039)	(0.0039)	(0.0039)	(0.003)	(0.0396)	(0.0029)
5000	0.1064	0.1064	0.1064	0.1045	0.1706	0.1044
	(0.0027)	(0.0027)	(0.0027)	(0.0021)	(0.0366)	(0.002)

Table F.30: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under gradual drift (priors: Equal), where the covariance matrix drifts from BWISH to BWISH. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4691	0.469	0.4691	0.3251	0.3216	0.3204
	(0.0232)	(0.0233)	(0.0232)	(0.028)	(0.0283)	(0.0286)
100	0.4237	0.4237	0.4237	0.2664	0.271	0.2634
	(0.0226)	(0.0226)	(0.0226)	(0.0165)	(0.0165)	(0.0162)
500	0.4651	0.4651	0.4651	0.1985	0.3186	0.1981
	(0.0176)	(0.0175)	(0.0175)	(0.0088)	(0.016)	(0.0086)
1000	0.2574	0.2677	0.279	0.217	0.2711	0.2143
	(0.0078)	(0.0122)	(0.0186)	(0.0562)	(0.0384)	(0.0532)
1500	0.2416	0.2557	0.2651	0.2494	0.2884	0.2507
	(0.0061)	(0.0092)	(0.011)	(0.0245)	(0.0477)	(0.027)
2000	0.2413	0.248	0.2522	0.2634	0.2791	0.266
	(0.0052)	(0.0063)	(0.0068)	(0.0244)	(0.041)	(0.0281)
2500	0.2434	0.2443	0.2467	0.2687	0.2741	0.2717
	(0.005)	(0.0052)	(0.0055)	(0.025)	(0.0328)	(0.0262)
3000	0.2432	0.2397	0.2435	0.2656	0.2685	0.27
	(0.005)	(0.0052)	(0.0068)	(0.0239)	(0.0344)	(0.0278)
3500	0.239	0.2333	0.245	0.2527	0.2543	0.2571
	(0.005)	(0.006)	(0.0112)	(0.0232)	(0.0264)	(0.0253)
4000	0.2301	0.2276	0.2427	0.2307	0.2392	0.2371
	(0.005)	(0.0087)	(0.0105)	(0.0221)	(0.0222)	(0.027)
4500	0.2166	0.2208	0.2249	0.2053	0.2202	0.2105
	(0.005)	(0.0088)	(0.0102)	(0.0214)	(0.0229)	(0.0239)
5000	0.1994	0.2029	0.1958	0.1766	0.1982	0.1819
	(0.0049)	(0.0108)	(0.0139)	(0.024)	(0.024)	(0.0252)

Table F.31: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4702	0.4703	0.4704	0.33	0.3269	0.3258
	(0.0222)	(0.0222)	(0.0222)	(0.0274)	(0.0279)	(0.0281)
100	0.4261	0.4261	0.4261	0.2719	0.2765	0.2691
	(0.0213)	(0.0214)	(0.0215)	(0.0159)	(0.0161)	(0.0157)
500	0.4654	0.4653	0.4654	0.2006	0.4224	0.2001
	(0.0174)	(0.0174)	(0.0173)	(0.0083)	(0.0157)	(0.0084)
1000	0.2563	0.2671	0.279	0.2162	0.3483	0.2153
	(0.0082)	(0.013)	(0.021)	(0.0491)	(0.0718)	(0.0491)
1500	0.24	0.2549	0.2638	0.2451	0.3096	0.2477
	(0.0058)	(0.0126)	(0.0141)	(0.0209)	(0.0471)	(0.0235)
2000	0.2398	0.2472	0.2511	0.2586	0.3137	0.2623
	(0.005)	(0.0101)	(0.0099)	(0.0219)	(0.0572)	(0.0262)
2500	0.2421	0.2435	0.2458	0.2636	0.3053	0.2678
	(0.0048)	(0.0075)	(0.0061)	(0.0222)	(0.0475)	(0.0248)
3000	0.2422	0.2392	0.2433	0.261	0.2992	0.2655
	(0.0048)	(0.0075)	(0.0072)	(0.023)	(0.0475)	(0.0272)
3500	0.2386	0.2339	0.2467	0.2489	0.286	0.2535
	(0.005)	(0.0068)	(0.0117)	(0.0222)	(0.0519)	(0.025)
4000	0.2301	0.2294	0.244	0.2287	0.2653	0.2334
	(0.0051)	(0.0093)	(0.0107)	(0.0226)	(0.0485)	(0.0272)
4500	0.2172	0.2229	0.2252	0.2028	0.244	0.2066
	(0.0052)	(0.0091)	(0.01)	(0.0205)	(0.0494)	(0.0232)
5000	0.2004	0.2031	0.1954	0.1746	0.2218	0.1782
	(0.0051)	(0.0089)	(0.0128)	(0.0208)	(0.0498)	(0.0243)

Table F.32: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under gradual drift (priors: Equal), where the covariance matrix drifts from BWISH to BWISH. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4545	0.4545	0.4546	0.3469	0.353	0.3467
	(0.0213)	(0.0212)	(0.0212)	(0.0218)	(0.0219)	(0.0216)
100	0.4034	0.4033	0.4034	0.2913	0.3098	0.2931
	(0.0195)	(0.0195)	(0.0195)	(0.0146)	(0.0155)	(0.0144)
500	0.4714	0.4714	0.4714	0.2063	0.33	0.2086
	(0.0169)	(0.0168)	(0.0168)	(0.0052)	(0.0116)	(0.0053)
1000	0.2718	0.2717	0.2717	0.2057	0.2904	0.207
	(0.008)	(0.008)	(0.008)	(0.0033)	(0.0092)	(0.0034)
1500	0.254	0.254	0.254	0.2175	0.2856	0.2184
	(0.0056)	(0.0056)	(0.0056)	(0.0028)	(0.0076)	(0.0028)
2000	0.253	0.253	0.253	0.2298	0.2677	0.2305
	(0.0048)	(0.0048)	(0.0048)	(0.0028)	(0.0061)	(0.0028)
2500	0.2542	0.2542	0.2542	0.2379	0.2575	0.2385
	(0.0046)	(0.0046)	(0.0046)	(0.003)	(0.0051)	(0.0029)
3000	0.2525	0.2525	0.2525	0.2392	0.2476	0.2398
	(0.0045)	(0.0045)	(0.0045)	(0.0031)	(0.0046)	(0.0031)
3500	0.2467	0.2467	0.2467	0.2323	0.2353	0.233
	(0.0046)	(0.0046)	(0.0046)	(0.0034)	(0.0045)	(0.0034)
4000	0.2363	0.2363	0.2363	0.2174	0.2198	0.2182
	(0.0046)	(0.0045)	(0.0046)	(0.0035)	(0.0043)	(0.0034)
4500	0.2216	0.2216	0.2216	0.1958	0.2013	0.1973
	(0.0045)	(0.0045)	(0.0045)	(0.0036)	(0.0043)	(0.0034)
5000	0.2037	0.2038	0.2037	0.1703	0.1811	0.1726
	(0.0043)	(0.0043)	(0.0043)	(0.0034)	(0.0041)	(0.0032)

Table F.33: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under gradual drift (priors: Equal), where the covariance matrix drifts from BWISH to BWISH. The standard error of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.429	0.4291	0.4289	0.272	0.2797	0.2711
	(0.027)	(0.027)	(0.0269)	(0.0264)	(0.0276)	(0.0263)
100	0.359	0.359	0.3591	0.2045	0.2258	0.2056
	(0.022)	(0.022)	(0.022)	(0.0138)	(0.0163)	(0.014)
500	0.4589	0.459	0.459	0.1268	0.2661	0.1283
	(0.0206)	(0.0206)	(0.0205)	(0.0038)	(0.0124)	(0.0039)
1000	0.2003	0.2003	0.2003	0.1314	0.2214	0.1324
	(0.008)	(0.008)	(0.008)	(0.0025)	(0.0095)	(0.0026)
1500	0.1811	0.1811	0.1811	0.1443	0.2103	0.1449
	(0.0053)	(0.0053)	(0.0053)	(0.0022)	(0.0075)	(0.0023)
2000	0.1801	0.1802	0.1802	0.1568	0.1921	0.1572
	(0.0043)	(0.0043)	(0.0043)	(0.0023)	(0.0054)	(0.0024)
2500	0.1811	0.1811	0.1811	0.1645	0.1824	0.1648
	(0.004)	(0.004)	(0.004)	(0.0025)	(0.0043)	(0.0025)
3000	0.1792	0.1792	0.1792	0.1653	0.1731	0.1656
	(0.0039)	(0.0039)	(0.0039)	(0.0025)	(0.004)	(0.0026)
3500	0.1731	0.1731	0.1731	0.1581	0.1615	0.1586
	(0.0038)	(0.0038)	(0.0038)	(0.0027)	(0.0037)	(0.0027)
4000	0.163	0.163	0.163	0.1439	0.1472	0.1446
	(0.0038)	(0.0038)	(0.0038)	(0.0027)	(0.0037)	(0.0027)
4500	0.1493	0.1494	0.1494	0.125	0.1311	0.1259
	(0.0037)	(0.0037)	(0.0037)	(0.0024)	(0.0035)	(0.0024)
5000	0.1334	0.1335	0.1335	0.1044	0.1142	0.1054
	(0.0036)	(0.0036)	(0.0036)	(0.0023)	(0.0034)	(0.0023)

Table F.34: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4563	0.4563	0.4562	0.3471	0.3511	0.3443
	(0.0214)	(0.0213)	(0.0213)	(0.0228)	(0.0236)	(0.023)
100	0.4056	0.4056	0.4056	0.2909	0.3071	0.2889
	(0.0193)	(0.0193)	(0.0194)	(0.0147)	(0.0159)	(0.0146)
500	0.4716	0.4715	0.4716	0.2044	0.4284	0.2038
	(0.0161)	(0.0161)	(0.0161)	(0.0056)	(0.0147)	(0.0057)
1000	0.2679	0.2679	0.268	0.2052	0.3218	0.2048
	(0.0079)	(0.0079)	(0.0079)	(0.0036)	(0.0195)	(0.0036)
1500	0.2499	0.25	0.25	0.2188	0.3481	0.2185
	(0.0055)	(0.0055)	(0.0055)	(0.003)	(0.0377)	(0.003)
2000	0.2505	0.2506	0.2506	0.2337	0.2982	0.2335
	(0.0045)	(0.0045)	(0.0045)	(0.0029)	(0.0621)	(0.0029)
2500	0.2541	0.2541	0.2541	0.2447	0.3067	0.2446
	(0.0044)	(0.0043)	(0.0043)	(0.0032)	(0.0218)	(0.0032)
3000	0.2556	0.2556	0.2556	0.2485	0.3084	0.2484
	(0.0044)	(0.0043)	(0.0043)	(0.0034)	(0.0225)	(0.0034)
3500	0.2525	0.2525	0.2525	0.2426	0.2864	0.2426
	(0.0045)	(0.0045)	(0.0045)	(0.0038)	(0.0258)	(0.0039)
4000	0.2442	0.2443	0.2442	0.2273	0.2643	0.2273
	(0.0048)	(0.0047)	(0.0048)	(0.0041)	(0.0208)	(0.0041)
4500	0.2309	0.231	0.2309	0.2043	0.2327	0.2044
	(0.0048)	(0.0048)	(0.0048)	(0.0041)	(0.0192)	(0.0042)
5000	0.2132	0.2132	0.2132	0.1773	0.1894	0.1774
	(0.0047)	(0.0047)	(0.0047)	(0.0039)	(0.0186)	(0.0039)

Table F.35: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4251	0.4248	0.425	0.5357	0.5376	0.5369
	(0.067)	(0.0669)	(0.0669)	(0.0848)	(0.0853)	(0.0866)
100	0.4226	0.4226	0.4226	0.4273	0.4351	0.4268
	(0.042)	(0.042)	(0.042)	(0.0634)	(0.0618)	(0.0643)
500	0.4729	0.473	0.4728	0.2316	0.4377	0.2311
	(0.0198)	(0.0198)	(0.0199)	(0.0141)	(0.0189)	(0.0139)
1000	0.2767	0.2873	0.297	0.2111	0.3622	0.211
	(0.0103)	(0.0148)	(0.0202)	(0.0094)	(0.0627)	(0.0098)
1500	0.2491	0.2574	0.2626	0.2169	0.3176	0.2176
	(0.0071)	(0.0099)	(0.0115)	(0.011)	(0.0472)	(0.0118)
2000	0.2415	0.2648	0.2863	0.26	0.3558	0.2615
	(0.0059)	(0.0225)	(0.0374)	(0.044)	(0.0544)	(0.0448)
2500	0.2384	0.2496	0.2585	0.2536	0.331	0.2567
	(0.0053)	(0.0109)	(0.0144)	(0.0278)	(0.0494)	(0.0307)
3000	0.235	0.238	0.2473	0.2504	0.3105	0.253
	(0.0052)	(0.0071)	(0.011)	(0.0337)	(0.0505)	(0.036)
3500	0.2289	0.229	0.2492	0.2394	0.2922	0.2424
	(0.0051)	(0.0085)	(0.0151)	(0.0257)	(0.0523)	(0.0288)
4000	0.2198	0.2253	0.2437	0.2213	0.2753	0.2246
	(0.005)	(0.0132)	(0.0133)	(0.0245)	(0.0538)	(0.0289)
4500	0.2073	0.2175	0.2158	0.1988	0.2606	0.203
	(0.005)	(0.0121)	(0.0182)	(0.0237)	(0.0558)	(0.0325)
5000	0.1919	0.1916	0.1835	0.1747	0.2323	0.1776
	(0.0048)	(0.0115)	(0.017)	(0.0244)	(0.0527)	(0.027)

Table F.36: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under gradual drift (priors: 70/30), where the covariance matrix drifts from BWISH to BWISH. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3102	0.3103	0.3103	0.5609	0.5696	0.5614
	(0.0179)	(0.018)	(0.018)	(0.0745)	(0.0737)	(0.0754)
100	0.3425	0.3425	0.3425	0.4528	0.4757	0.452
	(0.0209)	(0.0209)	(0.0209)	(0.0551)	(0.0548)	(0.0554)
500	0.4777	0.4778	0.4778	0.2361	0.3685	0.2367
	(0.0184)	(0.0184)	(0.0184)	(0.0103)	(0.0167)	(0.0103)
1000	0.2866	0.2865	0.2866	0.2108	0.3078	0.2114
	(0.0103)	(0.0103)	(0.0103)	(0.0055)	(0.0124)	(0.0055)
1500	0.2534	0.2533	0.2534	0.2114	0.2761	0.2121
	(0.007)	(0.007)	(0.007)	(0.0041)	(0.0084)	(0.0041)
2000	0.2428	0.2428	0.2429	0.2165	0.3007	0.2174
	(0.0058)	(0.0058)	(0.0058)	(0.0036)	(0.0167)	(0.0037)
2500	0.2379	0.2379	0.238	0.2196	0.2682	0.2208
	(0.0053)	(0.0053)	(0.0053)	(0.0034)	(0.0094)	(0.0035)
3000	0.233	0.2331	0.2331	0.2173	0.2457	0.2193
	(0.005)	(0.005)	(0.005)	(0.0035)	(0.0065)	(0.0035)
3500	0.2258	0.2258	0.2258	0.2079	0.2272	0.2113
	(0.0048)	(0.0048)	(0.0048)	(0.0039)	(0.0053)	(0.0035)
4000	0.2155	0.2155	0.2155	0.1916	0.2094	0.1972
	(0.0044)	(0.0044)	(0.0044)	(0.004)	(0.0046)	(0.0034)
4500	0.2024	0.2024	0.2024	0.17	0.1911	0.1785
	(0.0043)	(0.0043)	(0.0043)	(0.004)	(0.0042)	(0.0034)
5000	0.1868	0.1869	0.1869	0.1458	0.1718	0.1573
	(0.004)	(0.004)	(0.004)	(0.0034)	(0.004)	(0.0032)

Table F.37: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3099	0.31	0.31	0.5582	0.5674	0.5586
	(0.0186)	(0.0186)	(0.0186)	(0.0761)	(0.0756)	(0.0772)
100	0.3409	0.3409	0.3409	0.4486	0.4722	0.4475
	(0.0213)	(0.0213)	(0.0213)	(0.0553)	(0.055)	(0.0557)
500	0.4786	0.4786	0.4786	0.2358	0.4467	0.2354
	(0.0182)	(0.0183)	(0.0182)	(0.0101)	(0.0173)	(0.01)
1000	0.2902	0.2902	0.2901	0.213	0.3492	0.2127
	(0.0103)	(0.0103)	(0.0103)	(0.0055)	(0.0198)	(0.0055)
1500	0.2595	0.2595	0.2595	0.2164	0.3611	0.2162
	(0.0069)	(0.0069)	(0.0069)	(0.0042)	(0.0398)	(0.0042)
2000	0.2516	0.2516	0.2516	0.2245	0.3348	0.2243
	(0.0058)	(0.0058)	(0.0058)	(0.0038)	(0.0531)	(0.0038)
2500	0.2494	0.2494	0.2494	0.2307	0.3326	0.2305
	(0.0051)	(0.0051)	(0.0051)	(0.0037)	(0.0246)	(0.0037)
3000	0.2468	0.2468	0.2467	0.2319	0.3198	0.2318
	(0.0049)	(0.0049)	(0.0049)	(0.0039)	(0.0242)	(0.0039)
3500	0.241	0.241	0.241	0.2259	0.286	0.2259
	(0.005)	(0.005)	(0.0049)	(0.004)	(0.0301)	(0.004)
4000	0.2313	0.2313	0.2313	0.2124	0.2491	0.2124
	(0.0048)	(0.0048)	(0.0048)	(0.004)	(0.0185)	(0.004)
4500	0.2177	0.2177	0.2177	0.1928	0.2217	0.1929
	(0.0048)	(0.0048)	(0.0048)	(0.004)	(0.0182)	(0.0041)
5000	0.2006	0.2006	0.2006	0.1696	0.1948	0.1696
	(0.0046)	(0.0046)	(0.0046)	(0.0039)	(0.0189)	(0.0039)

Table F.38: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5296	0.5284	0.5284	0.8883	0.8885	0.8891
	(0.2532)	(0.2537)	(0.254)	(0.0513)	(0.0511)	(0.0511)
100	0.6491	0.6483	0.6486	0.8776	0.8756	0.8785
	(0.1382)	(0.1389)	(0.1387)	(0.0184)	(0.0178)	(0.0179)
500	0.5344	0.5344	0.5344	0.711	0.578	0.7109
	(0.0191)	(0.0191)	(0.0191)	(0.0396)	(0.0189)	(0.0397)
1000	0.6109	0.616	0.6174	0.4468	0.6053	0.4406
	(0.0222)	(0.023)	(0.0236)	(0.0682)	(0.0503)	(0.0718)
1500	0.5045	0.5183	0.5258	0.323	0.597	0.3146
	(0.0246)	(0.0258)	(0.0268)	(0.0506)	(0.0574)	(0.0527)
2000	0.4058	0.4193	0.4268	0.2547	0.5608	0.2486
	(0.0243)	(0.025)	(0.0261)	(0.0416)	(0.0493)	(0.0446)
2500	0.329	0.3405	0.3504	0.2175	0.5361	0.2118
	(0.0217)	(0.0226)	(0.0245)	(0.0322)	(0.0494)	(0.0342)
3000	0.2718	0.2857	0.3166	0.194	0.5085	0.1901
	(0.0186)	(0.0208)	(0.0394)	(0.0269)	(0.0566)	(0.03)
3500	0.23	0.2615	0.3454	0.1778	0.4881	0.175
	(0.0154)	(0.0308)	(0.0613)	(0.0222)	(0.0612)	(0.0239)
4000	0.2001	0.2806	0.3511	0.1681	0.4658	0.1656
	(0.0129)	(0.0447)	(0.0445)	(0.02)	(0.058)	(0.0206)
4500	0.1778	0.3012	0.312	0.1596	0.4465	0.1574
	(0.0105)	(0.0345)	(0.0371)	(0.0156)	(0.0601)	(0.0156)
5000	0.161	0.2884	0.3076	0.1901	0.473	0.1882
	(0.0087)	(0.0412)	(0.0887)	(0.1127)	(0.1019)	(0.1147)

Table F.39: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under gradual drift (priors: 90/10), where the covariance matrix drifts from BWISH to BWISH. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1132	0.1132	0.1132	0.8938	0.8939	0.8938
	(0.0546)	(0.0547)	(0.0546)	(0.0619)	(0.0619)	(0.0619)
100	0.3098	0.31	0.31	0.892	0.8923	0.8919
	(0.1056)	(0.1059)	(0.1057)	(0.0103)	(0.0095)	(0.0105)
500	0.5362	0.5362	0.5362	0.6956	0.693	0.6939
	(0.0195)	(0.0194)	(0.0194)	(0.0343)	(0.0218)	(0.0342)
1000	0.6059	0.606	0.6059	0.5056	0.6401	0.5054
	(0.0186)	(0.0186)	(0.0186)	(0.027)	(0.0176)	(0.0269)
1500	0.5042	0.5042	0.5042	0.3887	0.5659	0.3901
	(0.019)	(0.0189)	(0.019)	(0.0217)	(0.0168)	(0.0217)
2000	0.415	0.4151	0.415	0.3104	0.4829	0.3131
	(0.0189)	(0.0189)	(0.0189)	(0.0186)	(0.0171)	(0.0188)
2500	0.3447	0.3447	0.3447	0.2564	0.4077	0.26
	(0.0181)	(0.0181)	(0.0182)	(0.0158)	(0.0175)	(0.0162)
3000	0.2904	0.2904	0.2904	0.219	0.3448	0.2217
	(0.0165)	(0.0165)	(0.0165)	(0.0133)	(0.0167)	(0.0139)
3500	0.2482	0.2482	0.2481	0.1928	0.2969	0.1933
	(0.0156)	(0.0156)	(0.0156)	(0.0117)	(0.0166)	(0.0122)
4000	0.2147	0.2148	0.2148	0.1731	0.2633	0.1715
	(0.0139)	(0.0138)	(0.0139)	(0.0104)	(0.0156)	(0.0106)
4500	0.1889	0.1889	0.1889	0.1563	0.238	0.1551
	(0.012)	(0.012)	(0.012)	(0.0089)	(0.0164)	(0.009)
5000	0.1684	0.1684	0.1684	0.1432	0.2739	0.1422
	(0.0105)	(0.0105)	(0.0105)	(0.0076)	(0.0852)	(0.0076)

Table F.40: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard error of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1154	0.1156	0.1154	0.8943	0.8938	0.8945
	(0.0572)	(0.0572)	(0.0571)	(0.0566)	(0.0619)	(0.0566)
100	0.3171	0.3177	0.3181	0.8909	0.8918	0.8913
	(0.1061)	(0.1061)	(0.1058)	(0.0113)	(0.0098)	(0.011)
500	0.5367	0.5365	0.5364	0.6928	0.5853	0.6928
	(0.0197)	(0.0196)	(0.0196)	(0.0342)	(0.0188)	(0.0341)
1000	0.6062	0.6061	0.6062	0.5051	0.6365	0.5048
	(0.0186)	(0.0186)	(0.0187)	(0.0271)	(0.019)	(0.0272)
1500	0.5042	0.5041	0.5042	0.3899	0.5889	0.3895
	(0.019)	(0.0191)	(0.019)	(0.0221)	(0.0288)	(0.0221)
2000	0.4147	0.4146	0.4148	0.3129	0.6007	0.3126
	(0.0189)	(0.0189)	(0.0188)	(0.0194)	(0.0814)	(0.0195)
2500	0.3441	0.344	0.3441	0.2599	0.5377	0.2596
	(0.0183)	(0.0182)	(0.0182)	(0.0166)	(0.0446)	(0.0165)
3000	0.2896	0.2895	0.2897	0.2215	0.5094	0.2212
	(0.0167)	(0.0166)	(0.0166)	(0.0142)	(0.0495)	(0.0141)
3500	0.2471	0.2471	0.2472	0.193	0.439	0.1929
	(0.0154)	(0.0154)	(0.0154)	(0.0124)	(0.0591)	(0.0124)
4000	0.2138	0.2137	0.2138	0.1714	0.3669	0.1713
	(0.0138)	(0.0137)	(0.0136)	(0.0105)	(0.038)	(0.0106)
4500	0.1879	0.1879	0.1879	0.1548	0.3252	0.1547
	(0.012)	(0.0119)	(0.012)	(0.0089)	(0.0348)	(0.0089)
5000	0.1676	0.1676	0.1676	0.1419	0.3086	0.1419
	(0.0106)	(0.0105)	(0.0105)	(0.0076)	(0.0567)	(0.0076)

Table F.41: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under abrupt drift (priors: Equal) where the covariance matrix drifts from EYE to Wishart. The standard error of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4927	0.4931	0.4916	0.3125	0.3041	0.3034
	(0.076)	(0.076)	(0.0756)	(0.0612)	(0.0594)	(0.0596)
100	0.4248	0.4247	0.4244	0.2468	0.2409	0.2404
	(0.0524)	(0.0527)	(0.0524)	(0.0416)	(0.0404)	(0.0404)
500	0.2409	0.251	0.2443	0.1504	0.1488	0.1487
	(0.0194)	(0.0219)	(0.0207)	(0.0161)	(0.0161)	(0.0161)
1000	0.1839	0.1907	0.1864	0.1304	0.1294	0.1293
	(0.0125)	(0.0139)	(0.0132)	(0.0107)	(0.0109)	(0.0109)
1500	0.1613	0.1662	0.1634	0.1225	0.1217	0.1217
	(0.0097)	(0.0108)	(0.0103)	(0.0087)	(0.0087)	(0.0088)
2000	0.1486	0.1525	0.1504	0.1182	0.1176	0.1175
	(0.0082)	(0.009)	(0.0086)	(0.0075)	(0.0075)	(0.0075)
2500	0.1405	0.1438	0.1423	0.1156	0.115	0.1149
	(0.007)	(0.0076)	(0.0073)	(0.0065)	(0.0066)	(0.0066)
3000	0.1747	0.1779	0.1757	0.1404	0.1495	0.1265
	(0.0066)	(0.0078)	(0.0085)	(0.0148)	(0.0091)	(0.0075)
3500	0.1719	0.1753	0.1728	0.1384	0.1515	0.126
	(0.0061)	(0.0086)	(0.0105)	(0.0137)	(0.0139)	(0.0072)
4000	0.166	0.1699	0.1683	0.1358	0.1502	0.1249
	(0.0056)	(0.0084)	(0.0115)	(0.0127)	(0.0173)	(0.0071)
4500	0.1603	0.1648	0.1637	0.1334	0.1482	0.1236
	(0.0052)	(0.0082)	(0.0118)	(0.0118)	(0.0198)	(0.0071)
5000	0.1555	0.1603	0.1602	0.1314	0.1465	0.1225
	(0.0049)	(0.0078)	(0.0115)	(0.0112)	(0.0222)	(0.0072)

Table F.42: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under abrupt drift (priors: Equal) where the covariance matrix drifts from CS to AR. The standard error of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.482	0.4821	0.4817	0.3325	0.3325	0.3317
	(0.0816)	(0.081)	(0.0812)	(0.06)	(0.059)	(0.0601)
100	0.4198	0.4198	0.4195	0.2806	0.2788	0.2797
	(0.0568)	(0.0559)	(0.0567)	(0.0433)	(0.0428)	(0.0434)
500	0.2399	0.2506	0.244	0.1872	0.1866	0.1872
	(0.0197)	(0.0225)	(0.0206)	(0.0182)	(0.0183)	(0.0182)
1000	0.1836	0.1902	0.1862	0.1568	0.1565	0.1569
	(0.0126)	(0.0141)	(0.0132)	(0.0119)	(0.0118)	(0.0118)
1500	0.1609	0.1658	0.163	0.1431	0.1429	0.1431
	(0.0096)	(0.0106)	(0.0101)	(0.0092)	(0.0091)	(0.0091)
2000	0.1483	0.1522	0.1503	0.1351	0.135	0.1351
	(0.008)	(0.0088)	(0.0084)	(0.0076)	(0.0075)	(0.0076)
2500	0.1402	0.1435	0.1423	0.1301	0.1299	0.1301
	(0.007)	(0.0077)	(0.0076)	(0.0067)	(0.0067)	(0.0067)
3000	0.1854	0.1634	0.1606	0.1469	0.1441	0.144
	(0.007)	(0.0077)	(0.008)	(0.0094)	(0.0066)	(0.0067)
3500	0.2028	0.1598	0.1572	0.1446	0.1416	0.1416
	(0.0067)	(0.0079)	(0.0082)	(0.0089)	(0.0063)	(0.0068)
4000	0.2099	0.155	0.1529	0.1415	0.1383	0.1383
	(0.0064)	(0.0077)	(0.0088)	(0.0088)	(0.0059)	(0.0067)
4500	0.212	0.1507	0.1491	0.1388	0.1354	0.1354
	(0.006)	(0.0075)	(0.0091)	(0.009)	(0.0055)	(0.0063)
5000	0.2115	0.1471	0.1459	0.1364	0.1328	0.1328
	(0.0057)	(0.0073)	(0.0096)	(0.0091)	(0.0051)	(0.0061)

Table F.43: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under abrupt drift (priors: Equal) where the covariance matrix drifts from AR to EYE. The standard error of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4244	0.4238	0.4238	0.3824	0.3812	0.381
	(0.0725)	(0.0723)	(0.0728)	(0.0664)	(0.0665)	(0.0664)
100	0.3868	0.3866	0.387	0.3204	0.32	0.3194
	(0.0507)	(0.0507)	(0.0508)	(0.0439)	(0.0445)	(0.044)
500	0.2333	0.2439	0.2372	0.1928	0.1928	0.1926
	(0.0187)	(0.0218)	(0.0194)	(0.0173)	(0.0173)	(0.0171)
1000	0.1797	0.1864	0.1823	0.1579	0.1578	0.1577
	(0.012)	(0.0139)	(0.0125)	(0.0112)	(0.0114)	(0.0113)
1500	0.1579	0.1629	0.1601	0.1433	0.1433	0.1432
	(0.0094)	(0.0108)	(0.0098)	(0.009)	(0.0091)	(0.009)
2000	0.1462	0.1501	0.1483	0.1353	0.1353	0.1352
	(0.0079)	(0.009)	(0.0086)	(0.0074)	(0.0075)	(0.0075)
2500	0.1385	0.1418	0.1406	0.1301	0.13	0.1299
	(0.0069)	(0.0078)	(0.0075)	(0.0065)	(0.0065)	(0.0065)
3000	0.1756	0.1635	0.1632	0.1412	0.1346	0.1356
	(0.0066)	(0.0076)	(0.0074)	(0.0139)	(0.0063)	(0.0079)
3500	0.1863	0.1596	0.1602	0.1369	0.1309	0.1319
	(0.0062)	(0.0075)	(0.0079)	(0.0124)	(0.0059)	(0.0072)
4000	0.1888	0.1547	0.1556	0.1331	0.1279	0.1287
	(0.0057)	(0.0073)	(0.008)	(0.0111)	(0.0055)	(0.0066)
4500	0.1879	0.1502	0.1514	0.13	0.1253	0.126
	(0.0055)	(0.007)	(0.008)	(0.0099)	(0.0051)	(0.006)
5000	0.1855	0.1464	0.1478	0.1274	0.1232	0.1238
	(0.0053)	(0.0068)	(0.0081)	(0.009)	(0.0048)	(0.0056)

Table F.44: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under abrupt drift (priors: Equal) where the covariance matrix drifts from Wishart to AR. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.497	0.4954	0.4963	0.3417	0.3493	0.336
	(0.0783)	(0.0782)	(0.0778)	(0.0657)	(0.0683)	(0.0646)
100	0.4303	0.4297	0.4299	0.2838	0.3377	0.2792
	(0.0531)	(0.0537)	(0.0533)	(0.0435)	(0.0516)	(0.0425)
500	0.2414	0.252	0.2454	0.1793	0.2491	0.1776
	(0.0192)	(0.023)	(0.0214)	(0.0161)	(0.0428)	(0.016)
1000	0.1843	0.1913	0.1871	0.1535	0.2017	0.1523
	(0.0119)	(0.0141)	(0.0134)	(0.0112)	(0.0398)	(0.011)
1500	0.1612	0.1664	0.1636	0.1416	0.1785	0.1407
	(0.0094)	(0.011)	(0.0107)	(0.009)	(0.0343)	(0.0089)
2000	0.1485	0.1527	0.1507	0.1347	0.1655	0.134
	(0.0078)	(0.0089)	(0.0088)	(0.0077)	(0.0314)	(0.0076)
2500	0.1403	0.1439	0.1425	0.1302	0.1571	0.1296
	(0.0068)	(0.0076)	(0.0076)	(0.0067)	(0.0299)	(0.0066)
3000	0.1949	0.1692	0.1672	0.1595	0.1739	0.1596
	(0.0072)	(0.0073)	(0.0076)	(0.0067)	(0.0262)	(0.0068)
3500	0.2324	0.1649	0.1629	0.1562	0.1682	0.1562
	(0.0074)	(0.0072)	(0.0075)	(0.0064)	(0.0232)	(0.0064)
4000	0.2591	0.1599	0.1578	0.1518	0.1621	0.1516
	(0.0077)	(0.0071)	(0.0075)	(0.0062)	(0.0206)	(0.006)
4500	0.2786	0.1557	0.1536	0.1478	0.1569	0.1475
	(0.0078)	(0.0068)	(0.0078)	(0.0061)	(0.0185)	(0.0056)
5000	0.2934	0.1524	0.1501	0.1444	0.1524	0.144
	(0.008)	(0.0067)	(0.0078)	(0.0061)	(0.0169)	(0.0055)

APPENDIX G: GRADUAL DRIFT LDA SIMULATION

Table G.1: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 10) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.0803	0.0847	0.0806	0.0667	0.0799	0.0664
	(0.0155)	(0.0264)	(0.0155)	(0.0086)	(0.0152)	(0.0077)
100	0.0677	0.0721	0.0677	0.0628	0.0675	0.0628
	(0.0072)	(0.0206)	(0.0072)	(0.0052)	(0.0071)	(0.005)
500	0.0724	0.0797	0.0725	0.072	0.0724	0.0716
	(0.0026)	(0.0285)	(0.0026)	(0.0023)	(0.0026)	(0.0021)
1000	0.0914	0.1005	0.0913	0.0913	0.0913	0.0907
	(0.0026)	(0.0366)	(0.0026)	(0.0024)	(0.0026)	(0.0023)
1500	0.1117	0.1185	0.1111	0.1115	0.1112	0.1107
	(0.0033)	(0.0411)	(0.0032)	(0.0031)	(0.0032)	(0.0029)
2000	0.1308	0.1289	0.1287	0.1294	0.1288	0.1285
	(0.004)	(0.0393)	(0.0038)	(0.0037)	(0.0038)	(0.0036)
2500	0.1457	0.1298	0.1406	0.1417	0.1407	0.1408
	(0.0046)	(0.0352)	(0.0042)	(0.0041)	(0.0042)	(0.004)
3000	0.1545	0.1275	0.1443	0.1456	0.1445	0.1448
	(0.0051)	(0.04)	(0.0046)	(0.0046)	(0.0046)	(0.0045)
3500	0.1565	0.1188	0.1395	0.1404	0.1397	0.1399
	(0.0054)	(0.0466)	(0.0048)	(0.0047)	(0.0048)	(0.0047)
4000	0.152	0.1015	0.1264	0.1264	0.1268	0.1261
	(0.0055)	(0.0404)	(0.0047)	(0.0045)	(0.0047)	(0.0045)
4500	0.1423	0.0828	0.1075	0.1067	0.1082	0.1064
	(0.0054)	(0.0384)	(0.0046)	(0.0044)	(0.0046)	(0.0044)
5000	0.1293	0.065	0.0859	0.0848	0.0868	0.0845
	(0.0049)	(0.0356)	(0.004)	(0.0038)	(0.0041)	(0.0038)

Table G.2: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 10) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.0815	0.0873	0.0817	0.0677	0.0808	0.0667
	(0.015)	(0.0335)	(0.0152)	(0.0076)	(0.0146)	(0.0066)
100	0.0674	0.0728	0.0676	0.0633	0.0673	0.0633
	(0.0063)	(0.0285)	(0.0064)	(0.0043)	(0.0063)	(0.0041)
500	0.0755	0.0816	0.0755	0.0754	0.0755	0.0754
	(0.0014)	(0.0259)	(0.0014)	(0.0014)	(0.0014)	(0.0013)
1000	0.1026	0.1114	0.1026	0.1027	0.1026	0.1028
	(0.0013)	(0.0392)	(0.0013)	(0.0013)	(0.0013)	(0.0013)
1500	0.1353	0.1429	0.1352	0.1355	0.1352	0.1355
	(0.0016)	(0.033)	(0.0016)	(0.0016)	(0.0016)	(0.0016)
2000	0.1704	0.1749	0.1696	0.1702	0.1696	0.1702
	(0.0022)	(0.038)	(0.0021)	(0.0022)	(0.0021)	(0.0021)
2500	0.204	0.1958	0.2009	0.2016	0.2009	0.2015
	(0.0029)	(0.0377)	(0.0028)	(0.0029)	(0.0028)	(0.0029)
3000	0.2312	0.1989	0.2225	0.223	0.2227	0.2229
	(0.0036)	(0.0348)	(0.0035)	(0.0035)	(0.0035)	(0.0035)
3500	0.2482	0.1816	0.2282	0.228	0.2287	0.2279
	(0.0042)	(0.0367)	(0.0042)	(0.0042)	(0.0041)	(0.0041)
4000	0.2529	0.1503	0.2139	0.2126	0.2149	0.2124
	(0.0046)	(0.0462)	(0.0046)	(0.0045)	(0.0045)	(0.0045)
4500	0.2458	0.108	0.1797	0.1771	0.1811	0.177
	(0.0047)	(0.0434)	(0.005)	(0.0048)	(0.005)	(0.0047)
5000	0.229	0.0681	0.1305	0.1278	0.1321	0.1281
	(0.0048)	(0.0477)	(0.0049)	(0.0046)	(0.0048)	(0.0045)

Table G.3: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 10) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.0846	0.0887	0.0845	0.0758	0.0848	0.0736
	(0.0185)	(0.0306)	(0.0182)	(0.0121)	(0.0184)	(0.0108)
100	0.0706	0.0747	0.0707	0.0679	0.0708	0.0672
	(0.008)	(0.0202)	(0.008)	(0.0065)	(0.008)	(0.0062)
500	0.0855	0.0914	0.0855	0.0851	0.0855	0.0851
	(0.0024)	(0.0241)	(0.0024)	(0.0022)	(0.0024)	(0.0022)
1000	0.1291	0.1371	0.1291	0.1289	0.129	0.1289
	(0.0019)	(0.0321)	(0.0019)	(0.0019)	(0.0019)	(0.0019)
1500	0.1866	0.1947	0.1864	0.1862	0.1863	0.1864
	(0.0023)	(0.0355)	(0.0023)	(0.0022)	(0.0023)	(0.0022)
2000	0.2505	0.2539	0.2493	0.2491	0.2494	0.2493
	(0.0034)	(0.0352)	(0.0034)	(0.0033)	(0.0034)	(0.0033)
2500	0.3079	0.2888	0.3026	0.302	0.3032	0.3022
	(0.0052)	(0.034)	(0.0052)	(0.0052)	(0.0052)	(0.0052)
3000	0.3449	0.2763	0.3279	0.3266	0.3291	0.3267
	(0.0073)	(0.0276)	(0.0074)	(0.0074)	(0.0074)	(0.0074)
3500	0.3528	0.2234	0.3147	0.3129	0.316	0.3128
	(0.0086)	(0.0375)	(0.0081)	(0.008)	(0.0081)	(0.008)
4000	0.3341	0.154	0.2746	0.2732	0.2757	0.273
	(0.0079)	(0.0341)	(0.0076)	(0.0076)	(0.0076)	(0.0076)
4500	0.3015	0.1009	0.2186	0.2172	0.2194	0.2169
	(0.0064)	(0.0356)	(0.0101)	(0.0102)	(0.0101)	(0.0103)
5000	0.2646	0.0648	0.1488	0.1466	0.1494	0.146
	(0.0073)	(0.0397)	(0.0102)	(0.0104)	(0.0103)	(0.0104)

Table G.4: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 10) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.0875	0.0921	0.0873	0.0728	0.0881	0.0711
	(0.0196)	(0.031)	(0.0195)	(0.0108)	(0.0198)	(0.0093)
100	0.0702	0.0749	0.07	0.0659	0.0704	0.0655
	(0.0078)	(0.0267)	(0.0077)	(0.0054)	(0.008)	(0.0049)
500	0.0786	0.0867	0.0786	0.0781	0.0786	0.078
	(0.0015)	(0.0455)	(0.0016)	(0.0013)	(0.0015)	(0.0013)
1000	0.105	0.1146	0.1049	0.1046	0.1049	0.1044
	(0.0016)	(0.0388)	(0.0015)	(0.0014)	(0.0016)	(0.0014)
1500	0.1312	0.1397	0.1306	0.1302	0.1306	0.1301
	(0.002)	(0.04)	(0.0019)	(0.0018)	(0.0019)	(0.0018)
2000	0.1531	0.1564	0.1512	0.1507	0.1512	0.1507
	(0.0025)	(0.0415)	(0.0024)	(0.0024)	(0.0024)	(0.0023)
2500	0.1683	0.1628	0.1631	0.1625	0.1632	0.1626
	(0.0029)	(0.0485)	(0.0027)	(0.0027)	(0.0028)	(0.0027)
3000	0.1751	0.1541	0.1635	0.1628	0.1636	0.163
	(0.0032)	(0.0446)	(0.003)	(0.0029)	(0.003)	(0.0029)
3500	0.1735	0.1358	0.1521	0.1516	0.1524	0.1519
	(0.0035)	(0.0428)	(0.0032)	(0.0031)	(0.0032)	(0.0031)
4000	0.1645	0.1134	0.1318	0.1314	0.132	0.1316
	(0.0036)	(0.0456)	(0.0032)	(0.003)	(0.0031)	(0.003)
4500	0.15	0.0891	0.1063	0.1061	0.1066	0.1061
	(0.0036)	(0.0463)	(0.003)	(0.0028)	(0.003)	(0.0028)
5000	0.1321	0.0661	0.0795	0.0795	0.0798	0.0794
	(0.0036)	(0.045)	(0.0027)	(0.0026)	(0.0026)	(0.0025)

Table G.5: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 10) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1394	0.1442	0.139	0.1185	0.1469	0.1106
	(0.1058)	(0.1115)	(0.1049)	(0.0985)	(0.1087)	(0.0925)
100	0.0788	0.0834	0.0787	0.0729	0.0815	0.0715
	(0.0255)	(0.0391)	(0.0254)	(0.021)	(0.0277)	(0.0203)
500	0.0675	0.0738	0.0675	0.0674	0.0675	0.0672
	(0.0026)	(0.034)	(0.0026)	(0.0027)	(0.0026)	(0.0026)
1000	0.0808	0.0879	0.0808	0.0807	0.0807	0.0806
	(0.0016)	(0.0332)	(0.0016)	(0.0016)	(0.0015)	(0.0016)
1500	0.0937	0.1017	0.0936	0.0934	0.0936	0.0934
	(0.0012)	(0.0395)	(0.0012)	(0.0011)	(0.0012)	(0.0011)
2000	0.1033	0.1111	0.103	0.1027	0.1031	0.1028
	(0.0015)	(0.042)	(0.0015)	(0.0014)	(0.0015)	(0.0014)
2500	0.1088	0.1154	0.1078	0.1074	0.108	0.1076
	(0.002)	(0.0422)	(0.0018)	(0.0017)	(0.0019)	(0.0018)
3000	0.1105	0.1159	0.1084	0.108	0.1086	0.1082
	(0.0022)	(0.0444)	(0.0019)	(0.0018)	(0.002)	(0.0018)
3500	0.1096	0.1124	0.1061	0.1058	0.1063	0.106
	(0.002)	(0.0447)	(0.0015)	(0.0014)	(0.0016)	(0.0015)
4000	0.1073	0.1058	0.1024	0.1024	0.1026	0.1024
	(0.0015)	(0.0373)	(0.001)	(0.001)	(0.0011)	(0.001)
4500	0.1044	0.0955	0.0977	0.0978	0.0977	0.0978
	(0.0011)	(0.0305)	(0.0013)	(0.0012)	(0.0013)	(0.0012)
5000	0.1012	0.0787	0.0907	0.091	0.0906	0.0911
	(9e-04)	(0.0299)	(0.0024)	(0.0022)	(0.0024)	(0.0022)

Table G.6: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 10) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1543	0.1579	0.1544	0.1248	0.1665	0.12
	(0.0882)	(0.0925)	(0.0886)	(0.0703)	(0.094)	(0.0675)
100	0.0851	0.0889	0.0856	0.0789	0.09	0.0772
	(0.0231)	(0.0349)	(0.0282)	(0.0194)	(0.0305)	(0.0184)
500	0.0672	0.0715	0.0672	0.0671	0.0676	0.0669
	(0.0036)	(0.0262)	(0.0037)	(0.0036)	(0.0039)	(0.0035)
1000	0.0775	0.0857	0.0775	0.0775	0.0777	0.0774
	(0.0031)	(0.0385)	(0.0031)	(0.0031)	(0.0032)	(0.0031)
1500	0.0882	0.0988	0.0881	0.0883	0.0884	0.0882
	(0.0033)	(0.0471)	(0.0033)	(0.0033)	(0.0034)	(0.0033)
2000	0.0975	0.1083	0.0973	0.0975	0.0976	0.0973
	(0.0037)	(0.0501)	(0.0037)	(0.0037)	(0.0037)	(0.0037)
2500	0.1039	0.115	0.1033	0.1035	0.1037	0.1033
	(0.0039)	(0.0552)	(0.0038)	(0.0038)	(0.0039)	(0.0038)
3000	0.107	0.1171	0.1055	0.1056	0.1058	0.1055
	(0.004)	(0.0599)	(0.0038)	(0.0038)	(0.0039)	(0.0038)
3500	0.1066	0.1123	0.1034	0.1034	0.1037	0.1033
	(0.0036)	(0.0561)	(0.0032)	(0.0032)	(0.0033)	(0.0032)
4000	0.1036	0.1049	0.0982	0.0983	0.0985	0.0983
	(0.003)	(0.0558)	(0.0024)	(0.0024)	(0.0025)	(0.0024)
4500	0.099	0.0954	0.0917	0.092	0.0918	0.092
	(0.0023)	(0.0505)	(0.0017)	(0.0017)	(0.0018)	(0.0017)
5000	0.0935	0.0811	0.085	0.0857	0.0849	0.0855
	(0.0019)	(0.0455)	(0.0019)	(0.0018)	(0.0019)	(0.0018)

Table G.7: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 25) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1517	0.1586	0.1546	0.0947	0.149	0.0921
	(0.0336)	(0.0399)	(0.0354)	(0.0126)	(0.0326)	(0.0116)
100	0.0947	0.1024	0.0955	0.0802	0.0945	0.0794
	(0.0127)	(0.0236)	(0.0132)	(0.0072)	(0.0126)	(0.0067)
500	0.0913	0.0925	0.0914	0.0904	0.0913	0.0903
	(0.0023)	(0.0033)	(0.0024)	(0.0021)	(0.0023)	(0.002)
1000	0.1297	0.1299	0.1297	0.1292	0.1297	0.1292
	(0.0019)	(0.0028)	(0.0019)	(0.0017)	(0.0018)	(0.0017)
1500	0.1742	0.1731	0.1737	0.1734	0.1738	0.1734
	(0.0023)	(0.0027)	(0.0024)	(0.0022)	(0.0024)	(0.0022)
2000	0.2172	0.2093	0.2147	0.2141	0.2151	0.2141
	(0.0031)	(0.0036)	(0.0031)	(0.0029)	(0.0031)	(0.0029)
2500	0.2518	0.2243	0.2428	0.2414	0.2445	0.2414
	(0.004)	(0.0061)	(0.0042)	(0.004)	(0.0041)	(0.0039)
3000	0.2723	0.2159	0.2493	0.2461	0.2529	0.2461
	(0.0048)	(0.0061)	(0.0051)	(0.0048)	(0.0049)	(0.0048)
3500	0.2757	0.1833	0.2288	0.2239	0.2339	0.2238
	(0.0054)	(0.0067)	(0.006)	(0.0056)	(0.0056)	(0.0057)
4000	0.2624	0.1356	0.1853	0.1808	0.1903	0.1807
	(0.0057)	(0.0073)	(0.0058)	(0.0053)	(0.0055)	(0.0052)
4500	0.236	0.0917	0.1311	0.1297	0.1345	0.1296
	(0.0058)	(0.0056)	(0.0048)	(0.0044)	(0.0047)	(0.0043)
5000	0.2016	0.0572	0.081	0.0831	0.0827	0.0831
	(0.0056)	(0.0021)	(0.0033)	(0.003)	(0.0034)	(0.003)

Table G.8: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 25) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1664	0.1725	0.169	0.0886	0.1658	0.0851
	(0.044)	(0.0491)	(0.0455)	(0.0153)	(0.0437)	(0.014)
100	0.096	0.1034	0.0966	0.0735	0.097	0.0721
	(0.0151)	(0.0244)	(0.0157)	(0.007)	(0.0155)	(0.0065)
500	0.0745	0.0755	0.0745	0.0728	0.0746	0.0727
	(0.0024)	(0.0032)	(0.0025)	(0.0019)	(0.0025)	(0.0018)
1000	0.0893	0.0895	0.0892	0.0886	0.0892	0.0886
	(0.0016)	(0.0029)	(0.0016)	(0.0014)	(0.0016)	(0.0013)
1500	0.1059	0.1052	0.1056	0.1054	0.1056	0.1054
	(0.0018)	(0.0029)	(0.0018)	(0.0016)	(0.0018)	(0.0016)
2000	0.121	0.1182	0.1198	0.12	0.12	0.1201
	(0.002)	(0.0023)	(0.002)	(0.0018)	(0.002)	(0.0018)
2500	0.1328	0.1255	0.1297	0.1302	0.13	0.1303
	(0.0023)	(0.0025)	(0.0022)	(0.0021)	(0.0022)	(0.0021)
3000	0.14	0.1248	0.133	0.1339	0.1337	0.1341
	(0.0026)	(0.0072)	(0.0026)	(0.0024)	(0.0025)	(0.0024)
3500	0.1418	0.115	0.1286	0.1295	0.1297	0.1298
	(0.0027)	(0.0028)	(0.0027)	(0.0026)	(0.0026)	(0.0026)
4000	0.1384	0.0999	0.1169	0.1174	0.1186	0.1178
	(0.0029)	(0.0033)	(0.003)	(0.0026)	(0.0028)	(0.0026)
4500	0.1306	0.0812	0.0995	0.0996	0.1016	0.1
	(0.003)	(0.0041)	(0.003)	(0.0025)	(0.0027)	(0.0025)
5000	0.1195	0.0608	0.0785	0.0786	0.0805	0.0791
	(0.003)	(0.0122)	(0.0029)	(0.0023)	(0.0025)	(0.0023)

