Inflation in Iran: An Empirical Assessment of the Key Determinants*

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February 2023

Abstract:

Purpose: To study the key determinants of chronically high inflation in Iran.
Design/Methodology/Approach: Relying on annual data from 1978 to 2019, we employ an Auto-Regressive Distributed Lag Model (ARDL) and Error Correction Model (ECM) to study the inflationary effects of monetary and fiscal policies as well as exchange rate swings and sanctions intensification.
Findings: We find that increase in money supply, depreciation of nominal exchange rate, increase in fiscal deficit, and intensification of sanctions are among the key drivers of inflation in Iran. Their impact is profound in the long run, but in the short run only money supply and currency depreciation are significant. Also, when exploring the inflation in different components of Consumer Price Index (CPI), we find robust long- and short-run effects from money supply and exchange rate, while the effects of fiscal deficit and sanctions vary across different components.
Originality/Value: We contribute to the literature by setting apart the long- vs. short-run effects of key variables on inflation in Iran. We also employ improved measures of fiscal deficit and sanctions that are shown to be of significance in the long run. Lastly, we go beyond the aggregate index and examine the variations in different CPI components.

Keywords: Inflation; Money Supply; Exchange Rate; Fiscal Balance; Sanctions; Iran
JEL Codes: E31; O11; O53.

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* We thank the session participants at the Southern Economic Association Meeting (2021) for their helpful comments and suggestions.
† The views expressed in this paper are those of the authors and do not necessarily reflect those of the Monetary and Banking Research Institute or the Central Bank of Iran.
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1. Introduction

The sustained and broad-based growth in prices of goods and services, known as level inflation, is among the key measures of macroeconomic performance. While the relationship between inflation and real output growth is relatively weak (e.g., Taylor, 1996), it is quite possible for a country to experience low output growth while money growth and inflation rate are relatively high (Walsh, 2010, pp. 1-8). Such high inflation may hinder economic growth (Fischer, Sahay, and Végh, 2002, pp. 862-864), as does deflation (Guerrero and Parker, 2006).

The determinants of inflation are examined extensively. The seminal work of Friedman (1956, pp. 3-21) alongside Lucas (1980), McCandless and Weber (1995), and Rolnick and Weber (1997) suggest that money supply is the key long-term determinant of inflation. Grauwe and Polan (2005), Sargent and Surico (2011), and Teles, Uhlig, and Valle e Azevedo (2016) also find partial impacts from money supply. This impact is, in particular, large and prominent in countries with high inflation and low financial liberalization (Fischer et al. 2002; Gertler and Hofmann, 2018) or those with relatively high money growth (Wimanda, 2014; Breuer, McDermott, and Weber, 2018).

A government's fiscal deficit may be inflationary as well, with the relationship stronger in high inflation countries (Fischer et al., 2002; Catão and Terrones, 2005) and more evident in developing nations (e.g., Baldini and Poplawski-Ribeiro, 2011; Mohanty and John, 2015; Neumann and Ssozi, 2016; Combes et al., 2018). In special circumstances, an unsustainable fiscal deficit may force a government to obtain seigniorage (i.e., revenue from printing money), leading to hyperinflation (Romer, 2019, pp. 642-651). Such inflationary pressures can be restrained only by the creation of an independent central bank and major changes in fiscal policy regime (Sargent, 1982). Alternatively, a government may decide to re-valuate its debt via surprise inflation in order to stabilize debt levels. Such decision provides yet another channel for the interactions between fiscal deficit and inflation (Leeper, 1991; Sims, 1994; Woodford, 1995; Cochrane, 1998; Christiano and Fitzgerald, 2000; Leeper and Leith, 2016).

Large exchange rate swings can also impact inflation (e.g., Bahmani-Oskooee, 1991). The primary channel is through imports (Goldberg and Campa, 2010; Auer and Mehrotra, 2014; Benigno and Faia, 2016; Auer, Levchenko, and Sauré, 2019). This effect is larger in high inflation countries or those with incompetent monetary policy who are unable to maintain a flexible exchange rate while setting inflation targets (Bahmani-Oskooee and Malixi, 1992; Choudhri and Hakura, 2006; Jankov et al., 2008; Ito and Sato, 2008; Ha, Stocker, and Yilmazkuday, 2020).

Against the backdrop of these studies, we examine the key determinants of inflation in Iran, a country that has suffered from chronically high inflation in recent decades. We employ monetary and fiscal variables along with international factors. More precisely, we use an Auto-Regressive Distributed Lag function to model the variations in aggregate consumer price index and its components using money supply, free market exchange rate, fiscal deficit, and the intensification of international sanctions. In doing so, we use and expand upon the fiscal space dataset introduced by Kose et al. (2021). We also employ a continuous sanctions intensity measure, introduced by Laudati and Pesaran (2022), as well as a binary measure that captures constraining sanctions on Iran.

We find that, in the long run, monetary expansion, nominal exchange rate depreciation, and increase in fiscal deficit exhibit significant inflationary impacts, as do increases in sanctions intensity. In the short run, however, only money supply and currency depreciation are of importance. As for the components of consumer price index, though we find mixed effects from fiscal deficit and sanctions, the long- and short-run impacts of money supply and currency depreciation remain significant in several cases.

This paper is organized as follows: Section 2 reviews the literature on inflation in Iran. Section 3 describes the data, estimations strategy, and findings. Section 4 concludes.

2. Inflation in Iran

In recent decades, Iran's inflation has remained chronically high despite the general decline in inflation worldwide, including in MENA countries (Figure 1). In fact, except for recent increases (IMF, 2022), a significant decline in inflation can be observed in many developing countries. This decline results from a wide range of stabilization programs and structural reforms, leading to the improvement in fiscal frameworks and the establishment of clear mandate for central banks to control inflation (Ha, Kose, and Ohnsorge, 2019, 2022). Because of those programs and reforms, central banks in developing countries became more effective in pursuing their key mandates as they gained greater independence (Brumm, 2006; Jácome and Vázquez, 2008; Klomp and De Haan, 2010). This positive impact is strongest among more democratic nations, though it remains significant even among non-democratic countries (Garriga and Rodriguez, 2020). Further, entwined with independence, greater central bank transparency and credibility proved to be instrumental in curbing inflationary pressures in developing countries (Crowe and Meade, 2007; Dincer and Eichengreen, 2014).

Free of fiscal dominance and untroubled by nominal exchange rate anchors, independent monetary policy could potentially set the stage for successful inflation targeting (Masson, Savanstano, and Sharma, 1997). We observe this trend in many developing countries, including South Africa, Philippines, South Korea, Thailand, Brazil, Chile, Colombia, Mexico, and Peru (Taylor, 2014; Valera, Holmes, and Hassan, 2018; Frascaroli and Nobrega, 2018). Also, several studies have shown that inflation targeting is associated with lower inflation rates as well as lower inflation variability in developing countries (Lin and Ye, 2009; Abo-Zaid and Tuzemen, 2012;

Samarina, Terpstra, De Haan, 2014). Inflation targeting is, in particular, effective in curbing inflationary pressures that are caused by external shocks and uncertainties, as seen in the aftermath of the global financial crisis of 2007-9 (Roger, 2009; Duong, 2021; Duncan, Martínez-García, and Toledo, 2022). However, there are other studies that cast doubt on the effectiveness of inflation targeting (Ardakani, Kishor, and Song, 2018); but even those studies find that inflation targeting lowers exchange rate volatility and enhances fiscal discipline.

Despite the success of stabilization programs and structural reforms in other developing countries, Iran has continuously suffered from high rates and high variability of inflation, adversely affecting its economic growth through real output and investment channels (Esfahani, Mohaddes, and Pesaran, 2013). The institutional set-up for monetary and fiscal policies as well as enduring pressure from sanctions play important roles in Iran's chronic inflation (Mazarei, 2020).