Table G.9: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 25) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3742	0.3808	0.3771	0.248	0.3907	0.2413
	(0.1375)	(0.136)	(0.1368)	(0.1264)	(0.1397)	(0.1257)
100	0.1746	0.1866	0.176	0.1248	0.1915	0.1218
	(0.0584)	(0.0668)	(0.0588)	(0.0422)	(0.0631)	(0.0408)
500	0.0728	0.0739	0.0728	0.0706	0.0743	0.0704
	(0.0057)	(0.0073)	(0.0057)	(0.0049)	(0.0062)	(0.0048)
1000	0.0763	0.0768	0.0763	0.0755	0.077	0.0754
	(0.0032)	(0.0075)	(0.0032)	(0.0029)	(0.0034)	(0.0029)
1500	0.0835	0.0834	0.0833	0.0829	0.084	0.0828
	(0.0029)	(0.0033)	(0.0029)	(0.0028)	(0.0031)	(0.0027)
2000	0.0901	0.0896	0.0897	0.0895	0.0904	0.0894
	(0.003)	(0.0091)	(0.003)	(0.0029)	(0.0031)	(0.0028)
2500	0.0952	0.0928	0.0941	0.0941	0.0948	0.0939
	(0.0031)	(0.0036)	(0.0031)	(0.003)	(0.0033)	(0.003)
3000	0.098	0.0933	0.0955	0.0958	0.0963	0.0955
	(0.0031)	(0.0044)	(0.0031)	(0.003)	(0.0032)	(0.0029)
3500	0.0984	0.0905	0.0937	0.0943	0.0945	0.0941
	(0.003)	(0.0084)	(0.0028)	(0.0027)	(0.003)	(0.0026)
4000	0.0966	0.0843	0.0887	0.0898	0.0894	0.0896
	(0.0028)	(0.0036)	(0.0025)	(0.0023)	(0.0027)	(0.0022)
4500	0.0928	0.0758	0.0811	0.0828	0.0814	0.0827
	(0.0024)	(0.0109)	(0.002)	(0.0018)	(0.0022)	(0.0018)
5000	0.0875	0.064	0.0716	0.0742	0.0716	0.0742
	(0.0021)	(0.0106)	(0.0018)	(0.0017)	(0.0019)	(0.0017)

Table G.10: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 50) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.338	0.3379	0.3373	0.098	0.2747	0.0946
	(0.0655)	(0.0655)	(0.0651)	(0.0127)	(0.0504)	(0.0114)
100	0.1374	0.1574	0.1435	0.0828	0.1455	0.0819
	(0.021)	(0.0437)	(0.0263)	(0.0075)	(0.0404)	(0.0072)
500	0.0867	0.088	0.0871	0.0809	0.0895	0.081
	(0.0039)	(0.0043)	(0.0041)	(0.0026)	(0.017)	(0.0025)
1000	0.1028	0.1035	0.1032	0.1004	0.1052	0.1006
	(0.0027)	(0.0071)	(0.0063)	(0.0022)	(0.0161)	(0.0022)
1500	0.1237	0.1234	0.1234	0.1223	0.1266	0.1226
	(0.0029)	(0.0033)	(0.003)	(0.0024)	(0.0286)	(0.0024)
2000	0.1437	0.1408	0.1419	0.141	0.145	0.1415
	(0.0034)	(0.0055)	(0.0038)	(0.0028)	(0.0183)	(0.0028)
2500	0.159	0.1498	0.1534	0.1513	0.1573	0.1519
	(0.0041)	(0.0044)	(0.0041)	(0.0036)	(0.0169)	(0.0037)
3000	0.167	0.1481	0.1548	0.1499	0.1609	0.1505
	(0.0046)	(0.0064)	(0.0046)	(0.0043)	(0.0142)	(0.0044)
3500	0.1672	0.1356	0.1457	0.1374	0.1537	0.1377
	(0.0049)	(0.0073)	(0.005)	(0.0049)	(0.0145)	(0.0049)
4000	0.16	0.114	0.1275	0.1169	0.1372	0.1169
	(0.005)	(0.0048)	(0.0061)	(0.0047)	(0.018)	(0.0048)
4500	0.147	0.0894	0.1038	0.0936	0.1133	0.0935
	(0.0048)	(0.0066)	(0.0044)	(0.0042)	(0.0117)	(0.0043)
5000	0.1308	0.0661	0.0795	0.0714	0.0873	0.0713
	(0.0046)	(0.0078)	(0.0042)	(0.0035)	(0.0162)	(0.0035)

Table G.11: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 50) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3619	0.3619	0.3624	0.1038	0.3025	0.1012
	(0.0616)	(0.0617)	(0.0622)	(0.0119)	(0.051)	(0.0111)
100	0.1492	0.1671	0.1532	0.0842	0.1507	0.0831
	(0.0233)	(0.0429)	(0.0266)	(0.0064)	(0.0268)	(0.0062)
500	0.0806	0.0817	0.0807	0.0758	0.0808	0.0756
	(0.0032)	(0.0064)	(0.0033)	(0.002)	(0.0057)	(0.002)
1000	0.09	0.0903	0.0905	0.0883	0.0907	0.0881
	(0.002)	(0.0021)	(0.0121)	(0.0014)	(0.009)	(0.0014)
1500	0.1032	0.1029	0.103	0.1021	0.1036	0.1019
	(0.0019)	(0.0019)	(0.0021)	(0.0015)	(0.0059)	(0.0015)
2000	0.1154	0.1135	0.1142	0.1135	0.1149	0.1132
	(0.0021)	(0.0025)	(0.0029)	(0.0017)	(0.0074)	(0.0017)
2500	0.1246	0.119	0.121	0.1202	0.1222	0.1198
	(0.0024)	(0.0025)	(0.0026)	(0.0019)	(0.0068)	(0.0018)
3000	0.1296	0.1184	0.122	0.1207	0.1239	0.1202
	(0.0026)	(0.0027)	(0.0025)	(0.002)	(0.0092)	(0.0019)
3500	0.1302	0.1115	0.1167	0.1149	0.1193	0.1144
	(0.0028)	(0.0043)	(0.0027)	(0.0021)	(0.0084)	(0.002)
4000	0.1264	0.0987	0.1052	0.1039	0.1082	0.1034
	(0.0029)	(0.0026)	(0.0028)	(0.0022)	(0.0075)	(0.0022)
4500	0.1186	0.0816	0.0885	0.0891	0.0915	0.0887
	(0.003)	(0.0034)	(0.0026)	(0.0023)	(0.0075)	(0.0022)
5000	0.108	0.0628	0.069	0.0722	0.0715	0.072
	(0.0029)	(0.0044)	(0.0021)	(0.0022)	(0.0068)	(0.0021)

Table G.12: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 50) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3541	0.3539	0.3543	0.121	0.2969	0.116
	(0.0723)	(0.0724)	(0.0723)	(0.0291)	(0.0634)	(0.0285)
100	0.1488	0.1688	0.155	0.0888	0.1589	0.0867
	(0.0261)	(0.0491)	(0.0322)	(0.0102)	(0.0455)	(0.0096)
500	0.0816	0.0831	0.0819	0.0757	0.0838	0.0753
	(0.0038)	(0.0045)	(0.0039)	(0.0025)	(0.011)	(0.0025)
1000	0.091	0.0915	0.0913	0.0882	0.0923	0.0879
	(0.0026)	(0.0028)	(0.0044)	(0.0021)	(0.0108)	(0.002)
1500	0.1048	0.1045	0.1048	0.102	0.1061	0.1018
	(0.0027)	(0.0029)	(0.0083)	(0.0023)	(0.0093)	(0.0022)
2000	0.1172	0.1151	0.1156	0.1125	0.1182	0.1122
	(0.003)	(0.0057)	(0.0029)	(0.0023)	(0.0181)	(0.0023)
2500	0.1263	0.1203	0.1218	0.1174	0.1249	0.1171
	(0.0033)	(0.0071)	(0.0032)	(0.0025)	(0.0115)	(0.0025)
3000	0.1306	0.1184	0.1221	0.1154	0.1263	0.1152
	(0.0035)	(0.0035)	(0.0076)	(0.0027)	(0.0186)	(0.0027)
3500	0.1301	0.1103	0.1158	0.1071	0.1203	0.107
	(0.0037)	(0.004)	(0.0035)	(0.0029)	(0.0115)	(0.0029)
4000	0.1251	0.0966	0.1041	0.0942	0.109	0.0941
	(0.0037)	(0.007)	(0.0038)	(0.0028)	(0.0121)	(0.0028)
4500	0.1166	0.08	0.0887	0.0792	0.0938	0.0792
	(0.0036)	(0.0041)	(0.0033)	(0.0026)	(0.0139)	(0.0026)
5000	0.106	0.0631	0.0718	0.064	0.0768	0.064
	(0.0034)	(0.0038)	(0.003)	(0.0024)	(0.0183)	(0.0024)

Table G.13: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 50) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3766	0.3765	0.3762	0.1274	0.3288	0.1238
	(0.0721)	(0.0722)	(0.0719)	(0.0257)	(0.0635)	(0.0249)
100	0.1653	0.1851	0.1705	0.0912	0.17	0.09
	(0.0306)	(0.0509)	(0.0343)	(0.0108)	(0.0343)	(0.0103)
500	0.0805	0.0818	0.0807	0.0745	0.082	0.0744
	(0.0037)	(0.0043)	(0.0038)	(0.0022)	(0.0092)	(0.0022)
1000	0.087	0.0872	0.0873	0.0843	0.0883	0.0842
	(0.0021)	(0.0028)	(0.0061)	(0.0015)	(0.0091)	(0.0015)
1500	0.0969	0.0964	0.0965	0.0945	0.0978	0.0945
	(0.0019)	(0.002)	(0.002)	(0.0014)	(0.0099)	(0.0014)
2000	0.1051	0.1034	0.1039	0.1021	0.1051	0.102
	(0.0021)	(0.0025)	(0.0021)	(0.0016)	(0.0082)	(0.0015)
2500	0.1104	0.1064	0.1075	0.1056	0.1088	0.1055
	(0.0023)	(0.0074)	(0.0023)	(0.0017)	(0.0069)	(0.0017)
3000	0.1122	0.1039	0.1066	0.1046	0.1084	0.1045
	(0.0024)	(0.0024)	(0.0024)	(0.0018)	(0.013)	(0.0018)
3500	0.1107	0.097	0.1012	0.0991	0.1031	0.099
	(0.0025)	(0.003)	(0.0026)	(0.0019)	(0.0067)	(0.0018)
4000	0.1061	0.0867	0.0919	0.0901	0.0942	0.09
	(0.0025)	(0.0023)	(0.0024)	(0.0018)	(0.0062)	(0.0017)
4500	0.0991	0.0742	0.0795	0.0786	0.0821	0.0787
	(0.0024)	(0.002)	(0.0022)	(0.0018)	(0.0063)	(0.0017)
5000	0.0904	0.0603	0.0655	0.0659	0.068	0.0661
	(0.0023)	(0.002)	(0.002)	(0.0016)	(0.0063)	(0.0016)

Table G.14: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 50) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.485	0.4843	0.485	0.4223	0.4839	0.4177
	(0.1229)	(0.1221)	(0.1227)	(0.2002)	(0.1327)	(0.2042)
100	0.2982	0.3178	0.3041	0.2068	0.3181	0.2028
	(0.1)	(0.1052)	(0.1014)	(0.1056)	(0.1051)	(0.1058)
500	0.0823	0.0839	0.0827	0.0741	0.0895	0.0738
	(0.0077)	(0.0152)	(0.0081)	(0.0051)	(0.0277)	(0.0049)
1000	0.0781	0.0809	0.0791	0.0756	0.0816	0.0755
	(0.003)	(0.0078)	(0.0148)	(0.0022)	(0.0131)	(0.0022)
1500	0.0826	0.0834	0.0827	0.0811	0.0848	0.081
	(0.0021)	(0.0054)	(0.0028)	(0.0018)	(0.0107)	(0.0017)
2000	0.0873	0.0868	0.0871	0.0853	0.0893	0.0853
	(0.0019)	(0.0021)	(0.0102)	(0.0015)	(0.0153)	(0.0015)
2500	0.0905	0.0887	0.0891	0.0875	0.0913	0.0874
	(0.0018)	(0.0033)	(0.0019)	(0.0015)	(0.0089)	(0.0015)
3000	0.0919	0.0884	0.089	0.0872	0.0912	0.0871
	(0.0018)	(0.0102)	(0.0018)	(0.0015)	(0.0084)	(0.0015)
3500	0.0916	0.0855	0.0868	0.0847	0.0888	0.0846
	(0.0019)	(0.0051)	(0.002)	(0.0016)	(0.0092)	(0.0016)
4000	0.0897	0.0806	0.0824	0.0801	0.084	0.0799
	(0.002)	(0.0086)	(0.0021)	(0.0019)	(0.009)	(0.0018)
4500	0.0863	0.073	0.0759	0.0735	0.0766	0.0733
	(0.0021)	(0.0053)	(0.0024)	(0.0021)	(0.0059)	(0.002)
5000	0.0818	0.0637	0.0674	0.0652	0.0676	0.0651
	(0.0022)	(0.0089)	(0.0023)	(0.0023)	(0.0058)	(0.0021)

Table G.15: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 50) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.522	0.5214	0.5219	0.4376	0.5284	0.4293
	(0.1114)	(0.1113)	(0.1119)	(0.1658)	(0.1191)	(0.1671)
100	0.3557	0.3711	0.3608	0.2298	0.3779	0.2247
	(0.0967)	(0.0993)	(0.0973)	(0.0818)	(0.0991)	(0.0812)
500	0.089	0.0897	0.0892	0.0801	0.0954	0.0799
	(0.0103)	(0.0107)	(0.0104)	(0.0078)	(0.0184)	(0.0077)
1000	0.0791	0.0828	0.0794	0.0765	0.0822	0.0765
	(0.0045)	(0.0169)	(0.0051)	(0.0038)	(0.0097)	(0.0038)
1500	0.081	0.0818	0.0811	0.0798	0.0836	0.0799
	(0.0034)	(0.004)	(0.0034)	(0.003)	(0.0095)	(0.003)
2000	0.0841	0.084	0.084	0.0834	0.0865	0.0836
	(0.0029)	(0.0044)	(0.0068)	(0.0028)	(0.0116)	(0.0028)
2500	0.0864	0.0857	0.0859	0.0857	0.088	0.086
	(0.0025)	(0.0082)	(0.0076)	(0.0026)	(0.0077)	(0.0026)
3000	0.0874	0.0854	0.0856	0.0858	0.0881	0.0862
	(0.0023)	(0.0087)	(0.0026)	(0.0024)	(0.0082)	(0.0025)
3500	0.0872	0.0827	0.0838	0.0838	0.0864	0.0842
	(0.0022)	(0.003)	(0.0024)	(0.0022)	(0.0092)	(0.0022)
4000	0.0857	0.0785	0.0799	0.0797	0.0823	0.0801
	(0.0021)	(0.0071)	(0.0025)	(0.0019)	(0.0076)	(0.002)
4500	0.0828	0.0717	0.0739	0.0736	0.0761	0.0739
	(0.002)	(0.01)	(0.0077)	(0.0018)	(0.0103)	(0.0018)
5000	0.0789	0.0624	0.0654	0.0658	0.0674	0.0661
	(0.0018)	(0.0085)	(0.0041)	(0.0016)	(0.0104)	(0.0016)

Table G.16: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 100) under gradual drift (priors: Equal), where the covariance matrix drifts from EYE to EYE. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3368	0.3367	0.3368	0.2042	0.1977	0.1984
	(0.0386)	(0.0385)	(0.0385)	(0.0221)	(0.0213)	(0.0212)
100	0.4182	0.4185	0.4182	0.1709	0.1676	0.1679
	(0.0423)	(0.0422)	(0.0422)	(0.0151)	(0.015)	(0.0144)
500	0.1653	0.1718	0.1687	0.1389	0.1382	0.138
	(0.0074)	(0.0091)	(0.0084)	(0.0047)	(0.005)	(0.0046)
1000	0.1651	0.1674	0.1663	0.1515	0.1511	0.151
	(0.0044)	(0.0072)	(0.0046)	(0.0039)	(0.0041)	(0.0039)
1500	0.1772	0.1782	0.1779	0.1669	0.1665	0.1665
	(0.0037)	(0.0049)	(0.0039)	(0.0031)	(0.0033)	(0.0032)
2000	0.1905	0.1904	0.1903	0.1796	0.1792	0.1793
	(0.0037)	(0.0118)	(0.0039)	(0.0032)	(0.0033)	(0.0033)
2500	0.2012	0.1978	0.1985	0.1859	0.1855	0.1855
	(0.0041)	(0.006)	(0.0052)	(0.0033)	(0.0034)	(0.0033)
3000	0.2073	0.1991	0.2002	0.184	0.1834	0.1835
	(0.0045)	(0.0061)	(0.009)	(0.0033)	(0.0033)	(0.0033)
3500	0.2076	0.193	0.1943	0.1733	0.1726	0.1726
	(0.0048)	(0.0056)	(0.0072)	(0.0035)	(0.0035)	(0.0035)
4000	0.2019	0.1799	0.1817	0.1559	0.1551	0.1552
	(0.0051)	(0.0055)	(0.0061)	(0.0036)	(0.0035)	(0.0036)
4500	0.1906	0.1611	0.1635	0.1346	0.1339	0.1339
	(0.0051)	(0.0053)	(0.0063)	(0.0033)	(0.0034)	(0.0034)
5000	0.175	0.1394	0.1429	0.1125	0.1119	0.1118
	(0.0051)	(0.0053)	(0.0143)	(0.0028)	(0.0029)	(0.0028)

Table G.17: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 100) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.2627	0.2625	0.2627	0.1234	0.1669	0.119
	(0.0388)	(0.0389)	(0.0387)	(0.0161)	(0.0265)	(0.0151)
100	0.3809	0.3812	0.3813	0.0998	0.3115	0.0981
	(0.05)	(0.0498)	(0.05)	(0.0101)	(0.0402)	(0.0096)
500	0.1015	0.1067	0.1041	0.0861	0.1548	0.086
	(0.0056)	(0.0119)	(0.0065)	(0.0032)	(0.075)	(0.0032)
1000	0.1091	0.1111	0.1104	0.1025	0.1455	0.1025
	(0.0035)	(0.0096)	(0.0102)	(0.0027)	(0.0671)	(0.0028)
1500	0.1258	0.1262	0.1264	0.1212	0.1495	0.1211
	(0.0033)	(0.0044)	(0.0064)	(0.0027)	(0.0416)	(0.0031)
2000	0.1425	0.1407	0.1414	0.1366	0.1607	0.1365
	(0.0036)	(0.0039)	(0.0095)	(0.0029)	(0.0366)	(0.0033)
2500	0.1554	0.1494	0.1502	0.1438	0.1692	0.1436
	(0.0041)	(0.0046)	(0.0042)	(0.0031)	(0.0345)	(0.0036)
3000	0.162	0.1497	0.1508	0.1405	0.1704	0.1403
	(0.0046)	(0.0072)	(0.0048)	(0.0034)	(0.0321)	(0.0043)
3500	0.1615	0.1406	0.143	0.1272	0.1636	0.127
	(0.0049)	(0.0078)	(0.0101)	(0.0034)	(0.0336)	(0.0043)
4000	0.1537	0.1228	0.1268	0.1073	0.1474	0.1072
	(0.0049)	(0.0068)	(0.0076)	(0.0031)	(0.0337)	(0.0037)
4500	0.1406	0.1005	0.1059	0.0857	0.1243	0.0856
	(0.0048)	(0.01)	(0.0049)	(0.0028)	(0.0349)	(0.003)
5000	0.1242	0.0767	0.0835	0.0655	0.1028	0.0655
	(0.0043)	(0.0101)	(0.005)	(0.0023)	(0.043)	(0.0024)

Table G.18: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under gradual drift (priors: Equal), where the covariance matrix drifts from EYE to EYE. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3374	0.3374	0.3373	0.2077	0.2024	0.2026
	(0.0357)	(0.0359)	(0.0356)	(0.0187)	(0.018)	(0.018)
100	0.4286	0.4286	0.4287	0.1658	0.1632	0.1632
	(0.0381)	(0.0381)	(0.0379)	(0.0105)	(0.0102)	(0.0102)
500	0.1641	0.1703	0.1667	0.1378	0.1373	0.1373
	(0.0065)	(0.0085)	(0.0074)	(0.0024)	(0.0024)	(0.0024)
1000	0.166	0.1676	0.1668	0.1539	0.1535	0.1535
	(0.0034)	(0.0037)	(0.0036)	(0.0016)	(0.0016)	(0.0016)
1500	0.1805	0.1809	0.1813	0.1725	0.1722	0.1722
	(0.0029)	(0.0031)	(0.0031)	(0.0017)	(0.0017)	(0.0017)
2000	0.1957	0.1949	0.1955	0.1869	0.1866	0.1866
	(0.0029)	(0.0079)	(0.0031)	(0.0019)	(0.0019)	(0.0019)
2500	0.2076	0.204	0.2043	0.1939	0.1936	0.1936
	(0.0032)	(0.0036)	(0.0034)	(0.0023)	(0.0022)	(0.0022)
3000	0.2143	0.2067	0.2055	0.1916	0.1913	0.1913
	(0.0036)	(0.0036)	(0.0036)	(0.0024)	(0.0024)	(0.0024)
3500	0.2149	0.202	0.1985	0.1799	0.1795	0.1795
	(0.0038)	(0.0093)	(0.0053)	(0.0025)	(0.0025)	(0.0025)
4000	0.2092	0.1894	0.1837	0.1605	0.1601	0.1601
	(0.004)	(0.0052)	(0.0097)	(0.0025)	(0.0024)	(0.0024)
4500	0.1977	0.1706	0.1626	0.1367	0.1362	0.1362
	(0.0041)	(0.0066)	(0.0103)	(0.0023)	(0.0022)	(0.0022)
5000	0.1817	0.1477	0.1377	0.1116	0.1112	0.1112
	(0.0041)	(0.0069)	(0.0043)	(0.0018)	(0.0018)	(0.0018)

Table G.19: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.2787	0.2786	0.2787	0.1405	0.2056	0.1365
	(0.0374)	(0.0373)	(0.0374)	(0.016)	(0.0286)	(0.0151)
100	0.3983	0.3985	0.3982	0.106	0.3351	0.1044
	(0.0444)	(0.0445)	(0.0445)	(0.0085)	(0.0369)	(0.0081)
500	0.0951	0.0996	0.0971	0.0822	0.1312	0.082
	(0.0049)	(0.0068)	(0.0056)	(0.0024)	(0.0615)	(0.0024)
1000	0.0933	0.0943	0.0942	0.0895	0.1089	0.0894
	(0.0026)	(0.0032)	(0.012)	(0.0017)	(0.0303)	(0.0017)
1500	0.1006	0.1009	0.1021	0.0993	0.1138	0.0993
	(0.0021)	(0.0024)	(0.0152)	(0.0015)	(0.025)	(0.0015)
2000	0.1081	0.1075	0.1089	0.1075	0.1204	0.1075
	(0.0021)	(0.0022)	(0.0096)	(0.0016)	(0.0254)	(0.0016)
2500	0.1137	0.1114	0.1129	0.1119	0.1248	0.112
	(0.0023)	(0.0023)	(0.0113)	(0.0016)	(0.0247)	(0.0016)
3000	0.1164	0.1116	0.1129	0.1114	0.1253	0.1115
	(0.0024)	(0.0023)	(0.0109)	(0.0016)	(0.0256)	(0.0016)
3500	0.1162	0.1076	0.1089	0.106	0.1219	0.106
	(0.0024)	(0.0024)	(0.0154)	(0.0016)	(0.0284)	(0.0016)
4000	0.1131	0.0994	0.1004	0.0964	0.1137	0.0965
	(0.0025)	(0.0036)	(0.0155)	(0.0015)	(0.0242)	(0.0015)
4500	0.1075	0.0875	0.089	0.0844	0.1023	0.0844
	(0.0026)	(0.007)	(0.0224)	(0.0015)	(0.0222)	(0.0015)
5000	0.1	0.0726	0.0741	0.0709	0.0876	0.0711
	(0.0025)	(0.0028)	(0.0228)	(0.0014)	(0.0216)	(0.0014)

Table G.20: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 100) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3197	0.3193	0.3195	0.1917	0.2327	0.1846
	(0.0569)	(0.0569)	(0.0567)	(0.0517)	(0.0547)	(0.0516)
100	0.3952	0.3954	0.3953	0.1274	0.3309	0.124
	(0.0566)	(0.0568)	(0.057)	(0.0193)	(0.0477)	(0.0187)
500	0.102	0.1135	0.1065	0.0891	0.163	0.0885
	(0.0061)	(0.0192)	(0.0102)	(0.0036)	(0.076)	(0.0035)
1000	0.1044	0.1063	0.1064	0.1006	0.1413	0.1003
	(0.0036)	(0.0047)	(0.0199)	(0.003)	(0.068)	(0.0031)
1500	0.1168	0.1177	0.1176	0.1144	0.1442	0.1141
	(0.0031)	(0.009)	(0.0067)	(0.0029)	(0.0505)	(0.0029)
2000	0.1293	0.1284	0.1286	0.1248	0.1495	0.1246
	(0.0032)	(0.0074)	(0.0033)	(0.0029)	(0.0364)	(0.0042)
2500	0.1386	0.1345	0.1352	0.1285	0.1541	0.1282
	(0.0035)	(0.0065)	(0.0036)	(0.0029)	(0.0314)	(0.004)
3000	0.143	0.134	0.136	0.1245	0.1529	0.1241
	(0.0038)	(0.0044)	(0.0115)	(0.0028)	(0.028)	(0.0034)
3500	0.1419	0.1265	0.129	0.1137	0.1448	0.1133
	(0.0039)	(0.0061)	(0.0112)	(0.0029)	(0.0261)	(0.0029)
4000	0.1358	0.1131	0.116	0.0987	0.1324	0.0983
	(0.004)	(0.0103)	(0.0044)	(0.0029)	(0.0301)	(0.0028)
4500	0.1255	0.0952	0.0992	0.0817	0.1162	0.0813
	(0.0039)	(0.0107)	(0.0093)	(0.0028)	(0.0339)	(0.0028)
5000	0.1124	0.0753	0.0802	0.0647	0.1007	0.0645
	(0.0037)	(0.0091)	(0.0069)	(0.0023)	(0.0442)	(0.0023)

Table G.21: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3109	0.311	0.311	0.2081	0.2818	0.204
	(0.0501)	(0.0502)	(0.0501)	(0.0481)	(0.0585)	(0.048)
100	0.4127	0.4126	0.4127	0.1318	0.3594	0.1302
	(0.0513)	(0.0511)	(0.0512)	(0.0175)	(0.0457)	(0.0171)
500	0.1015	0.1128	0.1054	0.0873	0.1425	0.087
	(0.0058)	(0.0169)	(0.0122)	(0.003)	(0.0679)	(0.003)
1000	0.1011	0.1027	0.1031	0.0962	0.1179	0.0959
	(0.0031)	(0.0036)	(0.0189)	(0.002)	(0.0288)	(0.0019)
1500	0.1114	0.1118	0.113	0.1086	0.1254	0.1082
	(0.0024)	(0.003)	(0.0183)	(0.0017)	(0.0233)	(0.0016)
2000	0.1218	0.1208	0.1224	0.1189	0.1345	0.1185
	(0.0024)	(0.003)	(0.0161)	(0.0017)	(0.0249)	(0.0017)
2500	0.1293	0.1264	0.1277	0.1246	0.1395	0.1242
	(0.0025)	(0.0096)	(0.0156)	(0.0018)	(0.0236)	(0.0018)
3000	0.1327	0.1259	0.1274	0.1243	0.1403	0.1239
	(0.0026)	(0.0041)	(0.0164)	(0.0019)	(0.0253)	(0.0018)
3500	0.1319	0.1201	0.122	0.1177	0.1347	0.1175
	(0.0028)	(0.0112)	(0.0247)	(0.0019)	(0.0232)	(0.0019)
4000	0.1269	0.1077	0.1098	0.106	0.1233	0.106
	(0.0028)	(0.0061)	(0.023)	(0.0019)	(0.0233)	(0.0019)
4500	0.1184	0.0912	0.0946	0.0908	0.107	0.091
	(0.0028)	(0.0045)	(0.0301)	(0.0018)	(0.0221)	(0.0018)
5000	0.1073	0.0721	0.0768	0.0741	0.0887	0.0743
	(0.0027)	(0.0028)	(0.0367)	(0.0016)	(0.0236)	(0.0016)

Table G.22: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 100) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5598	0.5606	0.5595	0.6076	0.6095	0.606
	(0.156)	(0.1562)	(0.1559)	(0.1866)	(0.1619)	(0.1898)
100	0.4855	0.4861	0.4854	0.3785	0.4751	0.3751
	(0.0821)	(0.0822)	(0.082)	(0.1503)	(0.0907)	(0.1519)
500	0.1277	0.1345	0.1308	0.0958	0.2206	0.0949
	(0.0164)	(0.0254)	(0.0177)	(0.0103)	(0.0935)	(0.0102)
1000	0.0985	0.1043	0.1042	0.0892	0.1602	0.0889
	(0.0063)	(0.0277)	(0.0329)	(0.0044)	(0.0778)	(0.0043)
1500	0.099	0.113	0.1046	0.0947	0.1433	0.0946
	(0.0039)	(0.0261)	(0.0191)	(0.0031)	(0.0497)	(0.0032)
2000	0.1031	0.1063	0.1045	0.0997	0.133	0.0996
	(0.0032)	(0.0063)	(0.0047)	(0.003)	(0.0333)	(0.003)
2500	0.1062	0.1061	0.1058	0.1016	0.1305	0.1015
	(0.0028)	(0.0057)	(0.0108)	(0.0023)	(0.0291)	(0.0024)
3000	0.1074	0.1051	0.1046	0.1002	0.1282	0.1001
	(0.0027)	(0.0133)	(0.003)	(0.002)	(0.0275)	(0.002)
3500	0.1065	0.1005	0.1014	0.0958	0.1242	0.0957
	(0.0025)	(0.0053)	(0.0071)	(0.0018)	(0.034)	(0.0017)
4000	0.1036	0.0943	0.0951	0.0887	0.1148	0.0886
	(0.0023)	(0.0132)	(0.0052)	(0.0018)	(0.0316)	(0.0018)
4500	0.0992	0.0846	0.0862	0.0792	0.1034	0.0791
	(0.0022)	(0.0129)	(0.003)	(0.0021)	(0.0324)	(0.0021)
5000	0.0935	0.072	0.0756	0.0675	0.0913	0.0673
	(0.0022)	(0.0095)	(0.0153)	(0.0026)	(0.039)	(0.0026)

Table G.23: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5516	0.5517	0.5517	0.669	0.6994	0.6692
	(0.1352)	(0.1366)	(0.1353)	(0.1497)	(0.1225)	(0.1506)
100	0.5138	0.5146	0.5138	0.4276	0.5209	0.4256
	(0.0741)	(0.0742)	(0.0739)	(0.1199)	(0.0777)	(0.12)
500	0.1459	0.151	0.1482	0.1129	0.2168	0.1123
	(0.0186)	(0.0225)	(0.0192)	(0.0127)	(0.0823)	(0.0126)
1000	0.1047	0.1095	0.1084	0.0949	0.1369	0.0945
	(0.0082)	(0.0289)	(0.0235)	(0.0062)	(0.0377)	(0.0061)
1500	0.0997	0.1158	0.1058	0.0954	0.1281	0.095
	(0.0056)	(0.0326)	(0.0237)	(0.0046)	(0.0316)	(0.0045)
2000	0.1001	0.1039	0.1033	0.098	0.1239	0.0976
	(0.0045)	(0.0082)	(0.021)	(0.0041)	(0.0287)	(0.004)
2500	0.1005	0.1008	0.102	0.0992	0.1219	0.0988
	(0.004)	(0.0049)	(0.0203)	(0.0037)	(0.0288)	(0.0037)
3000	0.0997	0.0974	0.0993	0.0975	0.1182	0.0972
	(0.0035)	(0.0038)	(0.0219)	(0.0034)	(0.027)	(0.0033)
3500	0.0974	0.0927	0.0946	0.0931	0.1108	0.0928
	(0.0031)	(0.0032)	(0.0199)	(0.0028)	(0.0227)	(0.0028)
4000	0.0937	0.0867	0.0881	0.0867	0.1016	0.0866
	(0.0026)	(0.0124)	(0.0192)	(0.0021)	(0.0207)	(0.0021)
4500	0.0889	0.0789	0.0804	0.0791	0.0913	0.079
	(0.0022)	(0.0155)	(0.0269)	(0.0016)	(0.0225)	(0.0016)
5000	0.0832	0.0684	0.0711	0.0706	0.0785	0.0705
	(0.0019)	(0.0081)	(0.0277)	(0.0015)	(0.0166)	(0.0015)

Table G.24: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 250) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4271	0.427	0.4271	0.2777	0.2796	0.2725
	(0.0307)	(0.0307)	(0.0308)	(0.0249)	(0.0254)	(0.0251)
100	0.3582	0.3583	0.3582	0.2277	0.255	0.2248
	(0.0259)	(0.0259)	(0.0258)	(0.0153)	(0.0184)	(0.015)
500	0.2332	0.2447	0.2454	0.1727	0.3357	0.1719
	(0.0115)	(0.0184)	(0.0172)	(0.0102)	(0.0771)	(0.0102)
1000	0.2012	0.2107	0.2104	0.1873	0.2855	0.1874
	(0.006)	(0.0086)	(0.0076)	(0.0087)	(0.0665)	(0.009)
1500	0.2042	0.2081	0.2084	0.2015	0.2883	0.2024
	(0.0046)	(0.0053)	(0.0052)	(0.0091)	(0.0637)	(0.0103)
2000	0.2124	0.2138	0.2144	0.2125	0.2779	0.2138
	(0.0043)	(0.0049)	(0.0046)	(0.0094)	(0.0577)	(0.0103)
2500	0.2196	0.2186	0.2199	0.2173	0.2703	0.2188
	(0.0044)	(0.0047)	(0.0048)	(0.0102)	(0.048)	(0.0119)
3000	0.2231	0.2193	0.2215	0.2128	0.2639	0.2144
	(0.0047)	(0.005)	(0.0059)	(0.0086)	(0.0452)	(0.011)
3500	0.2218	0.2143	0.218	0.2006	0.2547	0.2021
	(0.0049)	(0.0054)	(0.007)	(0.0094)	(0.0439)	(0.0103)
4000	0.2153	0.2039	0.2081	0.1816	0.238	0.1829
	(0.0052)	(0.0063)	(0.0079)	(0.0076)	(0.0438)	(0.0089)
4500	0.2039	0.1876	0.1901	0.1595	0.2187	0.1607
	(0.0051)	(0.0066)	(0.0079)	(0.0079)	(0.0459)	(0.0093)
5000	0.1885	0.1635	0.1627	0.136	0.2001	0.1371
	(0.0051)	(0.0075)	(0.0088)	(0.0073)	(0.0559)	(0.0098)

Table G.25: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4058	0.4059	0.406	0.2928	0.3066	0.2885
	(0.0276)	(0.0276)	(0.0276)	(0.0215)	(0.0227)	(0.0212)
100	0.3496	0.3495	0.3495	0.2374	0.282	0.2347
	(0.0236)	(0.0236)	(0.0235)	(0.0137)	(0.0189)	(0.0135)
500	0.2399	0.2399	0.2399	0.172	0.292	0.1712
	(0.0114)	(0.0114)	(0.0114)	(0.0042)	(0.0275)	(0.0042)
1000	0.2004	0.2004	0.2004	0.1758	0.3095	0.1753
	(0.0054)	(0.0054)	(0.0054)	(0.0027)	(0.0621)	(0.0027)
1500	0.2011	0.2011	0.2011	0.1877	0.2619	0.1873
	(0.004)	(0.004)	(0.004)	(0.0024)	(0.0334)	(0.0024)
2000	0.2072	0.2072	0.2072	0.199	0.2507	0.1986
	(0.0037)	(0.0037)	(0.0037)	(0.0024)	(0.0312)	(0.0024)
2500	0.2121	0.2121	0.2121	0.206	0.2458	0.2057
	(0.0037)	(0.0037)	(0.0037)	(0.0026)	(0.0212)	(0.0026)
3000	0.2137	0.2136	0.2137	0.2067	0.2336	0.2065
	(0.0038)	(0.0038)	(0.0038)	(0.0027)	(0.0189)	(0.0027)
3500	0.2111	0.2111	0.2111	0.2001	0.2213	0.1999
	(0.0038)	(0.0038)	(0.0038)	(0.0027)	(0.0206)	(0.0027)
4000	0.2041	0.2041	0.2041	0.1866	0.2064	0.1865
	(0.0039)	(0.0039)	(0.0039)	(0.0027)	(0.0201)	(0.0027)
4500	0.1931	0.1931	0.1932	0.1684	0.1893	0.1683
	(0.0039)	(0.0039)	(0.0039)	(0.0026)	(0.0214)	(0.0026)
5000	0.1791	0.1791	0.1791	0.1475	0.1698	0.1474
	(0.0038)	(0.0038)	(0.0038)	(0.0024)	(0.0231)	(0.0024)

Table G.26: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 250) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4242	0.4239	0.4239	0.4252	0.4299	0.4235
	(0.0573)	(0.0572)	(0.0573)	(0.0908)	(0.0884)	(0.0929)
100	0.3866	0.3865	0.3863	0.315	0.3462	0.3131
	(0.0381)	(0.0381)	(0.0379)	(0.0487)	(0.0459)	(0.0491)
500	0.2549	0.2662	0.267	0.1816	0.3551	0.181
	(0.014)	(0.0206)	(0.0202)	(0.0087)	(0.0716)	(0.0088)
1000	0.2078	0.2337	0.2298	0.1894	0.3205	0.1887
	(0.0073)	(0.033)	(0.0266)	(0.0209)	(0.0679)	(0.0194)
1500	0.2047	0.2135	0.2135	0.2011	0.2999	0.2018
	(0.0052)	(0.0091)	(0.008)	(0.0109)	(0.0577)	(0.011)
2000	0.2094	0.2124	0.213	0.2105	0.2812	0.2118
	(0.0045)	(0.0057)	(0.0053)	(0.0095)	(0.0543)	(0.0107)
2500	0.2142	0.2137	0.2148	0.2148	0.2792	0.2164
	(0.0044)	(0.0048)	(0.005)	(0.0093)	(0.0543)	(0.0112)
3000	0.2161	0.2121	0.2141	0.2109	0.2723	0.2124
	(0.0045)	(0.0049)	(0.0058)	(0.0081)	(0.0485)	(0.009)
3500	0.214	0.2064	0.2099	0.2002	0.2537	0.2017
	(0.0045)	(0.0052)	(0.0069)	(0.0078)	(0.0413)	(0.0088)
4000	0.2077	0.1962	0.2003	0.1836	0.2364	0.1848
	(0.0047)	(0.0061)	(0.0078)	(0.008)	(0.0438)	(0.0097)
4500	0.197	0.1806	0.1831	0.1626	0.2189	0.1639
	(0.0046)	(0.0064)	(0.0077)	(0.0071)	(0.0467)	(0.0087)
5000	0.183	0.1591	0.1594	0.1399	0.2002	0.141
	(0.0046)	(0.0069)	(0.0078)	(0.0067)	(0.0503)	(0.0075)

Table G.27: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3454	0.3454	0.3454	0.4464	0.4686	0.445
	(0.0308)	(0.0307)	(0.0307)	(0.0728)	(0.0724)	(0.0739)
100	0.3661	0.3661	0.3661	0.3276	0.3823	0.3249
	(0.0299)	(0.0299)	(0.0299)	(0.0369)	(0.0394)	(0.0368)
500	0.2621	0.2622	0.2621	0.1843	0.3187	0.184
	(0.0145)	(0.0145)	(0.0145)	(0.0068)	(0.0284)	(0.0067)
1000	0.2057	0.2057	0.2057	0.1773	0.3339	0.1772
	(0.0067)	(0.0067)	(0.0067)	(0.0039)	(0.0585)	(0.0039)
1500	0.2	0.2	0.2	0.1846	0.2799	0.1845
	(0.0049)	(0.0049)	(0.0049)	(0.0032)	(0.0352)	(0.0032)
2000	0.2034	0.2034	0.2034	0.1934	0.2596	0.1933
	(0.0043)	(0.0043)	(0.0043)	(0.0028)	(0.0341)	(0.0029)
2500	0.2076	0.2076	0.2075	0.1997	0.2415	0.1996
	(0.004)	(0.004)	(0.004)	(0.0028)	(0.0214)	(0.0028)
3000	0.2094	0.2094	0.2094	0.2012	0.2367	0.2012
	(0.0039)	(0.0039)	(0.0039)	(0.0028)	(0.0219)	(0.0028)
3500	0.2078	0.2079	0.2078	0.1969	0.2274	0.1969
	(0.0039)	(0.0039)	(0.0039)	(0.0029)	(0.0192)	(0.0029)
4000	0.2023	0.2023	0.2023	0.1865	0.2166	0.1867
	(0.0039)	(0.0039)	(0.0039)	(0.0029)	(0.0209)	(0.0028)
4500	0.1929	0.1929	0.1929	0.171	0.1993	0.1713
	(0.0039)	(0.0039)	(0.0039)	(0.0028)	(0.0191)	(0.0027)
5000	0.1802	0.1802	0.1802	0.152	0.1787	0.1524
	(0.0038)	(0.0038)	(0.0038)	(0.0026)	(0.0188)	(0.0026)

Table G.28: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 250) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.6266	0.6271	0.626	0.8677	0.8676	0.8704
	(0.1801)	(0.1801)	(0.1805)	(0.0625)	(0.0568)	(0.057)
100	0.7023	0.7023	0.7022	0.8364	0.8256	0.8378
	(0.0815)	(0.0812)	(0.0816)	(0.0395)	(0.0366)	(0.0393)
500	0.6144	0.6174	0.6197	0.4832	0.6047	0.4803
	(0.0318)	(0.0326)	(0.0315)	(0.0695)	(0.055)	(0.0708)
1000	0.4097	0.4215	0.4224	0.285	0.5608	0.2822
	(0.0332)	(0.0347)	(0.0342)	(0.0462)	(0.0457)	(0.0444)
1500	0.2738	0.2819	0.2838	0.2047	0.5071	0.205
	(0.0255)	(0.0272)	(0.0267)	(0.0304)	(0.0603)	(0.0321)
2000	0.2021	0.2089	0.2121	0.1683	0.4268	0.1698
	(0.0173)	(0.0188)	(0.0194)	(0.0213)	(0.0863)	(0.0232)
2500	0.1637	0.1783	0.19	0.1522	0.4121	0.1532
	(0.0119)	(0.0428)	(0.0585)	(0.0342)	(0.111)	(0.0335)
3000	0.1421	0.2183	0.218	0.1578	0.4784	0.1589
	(0.0082)	(0.1033)	(0.0846)	(0.0519)	(0.1053)	(0.0517)
3500	0.1292	0.1882	0.1984	0.1515	0.4237	0.1531
	(0.0061)	(0.0635)	(0.053)	(0.0328)	(0.0877)	(0.034)
4000	0.1208	0.17	0.1879	0.145	0.3794	0.1472
	(0.0045)	(0.041)	(0.0399)	(0.0292)	(0.0828)	(0.0292)
4500	0.1155	0.165	0.1805	0.1407	0.3527	0.1431
	(0.0034)	(0.031)	(0.0313)	(0.0246)	(0.0829)	(0.0253)
5000	0.1117	0.1622	0.17	0.138	0.3397	0.14
	(0.0026)	(0.0284)	(0.0277)	(0.0233)	(0.0891)	(0.0236)

Table G.29: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3551	0.3547	0.3547	0.883	0.8843	0.8837
	(0.1573)	(0.1566)	(0.1566)	(0.0589)	(0.0582)	(0.0587)
100	0.623	0.6227	0.623	0.8477	0.8471	0.8483
	(0.0781)	(0.0783)	(0.078)	(0.0373)	(0.0325)	(0.037)
500	0.608	0.6079	0.608	0.5068	0.6397	0.5057
	(0.0274)	(0.0275)	(0.0275)	(0.0393)	(0.0243)	(0.0393)
1000	0.4173	0.4172	0.4173	0.3145	0.5549	0.3137
	(0.0271)	(0.0272)	(0.0271)	(0.0275)	(0.0514)	(0.0274)
1500	0.2903	0.2902	0.2903	0.2211	0.4993	0.2205
	(0.0244)	(0.0244)	(0.0244)	(0.0207)	(0.0729)	(0.0206)
2000	0.2151	0.2151	0.2151	0.1712	0.3874	0.1709
	(0.0181)	(0.0182)	(0.0181)	(0.0148)	(0.0712)	(0.0147)
2500	0.1709	0.171	0.1709	0.144	0.3108	0.1438
	(0.014)	(0.014)	(0.0139)	(0.0106)	(0.0635)	(0.0105)
3000	0.1437	0.1438	0.1437	0.1275	0.3059	0.1273
	(0.0106)	(0.0106)	(0.0106)	(0.0078)	(0.0815)	(0.0077)
3500	0.1269	0.127	0.1269	0.1173	0.2606	0.1172
	(0.0077)	(0.0077)	(0.0077)	(0.0057)	(0.0636)	(0.0056)
4000	0.1167	0.1167	0.1167	0.1111	0.2207	0.111
	(0.0056)	(0.0056)	(0.0056)	(0.0042)	(0.0479)	(0.0041)
4500	0.1103	0.1103	0.1103	0.107	0.1911	0.107
	(0.0039)	(0.0039)	(0.0039)	(0.003)	(0.0396)	(0.0029)
5000	0.1064	0.1064	0.1064	0.1045	0.1706	0.1044
	(0.0027)	(0.0027)	(0.0027)	(0.0021)	(0.0366)	(0.002)

Table G.30: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under gradual drift (priors: Equal), where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4691	0.469	0.4691	0.3251	0.3216	0.3204
	(0.0232)	(0.0233)	(0.0232)	(0.028)	(0.0283)	(0.0286)
100	0.4237	0.4237	0.4237	0.2664	0.271	0.2634
	(0.0226)	(0.0226)	(0.0226)	(0.0165)	(0.0165)	(0.0162)
500	0.4651	0.4651	0.4651	0.1985	0.3186	0.1981
	(0.0176)	(0.0175)	(0.0175)	(0.0088)	(0.016)	(0.0086)
1000	0.2574	0.2677	0.279	0.217	0.2711	0.2143
	(0.0078)	(0.0122)	(0.0186)	(0.0562)	(0.0384)	(0.0532)
1500	0.2416	0.2557	0.2651	0.2494	0.2884	0.2507
	(0.0061)	(0.0092)	(0.011)	(0.0245)	(0.0477)	(0.027)
2000	0.2413	0.248	0.2522	0.2634	0.2791	0.266
	(0.0052)	(0.0063)	(0.0068)	(0.0244)	(0.041)	(0.0281)
2500	0.2434	0.2443	0.2467	0.2687	0.2741	0.2717
	(0.005)	(0.0052)	(0.0055)	(0.025)	(0.0328)	(0.0262)
3000	0.2432	0.2397	0.2435	0.2656	0.2685	0.27
	(0.005)	(0.0052)	(0.0068)	(0.0239)	(0.0344)	(0.0278)
3500	0.239	0.2333	0.245	0.2527	0.2543	0.2571
	(0.005)	(0.006)	(0.0112)	(0.0232)	(0.0264)	(0.0253)
4000	0.2301	0.2276	0.2427	0.2307	0.2392	0.2371
	(0.005)	(0.0087)	(0.0105)	(0.0221)	(0.0222)	(0.027)
4500	0.2166	0.2208	0.2249	0.2053	0.2202	0.2105
	(0.005)	(0.0088)	(0.0102)	(0.0214)	(0.0229)	(0.0239)
5000	0.1994	0.2029	0.1958	0.1766	0.1982	0.1819
	(0.0049)	(0.0108)	(0.0139)	(0.024)	(0.024)	(0.0252)

Table G.31: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4702	0.4703	0.4704	0.33	0.3269	0.3258
	(0.0222)	(0.0222)	(0.0222)	(0.0274)	(0.0279)	(0.0281)
100	0.4261	0.4261	0.4261	0.2719	0.2765	0.2691
	(0.0213)	(0.0214)	(0.0215)	(0.0159)	(0.0161)	(0.0157)
500	0.4654	0.4653	0.4654	0.2006	0.4224	0.2001
	(0.0174)	(0.0174)	(0.0173)	(0.0083)	(0.0157)	(0.0084)
1000	0.2563	0.2671	0.279	0.2162	0.3483	0.2153
	(0.0082)	(0.013)	(0.021)	(0.0491)	(0.0718)	(0.0491)
1500	0.24	0.2549	0.2638	0.2451	0.3096	0.2477
	(0.0058)	(0.0126)	(0.0141)	(0.0209)	(0.0471)	(0.0235)
2000	0.2398	0.2472	0.2511	0.2586	0.3137	0.2623
	(0.005)	(0.0101)	(0.0099)	(0.0219)	(0.0572)	(0.0262)
2500	0.2421	0.2435	0.2458	0.2636	0.3053	0.2678
	(0.0048)	(0.0075)	(0.0061)	(0.0222)	(0.0475)	(0.0248)
3000	0.2422	0.2392	0.2433	0.261	0.2992	0.2655
	(0.0048)	(0.0075)	(0.0072)	(0.023)	(0.0475)	(0.0272)
3500	0.2386	0.2339	0.2467	0.2489	0.286	0.2535
	(0.005)	(0.0068)	(0.0117)	(0.0222)	(0.0519)	(0.025)
4000	0.2301	0.2294	0.244	0.2287	0.2653	0.2334
	(0.0051)	(0.0093)	(0.0107)	(0.0226)	(0.0485)	(0.0272)
4500	0.2172	0.2229	0.2252	0.2028	0.244	0.2066
	(0.0052)	(0.0091)	(0.01)	(0.0205)	(0.0494)	(0.0232)
5000	0.2004	0.2031	0.1954	0.1746	0.2218	0.1782
	(0.0051)	(0.0089)	(0.0128)	(0.0208)	(0.0498)	(0.0243)