As mentioned above, for example, inflation targeting tends to mitigate the impacts of external shocks and uncertainty. Yet, except for a short-lived attempt, Iran has never pursued transparent and credible inflation targeting despite being subject to crippling sanctions. This, as Masson et al. (1997) postulate, may result from some degree of fiscal dominance and a constant urge to intervene in foreign exchange markets.

Previous studies on Iran's inflation have found significant evidence for the importance of money supply, nominal exchange rate, nominal interest rate, import prices, and output (e.g., Bahmani-Oskooee, 1995; Liu and Adedeji, 2000; Celasun and Goswami, 2002; Abassinejad and Tashkini, 2005; Bonato, 2008; Kandil and Mirzaie, 2017; Monfared and Akın, 2017; Kandil and Mirzaie, 2021). Other studies highlight the importance of fiscal deficit and institutional arrangements that adversely affect central bank's independence (e.g., Alavirad and Athawale 2005; Kia, 2006; Samimi and Jamshidbaygi, 2011; Naini and Naderian, 2018; Mazarei, 2020).

The potential impact of sanctions on Iran's macroeconomic condition is also a unique factor (Kandil and Mirzaie, 2021); their effects on inflation are explored in several studies. For example, Pourshahabi and Dahmardeh (2014) examine the joint inflationary effects from sanctions and speculative currency attacks. Hemmati, Niakan, and Varahrami (2018) also show that the intensification of sanctions exhibits significant inflationary effects, even when money supply, exchange rate, and import prices are controlled for. Also, Ghorbani Dastgerdi, Yusof, and Shahbaz (2018) show that heavy sanctions put significant inflationary pressures on Iran's economy through nominal exchange rate depreciation and an increase in inflation expectations. To quantify sanctions, they rely on a principal component model and employ the variations in trade openness and foreign investment in a sanctions index. More recently, Laudati and Pesaran (2022) have introduced a sanctions intensity measure based on newspaper coverage. Employing this measure, they find that greater sanction intensity affects inflation directly and, more importantly, indirectly through exchange rate depreciation.

We contribute to this literature by exploring the monetary and fiscal determinants of inflation in Iran as well as the effects from the depreciation of nominal exchange rate and the intensification of sanctions. The dataset that we use in our study covers more than four decades, starting just before the Islamic revolution and ending before COVID19 pandemic, which enables us to examine the long- and short-run effects that shape the patterns of Iran's inflation. In doing so, we employ a well-measured fiscal deficit variable (Kose et al., 2021) along with a new sanctions intensity variable (Laudati and Pesaran, 2022). We further explore the heterogenous impact of the above factors on the components of the consumer price index, including prices of food and beverage, clothing and footwear, housing and utilities, furniture and appliances, health care, transportation, entertainment, and education. Comparing these effects will inform the public debate around the key determinants of inflation in Iran.

3. Empirical Analysis

To study the key determinants of Iran's inflation, we construct a generic model as presented in equation (1). We relate the consumer price index (*CPI*) at time t to money supply (M_t), exchange rate (E_t), fiscal balance (F_t), and a measure of sanctions intensity (S_t).[1]

$$CPI_t = \alpha + \beta_M M_t + \beta_E E_t + \beta_F F_t + \beta_s S_t + \varepsilon_t \quad (1)$$

We expect parameters β_M, β_E and β_s to be positive and statistically significant, while the anticipation regarding β_F is to capture the negative relationship between fiscal balance and inflation. To estimate these parameters, we employ an Auto-Regressive Distributed Lag Model (ARDL) and its Error Correction Model (ECM) (Pesaran, 2015, pp.120-127 and 523-527).

3.1. Data

We utilize the annual data from 1978 to 2019.[2] While using annual data lowers the number of observations, they provide a unique opportunity to examine the inflationary effects from government's budget deficit, measured more accurately on an annual basis in Iran, alongside the effects from monetary aggregates, nominal exchange rate, and sanctions.

The primary source of our data for CPI, its components, monetary measures, and exchange rate, is the Central Bank of Iran (2021a and 2021b). Rather than the official rate, however, we employ

[1] To capture the impact on inflation (i.e., growth in CPI), we consider logarithmic transformation of these variables in our estimations.

[2] The official calendar in Iran, on which the data in this study are based, is a solar calendar that begins as of March 21st. For the ease of communication, however, we use Gregorian calendar years in the manuscript. The year 1978, for example, includes a small part of the Iranian year 1356 (less than 3 months) and a large part of 1357. We use year 1978 to refer to the data for Iranian year 1357.

the non-official exchange rate, reflecting free market prices.[3] For our fiscal balance measure, we rely on a dataset developed by Kose et al. (2021) and consider the government's budget balance as percentage of GDP. Their data begins as of 1990. We generate the series from 1978 to 1989 using the data reported by the Central Bank of Iran (2021b) and Iran's Ministry of Economic Affairs and Finance (2021). Table 1 provides the summary statistics for the above variables. The data appendix also provides more information.

We use two measures for sanctions. We first employ the sanctions intensity measure, developed by Laudati and Pesaran (2022). To test the robustness of our results, we further employ a binary measure that captures the constraining multilateral sanctions against Iran (from 2010 to 2015) as well as the US maximum pressure sanctions (starting from 2018).[4] For this binary measure, we rely on the timing of major economic sanctions that were imposed on Iran. After a series of resolutions that raised significant concerns regarding Iran's nuclear program, in March 2010 the UN Security Council imposed constraining sanctions on Iran's banking, trade credits, and cargoes as part of UNSC Resolution 1929. Along with varying measures that were imposed by other countries (Felbermayr et al., 2020), the UNSC sanctions markedly intensified the economic pressures on Iran (Demir and Tabrizy, 2022). And they remained in place until they were lifted as part of the Joint Comprehensive Plan of Action (JCPOA), implemented starting from January 2016 (Dadpay and Tabrizy, 2021). The removal of sanctions was short-lived, however. The US exited the JCPOA agreement in May 2018 to pursue a maximum pressure policy (Landler, 2018). Based on this timing, our binary sanctions measure is set equal to one from 2010 to 2015 and from 2018 onwards; it is set equal to zero otherwise.

[3] We compare the CBI's non-official exchange rates (from 2013 to 2019) with the market rates that are reported by Bonbast (2021). We find no major discrepancies between the two series; detailed comparisons are available upon request.

[4] We are grateful to an anonymous referee for raising the importance of this robustness test.

3.2. Estimation Strategy

A preliminary step in time series analysis is to examine whether data are stationary across the full series. For this, we employ the DF-GLS unit-root test (Dickey and Fuller, 1979; Elliott, Rothenberg, and Stock 1996). We find that *Log(CPI)* is *I(1)*: at 1% level of significance, while we cannot reject the null hypothesis of unit root for its level, we can safely reject the null hypothesis for its first-difference variations. The same can be said about *Log(M)*, at 5% level of significance, and *Log(E)*, at 1% level of significance. However, the DF-GLS test results suggest that *Log(F)* and *Log(S)* are *I(0)*: at 1% level of significance, we can safely reject the null hypothesis of unit root for their level variations.

As summarized in Table 2, some of the variables are *I(1)* while others are *I(0)*. We can, thus, employ the ARDL bounds method developed by Pesaran, Shin, and Smith (2001), the requirement for which is that the variables in use should *not* be *I(2)* or of any higher order of integration. Equation (2) represents our parsimonious ARDL model:

$$\lambda(L,p)Log(CPI)_t = \alpha + \beta_M(L,q_M)Log(M)_t + \beta_E(L,q_E)Log(E)_t + \gamma t + u_t \qquad (2)$$

where:

$$\lambda(L,p) = 1 + \lambda_1 L + \lambda_2 L^2 + \cdots + \lambda_p L^p$$

$$\beta_j(L,q_j) = \beta_{j,0} + \beta_{j,1}L + \beta_{j,2}L^2 + \cdots + \beta_{j,q_j}L^{q_j};\ j \in \{M,E\}$$

$$L^i x_t = x_{t-i};\ i \in \{Log(CPI), Log(M), Log(E)\}$$

In this model, the contemporaneous variation in *Log(CPI)* is a function of its own lagged variations (under $\lambda(L,p)$ lag operator) as well as the contemporaneous and lagged variations in *Log(M)* and *Log(E)* (under $\beta_M(L,q_M)$ and $\beta_E(L,q_E)$ lag operators). We determine the order of this model (i.e., p, q_M, and q_E) using Bayesian information criterion (BIC) (Schwarz, 1978). This criterion is a function of regression's log-likelihood, number of parameters, and number of observations. Compared to other information criteria, it imposes greater penalty for degree of freedom lost, making it more useful for short time series (Greene, 2012, pp. 139-140).

We further reformulate the above ARDL equation under an unconstrained ECM:

$$\Delta Log(CPI)_t = \alpha + \beta_{CPI} Log(CPI)_{t-1} + \beta_M Log(M)_{t-1} + \beta_E Log(E)_{t-1} + \sum_{i=1}^{p} \gamma_{CPI,i}\, \Delta Log(CPI)_{t-i} + \sum_{i=0}^{q_M} \gamma_{M,i}\, \Delta Log(M)_{t-i} + \sum_{i=0}^{q_E} \gamma_{E,i}\, \Delta Log(E)_{t-i} + \gamma t + u_t \quad (3)$$

The parameters in equation (3) can be categorized under two groups: 1.) adjustment and long-run parameters, including β_{CPI}, β_M, and β_E; 2.) short-run parameters, including the set of parameters listed under γ_{CPI}, γ_M, and γ_E. The ECM form would, thus, enable us to examine long-run equilibrium relationships and, equally important, short-run dynamics. In particular, as Breuer et al. (2018) suggest, it allows us to include lagged money growth ($\Delta Log(M)_{t-i}$), an empirically important variable in modeling inflation ($\Delta Log(CPI)_t$).

We perform bounds test to examine the existence of a long-run relationship. The critical values of this test are computed by Pesaran et al. (2001) (PSS F-test and t-test). More recently, Kripfganz and Schneider (2020) have computed similar critical values and provided p-value approximations. We primarily rely on their p-values in this paper. Lastly, we employ the Breusch-Godfrey method (Breusch, 1978; Godfrey, 1978) to make sure that there are no serial correlations in the error term.

3.3. Results

3.3.1. Aggregate CPI

As depicted in Figure 2, the upward-sloping movement in *Log(CPI)* is accompanied by similar movements in *Log(M)* and *Log(E)*, suggesting that there may be a long-run cointegrating relationship between price levels, monetary aggregates, and nominal exchange rate in Iran. To test for cointegration, we employ an ARDL model and its ECM form as given by equations (2) and (3), respectively. Relying on BIC, the best model includes the first lag of *Log(CPI)* and the contemporaneous variations of *Log(M),* along with the contemporaneous variations, first lag, and second lag of *Log(E)*.[5] We refer to this model as ARDL(1,0,2).

Table 3 (column 1) reports the estimation results for ARDL(1,0,2). We find that lagged price index as well as contemporaneous variations in monetary aggregates and nominal exchange rate are positively and significantly correlated with contemporaneous price index, *Log(CPI)*. The parameter for lagged exchange rate movement is also significant, though it is negative. It should be noted that, for this estimation and the ones that follow, standard errors and covariance matrix are computed using Newey and West (1987) method, robust to the presence of heteroskedasticity and autocorrelation.

Turning to the ECM form, we test for the adjustment and long-run effects as well as short-run dynamics. In the ECM equation, however, the dependent variable is our inflation measure: Δ*Log(CPI)*. Table 4 (column 1) reports that an increase in lagged price levels is associated with lower contemporaneous inflation; as expected, the point estimate is between 0 and -1. Further, in the long run, monetary aggregates and nominal exchange rate are positively and significantly correlated with inflation as the p-values for the bounds tests (including PSS F-test and t-test) are low. Also, in the short run, monetary expansion and nominal exchange rate depreciation significantly amplify inflation. The short-run cost effect of nominal depreciation is intuitive. Previous studies have also reported that inflation can be strongly correlated with money supply growth, even in immediately preceding years (e.g., McCallum and Nelson, 2010, pp. 112-134).

[5] Detailed model selection summary is available upon request.

We further test for serial correlation among disturbances using Breusch-Godfrey test. The null hypothesis implying no serial correlation, we are confident that our estimations are not contaminated by serial correlation among disturbances since p-values are relatively high.

Next, we include the variations in fiscal balance as percentage of GDP. Though this variable is *I(0)*, it can safely be incorporated into our ARDL model.[6] With the new variable, BIC recommends an ARDL(1,0,3,0) model. Table 3 (column 2) reports that our fiscal balance parameter is negative and significant, implying that an increase in fiscal deficit is associated with higher inflation. With the p-values for the bounds tests being low, the ECM results (Table 4, column 2) offer further evidence for the long-run relationship between fiscal deficit and inflation. There is also some short-run evidence for such inflationary effect, though it is not robust (see below).

We further include the continuous variations in sanctions, which are also *I(0)*.[7] BIC recommends an ARDL(1,0,2,1) model when we include the sanctions measure without controlling for fiscal balance; it recommends an ARDL(1,0,2,0,1) model when we include both variables. Table 3 (columns 3 and 4) reports that lagged variations in sanctions are positively and significantly correlated with price levels, while contemporaneous variations are insignificant. Other parameters remain significant, except for the fiscal balance parameter when we jointly control for fiscal balance and sanctions (p-value=14.31%). Further, the ECM results (Table 4, columns 3 and 4) offer supportive evidence for the long-run relationship between sanctions and inflation even when we control for fiscal balance. The p-values for the bounds test suggest that, in the long run, monetary expansions, nominal exchange rate depreciation, increase in fiscal deficit,

[6] We transform the fiscal balance measure using natural log, defining *Log(F)* as log of fiscal balance divided by GDP (and multiplied by 100) plus eleven; that is why the time series for *Log(F)* is always greater than zero.
[7] We transform the measure for sanctions intensity using natural log, defining *Log(S)* as log of sanctions intensity (bounded between 0 and 1) plus one; that is why the time series for *Log(S)* is always greater than zero.

and increase in sanctions intensity amplify inflationary pressures in Iran. In the short run, however, only money supply and exchange rate are of significance; fiscal balance and sanctions exhibit no significant short-run effects when they are controlled for jointly.

To test the robustness of the obtained results, we include our binary sanctions measure as an exogenous variable. BIC recommends estimating an ARDL(3,1,0,0) model. The results are reported in Table 3 (column 5). We find significant inflationary effects from the depreciation of nominal exchange rate and the amplification of budget deficit. We also find that, compared to other years, Iran's economy experienced significant inflationary pressures during the years that it was subject to constraining multilateral sanctions or the US maximum pressure. Further, the ECM results and the bounds test (Table 4, column 5) are supportive of the long-run relationship between money supply, exchange rate, and fiscal deficit. Our binary sanctions measure also remains significant. And the short-run parameters are all statistically different from zero.

3.3.2. CPI Components

Beyond the aggregate CPI measure, we study the determinants of inflation in prices of food and beverage, clothing and footwear, housing and utilities, furniture and appliances, health care, transportation, entertainment, and education. For this, we employ equations (2) and (3), controlling jointly for fiscal balance and sanctions. Ideally, we would have controlled for component-specific covariates that capture price controls and government subsidies for each price component.[8] However, we face significant data limitations, which is why we only include the key variables that are shown to be of significance for the aggregate price measure.