Table G.32: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under gradual drift (priors: Equal), where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4545	0.4545	0.4546	0.3469	0.353	0.3467
	(0.0213)	(0.0212)	(0.0212)	(0.0218)	(0.0219)	(0.0216)
100	0.4034	0.4033	0.4034	0.2913	0.3098	0.2931
	(0.0195)	(0.0195)	(0.0195)	(0.0146)	(0.0155)	(0.0144)
500	0.4714	0.4714	0.4714	0.2063	0.33	0.2086
	(0.0169)	(0.0168)	(0.0168)	(0.0052)	(0.0116)	(0.0053)
1000	0.2718	0.2717	0.2717	0.2057	0.2904	0.207
	(0.008)	(0.008)	(0.008)	(0.0033)	(0.0092)	(0.0034)
1500	0.254	0.254	0.254	0.2175	0.2856	0.2184
	(0.0056)	(0.0056)	(0.0056)	(0.0028)	(0.0076)	(0.0028)
2000	0.253	0.253	0.253	0.2298	0.2677	0.2305
	(0.0048)	(0.0048)	(0.0048)	(0.0028)	(0.0061)	(0.0028)
2500	0.2542	0.2542	0.2542	0.2379	0.2575	0.2385
	(0.0046)	(0.0046)	(0.0046)	(0.003)	(0.0051)	(0.0029)
3000	0.2525	0.2525	0.2525	0.2392	0.2476	0.2398
	(0.0045)	(0.0045)	(0.0045)	(0.0031)	(0.0046)	(0.0031)
3500	0.2467	0.2467	0.2467	0.2323	0.2353	0.233
	(0.0046)	(0.0046)	(0.0046)	(0.0034)	(0.0045)	(0.0034)
4000	0.2363	0.2363	0.2363	0.2174	0.2198	0.2182
	(0.0046)	(0.0045)	(0.0046)	(0.0035)	(0.0043)	(0.0034)
4500	0.2216	0.2216	0.2216	0.1958	0.2013	0.1973
	(0.0045)	(0.0045)	(0.0045)	(0.0036)	(0.0043)	(0.0034)
5000	0.2037	0.2038	0.2037	0.1703	0.1811	0.1726
	(0.0043)	(0.0043)	(0.0043)	(0.0034)	(0.0041)	(0.0032)

Table G.33: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under gradual drift (priors: Equal), where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.429	0.4291	0.4289	0.272	0.2797	0.2711
	(0.027)	(0.027)	(0.0269)	(0.0264)	(0.0276)	(0.0263)
100	0.359	0.359	0.3591	0.2045	0.2258	0.2056
	(0.022)	(0.022)	(0.022)	(0.0138)	(0.0163)	(0.014)
500	0.4589	0.459	0.459	0.1268	0.2661	0.1283
	(0.0206)	(0.0206)	(0.0205)	(0.0038)	(0.0124)	(0.0039)
1000	0.2003	0.2003	0.2003	0.1314	0.2214	0.1324
	(0.008)	(0.008)	(0.008)	(0.0025)	(0.0095)	(0.0026)
1500	0.1811	0.1811	0.1811	0.1443	0.2103	0.1449
	(0.0053)	(0.0053)	(0.0053)	(0.0022)	(0.0075)	(0.0023)
2000	0.1801	0.1802	0.1802	0.1568	0.1921	0.1572
	(0.0043)	(0.0043)	(0.0043)	(0.0023)	(0.0054)	(0.0024)
2500	0.1811	0.1811	0.1811	0.1645	0.1824	0.1648
	(0.004)	(0.004)	(0.004)	(0.0025)	(0.0043)	(0.0025)
3000	0.1792	0.1792	0.1792	0.1653	0.1731	0.1656
	(0.0039)	(0.0039)	(0.0039)	(0.0025)	(0.004)	(0.0026)
3500	0.1731	0.1731	0.1731	0.1581	0.1615	0.1586
	(0.0038)	(0.0038)	(0.0038)	(0.0027)	(0.0037)	(0.0027)
4000	0.163	0.163	0.163	0.1439	0.1472	0.1446
	(0.0038)	(0.0038)	(0.0038)	(0.0027)	(0.0037)	(0.0027)
4500	0.1493	0.1494	0.1494	0.125	0.1311	0.1259
	(0.0037)	(0.0037)	(0.0037)	(0.0024)	(0.0035)	(0.0024)
5000	0.1334	0.1335	0.1335	0.1044	0.1142	0.1054
	(0.0036)	(0.0036)	(0.0036)	(0.0023)	(0.0034)	(0.0023)

Table G.34: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4563	0.4563	0.4562	0.3471	0.3511	0.3443
	(0.0214)	(0.0213)	(0.0213)	(0.0228)	(0.0236)	(0.023)
100	0.4056	0.4056	0.4056	0.2909	0.3071	0.2889
	(0.0193)	(0.0193)	(0.0194)	(0.0147)	(0.0159)	(0.0146)
500	0.4716	0.4715	0.4716	0.2044	0.4284	0.2038
	(0.0161)	(0.0161)	(0.0161)	(0.0056)	(0.0147)	(0.0057)
1000	0.2679	0.2679	0.268	0.2052	0.3218	0.2048
	(0.0079)	(0.0079)	(0.0079)	(0.0036)	(0.0195)	(0.0036)
1500	0.2499	0.25	0.25	0.2188	0.3481	0.2185
	(0.0055)	(0.0055)	(0.0055)	(0.003)	(0.0377)	(0.003)
2000	0.2505	0.2506	0.2506	0.2337	0.2982	0.2335
	(0.0045)	(0.0045)	(0.0045)	(0.0029)	(0.0621)	(0.0029)
2500	0.2541	0.2541	0.2541	0.2447	0.3067	0.2446
	(0.0044)	(0.0043)	(0.0043)	(0.0032)	(0.0218)	(0.0032)
3000	0.2556	0.2556	0.2556	0.2485	0.3084	0.2484
	(0.0044)	(0.0043)	(0.0043)	(0.0034)	(0.0225)	(0.0034)
3500	0.2525	0.2525	0.2525	0.2426	0.2864	0.2426
	(0.0045)	(0.0045)	(0.0045)	(0.0038)	(0.0258)	(0.0039)
4000	0.2442	0.2443	0.2442	0.2273	0.2643	0.2273
	(0.0048)	(0.0047)	(0.0048)	(0.0041)	(0.0208)	(0.0041)
4500	0.2309	0.231	0.2309	0.2043	0.2327	0.2044
	(0.0048)	(0.0048)	(0.0048)	(0.0041)	(0.0192)	(0.0042)
5000	0.2132	0.2132	0.2132	0.1773	0.1894	0.1774
	(0.0047)	(0.0047)	(0.0047)	(0.0039)	(0.0186)	(0.0039)

Table G.35: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4251	0.4248	0.425	0.5357	0.5376	0.5369
	(0.067)	(0.0669)	(0.0669)	(0.0848)	(0.0853)	(0.0866)
100	0.4226	0.4226	0.4226	0.4273	0.4351	0.4268
	(0.042)	(0.042)	(0.042)	(0.0634)	(0.0618)	(0.0643)
500	0.4729	0.473	0.4728	0.2316	0.4377	0.2311
	(0.0198)	(0.0198)	(0.0199)	(0.0141)	(0.0189)	(0.0139)
1000	0.2767	0.2873	0.297	0.2111	0.3622	0.211
	(0.0103)	(0.0148)	(0.0202)	(0.0094)	(0.0627)	(0.0098)
1500	0.2491	0.2574	0.2626	0.2169	0.3176	0.2176
	(0.0071)	(0.0099)	(0.0115)	(0.011)	(0.0472)	(0.0118)
2000	0.2415	0.2648	0.2863	0.26	0.3558	0.2615
	(0.0059)	(0.0225)	(0.0374)	(0.044)	(0.0544)	(0.0448)
2500	0.2384	0.2496	0.2585	0.2536	0.331	0.2567
	(0.0053)	(0.0109)	(0.0144)	(0.0278)	(0.0494)	(0.0307)
3000	0.235	0.238	0.2473	0.2504	0.3105	0.253
	(0.0052)	(0.0071)	(0.011)	(0.0337)	(0.0505)	(0.036)
3500	0.2289	0.229	0.2492	0.2394	0.2922	0.2424
	(0.0051)	(0.0085)	(0.0151)	(0.0257)	(0.0523)	(0.0288)
4000	0.2198	0.2253	0.2437	0.2213	0.2753	0.2246
	(0.005)	(0.0132)	(0.0133)	(0.0245)	(0.0538)	(0.0289)
4500	0.2073	0.2175	0.2158	0.1988	0.2606	0.203
	(0.005)	(0.0121)	(0.0182)	(0.0237)	(0.0558)	(0.0325)
5000	0.1919	0.1916	0.1835	0.1747	0.2323	0.1776
	(0.0048)	(0.0115)	(0.017)	(0.0244)	(0.0527)	(0.027)

Table G.36: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under gradual drift (priors: 70/30), where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3102	0.3103	0.3103	0.5609	0.5696	0.5614
	(0.0179)	(0.018)	(0.018)	(0.0745)	(0.0737)	(0.0754)
100	0.3425	0.3425	0.3425	0.4528	0.4757	0.452
	(0.0209)	(0.0209)	(0.0209)	(0.0551)	(0.0548)	(0.0554)
500	0.4777	0.4778	0.4778	0.2361	0.3685	0.2367
	(0.0184)	(0.0184)	(0.0184)	(0.0103)	(0.0167)	(0.0103)
1000	0.2866	0.2865	0.2866	0.2108	0.3078	0.2114
	(0.0103)	(0.0103)	(0.0103)	(0.0055)	(0.0124)	(0.0055)
1500	0.2534	0.2533	0.2534	0.2114	0.2761	0.2121
	(0.007)	(0.007)	(0.007)	(0.0041)	(0.0084)	(0.0041)
2000	0.2428	0.2428	0.2429	0.2165	0.3007	0.2174
	(0.0058)	(0.0058)	(0.0058)	(0.0036)	(0.0167)	(0.0037)
2500	0.2379	0.2379	0.238	0.2196	0.2682	0.2208
	(0.0053)	(0.0053)	(0.0053)	(0.0034)	(0.0094)	(0.0035)
3000	0.233	0.2331	0.2331	0.2173	0.2457	0.2193
	(0.005)	(0.005)	(0.005)	(0.0035)	(0.0065)	(0.0035)
3500	0.2258	0.2258	0.2258	0.2079	0.2272	0.2113
	(0.0048)	(0.0048)	(0.0048)	(0.0039)	(0.0053)	(0.0035)
4000	0.2155	0.2155	0.2155	0.1916	0.2094	0.1972
	(0.0044)	(0.0044)	(0.0044)	(0.004)	(0.0046)	(0.0034)
4500	0.2024	0.2024	0.2024	0.17	0.1911	0.1785
	(0.0043)	(0.0043)	(0.0043)	(0.004)	(0.0042)	(0.0034)
5000	0.1868	0.1869	0.1869	0.1458	0.1718	0.1573
	(0.004)	(0.004)	(0.004)	(0.0034)	(0.004)	(0.0032)

Table G.37: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3099 (0.0186)	0.31 (0.0186)	0.31 (0.0186)	0.5582 (0.0761)	0.5674 (0.0756)	0.5586 (0.0772)
100	0.3409 (0.0213)	0.3409 (0.0213)	0.3409 (0.0213)	0.4486 (0.0553)	0.4722 (0.055)	0.4475 (0.0557)
500	0.4786 (0.0182)	0.4786 (0.0183)	0.4786 (0.0182)	0.2358 (0.0101)	0.4467 (0.0173)	0.2354 (0.01)
1000	0.2902 (0.0103)	0.2902 (0.0103)	0.2901 (0.0103)	0.213 (0.0055)	0.3492 (0.0198)	0.2127 (0.0055)
1500	0.2595 (0.0069)	0.2595 (0.0069)	0.2595 (0.0069)	0.2164 (0.0042)	0.3611 (0.0398)	0.2162 (0.0042)
2000	0.2516 (0.0058)	0.2516 (0.0058)	0.2516 (0.0058)	0.2245 (0.0038)	0.3348 (0.0531)	0.2243 (0.0038)
2500	0.2494 (0.0051)	0.2494 (0.0051)	0.2494 (0.0051)	0.2307 (0.0037)	0.3326 (0.0246)	0.2305 (0.0037)
3000	0.2468 (0.0049)	0.2468 (0.0049)	0.2467 (0.0049)	0.2319 (0.0039)	0.3198 (0.0242)	0.2318 (0.0039)
3500	0.241 (0.005)	0.241 (0.005)	0.241 (0.0049)	0.2259 (0.004)	0.286 (0.0301)	0.2259 (0.004)
4000	0.2313 (0.0048)	0.2313 (0.0048)	0.2313 (0.0048)	0.2124 (0.004)	0.2491 (0.0185)	0.2124 (0.004)
4500	0.2177 (0.0048)	0.2177 (0.0048)	0.2177 (0.0048)	0.1928 (0.004)	0.2217 (0.0182)	0.1929 (0.0041)
5000	0.2006 (0.0046)	0.2006 (0.0046)	0.2006 (0.0046)	0.1696 (0.0039)	0.1948 (0.0189)	0.1696 (0.0039)

Table G.38: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5296	0.5284	0.5284	0.8883	0.8885	0.8891
	(0.2532)	(0.2537)	(0.254)	(0.0513)	(0.0511)	(0.0511)
100	0.6491	0.6483	0.6486	0.8776	0.8756	0.8785
	(0.1382)	(0.1389)	(0.1387)	(0.0184)	(0.0178)	(0.0179)
500	0.5344	0.5344	0.5344	0.711	0.578	0.7109
	(0.0191)	(0.0191)	(0.0191)	(0.0396)	(0.0189)	(0.0397)
1000	0.6109	0.616	0.6174	0.4468	0.6053	0.4406
	(0.0222)	(0.023)	(0.0236)	(0.0682)	(0.0503)	(0.0718)
1500	0.5045	0.5183	0.5258	0.323	0.597	0.3146
	(0.0246)	(0.0258)	(0.0268)	(0.0506)	(0.0574)	(0.0527)
2000	0.4058	0.4193	0.4268	0.2547	0.5608	0.2486
	(0.0243)	(0.025)	(0.0261)	(0.0416)	(0.0493)	(0.0446)
2500	0.329	0.3405	0.3504	0.2175	0.5361	0.2118
	(0.0217)	(0.0226)	(0.0245)	(0.0322)	(0.0494)	(0.0342)
3000	0.2718	0.2857	0.3166	0.194	0.5085	0.1901
	(0.0186)	(0.0208)	(0.0394)	(0.0269)	(0.0566)	(0.03)
3500	0.23	0.2615	0.3454	0.1778	0.4881	0.175
	(0.0154)	(0.0308)	(0.0613)	(0.0222)	(0.0612)	(0.0239)
4000	0.2001	0.2806	0.3511	0.1681	0.4658	0.1656
	(0.0129)	(0.0447)	(0.0445)	(0.02)	(0.058)	(0.0206)
4500	0.1778	0.3012	0.312	0.1596	0.4465	0.1574
	(0.0105)	(0.0345)	(0.0371)	(0.0156)	(0.0601)	(0.0156)
5000	0.161	0.2884	0.3076	0.1901	0.473	0.1882
	(0.0087)	(0.0412)	(0.0887)	(0.1127)	(0.1019)	(0.1147)

Table G.39: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under gradual drift (priors: 90/10), where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1132	0.1132	0.1132	0.8938	0.8939	0.8938
	(0.0546)	(0.0547)	(0.0546)	(0.0619)	(0.0619)	(0.0619)
100	0.3098	0.31	0.31	0.892	0.8923	0.8919
	(0.1056)	(0.1059)	(0.1057)	(0.0103)	(0.0095)	(0.0105)
500	0.5362	0.5362	0.5362	0.6956	0.693	0.6939
	(0.0195)	(0.0194)	(0.0194)	(0.0343)	(0.0218)	(0.0342)
1000	0.6059	0.606	0.6059	0.5056	0.6401	0.5054
	(0.0186)	(0.0186)	(0.0186)	(0.027)	(0.0176)	(0.0269)
1500	0.5042	0.5042	0.5042	0.3887	0.5659	0.3901
	(0.019)	(0.0189)	(0.019)	(0.0217)	(0.0168)	(0.0217)
2000	0.415	0.4151	0.415	0.3104	0.4829	0.3131
	(0.0189)	(0.0189)	(0.0189)	(0.0186)	(0.0171)	(0.0188)
2500	0.3447	0.3447	0.3447	0.2564	0.4077	0.26
	(0.0181)	(0.0181)	(0.0182)	(0.0158)	(0.0175)	(0.0162)
3000	0.2904	0.2904	0.2904	0.219	0.3448	0.2217
	(0.0165)	(0.0165)	(0.0165)	(0.0133)	(0.0167)	(0.0139)
3500	0.2482	0.2482	0.2481	0.1928	0.2969	0.1933
	(0.0156)	(0.0156)	(0.0156)	(0.0117)	(0.0166)	(0.0122)
4000	0.2147	0.2148	0.2148	0.1731	0.2633	0.1715
	(0.0139)	(0.0138)	(0.0139)	(0.0104)	(0.0156)	(0.0106)
4500	0.1889	0.1889	0.1889	0.1563	0.238	0.1551
	(0.012)	(0.012)	(0.012)	(0.0089)	(0.0164)	(0.009)
5000	0.1684	0.1684	0.1684	0.1432	0.2739	0.1422
	(0.0105)	(0.0105)	(0.0105)	(0.0076)	(0.0852)	(0.0076)

Table G.40: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1154	0.1156	0.1154	0.8943	0.8938	0.8945
	(0.0572)	(0.0572)	(0.0571)	(0.0566)	(0.0619)	(0.0566)
100	0.3171	0.3177	0.3181	0.8909	0.8918	0.8913
	(0.1061)	(0.1061)	(0.1058)	(0.0113)	(0.0098)	(0.011)
500	0.5367	0.5365	0.5364	0.6928	0.5853	0.6928
	(0.0197)	(0.0196)	(0.0196)	(0.0342)	(0.0188)	(0.0341)
1000	0.6062	0.6061	0.6062	0.5051	0.6365	0.5048
	(0.0186)	(0.0186)	(0.0187)	(0.0271)	(0.019)	(0.0272)
1500	0.5042	0.5041	0.5042	0.3899	0.5889	0.3895
	(0.019)	(0.0191)	(0.019)	(0.0221)	(0.0288)	(0.0221)
2000	0.4147	0.4146	0.4148	0.3129	0.6007	0.3126
	(0.0189)	(0.0189)	(0.0188)	(0.0194)	(0.0814)	(0.0195)
2500	0.3441	0.344	0.3441	0.2599	0.5377	0.2596
	(0.0183)	(0.0182)	(0.0182)	(0.0166)	(0.0446)	(0.0165)
3000	0.2896	0.2895	0.2897	0.2215	0.5094	0.2212
	(0.0167)	(0.0166)	(0.0166)	(0.0142)	(0.0495)	(0.0141)
3500	0.2471	0.2471	0.2472	0.193	0.439	0.1929
	(0.0154)	(0.0154)	(0.0154)	(0.0124)	(0.0591)	(0.0124)
4000	0.2138	0.2137	0.2138	0.1714	0.3669	0.1713
	(0.0138)	(0.0137)	(0.0136)	(0.0105)	(0.038)	(0.0106)
4500	0.1879	0.1879	0.1879	0.1548	0.3252	0.1547
	(0.012)	(0.0119)	(0.012)	(0.0089)	(0.0348)	(0.0089)
5000	0.1676	0.1676	0.1676	0.1419	0.3086	0.1419
	(0.0106)	(0.0105)	(0.0105)	(0.0076)	(0.0567)	(0.0076)

Table G.41: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under gradual drift (priors: Equal), where the covariance matrix drifts from AR to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4715	0.4716	0.4714	0.4445	0.4455	0.443
	(0.0738)	(0.0734)	(0.0737)	(0.071)	(0.0704)	(0.0718)
100	0.4737	0.4739	0.4735	0.4413	0.4476	0.4393
	(0.0516)	(0.0515)	(0.0521)	(0.0519)	(0.0517)	(0.0528)
500	0.4445	0.4461	0.4446	0.4228	0.4359	0.4218
	(0.0227)	(0.0226)	(0.0228)	(0.0247)	(0.0236)	(0.0247)
1000	0.4018	0.408	0.4044	0.3924	0.3991	0.3918
	(0.0165)	(0.0164)	(0.0165)	(0.0168)	(0.0172)	(0.0171)
1500	0.3664	0.3754	0.3724	0.3626	0.3662	0.3622
	(0.0131)	(0.0135)	(0.0139)	(0.0139)	(0.0139)	(0.0139)
2000	0.337	0.3472	0.3449	0.3366	0.3382	0.3363
	(0.0109)	(0.0115)	(0.0117)	(0.0118)	(0.0116)	(0.0117)
2500	0.3121	0.3227	0.3209	0.3141	0.3142	0.3139
	(0.0094)	(0.0101)	(0.0106)	(0.01)	(0.0102)	(0.0099)
3000	0.291	0.3018	0.3002	0.2946	0.2937	0.2943
	(0.0083)	(0.0091)	(0.0096)	(0.0088)	(0.0091)	(0.0088)
3500	0.2726	0.2836	0.2822	0.2773	0.2758	0.2771
	(0.0076)	(0.0085)	(0.0092)	(0.0081)	(0.0085)	(0.008)
4000	0.2564	0.2674	0.2662	0.2618	0.2599	0.2617
	(0.0069)	(0.0081)	(0.0091)	(0.0074)	(0.0082)	(0.0074)
4500	0.242	0.2533	0.2522	0.248	0.2458	0.2479
	(0.0065)	(0.0077)	(0.0093)	(0.0069)	(0.0083)	(0.0068)
5000	0.2292	0.241	0.2397	0.2356	0.2332	0.2355
	(0.006)	(0.0074)	(0.009)	(0.0063)	(0.0085)	(0.0063)

Table G.42: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under gradual drift (priors: Equal), where the covariance matrix drifts from EYE to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4816	0.4824	0.482	0.422	0.4177	0.4174
	(0.0721)	(0.0718)	(0.072)	(0.0674)	(0.0678)	(0.0676)
100	0.4741	0.4741	0.4739	0.4229	0.4221	0.4207
	(0.0511)	(0.0508)	(0.0508)	(0.0506)	(0.0508)	(0.0498)
500	0.4442	0.4468	0.4441	0.4272	0.4311	0.4269
	(0.023)	(0.0229)	(0.0231)	(0.023)	(0.0231)	(0.023)
1000	0.4097	0.4157	0.4121	0.4008	0.4038	0.401
	(0.0164)	(0.0166)	(0.0162)	(0.0165)	(0.0164)	(0.0165)
1500	0.376	0.3842	0.3811	0.371	0.3732	0.3713
	(0.0133)	(0.0138)	(0.0137)	(0.0134)	(0.0135)	(0.0133)
2000	0.3465	0.3555	0.3532	0.3439	0.3455	0.3441
	(0.0115)	(0.012)	(0.0121)	(0.0114)	(0.0117)	(0.0113)
2500	0.321	0.3306	0.3287	0.3203	0.3211	0.3204
	(0.0099)	(0.0106)	(0.0107)	(0.01)	(0.01)	(0.0099)
3000	0.2991	0.3087	0.3071	0.2998	0.3	0.2999
	(0.0088)	(0.0095)	(0.0098)	(0.0087)	(0.009)	(0.0087)
3500	0.28	0.2895	0.288	0.2817	0.2813	0.2818
	(0.0078)	(0.0088)	(0.0089)	(0.0079)	(0.008)	(0.0079)
4000	0.2632	0.2728	0.2714	0.2657	0.265	0.2657
	(0.0071)	(0.0082)	(0.0084)	(0.0071)	(0.0074)	(0.0071)
4500	0.2481	0.258	0.2565	0.2512	0.2502	0.2512
	(0.0065)	(0.0079)	(0.0083)	(0.0065)	(0.0069)	(0.0065)
5000	0.2347	0.2448	0.2436	0.2382	0.2371	0.2382
	(0.006)	(0.0075)	(0.0083)	(0.0061)	(0.0066)	(0.0061)

Table G.43: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under gradual drift (priors: Equal), where the covariance matrix drifts from CS to EYE. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4792	0.4795	0.4802	0.3399	0.3398	0.3397
	(0.0806)	(0.0805)	(0.0807)	(0.0638)	(0.0637)	(0.0637)
100	0.4232	0.4224	0.4228	0.294	0.2923	0.2933
	(0.0552)	(0.0549)	(0.0552)	(0.0464)	(0.0463)	(0.0463)
500	0.2932	0.2988	0.2957	0.2461	0.2455	0.246
	(0.021)	(0.023)	(0.0218)	(0.0199)	(0.0195)	(0.0197)
1000	0.2727	0.2778	0.2749	0.2502	0.2501	0.2502
	(0.0147)	(0.0156)	(0.0151)	(0.0141)	(0.014)	(0.014)
1500	0.2696	0.2738	0.2722	0.2549	0.2549	0.2549
	(0.0118)	(0.0119)	(0.0118)	(0.0112)	(0.0112)	(0.0112)
2000	0.2667	0.2691	0.2683	0.2546	0.2546	0.2546
	(0.0104)	(0.0104)	(0.0104)	(0.01)	(0.01)	(0.01)
2500	0.2616	0.2615	0.2611	0.2497	0.2497	0.2498
	(0.009)	(0.0092)	(0.0092)	(0.0089)	(0.0089)	(0.0089)
3000	0.2547	0.2523	0.252	0.2423	0.2423	0.2423
	(0.0081)	(0.0086)	(0.0086)	(0.0081)	(0.0081)	(0.0081)
3500	0.2467	0.2422	0.2421	0.2335	0.2335	0.2335
	(0.0073)	(0.008)	(0.0082)	(0.0075)	(0.0075)	(0.0075)
4000	0.238	0.2319	0.2321	0.2242	0.2242	0.2242
	(0.0066)	(0.0075)	(0.0081)	(0.0069)	(0.0069)	(0.0069)
4500	0.2289	0.2218	0.2221	0.2147	0.2147	0.2148
	(0.0062)	(0.0073)	(0.0079)	(0.0066)	(0.0066)	(0.0065)
5000	0.22	0.2123	0.213	0.2056	0.2055	0.2056
	(0.0058)	(0.007)	(0.0083)	(0.0062)	(0.0062)	(0.0061)

APPENDIX H: STATIONARY LDA ERROR RATE SIMULATION

Table H.1: The bias of each error rate estimator for 1,000 simulations for a selected number of time points, *Adaptive* estimator - Stationary multivariate Normal (p=100, optimal error rate = 0.1). The standard deviation of the estimator is provided in parentheses.

Time	AdaptPreq	AdaptResub	AdaptDEst	AdaptPosterior	Preq	AdaptPreqPost
50	0.079	0.1455	-0.2596	0.1582	0.0791	0.1633
	(0.0715)	(0.0815)	(0.0277)	(0.066)	(0.0715)	(0.0674)
100	-0.0487	-0.0126	-0.4256	-0.0116	-0.0486	0.0741
	(0.0511)	(0.0554)	(0)	(0.1885)	(0.0511)	(0.0479)
500	0.0927	0.0978	-0.0877	-0.0915	0.097	-0.0727
	(0.0225)	(0.0228)	(0.0101)	(0.1047)	(0.0225)	(0.1246)
1000	0.04	0.0363	-0.0405	-0.0396	0.0662	-0.0259
	(0.017)	(0.018)	(0.0074)	(0.1204)	(0.0146)	(0.133)
1500	0.0091	0.0071	-0.0267	-0.027	0.0499	-0.0211
	(0.0173)	(0.018)	(0.0063)	(0.1231)	(0.011)	(0.1257)
2000	0.0024	0.0019	-0.0204	-0.0221	0.0402	-0.0158
	(0.0173)	(0.0177)	(0.0056)	(0.1272)	(0.0092)	(0.133)
2500	0.0013	0.0011	-0.0166	-0.0128	0.0339	-0.0087
	(0.0164)	(0.0168)	(0.005)	(0.1314)	(0.0078)	(0.1339)
3000	0.001	0.001	-0.0143	-0.0105	0.0293	-0.0049
	(0.0157)	(0.0161)	(0.0046)	(0.1321)	(0.007)	(0.1375)
3500	9e-04	9e-04	-0.0129	-0.014	0.0258	-0.0108
	(0.0169)	(0.0173)	(0.0058)	(0.1262)	(0.0064)	(0.1274)
4000	0.001	0.001	-0.0113	-0.0168	0.0234	-0.0129
	(0.0157)	(0.0161)	(0.0041)	(0.1268)	(0.006)	(0.1302)
4500	-2e-04	-3e-04	-0.0103	-0.0159	0.0212	-0.0111
	(0.0147)	(0.0151)	(0.0038)	(0.1242)	(0.0055)	(0.1285)
5000	-1e-04	-1e-04	-0.0097	-0.0081	0.0194	-0.0053
	(0.0155)	(0.0159)	(0.0037)	(0.1327)	(0.0052)	(0.133)

Table H.2: The bias of each error rate estimator for 1,000 simulations for a selected number of time points, *AdaptiveMem* estimator - Stationary multivariate Normal (p=100, optimal error rate = 0.1). The standard deviation of the estimator is provided in parentheses.

Time	AdaptPreq	AdaptResub	AdaptDEst	AdaptPosterior	Preq	AdaptPreqPost
50	0.0793	0.1453	-0.2595	0.158	0.0794	0.1637
	(0.0718)	(0.0821)	(0.028)	(0.0666)	(0.0718)	(0.068)
100	-0.0494	-0.0136	-0.4262	-0.0122	-0.0493	0.0735
	(0.0515)	(0.0556)	(0)	(0.1891)	(0.0515)	(0.048)
500	0.089	0.0939	-0.081	-0.0837	0.0937	-0.0661
	(0.0202)	(0.0204)	(0.0092)	(0.1083)	(0.0204)	(0.1254)
1000	0.0358	0.0323	-0.0402	-0.0395	0.0617	-0.0251
	(0.0176)	(0.0187)	(0.0088)	(0.1212)	(0.0146)	(0.135)
1500	0.0087	0.0068	-0.0284	-0.0291	0.0461	-0.0243
	(0.0243)	(0.0251)	(0.0082)	(0.1238)	(0.0138)	(0.1242)
2000	0.002	0.0015	-0.0236	-0.024	0.0366	-0.0175
	(0.0254)	(0.0257)	(0.008)	(0.1283)	(0.0142)	(0.1333)
2500	9e-04	7e-04	-0.0206	-0.0182	0.0306	-0.0124
	(0.0245)	(0.0249)	(0.0078)	(0.1304)	(0.0147)	(0.1348)
3000	4e-04	4e-04	-0.0186	-0.0141	0.0264	-0.0065
	(0.0245)	(0.0248)	(0.0076)	(0.1319)	(0.0152)	(0.1389)
3500	3e-04	3e-04	-0.0173	-0.0165	0.0232	-0.0126
	(0.0252)	(0.0255)	(0.008)	(0.1288)	(0.0159)	(0.128)
4000	6e-04	6e-04	-0.0171	-0.019	0.0202	-0.0127
	(0.0261)	(0.0264)	(0.0088)	(0.1298)	(0.0163)	(0.1349)
4500	2e-04	2e-04	-0.0165	-0.021	0.0183	-0.0143
	(0.0282)	(0.0284)	(0.0084)	(0.1247)	(0.0167)	(0.1309)
5000	3e-04	3e-04	-0.0165	-0.0099	0.0164	-0.0056
	(0.0283)	(0.0285)	(0.0089)	(0.1374)	(0.0171)	(0.1381)

Table H.3: The bias of each error rate estimator for 1,000 simulations for a selected number of time points, *ShrinkageAvgVar* estimator - Stationary multivariate Normal (p=100, optimal error rate = 0.1). The standard deviation of the estimator is provided in parentheses.

Time	AdaptPreq	AdaptResub	AdaptDEst	AdaptPosterior	Preq	AdaptPreqPost
50	0.0966	0.0966	-0.1958	0.2747	0.0967	0.279
	(0.0643)	(0.0643)	(0.0074)	(0.0669)	(0.0643)	(0.0681)
100	0.078	0.078	-0.131	-0.1398	0.0783	-0.0889
	(0.0428)	(0.0428)	(0.01)	(0.0822)	(0.0428)	(0.1335)
500	0.036	0.036	-0.0402	-0.0443	0.0377	-0.0267
	(0.0158)	(0.0158)	(0.0077)	(0.12)	(0.0159)	(0.1355)
1000	0.0213	0.0213	-0.0224	-0.0228	0.0259	-0.0104
	(0.0112)	(0.0112)	(0.0061)	(0.1266)	(0.0108)	(0.1371)
1500	0.0128	0.0128	-0.0156	-0.0178	0.0206	-0.0122
	(0.0101)	(0.0101)	(0.0053)	(0.1281)	(0.0082)	(0.1312)
2000	0.0073	0.0073	-0.0123	-0.0151	0.017	-0.0099
	(0.0106)	(0.0106)	(0.0048)	(0.1302)	(0.0071)	(0.1336)
2500	0.004	0.004	-0.0103	-0.0112	0.0145	-0.0068
	(0.0106)	(0.0106)	(0.0044)	(0.1287)	(0.0063)	(0.1311)
3000	0.0027	0.0027	-0.0089	-0.0073	0.0127	-0.0016
	(0.0103)	(0.0103)	(0.0041)	(0.1321)	(0.0057)	(0.1377)
3500	0.002	0.002	-0.0078	-0.0116	0.0115	-0.0075
	(0.0106)	(0.0106)	(0.0039)	(0.128)	(0.0053)	(0.1303)
4000	0.0018	0.0018	-0.0071	-0.0128	0.0105	-0.0082
	(0.0102)	(0.0102)	(0.0037)	(0.1284)	(0.0049)	(0.1321)
4500	9e-04	9e-04	-0.0067	-0.0142	0.0095	-0.0093
	(0.0096)	(0.0096)	(0.0035)	(0.1238)	(0.0046)	(0.1279)
5000	4e-04	4e-04	-0.0065	-0.0012	0.0087	0.0033
	(0.0094)	(0.0094)	(0.0035)	(0.1364)	(0.0044)	(0.1393)

Table H.4: The bias of each error rate estimator for 1,000 simulations for a selected number of time points, *ShrinkageDiag* estimator - Stationary multivariate Normal (p=100, optimal error rate = 0.1). The standard deviation of the estimator is provided in parentheses.

Time	AdaptPreq	AdaptResub	AdaptDEst	AdaptPosterior	Preq	AdaptPreqPost
50	0.1004	0.1004	-0.2021	0.2705	0.1005	0.2752
	(0.0658)	(0.0658)	(0.007)	(0.0671)	(0.0658)	(0.0683)
100	0.0818	0.0818	-0.1342	-0.1425	0.082	-0.0922
	(0.0435)	(0.0435)	(0.01)	(0.0824)	(0.0435)	(0.1331)
500	0.0373	0.0373	-0.0404	-0.0443	0.0391	-0.0276
	(0.0159)	(0.0159)	(0.0077)	(0.1201)	(0.0161)	(0.133)
1000	0.0215	0.0215	-0.0224	-0.0223	0.0267	-0.0098
	(0.0113)	(0.0113)	(0.0061)	(0.1267)	(0.0108)	(0.1373)
1500	0.0126	0.0126	-0.0156	-0.0185	0.021	-0.0124
	(0.0102)	(0.0102)	(0.0053)	(0.1271)	(0.0083)	(0.132)
2000	0.007	0.007	-0.0123	-0.0151	0.0173	-0.0096
	(0.0107)	(0.0107)	(0.0048)	(0.1299)	(0.0072)	(0.1344)
2500	0.0038	0.0038	-0.0103	-0.0114	0.0147	-0.0068
	(0.0107)	(0.0107)	(0.0044)	(0.1281)	(0.0063)	(0.1309)
3000	0.0025	0.0025	-0.009	-0.0065	0.0129	-6e-04
	(0.0104)	(0.0104)	(0.0041)	(0.1323)	(0.0057)	(0.1384)
3500	0.0018	0.0018	-0.0079	-0.0106	0.0117	-0.0065
	(0.0106)	(0.0106)	(0.0039)	(0.1286)	(0.0054)	(0.131)
4000	0.0016	0.0016	-0.0072	-0.0129	0.0107	-0.0081
	(0.0102)	(0.0102)	(0.0037)	(0.1279)	(0.005)	(0.1318)
4500	9e-04	9e-04	-0.0068	-0.0144	0.0097	-0.0096
	(0.0097)	(0.0097)	(0.0035)	(0.1235)	(0.0046)	(0.127)
5000	3e-04	3e-04	-0.0066	-0.0017	0.0088	0.0027
	(0.0096)	(0.0096)	(0.0035)	(0.1361)	(0.0044)	(0.139)

Table H.5: The bias of each error rate estimator for 1,000 simulations for a selected number of time points, *ShrinkageIdentity* estimator - Stationary multivariate Normal (p=100, optimal error rate = 0.1). The standard deviation of the estimator is provided in parentheses.

Time	AdaptPreq	AdaptResub	AdaptDEst	AdaptPosterior	Preq	AdaptPreqPost
50	0.0516	0.0516	-0.2825	0.2086	0.0517	0.2151
	(0.0676)	(0.0676)	(0)	(0.0667)	(0.0676)	(0.068)
100	-0.0488	-0.0488	-0.3778	-0.3778	-0.0487	0.1222
	(0.0509)	(0.0509)	(0)	(0)	(0.0509)	(0)
500	0.0674	0.068	-0.1472	-0.1129	0.0692	-0.0619
	(0.0416)	(0.0425)	(0.0373)	(0.1649)	(0.0407)	(0.2278)
1000	0.0497	0.0501	-0.0804	-0.055	0.0626	-0.0313
	(0.044)	(0.0446)	(0.0194)	(0.1611)	(0.0389)	(0.1883)
1500	0.0219	0.0219	-0.0598	-0.0386	0.0505	-0.0271
	(0.0404)	(0.0406)	(0.0158)	(0.1586)	(0.0342)	(0.1702)
2000	0.0068	0.0068	-0.0511	-0.032	0.0412	-0.0222
	(0.0366)	(0.0367)	(0.0142)	(0.1576)	(0.0318)	(0.168)
2500	0.0038	0.0038	-0.0475	-0.0259	0.0345	-0.0159
	(0.0358)	(0.0359)	(0.0145)	(0.1616)	(0.0308)	(0.1743)
3000	0.0024	0.0025	-0.0451	-0.0173	0.0296	-0.0067
	(0.0351)	(0.0352)	(0.0149)	(0.1733)	(0.0301)	(0.1858)
3500	0.0028	0.0028	-0.042	-0.023	0.0276	-0.0145
	(0.0355)	(0.0355)	(0.0156)	(0.1596)	(0.0297)	(0.1705)
4000	0.0029	0.003	-0.04	-0.0218	0.0252	-0.014
	(0.0345)	(0.0346)	(0.0147)	(0.1684)	(0.0292)	(0.1778)
4500	0.0018	0.0018	-0.0402	-0.0249	0.0219	-0.0163
	(0.0347)	(0.0349)	(0.0177)	(0.1636)	(0.0288)	(0.1724)
5000	0.003	0.0031	-0.0392	-0.0169	0.0206	-0.0106
	(0.0358)	(0.0359)	(0.0191)	(0.1643)	(0.0286)	(0.1697)

Table H.6: The bias of each error rate estimator for 1,000 simulations for a selected number of time points, *Static* estimator - Stationary multivariate Normal (p=100, optimal error rate = 0.1). The standard deviation of the estimator is provided in parentheses.

Time	AdaptPreq	AdaptResub	AdaptDEst	AdaptPosterior	Preq	AdaptPreqPost
50	0.0796	0.1457	-0.2591	0.1583	0.0797	0.1638
	(0.0721)	(0.0823)	(0.028)	(0.067)	(0.0721)	(0.0684)
100	-0.0493	-0.0135	-0.426	-0.0105	-0.0492	0.0734
	(0.0515)	(0.0557)	(0)	(0.1873)	(0.0515)	(0.0481)
500	0.0868	0.0916	-0.0768	-0.0783	0.0917	-0.0601
	(0.0188)	(0.0188)	(0.0087)	(0.1089)	(0.0191)	(0.1273)
1000	0.0345	0.0311	-0.0379	-0.0346	0.0601	-0.0243
	(0.0149)	(0.0161)	(0.0071)	(0.1242)	(0.0121)	(0.1327)
1500	0.0088	0.0069	-0.025	-0.0257	0.0456	-0.0209
	(0.0163)	(0.017)	(0.0059)	(0.1231)	(0.0094)	(0.1264)
2000	0.0021	0.0016	-0.0189	-0.0171	0.0368	-0.0121
	(0.0164)	(0.0169)	(0.0053)	(0.13)	(0.0079)	(0.135)
2500	0.001	8e-04	-0.0152	-0.013	0.0311	-0.0103
	(0.016)	(0.0165)	(0.0047)	(0.1309)	(0.0069)	(0.1325)
3000	9e-04	8e-04	-0.0126	-0.007	0.027	-0.0036
	(0.0154)	(0.0159)	(0.0043)	(0.1333)	(0.0061)	(0.1358)
3500	7e-04	6e-04	-0.0108	-0.0105	0.024	-0.0085
	(0.0151)	(0.0156)	(0.004)	(0.1281)	(0.0057)	(0.1286)
4000	9e-04	9e-04	-0.0094	-0.0119	0.0217	-0.0096
	(0.0147)	(0.0151)	(0.0037)	(0.1286)	(0.0052)	(0.1305)
4500	0	0	-0.0084	-0.0116	0.0198	-0.009
	(0.0145)	(0.015)	(0.0035)	(0.1276)	(0.0049)	(0.1302)
5000	-2e-04	-1e-04	-0.0076	-0.0015	0.0181	5e-04
	(0.0149)	(0.0154)	(0.0033)	(0.1355)	(0.0046)	(0.1366)

APPENDIX I: ABRUPT LDA ERROR RATE SIMULATION

Table I.1: The bias of each error rate estimator for 1,000 simulations for a selected number of time points, *Adaptive* estimator - Abrupt multivariate Normal (p=100, optimal error rate = 0.1). The standard deviation of the estimator is provided in parentheses.

Time	AdaptPreq	AdaptResub	AdaptDEst	AdaptPosterior	Preq	AdaptPreqPost
50	0.0756	0.141	-0.2654	0.1488	0.0757	0.1542
	(0.0676)	(0.0781)	(0.027)	(0.0689)	(0.0676)	(0.0703)
100	-0.0446	-0.0089	-0.4275	-0.0136	-0.0445	0.0715
	(0.0498)	(0.0549)	(0)	(0.1896)	(0.0498)	(0.0497)
500	0.0947	0.0997	-0.086	-0.0881	0.0991	-0.0699
	(0.0224)	(0.0226)	(0.0102)	(0.1092)	(0.0223)	(0.1198)
1000	0.0387	0.0348	-0.0408	-0.0394	0.0662	-0.027
	(0.0174)	(0.0185)	(0.0076)	(0.1225)	(0.0143)	(0.1339)
1500	0.0083	0.0064	-0.0278	-0.0235	0.0493	-0.0118
	(0.0178)	(0.0184)	(0.0078)	(0.1301)	(0.0111)	(0.1406)
2000	0.0024	0.002	-0.0203	-0.017	0.0405	-0.0083
	(0.0168)	(0.0172)	(0.0062)	(0.1256)	(0.0091)	(0.1336)
2500	0.0011	0.001	-0.0164	-0.0183	0.0342	-0.0128
	(0.0166)	(0.017)	(0.005)	(0.1297)	(0.0078)	(0.1329)
3000	0.0444	0.0443	-0.071	-0.0877	-0.014	-0.0566
	(0.0273)	(0.0275)	(0.0141)	(0.126)	(0.0074)	(0.1466)
3500	0.007	0.0069	-0.0182	-0.0344	0.038	-0.0216
	(0.0249)	(0.025)	(0.01)	(0.128)	(0.0068)	(0.1363)
4000	0.0024	0.0024	-0.0083	-0.0146	0.0467	-0.0061
	(0.0228)	(0.0229)	(0.0093)	(0.1285)	(0.0062)	(0.133)
4500	0.0026	0.0026	-0.0053	-0.0055	0.0476	0.0013
	(0.0208)	(0.0208)	(0.0067)	(0.1346)	(0.0059)	(0.1399)
5000	1e-04	1e-04	-0.006	-0.0115	0.0453	-0.0034
	(0.0218)	(0.0219)	(0.0087)	(0.1279)	(0.0055)	(0.1346)

Table I.2: The bias of each error rate estimator for 1,000 simulations for a selected number of time points, *AdaptiveMem* estimator - Abrupt multivariate Normal (p=100, optimal error rate = 0.1). The standard deviation of the estimator is provided in parentheses.

Time	AdaptPreq	AdaptResub	AdaptDEst	AdaptPosterior	Preq	AdaptPreqPost
50	0.0749	0.1404	-0.2657	0.1485	0.075	0.1541
	(0.0679)	(0.0786)	(0.0269)	(0.0692)	(0.0679)	(0.0706)
100	-0.0449	-0.0092	-0.4274	-0.0133	-0.0448	0.072
	(0.0499)	(0.0552)	(0)	(0.1891)	(0.0499)	(0.0498)
500	0.0912	0.096	-0.0803	-0.0824	0.0958	-0.0641
	(0.0207)	(0.021)	(0.0097)	(0.1096)	(0.0208)	(0.1248)
1000	0.0351	0.0314	-0.0404	-0.0392	0.0622	-0.0255
	(0.0171)	(0.0183)	(0.0085)	(0.1217)	(0.0136)	(0.135)
1500	0.0084	0.0066	-0.0275	-0.0236	0.047	-0.012
	(0.0184)	(0.0189)	(0.0072)	(0.1289)	(0.0115)	(0.1397)
2000	0.0024	0.002	-0.0223	-0.0221	0.0375	-0.0121
	(0.0201)	(0.0206)	(0.0068)	(0.1227)	(0.0104)	(0.1329)
2500	0.0011	0.001	-0.0198	-0.0219	0.031	-0.0146
	(0.0219)	(0.0223)	(0.0071)	(0.1287)	(0.0102)	(0.1341)
3000	0.0337	0.034	-0.0811	-0.0703	-0.0719	-0.0576
	(0.0306)	(0.0308)	(0.0156)	(0.1387)	(0.0097)	(0.1528)
3500	0.0135	0.0135	-0.0095	-0.029	0.0134	-0.0149
	(0.0298)	(0.0298)	(0.015)	(0.1389)	(0.0102)	(0.1471)
4000	0.0053	0.0053	0.0035	-0.0076	0.042	0.004
	(0.0344)	(0.0346)	(0.016)	(0.1372)	(0.0107)	(0.1456)
4500	0.0031	0.0032	0.0031	-0.0023	0.0506	0.0058
	(0.0358)	(0.036)	(0.014)	(0.1392)	(0.0119)	(0.143)
5000	0.0011	0.0011	-0.001	-0.0084	0.0512	-1e-04
	(0.0373)	(0.0374)	(0.0134)	(0.1344)	(0.0131)	(0.1406)

Table I.3: The bias of each error rate estimator for 1,000 simulations for a selected number of time points, *ShrinkageAvgVar* estimator - Abrupt multivariate Normal (p=100, optimal error rate = 0.1). The standard deviation of the estimator is provided in parentheses.

Time	AdaptPreq	AdaptResub	AdaptDEst	AdaptPosterior	Preq	AdaptPreqPost
50	0.0934	0.0934	-0.2028	0.2668	0.0935	0.2663
	(0.0602)	(0.0602)	(0.0072)	(0.0692)	(0.0602)	(0.0699)
100	0.0804	0.0804	-0.1327	-0.1381	0.0806	-0.0833
	(0.0436)	(0.0436)	(0.0102)	(0.091)	(0.0436)	(0.1337)
500	0.0386	0.0386	-0.0371	-0.0363	0.0403	-0.0215
	(0.0169)	(0.0169)	(0.0077)	(0.1274)	(0.017)	(0.1325)
1000	0.0217	0.0217	-0.0198	-0.0189	0.027	-0.0095
	(0.0114)	(0.0114)	(0.006)	(0.1302)	(0.0111)	(0.1363)
1500	0.0128	0.0128	-0.0131	-0.0102	0.0214	-0.0027
	(0.0104)	(0.0104)	(0.0052)	(0.1346)	(0.0088)	(0.1384)
2000	0.0075	0.0075	-0.0096	-0.008	0.018	-0.0016
	(0.0107)	(0.0107)	(0.0047)	(0.1284)	(0.0074)	(0.131)
2500	0.0044	0.0044	-0.0075	-0.0081	0.0155	-0.0021
	(0.0109)	(0.0109)	(0.0044)	(0.134)	(0.0065)	(0.1382)
3000	0.025	0.025	-0.0189	-0.0238	-0.0471	-0.0096
	(0.0371)	(0.0372)	(0.009)	(0.1422)	(0.0074)	(0.1456)
3500	0.0049	0.0049	0.0262	0.0083	0.0136	0.0178
	(0.0296)	(0.0296)	(0.0097)	(0.1433)	(0.0077)	(0.1475)
4000	0.0023	0.0023	0.0312	0.0159	0.0313	0.0228
	(0.0256)	(0.0256)	(0.0087)	(0.1366)	(0.0074)	(0.1387)
4500	0.0025	0.0025	0.0284	0.0177	0.0374	0.023
	(0.0245)	(0.0245)	(0.0075)	(0.1405)	(0.0069)	(0.1421)
5000	0.001	0.001	0.0239	0.0111	0.0388	0.0169
	(0.0254)	(0.0254)	(0.0064)	(0.1359)	(0.0064)	(0.139)

Table I.4: The bias of each error rate estimator for 1,000 simulations for a selected number of time points, *ShrinkageDiag* estimator - Abrupt multivariate Normal (p=100, optimal error rate = 0.1). The standard deviation of the estimator is provided in parentheses.

Time	AdaptPreq	AdaptResub	AdaptDEst	AdaptPosterior	Preq	AdaptPreqPost
50	0.0956	0.0956	-0.2082	0.2628	0.0958	0.2651
	(0.0626)	(0.0626)	(0.0069)	(0.0691)	(0.0626)	(0.0701)
100	0.0825	0.0825	-0.1362	-0.1421	0.0828	-0.0863
	(0.0432)	(0.0432)	(0.0102)	(0.0877)	(0.0432)	(0.1357)
500	0.0393	0.0393	-0.0381	-0.0379	0.0412	-0.0232
	(0.0167)	(0.0167)	(0.0078)	(0.1267)	(0.0168)	(0.1316)
1000	0.022	0.022	-0.0205	-0.0187	0.0277	-0.0093
	(0.0114)	(0.0114)	(0.006)	(0.1309)	(0.011)	(0.1369)
1500	0.0127	0.0127	-0.0137	-0.0101	0.0217	-0.0025
	(0.0105)	(0.0105)	(0.0052)	(0.1347)	(0.0088)	(0.1387)
2000	0.0073	0.0073	-0.0101	-0.009	0.0182	-0.0024
	(0.0107)	(0.0107)	(0.0047)	(0.1282)	(0.0074)	(0.1315)
2500	0.0043	0.0043	-0.008	-0.0088	0.0157	-0.0026
	(0.0109)	(0.0109)	(0.0044)	(0.1333)	(0.0065)	(0.1382)
3000	0.0252	0.0252	-0.0185	-0.0238	-0.0471	-0.009
	(0.037)	(0.037)	(0.0091)	(0.1408)	(0.0074)	(0.1453)
3500	0.0057	0.0057	0.0265	0.0086	0.0137	0.0183
	(0.0292)	(0.0292)	(0.0099)	(0.1433)	(0.0076)	(0.1473)
4000	0.0027	0.0027	0.0313	0.0167	0.0314	0.0238
	(0.0255)	(0.0255)	(0.0088)	(0.1373)	(0.0073)	(0.1395)
4500	0.0021	0.0021	0.0284	0.0177	0.0374	0.0234
	(0.0241)	(0.0241)	(0.0077)	(0.1404)	(0.0069)	(0.1425)
5000	8e-04	8e-04	0.0238	0.0113	0.0388	0.0172
	(0.0249)	(0.0249)	(0.0065)	(0.1359)	(0.0065)	(0.1391)

Table I.5: The bias of each error rate estimator for 1,000 simulations for a selected number of time points, *ShrinkageIdentity* estimator - Abrupt multivariate Normal (p=100, optimal error rate = 0.1). The standard deviation of the estimator is provided in parentheses.

Time	AdaptPreq	AdaptResub	AdaptDEst	AdaptPosterior	Preq	AdaptPreqPost
50	0.0518	0.0518	-0.2844	0.2059	0.0519	0.2106
	(0.0636)	(0.0636)	(0)	(0.0692)	(0.0636)	(0.0704)
100	-0.0502	-0.0502	-0.3779	-0.3779	-0.0502	0.1221
	(0.0492)	(0.0492)	(0)	(0)	(0.0492)	(0)
500	0.0673	0.0678	-0.1464	-0.1154	0.069	-0.0719
	(0.0412)	(0.0418)	(0.0403)	(0.1613)	(0.0402)	(0.2186)
1000	0.0502	0.0505	-0.079	-0.0544	0.0631	-0.0322
	(0.0437)	(0.0442)	(0.0188)	(0.1594)	(0.0383)	(0.1867)
1500	0.0205	0.0206	-0.0589	-0.0354	0.0498	-0.0245
	(0.0398)	(0.04)	(0.0191)	(0.1568)	(0.0339)	(0.165)
2000	0.0078	0.0077	-0.0508	-0.0312	0.041	-0.0213
	(0.0358)	(0.0358)	(0.0148)	(0.1499)	(0.0313)	(0.1613)
2500	0.0039	0.0039	-0.0461	-0.0282	0.035	-0.0164
	(0.0342)	(0.0343)	(0.0136)	(0.1586)	(0.0298)	(0.174)
3000	0.0303	0.0303	-0.1518	-0.1016	-0.0971	-0.0918
	(0.0388)	(0.0389)	(0.017)	(0.1702)	(0.0269)	(0.1839)
3500	0.0163	0.0163	-0.0602	-0.0453	-0.0085	-0.0297
	(0.0394)	(0.0395)	(0.0189)	(0.1759)	(0.026)	(0.1927)
4000	0.0128	0.0129	-0.0263	-0.008	0.0327	0.0026
	(0.0437)	(0.0438)	(0.0199)	(0.1866)	(0.0258)	(0.1939)
4500	0.0115	0.0115	-0.0169	-0.0045	0.051	0.0062
	(0.0469)	(0.047)	(0.0208)	(0.1734)	(0.0261)	(0.1832)
5000	0.0085	0.0085	-0.0182	-0.0101	0.0567	0
	(0.0491)	(0.0492)	(0.0243)	(0.1722)	(0.0267)	(0.1822)

Table I.6: The bias of each error rate estimator for 1,000 simulations for a selected number of time points, *Static* estimator - Abrupt multivariate Normal (p=100, optimal error rate = 0.1). The standard deviation of the estimator is provided in parentheses.

Time	AdaptPreq	AdaptResub	AdaptDEst	AdaptPosterior	Preq	AdaptPreqPost
50	0.0751	0.1403	-0.2656	0.1489	0.0751	0.1541
	(0.0676)	(0.0783)	(0.027)	(0.069)	(0.0676)	(0.0704)
100	-0.0449	-0.0092	-0.4274	-0.0139	-0.0448	0.0719
	(0.0499)	(0.0551)	(0)	(0.1895)	(0.0499)	(0.0497)
500	0.0893	0.0941	-0.0761	-0.0779	0.0942	-0.0606
	(0.0189)	(0.0191)	(0.0091)	(0.1101)	(0.0192)	(0.1265)
1000	0.0339	0.0303	-0.0381	-0.0362	0.0609	-0.0264
	(0.0154)	(0.0164)	(0.007)	(0.1219)	(0.0123)	(0.1309)
1500	0.0082	0.0065	-0.025	-0.0176	0.0461	-0.0108
	(0.016)	(0.0166)	(0.0059)	(0.1341)	(0.0096)	(0.1389)
2000	0.0026	0.0022	-0.0186	-0.0123	0.0374	-0.0067
	(0.0161)	(0.0165)	(0.0052)	(0.1296)	(0.0079)	(0.1344)
2500	0.001	8e-04	-0.0148	-0.0156	0.0315	-0.0118
	(0.0157)	(0.0162)	(0.0047)	(0.1297)	(0.0068)	(0.1322)
3000	0.0184	0.0191	-0.2318	-0.1669	-0.194	-0.169
	(0.0352)	(0.035)	(0.005)	(0.1473)	(0.0067)	(0.1468)
3500	0.0124	0.0126	-0.1238	-0.0896	-0.0898	-0.0893
	(0.0338)	(0.0335)	(0.0051)	(0.1449)	(0.0066)	(0.1455)
4000	0.0076	0.0077	-0.0667	-0.0395	-0.0358	-0.0385
	(0.0324)	(0.0322)	(0.005)	(0.1473)	(0.0064)	(0.1474)
4500	0.0058	0.0058	-0.0328	-0.0116	-0.0045	-0.011
	(0.03)	(0.0299)	(0.0048)	(0.1513)	(0.0061)	(0.1508)
5000	0.0034	0.0034	-0.011	-0.0127	0.0152	-0.0122
	(0.0305)	(0.0302)	(0.0046)	(0.1471)	(0.0058)	(0.1469)

APPENDIX J: GRADUAL LDA ERROR RATE SIMULATION

Table J.1: The bias of each error rate estimator for 1,000 simulations for a selected number of time points, *Adaptive* estimator - Gradual multivariate Normal (p=100, optimal error rate = 0.1). The standard deviation of the estimator is provided in parentheses.

Time	AdaptPreq	AdaptResub	AdaptDEst	AdaptPosterior	Preq	AdaptPreqPost
50	0.0713	0.1386	-0.2736	0.1358	0.0714	0.1456
	(0.068)	(0.0768)	(0.0283)	(0.0686)	(0.068)	(0.0703)
100	-0.0416	-0.0052	-0.4303	-0.0242	-0.0414	0.0724
	(0.0491)	(0.0532)	(0)	(0.194)	(0.0491)	(0.0486)
500	0.0804	0.0857	-0.105	-0.1088	0.0839	-0.0876
	(0.0229)	(0.0233)	(0.0115)	(0.1127)	(0.0228)	(0.1297)
1000	0.0259	0.024	-0.0687	-0.0622	0.0413	-0.0528
	(0.0162)	(0.0172)	(0.0091)	(0.1319)	(0.0149)	(0.1392)
1500	-3e-04	-0.0013	-0.0636	-0.0464	0.0153	-0.0406
	(0.0158)	(0.017)	(0.0085)	(0.1452)	(0.0117)	(0.1491)
2000	-0.0065	-0.0061	-0.0617	-0.0497	-0.0011	-0.0439
	(0.0165)	(0.0178)	(0.0068)	(0.1406)	(0.0098)	(0.147)
2500	-0.0061	-0.0053	-0.0581	-0.0477	-0.0097	-0.0441
	(0.0167)	(0.0179)	(0.0071)	(0.1478)	(0.0087)	(0.1495)
3000	-0.0025	-0.0019	-0.0497	-0.0404	-0.0101	-0.0375
	(0.017)	(0.0182)	(0.0083)	(0.145)	(0.0079)	(0.1446)
3500	0.0036	0.0037	-0.0356	-0.0326	-0.0019	-0.0294
	(0.0164)	(0.0176)	(0.0064)	(0.1471)	(0.0074)	(0.1489)
4000	0.0101	0.0093	-0.0179	-0.0097	0.0141	-0.006
	(0.0156)	(0.0167)	(0.0073)	(0.1504)	(0.0068)	(0.1524)
4500	0.0173	0.0155	0.0012	-0.0119	0.0363	-0.006
	(0.0159)	(0.0168)	(0.0085)	(0.1433)	(0.0063)	(0.147)
5000	0.0227	0.02	0.0182	0.0018	0.0621	0.0122
	(0.0165)	(0.0169)	(0.0092)	(0.1396)	(0.006)	(0.1477)

Table J.2: The bias of each error rate estimator for 1,000 simulations for a selected number of time points, *AdaptiveMem* estimator - Gradual multivariate Normal (p=100, optimal error rate = 0.1). The standard deviation of the estimator is provided in parentheses.

Time	AdaptPreq	AdaptResub	AdaptDEst	AdaptPosterior	Preq	AdaptPreqPost
50	0.0713	0.1384	-0.2737	0.1359	0.0714	0.1459
	(0.0679)	(0.0765)	(0.0283)	(0.0686)	(0.0679)	(0.0703)
100	-0.0411	-0.0048	-0.4301	-0.0239	-0.041	0.0727
	(0.0492)	(0.0532)	(0)	(0.194)	(0.0492)	(0.0485)
500	0.0763	0.0816	-0.0991	-0.1008	0.0803	-0.082
	(0.02)	(0.0203)	(0.0104)	(0.1148)	(0.0201)	(0.1314)
1000	0.0222	0.0204	-0.0687	-0.0608	0.0373	-0.0529
	(0.0158)	(0.0168)	(0.01)	(0.133)	(0.0139)	(0.1387)
1500	-0.0018	-0.0025	-0.0659	-0.0464	0.0114	-0.0412
	(0.0189)	(0.0201)	(0.0101)	(0.1454)	(0.0119)	(0.1501)
2000	-0.0076	-0.007	-0.0657	-0.0508	-0.005	-0.0444
	(0.0222)	(0.0234)	(0.0121)	(0.1417)	(0.0118)	(0.1494)
2500	-0.0065	-0.0056	-0.0612	-0.0486	-0.0125	-0.0455
	(0.0222)	(0.0233)	(0.0127)	(0.1485)	(0.0119)	(0.1506)
3000	-0.0024	-0.0017	-0.0518	-0.0413	-0.0116	-0.0392
	(0.0227)	(0.0235)	(0.0124)	(0.1455)	(0.0121)	(0.1451)
3500	0.0041	0.0041	-0.0383	-0.0345	-0.0029	-0.0302
	(0.0226)	(0.0236)	(0.0137)	(0.147)	(0.0123)	(0.1513)
4000	0.0109	0.0101	-0.0211	-0.0114	0.0137	-0.0072
	(0.0234)	(0.0242)	(0.0156)	(0.1509)	(0.0125)	(0.1531)
4500	0.0178	0.0159	-0.0031	-0.0135	0.0359	-0.0084
	(0.0252)	(0.026)	(0.0151)	(0.1453)	(0.013)	(0.1494)
5000	0.0225	0.0198	0.012	-7e-04	0.0607	0.0099
	(0.0285)	(0.0292)	(0.0161)	(0.141)	(0.0137)	(0.1503)

Table J.3: The bias of each error rate estimator for 1,000 simulations for a selected number of time points, *ShrinkageAvgVar* estimator - Gradual multivariate Normal (p=100, optimal error rate = 0.1). The standard deviation of the estimator is provided in parentheses.

Time	AdaptPreq	AdaptResub	AdaptDEst	AdaptPosterior	Preq	AdaptPreqPost
50	0.0913	0.0913	-0.2131	0.2522	0.0915	0.254
	(0.0622)	(0.0622)	(0.008)	(0.0688)	(0.0622)	(0.0695)
100	0.0781	0.0781	-0.1412	-0.15	0.0784	-0.0987
	(0.0428)	(0.0428)	(0.0105)	(0.0918)	(0.0428)	(0.1377)
500	0.0277	0.0277	-0.0498	-0.0544	0.0291	-0.0362
	(0.0169)	(0.0169)	(0.0086)	(0.1298)	(0.0169)	(0.1404)
1000	0.0033	0.0033	-0.0419	-0.0329	0.0052	-0.023
	(0.0116)	(0.0116)	(0.0068)	(0.1395)	(0.0116)	(0.145)
1500	-0.0112	-0.0112	-0.0437	-0.026	-0.0111	-0.0184
	(0.0103)	(0.0103)	(0.0062)	(0.1474)	(0.0096)	(0.1497)
2000	-0.0182	-0.0182	-0.0445	-0.03	-0.0214	-0.024
	(0.0098)	(0.0098)	(0.0058)	(0.1455)	(0.0085)	(0.1468)
2500	-0.0189	-0.0189	-0.0415	-0.0327	-0.0253	-0.027
	(0.0101)	(0.0101)	(0.0056)	(0.1451)	(0.0077)	(0.1451)
3000	-0.0126	-0.0126	-0.0333	-0.0252	-0.0219	-0.0196
	(0.0112)	(0.0112)	(0.0056)	(0.1449)	(0.0072)	(0.1455)
3500	-0.0017	-0.0017	-0.0201	-0.0186	-0.0114	-0.013
	(0.0116)	(0.0116)	(0.0053)	(0.1463)	(0.0067)	(0.1471)
4000	0.0097	0.0097	-0.0035	0.0011	0.0051	0.0056
	(0.0108)	(0.0108)	(0.0051)	(0.1463)	(0.0062)	(0.1466)
4500	0.0205	0.0205	0.0145	2e-04	0.0257	0.0055
	(0.0114)	(0.0114)	(0.005)	(0.1419)	(0.0058)	(0.1443)
5000	0.0306	0.0306	0.0325	0.0183	0.0484	0.024
	(0.0136)	(0.0136)	(0.0047)	(0.1447)	(0.0055)	(0.1478)

Table J.4: The bias of each error rate estimator for 1,000 simulations for a selected number of time points, *ShrinkageDiag* estimator - Gradual multivariate Normal (p=100, optimal error rate = 0.1). The standard deviation of the estimator is provided in parentheses.

Time	AdaptPreq	AdaptResub	AdaptDEst	AdaptPosterior	Preq	AdaptPreqPost
50	0.0949	0.0949	-0.2184	0.2488	0.095	0.2511
	(0.0618)	(0.0618)	(0.0076)	(0.0689)	(0.0618)	(0.0697)
100	0.0808	0.0808	-0.1444	-0.1532	0.081	-0.1053
	(0.0438)	(0.0438)	(0.0104)	(0.0901)	(0.0438)	(0.1323)
500	0.0286	0.0286	-0.0508	-0.0563	0.0301	-0.0372
	(0.0172)	(0.0172)	(0.0086)	(0.1272)	(0.0172)	(0.1401)
1000	0.0036	0.0036	-0.0426	-0.034	0.0057	-0.0236
	(0.0116)	(0.0116)	(0.0069)	(0.1391)	(0.0116)	(0.1458)
1500	-0.0112	-0.0112	-0.0444	-0.0266	-0.0109	-0.0187
	(0.0104)	(0.0104)	(0.0062)	(0.1472)	(0.0096)	(0.1503)
2000	-0.018	-0.018	-0.0452	-0.0308	-0.0213	-0.0248
	(0.0099)	(0.0099)	(0.0058)	(0.1457)	(0.0085)	(0.147)
2500	-0.0186	-0.0186	-0.0422	-0.0333	-0.0254	-0.0275
	(0.0103)	(0.0103)	(0.0056)	(0.1453)	(0.0077)	(0.1454)
3000	-0.0123	-0.0123	-0.034	-0.0266	-0.0221	-0.021
	(0.0114)	(0.0114)	(0.0056)	(0.1442)	(0.0072)	(0.1449)
3500	-0.0014	-0.0014	-0.0206	-0.0189	-0.0115	-0.0136
	(0.0119)	(0.0119)	(0.0053)	(0.1462)	(0.0067)	(0.1465)
4000	0.0098	0.0098	-0.0037	6e-04	0.0051	0.0051
	(0.0108)	(0.0108)	(0.0052)	(0.1461)	(0.0062)	(0.1464)
4500	0.0206	0.0206	0.0146	1e-04	0.0259	0.0055
	(0.0115)	(0.0115)	(0.0051)	(0.1416)	(0.0059)	(0.1441)
5000	0.0306	0.0306	0.0327	0.0186	0.0488	0.0244
	(0.0135)	(0.0135)	(0.0047)	(0.1446)	(0.0055)	(0.1477)

Table J.5: The bias of each error rate estimator for 1,000 simulations for a selected number of time points, *ShrinkageIdentity* estimator - Gradual multivariate Normal (p=100, optimal error rate = 0.1). The standard deviation of the estimator is provided in parentheses.

Time	AdaptPreq	AdaptResub	AdaptDEst	AdaptPosterior	Preq	AdaptPreqPost
50	0.053	0.053	-0.2912	0.1971	0.0531	0.2038
	(0.0662)	(0.0662)	(0)	(0.0689)	(0.0662)	(0.0701)
100	-0.0468	-0.0468	-0.3821	-0.3821	-0.0468	0.1179
	(0.0474)	(0.0474)	(0)	(0)	(0.0474)	(0)
500	0.0584	0.0589	-0.1617	-0.1236	0.0598	-0.0829
	(0.0406)	(0.0414)	(0.0295)	(0.167)	(0.0399)	(0.2198)
1000	0.0314	0.0317	-0.1037	-0.0796	0.0383	-0.0628
	(0.0367)	(0.0373)	(0.0236)	(0.1552)	(0.0346)	(0.1803)
1500	0.0057	0.0058	-0.0956	-0.0534	0.0145	-0.0494
	(0.031)	(0.0312)	(0.0171)	(0.1792)	(0.0302)	(0.1803)
2000	-0.0054	-0.0054	-0.0939	-0.0626	-0.002	-0.0541
	(0.029)	(0.0291)	(0.0246)	(0.1694)	(0.0281)	(0.1798)
2500	-0.0064	-0.0064	-0.0901	-0.0584	-0.0096	-0.0574
	(0.0262)	(0.0263)	(0.0161)	(0.1735)	(0.0263)	(0.1717)
3000	-0.0027	-0.0027	-0.0821	-0.0509	-0.0107	-0.0423
	(0.0271)	(0.0272)	(0.0159)	(0.1747)	(0.0251)	(0.1874)
3500	0.003	0.003	-0.0705	-0.0472	-0.0045	-0.0418
	(0.0286)	(0.0287)	(0.0178)	(0.1745)	(0.0246)	(0.1796)
4000	0.0124	0.0124	-0.0528	-0.0211	0.0107	-0.0132
	(0.0296)	(0.0296)	(0.0159)	(0.1838)	(0.0243)	(0.1928)
4500	0.0216	0.0216	-0.0338	-0.0321	0.0317	-0.0232
	(0.0317)	(0.0317)	(0.016)	(0.1648)	(0.0244)	(0.1761)
5000	0.0302	0.0302	-0.0158	-0.0128	0.0572	-9e-04
	(0.0349)	(0.0349)	(0.0191)	(0.1673)	(0.0248)	(0.1774)

Table J.6: The bias of each error rate estimator for 1,000 simulations for a selected number of time points, *Static* estimator - Gradual multivariate Normal (p=100, optimal error rate = 0.1). The standard deviation of the estimator is provided in parentheses.

Time	AdaptPreq	AdaptResub	AdaptDEst	AdaptPosterior	Preq	AdaptPreqPost
50	0.0712	0.1383	-0.2738	0.1359	0.0712	0.1461
	(0.068)	(0.0766)	(0.0283)	(0.0684)	(0.068)	(0.0701)
100	-0.0409	-0.0046	-0.4299	-0.0236	-0.0408	0.0729
	(0.0491)	(0.0532)	(0)	(0.194)	(0.0491)	(0.0484)
500	0.0742	0.0793	-0.0956	-0.0944	0.0784	-0.0789
	(0.0187)	(0.019)	(0.0099)	(0.1172)	(0.0189)	(0.1312)
1000	0.0207	0.0191	-0.0679	-0.0588	0.0356	-0.0524
	(0.0143)	(0.0153)	(0.0081)	(0.1347)	(0.0128)	(0.1384)
1500	-0.0024	-0.003	-0.0654	-0.0462	0.0105	-0.0427
	(0.0153)	(0.0165)	(0.0072)	(0.1452)	(0.0105)	(0.1469)
2000	-0.0081	-0.0075	-0.0669	-0.0521	-0.0061	-0.0477
	(0.016)	(0.0173)	(0.0063)	(0.1427)	(0.009)	(0.1473)
2500	-0.0092	-0.008	-0.0677	-0.0519	-0.0166	-0.0509
	(0.0158)	(0.0171)	(0.0058)	(0.1483)	(0.008)	(0.1468)
3000	-0.0069	-0.0058	-0.0654	-0.047	-0.0211	-0.0447
	(0.0158)	(0.0169)	(0.0055)	(0.1453)	(0.0073)	(0.1465)
3500	-0.0025	-0.0017	-0.059	-0.0452	-0.0198	-0.0441
	(0.0165)	(0.0176)	(0.0052)	(0.1477)	(0.0068)	(0.1481)
4000	0.0014	0.0018	-0.0484	-0.0281	-0.0131	-0.0273
	(0.0158)	(0.017)	(0.0049)	(0.1487)	(0.0063)	(0.1487)
4500	0.0065	0.0061	-0.0337	-0.0312	-0.0015	-0.0296
	(0.0154)	(0.0165)	(0.0047)	(0.1466)	(0.0061)	(0.1477)
5000	0.0117	0.0106	-0.0155	-0.011	0.014	-0.0091
	(0.0148)	(0.0159)	(0.0045)	(0.1492)	(0.0058)	(0.1504)

APPENDIX K: STATIONARY LDA MISSING DATA SIMULATION

Table K.1: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 50) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.1, missing data = 5%

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3724	0.3727	0.3726	0.1915	0.3478	0.1849
	(0.0528)	(0.0527)	(0.0526)	(0.0197)	(0.0466)	(0.0184)
100	0.2239	0.2354	0.2277	0.1563	0.2239	0.1529
	(0.0267)	(0.0379)	(0.03)	(0.0114)	(0.0281)	(0.0108)
500	0.12	0.1214	0.1202	0.1164	0.1207	0.1158
	(0.0042)	(0.0047)	(0.0043)	(0.0031)	(0.0098)	(0.003)
1000	0.1097	0.1102	0.1102	0.1091	0.1101	0.1089
	(0.0019)	(0.0022)	(0.0078)	(0.0018)	(0.0058)	(0.0017)
1500	0.1064	0.1068	0.1066	0.1065	0.1069	0.1064
	(0.0013)	(0.0014)	(0.0014)	(0.0013)	(0.0041)	(0.0013)
2000	0.1048	0.1052	0.1051	0.1054	0.1054	0.1052
	(0.001)	(0.0015)	(0.0011)	(0.0011)	(0.0037)	(0.0011)
2500	0.1039	0.1043	0.1043	0.1047	0.1046	0.1046
	(8e-04)	(9e-04)	(9e-04)	(9e-04)	(0.003)	(9e-04)
3000	0.1032	0.1037	0.1038	0.1043	0.1041	0.1042
	(6e-04)	(8e-04)	(8e-04)	(8e-04)	(0.0029)	(8e-04)
3500	0.1028	0.1033	0.1035	0.1039	0.1038	0.1038
	(6e-04)	(7e-04)	(7e-04)	(7e-04)	(0.0033)	(7e-04)
4000	0.1024	0.103	0.1034	0.1038	0.1037	0.1037
	(5e-04)	(6e-04)	(7e-04)	(7e-04)	(0.0035)	(7e-04)
4500	0.1021	0.1029	0.1033	0.1036	0.1036	0.1036
	(4e-04)	(0.0034)	(8e-04)	(7e-04)	(0.0036)	(7e-04)
5000	0.1019	0.1027	0.1032	0.1036	0.1034	0.1035
	(4e-04)	(8e-04)	(7e-04)	(7e-04)	(0.0029)	(7e-04)

Table K.2: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 100) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.1, missing data = 5%

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.343	0.3431	0.3426	0.2212	0.256	0.2151
	(0.0368)	(0.0368)	(0.037)	(0.0238)	(0.0291)	(0.0228)
100	0.3808	0.3807	0.3804	0.1817	0.3559	0.1787
	(0.0393)	(0.0394)	(0.0393)	(0.0151)	(0.0368)	(0.0145)
500	0.1455	0.1529	0.1489	0.1291	0.203	0.1286
	(0.0072)	(0.0138)	(0.0083)	(0.0047)	(0.0761)	(0.0046)
1000	0.1242	0.1265	0.1257	0.1201	0.1693	0.12
	(0.004)	(0.0074)	(0.0117)	(0.0033)	(0.0718)	(0.0033)
1500	0.1169	0.1187	0.1188	0.1169	0.1509	0.1169
	(0.0027)	(0.0041)	(0.0144)	(0.0028)	(0.0544)	(0.0029)
2000	0.1131	0.1147	0.1158	0.1153	0.1409	0.1154
	(0.0021)	(0.0027)	(0.0209)	(0.0028)	(0.0456)	(0.0028)
2500	0.1107	0.1125	0.1128	0.1142	0.1368	0.1143
	(0.0018)	(0.0041)	(0.0144)	(0.0026)	(0.0384)	(0.0026)
3000	0.1091	0.1112	0.1121	0.1135	0.1335	0.1137
	(0.0015)	(0.0089)	(0.0204)	(0.0025)	(0.0344)	(0.0026)
3500	0.1079	0.1101	0.1115	0.113	0.1322	0.1132
	(0.0013)	(0.0032)	(0.0225)	(0.0025)	(0.0292)	(0.0025)
4000	0.107	0.1097	0.1104	0.1127	0.1323	0.1129
	(0.0012)	(0.0072)	(0.0184)	(0.0025)	(0.0326)	(0.0025)
4500	0.1063	0.109	0.1104	0.1124	0.1364	0.1127
	(0.0011)	(0.0033)	(0.0221)	(0.0026)	(0.0429)	(0.0025)
5000	0.1057	0.1086	0.1101	0.1123	0.1385	0.1126
	(0.001)	(0.002)	(0.022)	(0.0024)	(0.0464)	(0.0025)

Table K.3: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.1, missing data = 5%

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3454	0.3456	0.3455	0.2313	0.284	0.228
	(0.0364)	(0.0364)	(0.0365)	(0.0219)	(0.0309)	(0.0216)
100	0.3918	0.3917	0.3921	0.1847	0.3688	0.1833
	(0.0413)	(0.0414)	(0.0412)	(0.0128)	(0.0368)	(0.0125)
500	0.142	0.1489	0.1449	0.1277	0.1877	0.1277
	(0.0062)	(0.0132)	(0.0118)	(0.0037)	(0.0721)	(0.0036)
1000	0.12	0.1217	0.1215	0.1168	0.1417	0.1169
	(0.0029)	(0.0036)	(0.0146)	(0.0022)	(0.0394)	(0.0022)
1500	0.1131	0.1141	0.1156	0.1126	0.1298	0.1127
	(0.0019)	(0.0021)	(0.0203)	(0.0017)	(0.0288)	(0.0016)
2000	0.1098	0.1107	0.1123	0.1105	0.124	0.1105
	(0.0014)	(0.0016)	(0.0166)	(0.0014)	(0.0258)	(0.0014)
2500	0.1078	0.1088	0.1114	0.1092	0.1219	0.1092
	(0.0011)	(0.0028)	(0.0228)	(0.0011)	(0.0242)	(0.0011)
3000	0.1065	0.1074	0.1097	0.1083	0.1206	0.1084
	(9e-04)	(0.0017)	(0.0173)	(0.001)	(0.0273)	(0.001)
3500	0.1056	0.1065	0.1089	0.1078	0.1193	0.1078
	(8e-04)	(0.001)	(0.0168)	(0.001)	(0.0223)	(0.001)
4000	0.1048	0.1059	0.1085	0.1073	0.1193	0.1074
	(7e-04)	(0.0021)	(0.0182)	(9e-04)	(0.0257)	(9e-04)
4500	0.1043	0.1054	0.108	0.107	0.1191	0.1071
	(6e-04)	(9e-04)	(0.0157)	(9e-04)	(0.0271)	(9e-04)
5000	0.1039	0.105	0.108	0.1068	0.1184	0.1068
	(5e-04)	(8e-04)	(0.0174)	(9e-04)	(0.0234)	(9e-04)

Table K.4: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.05, missing data = 10%

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3047	0.3046	0.3044	0.1618	0.2103	0.1566
	(0.0388)	(0.039)	(0.0389)	(0.0196)	(0.0292)	(0.0188)
100	0.3246	0.3245	0.3245	0.117	0.3045	0.1148
	(0.0437)	(0.0439)	(0.0437)	(0.0102)	(0.0413)	(0.0098)
500	0.0817	0.0869	0.0843	0.0711	0.1266	0.071
	(0.0051)	(0.0078)	(0.0129)	(0.0027)	(0.0795)	(0.0026)
1000	0.0644	0.0656	0.0654	0.0629	0.0817	0.0629
	(0.0021)	(0.0029)	(0.0122)	(0.0016)	(0.0351)	(0.0016)
1500	0.0592	0.06	0.0603	0.0598	0.0713	0.0598
	(0.0014)	(0.0021)	(0.0121)	(0.0012)	(0.0256)	(0.0012)
2000	0.0568	0.0577	0.0582	0.0581	0.0686	0.0581
	(0.001)	(0.0095)	(0.0114)	(0.001)	(0.0276)	(0.001)
2500	0.0554	0.056	0.0573	0.0571	0.067	0.0572
	(8e-04)	(0.001)	(0.0137)	(9e-04)	(0.0249)	(9e-04)
3000	0.0545	0.0551	0.0567	0.0565	0.0658	0.0565
	(6e-04)	(8e-04)	(0.0159)	(7e-04)	(0.0237)	(7e-04)
3500	0.0538	0.0545	0.0567	0.0561	0.0652	0.0561
	(6e-04)	(7e-04)	(0.0208)	(7e-04)	(0.0226)	(7e-04)
4000	0.0533	0.0541	0.0564	0.0558	0.065	0.0558
	(5e-04)	(0.0017)	(0.0209)	(7e-04)	(0.0248)	(7e-04)
4500	0.0529	0.0537	0.0562	0.0556	0.0646	0.0556
	(4e-04)	(6e-04)	(0.02)	(7e-04)	(0.0232)	(7e-04)
5000	0.0526	0.0534	0.0565	0.0554	0.0639	0.0554
	(4e-04)	(5e-04)	(0.0243)	(6e-04)	(0.0203)	(6e-04)

Table K.5: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.1, missing data = 5%

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4077	0.4077	0.4077	0.2995	0.3157	0.2961
	(0.0277)	(0.0278)	(0.0277)	(0.0235)	(0.0249)	(0.0235)
100	0.3516	0.3516	0.3516	0.2417	0.2903	0.2397
	(0.0243)	(0.0243)	(0.0243)	(0.0156)	(0.0205)	(0.0154)
500	0.2243	0.2243	0.2243	0.1536	0.2792	0.1532
	(0.0121)	(0.0121)	(0.0121)	(0.0044)	(0.0282)	(0.0043)
1000	0.1565	0.1565	0.1565	0.1347	0.2787	0.1346
	(0.0055)	(0.0055)	(0.0055)	(0.0027)	(0.0763)	(0.0027)
1500	0.1366	0.1367	0.1367	0.1268	0.2155	0.1267
	(0.0035)	(0.0035)	(0.0035)	(0.0021)	(0.0398)	(0.0021)
2000	0.127	0.127	0.127	0.1223	0.2213	0.1222
	(0.0026)	(0.0026)	(0.0026)	(0.0018)	(0.0482)	(0.0017)
2500	0.1214	0.1214	0.1214	0.1194	0.1794	0.1193
	(0.002)	(0.002)	(0.002)	(0.0015)	(0.0389)	(0.0014)
3000	0.1178	0.1178	0.1178	0.1172	0.1659	0.1172
	(0.0016)	(0.0017)	(0.0016)	(0.0014)	(0.0342)	(0.0014)
3500	0.1152	0.1152	0.1152	0.1157	0.1572	0.1157
	(0.0014)	(0.0014)	(0.0014)	(0.0012)	(0.0327)	(0.0012)
4000	0.1133	0.1133	0.1133	0.1145	0.1519	0.1145
	(0.0012)	(0.0012)	(0.0012)	(0.0011)	(0.0281)	(0.0011)
4500	0.1118	0.1118	0.1118	0.1135	0.1498	0.1135
	(0.0011)	(0.0011)	(0.0011)	(0.0011)	(0.0276)	(0.0011)
5000	0.1106	0.1106	0.1106	0.1128	0.1465	0.1128
	(0.001)	(0.001)	(0.001)	(0.0011)	(0.0263)	(0.0011)

Table K.6: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses. Optimal error rate=0.05, missing data = 10%

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3595	0.3596	0.3594	0.2231	0.2479	0.2183
	(0.0334)	(0.0335)	(0.0335)	(0.0239)	(0.0285)	(0.0234)
100	0.2916	0.2915	0.2914	0.1612	0.2277	0.1585
	(0.0251)	(0.0252)	(0.0252)	(0.0132)	(0.0234)	(0.0128)
500	0.1712	0.1713	0.1713	0.0885	0.2379	0.0877
	(0.013)	(0.013)	(0.0131)	(0.0033)	(0.0337)	(0.0033)
1000	0.101	0.101	0.101	0.0753	0.2413	0.0749
	(0.0054)	(0.0054)	(0.0054)	(0.002)	(0.0839)	(0.002)
1500	0.0821	0.0821	0.0821	0.0698	0.1681	0.0695
	(0.0033)	(0.0033)	(0.0033)	(0.0016)	(0.0467)	(0.0015)
2000	0.0732	0.0732	0.0732	0.0666	0.1806	0.0663
	(0.0023)	(0.0023)	(0.0023)	(0.0013)	(0.0574)	(0.0013)
2500	0.0682	0.0682	0.0682	0.0644	0.1249	0.0642
	(0.0018)	(0.0018)	(0.0018)	(0.0011)	(0.0412)	(0.0011)
3000	0.065	0.065	0.065	0.0629	0.1153	0.0628
	(0.0015)	(0.0015)	(0.0015)	(0.001)	(0.0401)	(0.001)
3500	0.0628	0.0628	0.0628	0.0619	0.1072	0.0617
	(0.0013)	(0.0013)	(0.0013)	(0.001)	(0.0368)	(9e-04)
4000	0.0611	0.0611	0.0611	0.061	0.1039	0.0609
	(0.0011)	(0.0011)	(0.0011)	(9e-04)	(0.0348)	(9e-04)
4500	0.0599	0.0599	0.0599	0.0604	0.1016	0.0602
	(0.001)	(0.001)	(0.001)	(8e-04)	(0.0315)	(8e-04)
5000	0.0589	0.0589	0.0589	0.0598	0.0982	0.0597
	(9e-04)	(9e-04)	(9e-04)	(8e-04)	(0.0311)	(8e-04)

APPENDIX L: ABRUPT LDA MISSING DATA SIMULATION

Table L.1: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 50) under abrupt drift (priors: Equal) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05, missing data = 5%

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3746	0.3743	0.3746	0.1214	0.3193	0.1167
	(0.0623)	(0.0627)	(0.0623)	(0.0165)	(0.0538)	(0.0146)
100	0.16	0.1763	0.1646	0.0925	0.1617	0.0907
	(0.0262)	(0.0459)	(0.0302)	(0.0085)	(0.0306)	(0.008)
500	0.0653	0.0664	0.0655	0.0629	0.0664	0.0627
	(0.0033)	(0.0035)	(0.0033)	(0.0023)	(0.0092)	(0.0023)
1000	0.0573	0.0577	0.0574	0.0574	0.0586	0.0573
	(0.0015)	(0.0016)	(0.0016)	(0.0014)	(0.0132)	(0.0013)
1500	0.0548	0.0552	0.055	0.0555	0.0558	0.0554
	(0.001)	(0.0021)	(0.0013)	(0.001)	(0.0072)	(0.001)
2000	0.0536	0.0539	0.0539	0.0545	0.0547	0.0545
	(7e-04)	(9e-04)	(8e-04)	(8e-04)	(0.0078)	(8e-04)
2500	0.0529	0.0532	0.0533	0.054	0.054	0.0539
	(6e-04)	(7e-04)	(9e-04)	(7e-04)	(0.007)	(7e-04)
3000	0.3839	0.104	0.2005	0.1533	0.233	0.1557
	(0.0118)	(0.0102)	(0.0193)	(0.0121)	(0.0124)	(0.0123)
3500	0.2807	0.0666	0.1113	0.0908	0.1354	0.0912
	(0.0075)	(0.0096)	(0.0119)	(0.0053)	(0.0099)	(0.0054)
4000	0.2303	0.0581	0.0764	0.0702	0.0874	0.0703
	(0.0057)	(0.002)	(0.0058)	(0.0029)	(0.0104)	(0.0029)
4500	0.1993	0.0554	0.0634	0.0615	0.0683	0.0615
	(0.0046)	(0.003)	(0.0034)	(0.0018)	(0.011)	(0.0018)
5000	0.1777	0.054	0.0579	0.0572	0.0604	0.0572
	(0.0039)	(0.0021)	(0.0019)	(0.0012)	(0.0114)	(0.0012)

Table L.2: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 100) under abrupt drift (priors: Equal) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3495	0.3496	0.3496	0.2276	0.2634	0.2224
	(0.0371)	(0.0374)	(0.0371)	(0.0234)	(0.0288)	(0.0222)
100	0.4174	0.4175	0.4176	0.1852	0.3652	0.1828
	(0.0411)	(0.0417)	(0.0412)	(0.0152)	(0.037)	(0.0148)
500	0.1429	0.1489	0.1459	0.1313	0.1955	0.1311
	(0.0067)	(0.0096)	(0.0078)	(0.0044)	(0.0723)	(0.0043)
1000	0.1229	0.1252	0.1254	0.1222	0.1641	0.1222
	(0.0035)	(0.0074)	(0.0182)	(0.0036)	(0.0669)	(0.0035)
1500	0.1159	0.1175	0.1174	0.1186	0.1484	0.1188
	(0.0024)	(0.0032)	(0.0052)	(0.0031)	(0.0568)	(0.0031)
2000	0.1124	0.114	0.1142	0.1169	0.1378	0.1171
	(0.0019)	(0.0029)	(0.0121)	(0.0029)	(0.0432)	(0.0029)
2500	0.1101	0.1118	0.1117	0.1156	0.1343	0.1159
	(0.0016)	(0.0022)	(0.0026)	(0.0028)	(0.0387)	(0.0028)
3000	0.3705	0.1992	0.2602	0.1905	0.2868	0.189
	(0.0122)	(0.0193)	(0.016)	(0.0143)	(0.0433)	(0.0145)
3500	0.292	0.138	0.1758	0.1359	0.2176	0.1353
	(0.0089)	(0.0119)	(0.0144)	(0.0067)	(0.0392)	(0.0067)
4000	0.2474	0.1223	0.14	0.1204	0.181	0.1204
	(0.0069)	(0.0066)	(0.0107)	(0.0036)	(0.0511)	(0.0039)
4500	0.2187	0.1168	0.1244	0.115	0.1601	0.1153
	(0.0055)	(0.0111)	(0.0087)	(0.0024)	(0.0487)	(0.003)
5000	0.1986	0.1136	0.117	0.1128	0.153	0.1132
	(0.0046)	(0.0088)	(0.0028)	(0.0022)	(0.0539)	(0.0028)

Table L.3: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under abrupt drift (priors: Equal) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05, missing data = 5%

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.2813	0.2811	0.281	0.1444	0.2034	0.1393
	(0.0382)	(0.0383)	(0.0385)	(0.0169)	(0.0302)	(0.0159)
100	0.352	0.3519	0.3521	0.1065	0.3208	0.1043
	(0.0474)	(0.0474)	(0.0471)	(0.0089)	(0.0403)	(0.0086)
500	0.0798	0.0844	0.0822	0.0685	0.1247	0.0682
	(0.0048)	(0.007)	(0.013)	(0.0024)	(0.0738)	(0.0024)
1000	0.0635	0.0648	0.0644	0.0614	0.0838	0.0613
	(0.002)	(0.007)	(0.0102)	(0.0015)	(0.0418)	(0.0014)
1500	0.0587	0.0597	0.0601	0.0586	0.0732	0.0585
	(0.0013)	(0.0106)	(0.0117)	(0.001)	(0.0294)	(0.001)
2000	0.0565	0.0572	0.0582	0.0572	0.0703	0.0571
	(0.001)	(0.003)	(0.0128)	(9e-04)	(0.0316)	(9e-04)
2500	0.0551	0.0557	0.0572	0.0564	0.0682	0.0563
	(7e-04)	(9e-04)	(0.0152)	(8e-04)	(0.0256)	(8e-04)
3000	0.2629	0.1246	0.1633	0.1302	0.1957	0.1298
	(0.0091)	(0.0126)	(0.0126)	(0.0127)	(0.0278)	(0.0129)
3500	0.1933	0.0786	0.1085	0.0895	0.1442	0.0894
	(0.0058)	(0.0127)	(0.0159)	(0.0066)	(0.0304)	(0.0066)
4000	0.1615	0.0653	0.082	0.0738	0.1142	0.0737
	(0.0043)	(0.0045)	(0.02)	(0.0039)	(0.0307)	(0.0039)
4500	0.1427	0.0607	0.0703	0.0658	0.0988	0.0658
	(0.0035)	(0.0123)	(0.0286)	(0.0025)	(0.0384)	(0.0025)
5000	0.1297	0.0577	0.0646	0.061	0.0894	0.061
	(0.0029)	(0.0069)	(0.0313)	(0.0016)	(0.046)	(0.0016)

Table L.4: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under abrupt drift (priors: Equal) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.05, missing data = 5%

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3638	0.3636	0.3636	0.2158	0.2366	0.2116
	(0.0314)	(0.0313)	(0.0314)	(0.0229)	(0.0266)	(0.0225)
100	0.294	0.2939	0.2939	0.1563	0.2143	0.1542
	(0.0256)	(0.0256)	(0.0256)	(0.0119)	(0.0201)	(0.0117)
500	0.1566	0.1567	0.1566	0.0865	0.222	0.086
	(0.0113)	(0.0113)	(0.0113)	(0.0032)	(0.0318)	(0.0031)
1000	0.0933	0.0933	0.0933	0.0736	0.2313	0.0734
	(0.0044)	(0.0044)	(0.0044)	(0.002)	(0.0853)	(0.0019)
1500	0.0769	0.0769	0.0769	0.0684	0.1558	0.0683
	(0.0028)	(0.0028)	(0.0028)	(0.0015)	(0.041)	(0.0015)
2000	0.0695	0.0695	0.0695	0.0654	0.1673	0.0653
	(0.002)	(0.002)	(0.002)	(0.0012)	(0.0516)	(0.0012)
2500	0.0653	0.0653	0.0653	0.0634	0.1173	0.0633
	(0.0015)	(0.0015)	(0.0015)	(0.001)	(0.0382)	(0.001)
3000	0.2667	0.2667	0.2668	0.0976	0.2145	0.0968
	(0.0092)	(0.0092)	(0.0092)	(0.0092)	(0.0335)	(0.0092)
3500	0.199	0.1991	0.1991	0.0765	0.1631	0.076
	(0.0061)	(0.0061)	(0.0061)	(0.004)	(0.0309)	(0.0039)
4000	0.1665	0.1666	0.1666	0.069	0.1385	0.0688
	(0.0046)	(0.0046)	(0.0046)	(0.0024)	(0.0271)	(0.0023)
4500	0.1469	0.1469	0.1469	0.0652	0.1241	0.065
	(0.0037)	(0.0037)	(0.0037)	(0.0017)	(0.0246)	(0.0017)
5000	0.1334	0.1334	0.1334	0.0628	0.1143	0.0626
	(0.0031)	(0.0031)	(0.0031)	(0.0013)	(0.0239)	(0.0013)

APPENDIX M: GRADUAL LDA MISSING DATA SIMULATION

Table M.1: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 50) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1, missing data = 5%

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4098	0.4097	0.4099	0.1849	0.3666	0.1814
	(0.0524)	(0.0524)	(0.0526)	(0.0192)	(0.0468)	(0.0177)
100	0.2316	0.2487	0.237	0.1558	0.2332	0.1543
	(0.0286)	(0.0455)	(0.0333)	(0.0113)	(0.0314)	(0.0107)
500	0.1497	0.1516	0.15	0.1414	0.1513	0.1411
	(0.0052)	(0.0061)	(0.0052)	(0.0033)	(0.0172)	(0.0032)
1000	0.1635	0.1637	0.1635	0.1594	0.1644	0.159
	(0.0031)	(0.0032)	(0.0043)	(0.0021)	(0.0093)	(0.002)
1500	0.1821	0.1812	0.1815	0.1788	0.1823	0.1783
	(0.0029)	(0.0036)	(0.0029)	(0.0021)	(0.0086)	(0.0021)
2000	0.198	0.1948	0.1958	0.1944	0.1969	0.1936
	(0.0032)	(0.0044)	(0.0031)	(0.0024)	(0.0104)	(0.0023)
2500	0.2091	0.2007	0.2035	0.2031	0.2047	0.2022
	(0.0037)	(0.0037)	(0.0037)	(0.0029)	(0.0071)	(0.0029)
3000	0.2142	0.1979	0.2032	0.2035	0.2048	0.2024
	(0.004)	(0.0041)	(0.0038)	(0.0032)	(0.0073)	(0.0031)
3500	0.2127	0.1861	0.194	0.1943	0.1961	0.1933
	(0.0043)	(0.004)	(0.0042)	(0.0036)	(0.0076)	(0.0034)
4000	0.2052	0.1672	0.1769	0.1768	0.1794	0.176
	(0.0043)	(0.0037)	(0.0043)	(0.0036)	(0.008)	(0.0035)
4500	0.1923	0.1437	0.1532	0.1536	0.156	0.1533
	(0.0044)	(0.0039)	(0.0043)	(0.0036)	(0.0094)	(0.0035)
5000	0.1755	0.1182	0.1259	0.1282	0.1286	0.1283
	(0.0043)	(0.0032)	(0.0034)	(0.0033)	(0.0083)	(0.0032)

Table M.2: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1, missing data = 5%

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3415	0.3415	0.3415	0.2328	0.2951	0.2277
	(0.0347)	(0.0346)	(0.0347)	(0.0216)	(0.033)	(0.021)
100	0.4335	0.4336	0.4337	0.1903	0.3885	0.1877
	(0.037)	(0.0368)	(0.037)	(0.0133)	(0.0341)	(0.013)
500	0.1757	0.1871	0.1807	0.1562	0.2131	0.1559
	(0.0073)	(0.0153)	(0.0102)	(0.004)	(0.061)	(0.0039)
1000	0.1805	0.1829	0.1822	0.1727	0.1977	0.1726
	(0.004)	(0.0071)	(0.0135)	(0.0025)	(0.0291)	(0.0024)
1500	0.1986	0.1989	0.1998	0.1935	0.2128	0.1934
	(0.0036)	(0.0075)	(0.013)	(0.0023)	(0.0251)	(0.0023)
2000	0.2159	0.2138	0.216	0.2107	0.2286	0.2107
	(0.0037)	(0.0038)	(0.0186)	(0.0026)	(0.0272)	(0.0025)
2500	0.229	0.2233	0.2248	0.2204	0.2378	0.2207
	(0.004)	(0.0054)	(0.0154)	(0.0029)	(0.0243)	(0.0029)
3000	0.2357	0.2237	0.2244	0.2201	0.2384	0.2206
	(0.0043)	(0.0043)	(0.0163)	(0.0031)	(0.0235)	(0.0031)
3500	0.2351	0.214	0.2135	0.2091	0.2291	0.2098
	(0.0046)	(0.0044)	(0.0164)	(0.0033)	(0.0235)	(0.0033)
4000	0.2276	0.195	0.1937	0.1897	0.2105	0.1904
	(0.0049)	(0.0056)	(0.0197)	(0.0032)	(0.0225)	(0.0032)
4500	0.2142	0.1686	0.1669	0.165	0.1855	0.1655
	(0.0049)	(0.0065)	(0.0195)	(0.0029)	(0.0257)	(0.003)
5000	0.1959	0.1376	0.1366	0.1378	0.1559	0.138
	(0.0048)	(0.0042)	(0.0237)	(0.0028)	(0.0283)	(0.0028)

Table M.3: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses. Optimal error rate = 0.1, missing data = 5%

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4076	0.4078	0.4077	0.3005	0.3169	0.297
	(0.028)	(0.0279)	(0.0279)	(0.0233)	(0.0248)	(0.0228)
100	0.3555	0.3556	0.3556	0.245	0.2934	0.243
	(0.0237)	(0.0236)	(0.0236)	(0.0146)	(0.0199)	(0.0145)
500	0.2489	0.2489	0.249	0.1779	0.299	0.1774
	(0.0119)	(0.0119)	(0.0118)	(0.0046)	(0.0253)	(0.0046)
1000	0.2085	0.2085	0.2085	0.183	0.3202	0.1827
	(0.0061)	(0.0061)	(0.0061)	(0.003)	(0.0647)	(0.003)
1500	0.2109	0.2109	0.2109	0.1975	0.273	0.1973
	(0.0044)	(0.0044)	(0.0044)	(0.0026)	(0.0341)	(0.0026)
2000	0.2201	0.2201	0.2201	0.2119	0.2685	0.2118
	(0.0039)	(0.0039)	(0.0039)	(0.0026)	(0.0306)	(0.0026)
2500	0.2288	0.2288	0.2288	0.2218	0.2643	0.222
	(0.004)	(0.004)	(0.004)	(0.0028)	(0.0207)	(0.0028)
3000	0.234	0.234	0.234	0.2247	0.2524	0.225
	(0.0041)	(0.0041)	(0.0041)	(0.003)	(0.0188)	(0.003)
3500	0.2343	0.2343	0.2343	0.2192	0.2407	0.2195
	(0.0044)	(0.0044)	(0.0044)	(0.0031)	(0.0195)	(0.0031)
4000	0.2293	0.2293	0.2293	0.2054	0.225	0.2057
	(0.0046)	(0.0046)	(0.0046)	(0.0032)	(0.0207)	(0.0032)
4500	0.219	0.2189	0.2189	0.1854	0.2052	0.1856
	(0.0046)	(0.0046)	(0.0047)	(0.0031)	(0.0208)	(0.0031)
5000	0.2039	0.2039	0.2039	0.1613	0.1822	0.1614
	(0.0047)	(0.0047)	(0.0047)	(0.003)	(0.0205)	(0.003)