[8] We are grateful to an anonymous referee for raising this point.

We continue to use BIC to select the lag structures. Instead of *Log(CPI)*, however, we study the price index of a given component; e.g., $Log(CPI_{Food\&Bev.})$. For brevity, we only describe the ECM results.[9]

Figures 5A and B show that the indices for CPI components have been markedly increasing since 1978, despite significant heterogeneities. Also, Tables 5A and B show that for all components the point estimate for ECM adjustment parameter is between 0 and -1. Nevertheless, there are significant differences between the determinants of price movements across different components.

Similar to the evidence for aggregate index, money supply is a significant long-run determinant of inflation for most CPI components. This is, in particular, evident in prices of food and beverages, furniture and appliances, and health care. To this list, we can add housing and utilities, though the p-value for its PSS t-test is relatively high. We can also add education prices. Considering limited degrees of freedom, however, we are unable to compute the p-values for PSS tests in this case. Further, changes in money supply exhibit significant inflationary effects in the short run; exceptions include health care and entertainment prices.

As for the exchange rate, we find significant long-run impacts on furniture and appliances as well as entertainment prices. To this list, we can add housing and utilities along with transportation, though the p-values for their PSS t-tests are relatively high. Further, except for education prices, nominal exchange rate depreciation exhibits a significant short-run inflationary effect among all components. The short-run impact on housing and utility prices is evident at 15% level of significance. Plus, one of the lagged parameters for transportation prices has a different sign. Otherwise, the short-run effect of nominal depreciation is widely evident.

[9] The ARDL results are available upon request.

The long run effects from fiscal balance and sanctions on price components are mixed. In some cases, the long-run inflationary effect from fiscal deficit is in line with its impact on the aggregate index (e.g., clothing and footwear, furniture and appliances, and entertainment), while in other cases we observe disinflationary effects (e.g., health care). Similarly, long-run inflationary effects from sanctions are evident in some components (e.g., health care), while in other cases we observe disinflationary effects (e.g., clothing and footwear, furniture and appliances, entertainment, and education). The same could be said about their short-run effects. Lastly, with regard to Breusch-Godfrey test, there appear to be no serial correlations among disturbance terms except for the education price index.

Taken together, the estimation results for aggregate CPI and its components suggest that monetary expansion and nominal exchange rate depreciation have significant long- and short-run inflationary effects. Though we find that fiscal deficit and sanctions are associated with aggregate CPI inflation in the long run, the results for CPI components are mixed.

4. Conclusion

Iran's economy has suffered from chronically high inflation since the early 1980s, adversely affecting its macroeconomic stability and growth. We find that money supply and currency depreciation are important determinants of this chronic inflation. Their inflationary impact is evident in, both, long and short run. Beyond the aggregate index, they also affect inflation in several CPI components. Further, increase in fiscal deficit and sanctions intensity appear to be inflationary in the long run. Their impact is, in particular, evident on aggregate CPI.

To combat this chronic inflation, policy makers in Iran face multiple challenges. Yet, as shown by Sargent (1982), greater central bank independence coupled with sharp alteration in fiscal policy regime may be instrumental in controlling inflation. Greater flexibility of exchange rate may also be instrumental in the long run. Lastly, the removal of sanctions may help policy makers to successfully alter their fiscal regime, lower the inflationary impacts of currency depreciation, and remove a direct cause of inflation in Iran.

Future research can explore the dynamics of CPI components more fully. Along with the key determinants that are examined in this study, the effects from price controls and government subsidies can be quantified using micro-level data. Such data may also help with understanding the spatial heterogeneities in CPI components movements.

Data Appendix

In this appendix, we briefly describe the variables that are used in our study:

- *Log(CPI)* is the natural log of consumer price index, obtained from Central Bank of Iran (2021a). Taking the natural log, we add one to the index since the index value is less than one from 1978 to 1990.
- *Log(M)* is the log of M2 (i.e., money plus quasi money measured in billion IR rials), obtained from Central Bank of Iran (2021b).
- *Log(E)* is the natural log of nominal exchange rate (i.e., the price of one US dollar in IR rials), obtained from Central Bank of Iran (2021b). We use the non-official rates, reflecting free market prices.
- *Log(F)* is the natural log of fiscal balance divided by GDP and multiplied by 100. The primary source of our fiscal data is Kose et al. (2021). Their data, however, begin as of 1990. We use the budget deficit data from 1978 to 1989, obtained from Central Bank of Iran (2021b), along with the GDP data, obtained from Ministry of Economic Affairs and Finance (2021), to construct the remainder of the series. Taking the natural log, we add eleven to the relative figures to make them greater than zero.
- *Log(S)* is the natural log of sanctions intensity measure (Laudati and Pesaran, 2022), which is based on the number of news articles on Iran's sanctions that appear in six leading newspapers. Taking the natural log, we add one to the intensity measure.
- *Sanctions Dummy* is a binary variable that is set equal to one for 2010-2015 and 2018 onwards. It is equal to zero, otherwise.

Tables

Table 1: Summary statistics

Variable	Mean (SD)	Min.	Max.
Log(CPI)	2.14 (1.62)	0.13	5.32
Log(M)	12.24 (2.80)	7.86	17.02
Log(E)	8.29 (1.78)	4.61	11.77
Log(F)	1.92 (0.53)	0.15	2.87
Log(S)	0.19 (0.15)	0.00	0.68

Notes: Standard deviations are in parenthesis. *CPI* stands for consumer price index plus one; *M* stands for money supply; *E* stands for nominal exchange rate; *F* stands for the ratio of fiscal balance over GDP, multiplied by 100 plus eleven; And *S* stands for sanctions intensity plus one. See the data appendix for more detail.

Table 2: Unit-root test results

Variable	DF-GLS test statistic
Log(CPI)	-0.30
Δ*Log(CPI)*	-4.13^{***}
Log(M)	-1.78
Δ*Log(M)*	-3.75^{**}
Log(E)	-1.84
Δ*Log(E)*	-4.76^{***}
Log(F)	-4.56^{***}
Log(S)	-4.60^{***}

Note: See Table 1 and the data appendix for summary statistics and variable definitions.
*** p-value<0.01 and ** p-value<0.05

Table 3: ARDL results

	1	2	3	4	5
	Log(CPI)$_t$	*Log(CPI)$_t$*	*Log(CPI)$_t$*	*Log(CPI)$_t$*	*Log(CPI)$_t$*
Log(CPI)$_{t-1}$	0.734***	0.703***	0.738***	0.732***	1.060***
	(0.042)	(0.048)	(0.047)	(0.051)	(0.171)
Log(CPI)$_{t-2}$					-0.821***
					(0.176)
Log(CPI)$_{t-3}$					0.409***
					(0.064)
Log(M)$_t$	0.196**	0.189**	0.170**	0.177*	0.187
	(0.076)	(0.081)	(0.082)	(0.089)	(0.179)
Log(M)$_{t-1}$					0.194
					(0.148)
Log(E)$_t$	0.166***	0.175***	0.175***	0.178***	0.138***
	(0.015)	(0.016)	(0.020)	(0.020)	(0.020)
Log(E)$_{t-1}$	0.060*	0.042	0.031	0.033	
	(0.031)	(0.036)	(0.025)	(0.024)	
Log(E)$_{t-2}$	-0.184***	-0.103**	-0.147***	-0.149***	
	(0.030)	(0.048)	(0.028)	(0.028)	
Log(E)$_{t-3}$		-0.069*			
		(0.037)			
Log(F)$_t$		-0.021***		-0.011	-0.020***
		(0.007)		(0.007)	(0.005)
Log(S)$_t$			0.040	0.025	
			(0.038)	(0.039)	
Log(S)$_{t-1}$			0.097**	0.087*	
			(0.040)	(0.045)	
<u>Exogenous covariate:</u>					
Sanctions Dummy$_t$					0.083***
					(0.013)
Observations	40	39	40	40	39
Time Trend	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes
Log-likelihood	86.94	88.04	90.41	90.97	89.22

Notes: See Table 1 and the data appendix for summary statistics and variable definitions. Optimal lag orders are determined using BIC. Log-likelihood is reported under the additional assumption that errors are normally distributed. Standard errors are reported in parentheses. They are robust to the presence of heteroskedasticity and autocorrelation (Newey and West, 1987).
*** p-value<0.01, ** p-value<0.05, and * p-value<0.1.