APPENDIX L: STATIONARY QDA SIMULATION

Table N.1: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 10) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4558	0.4565	0.4561	0.4542	0.4417	0.4614
	(0.0742)	(0.0745)	(0.0746)	(0.0705)	(0.0692)	(0.0692)
100	0.4052	0.4057	0.4057	0.4198	0.3986	0.4264
	(0.0533)	(0.0531)	(0.0532)	(0.0494)	(0.0497)	(0.0485)
500	0.3159	0.3175	0.3162	0.3327	0.3142	0.3358
	(0.0238)	(0.0256)	(0.0239)	(0.0242)	(0.023)	(0.024)
1000	0.2911	0.2932	0.2913	0.3026	0.2901	0.3047
	(0.0169)	(0.0214)	(0.0168)	(0.018)	(0.0167)	(0.0177)
1500	0.2802	0.2827	0.2804	0.2891	0.2795	0.2907
	(0.0141)	(0.0208)	(0.0141)	(0.0152)	(0.014)	(0.0151)
2000	0.2736	0.2763	0.2738	0.2809	0.273	0.2822
	(0.0127)	(0.0211)	(0.0126)	(0.0136)	(0.0125)	(0.0136)
2500	0.2692	0.2719	0.2693	0.2754	0.2686	0.2765
	(0.0117)	(0.0212)	(0.0117)	(0.0126)	(0.0115)	(0.0127)
3000	0.2661	0.2692	0.2663	0.2717	0.2657	0.2726
	(0.0109)	(0.0215)	(0.0109)	(0.0118)	(0.0107)	(0.0119)
3500	0.2638	0.267	0.2639	0.2688	0.2634	0.2696
	(0.0104)	(0.0218)	(0.0103)	(0.0112)	(0.0102)	(0.0113)
4000	0.262	0.2653	0.2621	0.2665	0.2616	0.2673
	(0.01)	(0.022)	(0.0099)	(0.0106)	(0.0097)	(0.0107)
4500	0.2605	0.2638	0.2605	0.2646	0.26	0.2652
	(0.0097)	(0.0223)	(0.0095)	(0.0102)	(0.0094)	(0.0103)
5000	0.2592	0.2626	0.2592	0.263	0.2588	0.2636
	(0.0092)	(0.0225)	(0.009)	(0.0097)	(0.0089)	(0.0097)

Table N.2: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 10) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4448	0.4446	0.4448	0.4232	0.4302	0.4306
	(0.0708)	(0.0707)	(0.0704)	(0.0705)	(0.0678)	(0.0742)
100	0.3712	0.3714	0.371	0.3769	0.3666	0.3851
	(0.0499)	(0.0498)	(0.0499)	(0.0485)	(0.0488)	(0.0513)
500	0.2561	0.2573	0.256	0.2668	0.2562	0.2697
	(0.0198)	(0.0237)	(0.0198)	(0.0196)	(0.0197)	(0.0197)
1000	0.2299	0.2317	0.2299	0.2367	0.2301	0.2383
	(0.0135)	(0.0212)	(0.0135)	(0.0133)	(0.0135)	(0.0134)
1500	0.2197	0.2216	0.2196	0.2247	0.2198	0.2258
	(0.0107)	(0.021)	(0.0107)	(0.0105)	(0.0108)	(0.0107)
2000	0.214	0.2162	0.2139	0.218	0.2141	0.2188
	(0.0093)	(0.0222)	(0.0092)	(0.0091)	(0.0094)	(0.0093)
2500	0.2104	0.213	0.2104	0.2137	0.2105	0.2143
	(0.0081)	(0.0231)	(0.0081)	(0.008)	(0.0083)	(0.0081)
3000	0.2077	0.2105	0.2077	0.2105	0.2078	0.2111
	(0.0073)	(0.0242)	(0.0073)	(0.0073)	(0.0074)	(0.0074)
3500	0.2057	0.2087	0.2057	0.2081	0.2058	0.2086
	(0.0068)	(0.0252)	(0.0069)	(0.0069)	(0.0069)	(0.0069)
4000	0.2041	0.2073	0.2041	0.2062	0.2042	0.2067
	(0.0066)	(0.0261)	(0.0066)	(0.0066)	(0.0066)	(0.0066)
4500	0.2029	0.2062	0.2029	0.2048	0.203	0.2052
	(0.0062)	(0.0268)	(0.0062)	(0.0062)	(0.0062)	(0.0062)
5000	0.202	0.2054	0.202	0.2038	0.2021	0.2041
	(0.0059)	(0.0273)	(0.0059)	(0.0059)	(0.0059)	(0.0059)

Table N.3: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 25) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4989	0.4985	0.4991	0.4586	0.4536	0.4572
	(0.0754)	(0.0756)	(0.0756)	(0.0691)	(0.0685)	(0.0678)
100	0.4496	0.45	0.4501	0.4175	0.4253	0.4172
	(0.0552)	(0.0556)	(0.0553)	(0.048)	(0.0476)	(0.0473)
500	0.2811	0.2889	0.2813	0.2962	0.276	0.2988
	(0.0213)	(0.0274)	(0.0214)	(0.0243)	(0.0213)	(0.0246)
1000	0.232	0.2373	0.2321	0.2476	0.229	0.2497
	(0.0159)	(0.0187)	(0.016)	(0.0199)	(0.0162)	(0.0203)
1500	0.2095	0.2136	0.2095	0.2231	0.2073	0.225
	(0.0141)	(0.0153)	(0.014)	(0.0173)	(0.0143)	(0.0178)
2000	0.1955	0.1991	0.1956	0.2076	0.1938	0.2093
	(0.0127)	(0.0132)	(0.0126)	(0.0154)	(0.0131)	(0.0159)
2500	0.186	0.1894	0.1861	0.1971	0.1845	0.1987
	(0.0118)	(0.0118)	(0.0115)	(0.014)	(0.0121)	(0.0144)
3000	0.179	0.1823	0.1792	0.1893	0.1776	0.1907
	(0.0112)	(0.011)	(0.0109)	(0.0131)	(0.0115)	(0.0134)
3500	0.1735	0.1768	0.1737	0.1832	0.1723	0.1845
	(0.0105)	(0.0102)	(0.0102)	(0.0122)	(0.0109)	(0.0125)
4000	0.1691	0.1724	0.1694	0.1783	0.1681	0.1795
	(0.0101)	(0.0096)	(0.0097)	(0.0115)	(0.0104)	(0.0118)
4500	0.1654	0.1689	0.1658	0.1743	0.1646	0.1755
	(0.0097)	(0.0091)	(0.0093)	(0.0109)	(0.0099)	(0.0111)
5000	0.1624	0.1659	0.1628	0.171	0.1617	0.1721
	(0.0094)	(0.0087)	(0.0089)	(0.0104)	(0.0096)	(0.0106)

Table N.4: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 25) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4956	0.4953	0.4953	0.4636	0.4563	0.4736
	(0.0721)	(0.0721)	(0.0721)	(0.0704)	(0.0709)	(0.0719)
100	0.4488	0.4492	0.4486	0.4207	0.4271	0.4291
	(0.0527)	(0.0523)	(0.0526)	(0.0503)	(0.0462)	(0.0497)
500	0.2684	0.2753	0.2685	0.2762	0.2649	0.278
	(0.0196)	(0.0281)	(0.0196)	(0.0203)	(0.0191)	(0.0203)
1000	0.2158	0.2209	0.2159	0.2228	0.2141	0.2237
	(0.0132)	(0.0187)	(0.0131)	(0.0135)	(0.0129)	(0.0133)
1500	0.1937	0.1974	0.1937	0.1994	0.1926	0.2001
	(0.0106)	(0.0141)	(0.0105)	(0.0107)	(0.0103)	(0.0105)
2000	0.1812	0.1843	0.1813	0.1861	0.1804	0.1865
	(0.0089)	(0.0112)	(0.0088)	(0.0089)	(0.0087)	(0.0089)
2500	0.1729	0.1755	0.173	0.1771	0.1723	0.1775
	(0.0077)	(0.0096)	(0.0076)	(0.0078)	(0.0075)	(0.0077)
3000	0.167	0.1693	0.1671	0.1707	0.1665	0.171
	(0.0069)	(0.0084)	(0.0069)	(0.007)	(0.0068)	(0.007)
3500	0.1625	0.1645	0.1626	0.1658	0.1621	0.166
	(0.0062)	(0.0074)	(0.0062)	(0.0063)	(0.0061)	(0.0063)
4000	0.1589	0.1608	0.1591	0.162	0.1586	0.1621
	(0.0058)	(0.0068)	(0.0058)	(0.0059)	(0.0057)	(0.0058)
4500	0.156	0.1578	0.1562	0.1589	0.1557	0.159
	(0.0054)	(0.0062)	(0.0053)	(0.0054)	(0.0053)	(0.0053)
5000	0.1537	0.1554	0.1538	0.1563	0.1534	0.1564
	(0.0051)	(0.0058)	(0.0051)	(0.0052)	(0.0051)	(0.0051)

Table N.5: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 50) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5015	0.5016	0.5012	0.4639	0.4526	0.4594
	(0.0697)	(0.0696)	(0.0697)	(0.0697)	(0.0703)	(0.0694)
100	0.4947	0.4946	0.4943	0.4287	0.4403	0.4232
	(0.0537)	(0.0536)	(0.0536)	(0.0483)	(0.0479)	(0.047)
500	0.2954	0.3166	0.2982	0.2988	0.2964	0.2976
	(0.023)	(0.0396)	(0.0257)	(0.0263)	(0.0465)	(0.0263)
1000	0.2186	0.2314	0.2202	0.2392	0.2246	0.2394
	(0.0156)	(0.0237)	(0.0168)	(0.0223)	(0.0472)	(0.023)
1500	0.1833	0.1927	0.1846	0.207	0.1898	0.2075
	(0.0131)	(0.0177)	(0.0138)	(0.0199)	(0.0433)	(0.0207)
2000	0.1624	0.1699	0.1634	0.1865	0.1691	0.1873
	(0.0119)	(0.0149)	(0.0121)	(0.0178)	(0.0406)	(0.0186)
2500	0.1482	0.1548	0.1491	0.1726	0.155	0.1735
	(0.011)	(0.013)	(0.011)	(0.0163)	(0.039)	(0.017)
3000	0.1378	0.1438	0.1388	0.1623	0.1448	0.1632
	(0.0104)	(0.0117)	(0.0103)	(0.0153)	(0.0382)	(0.016)
3500	0.1298	0.1354	0.1308	0.1542	0.137	0.1552
	(0.0099)	(0.0106)	(0.0096)	(0.0144)	(0.0379)	(0.0149)
4000	0.1234	0.1288	0.1245	0.1476	0.1308	0.1487
	(0.0095)	(0.0098)	(0.009)	(0.0135)	(0.0377)	(0.0139)
4500	0.118	0.1234	0.1193	0.1423	0.1256	0.1434
	(0.0091)	(0.0092)	(0.0085)	(0.0128)	(0.0376)	(0.0133)
5000	0.1136	0.1189	0.115	0.1379	0.1214	0.139
	(0.0088)	(0.0087)	(0.0081)	(0.0123)	(0.0375)	(0.0127)

Table N.6: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 50) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4987	0.4985	0.4987	0.4688	0.4265	0.4706
	(0.0702)	(0.07)	(0.0702)	(0.0694)	(0.0688)	(0.067)
100	0.4934	0.4933	0.493	0.4319	0.4197	0.432
	(0.0541)	(0.0539)	(0.0539)	(0.0485)	(0.0474)	(0.0477)
500	0.2666	0.2875	0.2686	0.254	0.2584	0.2479
	(0.0214)	(0.0403)	(0.0239)	(0.0189)	(0.0324)	(0.0192)
1000	0.1817	0.1939	0.1828	0.18	0.1796	0.1759
	(0.0129)	(0.0227)	(0.014)	(0.012)	(0.0295)	(0.012)
1500	0.1459	0.1545	0.1467	0.1467	0.1454	0.1437
	(0.0093)	(0.0158)	(0.01)	(0.009)	(0.0262)	(0.0091)
2000	0.1257	0.1323	0.1263	0.1273	0.1258	0.1249
	(0.0076)	(0.0124)	(0.0081)	(0.0073)	(0.0246)	(0.0075)
2500	0.1125	0.118	0.1131	0.1146	0.1133	0.1125
	(0.0065)	(0.0101)	(0.0069)	(0.0062)	(0.0242)	(0.0064)
3000	0.1034	0.1081	0.104	0.1056	0.1044	0.1039
	(0.0058)	(0.0087)	(0.0061)	(0.0056)	(0.0237)	(0.0057)
3500	0.0965	0.1007	0.0971	0.0989	0.0978	0.0974
	(0.0052)	(0.0075)	(0.0054)	(0.005)	(0.0233)	(0.0051)
4000	0.0912	0.0949	0.0918	0.0936	0.0927	0.0923
	(0.0047)	(0.0068)	(0.005)	(0.0046)	(0.0229)	(0.0047)
4500	0.0869	0.0903	0.0876	0.0894	0.0887	0.0882
	(0.0043)	(0.0061)	(0.0045)	(0.0043)	(0.0226)	(0.0043)
5000	0.0834	0.0866	0.0842	0.086	0.0854	0.0849
	(0.0041)	(0.0056)	(0.0042)	(0.004)	(0.0223)	(0.004)

Table N.7: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 100) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4988	0.4988	0.4992	0.4754	0.4703	0.4659
	(0.0711)	(0.0709)	(0.0712)	(0.069)	(0.0741)	(0.0671)
100	0.4999	0.4998	0.5	0.4426	0.4431	0.4329
	(0.0499)	(0.0497)	(0.05)	(0.048)	(0.0562)	(0.0447)
500	0.355	0.4132	0.3791	0.3148	0.4195	0.3109
	(0.0294)	(0.0604)	(0.0491)	(0.0316)	(0.0608)	(0.0323)
1000	0.2327	0.2821	0.2524	0.2534	0.3777	0.2522
	(0.0176)	(0.0485)	(0.0358)	(0.0273)	(0.1074)	(0.0285)
1500	0.1787	0.2139	0.1928	0.2202	0.3557	0.2202
	(0.0132)	(0.0341)	(0.0253)	(0.0248)	(0.1298)	(0.0258)
2000	0.1476	0.1749	0.1586	0.1981	0.3375	0.1989
	(0.011)	(0.0264)	(0.0198)	(0.0233)	(0.1389)	(0.0244)
2500	0.1273	0.1497	0.1364	0.1827	0.3195	0.1841
	(0.0098)	(0.0218)	(0.0164)	(0.022)	(0.1423)	(0.023)
3000	0.1128	0.132	0.1206	0.171	0.3031	0.1728
	(0.009)	(0.0187)	(0.0141)	(0.0206)	(0.1429)	(0.0215)
3500	0.1019	0.1188	0.1089	0.1618	0.2885	0.1638
	(0.0084)	(0.0164)	(0.0125)	(0.0195)	(0.1416)	(0.0203)
4000	0.0933	0.1086	0.0998	0.1545	0.2756	0.1567
	(0.008)	(0.0148)	(0.0113)	(0.0188)	(0.1392)	(0.0196)
4500	0.0864	0.1004	0.0924	0.1484	0.2645	0.1509
	(0.0077)	(0.0135)	(0.0104)	(0.0179)	(0.1362)	(0.0186)
5000	0.0807	0.0937	0.0864	0.1432	0.2549	0.1459
	(0.0075)	(0.0124)	(0.0097)	(0.0172)	(0.1328)	(0.0179)

Table N.8: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4967	0.4965	0.4971	0.4795	0.4349	0.4784
	(0.0699)	(0.0699)	(0.0697)	(0.0736)	(0.0693)	(0.0742)
100	0.4987	0.4987	0.499	0.4514	0.3912	0.4456
	(0.0491)	(0.0491)	(0.0491)	(0.0504)	(0.046)	(0.0509)
500	0.3451	0.4048	0.3681	0.2757	0.373	0.2596
	(0.0282)	(0.0644)	(0.0487)	(0.0198)	(0.0709)	(0.0199)
1000	0.2131	0.2628	0.2309	0.1843	0.3172	0.1726
	(0.0157)	(0.0509)	(0.0346)	(0.0121)	(0.131)	(0.0122)
1500	0.1567	0.1914	0.1691	0.1406	0.2823	0.1317
	(0.0111)	(0.0352)	(0.0239)	(0.0087)	(0.1491)	(0.0088)
2000	0.1252	0.1517	0.1347	0.1149	0.2544	0.1078
	(0.0085)	(0.0268)	(0.0182)	(0.0069)	(0.1518)	(0.007)
2500	0.1053	0.1267	0.1131	0.0982	0.2316	0.0923
	(0.007)	(0.0215)	(0.0146)	(0.0058)	(0.1484)	(0.0058)
3000	0.0913	0.1094	0.0981	0.0862	0.2133	0.0812
	(0.0059)	(0.018)	(0.0123)	(0.0049)	(0.1433)	(0.005)
3500	0.081	0.0966	0.0871	0.0773	0.1991	0.073
	(0.0051)	(0.0155)	(0.0106)	(0.0044)	(0.1387)	(0.0044)
4000	0.0731	0.0869	0.0787	0.0705	0.1877	0.0666
	(0.0046)	(0.0136)	(0.0093)	(0.0039)	(0.1346)	(0.004)
4500	0.0669	0.0792	0.0721	0.065	0.1781	0.0614
	(0.0041)	(0.0121)	(0.0084)	(0.0036)	(0.1307)	(0.0036)
5000	0.0618	0.073	0.0667	0.0605	0.17	0.0573
	(0.0038)	(0.0109)	(0.0076)	(0.0033)	(0.1272)	(0.0033)

Table N.9: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 250) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5037	0.5037	0.504	0.4881	0.4863	0.4789
	(0.0692)	(0.0694)	(0.0695)	(0.0694)	(0.0694)	(0.068)
100	0.5032	0.5033	0.5033	0.4635	0.4765	0.4547
	(0.0504)	(0.0506)	(0.0504)	(0.0487)	(0.055)	(0.0484)
500	0.4996	0.4996	0.4996	0.3446	0.4067	0.3397
	(0.0227)	(0.0227)	(0.0228)	(0.0555)	(0.0496)	(0.0562)
1000	0.3617	0.4297	0.4105	0.3344	0.4087	0.3335
	(0.0258)	(0.0579)	(0.0549)	(0.0381)	(0.0499)	(0.0382)
1500	0.2597	0.35	0.3213	0.3185	0.3985	0.3206
	(0.0198)	(0.0751)	(0.0653)	(0.035)	(0.0503)	(0.0352)
2000	0.2015	0.2773	0.2528	0.3105	0.3926	0.3158
	(0.0154)	(0.0635)	(0.0539)	(0.0367)	(0.0544)	(0.0381)
2500	0.1646	0.227	0.2067	0.3046	0.3857	0.3123
	(0.0125)	(0.0521)	(0.044)	(0.0388)	(0.06)	(0.0414)
3000	0.1391	0.1918	0.1747	0.2996	0.3796	0.3101
	(0.0105)	(0.044)	(0.0369)	(0.0386)	(0.0638)	(0.0441)
3500	0.1205	0.1661	0.1513	0.2948	0.3746	0.3081
	(0.0092)	(0.0382)	(0.0318)	(0.038)	(0.0663)	(0.0465)
4000	0.1063	0.1465	0.1335	0.2906	0.3708	0.3069
	(0.0081)	(0.0337)	(0.0279)	(0.0367)	(0.0675)	(0.0487)
4500	0.0952	0.1311	0.1196	0.2867	0.3689	0.3058
	(0.0073)	(0.0301)	(0.0249)	(0.0355)	(0.0677)	(0.0506)
5000	0.0861	0.1187	0.1086	0.2835	0.3681	0.3051
	(0.0066)	(0.0273)	(0.0225)	(0.0346)	(0.0674)	(0.0524)

Table N.10: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 250) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5038	0.5041	0.5038	0.4872	0.4879	0.4792
	(0.0693)	(0.0694)	(0.0695)	(0.0677)	(0.0686)	(0.0665)
100	0.5032	0.5035	0.5034	0.462	0.4762	0.4543
	(0.0505)	(0.0504)	(0.0505)	(0.0482)	(0.056)	(0.0474)
500	0.4996	0.4996	0.4996	0.3442	0.4065	0.3393
	(0.0228)	(0.0228)	(0.0228)	(0.0557)	(0.0498)	(0.0563)
1000	0.3623	0.4297	0.411	0.3338	0.4095	0.3331
	(0.0255)	(0.0576)	(0.0545)	(0.0379)	(0.05)	(0.0384)
1500	0.2603	0.35	0.3219	0.3178	0.3992	0.3201
	(0.0195)	(0.075)	(0.065)	(0.0351)	(0.0512)	(0.0357)
2000	0.202	0.2773	0.2533	0.3092	0.394	0.3145
	(0.0151)	(0.0635)	(0.0536)	(0.036)	(0.0559)	(0.0382)
2500	0.1649	0.2271	0.2072	0.3029	0.386	0.311
	(0.0123)	(0.0522)	(0.0437)	(0.0377)	(0.062)	(0.0416)
3000	0.1394	0.1919	0.1751	0.2974	0.3789	0.3085
	(0.0104)	(0.0442)	(0.0367)	(0.0379)	(0.0664)	(0.0443)
3500	0.1208	0.1662	0.1516	0.2924	0.3735	0.3064
	(0.0091)	(0.0383)	(0.0316)	(0.0378)	(0.069)	(0.0466)
4000	0.1066	0.1466	0.1339	0.2884	0.3697	0.3051
	(0.008)	(0.0338)	(0.0277)	(0.037)	(0.0703)	(0.0486)
4500	0.0954	0.1313	0.1199	0.2844	0.3679	0.3038
	(0.0072)	(0.0302)	(0.0248)	(0.0358)	(0.0709)	(0.0502)
5000	0.0864	0.1188	0.1089	0.2814	0.3675	0.3031
	(0.0066)	(0.0273)	(0.0224)	(0.0352)	(0.071)	(0.0518)

Table N.11: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 250) under stationarity, for a covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5013	0.5016	0.5016	0.4277	0.483	0.4663
	(0.0673)	(0.0671)	(0.0673)	(0.0682)	(0.073)	(0.0662)
100	0.501	0.5014	0.5013	0.3841	0.4677	0.4359
	(0.0485)	(0.0483)	(0.0484)	(0.0579)	(0.059)	(0.0466)
500	0.4921	0.4923	0.4923	0.2572	0.3663	0.3093
	(0.0238)	(0.0238)	(0.0238)	(0.0709)	(0.0612)	(0.0591)
1000	0.3437	0.4175	0.4151	0.2251	0.3673	0.2974
	(0.0279)	(0.0607)	(0.0635)	(0.0501)	(0.0609)	(0.0424)
1500	0.2412	0.3313	0.3269	0.2038	0.3586	0.2818
	(0.0202)	(0.0734)	(0.0756)	(0.0448)	(0.0735)	(0.0401)
2000	0.1847	0.2579	0.2541	0.1937	0.3562	0.2753
	(0.0154)	(0.0597)	(0.0612)	(0.0442)	(0.0809)	(0.042)
2500	0.1495	0.2092	0.2061	0.1862	0.3509	0.2713
	(0.0124)	(0.0486)	(0.0496)	(0.045)	(0.0832)	(0.0464)
3000	0.1256	0.1758	0.1731	0.18	0.344	0.2683
	(0.0104)	(0.0409)	(0.0416)	(0.0447)	(0.0839)	(0.0504)
3500	0.1082	0.1516	0.1492	0.1749	0.3377	0.2665
	(0.009)	(0.0356)	(0.0358)	(0.0431)	(0.0844)	(0.0532)
4000	0.0951	0.1332	0.1311	0.1707	0.333	0.2652
	(0.0079)	(0.0316)	(0.0314)	(0.041)	(0.0844)	(0.0559)
4500	0.0849	0.1188	0.117	0.1669	0.3291	0.264
	(0.0071)	(0.0282)	(0.028)	(0.0391)	(0.0834)	(0.0579)
5000	0.0766	0.1073	0.1058	0.1635	0.3251	0.2631
	(0.0064)	(0.0255)	(0.0253)	(0.0371)	(0.0824)	(0.06)

Table N.12: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5038	0.5038	0.5039	0.4903	0.4493	0.4876
	(0.0713)	(0.0712)	(0.071)	(0.0713)	(0.0679)	(0.0713)
100	0.5028	0.5028	0.503	0.4698	0.3907	0.4638
	(0.05)	(0.0499)	(0.05)	(0.0491)	(0.0451)	(0.0489)
500	0.4996	0.4996	0.4995	0.2979	0.3237	0.2763
	(0.0223)	(0.0224)	(0.0223)	(0.0198)	(0.0329)	(0.019)
1000	0.3544	0.4127	0.3967	0.2059	0.358	0.1837
	(0.0245)	(0.0607)	(0.053)	(0.0129)	(0.0564)	(0.0117)
1500	0.2491	0.3229	0.3012	0.1529	0.3381	0.1348
	(0.0179)	(0.0749)	(0.0616)	(0.0095)	(0.0801)	(0.0085)
2000	0.1903	0.2506	0.2327	0.1199	0.3356	0.1055
	(0.0137)	(0.0613)	(0.0496)	(0.0073)	(0.0906)	(0.0066)
2500	0.1536	0.2027	0.1883	0.0983	0.3472	0.0864
	(0.011)	(0.0498)	(0.0402)	(0.006)	(0.0892)	(0.0054)
3000	0.1287	0.1699	0.1578	0.0831	0.3464	0.0731
	(0.0092)	(0.0416)	(0.0336)	(0.005)	(0.0955)	(0.0046)
3500	0.1107	0.1461	0.1358	0.072	0.3403	0.0633
	(0.0079)	(0.0358)	(0.0289)	(0.0043)	(0.1037)	(0.0039)
4000	0.0971	0.1281	0.1192	0.0635	0.3345	0.0558
	(0.0069)	(0.0313)	(0.0253)	(0.0038)	(0.1097)	(0.0035)
4500	0.0865	0.1141	0.1062	0.0567	0.3347	0.0499
	(0.0062)	(0.0278)	(0.0225)	(0.0034)	(0.1095)	(0.0031)
5000	0.078	0.1028	0.0957	0.0513	0.3314	0.0452
	(0.0055)	(0.0251)	(0.0202)	(0.0031)	(0.1086)	(0.0028)

Table N.13: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5037	0.5038	0.5039	0.4924	0.4491	0.4848
	(0.0715)	(0.0713)	(0.0711)	(0.0728)	(0.0671)	(0.0694)
100	0.503	0.5028	0.5029	0.4708	0.3944	0.4652
	(0.0501)	(0.0499)	(0.0499)	(0.0492)	(0.0455)	(0.0473)
500	0.4997	0.4996	0.4996	0.3021	0.3275	0.2806
	(0.0224)	(0.0224)	(0.0224)	(0.0205)	(0.033)	(0.0189)
1000	0.3565	0.4141	0.3985	0.2112	0.3614	0.1889
	(0.0245)	(0.0598)	(0.0522)	(0.0131)	(0.0568)	(0.012)
1500	0.2511	0.3249	0.303	0.1574	0.3412	0.1392
	(0.018)	(0.0746)	(0.0608)	(0.0096)	(0.0802)	(0.0086)
2000	0.192	0.2525	0.2345	0.1237	0.3383	0.1092
	(0.0137)	(0.0611)	(0.0491)	(0.0074)	(0.0911)	(0.0067)
2500	0.1552	0.2044	0.1899	0.1016	0.35	0.0896
	(0.011)	(0.0496)	(0.0397)	(0.006)	(0.0893)	(0.0055)
3000	0.13	0.1714	0.1593	0.086	0.3489	0.0759
	(0.0092)	(0.0416)	(0.0333)	(0.0051)	(0.0956)	(0.0046)
3500	0.1119	0.1475	0.1371	0.0745	0.3417	0.0658
	(0.0079)	(0.0357)	(0.0286)	(0.0044)	(0.1045)	(0.004)
4000	0.0982	0.1294	0.1204	0.0657	0.3356	0.058
	(0.007)	(0.0313)	(0.025)	(0.0039)	(0.1107)	(0.0035)
4500	0.0875	0.1152	0.1073	0.0588	0.3358	0.0519
	(0.0062)	(0.0278)	(0.0223)	(0.0035)	(0.1104)	(0.0032)
5000	0.0788	0.1039	0.0967	0.0532	0.3324	0.047
	(0.0056)	(0.025)	(0.02)	(0.0032)	(0.1101)	(0.0029)

Table N.14: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under stationarity, for a covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5018	0.5021	0.502	0.3729	0.4288	0.4673
	(0.0724)	(0.0723)	(0.0724)	(0.0627)	(0.066)	(0.0669)
100	0.5024	0.5025	0.5024	0.2747	0.3645	0.4308
	(0.0503)	(0.0503)	(0.0503)	(0.0415)	(0.0465)	(0.0481)
500	0.4926	0.4928	0.4928	0.0998	0.259	0.2217
	(0.0243)	(0.0244)	(0.0244)	(0.0122)	(0.0366)	(0.0173)
1000	0.3355	0.4061	0.4045	0.0609	0.2948	0.136
	(0.028)	(0.0655)	(0.0666)	(0.0069)	(0.0606)	(0.0101)
1500	0.2308	0.3149	0.3118	0.0444	0.2495	0.0967
	(0.0197)	(0.0765)	(0.0774)	(0.0048)	(0.0825)	(0.007)
2000	0.1747	0.2414	0.2387	0.0348	0.2092	0.0744
	(0.0148)	(0.0606)	(0.0611)	(0.0037)	(0.0964)	(0.0053)
2500	0.1403	0.1942	0.192	0.0285	0.1821	0.0604
	(0.0119)	(0.0488)	(0.0492)	(0.003)	(0.1068)	(0.0043)
3000	0.1172	0.1622	0.1604	0.0242	0.1629	0.0508
	(0.0099)	(0.0408)	(0.0411)	(0.0025)	(0.1134)	(0.0036)
3500	0.1006	0.1392	0.1377	0.021	0.1483	0.0438
	(0.0085)	(0.035)	(0.0352)	(0.0022)	(0.117)	(0.0031)
4000	0.0881	0.122	0.1207	0.0186	0.1361	0.0385
	(0.0074)	(0.0306)	(0.0308)	(0.0019)	(0.1173)	(0.0027)
4500	0.0784	0.1085	0.1073	0.0166	0.1255	0.0343
	(0.0066)	(0.0272)	(0.0274)	(0.0017)	(0.115)	(0.0024)
5000	0.0706	0.0977	0.0967	0.0151	0.1162	0.0309
	(0.0059)	(0.0245)	(0.0247)	(0.0016)	(0.1117)	(0.0022)

Table N.15: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5052	0.506	0.5056	0.4918	0.4926	0.4853
	(0.071)	(0.0712)	(0.0709)	(0.0676)	(0.0706)	(0.0665)
100	0.5019	0.5022	0.5019	0.4739	0.4881	0.4667
	(0.0486)	(0.0486)	(0.0486)	(0.046)	(0.0508)	(0.0453)
500	0.5005	0.5005	0.5006	0.3822	0.4271	0.3766
	(0.0224)	(0.0225)	(0.0224)	(0.056)	(0.0656)	(0.0579)
1000	0.5005	0.5005	0.5006	0.3102	0.3896	0.3065
	(0.0163)	(0.0163)	(0.0163)	(0.0697)	(0.0627)	(0.0706)
1500	0.4195	0.45	0.4623	0.3413	0.4003	0.3399
	(0.0273)	(0.0381)	(0.0387)	(0.0491)	(0.054)	(0.0492)
2000	0.3289	0.4059	0.4314	0.3507	0.3957	0.3511
	(0.0259)	(0.0685)	(0.0689)	(0.0388)	(0.0621)	(0.0388)
2500	0.2666	0.3557	0.3873	0.358	0.3926	0.3599
	(0.0215)	(0.0796)	(0.0826)	(0.0327)	(0.0615)	(0.0327)
3000	0.2235	0.3062	0.336	0.3639	0.3931	0.3668
	(0.0181)	(0.0752)	(0.0793)	(0.029)	(0.0599)	(0.0288)
3500	0.1922	0.2653	0.2916	0.3687	0.3919	0.3721
	(0.0156)	(0.0668)	(0.0706)	(0.0262)	(0.0606)	(0.0259)
4000	0.1685	0.2331	0.2563	0.3723	0.3891	0.3762
	(0.0136)	(0.0591)	(0.0625)	(0.0243)	(0.0622)	(0.0235)
4500	0.1499	0.2076	0.2284	0.3749	0.3859	0.3794
	(0.0121)	(0.0527)	(0.0558)	(0.0227)	(0.0643)	(0.0217)
5000	0.1351	0.1871	0.2059	0.3771	0.3838	0.3819
	(0.0109)	(0.0475)	(0.0504)	(0.0211)	(0.0662)	(0.0201)

Table N.16: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under stationarity, for a covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.503	0.503	0.5028	0.421	0.4826	0.4611
	(0.0701)	(0.0704)	(0.0703)	(0.0689)	(0.0716)	(0.0678)
100	0.5023	0.5022	0.5019	0.3785	0.4774	0.4376
	(0.0484)	(0.0486)	(0.0486)	(0.0633)	(0.0552)	(0.05)
500	0.4999	0.5001	0.4999	0.2854	0.404	0.3469
	(0.0222)	(0.0223)	(0.0222)	(0.0804)	(0.0824)	(0.0616)
1000	0.5011	0.5012	0.5011	0.2346	0.3285	0.2868
	(0.016)	(0.016)	(0.016)	(0.0794)	(0.085)	(0.0686)
1500	0.4116	0.4415	0.4555	0.252	0.3437	0.3191
	(0.0272)	(0.042)	(0.0422)	(0.0582)	(0.0733)	(0.0487)
2000	0.323	0.3914	0.4189	0.2577	0.3398	0.3323
	(0.0291)	(0.0741)	(0.075)	(0.0479)	(0.0832)	(0.0386)
2500	0.2629	0.3395	0.3709	0.2619	0.3352	0.3419
	(0.0256)	(0.0842)	(0.0877)	(0.042)	(0.0886)	(0.0327)
3000	0.2212	0.2919	0.3206	0.2651	0.3326	0.3491
	(0.0221)	(0.0796)	(0.0835)	(0.0386)	(0.093)	(0.0289)
3500	0.1908	0.2537	0.2787	0.2679	0.3311	0.3543
	(0.0193)	(0.0716)	(0.0751)	(0.0357)	(0.0961)	(0.0258)
4000	0.1679	0.2236	0.2457	0.2702	0.3264	0.3584
	(0.0171)	(0.0639)	(0.067)	(0.0332)	(0.097)	(0.0233)
4500	0.15	0.1998	0.2195	0.2715	0.319	0.3614
	(0.0153)	(0.0574)	(0.0601)	(0.0313)	(0.0965)	(0.0215)
5000	0.1357	0.1806	0.1985	0.2724	0.3107	0.3637
	(0.0139)	(0.0519)	(0.0544)	(0.0298)	(0.0949)	(0.0199)

Table N.17: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.502	0.502	0.5022	0.4888	0.4559	0.4855
	(0.0706)	(0.0706)	(0.0709)	(0.0704)	(0.0698)	(0.0716)
100	0.5003	0.5001	0.5001	0.4768	0.4029	0.4723
	(0.0497)	(0.0497)	(0.0497)	(0.0493)	(0.0461)	(0.0497)
500	0.5008	0.5008	0.5008	0.3281	0.2414	0.3029
	(0.023)	(0.0229)	(0.0229)	(0.0208)	(0.0213)	(0.0196)
1000	0.5001	0.5001	0.5002	0.2079	0.2609	0.1872
	(0.0158)	(0.0159)	(0.0158)	(0.0122)	(0.0396)	(0.0115)
1500	0.4158	0.4451	0.4572	0.1669	0.3128	0.1454
	(0.0264)	(0.0373)	(0.0393)	(0.0133)	(0.0406)	(0.0122)
2000	0.3225	0.3974	0.4227	0.1333	0.3142	0.1146
	(0.0241)	(0.0681)	(0.072)	(0.0109)	(0.0681)	(0.0097)
2500	0.2601	0.3447	0.3761	0.1089	0.2919	0.0932
	(0.0197)	(0.0781)	(0.0854)	(0.0088)	(0.0729)	(0.0079)
3000	0.2173	0.2937	0.3225	0.0916	0.2756	0.0783
	(0.0166)	(0.0717)	(0.0789)	(0.0074)	(0.0728)	(0.0066)
3500	0.1864	0.2531	0.2782	0.0788	0.2744	0.0674
	(0.0142)	(0.0627)	(0.069)	(0.0063)	(0.0744)	(0.0057)
4000	0.1632	0.2218	0.2438	0.0691	0.2906	0.0591
	(0.0124)	(0.0551)	(0.0607)	(0.0055)	(0.0703)	(0.005)
4500	0.1451	0.1972	0.2169	0.0615	0.2977	0.0526
	(0.0111)	(0.049)	(0.054)	(0.0049)	(0.0696)	(0.0044)
5000	0.1306	0.1776	0.1953	0.0554	0.2954	0.0474
	(0.0099)	(0.0441)	(0.0486)	(0.0044)	(0.0733)	(0.004)

Table N.18: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5021	0.5019	0.502	0.4891	0.4567	0.4872
	(0.0708)	(0.0706)	(0.0709)	(0.0719)	(0.0699)	(0.0724)
100	0.5003	0.5001	0.5	0.4786	0.403	0.4732
	(0.0497)	(0.0498)	(0.0497)	(0.0491)	(0.0465)	(0.0502)
500	0.5008	0.5008	0.5008	0.3293	0.2417	0.3042
	(0.023)	(0.023)	(0.0229)	(0.021)	(0.0221)	(0.0206)
1000	0.5001	0.5002	0.5002	0.2089	0.2613	0.1882
	(0.0158)	(0.0158)	(0.0158)	(0.0118)	(0.0396)	(0.0116)
1500	0.416	0.445	0.4569	0.1674	0.3133	0.1461
	(0.0267)	(0.0373)	(0.0395)	(0.0123)	(0.0406)	(0.0112)
2000	0.3228	0.3975	0.4227	0.1337	0.3157	0.1151
	(0.0242)	(0.0681)	(0.0721)	(0.0098)	(0.0667)	(0.0088)
2500	0.2603	0.3448	0.3763	0.1094	0.2944	0.0938
	(0.0198)	(0.0782)	(0.0854)	(0.0081)	(0.0725)	(0.0071)
3000	0.2175	0.2938	0.3227	0.092	0.2784	0.0788
	(0.0166)	(0.0717)	(0.0791)	(0.0068)	(0.0737)	(0.006)
3500	0.1866	0.2532	0.2784	0.0792	0.2768	0.0678
	(0.0142)	(0.0627)	(0.0692)	(0.0058)	(0.0753)	(0.0051)
4000	0.1633	0.2219	0.244	0.0695	0.2933	0.0595
	(0.0125)	(0.0551)	(0.0608)	(0.0051)	(0.0713)	(0.0045)
4500	0.1452	0.1974	0.2171	0.0618	0.3006	0.0529
	(0.0111)	(0.0491)	(0.0541)	(0.0045)	(0.0709)	(0.004)
5000	0.1307	0.1777	0.1954	0.0557	0.2987	0.0477
	(0.01)	(0.0442)	(0.0487)	(0.0041)	(0.0749)	(0.0036)

Table N.19: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under stationarity, for a covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5034	0.5034	0.5034	0.3004	0.4297	0.4419
	(0.0703)	(0.07)	(0.0702)	(0.0624)	(0.0661)	(0.0676)
100	0.5026	0.5028	0.5028	0.175	0.3589	0.3942
	(0.0513)	(0.0512)	(0.0513)	(0.0376)	(0.0456)	(0.047)
500	0.5009	0.501	0.501	0.0394	0.1829	0.1891
	(0.0229)	(0.023)	(0.0229)	(0.0083)	(0.0193)	(0.017)
1000	0.5006	0.5005	0.5006	0.0201	0.1687	0.1066
	(0.0155)	(0.0154)	(0.0155)	(0.0042)	(0.0401)	(0.0092)
1500	0.4052	0.4347	0.4507	0.0137	0.2085	0.076
	(0.0297)	(0.0407)	(0.0437)	(0.0028)	(0.0477)	(0.0066)
2000	0.3099	0.3798	0.4114	0.0104	0.1842	0.0582
	(0.0259)	(0.0709)	(0.0778)	(0.0021)	(0.0591)	(0.0051)
2500	0.2487	0.3225	0.3596	0.0084	0.1585	0.0468
	(0.021)	(0.0767)	(0.0882)	(0.0017)	(0.0588)	(0.0041)
3000	0.2074	0.2718	0.3049	0.007	0.1346	0.0391
	(0.0176)	(0.0678)	(0.0789)	(0.0014)	(0.052)	(0.0034)
3500	0.1778	0.2335	0.262	0.006	0.1159	0.0335
	(0.0151)	(0.0586)	(0.0683)	(0.0012)	(0.0456)	(0.0029)
4000	0.1556	0.2044	0.2294	0.0053	0.1017	0.0294
	(0.0132)	(0.0513)	(0.0599)	(0.0011)	(0.0405)	(0.0026)
4500	0.1383	0.1817	0.204	0.0047	0.0905	0.0261
	(0.0117)	(0.0456)	(0.0532)	(9e-04)	(0.0365)	(0.0023)
5000	0.1245	0.1635	0.1836	0.0042	0.0815	0.0235
	(0.0106)	(0.0411)	(0.0479)	(9e-04)	(0.0334)	(0.002)

Table N.20: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt (10) data (p = 100) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5032	0.5005	0.5007	0.4668	0.4492	0.4597
	(0.0713)	(0.0715)	(0.0714)	(0.071)	(0.0723)	(0.0729)
100	0.5007	0.5	0.5001	0.429	0.4097	0.421
	(0.0501)	(0.051)	(0.0512)	(0.051)	(0.0514)	(0.0503)
500	0.3505	0.4125	0.3754	0.2755	0.3943	0.2683
	(0.0286)	(0.0639)	(0.0509)	(0.0214)	(0.069)	(0.0222)
1000	0.2211	0.2746	0.2419	0.2005	0.3492	0.1953
	(0.0167)	(0.0514)	(0.0371)	(0.0168)	(0.1255)	(0.0178)
1500	0.1646	0.2024	0.1795	0.1607	0.3208	0.1568
	(0.0118)	(0.0357)	(0.0258)	(0.0137)	(0.1466)	(0.0143)
2000	0.1328	0.1619	0.1443	0.1361	0.2949	0.1329
	(0.0092)	(0.0272)	(0.0197)	(0.0116)	(0.1514)	(0.0121)
2500	0.1123	0.1359	0.1217	0.1191	0.2734	0.1164
	(0.0076)	(0.0219)	(0.0159)	(0.0101)	(0.1513)	(0.0105)
3000	0.0979	0.1178	0.106	0.1065	0.2549	0.1043
	(0.0065)	(0.0185)	(0.0134)	(0.009)	(0.1483)	(0.0094)
3500	0.0872	0.1045	0.0944	0.0972	0.2395	0.0953
	(0.0056)	(0.0159)	(0.0116)	(0.0081)	(0.1444)	(0.0084)
4000	0.0789	0.0942	0.0854	0.0897	0.2267	0.0881
	(0.005)	(0.0139)	(0.0102)	(0.0073)	(0.1404)	(0.0076)
4500	0.0723	0.086	0.0784	0.0838	0.2158	0.0823
	(0.0045)	(0.0124)	(0.0091)	(0.0066)	(0.1363)	(0.0069)
5000	0.0669	0.0794	0.0726	0.0788	0.2063	0.0774
	(0.0041)	(0.0112)	(0.0082)	(0.0062)	(0.1324)	(0.0064)

Table N.21: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt (25) data (p = 100) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5028	0.5027	0.5025	0.4708	0.4364	0.4664
	(0.0713)	(0.0713)	(0.0711)	(0.0705)	(0.0702)	(0.0685)
100	0.5024	0.5022	0.502	0.433	0.3943	0.4263
	(0.0498)	(0.0499)	(0.0497)	(0.0486)	(0.048)	(0.0478)
500	0.3471	0.4064	0.3707	0.2664	0.3754	0.2545
	(0.0282)	(0.0664)	(0.051)	(0.0191)	(0.0703)	(0.0192)
1000	0.216	0.2664	0.2349	0.184	0.3201	0.1752
	(0.0162)	(0.0535)	(0.0372)	(0.0125)	(0.1301)	(0.0126)
1500	0.1593	0.1947	0.1727	0.1425	0.2847	0.1358
	(0.0113)	(0.0372)	(0.0257)	(0.0092)	(0.1477)	(0.0092)
2000	0.1276	0.1548	0.1379	0.1176	0.257	0.1123
	(0.0088)	(0.0282)	(0.0196)	(0.0074)	(0.1512)	(0.0074)
2500	0.1074	0.1294	0.1159	0.101	0.2345	0.0966
	(0.0073)	(0.0228)	(0.0159)	(0.0062)	(0.1484)	(0.0062)
3000	0.0933	0.1118	0.1006	0.0893	0.2165	0.0854
	(0.0062)	(0.0191)	(0.0133)	(0.0053)	(0.1438)	(0.0054)
3500	0.0828	0.0988	0.0893	0.0803	0.2019	0.077
	(0.0054)	(0.0164)	(0.0115)	(0.0047)	(0.1389)	(0.0048)
4000	0.0748	0.0889	0.0808	0.0734	0.1901	0.0705
	(0.0048)	(0.0144)	(0.0101)	(0.0042)	(0.1341)	(0.0042)
4500	0.0684	0.0811	0.074	0.068	0.1805	0.0653
	(0.0043)	(0.0128)	(0.009)	(0.0037)	(0.1296)	(0.0038)
5000	0.0632	0.0748	0.0685	0.0635	0.1728	0.061
	(0.0039)	(0.0116)	(0.0081)	(0.0035)	(0.1262)	(0.0035)

Table N.22: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under stationarity, for a AR covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4983	0.4984	0.498	0.3125	0.2827	0.2832
	(0.0673)	(0.0672)	(0.0673)	(0.0603)	(0.061)	(0.0617)
100	0.499	0.4988	0.4986	0.1883	0.1709	0.1709
	(0.048)	(0.0478)	(0.0479)	(0.0341)	(0.0344)	(0.0348)
500	0.2251	0.2932	0.2407	0.039	0.0354	0.0354
	(0.0252)	(0.0911)	(0.0477)	(0.007)	(0.007)	(0.0071)
1000	0.1125	0.1478	0.1205	0.0195	0.0177	0.0177
	(0.0126)	(0.0473)	(0.0242)	(0.0035)	(0.0035)	(0.0036)
1500	0.075	0.0986	0.0803	0.013	0.0118	0.0118
	(0.0084)	(0.0316)	(0.0161)	(0.0023)	(0.0023)	(0.0024)
2000	0.0563	0.0739	0.0602	0.0098	0.0089	0.0089
	(0.0063)	(0.0237)	(0.0121)	(0.0017)	(0.0018)	(0.0018)
2500	0.045	0.0591	0.0482	0.0078	0.0071	0.0071
	(0.005)	(0.0189)	(0.0097)	(0.0014)	(0.0014)	(0.0014)
3000	0.0375	0.0493	0.0402	0.0065	0.0059	0.0059
	(0.0042)	(0.0158)	(0.0081)	(0.0012)	(0.0012)	(0.0012)
3500	0.0322	0.0422	0.0344	0.0056	0.0051	0.0051
	(0.0036)	(0.0135)	(0.0069)	(0.001)	(0.001)	(0.001)
4000	0.0281	0.037	0.0301	0.0049	0.0044	0.0044
	(0.0031)	(0.0118)	(0.006)	(9e-04)	(9e-04)	(9e-04)
4500	0.025	0.0329	0.0268	0.0043	0.0039	0.0039
	(0.0028)	(0.0105)	(0.0054)	(8e-04)	(8e-04)	(8e-04)
5000	0.0225	0.0296	0.0241	0.0039	0.0035	0.0035
	(0.0025)	(0.0095)	(0.0048)	(7e-04)	(7e-04)	(7e-04)

Table N.23: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under stationarity, for a CS covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4977	0.4973	0.4976	0.1213	0.1032	0.1163
	(0.0676)	(0.0676)	(0.0677)	(0.0456)	(0.0459)	(0.0463)
100	0.4989	0.4985	0.4985	0.0608	0.0516	0.0583
	(0.048)	(0.048)	(0.0481)	(0.0229)	(0.023)	(0.0232)
500	0.2187	0.2791	0.2305	0.0122	0.0103	0.0117
	(0.0237)	(0.0874)	(0.0426)	(0.0046)	(0.0046)	(0.0047)
1000	0.1094	0.1401	0.1153	0.0061	0.0052	0.0058
	(0.0119)	(0.0446)	(0.0214)	(0.0023)	(0.0023)	(0.0023)
1500	0.0729	0.0934	0.0769	0.0041	0.0034	0.0039
	(0.0079)	(0.0298)	(0.0143)	(0.0015)	(0.0015)	(0.0016)
2000	0.0547	0.0701	0.0577	0.003	0.0026	0.0029
	(0.0059)	(0.0223)	(0.0107)	(0.0011)	(0.0011)	(0.0012)
2500	0.0437	0.056	0.0461	0.0024	0.0021	0.0023
	(0.0047)	(0.0179)	(0.0086)	(9e-04)	(9e-04)	(9e-04)
3000	0.0365	0.0467	0.0384	0.002	0.0017	0.0019
	(0.004)	(0.0149)	(0.0071)	(8e-04)	(8e-04)	(8e-04)
3500	0.0312	0.04	0.0329	0.0017	0.0015	0.0017
	(0.0034)	(0.0128)	(0.0061)	(7e-04)	(7e-04)	(7e-04)
4000	0.0273	0.035	0.0288	0.0015	0.0013	0.0015
	(0.003)	(0.0112)	(0.0054)	(6e-04)	(6e-04)	(6e-04)
4500	0.0243	0.0311	0.0256	0.0014	0.0011	0.0013
	(0.0026)	(0.0099)	(0.0048)	(5e-04)	(5e-04)	(5e-04)
5000	0.0219	0.028	0.0231	0.0012	0.001	0.0012
	(0.0024)	(0.0089)	(0.0043)	(5e-04)	(5e-04)	(5e-04)

Table N.24: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under stationarity, for a EYE covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4981	0.4981	0.498	0.307	0.2112	0.2133
	(0.0676)	(0.0674)	(0.0674)	(0.063)	(0.0612)	(0.0611)
100	0.4987	0.4988	0.4987	0.2137	0.1453	0.1467
	(0.0481)	(0.048)	(0.0481)	(0.0388)	(0.0366)	(0.0363)
500	0.4088	0.4462	0.4236	0.093	0.0703	0.0707
	(0.0244)	(0.0427)	(0.0342)	(0.0126)	(0.0116)	(0.0114)
1000	0.3086	0.3471	0.3222	0.0705	0.0573	0.0575
	(0.017)	(0.0397)	(0.0284)	(0.0078)	(0.0073)	(0.0072)
1500	0.2552	0.2839	0.2654	0.0622	0.0526	0.0527
	(0.0135)	(0.0293)	(0.0214)	(0.006)	(0.0058)	(0.0058)
2000	0.2213	0.244	0.2295	0.0578	0.0501	0.0502
	(0.0113)	(0.0232)	(0.0172)	(0.0051)	(0.0049)	(0.0049)
2500	0.1976	0.2166	0.2049	0.0551	0.0486	0.0487
	(0.0098)	(0.0194)	(0.0144)	(0.0045)	(0.0044)	(0.0044)
3000	0.1798	0.1963	0.1867	0.0533	0.0475	0.0477
	(0.0087)	(0.0166)	(0.0125)	(0.0042)	(0.004)	(0.004)
3500	0.1661	0.1807	0.1729	0.0519	0.0467	0.0468
	(0.0078)	(0.0144)	(0.011)	(0.0038)	(0.0037)	(0.0037)
4000	0.1551	0.1682	0.1619	0.0509	0.0462	0.0463
	(0.0071)	(0.0129)	(0.0099)	(0.0035)	(0.0034)	(0.0034)
4500	0.146	0.1581	0.153	0.05	0.0457	0.0458
	(0.0065)	(0.0116)	(0.009)	(0.0033)	(0.0032)	(0.0032)
5000	0.1384	0.1497	0.1457	0.0493	0.0453	0.0454
	(0.006)	(0.0106)	(0.0083)	(0.0031)	(0.003)	(0.003)

APPENDIX M: ABRUPT DRIFT QDA SIMULATION

Table O.1: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 10) under abrupt drift (priors: Equal) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.449	0.4492	0.4494	0.4531	0.4302	0.4586
	(0.0712)	(0.0715)	(0.0717)	(0.0692)	(0.0665)	(0.0687)
100	0.3901	0.3907	0.3905	0.417	0.3816	0.4215
	(0.0489)	(0.0503)	(0.0498)	(0.0485)	(0.0478)	(0.0487)
500	0.2949	0.2966	0.2951	0.3193	0.2927	0.3224
	(0.0227)	(0.0272)	(0.0228)	(0.0228)	(0.0223)	(0.0236)
1000	0.2701	0.2724	0.2702	0.2869	0.2688	0.289
	(0.0167)	(0.0241)	(0.0168)	(0.0176)	(0.0166)	(0.0179)
1500	0.2594	0.2624	0.2595	0.2724	0.2585	0.2739
	(0.0146)	(0.0248)	(0.0146)	(0.0153)	(0.0143)	(0.0155)
2000	0.2525	0.256	0.2525	0.2631	0.2517	0.2643
	(0.0131)	(0.0257)	(0.0131)	(0.0139)	(0.0129)	(0.014)
2500	0.2481	0.2521	0.2481	0.2571	0.2474	0.2581
	(0.0121)	(0.0267)	(0.012)	(0.0128)	(0.0118)	(0.0129)
3000	0.2909	0.2871	0.2901	0.2974	0.2896	0.298
	(0.0109)	(0.0231)	(0.0108)	(0.0115)	(0.0107)	(0.0116)
3500	0.3161	0.297	0.3111	0.3166	0.3107	0.3168
	(0.0102)	(0.0225)	(0.0102)	(0.0107)	(0.0101)	(0.0109)
4000	0.331	0.3029	0.3187	0.3232	0.3185	0.3232
	(0.0095)	(0.0224)	(0.0095)	(0.0102)	(0.0095)	(0.0102)
4500	0.3398	0.3092	0.32	0.3241	0.3199	0.3239
	(0.0091)	(0.0223)	(0.009)	(0.0096)	(0.009)	(0.0096)
5000	0.3444	0.3219	0.3186	0.3225	0.3185	0.3224
	(0.0089)	(0.0217)	(0.0085)	(0.009)	(0.0084)	(0.009)

Table O.2: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 10) under abrupt drift (priors: Equal) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4616	0.4613	0.4614	0.4615	0.4475	0.4631
	(0.0715)	(0.0718)	(0.0718)	(0.0702)	(0.0699)	(0.0723)
100	0.4052	0.405	0.405	0.4254	0.3996	0.4263
	(0.0504)	(0.0506)	(0.0506)	(0.0495)	(0.0494)	(0.0492)
500	0.3051	0.3058	0.3051	0.3181	0.3049	0.3186
	(0.0217)	(0.023)	(0.0219)	(0.0221)	(0.0218)	(0.0222)
1000	0.2802	0.2815	0.2802	0.2878	0.2801	0.2882
	(0.0151)	(0.0182)	(0.0152)	(0.015)	(0.0151)	(0.0153)
1500	0.2696	0.2709	0.2695	0.2748	0.2695	0.275
	(0.0119)	(0.017)	(0.0121)	(0.012)	(0.012)	(0.0121)
2000	0.2634	0.2649	0.2634	0.2674	0.2634	0.2676
	(0.0104)	(0.0171)	(0.0105)	(0.0104)	(0.0104)	(0.0104)
2500	0.2597	0.2613	0.2596	0.2629	0.2596	0.263
	(0.0092)	(0.0175)	(0.0092)	(0.0093)	(0.0092)	(0.0093)
3000	0.2868	0.2836	0.286	0.2883	0.286	0.2883
	(0.0084)	(0.016)	(0.0084)	(0.0085)	(0.0084)	(0.0086)
3500	0.2986	0.2832	0.2944	0.2955	0.2945	0.2953
	(0.0078)	(0.0165)	(0.0079)	(0.008)	(0.0079)	(0.008)
4000	0.3025	0.2805	0.2934	0.2937	0.2937	0.2935
	(0.0072)	(0.0169)	(0.0073)	(0.0073)	(0.0072)	(0.0074)
4500	0.3022	0.2775	0.2888	0.2888	0.2892	0.2887
	(0.0068)	(0.0174)	(0.0068)	(0.0069)	(0.0068)	(0.0069)
5000	0.3	0.2758	0.2835	0.2833	0.2839	0.2833
	(0.0063)	(0.0184)	(0.0064)	(0.0064)	(0.0063)	(0.0064)

Table O.3: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 10) under abrupt drift (priors: 70/30) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5094	0.509	0.5092	0.4182	0.3709	0.4306
	(0.1107)	(0.1101)	(0.1106)	(0.0782)	(0.0777)	(0.08)
100	0.4095	0.4093	0.4092	0.384	0.3383	0.3925
	(0.0674)	(0.0673)	(0.0674)	(0.0536)	(0.0514)	(0.0576)
500	0.2929	0.2941	0.2928	0.2989	0.2815	0.3012
	(0.0282)	(0.0307)	(0.0282)	(0.0321)	(0.0264)	(0.0338)
1000	0.2641	0.2664	0.2641	0.2682	0.2599	0.2695
	(0.0224)	(0.029)	(0.0224)	(0.0252)	(0.0217)	(0.0259)
1500	0.251	0.2538	0.251	0.2538	0.2489	0.2548
	(0.0193)	(0.0293)	(0.0192)	(0.0212)	(0.019)	(0.0216)
2000	0.2434	0.2465	0.2434	0.2454	0.2422	0.2461
	(0.0178)	(0.0301)	(0.0177)	(0.019)	(0.0176)	(0.0194)
2500	0.2379	0.2415	0.2379	0.2393	0.2372	0.2399
	(0.0165)	(0.0307)	(0.0163)	(0.0173)	(0.0163)	(0.0176)
3000	0.2724	0.2657	0.2708	0.2715	0.2705	0.2722
	(0.0148)	(0.0288)	(0.0148)	(0.0157)	(0.0148)	(0.016)
3500	0.2886	0.269	0.2805	0.2796	0.2805	0.2799
	(0.0138)	(0.029)	(0.014)	(0.0148)	(0.014)	(0.0151)
4000	0.2945	0.2703	0.2781	0.2765	0.2783	0.2767
	(0.0133)	(0.0312)	(0.0131)	(0.0138)	(0.0131)	(0.014)
4500	0.295	0.2975	0.272	0.2703	0.2723	0.2704
	(0.0128)	(0.0351)	(0.0121)	(0.0126)	(0.0121)	(0.0128)
5000	0.2929	0.3301	0.2655	0.2638	0.2657	0.2638
	(0.0122)	(0.0348)	(0.0112)	(0.0116)	(0.0112)	(0.0118)

Table O.4: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 10) under abrupt drift (priors: 70/30) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5213	0.5218	0.521	0.4209	0.3738	0.4324
	(0.1136)	(0.1134)	(0.1131)	(0.082)	(0.0801)	(0.0776)
100	0.4068	0.4074	0.4068	0.3753	0.3298	0.3826
	(0.0685)	(0.0688)	(0.0681)	(0.0546)	(0.0512)	(0.0526)
500	0.2789	0.2803	0.2789	0.2815	0.2635	0.2817
	(0.0233)	(0.0295)	(0.0233)	(0.0221)	(0.0212)	(0.022)
1000	0.2527	0.2546	0.2527	0.2545	0.2453	0.2544
	(0.0154)	(0.0272)	(0.0153)	(0.015)	(0.0145)	(0.0153)
1500	0.2418	0.2438	0.2418	0.2432	0.237	0.2429
	(0.0123)	(0.027)	(0.0123)	(0.0121)	(0.0118)	(0.0123)
2000	0.2358	0.2381	0.2357	0.2368	0.2322	0.2365
	(0.0104)	(0.0274)	(0.0104)	(0.0104)	(0.0101)	(0.0105)
2500	0.2316	0.2343	0.2316	0.2324	0.2288	0.2323
	(0.009)	(0.0283)	(0.009)	(0.009)	(0.0087)	(0.0091)
3000	0.2581	0.2552	0.2568	0.2571	0.2546	0.2569
	(0.0085)	(0.0274)	(0.0085)	(0.0085)	(0.0083)	(0.0086)
3500	0.27	0.2596	0.2633	0.2616	0.2617	0.2612
	(0.0082)	(0.0276)	(0.0081)	(0.0081)	(0.0079)	(0.0082)
4000	0.2741	0.2629	0.2606	0.2579	0.2594	0.2575
	(0.0077)	(0.0295)	(0.0076)	(0.0076)	(0.0074)	(0.0077)
4500	0.2742	0.2929	0.2553	0.2524	0.2543	0.2521
	(0.0072)	(0.0333)	(0.0071)	(0.0071)	(0.0069)	(0.0071)
5000	0.2722	0.3269	0.25	0.2471	0.2492	0.2467
	(0.0068)	(0.0325)	(0.0066)	(0.0066)	(0.0065)	(0.0067)

Table O.5: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 10) under abrupt drift (priors: 90/10) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.7543	0.7544	0.7544	0.5462	0.5099	0.5698
	(0.0667)	(0.0671)	(0.0669)	(0.2151)	(0.2382)	(0.2017)
100	0.729	0.7292	0.7286	0.387	0.3212	0.407
	(0.1348)	(0.1352)	(0.1356)	(0.135)	(0.1471)	(0.13)
500	0.3116	0.3121	0.3115	0.2322	0.2168	0.2352
	(0.052)	(0.0539)	(0.0524)	(0.0516)	(0.0385)	(0.0532)
1000	0.2497	0.2507	0.2497	0.2004	0.2119	0.1997
	(0.0374)	(0.0422)	(0.0376)	(0.0418)	(0.033)	(0.0419)
1500	0.2242	0.2259	0.2242	0.1855	0.2044	0.1837
	(0.0343)	(0.0423)	(0.0343)	(0.0368)	(0.0329)	(0.0363)
2000	0.2087	0.2109	0.2088	0.1761	0.1971	0.1739
	(0.032)	(0.0425)	(0.032)	(0.0328)	(0.0321)	(0.0318)
2500	0.198	0.2005	0.1981	0.1693	0.1907	0.167
	(0.0299)	(0.0421)	(0.0299)	(0.0295)	(0.0307)	(0.0284)
3000	0.2077	0.2066	0.2059	0.1801	0.2005	0.1779
	(0.0266)	(0.0406)	(0.0265)	(0.026)	(0.0274)	(0.0252)
3500	0.2079	0.2095	0.2018	0.1771	0.1978	0.1745
	(0.024)	(0.0403)	(0.0238)	(0.0231)	(0.0246)	(0.0223)
4000	0.2041	0.2209	0.194	0.1709	0.1909	0.1682
	(0.0217)	(0.0463)	(0.0212)	(0.0205)	(0.0219)	(0.0198)
4500	0.1987	0.2648	0.1866	0.1651	0.184	0.1622
	(0.0199)	(0.0581)	(0.0191)	(0.0184)	(0.0198)	(0.0177)
5000	0.193	0.3137	0.1804	0.1602	0.1782	0.1574
	(0.0182)	(0.0635)	(0.0174)	(0.0166)	(0.018)	(0.016)

Table O.6: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 10) under abrupt drift (priors: 90/10) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.7492	0.7486	0.7496	0.5485	0.5228	0.5681
	(0.0656)	(0.0653)	(0.066)	(0.2129)	(0.2301)	(0.2016)
100	0.7246	0.7242	0.7248	0.3694	0.324	0.3868
	(0.1408)	(0.1409)	(0.1403)	(0.1293)	(0.1421)	(0.1249)
500	0.2709	0.2717	0.2708	0.1927	0.1658	0.1941
	(0.0524)	(0.056)	(0.0523)	(0.0291)	(0.031)	(0.0288)
1000	0.2034	0.2046	0.2033	0.1632	0.1509	0.1627
	(0.0275)	(0.0376)	(0.0275)	(0.0177)	(0.0184)	(0.0175)
1500	0.1806	0.1827	0.1805	0.1527	0.146	0.1519
	(0.0192)	(0.0363)	(0.0191)	(0.0135)	(0.014)	(0.0134)
2000	0.1685	0.1713	0.1684	0.1468	0.1428	0.1459
	(0.015)	(0.0388)	(0.015)	(0.0113)	(0.0116)	(0.0113)
2500	0.161	0.1643	0.1609	0.1432	0.1408	0.1424
	(0.0127)	(0.0414)	(0.0127)	(0.0098)	(0.01)	(0.0097)
3000	0.1875	0.1844	0.186	0.17	0.1698	0.1692
	(0.0113)	(0.0419)	(0.0113)	(0.0092)	(0.0092)	(0.0092)
3500	0.199	0.1911	0.1914	0.1744	0.1783	0.1726
	(0.0103)	(0.0431)	(0.0102)	(0.0086)	(0.0085)	(0.0087)
4000	0.202	0.2063	0.1863	0.1696	0.1754	0.1672
	(0.0094)	(0.0484)	(0.0093)	(0.008)	(0.0079)	(0.008)
4500	0.2006	0.2575	0.1795	0.1636	0.17	0.161
	(0.0089)	(0.0567)	(0.0085)	(0.0073)	(0.0073)	(0.0073)
5000	0.1973	0.31	0.1735	0.1584	0.1652	0.1558
	(0.0083)	(0.0583)	(0.0078)	(0.0067)	(0.0067)	(0.0068)

Table O.7: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 25) under abrupt drift (priors: Equal) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4944	0.4945	0.4939	0.4556	0.4478	0.4507
	(0.0736)	(0.0739)	(0.0737)	(0.0675)	(0.0659)	(0.068)
100	0.4432	0.4445	0.4431	0.4114	0.4183	0.4064
	(0.053)	(0.0536)	(0.0532)	(0.0474)	(0.0459)	(0.0463)
500	0.2716	0.2786	0.2716	0.2871	0.2666	0.286
	(0.0219)	(0.0269)	(0.0219)	(0.0242)	(0.0205)	(0.0252)
1000	0.2223	0.2271	0.2222	0.2378	0.2193	0.2377
	(0.0162)	(0.0186)	(0.0161)	(0.0198)	(0.0154)	(0.0207)
1500	0.2001	0.2038	0.2	0.2138	0.1979	0.214
	(0.0141)	(0.0152)	(0.014)	(0.0173)	(0.0135)	(0.018)
2000	0.1865	0.1898	0.1864	0.1988	0.1847	0.1992
	(0.013)	(0.0133)	(0.0129)	(0.0158)	(0.0126)	(0.0166)
2500	0.1773	0.1804	0.1773	0.1885	0.1758	0.1889
	(0.012)	(0.012)	(0.0119)	(0.0145)	(0.0116)	(0.0152)
3000	0.2206	0.2112	0.2167	0.2238	0.2163	0.2237
	(0.0107)	(0.0105)	(0.0107)	(0.0128)	(0.0104)	(0.0134)
3500	0.2396	0.2058	0.2221	0.226	0.2223	0.2254
	(0.0101)	(0.0093)	(0.0102)	(0.012)	(0.0101)	(0.0124)
4000	0.2463	0.1966	0.2148	0.2183	0.2152	0.2177
	(0.0094)	(0.0084)	(0.0095)	(0.0111)	(0.0096)	(0.0113)
4500	0.2464	0.1883	0.2059	0.2093	0.2062	0.2088
	(0.0089)	(0.0077)	(0.0088)	(0.0101)	(0.0089)	(0.0103)
5000	0.2434	0.1813	0.1978	0.2011	0.1981	0.2007
	(0.0085)	(0.0072)	(0.0081)	(0.0093)	(0.0082)	(0.0096)

Table O.8: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 25) under abrupt drift (priors: Equal) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4957	0.4955	0.496	0.4509	0.4456	0.4655
	(0.0738)	(0.0738)	(0.0736)	(0.065)	(0.0678)	(0.0679)
100	0.442	0.4424	0.4427	0.4021	0.416	0.4145
	(0.0542)	(0.0539)	(0.0539)	(0.0466)	(0.0438)	(0.0486)
500	0.2459	0.252	0.2461	0.2485	0.2416	0.2508
	(0.0195)	(0.0278)	(0.0195)	(0.019)	(0.0184)	(0.0197)
1000	0.1941	0.1984	0.1943	0.1976	0.192	0.1988
	(0.0125)	(0.0177)	(0.0125)	(0.0123)	(0.0122)	(0.0129)
1500	0.172	0.1752	0.1722	0.1751	0.1706	0.1759
	(0.0097)	(0.0131)	(0.0097)	(0.0097)	(0.0096)	(0.0099)
2000	0.1598	0.1623	0.1599	0.1624	0.1588	0.163
	(0.0083)	(0.0106)	(0.0083)	(0.0082)	(0.0083)	(0.0085)
2500	0.1519	0.154	0.152	0.1542	0.151	0.1546
	(0.0072)	(0.009)	(0.0072)	(0.0071)	(0.0071)	(0.0073)
3000	0.2057	0.1954	0.2017	0.1994	0.2019	0.1982
	(0.0072)	(0.0086)	(0.0071)	(0.007)	(0.0071)	(0.0071)
3500	0.2317	0.1943	0.2123	0.2051	0.2147	0.2031
	(0.007)	(0.0079)	(0.0071)	(0.0069)	(0.0068)	(0.007)
4000	0.243	0.1881	0.2081	0.2009	0.2111	0.1988
	(0.0068)	(0.0073)	(0.007)	(0.0066)	(0.0066)	(0.0066)
4500	0.2464	0.182	0.2013	0.195	0.2043	0.193
	(0.0066)	(0.0068)	(0.0066)	(0.0063)	(0.0063)	(0.0063)
5000	0.2455	0.1766	0.1947	0.1891	0.1975	0.1874
	(0.0063)	(0.0064)	(0.0063)	(0.006)	(0.006)	(0.006)

Table O.9: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 25) under abrupt drift (priors: 70/30) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.6364	0.6357	0.6366	0.418	0.3881	0.438
	(0.0819)	(0.0819)	(0.082)	(0.0849)	(0.0792)	(0.0822)
100	0.5703	0.5708	0.5708	0.3784	0.3427	0.3913
	(0.0875)	(0.0871)	(0.088)	(0.0586)	(0.0498)	(0.0602)
500	0.3068	0.3106	0.3071	0.2785	0.2663	0.2819
	(0.0278)	(0.0277)	(0.028)	(0.0297)	(0.0211)	(0.0319)
1000	0.2465	0.2504	0.2467	0.2368	0.2289	0.2389
	(0.0194)	(0.0196)	(0.0193)	(0.0205)	(0.0183)	(0.0214)
1500	0.22	0.2232	0.2201	0.2159	0.209	0.2176
	(0.0158)	(0.0159)	(0.0156)	(0.0163)	(0.016)	(0.0171)
2000	0.2044	0.2074	0.2045	0.2031	0.1963	0.2045
	(0.0134)	(0.0134)	(0.013)	(0.0138)	(0.014)	(0.0143)
2500	0.1937	0.1966	0.1939	0.1942	0.1872	0.1955
	(0.0117)	(0.0115)	(0.0114)	(0.0122)	(0.0123)	(0.0127)
3000	0.2307	0.2251	0.2248	0.2222	0.2201	0.2227
	(0.0106)	(0.0105)	(0.0105)	(0.0112)	(0.0112)	(0.0115)
3500	0.2451	0.2198	0.2255	0.2223	0.2222	0.2225
	(0.0101)	(0.0094)	(0.0097)	(0.0103)	(0.0105)	(0.0106)
4000	0.2484	0.2105	0.2181	0.2151	0.2157	0.2151
	(0.0095)	(0.0084)	(0.0088)	(0.0094)	(0.0095)	(0.0098)
4500	0.2467	0.2011	0.2098	0.2069	0.208	0.207
	(0.0091)	(0.0077)	(0.0081)	(0.0088)	(0.0087)	(0.0091)
5000	0.2424	0.1929	0.202	0.1994	0.2007	0.1995
	(0.0087)	(0.0071)	(0.0075)	(0.008)	(0.0081)	(0.0083)

Table O.10: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 25) under abrupt drift (priors: 70/30) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.637	0.6365	0.6365	0.4111	0.3803	0.4279
	(0.0821)	(0.0821)	(0.082)	(0.0854)	(0.0787)	(0.0825)
100	0.5715	0.5717	0.5717	0.3681	0.3387	0.378
	(0.0888)	(0.0891)	(0.0885)	(0.0548)	(0.0515)	(0.0534)
500	0.2749	0.2778	0.275	0.2422	0.2345	0.2417
	(0.0263)	(0.0282)	(0.026)	(0.0206)	(0.0167)	(0.0201)
1000	0.2089	0.212	0.2091	0.196	0.1896	0.1952
	(0.0154)	(0.0178)	(0.0153)	(0.0132)	(0.0114)	(0.0132)
1500	0.1826	0.185	0.1827	0.1754	0.1698	0.1748
	(0.0115)	(0.0132)	(0.0114)	(0.0102)	(0.0092)	(0.0101)
2000	0.1682	0.1701	0.1682	0.1634	0.1587	0.163
	(0.0093)	(0.0107)	(0.0093)	(0.0083)	(0.0079)	(0.0083)
2500	0.1587	0.1603	0.1587	0.1553	0.1512	0.155
	(0.008)	(0.0091)	(0.008)	(0.0073)	(0.0069)	(0.0073)
3000	0.2083	0.2014	0.2032	0.1969	0.1973	0.1957
	(0.0078)	(0.0084)	(0.0077)	(0.0075)	(0.007)	(0.0073)
3500	0.2326	0.2013	0.2116	0.202	0.2082	0.2004
	(0.0074)	(0.0077)	(0.0072)	(0.0071)	(0.0068)	(0.0069)
4000	0.2431	0.1951	0.2073	0.1978	0.2055	0.1963
	(0.0071)	(0.0071)	(0.0067)	(0.0067)	(0.0063)	(0.0065)
4500	0.2458	0.1882	0.201	0.1922	0.2001	0.1908
	(0.0067)	(0.0066)	(0.0064)	(0.0061)	(0.0059)	(0.0059)
5000	0.2444	0.1822	0.1947	0.1865	0.1943	0.1853
	(0.0064)	(0.0062)	(0.006)	(0.0057)	(0.0055)	(0.0055)

Table O.11: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 25) under abrupt drift (priors: 90/10) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.6515	0.6513	0.6503	0.5328	0.523	0.573
	(0.1249)	(0.1247)	(0.1244)	(0.2213)	(0.2276)	(0.198)
100	0.7752	0.775	0.7745	0.3638	0.3269	0.4104
	(0.0663)	(0.0663)	(0.0661)	(0.1392)	(0.1485)	(0.1306)
500	0.4438	0.4434	0.4433	0.2054	0.1532	0.2212
	(0.0778)	(0.0778)	(0.0776)	(0.0518)	(0.0339)	(0.0559)
1000	0.2868	0.2862	0.2865	0.1678	0.1492	0.1752
	(0.0405)	(0.0405)	(0.0404)	(0.0421)	(0.0213)	(0.0443)
1500	0.2319	0.2318	0.2318	0.1491	0.1483	0.1537
	(0.0307)	(0.0302)	(0.0306)	(0.0364)	(0.0199)	(0.0375)
2000	0.2017	0.2023	0.2017	0.137	0.1451	0.1403
	(0.0265)	(0.0258)	(0.0264)	(0.032)	(0.0204)	(0.0327)
2500	0.1822	0.1833	0.1823	0.1288	0.1414	0.1314
	(0.0247)	(0.0241)	(0.0246)	(0.029)	(0.0214)	(0.0297)
3000	0.1991	0.1935	0.1909	0.1465	0.1564	0.1484
	(0.0209)	(0.0201)	(0.021)	(0.0259)	(0.0185)	(0.0265)
3500	0.2034	0.1845	0.1829	0.1437	0.1535	0.1447
	(0.0189)	(0.0177)	(0.0187)	(0.023)	(0.0165)	(0.0234)
4000	0.2016	0.1753	0.1742	0.1385	0.1488	0.1391
	(0.0174)	(0.0158)	(0.0168)	(0.0204)	(0.0148)	(0.0207)
4500	0.1972	0.1668	0.1665	0.1336	0.1443	0.1339
	(0.0161)	(0.0142)	(0.0152)	(0.0183)	(0.0135)	(0.0186)
5000	0.1916	0.1591	0.1597	0.1293	0.1401	0.1295
	(0.015)	(0.0129)	(0.0138)	(0.0167)	(0.0124)	(0.0169)

Table O.12: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 25) under abrupt drift (priors: 90/10) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.6493	0.6494	0.6493	0.5328	0.5212	0.5485
	(0.1276)	(0.1278)	(0.1283)	(0.2247)	(0.2291)	(0.2111)
100	0.7746	0.7746	0.7745	0.3465	0.3215	0.3651
	(0.0683)	(0.0684)	(0.0686)	(0.1341)	(0.1397)	(0.1271)
500	0.4452	0.4456	0.445	0.1687	0.1439	0.1722
	(0.0782)	(0.0782)	(0.0778)	(0.0298)	(0.0306)	(0.0292)
1000	0.2697	0.2701	0.2697	0.1335	0.1206	0.1346
	(0.04)	(0.0401)	(0.0399)	(0.0167)	(0.0166)	(0.0161)
1500	0.2085	0.209	0.2086	0.1185	0.1103	0.1189
	(0.0269)	(0.0271)	(0.0269)	(0.0123)	(0.0119)	(0.0119)
2000	0.1772	0.1779	0.1772	0.1101	0.1044	0.1103
	(0.0204)	(0.0206)	(0.0204)	(0.0099)	(0.0096)	(0.0095)
2500	0.1578	0.1585	0.1579	0.1044	0.1002	0.1044
	(0.0165)	(0.0166)	(0.0164)	(0.0083)	(0.0082)	(0.0081)
3000	0.1883	0.1813	0.1784	0.1283	0.1295	0.1271
	(0.0145)	(0.0145)	(0.0145)	(0.0079)	(0.0083)	(0.0076)
3500	0.1987	0.1762	0.1737	0.1276	0.1321	0.1258
	(0.0131)	(0.0129)	(0.0128)	(0.0071)	(0.0077)	(0.007)
4000	0.2002	0.1697	0.1674	0.1248	0.1313	0.1229
	(0.012)	(0.0116)	(0.0114)	(0.0065)	(0.007)	(0.0063)
4500	0.1975	0.1635	0.1617	0.1222	0.1299	0.1203
	(0.0111)	(0.0105)	(0.0103)	(0.0059)	(0.0066)	(0.0059)
5000	0.1931	0.1579	0.1565	0.1199	0.1283	0.118
	(0.0103)	(0.0098)	(0.0094)	(0.0055)	(0.0061)	(0.0055)

Table O.13: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 50) under abrupt drift (priors: Equal) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.497	0.497	0.4967	0.4714	0.4351	0.4755
	(0.0746)	(0.0744)	(0.0742)	(0.0701)	(0.0673)	(0.0706)
100	0.4916	0.4916	0.4912	0.4366	0.4254	0.4357
	(0.0543)	(0.0542)	(0.0542)	(0.0503)	(0.045)	(0.0499)
500	0.2718	0.2913	0.274	0.2631	0.2635	0.2557
	(0.0218)	(0.0399)	(0.0238)	(0.0199)	(0.0281)	(0.0198)
1000	0.1877	0.1993	0.1891	0.189	0.1847	0.1839
	(0.0132)	(0.0227)	(0.0143)	(0.0125)	(0.0232)	(0.0122)
1500	0.1514	0.1596	0.1524	0.1543	0.1501	0.1506
	(0.0098)	(0.016)	(0.0105)	(0.0095)	(0.0208)	(0.0092)
2000	0.1309	0.1373	0.1317	0.1343	0.1304	0.1312
	(0.008)	(0.0125)	(0.0085)	(0.0079)	(0.0202)	(0.0076)
2500	0.1177	0.1231	0.1185	0.1212	0.1177	0.1187
	(0.0067)	(0.0103)	(0.0071)	(0.0067)	(0.0194)	(0.0064)
3000	0.1691	0.1616	0.1621	0.1651	0.1641	0.1597
	(0.0068)	(0.0092)	(0.0072)	(0.0069)	(0.0176)	(0.0068)
3500	0.1906	0.1576	0.1636	0.1649	0.1702	0.1588
	(0.0066)	(0.0083)	(0.0073)	(0.0064)	(0.0178)	(0.0063)
4000	0.1967	0.1487	0.1555	0.1569	0.1629	0.1513
	(0.0063)	(0.0076)	(0.0069)	(0.0058)	(0.0179)	(0.0057)
4500	0.1957	0.1402	0.147	0.1485	0.1543	0.1434
	(0.0059)	(0.0068)	(0.0063)	(0.0054)	(0.0182)	(0.0053)
5000	0.1914	0.1326	0.1391	0.1407	0.1461	0.1361
	(0.0056)	(0.0062)	(0.0058)	(0.005)	(0.0183)	(0.0049)

Table O.14: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 50) under abrupt drift (priors: Equal) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4978	0.4966	0.4966	0.4752	0.4361	0.4783
	(0.0746)	(0.0744)	(0.0746)	(0.0721)	(0.0676)	(0.0712)
100	0.4928	0.4918	0.4918	0.4394	0.4286	0.4396
	(0.054)	(0.0533)	(0.0534)	(0.0505)	(0.0447)	(0.0507)
500	0.2774	0.2958	0.2793	0.2696	0.2696	0.2625
	(0.0209)	(0.0391)	(0.0228)	(0.0194)	(0.0275)	(0.0195)
1000	0.1926	0.2036	0.1937	0.195	0.1898	0.19
	(0.0128)	(0.0226)	(0.0137)	(0.0124)	(0.0224)	(0.0122)
1500	0.1564	0.1641	0.1572	0.1603	0.1552	0.1566
	(0.0095)	(0.0161)	(0.0103)	(0.0096)	(0.0203)	(0.0094)
2000	0.1358	0.1418	0.1365	0.1401	0.1354	0.137
	(0.0077)	(0.0126)	(0.0083)	(0.0079)	(0.019)	(0.0078)
2500	0.1224	0.1273	0.1229	0.1266	0.1223	0.124
	(0.0066)	(0.0104)	(0.007)	(0.0068)	(0.0181)	(0.0066)
3000	0.173	0.1655	0.1663	0.1687	0.1682	0.1645
	(0.0067)	(0.0094)	(0.007)	(0.007)	(0.0165)	(0.0071)
3500	0.1942	0.1622	0.1683	0.1695	0.1748	0.1642
	(0.0066)	(0.0085)	(0.007)	(0.0065)	(0.0166)	(0.0066)
4000	0.2009	0.1535	0.1605	0.1621	0.168	0.157
	(0.0063)	(0.0077)	(0.0066)	(0.006)	(0.017)	(0.006)
4500	0.2002	0.1451	0.152	0.1538	0.1594	0.1492
	(0.0061)	(0.007)	(0.0061)	(0.0056)	(0.017)	(0.0056)
5000	0.1961	0.1377	0.1443	0.1462	0.1513	0.1419
	(0.0057)	(0.0065)	(0.0058)	(0.0052)	(0.017)	(0.0052)

Table O.15: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 50) under abrupt drift (priors: 70/30) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4455	0.4454	0.4455	0.4136	0.4308	0.444
	(0.048)	(0.0479)	(0.0481)	(0.0892)	(0.097)	(0.0852)
100	0.5731	0.573	0.5732	0.3854	0.3664	0.4074
	(0.041)	(0.0408)	(0.0411)	(0.064)	(0.0591)	(0.0644)
500	0.3599	0.3658	0.3611	0.2899	0.2936	0.2965
	(0.0314)	(0.0322)	(0.0315)	(0.0378)	(0.027)	(0.0405)
1000	0.2674	0.2749	0.2687	0.2414	0.2463	0.2451
	(0.0203)	(0.0231)	(0.0208)	(0.033)	(0.028)	(0.0351)
1500	0.225	0.2311	0.226	0.214	0.2182	0.2168
	(0.0181)	(0.0198)	(0.0182)	(0.03)	(0.0313)	(0.0317)
2000	0.1991	0.2042	0.1999	0.1957	0.1989	0.1981
	(0.0174)	(0.0183)	(0.0172)	(0.0275)	(0.0338)	(0.0287)
2500	0.1815	0.186	0.1822	0.1829	0.1849	0.185
	(0.0171)	(0.0174)	(0.0168)	(0.0257)	(0.0353)	(0.0269)
3000	0.2167	0.2164	0.2092	0.2069	0.2144	0.2082
	(0.0147)	(0.015)	(0.0148)	(0.0231)	(0.0336)	(0.024)
3500	0.2291	0.2073	0.2036	0.201	0.2129	0.2015
	(0.0135)	(0.0132)	(0.0133)	(0.0204)	(0.0351)	(0.0211)
4000	0.2301	0.1931	0.1911	0.1893	0.2028	0.1894
	(0.0126)	(0.0117)	(0.0119)	(0.018)	(0.0372)	(0.0186)
4500	0.2255	0.1796	0.1788	0.1775	0.1917	0.1774
	(0.0118)	(0.0104)	(0.0107)	(0.0161)	(0.039)	(0.0166)
5000	0.2184	0.168	0.1678	0.1668	0.1814	0.1668
	(0.011)	(0.0095)	(0.0098)	(0.0146)	(0.0401)	(0.015)

Table O.16: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 50) under abrupt drift (priors: 70/30) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4437	0.4437	0.4434	0.402	0.3855	0.4259
	(0.0466)	(0.0467)	(0.0464)	(0.0872)	(0.0795)	(0.083)
100	0.5726	0.5726	0.5725	0.3629	0.3411	0.3787
	(0.0403)	(0.0404)	(0.0402)	(0.0582)	(0.0508)	(0.0549)
500	0.3392	0.3459	0.3404	0.2234	0.2741	0.2204
	(0.0322)	(0.0363)	(0.0326)	(0.0198)	(0.0176)	(0.0196)
1000	0.2209	0.2289	0.2217	0.1608	0.1968	0.158
	(0.0187)	(0.0253)	(0.0192)	(0.0122)	(0.0161)	(0.0118)
1500	0.1708	0.1767	0.1713	0.1316	0.1562	0.1294
	(0.0133)	(0.0182)	(0.0137)	(0.009)	(0.0147)	(0.0088)
2000	0.1429	0.1476	0.1434	0.1145	0.1326	0.1125
	(0.0103)	(0.0141)	(0.0106)	(0.0073)	(0.014)	(0.0073)
2500	0.1251	0.129	0.1256	0.1031	0.1173	0.1015
	(0.0085)	(0.0115)	(0.0088)	(0.0063)	(0.0137)	(0.0063)
3000	0.1679	0.1695	0.1607	0.139	0.1552	0.1346
	(0.0081)	(0.0103)	(0.0083)	(0.0066)	(0.0133)	(0.0063)
3500	0.186	0.1683	0.1623	0.1413	0.161	0.1365
	(0.0076)	(0.0091)	(0.0078)	(0.006)	(0.014)	(0.0059)
4000	0.1915	0.1599	0.1555	0.1365	0.1565	0.1321
	(0.0073)	(0.0083)	(0.0072)	(0.0056)	(0.015)	(0.0054)
4500	0.1907	0.1507	0.1477	0.1306	0.1498	0.1266
	(0.0069)	(0.0075)	(0.0067)	(0.0051)	(0.0157)	(0.005)
5000	0.1868	0.1425	0.1404	0.125	0.143	0.1213
	(0.0065)	(0.0068)	(0.0062)	(0.0048)	(0.0161)	(0.0047)

Table O.17: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 50) under abrupt drift (priors: 90/10) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4448	0.4453	0.4459	0.5337	0.5674	0.5879
	(0.1033)	(0.1028)	(0.1026)	(0.2282)	(0.2057)	(0.196)
100	0.6733	0.6736	0.6737	0.3566	0.3464	0.4274
	(0.0559)	(0.0556)	(0.0554)	(0.1407)	(0.135)	(0.1272)
500	0.7493	0.7491	0.7489	0.2126	0.1485	0.2407
	(0.0896)	(0.0901)	(0.0899)	(0.0567)	(0.0308)	(0.0657)
1000	0.434	0.4335	0.4337	0.1813	0.1269	0.1963
	(0.055)	(0.0554)	(0.0552)	(0.0522)	(0.0179)	(0.0591)
1500	0.3268	0.3262	0.3265	0.1625	0.126	0.1728
	(0.0368)	(0.0371)	(0.037)	(0.0491)	(0.0143)	(0.0541)
2000	0.2726	0.2724	0.2724	0.149	0.128	0.1566
	(0.0289)	(0.0289)	(0.0289)	(0.0458)	(0.0148)	(0.0495)
2500	0.2383	0.2384	0.238	0.1385	0.1286	0.1446
	(0.0245)	(0.0243)	(0.0245)	(0.0426)	(0.0159)	(0.0455)
3000	0.2264	0.2273	0.2214	0.1435	0.1294	0.1486
	(0.0203)	(0.0201)	(0.0204)	(0.0366)	(0.016)	(0.0391)
3500	0.2155	0.2089	0.2044	0.1384	0.1261	0.1424
	(0.0177)	(0.0174)	(0.0176)	(0.0318)	(0.0159)	(0.0339)
4000	0.205	0.1926	0.1896	0.1312	0.1219	0.1345
	(0.0158)	(0.0152)	(0.0154)	(0.028)	(0.0165)	(0.0298)
4500	0.1952	0.179	0.177	0.1245	0.1178	0.1272
	(0.0142)	(0.0136)	(0.0138)	(0.025)	(0.0178)	(0.0266)
5000	0.186	0.1676	0.1662	0.1185	0.114	0.1208
	(0.013)	(0.0123)	(0.0125)	(0.0226)	(0.02)	(0.024)

Table O.18: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 50) under abrupt drift (priors: 90/10) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.441	0.442	0.441	0.5232	0.5257	0.542
	(0.1108)	(0.1103)	(0.1108)	(0.2327)	(0.2293)	(0.2207)
100	0.6701	0.6708	0.67	0.3367	0.3279	0.3588
	(0.0598)	(0.0596)	(0.0597)	(0.1473)	(0.1487)	(0.141)
500	0.7539	0.7547	0.7534	0.1599	0.1454	0.1643
	(0.089)	(0.09)	(0.0886)	(0.0317)	(0.0323)	(0.0303)
1000	0.4317	0.4326	0.4313	0.119	0.1221	0.1192
	(0.0558)	(0.0564)	(0.0552)	(0.0176)	(0.0178)	(0.0166)
1500	0.3137	0.3155	0.3135	0.0999	0.1111	0.0995
	(0.0382)	(0.0385)	(0.0378)	(0.0122)	(0.0123)	(0.0118)
2000	0.2505	0.2529	0.2505	0.0886	0.1014	0.0879
	(0.0291)	(0.0294)	(0.0287)	(0.0096)	(0.0097)	(0.0093)
2500	0.2106	0.213	0.2106	0.0809	0.0928	0.0802
	(0.0235)	(0.024)	(0.0233)	(0.0078)	(0.0083)	(0.0076)
3000	0.2106	0.2153	0.202	0.0954	0.1023	0.0936
	(0.0196)	(0.02)	(0.0193)	(0.0073)	(0.0094)	(0.0071)
3500	0.2039	0.1981	0.1867	0.0938	0.1017	0.0915
	(0.017)	(0.0171)	(0.0168)	(0.0065)	(0.0099)	(0.0063)
4000	0.1951	0.1824	0.173	0.0903	0.0991	0.0879
	(0.015)	(0.015)	(0.0147)	(0.0058)	(0.0105)	(0.0057)
4500	0.1857	0.1689	0.1611	0.0868	0.096	0.0844
	(0.0134)	(0.0133)	(0.0131)	(0.0053)	(0.0113)	(0.0051)
5000	0.1766	0.1575	0.1511	0.0836	0.0929	0.0813
	(0.0122)	(0.0121)	(0.0118)	(0.0048)	(0.0121)	(0.0047)

Table O.19: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 100) under abrupt drift (priors: Equal) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5044	0.5045	0.5046	0.483	0.4348	0.4793
	(0.0681)	(0.0679)	(0.0678)	(0.0703)	(0.0696)	(0.0702)
100	0.503	0.5029	0.5031	0.4565	0.3945	0.4502
	(0.05)	(0.0497)	(0.0497)	(0.0492)	(0.0466)	(0.051)
500	0.3516	0.4109	0.3734	0.2826	0.3733	0.2663
	(0.0283)	(0.0645)	(0.0483)	(0.0201)	(0.0683)	(0.0194)
1000	0.2196	0.2697	0.2371	0.1913	0.3109	0.1798
	(0.0164)	(0.0519)	(0.035)	(0.0124)	(0.126)	(0.0121)
1500	0.1627	0.198	0.175	0.147	0.2731	0.1385
	(0.0114)	(0.0365)	(0.0242)	(0.0091)	(0.1429)	(0.0089)
2000	0.1307	0.1577	0.1401	0.1208	0.2448	0.1139
	(0.0087)	(0.028)	(0.0184)	(0.0071)	(0.1464)	(0.007)
2500	0.1102	0.1321	0.118	0.1035	0.2222	0.0978
	(0.0071)	(0.0226)	(0.0149)	(0.006)	(0.1433)	(0.0059)
3000	0.1615	0.1683	0.1577	0.1647	0.2547	0.1632
	(0.007)	(0.0193)	(0.0131)	(0.0065)	(0.1265)	(0.0064)
3500	0.1797	0.1615	0.1546	0.1708	0.2563	0.1674
	(0.0067)	(0.0173)	(0.0118)	(0.0073)	(0.1234)	(0.0074)
4000	0.182	0.1485	0.1434	0.1586	0.2466	0.1549
	(0.0062)	(0.0155)	(0.0108)	(0.0068)	(0.1226)	(0.0068)
4500	0.1773	0.1362	0.1322	0.1463	0.2348	0.1428
	(0.0059)	(0.0138)	(0.0098)	(0.0062)	(0.1213)	(0.0062)
5000	0.1698	0.1256	0.1224	0.1354	0.2237	0.1321
	(0.0055)	(0.0125)	(0.0088)	(0.0057)	(0.1197)	(0.0057)

Table O.20: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under abrupt drift (priors: Equal) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.507	0.507	0.5072	0.4818	0.4351	0.4778
	(0.0682)	(0.0684)	(0.0683)	(0.07)	(0.071)	(0.0697)
100	0.5042	0.5042	0.504	0.4546	0.3942	0.4473
	(0.0508)	(0.0509)	(0.0507)	(0.0491)	(0.0486)	(0.0502)
500	0.3489	0.408	0.3684	0.2797	0.3705	0.2647
	(0.0285)	(0.0654)	(0.0485)	(0.0206)	(0.0708)	(0.0206)
1000	0.2173	0.2671	0.2331	0.1893	0.3073	0.1781
	(0.0163)	(0.0531)	(0.0347)	(0.0124)	(0.1279)	(0.0123)
1500	0.1603	0.1952	0.1714	0.145	0.2691	0.1366
	(0.0113)	(0.0373)	(0.0241)	(0.0089)	(0.1451)	(0.0088)
2000	0.1287	0.1554	0.1373	0.119	0.2408	0.1125
	(0.0087)	(0.0284)	(0.0183)	(0.0071)	(0.1481)	(0.0071)
2500	0.1084	0.1301	0.1156	0.1019	0.218	0.0965
	(0.0072)	(0.0229)	(0.0151)	(0.0059)	(0.1442)	(0.0058)
3000	0.1628	0.1681	0.1581	0.1631	0.253	0.1621
	(0.0071)	(0.0197)	(0.0133)	(0.0066)	(0.1263)	(0.0067)
3500	0.1824	0.1609	0.1551	0.1692	0.2554	0.1663
	(0.0066)	(0.0172)	(0.0119)	(0.0077)	(0.1232)	(0.0077)
4000	0.1851	0.1476	0.1437	0.1572	0.2459	0.154
	(0.0063)	(0.0152)	(0.0106)	(0.0072)	(0.1227)	(0.0071)
4500	0.1805	0.1352	0.1323	0.145	0.2342	0.1419
	(0.006)	(0.0135)	(0.0095)	(0.0066)	(0.1216)	(0.0065)
5000	0.1729	0.1245	0.1222	0.1341	0.2229	0.1312
	(0.0056)	(0.0121)	(0.0085)	(0.0061)	(0.1201)	(0.0059)

Table O.21: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 100) under abrupt drift (priors: 70/30) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3048	0.3051	0.3053	0.4146	0.477	0.456
	(0.0657)	(0.0656)	(0.0647)	(0.0915)	(0.1243)	(0.0821)
100	0.3388	0.3389	0.3387	0.3864	0.4045	0.4184
	(0.0258)	(0.0258)	(0.0253)	(0.0701)	(0.0917)	(0.0655)
500	0.4543	0.4568	0.4559	0.2902	0.3203	0.2966
	(0.0322)	(0.0323)	(0.0324)	(0.0391)	(0.0282)	(0.0417)
1000	0.3348	0.3484	0.3418	0.2347	0.3274	0.2383
	(0.0215)	(0.0268)	(0.0244)	(0.0331)	(0.053)	(0.0349)
1500	0.2635	0.2804	0.2718	0.2036	0.3188	0.2065
	(0.0172)	(0.0266)	(0.0222)	(0.0306)	(0.081)	(0.0318)
2000	0.2179	0.233	0.2251	0.1833	0.3047	0.186
	(0.0149)	(0.0237)	(0.0196)	(0.0286)	(0.0941)	(0.0296)
2500	0.1865	0.1996	0.1926	0.1687	0.2918	0.1714
	(0.0136)	(0.0211)	(0.0175)	(0.0261)	(0.1014)	(0.0271)
3000	0.2111	0.2229	0.2091	0.1918	0.3038	0.1922
	(0.0116)	(0.0177)	(0.0147)	(0.0228)	(0.098)	(0.0234)
3500	0.216	0.2124	0.1984	0.1852	0.2998	0.184
	(0.0102)	(0.0151)	(0.0129)	(0.0199)	(0.0962)	(0.0205)
4000	0.2115	0.1968	0.1822	0.1717	0.29	0.1701
	(0.0093)	(0.0134)	(0.0114)	(0.0176)	(0.0961)	(0.0181)
4500	0.2029	0.1807	0.167	0.1584	0.2789	0.1567
	(0.0086)	(0.0121)	(0.0102)	(0.0157)	(0.0964)	(0.0162)
5000	0.1928	0.1662	0.1537	0.1464	0.268	0.1448
	(0.0079)	(0.0109)	(0.0093)	(0.0141)	(0.0966)	(0.0146)

Table O.22: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under abrupt drift (priors: 70/30) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3108	0.3107	0.3109	0.3894	0.3833	0.4124
	(0.0664)	(0.0663)	(0.0664)	(0.0832)	(0.0775)	(0.0812)
100	0.3419	0.342	0.3419	0.3594	0.3327	0.3766
	(0.0266)	(0.0265)	(0.0266)	(0.058)	(0.049)	(0.0537)
500	0.4575	0.4589	0.4577	0.2276	0.3095	0.2197
	(0.0334)	(0.033)	(0.0333)	(0.0192)	(0.0251)	(0.0186)
1000	0.3248	0.3398	0.3303	0.153	0.309	0.1456
	(0.023)	(0.0311)	(0.0266)	(0.0111)	(0.0628)	(0.0108)
1500	0.2419	0.2601	0.2481	0.1167	0.2704	0.1109
	(0.017)	(0.0308)	(0.0229)	(0.008)	(0.0795)	(0.0078)
2000	0.1916	0.2072	0.1968	0.0953	0.2375	0.0907
	(0.0134)	(0.0258)	(0.0187)	(0.0063)	(0.0835)	(0.0061)
2500	0.1587	0.1718	0.163	0.0813	0.2126	0.0774
	(0.0109)	(0.0215)	(0.0154)	(0.0053)	(0.0855)	(0.0051)
3000	0.196	0.2119	0.1886	0.132	0.2392	0.1264
	(0.0098)	(0.0182)	(0.0132)	(0.0064)	(0.0811)	(0.0062)
3500	0.2066	0.2	0.1801	0.1353	0.2398	0.1294
	(0.009)	(0.0157)	(0.0117)	(0.0072)	(0.0846)	(0.0068)
4000	0.2046	0.1844	0.1654	0.1273	0.2315	0.1216
	(0.0082)	(0.0139)	(0.0104)	(0.0067)	(0.0887)	(0.0063)
4500	0.1971	0.1689	0.1516	0.1181	0.221	0.1128
	(0.0075)	(0.0124)	(0.0093)	(0.0061)	(0.0916)	(0.0058)
5000	0.1875	0.1552	0.1396	0.1096	0.211	0.1048
	(0.0069)	(0.0111)	(0.0084)	(0.0056)	(0.0937)	(0.0053)

Table O.23: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 100) under abrupt drift (priors: 90/10) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1006	0.1009	0.1005	0.5322	0.6558	0.5977
	(0.0441)	(0.0439)	(0.0435)	(0.229)	(0.1897)	(0.1925)
100	0.333	0.333	0.333	0.3513	0.42	0.4512
	(0.0199)	(0.02)	(0.0196)	(0.1397)	(0.1433)	(0.1327)
500	0.7861	0.786	0.7864	0.2255	0.1651	0.2698
	(0.0128)	(0.0128)	(0.0129)	(0.0582)	(0.0316)	(0.071)
1000	0.726	0.7256	0.7273	0.2047	0.1343	0.2292
	(0.0721)	(0.0719)	(0.0716)	(0.0552)	(0.0184)	(0.0638)
1500	0.5201	0.5197	0.5209	0.187	0.1251	0.2038
	(0.0535)	(0.0534)	(0.0532)	(0.0537)	(0.0166)	(0.0601)
2000	0.4155	0.415	0.416	0.1715	0.1232	0.1843
	(0.0404)	(0.0403)	(0.0401)	(0.0522)	(0.023)	(0.0569)
2500	0.3527	0.3523	0.3531	0.1596	0.1259	0.1701
	(0.0325)	(0.0325)	(0.0323)	(0.0499)	(0.0304)	(0.0536)
3000	0.3109	0.3108	0.3109	0.1571	0.1267	0.1657
	(0.0272)	(0.0273)	(0.0271)	(0.0427)	(0.0321)	(0.0459)
3500	0.2809	0.2797	0.2801	0.1475	0.1251	0.1543
	(0.0235)	(0.0238)	(0.0233)	(0.037)	(0.03)	(0.0396)
4000	0.258	0.2552	0.2556	0.1364	0.1229	0.142
	(0.0206)	(0.0211)	(0.0207)	(0.0325)	(0.0279)	(0.0347)
4500	0.2395	0.235	0.2349	0.1262	0.1209	0.1308
	(0.0184)	(0.0191)	(0.0185)	(0.0289)	(0.0271)	(0.0309)
5000	0.2238	0.2177	0.2171	0.117	0.1194	0.1211
	(0.0166)	(0.0172)	(0.0167)	(0.0261)	(0.0275)	(0.0278)