Table 4: ECM results

	1	2	3	4	5
	ΔLog(CPI)ₜ	*ΔLog(CPI)ₜ*	*ΔLog(CPI)ₜ*	*ΔLog(CPI)ₜ*	*ΔLog(CPI)ₜ*
Adjustment:					
$Log(CPI)_{t-1}$	-0.266***	-0.297***	-0.262***	-0.268***	-0.352***
	(0.043)	(0.043)	(0.041)	(0.042)	(0.054)
Long run:					
$Log(M)_{t-1}$	0.736***	0.636***	0.648***	0.663***	1.082***
	(0.186)	(0.190)	(0.209)	(0.221)	(0.097)
$Log(E)_{t-1}$	0.158***	0.151**	0.225***	0.229***	0.394***
	(0.055)	(0.071)	(0.059)	(0.060)	(0.031)
$Log(F)_{t-1}$		-0.072***		-0.041*	-0.056***
		(0.018)		(0.024)	(0.017)
$Log(S)_{t-1}$			0.525***	0.418*	
			(0.187)	(0.205)	
Short run:					
$\Delta Log(CPI)_{t-1}$					0.041***
					(0.104)
$\Delta Log(CPI)_{t-2}$					-0.409***
					(0.094)
$\Delta Log(M)_t$	0.196***	0.189***	0.170**	0.177**	0.187*
	(0.071)	(0.068)	(0.069)	(0.069)	(0.102)
$\Delta Log(E)_t$	0.166***	0.175***	0.175***	0.178***	0.138***
	(0.025)	(0.025)	(0.029)	(0.029)	(0.020)
$\Delta Log(E)_{t-1}$	0.184***	0.172***	0.147***	0.149***	
	(0.025)	(0.025)	(0.033)	(0.034)	
$\Delta Log(E)_{t-2}$		0.069*			
		(0.035)			
$\Delta Log(F)_t$		-0.021*		-0.011	-0.020*
		(0.011)		(0.012)	(0.011)
$\Delta Log(S)_t$			0.040	0.025	
			(0.043)	(0.029)	
Exogenous covariate:					
Sanctions Dummy$_t$					0.083***
					(0.016)
Observations	40	39	40	40	39
Time Trend	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes
Log-likelihood	86.94	88.04	90.41	90.97	89.22
R-squared	0.88	0.89	0.90	0.90	0.90
Adj. R-squared	0.85	0.87	0.87	0.87	0.87
P-value:					
PSS F-test	0	0	0	0	0
PSS t-test	0	0	0	0	0
BG LM-test	0.93	0.85	0.61	0.66	0.85

Notes: See the notes in Table 3. The p-values for the bounds tests are based on Kripfganz and Schneider (2020); the null hypothesis implies no level relationship. The p-values for BG LM-test are based on Breusch (1978) and Godfrey (1978); the null hypothesis implies no serial correlations in the disturbances.

Table 5A: ECM results for CPI components

	1 Food & Beverage *ΔLog (Prices)$_t$*	2 Clothing & Footwear *ΔLog (Prices)$_t$*	3 Housing & Utilities *ΔLog (Prices)$_t$*	4 Furniture & Appliances *ΔLog (Prices)$_t$*
Adjustment:				
Log (Prices)$_{t-1}$	-0.324***	-0.289***	-0.141**	-0.601***
	(0.056)	(0.058)	(0.052)	(0.091)
Long run:				
Log(M)$_{t-1}$	0.580**	0.105	1.421***	0.293**
	(0.245)	(0.205)	(0.288)	(0.135)
Log(E)$_{t-1}$	0.017	0.133	0.189*	0.261***
	(0.092)	(0.091)	(0.109)	(0.068)
Log(F)$_{t-1}$	-0.058	-0.065*	0.287	-0.389***
	(0.041)	(0.035)	(0.178)	(0.058)
Log(S)$_{t-1}$	0.065	-0.761***	-0.621	-0.804***
	(0.304)	(0.193)	(0.719)	(0.097)
Short run:				
ΔLog (Prices)$_{t-1}$	-0.090	0.453***	0.256**	
	(0.134)	(0.095)	(0.106)	
ΔLog (Prices)$_{t-2}$	-0.312**			
	(0.124)			
ΔLog (M)$_t$	0.188**	0.250*	0.200***	0.535***
	(0.085)	(0.123)	(0.064)	(0.176)
ΔLog (E)$_t$	0.308***	0.344***	0.027	0.523***
	(0.042)	(0.041)	(0.018)	(0.052)
ΔLog (E)$_{t-1}$	0.201***	0.165***		0.232***
	(0.065)	(0.045)		(0.046)
ΔLog (E)$_{t-2}$	0.217**	0.130*		0.422***
	(0.083)	(0.066)		(0.073)
ΔLog (F)$_t$	-0.019	-0.019	0.006	-0.096***
	(0.018)	(0.014)	(0.013)	(0.022)
ΔLog (F)$_{t-1}$				0.091**
				(0.037)
ΔLog (F)$_{t-2}$				0.052*
				(0.029)
ΔLog (F)$_{t-3}$				0.063**
				(0.023)
ΔLog (S)$_t$	-0.084	-0.220**	-0.079	-0.483***
	(0.100)	(0.097)	(0.066)	(0.131)
ΔLog (S)$_{t-1}$			0.257**	
			(0.094)	
ΔLog (S)$_{t-2}$			0.225***	
			(0.072)	
ΔLog (S)$_{t-3}$			0.143***	
			(0.047)	

Observations	39	39	38	38
Time Trend	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes
Log-likelihood	78.23	83.80	88.41	80.74
R-squared	0.89	0.93	0.83	0.94
Adj. R-squared	0.84	0.90	0.75	0.90
P-value:				
PSS F-test	0	0	0.05	0
PSS t-test	0	0	0.45	0
BG LM-test	0.16	0.50	0.34	0.99

Notes: See the notes in Table 4.

Table 5B: ECM results for CPI components

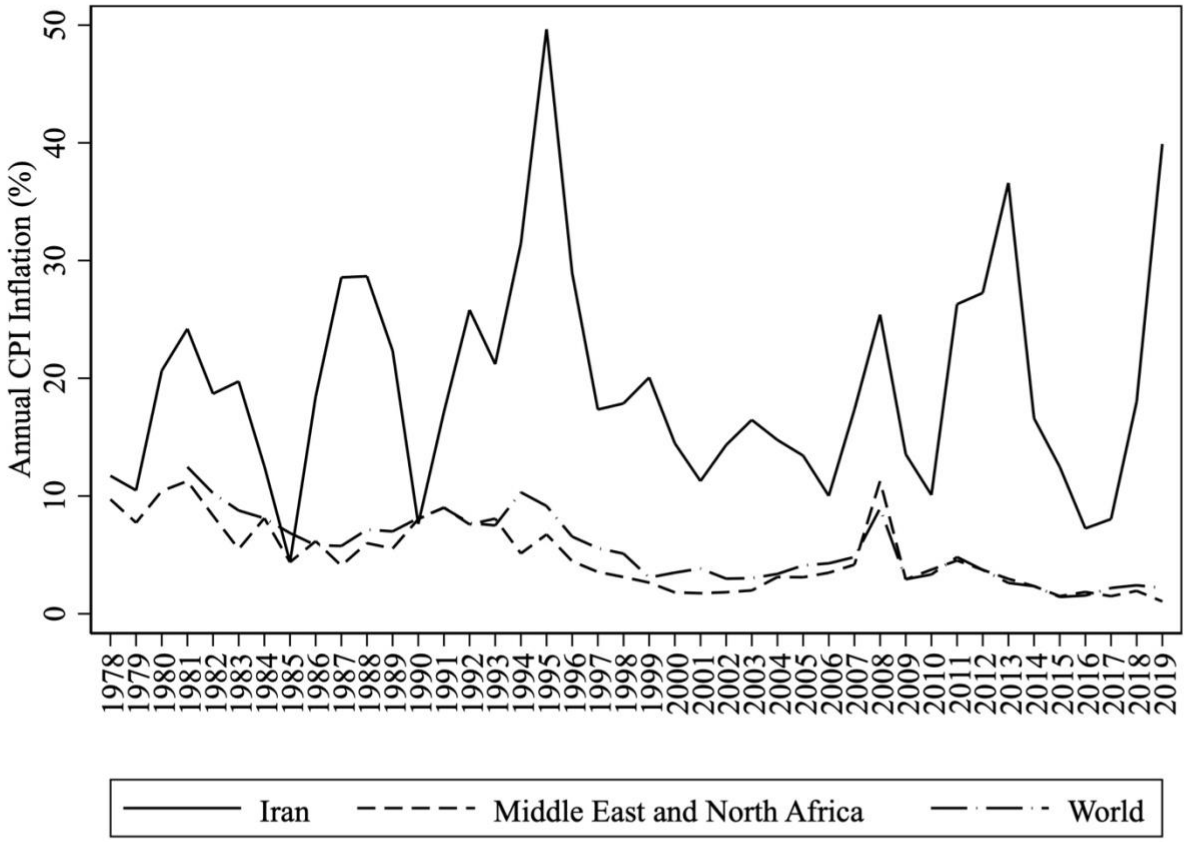
	1	2	3	4
	Health Care	Transportation	Entertainment	Education
	ΔLog (Prices)$_t$	*ΔLog (Prices)$_t$*	*ΔLog (Prices)$_t$*	*ΔLog (Prices)$_t$*
Adjustment:				
Log (Prices)$_{t-1}$	-0.168***	-0.247*	-0.387***	-0.825***
	(0.020)	(0.130)	(0.064)	(0.138)
Long run:				
Log(M)$_{t-1}$	0.472*	0.343	-0.046	2.277***
	(0.227)	(0.255)	(0.180)	(0.167)
Log(E)$_{t-1}$	-0.049	0.621**	0.615***	0.007
	(0.120)	(0.230)	(0.121)	(0.039)
Log(F)$_{t-1}$	0.476***	-0.243	-0.227***	0.021
	(0.083)	(0.185)	(0.080)	(0.068)
Log(S)$_{t-1}$	1.372**	0.413	-0.503*	-1.627***
	(0.598)	(0.828)	(0.348)	(0.403)
Short run:				
ΔLog (Prices)$_{t-1}$			0.521***	0.245
			(0.078)	(0.151)
ΔLog (Prices)$_{t-2}$				0.841***
				(0.149)
ΔLog (Prices)$_{t-3}$				0.373***
				(0.109)
ΔLog (M)$_t$	0.080	0.385**	-0.018	2.264***
	(0.051)	(0.148)	(0.076)	(0.306)
ΔLog (M)$_{t-1}$				-1.107***
				(0.305)
ΔLog (M)$_{t-2}$				-2.134***
				(0.385)
ΔLog (M)$_{t-3}$				-0.489**
				(0.181)
ΔLog (E)$_t$	0.074***	0.461***	0.544***	0.053
	(0.025)	(0.045)	(0.056)	(0.060)
ΔLog (E)$_{t-1}$	0.093***	-0.027		-0.308***
	(0.028)	(0.062)		(0.084)
ΔLog (E)$_{t-2}$	0.126***	0.198***		
	(0.034)	(0.046)		
ΔLog (E)$_{t-3}$		-0.218***		
		(0.069)		
ΔLog (F)$_t$	0.010	-0.051***	-0.088***	0.030
	(0.011)	(0.016)	(0.024)	(0.024)
ΔLog (F)$_{t-1}$	-0.065***	0.041		0.062
	(0.013)	(0.029)		(0.044)
ΔLog (F)$_{t-2}$	-0.024**	0.039		0.046
	(0.010)	(0.023)		(0.038)
ΔLog (F)$_{t-3}$		0.058***		0.055*

		(0.019)		(0.027)
ΔLog (S)ₜ	-0.072	-0.452***	-0.195**	-0.544***
	(0.058)	(0.095)	(0.092)	(0.166)
$\Delta Log\ (S)_{t-1}$	-0.228***	-0.146**		0.846***
	(0.054)	(0.055)		(0.180)
$\Delta Log\ (S)_{t-2}$	-0.118***			1.537***
	(0.038)			(0.182)
$\Delta Log\ (S)_{t-3}$				0.881***
				(0.179)
Observations	39	38	40	38
Time Trend	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes
Log-likelihood	103.90	94.15	61.41	87.81
R-squared	0.96	0.94	0.86	0.97
Adj. R-squared	0.93	0.89	0.82	0.93
P-value:				
PSS F-test	0	0.03	0	NA
PSS t-test	0	0.69	0	NA
BG LM-test	0.87	0.26	0.60	0.06

Notes: See the notes in Table 4.