Table O.24: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under abrupt drift (priors: 90/10) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1042	0.104	0.1039	0.5021	0.5091	0.511
	(0.045)	(0.0449)	(0.0448)	(0.2367)	(0.2308)	(0.2296)
100	0.3337	0.3337	0.3334	0.3168	0.3174	0.3305
	(0.0203)	(0.0203)	(0.0207)	(0.1477)	(0.1449)	(0.1426)
500	0.7871	0.7872	0.787	0.146	0.1452	0.1495
	(0.0124)	(0.0125)	(0.0125)	(0.0317)	(0.0319)	(0.0311)
1000	0.7402	0.7408	0.7398	0.1046	0.1238	0.1027
	(0.0716)	(0.0719)	(0.0718)	(0.0167)	(0.0181)	(0.0165)
1500	0.5295	0.53	0.5293	0.0834	0.1163	0.0807
	(0.0536)	(0.0538)	(0.0537)	(0.0115)	(0.0135)	(0.0114)
2000	0.4212	0.4219	0.4211	0.0702	0.1126	0.0675
	(0.0405)	(0.0406)	(0.0406)	(0.0089)	(0.0126)	(0.0088)
2500	0.3537	0.3555	0.354	0.0612	0.11	0.0588
	(0.033)	(0.0329)	(0.033)	(0.0073)	(0.015)	(0.0072)
3000	0.3132	0.3169	0.3123	0.0816	0.1106	0.0772
	(0.0274)	(0.0271)	(0.0275)	(0.0068)	(0.0157)	(0.0067)
3500	0.2832	0.2831	0.2801	0.0797	0.1106	0.0749
	(0.0235)	(0.0232)	(0.0236)	(0.0062)	(0.0171)	(0.006)
4000	0.2598	0.2561	0.2539	0.0756	0.1098	0.071
	(0.0206)	(0.0205)	(0.0209)	(0.0055)	(0.0201)	(0.0054)
4500	0.2403	0.2337	0.2316	0.0712	0.1079	0.0668
	(0.0184)	(0.0183)	(0.0187)	(0.005)	(0.0226)	(0.0049)
5000	0.2236	0.2149	0.2127	0.0671	0.106	0.063
	(0.0165)	(0.0165)	(0.0169)	(0.0045)	(0.0254)	(0.0044)

Table O.25: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under stationarity, for a Wishart covariance matrix. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5038	0.5037	0.5035	0.504	0.4495	0.504
	(0.0712)	(0.0712)	(0.0711)	(0.0705)	(0.0677)	(0.0703)
100	0.503	0.5027	0.5029	0.503	0.3909	0.5028
	(0.0502)	(0.05)	(0.0499)	(0.05)	(0.0451)	(0.05)
500	0.4997	0.4996	0.4996	0.4997	0.4184	0.4994
	(0.0224)	(0.0223)	(0.0224)	(0.0223)	(0.0212)	(0.0223)
1000	0.4992	0.4993	0.4992	0.4993	0.4585	0.4992
	(0.0166)	(0.0166)	(0.0166)	(0.0165)	(0.0156)	(0.0165)
1500	0.4995	0.4995	0.4995	0.4995	0.4723	0.4994
	(0.0132)	(0.0132)	(0.0132)	(0.0131)	(0.0124)	(0.0131)
2000	0.4996	0.4996	0.4996	0.4996	0.4791	0.4995
	(0.0116)	(0.0115)	(0.0115)	(0.0115)	(0.0111)	(0.0115)
2500	0.4995	0.4995	0.4995	0.4995	0.4832	0.4994
	(0.0103)	(0.0103)	(0.0103)	(0.0102)	(0.0099)	(0.0102)
3000	0.4998	0.4998	0.4997	0.4998	0.4862	0.4997
	(0.0095)	(0.0095)	(0.0095)	(0.0095)	(0.0093)	(0.0095)
3500	0.4998	0.4998	0.4997	0.4998	0.4881	0.4997
	(0.0088)	(0.0088)	(0.0088)	(0.0088)	(0.0086)	(0.0088)
4000	0.5	0.5	0.5	0.5	0.4898	0.4999
	(0.0082)	(0.0082)	(0.0082)	(0.0082)	(0.0081)	(0.0082)
4500	0.5001	0.5001	0.5001	0.5001	0.4911	0.5001
	(0.0077)	(0.0077)	(0.0077)	(0.0077)	(0.0075)	(0.0077)
5000	0.5002	0.5001	0.5002	0.5002	0.4921	0.5001
	(0.0073)	(0.0072)	(0.0072)	(0.0072)	(0.0071)	(0.0072)

Table O.26: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 250) under abrupt drift (priors: Equal) where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4984	0.4985	0.4983	0.4218	0.4825	0.4638
	(0.0697)	(0.0698)	(0.0697)	(0.0698)	(0.0717)	(0.0699)
100	0.5013	0.5012	0.5011	0.3729	0.4629	0.4322
	(0.0482)	(0.0482)	(0.0482)	(0.0613)	(0.0618)	(0.0495)
500	0.4917	0.4917	0.4918	0.2526	0.3661	0.3077
	(0.0252)	(0.0252)	(0.0252)	(0.0743)	(0.0644)	(0.0613)
1000	0.3427	0.4124	0.4163	0.2171	0.3641	0.2942
	(0.0312)	(0.063)	(0.0653)	(0.0503)	(0.0641)	(0.0414)
1500	0.2401	0.3248	0.3282	0.1962	0.3505	0.279
	(0.0227)	(0.0743)	(0.0769)	(0.0445)	(0.0747)	(0.0388)
2000	0.1836	0.2524	0.2548	0.186	0.3468	0.2718
	(0.0174)	(0.0603)	(0.0623)	(0.0448)	(0.0823)	(0.0419)
2500	0.1485	0.2045	0.2064	0.1792	0.3425	0.2677
	(0.014)	(0.0489)	(0.0505)	(0.046)	(0.0855)	(0.0462)
3000	0.1933	0.2346	0.2327	0.1925	0.3634	0.2925
	(0.0121)	(0.041)	(0.0421)	(0.041)	(0.0742)	(0.0415)
3500	0.2012	0.2281	0.2169	0.1764	0.3677	0.2799
	(0.011)	(0.038)	(0.0361)	(0.0376)	(0.0706)	(0.0461)
4000	0.1938	0.2074	0.1947	0.1585	0.3555	0.2565
	(0.01)	(0.0352)	(0.0315)	(0.0351)	(0.0702)	(0.0551)
4500	0.1814	0.1865	0.1748	0.143	0.3356	0.2363
	(0.0091)	(0.0318)	(0.028)	(0.0333)	(0.0705)	(0.0641)
5000	0.168	0.1687	0.1581	0.1301	0.3147	0.2196
	(0.0083)	(0.0288)	(0.0252)	(0.0323)	(0.07)	(0.0722)

Table O.27: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 250) under abrupt drift (priors: Equal) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.499	0.4986	0.4986	0.4867	0.4886	0.4796
	(0.0722)	(0.0725)	(0.0727)	(0.0726)	(0.0741)	(0.0706)
100	0.5007	0.5004	0.5004	0.462	0.4724	0.4528
	(0.0498)	(0.0497)	(0.0498)	(0.0493)	(0.057)	(0.0478)
500	0.5002	0.5001	0.5	0.346	0.4066	0.3404
	(0.0224)	(0.0224)	(0.0225)	(0.0546)	(0.0507)	(0.0553)
1000	0.3624	0.4295	0.4124	0.3335	0.4102	0.3317
	(0.0264)	(0.057)	(0.0547)	(0.0364)	(0.0499)	(0.0368)
1500	0.2603	0.3479	0.3225	0.3176	0.3997	0.3192
	(0.0201)	(0.073)	(0.0645)	(0.0341)	(0.05)	(0.0348)
2000	0.2018	0.2754	0.2534	0.3092	0.3945	0.3134
	(0.0154)	(0.0617)	(0.0528)	(0.0363)	(0.0557)	(0.038)
2500	0.1648	0.2253	0.2071	0.3031	0.3868	0.3099
	(0.0126)	(0.0507)	(0.0431)	(0.0385)	(0.0616)	(0.0417)
3000	0.2038	0.2501	0.232	0.327	0.4001	0.3337
	(0.0113)	(0.0424)	(0.036)	(0.0332)	(0.0546)	(0.0369)
3500	0.2097	0.2422	0.2182	0.3206	0.4054	0.326
	(0.0102)	(0.038)	(0.0309)	(0.0328)	(0.051)	(0.0408)
4000	0.2017	0.2212	0.1971	0.2931	0.4045	0.3003
	(0.0093)	(0.0349)	(0.027)	(0.034)	(0.0529)	(0.0499)
4500	0.189	0.1996	0.1776	0.2661	0.3995	0.277
	(0.0086)	(0.0316)	(0.024)	(0.0358)	(0.0593)	(0.06)
5000	0.1756	0.1809	0.1609	0.2427	0.3917	0.2575
	(0.0078)	(0.0286)	(0.0216)	(0.0369)	(0.0662)	(0.0692)

Table O.28: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under abrupt drift (priors: Equal) where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4986	0.4979	0.4984	0.3889	0.437	0.4719
	(0.0718)	(0.0715)	(0.0718)	(0.0633)	(0.0693)	(0.0719)
100	0.4985	0.4982	0.4984	0.2985	0.3745	0.4353
	(0.0496)	(0.0493)	(0.0495)	(0.0434)	(0.047)	(0.0494)
500	0.4933	0.4933	0.4934	0.1215	0.2787	0.2412
	(0.0244)	(0.0244)	(0.0244)	(0.0141)	(0.0342)	(0.0184)
1000	0.3462	0.4152	0.4093	0.0788	0.3107	0.1575
	(0.0296)	(0.062)	(0.0626)	(0.0083)	(0.0595)	(0.0112)
1500	0.2423	0.3277	0.3191	0.0595	0.2654	0.1152
	(0.0216)	(0.0754)	(0.0748)	(0.0059)	(0.0799)	(0.008)
2000	0.1846	0.2539	0.2468	0.0477	0.222	0.0901
	(0.0164)	(0.0611)	(0.0604)	(0.0046)	(0.0914)	(0.0061)
2500	0.1489	0.2052	0.1994	0.0398	0.192	0.0738
	(0.0132)	(0.0495)	(0.0488)	(0.0038)	(0.101)	(0.0049)
3000	0.1902	0.2313	0.2236	0.0696	0.2268	0.1308
	(0.0114)	(0.0415)	(0.0407)	(0.0062)	(0.0895)	(0.0075)
3500	0.1951	0.2229	0.2074	0.0675	0.2267	0.1342
	(0.0101)	(0.0387)	(0.035)	(0.0067)	(0.0875)	(0.0128)
4000	0.1861	0.2025	0.1859	0.0615	0.2134	0.1212
	(0.0091)	(0.0359)	(0.0306)	(0.0061)	(0.0882)	(0.0115)
4500	0.1729	0.1823	0.1669	0.0559	0.1978	0.1092
	(0.0083)	(0.0325)	(0.0272)	(0.0054)	(0.0887)	(0.0102)
5000	0.1594	0.1649	0.151	0.051	0.1831	0.099
	(0.0075)	(0.0294)	(0.0246)	(0.0049)	(0.0885)	(0.0092)

Table O.29: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under abrupt drift (priors: Equal) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4988	0.4983	0.4985	0.4901	0.4552	0.4926
	(0.0717)	(0.0718)	(0.0712)	(0.0709)	(0.0682)	(0.0715)
100	0.4985	0.4984	0.4984	0.4694	0.396	0.4668
	(0.0495)	(0.0495)	(0.0493)	(0.0506)	(0.0461)	(0.0486)
500	0.4995	0.4995	0.4996	0.299	0.326	0.279
	(0.0231)	(0.0231)	(0.0231)	(0.0202)	(0.0336)	(0.0195)
1000	0.3549	0.41	0.3957	0.2079	0.3645	0.1868
	(0.0251)	(0.0604)	(0.0524)	(0.0132)	(0.0561)	(0.0123)
1500	0.2497	0.3205	0.299	0.1548	0.3458	0.1374
	(0.0182)	(0.0757)	(0.0589)	(0.0097)	(0.0809)	(0.0087)
2000	0.1909	0.2489	0.2311	0.1216	0.3435	0.1076
	(0.0138)	(0.0618)	(0.0473)	(0.0074)	(0.0919)	(0.0067)
2500	0.1542	0.2015	0.1871	0.0998	0.3552	0.0883
	(0.0111)	(0.0502)	(0.0382)	(0.006)	(0.0901)	(0.0055)
3000	0.1962	0.2301	0.2159	0.1611	0.3727	0.1538
	(0.0099)	(0.0421)	(0.0319)	(0.0069)	(0.0809)	(0.0073)
3500	0.2032	0.2237	0.2038	0.1761	0.3794	0.1685
	(0.0089)	(0.0383)	(0.0276)	(0.0132)	(0.0805)	(0.0158)
4000	0.1956	0.2048	0.184	0.1614	0.3743	0.1532
	(0.0082)	(0.0355)	(0.0242)	(0.0126)	(0.0874)	(0.0145)
4500	0.183	0.1851	0.1657	0.146	0.3613	0.1384
	(0.0074)	(0.0323)	(0.0215)	(0.0112)	(0.0951)	(0.013)
5000	0.1695	0.1678	0.1501	0.1326	0.347	0.1256
	(0.0067)	(0.0292)	(0.0194)	(0.0101)	(0.1015)	(0.0117)

Table O.30: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 250) under abrupt drift (priors: 70/30) where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3066	0.3068	0.3066	0.3755	0.5181	0.4574
	(0.0671)	(0.0671)	(0.0671)	(0.084)	(0.136)	(0.0837)
100	0.3038	0.304	0.3038	0.3407	0.4919	0.4358
	(0.0461)	(0.0458)	(0.046)	(0.0792)	(0.1365)	(0.0762)
500	0.4631	0.4632	0.4632	0.2759	0.3502	0.3455
	(0.0148)	(0.0148)	(0.0148)	(0.0678)	(0.0547)	(0.0645)
1000	0.4666	0.4678	0.4681	0.2559	0.326	0.3233
	(0.0234)	(0.0229)	(0.023)	(0.0429)	(0.0325)	(0.0418)
1500	0.4073	0.4102	0.4107	0.2264	0.3161	0.3048
	(0.0174)	(0.0169)	(0.017)	(0.0444)	(0.0346)	(0.0484)
2000	0.3625	0.3739	0.3751	0.2088	0.3049	0.2947
	(0.0148)	(0.0162)	(0.016)	(0.0452)	(0.0364)	(0.0569)
2500	0.3211	0.3413	0.3427	0.196	0.2967	0.2864
	(0.0132)	(0.0195)	(0.0187)	(0.0438)	(0.0423)	(0.0616)
3000	0.3168	0.3315	0.3348	0.2044	0.3077	0.2987
	(0.0114)	(0.0171)	(0.0162)	(0.0379)	(0.0435)	(0.0591)
3500	0.3099	0.3119	0.3215	0.1871	0.3068	0.2793
	(0.0102)	(0.0192)	(0.0157)	(0.0351)	(0.0417)	(0.0629)
4000	0.2984	0.2916	0.3002	0.1684	0.3031	0.2554
	(0.0091)	(0.0219)	(0.0156)	(0.0348)	(0.038)	(0.0695)
4500	0.2828	0.2694	0.2765	0.1525	0.2965	0.2346
	(0.0083)	(0.0232)	(0.0155)	(0.0356)	(0.0362)	(0.0765)
5000	0.2651	0.2471	0.2534	0.1388	0.2862	0.2172
	(0.0077)	(0.0229)	(0.0148)	(0.0358)	(0.0367)	(0.083)

Table O.31: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 250) under abrupt drift (priors: 70/30) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3067	0.3067	0.3068	0.4135	0.5237	0.4679
	(0.0671)	(0.0671)	(0.067)	(0.0945)	(0.1354)	(0.0841)
100	0.3039	0.3038	0.304	0.4062	0.4983	0.4522
	(0.0461)	(0.046)	(0.0458)	(0.0825)	(0.1363)	(0.0761)
500	0.4894	0.4893	0.4894	0.3522	0.3543	0.3682
	(0.0349)	(0.0349)	(0.0349)	(0.0628)	(0.0543)	(0.064)
1000	0.3948	0.3948	0.3948	0.335	0.3292	0.3454
	(0.0202)	(0.0202)	(0.0202)	(0.04)	(0.0301)	(0.0414)
1500	0.3602	0.3617	0.3619	0.3206	0.3279	0.3304
	(0.015)	(0.015)	(0.0151)	(0.0435)	(0.0277)	(0.0456)
2000	0.3301	0.3383	0.3388	0.3096	0.3282	0.322
	(0.0118)	(0.014)	(0.0132)	(0.0453)	(0.0324)	(0.0529)
2500	0.2987	0.3144	0.3144	0.3005	0.3292	0.3161
	(0.0102)	(0.0175)	(0.0146)	(0.0447)	(0.0397)	(0.0589)
3000	0.2984	0.3102	0.3113	0.3153	0.3371	0.3304
	(0.0091)	(0.0153)	(0.0127)	(0.0394)	(0.0452)	(0.057)
3500	0.2947	0.2969	0.3023	0.3003	0.3374	0.3138
	(0.0083)	(0.0168)	(0.0124)	(0.0373)	(0.0487)	(0.0612)
4000	0.2865	0.2808	0.2853	0.2751	0.3357	0.2895
	(0.0075)	(0.0195)	(0.0124)	(0.0376)	(0.0509)	(0.0689)
4500	0.2741	0.2619	0.2653	0.2511	0.3318	0.2674
	(0.0067)	(0.0213)	(0.0125)	(0.0393)	(0.0527)	(0.0775)
5000	0.2593	0.2421	0.2449	0.2301	0.3261	0.2486
	(0.0063)	(0.0214)	(0.0122)	(0.0414)	(0.0533)	(0.0854)

Table O.32: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under abrupt drift (priors: 70/30) where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3064	0.3062	0.3063	0.3477	0.3786	0.3901
	(0.0685)	(0.0687)	(0.0688)	(0.0801)	(0.0824)	(0.0868)
100	0.3011	0.3011	0.3012	0.2747	0.3174	0.3514
	(0.047)	(0.0469)	(0.0471)	(0.0461)	(0.0518)	(0.0575)
500	0.465	0.465	0.465	0.1119	0.3237	0.2048
	(0.0148)	(0.0148)	(0.0148)	(0.0139)	(0.0283)	(0.0178)
1000	0.4685	0.4699	0.47	0.0694	0.3116	0.1338
	(0.0242)	(0.024)	(0.024)	(0.0078)	(0.0172)	(0.0101)
1500	0.4104	0.4124	0.4128	0.0509	0.3059	0.0975
	(0.0176)	(0.0174)	(0.0172)	(0.0056)	(0.0169)	(0.0072)
2000	0.3625	0.376	0.3773	0.0403	0.3057	0.0762
	(0.0161)	(0.0177)	(0.0164)	(0.0043)	(0.0177)	(0.0055)
2500	0.3125	0.3401	0.3404	0.0333	0.3019	0.0624
	(0.0151)	(0.0244)	(0.0218)	(0.0035)	(0.0269)	(0.0044)
3000	0.3098	0.3297	0.3317	0.061	0.3022	0.1134
	(0.013)	(0.0211)	(0.019)	(0.0053)	(0.0267)	(0.0072)
3500	0.3005	0.302	0.3105	0.0586	0.2963	0.1125
	(0.0115)	(0.0213)	(0.0186)	(0.0053)	(0.0233)	(0.0091)
4000	0.2852	0.2727	0.2819	0.0537	0.2816	0.1033
	(0.0103)	(0.0205)	(0.0177)	(0.0049)	(0.0225)	(0.0085)
4500	0.2665	0.2465	0.2546	0.0486	0.2616	0.093
	(0.0094)	(0.0196)	(0.0164)	(0.0044)	(0.0239)	(0.0076)
5000	0.2472	0.2237	0.2308	0.0442	0.2418	0.0842
	(0.0085)	(0.0184)	(0.0151)	(0.004)	(0.0266)	(0.0069)

Table O.33: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under abrupt drift (priors: 70/30) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3064	0.3066	0.3066	0.3824	0.3871	0.3996
	(0.0685)	(0.0686)	(0.0686)	(0.0902)	(0.0844)	(0.088)
100	0.3011	0.3012	0.3012	0.3524	0.3315	0.3691
	(0.047)	(0.0471)	(0.047)	(0.0607)	(0.0531)	(0.0598)
500	0.4811	0.4811	0.481	0.2551	0.33	0.2445
	(0.0353)	(0.0353)	(0.0353)	(0.0199)	(0.0273)	(0.0202)
1000	0.3909	0.3909	0.3909	0.1841	0.3143	0.1693
	(0.0202)	(0.0203)	(0.0203)	(0.0118)	(0.0171)	(0.012)
1500	0.3593	0.3598	0.3601	0.1402	0.3223	0.1269
	(0.015)	(0.0152)	(0.0151)	(0.0084)	(0.0279)	(0.0086)
2000	0.3287	0.3364	0.3384	0.1116	0.34	0.1006
	(0.0123)	(0.0147)	(0.0138)	(0.0066)	(0.0518)	(0.0067)
2500	0.2902	0.3079	0.3098	0.0924	0.3406	0.0831
	(0.0112)	(0.0205)	(0.0175)	(0.0055)	(0.0718)	(0.0055)
3000	0.291	0.3035	0.3066	0.1499	0.3438	0.1399
	(0.0098)	(0.0179)	(0.0152)	(0.0064)	(0.0784)	(0.0071)
3500	0.286	0.2847	0.2928	0.1552	0.34	0.1447
	(0.0087)	(0.0182)	(0.0148)	(0.0076)	(0.0734)	(0.009)
4000	0.2756	0.2618	0.2709	0.1479	0.3336	0.1378
	(0.0078)	(0.0186)	(0.0141)	(0.0075)	(0.0674)	(0.0085)
4500	0.2616	0.2398	0.2479	0.1357	0.3246	0.1263
	(0.0071)	(0.0188)	(0.0133)	(0.007)	(0.0633)	(0.0078)
5000	0.2459	0.2196	0.2267	0.1238	0.3167	0.1151
	(0.0065)	(0.0183)	(0.0124)	(0.0063)	(0.0603)	(0.0071)

Table O.34: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 250) under abrupt drift (priors: 90/10) where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1028	0.1029	0.1029	0.5164	0.7194	0.5924
	(0.0456)	(0.0455)	(0.0457)	(0.2329)	(0.173)	(0.1937)
100	0.1029	0.1028	0.1028	0.3449	0.6385	0.4839
	(0.0298)	(0.0298)	(0.0298)	(0.1518)	(0.2041)	(0.1426)
500	0.5306	0.5306	0.5306	0.2336	0.24	0.3515
	(0.0098)	(0.0098)	(0.0099)	(0.0698)	(0.0766)	(0.0839)
1000	0.7152	0.7152	0.7152	0.2296	0.1702	0.3178
	(0.0082)	(0.0082)	(0.0082)	(0.0495)	(0.0388)	(0.0599)
1500	0.7769	0.7769	0.7769	0.2247	0.1468	0.3014
	(0.0072)	(0.0072)	(0.0072)	(0.0475)	(0.0264)	(0.0578)
2000	0.8029	0.8028	0.8027	0.2183	0.1357	0.2898
	(0.0169)	(0.017)	(0.0171)	(0.0453)	(0.0205)	(0.0592)
2500	0.7137	0.7136	0.7135	0.2108	0.1293	0.2805
	(0.0475)	(0.0474)	(0.0476)	(0.0419)	(0.017)	(0.0604)
3000	0.6114	0.6114	0.6114	0.195	0.1254	0.2666
	(0.0398)	(0.0398)	(0.0401)	(0.0365)	(0.0159)	(0.0629)
3500	0.5384	0.5383	0.5383	0.1738	0.1222	0.2461
	(0.0342)	(0.0342)	(0.0344)	(0.0322)	(0.0152)	(0.0742)
4000	0.4837	0.4837	0.4836	0.1547	0.1199	0.2272
	(0.03)	(0.03)	(0.0302)	(0.0285)	(0.0149)	(0.088)
4500	0.441	0.441	0.4409	0.1388	0.1177	0.2111
	(0.0267)	(0.0269)	(0.0269)	(0.0254)	(0.0143)	(0.101)
5000	0.4069	0.4069	0.4068	0.1257	0.116	0.1975
	(0.024)	(0.0243)	(0.0242)	(0.0229)	(0.0129)	(0.1122)

Table O.35: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 250) under abrupt drift (priors: 90/10) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1028	0.1029	0.1028	0.5198	0.722	0.5966
	(0.0457)	(0.0457)	(0.0457)	(0.2311)	(0.1721)	(0.1925)
100	0.1029	0.1029	0.1028	0.3552	0.6357	0.4921
	(0.0299)	(0.0298)	(0.0298)	(0.1505)	(0.202)	(0.1415)
500	0.681	0.6811	0.681	0.2756	0.2373	0.368
	(0.0116)	(0.0117)	(0.0117)	(0.0752)	(0.077)	(0.0853)
1000	0.7903	0.7904	0.7903	0.2769	0.1689	0.333
	(0.0092)	(0.0092)	(0.0092)	(0.0567)	(0.0392)	(0.0619)
1500	0.6851	0.6853	0.6851	0.2738	0.1464	0.3161
	(0.0604)	(0.0604)	(0.0605)	(0.0558)	(0.0268)	(0.06)
2000	0.5389	0.5391	0.5389	0.2683	0.137	0.3047
	(0.0457)	(0.0457)	(0.0457)	(0.0525)	(0.021)	(0.0604)
2500	0.4511	0.4512	0.4511	0.2626	0.1326	0.2963
	(0.0367)	(0.0367)	(0.0368)	(0.0503)	(0.0185)	(0.0614)
3000	0.3925	0.3926	0.3925	0.2503	0.1296	0.2834
	(0.0308)	(0.0308)	(0.0308)	(0.0464)	(0.018)	(0.0652)
3500	0.3508	0.3509	0.3508	0.2297	0.1267	0.2628
	(0.0266)	(0.0266)	(0.0266)	(0.0432)	(0.018)	(0.0765)
4000	0.3195	0.3196	0.3195	0.209	0.1242	0.2432
	(0.0233)	(0.0233)	(0.0233)	(0.0413)	(0.0174)	(0.0897)
4500	0.295	0.2951	0.295	0.1907	0.1222	0.2265
	(0.0208)	(0.0208)	(0.0208)	(0.0412)	(0.0176)	(0.1022)
5000	0.2755	0.2756	0.2755	0.1748	0.1208	0.2125
	(0.0188)	(0.0188)	(0.0188)	(0.0415)	(0.0182)	(0.1132)

Table O.36: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under abrupt drift (priors: 90/10) where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1045	0.1042	0.1042	0.5063	0.5085	0.508
	(0.046)	(0.0459)	(0.0458)	(0.2321)	(0.2305)	(0.2311)
100	0.1022	0.1021	0.1021	0.315	0.3172	0.3187
	(0.031)	(0.0309)	(0.0309)	(0.1473)	(0.1465)	(0.1466)
500	0.5332	0.5332	0.5332	0.1219	0.1507	0.139
	(0.0106)	(0.0106)	(0.0106)	(0.0321)	(0.0328)	(0.0316)
1000	0.7168	0.7169	0.7169	0.0779	0.1256	0.0952
	(0.0085)	(0.0085)	(0.0085)	(0.0165)	(0.0178)	(0.0161)
1500	0.7776	0.7776	0.7776	0.0573	0.1174	0.0715
	(0.0071)	(0.0071)	(0.0071)	(0.0112)	(0.0127)	(0.011)
2000	0.8043	0.8043	0.8043	0.0453	0.1132	0.0569
	(0.0161)	(0.016)	(0.016)	(0.0085)	(0.0101)	(0.0084)
2500	0.7149	0.7151	0.7153	0.0374	0.1106	0.0472
	(0.0476)	(0.0475)	(0.0476)	(0.0068)	(0.0084)	(0.0067)
3000	0.6125	0.6127	0.6128	0.0528	0.1088	0.0737
	(0.0398)	(0.0397)	(0.0398)	(0.0078)	(0.0074)	(0.0075)
3500	0.5394	0.5395	0.5396	0.0507	0.1077	0.0701
	(0.0342)	(0.0341)	(0.0342)	(0.0067)	(0.0067)	(0.0066)
4000	0.4844	0.4846	0.4846	0.0467	0.1067	0.0647
	(0.0299)	(0.0299)	(0.0299)	(0.0059)	(0.0063)	(0.0058)
4500	0.4417	0.4418	0.4419	0.0429	0.1059	0.0594
	(0.0266)	(0.0266)	(0.0267)	(0.0052)	(0.0057)	(0.0052)
5000	0.4075	0.4076	0.4077	0.0394	0.1054	0.0548
	(0.0241)	(0.024)	(0.0241)	(0.0047)	(0.0053)	(0.0047)

Table O.37: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under abrupt drift (priors: 90/10) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1044	0.1042	0.1042	0.5076	0.5087	0.5079
	(0.0461)	(0.0459)	(0.0458)	(0.2324)	(0.2299)	(0.2314)
100	0.1021	0.102	0.102	0.3164	0.317	0.3191
	(0.031)	(0.0309)	(0.0309)	(0.1473)	(0.1457)	(0.1459)
500	0.6914	0.6914	0.6914	0.1451	0.1536	0.1487
	(0.012)	(0.012)	(0.012)	(0.0318)	(0.0337)	(0.0315)
1000	0.7951	0.7951	0.7951	0.1122	0.1297	0.108
	(0.0125)	(0.0125)	(0.0126)	(0.0163)	(0.0205)	(0.0162)
1500	0.6579	0.658	0.6581	0.0906	0.138	0.084
	(0.0606)	(0.0605)	(0.0605)	(0.0111)	(0.0179)	(0.011)
2000	0.5186	0.5188	0.5188	0.0752	0.1292	0.0685
	(0.0455)	(0.0455)	(0.0454)	(0.0085)	(0.0143)	(0.0084)
2500	0.4349	0.435	0.435	0.0639	0.1243	0.0577
	(0.0367)	(0.0367)	(0.0366)	(0.0069)	(0.0125)	(0.0068)
3000	0.3791	0.3791	0.3792	0.0988	0.121	0.0881
	(0.0306)	(0.0305)	(0.0305)	(0.0091)	(0.0114)	(0.0079)
3500	0.3393	0.3393	0.3394	0.0956	0.1183	0.0847
	(0.0263)	(0.0262)	(0.0262)	(0.0078)	(0.0102)	(0.0069)
4000	0.3093	0.3094	0.3094	0.0891	0.1162	0.0789
	(0.0231)	(0.023)	(0.023)	(0.0069)	(0.0096)	(0.0062)
4500	0.286	0.2861	0.2861	0.0828	0.1146	0.0733
	(0.0206)	(0.0206)	(0.0205)	(0.0062)	(0.0089)	(0.0055)
5000	0.2674	0.2675	0.2675	0.077	0.1133	0.0682
	(0.0187)	(0.0187)	(0.0187)	(0.0056)	(0.0083)	(0.005)

Table O.38: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under abrupt drift (priors: Equal) where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5013	0.5014	0.5017	0.4487	0.485	0.4685
	(0.0715)	(0.071)	(0.0711)	(0.0669)	(0.0724)	(0.0686)
100	0.5004	0.5007	0.5007	0.4136	0.4767	0.4444
	(0.0514)	(0.0511)	(0.0512)	(0.0525)	(0.0569)	(0.0467)
500	0.4994	0.4994	0.4994	0.3275	0.416	0.3621
	(0.0219)	(0.022)	(0.022)	(0.0715)	(0.0705)	(0.0578)
1000	0.4995	0.4995	0.4995	0.2723	0.3515	0.303
	(0.0155)	(0.0156)	(0.0156)	(0.079)	(0.0753)	(0.0692)
1500	0.4166	0.4491	0.4618	0.2907	0.362	0.3324
	(0.0256)	(0.0381)	(0.0392)	(0.0582)	(0.0668)	(0.0486)
2000	0.3263	0.4058	0.431	0.2947	0.3578	0.3437
	(0.025)	(0.0693)	(0.0708)	(0.0481)	(0.0768)	(0.0385)
2500	0.265	0.3564	0.3879	0.2977	0.355	0.3522
	(0.0212)	(0.0808)	(0.0852)	(0.0421)	(0.0825)	(0.0326)
3000	0.2419	0.3354	0.3652	0.2806	0.3664	0.358
	(0.0197)	(0.0822)	(0.0862)	(0.0372)	(0.0788)	(0.0282)
3500	0.2142	0.2994	0.3266	0.2523	0.3714	0.3412
	(0.0171)	(0.0755)	(0.0799)	(0.036)	(0.0787)	(0.0282)
4000	0.1898	0.2654	0.2895	0.2274	0.3711	0.3104
	(0.0151)	(0.0674)	(0.0714)	(0.0389)	(0.0794)	(0.0357)
4500	0.1696	0.237	0.2583	0.2069	0.3669	0.2841
	(0.0134)	(0.0602)	(0.0637)	(0.0439)	(0.0796)	(0.0465)
5000	0.1531	0.2137	0.2328	0.1902	0.3634	0.2629
	(0.012)	(0.0543)	(0.0574)	(0.0491)	(0.0779)	(0.0569)

Table O.39: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under abrupt drift (priors: Equal) where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5016	0.5019	0.5017	0.4911	0.4898	0.4863
	(0.0714)	(0.0712)	(0.0709)	(0.0702)	(0.0717)	(0.0665)
100	0.5003	0.501	0.5004	0.4731	0.4831	0.4673
	(0.0514)	(0.0513)	(0.0512)	(0.0486)	(0.0545)	(0.0454)
500	0.4994	0.4995	0.4993	0.3847	0.4261	0.3801
	(0.0226)	(0.0226)	(0.0225)	(0.0568)	(0.0639)	(0.0573)
1000	0.4995	0.4996	0.4995	0.3131	0.3886	0.3099
	(0.0158)	(0.0158)	(0.0158)	(0.0734)	(0.0624)	(0.0733)
1500	0.4193	0.4519	0.4641	0.344	0.3994	0.3421
	(0.0262)	(0.0373)	(0.0375)	(0.0518)	(0.0528)	(0.0513)
2000	0.329	0.4107	0.4347	0.354	0.3958	0.3538
	(0.025)	(0.0678)	(0.0681)	(0.0405)	(0.0609)	(0.04)
2500	0.267	0.3629	0.393	0.3612	0.3929	0.3622
	(0.0209)	(0.0803)	(0.0832)	(0.0342)	(0.0614)	(0.0335)
3000	0.2891	0.3723	0.3981	0.3798	0.4083	0.3819
	(0.018)	(0.0717)	(0.0743)	(0.029)	(0.0521)	(0.0282)
3500	0.2817	0.354	0.3767	0.3865	0.4156	0.3894
	(0.0159)	(0.0667)	(0.0697)	(0.0264)	(0.0479)	(0.0264)
4000	0.2629	0.3239	0.3434	0.3662	0.4163	0.3654
	(0.0141)	(0.0612)	(0.0638)	(0.0268)	(0.0492)	(0.0273)
4500	0.2414	0.2933	0.31	0.3357	0.4122	0.3336
	(0.0126)	(0.0555)	(0.0575)	(0.0327)	(0.0543)	(0.0341)
5000	0.2209	0.2659	0.2806	0.3087	0.4063	0.3066
	(0.0115)	(0.0504)	(0.0519)	(0.0416)	(0.0603)	(0.0432)

Table O.40: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under abrupt drift (priors: Equal) where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.501	0.5012	0.5013	0.3255	0.4374	0.4483
	(0.0701)	(0.0701)	(0.0704)	(0.0602)	(0.0676)	(0.068)
100	0.5003	0.5006	0.5005	0.2017	0.3648	0.3956
	(0.0505)	(0.0509)	(0.0508)	(0.0386)	(0.0461)	(0.0486)
500	0.4994	0.4994	0.4996	0.0493	0.1844	0.1913
	(0.0224)	(0.0224)	(0.0225)	(0.0091)	(0.0195)	(0.0168)
1000	0.4994	0.4994	0.4996	0.0254	0.1638	0.1081
	(0.016)	(0.016)	(0.016)	(0.0046)	(0.0383)	(0.0092)
1500	0.3999	0.4283	0.4424	0.0175	0.2052	0.0771
	(0.0249)	(0.0406)	(0.045)	(0.0032)	(0.0452)	(0.0067)
2000	0.3044	0.3707	0.3996	0.0133	0.1785	0.059
	(0.021)	(0.0719)	(0.0801)	(0.0024)	(0.0545)	(0.0051)
2500	0.244	0.3126	0.3459	0.0107	0.1518	0.0475
	(0.017)	(0.0761)	(0.0884)	(0.0019)	(0.0531)	(0.0041)
3000	0.2889	0.3417	0.3688	0.0328	0.2063	0.0952
	(0.0148)	(0.0633)	(0.0739)	(0.0082)	(0.0446)	(0.0053)
3500	0.2963	0.337	0.3597	0.0313	0.2194	0.1015
	(0.013)	(0.057)	(0.0665)	(0.0077)	(0.0402)	(0.0057)
4000	0.2853	0.3146	0.3331	0.0287	0.2132	0.0948
	(0.0116)	(0.0515)	(0.06)	(0.0068)	(0.0371)	(0.0054)
4500	0.2669	0.2876	0.303	0.0262	0.1998	0.0862
	(0.0106)	(0.0466)	(0.0539)	(0.0061)	(0.0342)	(0.0048)
5000	0.247	0.262	0.2754	0.0239	0.1848	0.0784
	(0.0096)	(0.0422)	(0.0487)	(0.0055)	(0.0316)	(0.0044)

Table O.41: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under abrupt drift (priors: 70/30) where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.309	0.3094	0.3093	0.37	0.5278	0.4478
	(0.0685)	(0.0686)	(0.0683)	(0.0884)	(0.1416)	(0.0806)
100	0.3031	0.3032	0.3031	0.3319	0.5175	0.4355
	(0.049)	(0.0491)	(0.049)	(0.0871)	(0.1452)	(0.0741)
500	0.3799	0.3799	0.38	0.2505	0.3778	0.3373
	(0.0137)	(0.0137)	(0.0137)	(0.1061)	(0.094)	(0.0951)
1000	0.5189	0.5189	0.5188	0.2305	0.3381	0.2999
	(0.0242)	(0.0243)	(0.0243)	(0.0736)	(0.0485)	(0.067)
1500	0.4471	0.4471	0.4471	0.2332	0.3235	0.2988
	(0.0194)	(0.0194)	(0.0194)	(0.0528)	(0.0326)	(0.0477)
2000	0.4104	0.4104	0.4104	0.2252	0.3172	0.3026
	(0.0154)	(0.0154)	(0.0155)	(0.0444)	(0.0267)	(0.0396)
2500	0.3878	0.3882	0.3882	0.2155	0.3127	0.303
	(0.013)	(0.013)	(0.013)	(0.0437)	(0.029)	(0.038)
3000	0.3734	0.3738	0.3737	0.2208	0.3168	0.3129
	(0.0112)	(0.0112)	(0.0112)	(0.0394)	(0.0292)	(0.0331)
3500	0.363	0.3632	0.3632	0.2048	0.3169	0.3104
	(0.01)	(0.01)	(0.01)	(0.0367)	(0.0296)	(0.032)
4000	0.3551	0.3553	0.3553	0.1899	0.3159	0.3039
	(0.009)	(0.009)	(0.009)	(0.0349)	(0.0286)	(0.0312)
4500	0.3489	0.349	0.3491	0.1774	0.3145	0.2905
	(0.0083)	(0.0083)	(0.0083)	(0.0345)	(0.0265)	(0.0311)
5000	0.3434	0.3434	0.3437	0.1664	0.3131	0.2726
	(0.0076)	(0.0077)	(0.0077)	(0.0353)	(0.0244)	(0.0325)

Table O.42: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under abrupt drift (priors: 70/30) where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3093	0.3091	0.3087	0.333	0.3692	0.3777
	(0.0642)	(0.0643)	(0.0643)	(0.0745)	(0.0786)	(0.08)
100	0.3049	0.3048	0.3046	0.2393	0.3056	0.3394
	(0.0465)	(0.0466)	(0.0467)	(0.0474)	(0.0509)	(0.0562)
500	0.4121	0.4121	0.4121	0.0616	0.246	0.1802
	(0.0134)	(0.0134)	(0.0134)	(0.0119)	(0.0181)	(0.0171)
1000	0.4892	0.4892	0.4891	0.0316	0.3202	0.1057
	(0.0255)	(0.0255)	(0.0256)	(0.006)	(0.0136)	(0.0095)
1500	0.4256	0.4257	0.4256	0.0214	0.313	0.0749
	(0.0183)	(0.0184)	(0.0184)	(0.004)	(0.0113)	(0.0066)
2000	0.3942	0.3942	0.3942	0.0162	0.3097	0.0572
	(0.0148)	(0.0148)	(0.0148)	(0.003)	(0.0102)	(0.005)
2500	0.3752	0.3753	0.3752	0.013	0.3077	0.0461
	(0.0124)	(0.0124)	(0.0124)	(0.0024)	(0.0091)	(0.004)
3000	0.3628	0.3629	0.3628	0.0319	0.3066	0.0893
	(0.0108)	(0.0109)	(0.0108)	(0.0051)	(0.0083)	(0.0055)
3500	0.3538	0.3538	0.3538	0.0323	0.3056	0.1063
	(0.0096)	(0.0096)	(0.0096)	(0.0052)	(0.0077)	(0.0074)
4000	0.3468	0.3464	0.347	0.0305	0.305	0.106
	(0.0088)	(0.0091)	(0.0088)	(0.0047)	(0.0073)	(0.0096)
4500	0.34	0.3382	0.3402	0.0281	0.3044	0.098
	(0.0079)	(0.0097)	(0.0082)	(0.0042)	(0.0068)	(0.0093)
5000	0.3314	0.3262	0.33	0.0257	0.304	0.0897
	(0.0069)	(0.0121)	(0.0092)	(0.0038)	(0.0066)	(0.0086)

Table O.43: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under abrupt drift (priors: 90/10) where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1043	0.1042	0.1048	0.5013	0.7232	0.5823
	(0.0428)	(0.0431)	(0.0429)	(0.2258)	(0.1729)	(0.1901)
100	0.1027	0.1026	0.1029	0.334	0.6836	0.492
	(0.0304)	(0.0304)	(0.0305)	(0.1474)	(0.2038)	(0.1349)
500	0.4065	0.4066	0.4066	0.2326	0.3629	0.4395
	(0.0124)	(0.0124)	(0.0125)	(0.141)	(0.1589)	(0.1405)
1000	0.6531	0.6532	0.6531	0.2327	0.2329	0.3855
	(0.0091)	(0.009)	(0.0092)	(0.0818)	(0.0813)	(0.0885)
1500	0.7358	0.7359	0.7358	0.2313	0.1884	0.3596
	(0.0077)	(0.0077)	(0.0078)	(0.0602)	(0.0543)	(0.0675)
2000	0.7768	0.7768	0.7768	0.2271	0.1664	0.3421
	(0.0066)	(0.0066)	(0.0066)	(0.0494)	(0.0407)	(0.0574)
2500	0.8006	0.8007	0.8007	0.2232	0.1531	0.3293
	(0.009)	(0.009)	(0.009)	(0.0434)	(0.0325)	(0.0518)
3000	0.7457	0.7462	0.7461	0.203	0.1444	0.2914
	(0.0415)	(0.0416)	(0.0415)	(0.0365)	(0.0273)	(0.0436)
3500	0.6539	0.6542	0.6541	0.1883	0.1387	0.265
	(0.0366)	(0.0366)	(0.0366)	(0.0314)	(0.024)	(0.0392)
4000	0.5847	0.585	0.5849	0.1769	0.1345	0.246
	(0.032)	(0.0321)	(0.032)	(0.028)	(0.0214)	(0.0389)
4500	0.5308	0.5311	0.531	0.1671	0.131	0.2314
	(0.0285)	(0.0286)	(0.0285)	(0.0257)	(0.0191)	(0.0419)
5000	0.4877	0.488	0.4879	0.1572	0.128	0.2191
	(0.0257)	(0.0257)	(0.0257)	(0.0237)	(0.0172)	(0.0471)

Table O.44: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under abrupt drift (priors: 90/10) where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1035	0.1034	0.1033	0.4961	0.4954	0.4946
	(0.0439)	(0.0439)	(0.0437)	(0.2301)	(0.2308)	(0.2312)
100	0.1021	0.1021	0.1021	0.307	0.3064	0.304
	(0.0303)	(0.0303)	(0.0303)	(0.1378)	(0.1386)	(0.139)
500	0.4233	0.4233	0.4233	0.1145	0.1409	0.0988
	(0.0087)	(0.0088)	(0.0087)	(0.03)	(0.0302)	(0.0302)
1000	0.662	0.662	0.6619	0.0685	0.1234	0.0588
	(0.008)	(0.008)	(0.008)	(0.0155)	(0.0165)	(0.0154)
1500	0.7412	0.7412	0.7412	0.0487	0.1157	0.0421
	(0.007)	(0.007)	(0.007)	(0.0105)	(0.012)	(0.0104)
2000	0.7809	0.781	0.7809	0.0375	0.1118	0.0327
	(0.0062)	(0.0062)	(0.0062)	(0.0079)	(0.0097)	(0.0078)
2500	0.7868	0.7868	0.7868	0.0305	0.1093	0.0267
	(0.032)	(0.032)	(0.032)	(0.0064)	(0.0081)	(0.0063)
3000	0.6884	0.6884	0.6884	0.055	0.1078	0.0528
	(0.0435)	(0.0435)	(0.0437)	(0.0084)	(0.0071)	(0.0063)
3500	0.6043	0.6044	0.6044	0.0593	0.1067	0.0575
	(0.0371)	(0.0372)	(0.0373)	(0.0073)	(0.0065)	(0.0056)
4000	0.5413	0.5414	0.5414	0.0605	0.1059	0.059
	(0.0325)	(0.0325)	(0.0326)	(0.0064)	(0.0059)	(0.0049)
4500	0.4923	0.4923	0.4924	0.0595	0.1053	0.0585
	(0.0289)	(0.0289)	(0.029)	(0.0056)	(0.0055)	(0.0045)
5000	0.4531	0.4531	0.4531	0.0574	0.1047	0.0571
	(0.0259)	(0.026)	(0.0261)	(0.0051)	(0.0051)	(0.004)

Table O.45: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under abrupt drift (priors: Equal) where the covariance matrix drifts from CS to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5047	0.5045	0.5045	0.1119	0.0926	0.1046
	(0.068)	(0.0681)	(0.068)	(0.0453)	(0.0427)	(0.0445)
100	0.5032	0.5032	0.5032	0.056	0.0463	0.0523
	(0.0498)	(0.0498)	(0.05)	(0.0226)	(0.0214)	(0.0223)
500	0.2155	0.2711	0.2252	0.0112	0.0093	0.0105
	(0.0239)	(0.0834)	(0.039)	(0.0045)	(0.0043)	(0.0045)
1000	0.1078	0.1358	0.1126	0.0056	0.0046	0.0052
	(0.012)	(0.0422)	(0.0196)	(0.0023)	(0.0021)	(0.0022)
1500	0.0718	0.0906	0.0751	0.0037	0.0031	0.0035
	(0.008)	(0.0281)	(0.013)	(0.0015)	(0.0014)	(0.0015)
2000	0.0539	0.0679	0.0563	0.0028	0.0023	0.0026
	(0.006)	(0.0211)	(0.0098)	(0.0011)	(0.0011)	(0.0011)
2500	0.0431	0.0543	0.045	0.0022	0.0019	0.0021
	(0.0048)	(0.0169)	(0.0078)	(9e-04)	(9e-04)	(9e-04)
3000	0.0895	0.1129	0.1084	0.0729	0.0694	0.0589
	(0.0072)	(0.0156)	(0.0093)	(0.0066)	(0.0069)	(0.0103)
3500	0.0912	0.143	0.1303	0.0818	0.1108	0.0695
	(0.0093)	(0.0252)	(0.0239)	(0.0092)	(0.0145)	(0.0235)
4000	0.0861	0.1535	0.138	0.0795	0.1449	0.0724
	(0.0092)	(0.0285)	(0.0324)	(0.0112)	(0.0203)	(0.035)
4500	0.0803	0.1547	0.1439	0.0753	0.1624	0.0728
	(0.0086)	(0.029)	(0.036)	(0.0128)	(0.0285)	(0.0441)
5000	0.0748	0.1518	0.1481	0.0711	0.1669	0.0726
	(0.0079)	(0.028)	(0.0375)	(0.0141)	(0.0344)	(0.0514)

Table O.46: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under abrupt drift (priors: Equal) where the covariance matrix drifts from CS to AR. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5049	0.505	0.5051	0.1138	0.0954	0.1064
	(0.0679)	(0.0676)	(0.0679)	(0.0449)	(0.0438)	(0.0443)
100	0.5031	0.5036	0.5037	0.057	0.0477	0.0533
	(0.0502)	(0.05)	(0.0496)	(0.0225)	(0.0219)	(0.0222)
500	0.2163	0.2735	0.2265	0.0114	0.0095	0.0107
	(0.0237)	(0.0848)	(0.0398)	(0.0045)	(0.0044)	(0.0044)
1000	0.1081	0.1371	0.1133	0.0057	0.0048	0.0053
	(0.0119)	(0.0429)	(0.02)	(0.0023)	(0.0022)	(0.0022)
1500	0.0721	0.0914	0.0755	0.0038	0.0032	0.0036
	(0.0079)	(0.0286)	(0.0133)	(0.0015)	(0.0015)	(0.0015)
2000	0.0541	0.0685	0.0566	0.0029	0.0024	0.0027
	(0.0059)	(0.0215)	(0.01)	(0.0011)	(0.0011)	(0.0011)
2500	0.0433	0.0548	0.0453	0.0023	0.0019	0.0021
	(0.0047)	(0.0172)	(0.008)	(9e-04)	(9e-04)	(9e-04)
3000	0.0449	0.058	0.0586	0.0153	0.0105	0.0111
	(0.0043)	(0.0153)	(0.0157)	(0.0132)	(0.0054)	(0.0065)
3500	0.0385	0.0501	0.0502	0.0131	0.0094	0.0104
	(0.0037)	(0.0139)	(0.0136)	(0.0114)	(0.0065)	(0.0085)
4000	0.0337	0.0445	0.044	0.0115	0.0084	0.0097
	(0.0032)	(0.0139)	(0.0119)	(0.01)	(0.0063)	(0.0099)
4500	0.0299	0.0398	0.0391	0.0102	0.0076	0.0089
	(0.0029)	(0.0129)	(0.0106)	(0.0089)	(0.0067)	(0.0105)
5000	0.0269	0.0362	0.0352	0.0092	0.0069	0.0082
	(0.0026)	(0.0124)	(0.0095)	(0.008)	(0.0067)	(0.0106)

Table O.47: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under abrupt drift (priors: Equal) where the covariance matrix drifts from EYE to CS. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5043	0.5046	0.5047	0.2787	0.1794	0.1815
	(0.0685)	(0.068)	(0.0677)	(0.0598)	(0.0569)	(0.0568)
100	0.5038	0.5032	0.5035	0.1833	0.1163	0.1177
	(0.0502)	(0.0498)	(0.0496)	(0.0365)	(0.0333)	(0.0333)
500	0.3959	0.4394	0.412	0.071	0.051	0.0515
	(0.0266)	(0.0487)	(0.039)	(0.0107)	(0.0097)	(0.0098)
1000	0.2837	0.3259	0.2985	0.0521	0.0407	0.041
	(0.0184)	(0.0436)	(0.0312)	(0.0065)	(0.0061)	(0.0061)
1500	0.227	0.258	0.238	0.0451	0.037	0.0372
	(0.0144)	(0.0319)	(0.0232)	(0.0051)	(0.0048)	(0.0049)
2000	0.1922	0.2166	0.2009	0.0414	0.035	0.0352
	(0.0123)	(0.0251)	(0.0186)	(0.0043)	(0.0041)	(0.0042)
2500	0.1686	0.1887	0.176	0.0391	0.0338	0.0339
	(0.0113)	(0.0209)	(0.0159)	(0.0037)	(0.0036)	(0.0036)
3000	0.1546	0.1756	0.1708	0.051	0.0474	0.0469
	(0.0112)	(0.0191)	(0.0211)	(0.0097)	(0.0105)	(0.0101)
3500	0.1327	0.1505	0.1466	0.0438	0.0406	0.0403
	(0.0112)	(0.0166)	(0.0187)	(0.0083)	(0.009)	(0.0087)
4000	0.1161	0.1318	0.1283	0.0383	0.0355	0.0352
	(0.0113)	(0.0146)	(0.0166)	(0.0073)	(0.0078)	(0.0076)
4500	0.1033	0.1172	0.114	0.0341	0.0316	0.0313
	(0.0111)	(0.0131)	(0.0148)	(0.0065)	(0.007)	(0.0067)
5000	0.093	0.1055	0.1026	0.0307	0.0284	0.0282
	(0.0107)	(0.0119)	(0.0137)	(0.0059)	(0.0063)	(0.0061)

APPENDIX N: GRADUAL DRIFT QDA SIMULATION

Table P.1: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 10) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4427	0.4423	0.4426	0.4212	0.4289	0.4464
	(0.0714)	(0.0711)	(0.0715)	(0.0702)	(0.0692)	(0.0675)
100	0.3884	0.3882	0.3884	0.3828	0.382	0.4058
	(0.0506)	(0.0505)	(0.0506)	(0.0502)	(0.0503)	(0.048)
500	0.3096	0.3113	0.3096	0.3137	0.308	0.3238
	(0.0226)	(0.0255)	(0.0225)	(0.0233)	(0.0227)	(0.0236)
1000	0.2974	0.2998	0.2974	0.3007	0.2963	0.3065
	(0.0168)	(0.0225)	(0.0168)	(0.0172)	(0.0168)	(0.0174)
1500	0.2978	0.3006	0.2978	0.3004	0.2971	0.3042
	(0.014)	(0.0214)	(0.014)	(0.0143)	(0.014)	(0.0147)
2000	0.3006	0.3038	0.3005	0.3027	0.3	0.3056
	(0.0124)	(0.0212)	(0.0125)	(0.0127)	(0.0125)	(0.013)
2500	0.3045	0.3078	0.3044	0.3063	0.3039	0.3085
	(0.0114)	(0.0209)	(0.0113)	(0.0116)	(0.0113)	(0.0118)
3000	0.3082	0.3112	0.3079	0.3095	0.3075	0.3113
	(0.0106)	(0.0208)	(0.0105)	(0.0107)	(0.0105)	(0.011)
3500	0.3112	0.3131	0.3103	0.3117	0.31	0.3131
	(0.0099)	(0.0211)	(0.0099)	(0.01)	(0.0098)	(0.0103)
4000	0.3133	0.3135	0.3115	0.3128	0.3113	0.3139
	(0.0094)	(0.0215)	(0.0093)	(0.0094)	(0.0092)	(0.0097)
4500	0.3142	0.3121	0.3112	0.3124	0.3111	0.3133
	(0.009)	(0.0222)	(0.0089)	(0.0091)	(0.0089)	(0.0093)
5000	0.314	0.309	0.3092	0.3103	0.3092	0.3111
	(0.0087)	(0.0229)	(0.0085)	(0.0086)	(0.0085)	(0.0089)

Table P.2: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 10) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4454	0.4451	0.4454	0.4292	0.4254	0.446
	(0.0715)	(0.0715)	(0.0716)	(0.0698)	(0.0673)	(0.0689)
100	0.3756	0.3756	0.3756	0.3772	0.3661	0.3931
	(0.0491)	(0.0492)	(0.0492)	(0.0483)	(0.0456)	(0.0483)
500	0.2779	0.279	0.2778	0.2824	0.2761	0.2869
	(0.0207)	(0.0243)	(0.0206)	(0.0214)	(0.0208)	(0.0209)
1000	0.2676	0.2691	0.2676	0.2705	0.2667	0.2726
	(0.0145)	(0.0206)	(0.0145)	(0.0149)	(0.0147)	(0.0147)
1500	0.2712	0.2729	0.2712	0.2734	0.2706	0.2746
	(0.0118)	(0.0198)	(0.0118)	(0.012)	(0.012)	(0.0119)
2000	0.2778	0.279	0.2776	0.2795	0.2772	0.2802
	(0.0103)	(0.0191)	(0.0102)	(0.0104)	(0.0103)	(0.0103)
2500	0.2846	0.2851	0.2843	0.2858	0.2839	0.2863
	(0.0093)	(0.0185)	(0.0092)	(0.0093)	(0.0093)	(0.0093)
3000	0.291	0.2899	0.2903	0.2917	0.29	0.2919
	(0.0085)	(0.0182)	(0.0085)	(0.0086)	(0.0086)	(0.0085)
3500	0.2966	0.2927	0.2952	0.2965	0.295	0.2965
	(0.0079)	(0.018)	(0.0079)	(0.008)	(0.008)	(0.0079)
4000	0.3006	0.293	0.2981	0.2993	0.298	0.2992
	(0.0073)	(0.0181)	(0.0073)	(0.0074)	(0.0073)	(0.0073)
4500	0.3032	0.2907	0.299	0.3	0.2989	0.2998
	(0.0069)	(0.0186)	(0.0069)	(0.0069)	(0.0069)	(0.0069)
5000	0.304	0.2863	0.2973	0.2982	0.2972	0.298
	(0.0067)	(0.0192)	(0.0067)	(0.0067)	(0.0067)	(0.0067)

Table P.3: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 50) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4998	0.4995	0.4996	0.4651	0.4509	0.4589
	(0.0691)	(0.0692)	(0.0691)	(0.0664)	(0.0701)	(0.0664)
100	0.493	0.4929	0.4929	0.424	0.4349	0.4194
	(0.0526)	(0.0527)	(0.0527)	(0.046)	(0.0484)	(0.0467)
500	0.3053	0.3278	0.3095	0.3045	0.3058	0.3034
	(0.0228)	(0.0396)	(0.0264)	(0.0265)	(0.0455)	(0.0272)
1000	0.2457	0.2596	0.2482	0.2633	0.2511	0.2633
	(0.016)	(0.0244)	(0.0177)	(0.0227)	(0.0453)	(0.0235)
1500	0.2261	0.2367	0.228	0.2492	0.2323	0.2496
	(0.0143)	(0.0189)	(0.0151)	(0.0208)	(0.0425)	(0.0215)
2000	0.2191	0.2283	0.2207	0.245	0.2255	0.2457
	(0.0137)	(0.0168)	(0.0141)	(0.0198)	(0.0407)	(0.0204)
2500	0.2172	0.2254	0.2187	0.2445	0.2238	0.2455
	(0.013)	(0.0149)	(0.0131)	(0.0185)	(0.0395)	(0.0191)
3000	0.2175	0.2244	0.2183	0.245	0.2239	0.2462
	(0.0127)	(0.0138)	(0.0126)	(0.0177)	(0.0388)	(0.0183)
3500	0.2182	0.2234	0.2179	0.245	0.2241	0.2462
	(0.0126)	(0.013)	(0.0122)	(0.017)	(0.0384)	(0.0176)
4000	0.2185	0.2213	0.2163	0.2432	0.2234	0.2445
	(0.0125)	(0.0122)	(0.0118)	(0.0162)	(0.0384)	(0.0168)
4500	0.2177	0.2172	0.2127	0.2389	0.2207	0.2403
	(0.0124)	(0.0115)	(0.0114)	(0.0156)	(0.0386)	(0.016)
5000	0.2154	0.2107	0.2067	0.2321	0.2156	0.2335
	(0.0124)	(0.0111)	(0.011)	(0.015)	(0.039)	(0.0154)

Table P.4: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 50) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5009	0.5012	0.5009	0.4755	0.4346	0.4734
	(0.0715)	(0.0716)	(0.0715)	(0.0684)	(0.0705)	(0.0724)
100	0.4945	0.4947	0.4946	0.444	0.4286	0.4388
	(0.0532)	(0.0533)	(0.0532)	(0.0492)	(0.049)	(0.0512)
500	0.2951	0.3145	0.2971	0.2892	0.2872	0.2782
	(0.0217)	(0.039)	(0.0244)	(0.0204)	(0.0265)	(0.0204)
1000	0.2271	0.2393	0.2284	0.2304	0.2246	0.2226
	(0.0138)	(0.0232)	(0.0153)	(0.0139)	(0.0221)	(0.0135)
1500	0.2052	0.2141	0.2062	0.2104	0.2042	0.2041
	(0.0109)	(0.017)	(0.0118)	(0.0111)	(0.0207)	(0.0109)
2000	0.1975	0.2047	0.1984	0.2035	0.1974	0.1982
	(0.0094)	(0.0139)	(0.0101)	(0.0096)	(0.0201)	(0.0094)
2500	0.1959	0.2016	0.1963	0.2018	0.1959	0.1973
	(0.0083)	(0.0118)	(0.0088)	(0.0087)	(0.0199)	(0.0084)
3000	0.1965	0.2006	0.1961	0.2019	0.1962	0.1977
	(0.0075)	(0.0103)	(0.008)	(0.0078)	(0.02)	(0.0076)
3500	0.1978	0.1995	0.1958	0.2017	0.1964	0.1978
	(0.007)	(0.0092)	(0.0072)	(0.0072)	(0.0201)	(0.007)
4000	0.1983	0.1968	0.1939	0.1998	0.1949	0.196
	(0.0064)	(0.0083)	(0.0066)	(0.0067)	(0.0202)	(0.0065)
4500	0.1975	0.1917	0.1895	0.1956	0.191	0.1919
	(0.006)	(0.0076)	(0.0062)	(0.0063)	(0.0207)	(0.0061)
5000	0.195	0.1843	0.1827	0.1889	0.1845	0.1853
	(0.0058)	(0.0071)	(0.0058)	(0.0059)	(0.0211)	(0.0058)

Table P.5: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 100) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4996	0.4998	0.4993	0.4718	0.4676	0.4628
	(0.0699)	(0.0699)	(0.0697)	(0.0671)	(0.0715)	(0.0674)
100	0.5001	0.5003	0.5002	0.4409	0.4437	0.4319
	(0.0513)	(0.051)	(0.051)	(0.0487)	(0.0549)	(0.0475)
500	0.3683	0.424	0.3953	0.3297	0.4256	0.3259
	(0.0293)	(0.0573)	(0.0498)	(0.0297)	(0.0554)	(0.0304)
1000	0.2667	0.317	0.2906	0.2903	0.3977	0.2882
	(0.0182)	(0.0479)	(0.038)	(0.0257)	(0.0933)	(0.0263)
1500	0.2293	0.2664	0.247	0.277	0.3823	0.2761
	(0.0142)	(0.0346)	(0.0275)	(0.0237)	(0.1063)	(0.0243)
2000	0.2126	0.2425	0.2269	0.2744	0.3697	0.2742
	(0.0124)	(0.0279)	(0.022)	(0.0228)	(0.1099)	(0.0236)
2500	0.2049	0.23	0.217	0.2758	0.3602	0.2761
	(0.0117)	(0.0235)	(0.0186)	(0.0213)	(0.1093)	(0.022)
3000	0.2011	0.2224	0.2113	0.2774	0.3529	0.278
	(0.0113)	(0.0204)	(0.0163)	(0.02)	(0.1076)	(0.0206)
3500	0.1989	0.2166	0.2069	0.2776	0.3472	0.2785
	(0.0113)	(0.0183)	(0.0149)	(0.0196)	(0.1059)	(0.0201)
4000	0.1968	0.2105	0.2018	0.2752	0.342	0.2764
	(0.0113)	(0.0167)	(0.0138)	(0.0187)	(0.1045)	(0.0192)
4500	0.1936	0.2029	0.1951	0.2692	0.336	0.2707
	(0.0114)	(0.0155)	(0.013)	(0.0182)	(0.1033)	(0.0187)
5000	0.1891	0.1937	0.1863	0.2597	0.3287	0.2614
	(0.0115)	(0.0145)	(0.0123)	(0.0176)	(0.1025)	(0.0181)

Table P.6: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4954	0.4952	0.4954	0.4817	0.4374	0.4851
	(0.07)	(0.0697)	(0.0701)	(0.0702)	(0.0669)	(0.0656)
100	0.4971	0.4971	0.4971	0.4556	0.3954	0.4523
	(0.0496)	(0.0493)	(0.0496)	(0.0504)	(0.0476)	(0.0484)
500	0.3605	0.4121	0.3789	0.2971	0.3767	0.2819
	(0.0285)	(0.0609)	(0.0456)	(0.0202)	(0.0639)	(0.0195)
1000	0.2486	0.2945	0.2643	0.2252	0.3238	0.2124
	(0.0167)	(0.0501)	(0.0332)	(0.0135)	(0.1109)	(0.0132)
1500	0.2052	0.2386	0.2168	0.1962	0.2931	0.185
	(0.0121)	(0.0354)	(0.0237)	(0.0107)	(0.1214)	(0.0103)
2000	0.1848	0.2109	0.194	0.1838	0.2765	0.1734
	(0.0098)	(0.0275)	(0.0184)	(0.009)	(0.1241)	(0.0087)
2500	0.1745	0.1958	0.1822	0.1792	0.2667	0.1689
	(0.0086)	(0.0225)	(0.0152)	(0.0081)	(0.1236)	(0.0079)
3000	0.1689	0.1864	0.1751	0.1772	0.2607	0.1668
	(0.0077)	(0.019)	(0.013)	(0.0076)	(0.123)	(0.0073)
3500	0.165	0.1789	0.1693	0.175	0.2562	0.1645
	(0.007)	(0.0163)	(0.0113)	(0.007)	(0.1229)	(0.0067)
4000	0.1614	0.1712	0.1627	0.1709	0.2511	0.1605
	(0.0064)	(0.0145)	(0.01)	(0.0064)	(0.1231)	(0.006)
4500	0.1571	0.1623	0.1546	0.164	0.2444	0.1539
	(0.0059)	(0.0128)	(0.009)	(0.0059)	(0.1238)	(0.0056)
5000	0.1515	0.1522	0.1451	0.155	0.2361	0.1455
	(0.0055)	(0.0115)	(0.0081)	(0.0054)	(0.1243)	(0.0052)

Table P.7: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 250) under gradual drift (priors: Equal), where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4997	0.4997	0.4999	0.4224	0.4781	0.4617
	(0.0704)	(0.0706)	(0.0707)	(0.0673)	(0.0738)	(0.0672)
100	0.5003	0.5002	0.5004	0.3832	0.4633	0.4358
	(0.0504)	(0.0505)	(0.0507)	(0.0563)	(0.0566)	(0.0467)
500	0.4924	0.4924	0.4925	0.2757	0.3798	0.3259
	(0.0243)	(0.0244)	(0.0244)	(0.0701)	(0.0571)	(0.0566)
1000	0.3708	0.4311	0.4323	0.2595	0.3888	0.3299
	(0.0289)	(0.0524)	(0.0528)	(0.047)	(0.0524)	(0.0373)
1500	0.2854	0.3693	0.3678	0.256	0.3876	0.333
	(0.0221)	(0.0671)	(0.066)	(0.0392)	(0.0578)	(0.0314)
2000	0.2388	0.3136	0.3114	0.2603	0.3928	0.341
	(0.0178)	(0.0594)	(0.0575)	(0.0367)	(0.0602)	(0.0293)
2500	0.2112	0.2751	0.273	0.2659	0.396	0.3492
	(0.0148)	(0.0503)	(0.0483)	(0.0346)	(0.0606)	(0.0274)
3000	0.1934	0.2482	0.2464	0.2694	0.397	0.3556
	(0.0129)	(0.0434)	(0.0413)	(0.0332)	(0.0606)	(0.0267)
3500	0.1805	0.2279	0.2262	0.2702	0.3913	0.3591
	(0.0118)	(0.0383)	(0.0362)	(0.0323)	(0.0611)	(0.0266)
4000	0.1699	0.2107	0.2091	0.2673	0.381	0.3598
	(0.0109)	(0.0345)	(0.0323)	(0.0317)	(0.0614)	(0.0277)
4500	0.1602	0.195	0.1937	0.2617	0.3684	0.3575
	(0.0103)	(0.0312)	(0.0292)	(0.0311)	(0.0606)	(0.0294)
5000	0.1505	0.1802	0.1797	0.2529	0.3536	0.3514
	(0.01)	(0.0284)	(0.0269)	(0.0308)	(0.06)	(0.0323)

Table P.8: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 250) under gradual drift (priors: Equal), where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4974	0.4969	0.4968	0.3704	0.4345	0.4714
	(0.0715)	(0.0712)	(0.0715)	(0.0634)	(0.0677)	(0.0718)
100	0.5002	0.4997	0.4998	0.2745	0.3732	0.4384
	(0.0496)	(0.0496)	(0.0499)	(0.0427)	(0.0464)	(0.0488)
500	0.4935	0.4935	0.4935	0.111	0.2862	0.2542
	(0.0255)	(0.0253)	(0.0254)	(0.0134)	(0.0339)	(0.0192)
1000	0.3657	0.4256	0.421	0.0839	0.33	0.1924
	(0.0295)	(0.0551)	(0.0562)	(0.0084)	(0.0533)	(0.0132)
1500	0.274	0.3565	0.349	0.0793	0.2981	0.1672
	(0.0222)	(0.0687)	(0.0688)	(0.007)	(0.069)	(0.0111)
2000	0.2232	0.2956	0.2889	0.0812	0.2613	0.156
	(0.0173)	(0.059)	(0.0584)	(0.0063)	(0.0733)	(0.0101)
2500	0.1922	0.2533	0.2478	0.0864	0.2339	0.1528
	(0.0141)	(0.0493)	(0.0484)	(0.0058)	(0.0774)	(0.01)
3000	0.1714	0.2235	0.2192	0.0925	0.2136	0.1529
	(0.012)	(0.0418)	(0.0411)	(0.0056)	(0.0802)	(0.0103)
3500	0.1563	0.2011	0.1976	0.0972	0.1979	0.1517
	(0.0104)	(0.0361)	(0.0356)	(0.0054)	(0.0825)	(0.0102)
4000	0.1441	0.1826	0.1797	0.0993	0.1844	0.1467
	(0.0091)	(0.0317)	(0.0312)	(0.0052)	(0.084)	(0.0096)
4500	0.1334	0.1666	0.1638	0.0978	0.1722	0.138
	(0.0081)	(0.0282)	(0.0278)	(0.005)	(0.0852)	(0.0088)
5000	0.1236	0.1521	0.1495	0.0929	0.1606	0.1276
	(0.0074)	(0.0254)	(0.025)	(0.0046)	(0.0857)	(0.0079)

Table P.9: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under gradual drift (priors: Equal), where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5038	0.5038	0.5041	0.3936	0.485	0.4378
	(0.0686)	(0.0686)	(0.0686)	(0.0688)	(0.0712)	(0.0732)
100	0.5003	0.5003	0.5004	0.3561	0.4792	0.4165
	(0.0492)	(0.0492)	(0.0492)	(0.0605)	(0.0565)	(0.0531)
500	0.5012	0.5012	0.5011	0.3094	0.4154	0.368
	(0.0222)	(0.0222)	(0.0221)	(0.061)	(0.0731)	(0.0426)
1000	0.5001	0.5001	0.5	0.299	0.3628	0.3469
	(0.0157)	(0.0157)	(0.0157)	(0.0554)	(0.0719)	(0.0423)
1500	0.4576	0.4576	0.4678	0.3277	0.382	0.3756
	(0.0304)	(0.0304)	(0.0317)	(0.0378)	(0.0586)	(0.0292)
2000	0.4266	0.4266	0.4468	0.3458	0.3888	0.3917
	(0.0538)	(0.0538)	(0.0537)	(0.0296)	(0.0596)	(0.0225)
2500	0.397	0.397	0.4221	0.3585	0.3943	0.403
	(0.0636)	(0.0636)	(0.0639)	(0.0243)	(0.0581)	(0.0184)
3000	0.37	0.37	0.3945	0.3671	0.3989	0.4117
	(0.0638)	(0.0638)	(0.0645)	(0.021)	(0.057)	(0.0158)
3500	0.3472	0.3472	0.3693	0.3708	0.4017	0.4176
	(0.0598)	(0.0598)	(0.0607)	(0.0189)	(0.0568)	(0.0138)
4000	0.3276	0.3276	0.3466	0.3687	0.4025	0.421
	(0.055)	(0.055)	(0.0559)	(0.0185)	(0.057)	(0.0125)
4500	0.3077	0.3077	0.3236	0.3608	0.3994	0.4215
	(0.05)	(0.05)	(0.051)	(0.0189)	(0.0574)	(0.0118)
5000	0.2864	0.2864	0.3075	0.3471	0.3934	0.4179
	(0.0455)	(0.0455)	(0.0476)	(0.0195)	(0.058)	(0.0115)

Table P.10: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.5039	0.5038	0.5037	0.4931	0.4945	0.49
	(0.0688)	(0.0686)	(0.0686)	(0.0674)	(0.0689)	(0.0664)
100	0.5004	0.5002	0.5002	0.4784	0.4884	0.4717
	(0.0492)	(0.0492)	(0.0492)	(0.0476)	(0.0523)	(0.0463)
500	0.5009	0.501	0.501	0.3918	0.4319	0.3864
	(0.0223)	(0.0224)	(0.0224)	(0.0542)	(0.0614)	(0.055)
1000	0.4998	0.4998	0.4998	0.3385	0.4072	0.3346
	(0.0157)	(0.0157)	(0.0157)	(0.0665)	(0.0545)	(0.067)
1500	0.4443	0.4648	0.4738	0.3744	0.4217	0.3725
	(0.0219)	(0.0263)	(0.0278)	(0.0452)	(0.0426)	(0.0453)
2000	0.3787	0.4364	0.4556	0.3925	0.4266	0.3916
	(0.0237)	(0.048)	(0.0484)	(0.0345)	(0.0428)	(0.0344)
2500	0.3316	0.4066	0.432	0.4055	0.4293	0.4057
	(0.0217)	(0.06)	(0.0607)	(0.0281)	(0.0407)	(0.0281)
3000	0.2976	0.3753	0.4018	0.4148	0.4327	0.4157
	(0.0194)	(0.0628)	(0.0641)	(0.0237)	(0.0386)	(0.0236)
3500	0.2718	0.3452	0.37	0.4211	0.4338	0.4223
	(0.0172)	(0.0605)	(0.0618)	(0.0206)	(0.0383)	(0.0205)
4000	0.2508	0.3174	0.3399	0.4248	0.4332	0.4266
	(0.0156)	(0.0562)	(0.0574)	(0.0183)	(0.0388)	(0.0182)
4500	0.2325	0.2917	0.3121	0.4263	0.4312	0.4286
	(0.0144)	(0.0513)	(0.0528)	(0.0166)	(0.0403)	(0.0164)
5000	0.2156	0.2678	0.2875	0.4256	0.4278	0.4284
	(0.0134)	(0.0467)	(0.0486)	(0.0152)	(0.0431)	(0.0151)

Table P.11: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under gradual drift (priors: Equal), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4988	0.4979	0.4976	0.4882	0.4607	0.4903
	(0.0731)	(0.0727)	(0.0725)	(0.0687)	(0.068)	(0.0689)
100	0.5008	0.5002	0.5003	0.4754	0.405	0.4722
	(0.0516)	(0.0516)	(0.0514)	(0.0491)	(0.047)	(0.0479)
500	0.5009	0.5007	0.5007	0.3452	0.2577	0.3202
	(0.0225)	(0.0225)	(0.0225)	(0.0214)	(0.0216)	(0.0205)
1000	0.5013	0.5011	0.5012	0.2452	0.287	0.2219
	(0.0156)	(0.0156)	(0.0156)	(0.0135)	(0.0336)	(0.0128)
1500	0.4411	0.4608	0.4695	0.2804	0.3383	0.26
	(0.0229)	(0.0284)	(0.0303)	(0.018)	(0.0333)	(0.0209)
2000	0.3694	0.4287	0.4468	0.3101	0.3492	0.2941
	(0.0237)	(0.0512)	(0.0534)	(0.0189)	(0.0517)	(0.023)
2500	0.318	0.3963	0.4205	0.3324	0.3471	0.3206
	(0.0211)	(0.0641)	(0.0674)	(0.0184)	(0.0573)	(0.0229)
3000	0.2806	0.3612	0.3864	0.3503	0.3425	0.3426
	(0.0182)	(0.0661)	(0.0697)	(0.0172)	(0.0567)	(0.0216)
3500	0.2523	0.3277	0.351	0.3637	0.3426	0.3595
	(0.0158)	(0.0624)	(0.0657)	(0.016)	(0.0575)	(0.0207)
4000	0.2293	0.2973	0.3184	0.3716	0.3473	0.3695
	(0.0141)	(0.0569)	(0.06)	(0.0158)	(0.057)	(0.0209)
4500	0.2095	0.2702	0.2892	0.3702	0.3596	0.3679
	(0.0125)	(0.0515)	(0.0544)	(0.0174)	(0.0529)	(0.0229)
5000	0.1919	0.2459	0.2629	0.3524	0.3629	0.3477
	(0.0114)	(0.0467)	(0.0493)	(0.0192)	(0.0544)	(0.0241)

Table P.12: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under gradual drift (priors: 70/30), where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3074	0.3072	0.3074	0.3864	0.5342	0.4562
	(0.0637)	(0.064)	(0.0636)	(0.0894)	(0.1373)	(0.0812)
100	0.303	0.3027	0.3029	0.3636	0.5206	0.4497
	(0.0462)	(0.0465)	(0.0463)	(0.0845)	(0.1373)	(0.0746)
500	0.3825	0.3825	0.3825	0.321	0.3987	0.3884
	(0.0138)	(0.0137)	(0.0137)	(0.0992)	(0.0973)	(0.091)
1000	0.5149	0.515	0.5149	0.3116	0.35	0.3612
	(0.026)	(0.026)	(0.026)	(0.0706)	(0.0517)	(0.0662)
1500	0.4439	0.4439	0.4439	0.3194	0.3342	0.3608
	(0.0199)	(0.02)	(0.0199)	(0.0497)	(0.0364)	(0.0477)
2000	0.408	0.408	0.408	0.3272	0.3286	0.3728
	(0.0157)	(0.0157)	(0.0157)	(0.041)	(0.0311)	(0.0399)
2500	0.3863	0.3864	0.3864	0.3365	0.327	0.3854
	(0.0132)	(0.0132)	(0.0132)	(0.0379)	(0.0321)	(0.0365)
3000	0.3713	0.3718	0.3719	0.3457	0.3249	0.3959
	(0.0115)	(0.0115)	(0.0115)	(0.0364)	(0.0324)	(0.0342)
3500	0.3596	0.361	0.3613	0.3532	0.3243	0.4036
	(0.0103)	(0.0104)	(0.0104)	(0.0348)	(0.0325)	(0.0323)
4000	0.35	0.3522	0.3526	0.3593	0.325	0.4091
	(0.0094)	(0.0095)	(0.0095)	(0.0331)	(0.0339)	(0.0305)
4500	0.3419	0.3439	0.3422	0.363	0.3256	0.4126
	(0.0085)	(0.0087)	(0.0097)	(0.0314)	(0.0365)	(0.029)
5000	0.3345	0.331	0.3268	0.3635	0.3231	0.4133
	(0.0079)	(0.0095)	(0.0143)	(0.0301)	(0.0387)	(0.0275)

Table P.13: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.307	0.3074	0.3071	0.4118	0.5386	0.4657
	(0.0636)	(0.0637)	(0.064)	(0.0956)	(0.136)	(0.0814)
100	0.3027	0.303	0.3026	0.4127	0.5253	0.466
	(0.0462)	(0.0462)	(0.0465)	(0.0868)	(0.1362)	(0.0726)
500	0.4669	0.4668	0.4669	0.3854	0.4026	0.409
	(0.0344)	(0.0345)	(0.0345)	(0.0896)	(0.0941)	(0.0881)
1000	0.3832	0.3832	0.3832	0.3632	0.3527	0.3775
	(0.0202)	(0.0202)	(0.0202)	(0.0653)	(0.0511)	(0.0653)
1500	0.3554	0.3554	0.3554	0.363	0.3372	0.3747
	(0.0148)	(0.0149)	(0.0149)	(0.0467)	(0.04)	(0.0469)
2000	0.3416	0.3416	0.3416	0.3759	0.333	0.3851
	(0.0123)	(0.0124)	(0.0124)	(0.0392)	(0.0326)	(0.0394)
2500	0.3332	0.3333	0.3333	0.3885	0.332	0.3961
	(0.0104)	(0.0105)	(0.0105)	(0.0357)	(0.0296)	(0.0358)
3000	0.3273	0.3276	0.3277	0.3983	0.3308	0.4049
	(0.0095)	(0.0096)	(0.0096)	(0.0332)	(0.0295)	(0.0331)
3500	0.3224	0.3233	0.3235	0.4047	0.3322	0.411
	(0.0086)	(0.0087)	(0.0088)	(0.0308)	(0.0304)	(0.0311)
4000	0.3177	0.3193	0.3197	0.4094	0.3342	0.4152
	(0.0077)	(0.0079)	(0.008)	(0.0291)	(0.032)	(0.0292)
4500	0.3128	0.3147	0.3129	0.4121	0.3347	0.4177
	(0.007)	(0.0074)	(0.0087)	(0.0278)	(0.0336)	(0.0277)
5000	0.3075	0.305	0.3	0.4125	0.3338	0.418
	(0.0064)	(0.0087)	(0.0132)	(0.0262)	(0.0357)	(0.0264)

Table P.14: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under gradual drift (priors: 70/30), where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3058	0.3056	0.3057	0.3393	0.3738	0.371
	(0.0651)	(0.0652)	(0.0652)	(0.0754)	(0.0806)	(0.0812)
100	0.3011	0.3009	0.3009	0.2584	0.3125	0.3254
	(0.0467)	(0.0468)	(0.0468)	(0.0471)	(0.0516)	(0.0532)
500	0.417	0.417	0.417	0.0767	0.2551	0.1802
	(0.0138)	(0.0138)	(0.0138)	(0.0131)	(0.0183)	(0.0172)
1000	0.4937	0.4936	0.4936	0.0438	0.3279	0.1269
	(0.025)	(0.0249)	(0.025)	(0.007)	(0.0132)	(0.011)
1500	0.4291	0.429	0.429	0.0348	0.3185	0.1111
	(0.0183)	(0.0182)	(0.0183)	(0.0051)	(0.0109)	(0.009)
2000	0.3968	0.3967	0.3967	0.0337	0.3139	0.1104
	(0.0148)	(0.0146)	(0.0148)	(0.0043)	(0.0095)	(0.0087)
2500	0.3773	0.3772	0.3772	0.0363	0.311	0.1179
	(0.0127)	(0.0126)	(0.0127)	(0.0041)	(0.0087)	(0.0089)
3000	0.3644	0.3644	0.3644	0.0405	0.3091	0.1265
	(0.0112)	(0.0111)	(0.0112)	(0.004)	(0.0079)	(0.0089)
3500	0.3551	0.3551	0.3551	0.0446	0.3078	0.1338
	(0.0102)	(0.0102)	(0.0102)	(0.0039)	(0.0075)	(0.009)
4000	0.348	0.3481	0.3481	0.0471	0.3067	0.1381
	(0.0093)	(0.0093)	(0.0093)	(0.0038)	(0.007)	(0.0088)
4500	0.3421	0.3425	0.3426	0.0473	0.306	0.1381
	(0.0083)	(0.0084)	(0.0085)	(0.0037)	(0.0065)	(0.0085)
5000	0.3363	0.3372	0.3378	0.0454	0.3054	0.1348
	(0.0075)	(0.0077)	(0.0078)	(0.0034)	(0.0062)	(0.008)

Table P.15: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under gradual drift (priors: 70/30), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.3057	0.3059	0.3059	0.3715	0.3769	0.3843
	(0.0652)	(0.0652)	(0.0651)	(0.0855)	(0.084)	(0.0866)
100	0.3008	0.3011	0.3011	0.3409	0.3306	0.3561
	(0.0468)	(0.0468)	(0.0468)	(0.059)	(0.0553)	(0.0622)
500	0.4606	0.4606	0.4605	0.275	0.2853	0.2653
	(0.0336)	(0.0335)	(0.0335)	(0.0223)	(0.0191)	(0.0227)
1000	0.3807	0.3807	0.3807	0.2326	0.3321	0.2164
	(0.0196)	(0.0196)	(0.0196)	(0.0143)	(0.0181)	(0.0146)
1500	0.3537	0.3538	0.3537	0.2194	0.3213	0.2022
	(0.0147)	(0.0147)	(0.0146)	(0.012)	(0.0137)	(0.012)
2000	0.3402	0.3403	0.3403	0.2294	0.316	0.2131
	(0.0118)	(0.0119)	(0.0119)	(0.0136)	(0.0115)	(0.0148)
2500	0.332	0.3321	0.3321	0.2501	0.3163	0.2361
	(0.0104)	(0.0104)	(0.0104)	(0.0143)	(0.0154)	(0.0165)
3000	0.3267	0.3267	0.3267	0.266	0.3304	0.2538
	(0.0094)	(0.0094)	(0.0094)	(0.0147)	(0.0241)	(0.0175)
3500	0.3228	0.3229	0.3229	0.2773	0.3376	0.2662
	(0.0087)	(0.0087)	(0.0087)	(0.0148)	(0.0331)	(0.0177)
4000	0.3197	0.3199	0.3199	0.282	0.3356	0.2713
	(0.0079)	(0.0079)	(0.008)	(0.0152)	(0.0396)	(0.0183)
4500	0.3165	0.3172	0.3174	0.2785	0.3336	0.268
	(0.007)	(0.0072)	(0.0073)	(0.0151)	(0.0441)	(0.0179)
5000	0.3123	0.3137	0.3146	0.2689	0.3312	0.259
	(0.0061)	(0.0066)	(0.0067)	(0.0143)	(0.0457)	(0.0168)

Table P.16: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under gradual drift (priors: 90/10), where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.1012	0.1012	0.1013	0.5124	0.7394	0.5846
	(0.0422)	(0.0422)	(0.0423)	(0.2302)	(0.1679)	(0.196)
100	0.1006	0.1006	0.1006	0.3419	0.7066	0.4874
	(0.0299)	(0.0298)	(0.0298)	(0.1511)	(0.1949)	(0.1443)
500	0.4115	0.4115	0.4115	0.2843	0.3656	0.4496
	(0.0119)	(0.0119)	(0.0119)	(0.132)	(0.1509)	(0.1375)
1000	0.6558	0.6558	0.6558	0.2882	0.234	0.3991
	(0.0087)	(0.0088)	(0.0088)	(0.0803)	(0.0776)	(0.0867)
1500	0.737	0.737	0.737	0.2889	0.1896	0.3764
	(0.0075)	(0.0075)	(0.0075)	(0.0632)	(0.052)	(0.067)
2000	0.7779	0.7778	0.7779	0.288	0.1671	0.3628
	(0.0064)	(0.0064)	(0.0064)	(0.0558)	(0.0392)	(0.0588)
2500	0.8017	0.8017	0.8017	0.2862	0.1538	0.3541
	(0.0078)	(0.0078)	(0.0078)	(0.0503)	(0.0314)	(0.0547)
3000	0.7574	0.7571	0.7573	0.2836	0.1448	0.3473
	(0.042)	(0.042)	(0.042)	(0.0466)	(0.0264)	(0.0516)
3500	0.6651	0.6649	0.6651	0.2799	0.1386	0.3419
	(0.0396)	(0.0396)	(0.0396)	(0.044)	(0.0227)	(0.0496)
4000	0.5945	0.5943	0.5944	0.2753	0.1345	0.3373
	(0.0346)	(0.0347)	(0.0346)	(0.0421)	(0.02)	(0.0483)
4500	0.5395	0.5393	0.5395	0.2697	0.1313	0.333
	(0.0308)	(0.0309)	(0.0308)	(0.0403)	(0.0181)	(0.0473)
5000	0.4956	0.4954	0.4955	0.2622	0.1285	0.3298
	(0.0278)	(0.0278)	(0.0278)	(0.0386)	(0.0166)	(0.0462)

Table P.17: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate mvt data (p = 500) under gradual drift (priors: 90/10), where the covariance matrix drifts from Wishart to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.101	0.1011	0.1011	0.5149	0.7344	0.5905
	(0.0421)	(0.0422)	(0.0421)	(0.2289)	(0.1716)	(0.1916)
100	0.1006	0.1006	0.1005	0.3524	0.6999	0.5012
	(0.0298)	(0.0298)	(0.0298)	(0.1517)	(0.1966)	(0.1376)
500	0.705	0.705	0.705	0.3248	0.3559	0.4726
	(0.0122)	(0.0122)	(0.0122)	(0.1406)	(0.1453)	(0.1359)
1000	0.7959	0.7958	0.796	0.3201	0.2311	0.4134
	(0.0254)	(0.0256)	(0.0255)	(0.0875)	(0.0797)	(0.0879)
1500	0.6212	0.6211	0.6216	0.3162	0.188	0.3857
	(0.0608)	(0.0609)	(0.0609)	(0.0672)	(0.0539)	(0.0678)
2000	0.4908	0.4907	0.4911	0.3126	0.1661	0.3684
	(0.0459)	(0.046)	(0.046)	(0.0588)	(0.0407)	(0.0592)
2500	0.4127	0.4126	0.4129	0.3087	0.1532	0.3562
	(0.0369)	(0.037)	(0.0369)	(0.0538)	(0.0328)	(0.0551)
3000	0.3606	0.3605	0.3608	0.3052	0.1447	0.3471
	(0.0309)	(0.031)	(0.0309)	(0.0504)	(0.0276)	(0.0522)
3500	0.3233	0.3233	0.3235	0.302	0.1392	0.3397
	(0.0266)	(0.0266)	(0.0266)	(0.0485)	(0.024)	(0.0506)
4000	0.2954	0.2954	0.2956	0.2987	0.1361	0.3332
	(0.0233)	(0.0234)	(0.0234)	(0.0469)	(0.0213)	(0.0493)
4500	0.2737	0.2736	0.2738	0.2958	0.1335	0.3277
	(0.0208)	(0.0208)	(0.0208)	(0.0457)	(0.0193)	(0.0484)
5000	0.2563	0.2563	0.2564	0.2943	0.1312	0.3236
	(0.0187)	(0.0188)	(0.0188)	(0.045)	(0.0176)	(0.0475)

Table P.18: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 500) under gradual drift (priors: 90/10), where the covariance matrix drifts from BWISH to BWISH. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.103	0.1029	0.103	0.5136	0.5143	0.514
	(0.0436)	(0.0434)	(0.0433)	(0.2338)	(0.2344)	(0.2336)
100	0.1009	0.1009	0.1009	0.3169	0.317	0.3171
	(0.0301)	(0.0301)	(0.03)	(0.1437)	(0.1439)	(0.1436)
500	0.4487	0.4486	0.4486	0.1215	0.1428	0.1294
	(0.0092)	(0.0092)	(0.0092)	(0.0315)	(0.0313)	(0.0309)
1000	0.6743	0.6742	0.6742	0.0793	0.1318	0.1002
	(0.0081)	(0.0081)	(0.0081)	(0.0164)	(0.018)	(0.0162)
1500	0.7496	0.7496	0.7496	0.0618	0.1211	0.0885
	(0.007)	(0.007)	(0.007)	(0.0113)	(0.0129)	(0.0115)
2000	0.7872	0.7872	0.7872	0.0525	0.1158	0.0837
	(0.0062)	(0.0062)	(0.0062)	(0.0087)	(0.0102)	(0.0092)
2500	0.7794	0.7792	0.7794	0.0469	0.1126	0.0827
	(0.0386)	(0.0387)	(0.0386)	(0.007)	(0.0087)	(0.0078)
3000	0.6746	0.6745	0.6746	0.0434	0.1106	0.0818
	(0.0433)	(0.0434)	(0.0433)	(0.006)	(0.0075)	(0.0068)
3500	0.5926	0.5924	0.5925	0.0407	0.1091	0.0803
	(0.037)	(0.0371)	(0.037)	(0.0052)	(0.0068)	(0.006)
4000	0.531	0.5309	0.531	0.0385	0.1079	0.0786
	(0.0325)	(0.0326)	(0.0325)	(0.0046)	(0.0062)	(0.0055)
4500	0.4831	0.483	0.4831	0.0369	0.1071	0.0766
	(0.0289)	(0.029)	(0.0289)	(0.0041)	(0.0057)	(0.005)
5000	0.4448	0.4448	0.4448	0.0359	0.1064	0.0746
	(0.026)	(0.0261)	(0.026)	(0.0038)	(0.0052)	(0.0048)

Table P.19: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under gradual drift (priors: Equal), where the covariance matrix drifts from AR to CS. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4954	0.4953	0.495	0.2967	0.2655	0.2658
	(0.07)	(0.0701)	(0.0698)	(0.0596)	(0.0626)	(0.0623)
100	0.4972	0.497	0.4968	0.1749	0.1568	0.1569
	(0.0495)	(0.0497)	(0.0494)	(0.0344)	(0.0361)	(0.0354)
500	0.2256	0.2924	0.2408	0.0361	0.0323	0.0323
	(0.0267)	(0.0939)	(0.0501)	(0.007)	(0.0073)	(0.0072)
1000	0.1129	0.1482	0.1208	0.018	0.0162	0.0162
	(0.0133)	(0.0498)	(0.0258)	(0.0035)	(0.0037)	(0.0036)
1500	0.0753	0.0989	0.0805	0.012	0.0108	0.0108
	(0.0089)	(0.0332)	(0.0172)	(0.0023)	(0.0024)	(0.0024)
2000	0.0565	0.0742	0.0605	0.0091	0.0081	0.0081
	(0.0067)	(0.0249)	(0.0129)	(0.0017)	(0.0018)	(0.0018)
2500	0.0452	0.0594	0.0484	0.0073	0.0065	0.0066
	(0.0053)	(0.0199)	(0.0103)	(0.0014)	(0.0015)	(0.0014)
3000	0.0377	0.0496	0.0404	0.0061	0.0055	0.0055
	(0.0045)	(0.0166)	(0.0086)	(0.0012)	(0.0012)	(0.0012)
3500	0.0324	0.0425	0.0346	0.0053	0.0047	0.0047
	(0.0038)	(0.0142)	(0.0074)	(0.001)	(0.0011)	(0.001)
4000	0.0283	0.0372	0.0303	0.0046	0.0041	0.0042
	(0.0033)	(0.0125)	(0.0064)	(9e-04)	(9e-04)	(9e-04)
4500	0.0252	0.0331	0.027	0.0041	0.0037	0.0037
	(0.003)	(0.0111)	(0.0057)	(8e-04)	(8e-04)	(8e-04)
5000	0.0227	0.0298	0.0243	0.0037	0.0033	0.0033
	(0.0027)	(0.01)	(0.0052)	(7e-04)	(7e-04)	(7e-04)

Table P.20: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under gradual drift (priors: Equal), where the covariance matrix drifts from CS to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4952	0.4954	0.4959	0.4205	0.4134	0.4003
	(0.0697)	(0.07)	(0.07)	(0.0724)	(0.0899)	(0.0887)
100	0.497	0.4971	0.4973	0.404	0.3975	0.3937
	(0.0493)	(0.0496)	(0.0496)	(0.056)	(0.0647)	(0.0676)
500	0.366	0.3661	0.3662	0.2988	0.3401	0.2882
	(0.0264)	(0.0263)	(0.0263)	(0.0243)	(0.0553)	(0.0265)
1000	0.2385	0.2559	0.2392	0.2374	0.3079	0.2236
	(0.0155)	(0.0171)	(0.0154)	(0.0156)	(0.1073)	(0.0164)
1500	0.179	0.2042	0.1807	0.2019	0.2766	0.1874
	(0.0109)	(0.0128)	(0.0109)	(0.0121)	(0.1294)	(0.0126)
2000	0.1446	0.1706	0.1542	0.1772	0.2483	0.1631
	(0.0085)	(0.0102)	(0.009)	(0.01)	(0.1332)	(0.0102)
2500	0.1224	0.1481	0.1366	0.159	0.2276	0.1456
	(0.0071)	(0.0085)	(0.0078)	(0.0085)	(0.1328)	(0.0086)
3000	0.1067	0.1316	0.1223	0.1457	0.21	0.1328
	(0.0061)	(0.0073)	(0.0068)	(0.0075)	(0.1286)	(0.0075)
3500	0.0949	0.1191	0.1108	0.1351	0.195	0.1229
	(0.0053)	(0.0063)	(0.0059)	(0.0066)	(0.123)	(0.0066)
4000	0.0858	0.1091	0.1015	0.1264	0.1827	0.1147
	(0.0048)	(0.0056)	(0.0053)	(0.006)	(0.1179)	(0.006)
4500	0.0786	0.101	0.0939	0.119	0.1735	0.1079
	(0.0043)	(0.0051)	(0.0048)	(0.0055)	(0.1146)	(0.0054)
5000	0.0726	0.0943	0.0877	0.1126	0.1667	0.102
	(0.0039)	(0.0049)	(0.0044)	(0.005)	(0.1126)	(0.005)

Table P.21: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under gradual drift (priors: Equal), where the covariance matrix drifts from EYE to CS. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.4952	0.4952	0.4954	0.2705	0.1738	0.1755
	(0.0698)	(0.0698)	(0.07)	(0.0615)	(0.0602)	(0.0592)
100	0.4974	0.497	0.4972	0.1752	0.1115	0.1124
	(0.0497)	(0.0495)	(0.0496)	(0.0371)	(0.0335)	(0.0331)
500	0.3925	0.4362	0.4083	0.0745	0.055	0.0553
	(0.0267)	(0.0492)	(0.04)	(0.0115)	(0.0105)	(0.0103)
1000	0.2875	0.3301	0.3018	0.0772	0.0662	0.0663
	(0.0177)	(0.0436)	(0.0313)	(0.0089)	(0.0085)	(0.0084)
1500	0.2378	0.2692	0.2483	0.0889	0.0812	0.0812
	(0.0138)	(0.0318)	(0.0231)	(0.0084)	(0.0083)	(0.0081)
2000	0.208	0.233	0.2161	0.0944	0.0885	0.0886
	(0.0116)	(0.0249)	(0.0184)	(0.0077)	(0.0076)	(0.0075)
2500	0.1867	0.2085	0.193	0.0948	0.0901	0.0901
	(0.01)	(0.0202)	(0.0152)	(0.007)	(0.0069)	(0.0068)
3000	0.1683	0.1886	0.1733	0.0912	0.0873	0.0873
	(0.0087)	(0.0171)	(0.0129)	(0.0063)	(0.0062)	(0.0061)
3500	0.1506	0.1707	0.1549	0.0848	0.0814	0.0814
	(0.0077)	(0.0148)	(0.0112)	(0.0056)	(0.0056)	(0.0055)
4000	0.1339	0.1534	0.1377	0.0762	0.0732	0.0732
	(0.0068)	(0.0133)	(0.0098)	(0.005)	(0.005)	(0.0049)
4500	0.1193	0.1376	0.1226	0.0679	0.0653	0.0653
	(0.006)	(0.012)	(0.0087)	(0.0045)	(0.0044)	(0.0044)
5000	0.1074	0.124	0.1104	0.0611	0.0588	0.0588
	(0.0054)	(0.0108)	(0.0079)	(0.004)	(0.004)	(0.0039)

Table P.22: The conditional error rate for each estimator type for 1,000 simulations for a selected number of time points. Multivariate normal data (p = 100) under gradual drift (priors: Equal), where the covariance matrix drifts from EYE to Wishart. The standard deviation of the CER is provided in parentheses.

Time	Static	Adapt	AdaptMem	ShrinkDiag	ShrinkEye	ShrinkMuEye
50	0.496	0.4954	0.4954	0.424	0.344	0.3636
	(0.0694)	(0.07)	(0.07)	(0.0661)	(0.0707)	(0.0675)
100	0.498	0.4967	0.4971	0.3989	0.3401	0.3588
	(0.0497)	(0.0496)	(0.0495)	(0.0468)	(0.0498)	(0.0482)
500	0.3709	0.3704	0.3706	0.3103	0.2977	0.2899
	(0.026)	(0.0256)	(0.0257)	(0.0217)	(0.0411)	(0.0236)
1000	0.242	0.2573	0.2427	0.2534	0.2336	0.233
	(0.0161)	(0.0174)	(0.016)	(0.015)	(0.0764)	(0.0159)
1500	0.1814	0.205	0.1839	0.2144	0.189	0.1953
	(0.0115)	(0.0127)	(0.0115)	(0.0118)	(0.081)	(0.0126)
2000	0.1465	0.1712	0.1563	0.1866	0.1609	0.169
	(0.0091)	(0.01)	(0.0095)	(0.0098)	(0.0799)	(0.0103)
2500	0.1237	0.1484	0.1375	0.1661	0.1438	0.15
	(0.0075)	(0.0083)	(0.008)	(0.0084)	(0.0815)	(0.0088)
3000	0.1076	0.1314	0.1225	0.1505	0.1315	0.1357
	(0.0064)	(0.0071)	(0.0068)	(0.0073)	(0.0821)	(0.0075)
3500	0.0957	0.1187	0.1107	0.1385	0.1217	0.1248
	(0.0056)	(0.0064)	(0.006)	(0.0066)	(0.0813)	(0.0066)
4000	0.0864	0.1085	0.1013	0.1288	0.1137	0.116
	(0.005)	(0.0057)	(0.0054)	(0.0061)	(0.0798)	(0.006)
4500	0.079	0.1004	0.0936	0.1207	0.1069	0.1087
	(0.0045)	(0.0052)	(0.0048)	(0.0055)	(0.0778)	(0.0055)
5000	0.0729	0.0937	0.0873	0.114	0.1011	0.1026
	(0.0041)	(0.0056)	(0.0044)	(0.0051)	(0.0756)	(0.005)

VITA

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