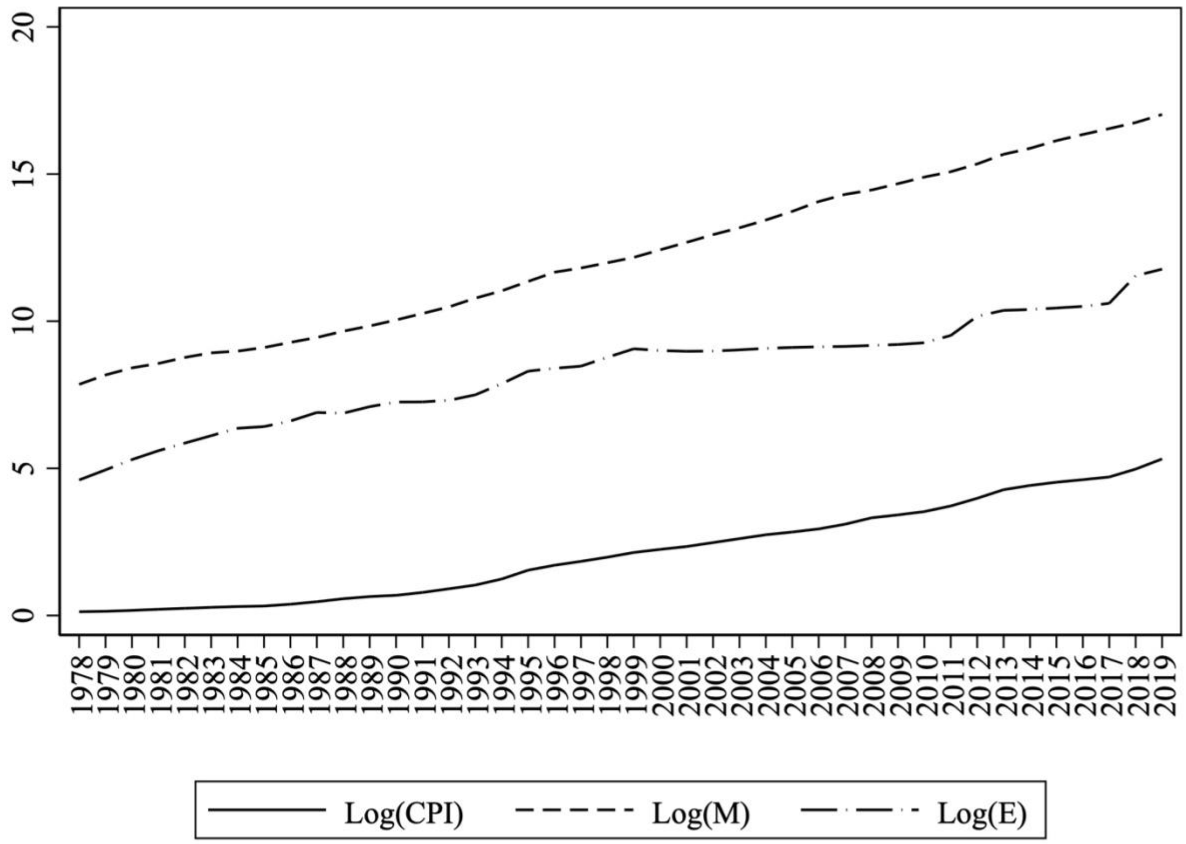
Figures

Figure 1. Inflation in the world, MENA region, and Iran



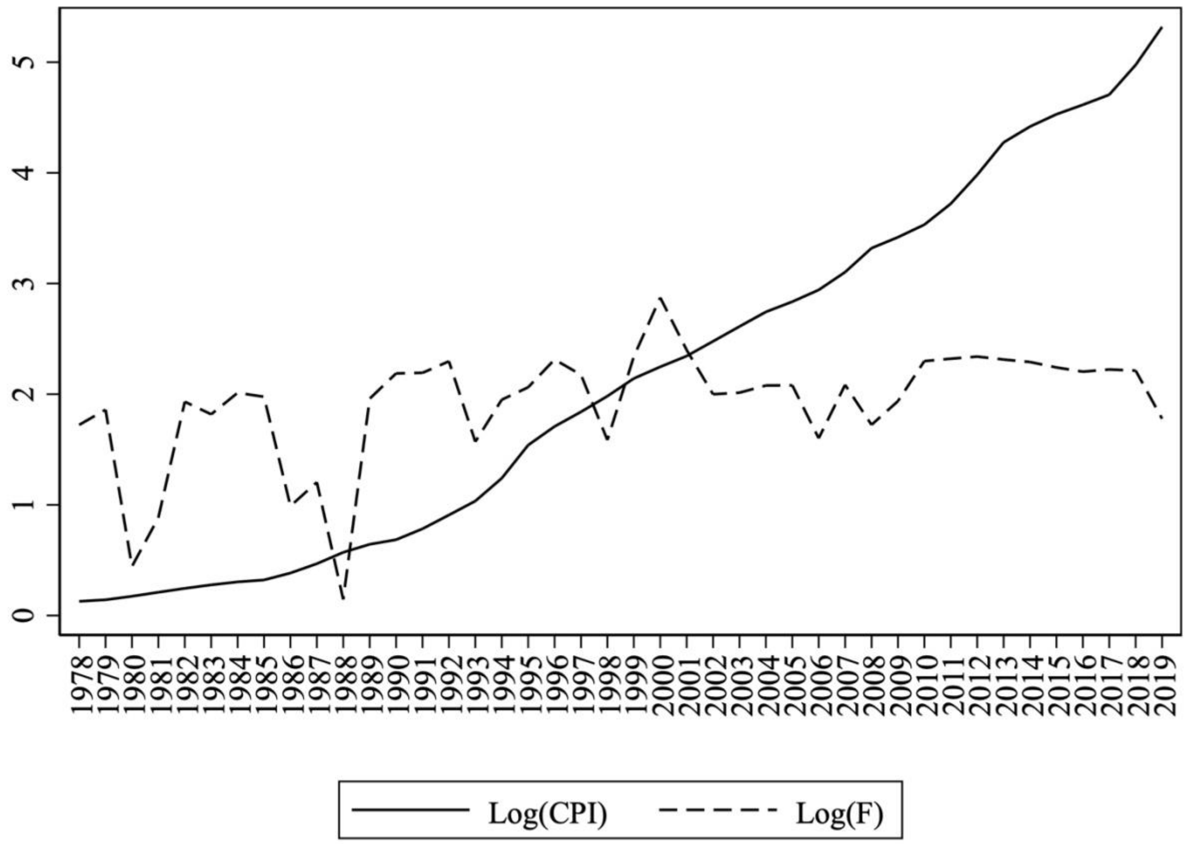
Source: International Monetary Fund (2021)

Figure 2. Time series for *Log(CPI)*, *Log(M)*, and *Log(E)*



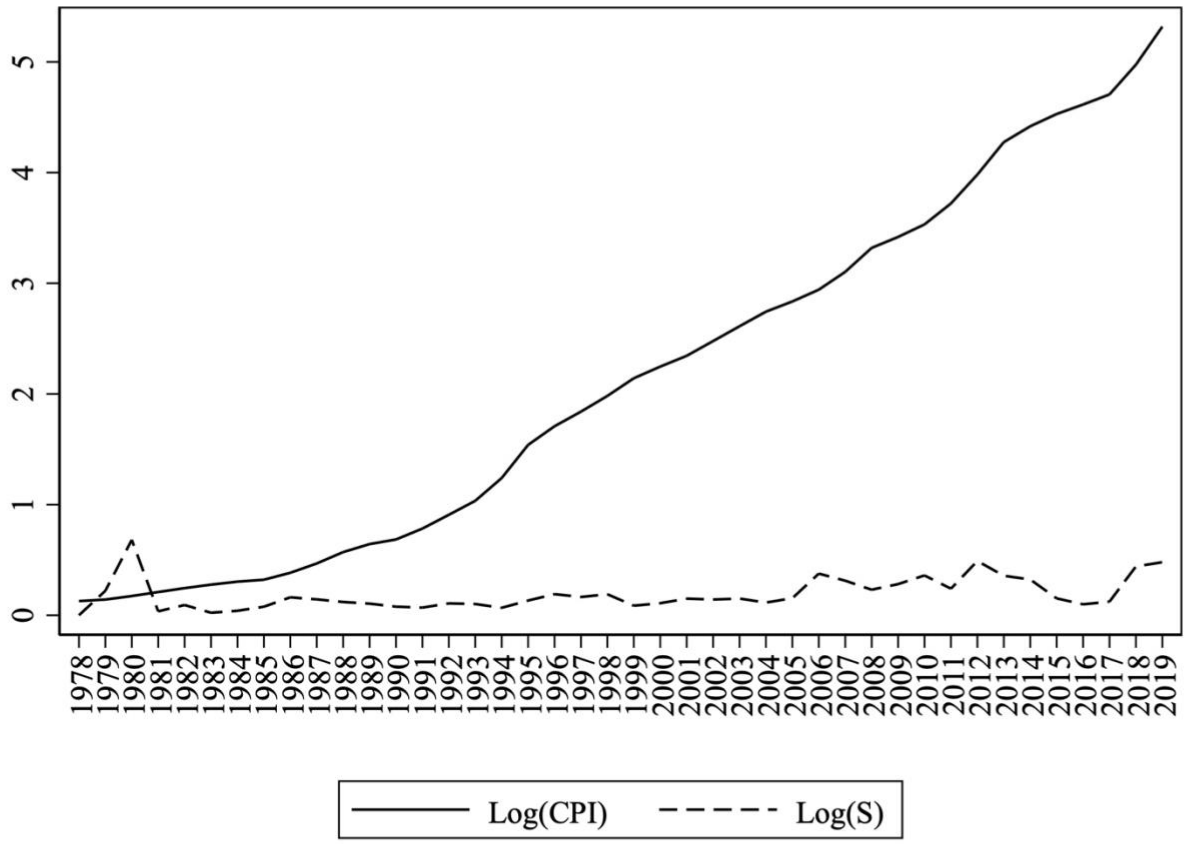
Sources: Central Bank of Iran (2021a and 2021b)

Figure 3. Time series for *Log(CPI)* and *Log(F)*



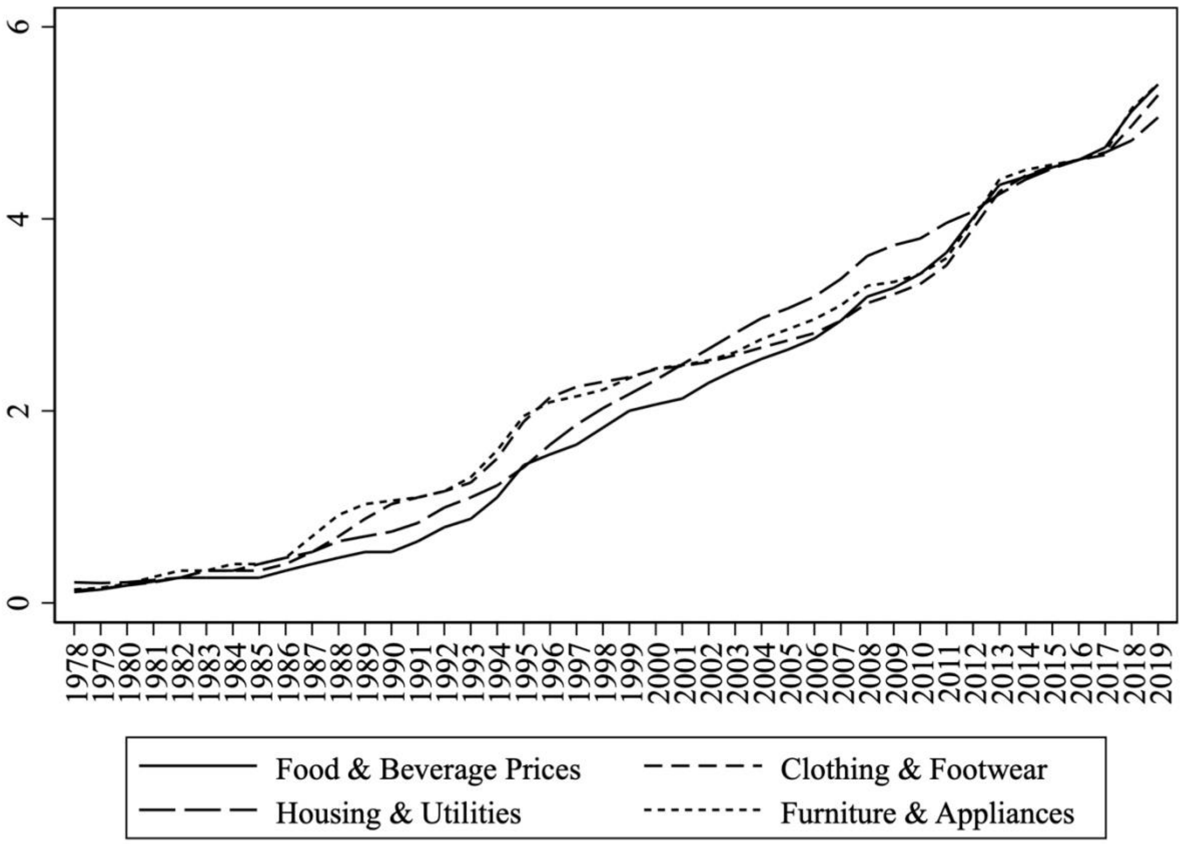
Sources: Central Bank of Iran (2021a), Kose et al. (2021), and authors computations using Central Bank of Iran (2021b) and Ministry of Economic Affairs and Finance (2021)

Figure 4. Time series for *Log(CPI)* and *Log(S)*



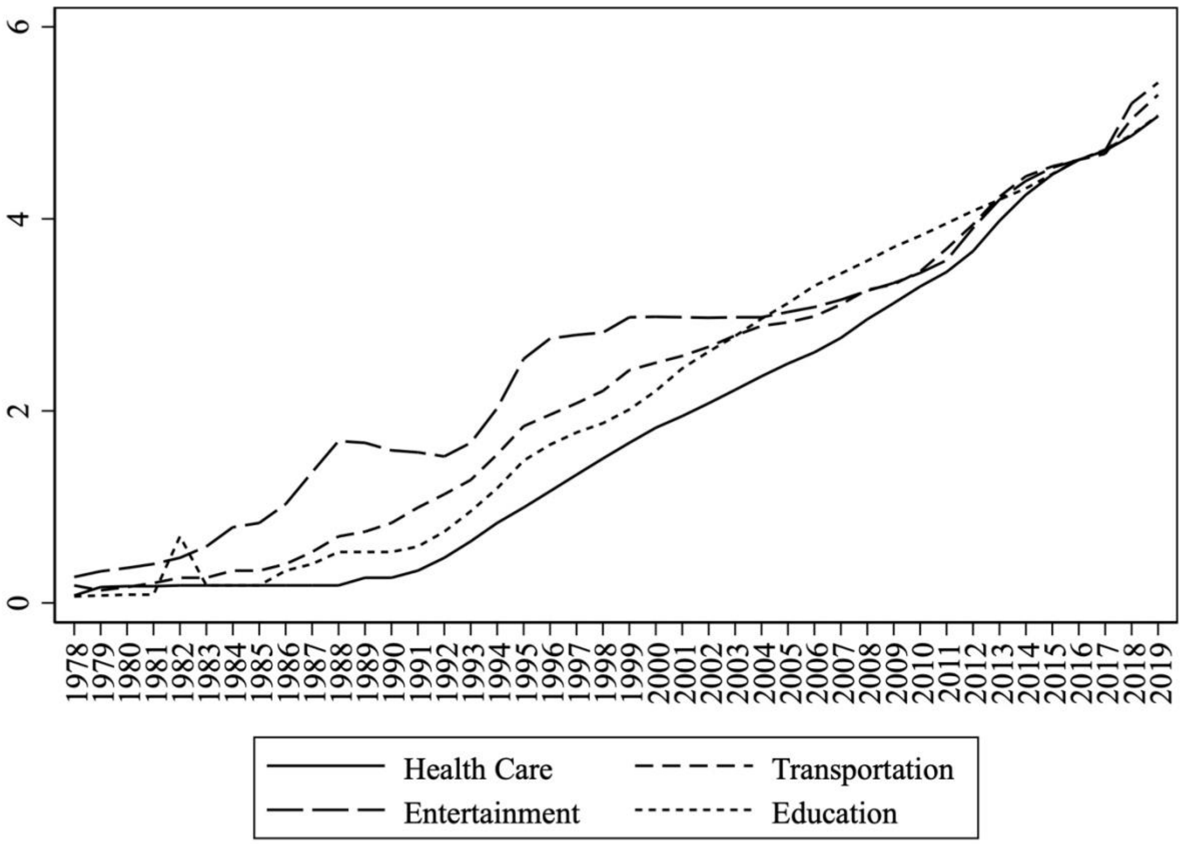
Sources: Central Bank of Iran (2021a) and Laudati and Pesaran (2022)

Figure 5A. CPI components in natural log



Sources: Central Bank of Iran (2021b)

Figure 5B. CPI components in natural log



Sources: Central Bank of Iran (2021b)

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