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DEDICATION

to

My parents

SANGHO LEE and

MYOUNGSEON CHI

For

Encouraging me to follow my dreams

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Abstract

In the first chapter, we offer a new way of examining the relationship between bilateral FDI flows and economic growth in the long-run using a unique dataset. Moreover, we provide a three-regime analysis under the North-Emerging South-South framework to highlight heterogeneity in parameters based on income levels. The framework also allows us to show an evidence of a positive association between bilateral FDI flows and business cycle synchronization especially for the North & North and Emerging & Emerging country pairs. Our comprehensive analysis addresses issues regarding sample selection, endogeneity, cross-sectional dependency, and co-integration.

In the second chapter, we show that the efficacy of fiscal decentralization in enhancing economic growth or labor productivity growth depends on whether taxes are collected at the central level or at the sub-national level. To empirically examine the differential effects, we introduce a distinct measure of fiscal decentralization that serves as a proxy for taxes collected at the sub-national level. In addition to proposing a new measure, our analysis examines the long-run association between fiscal decentralization and economic or labor productivity growth; considers heterogeneity in parameters by federalism status and income levels; identifies sources of growth; and incorporates nonlinearity to show that neither a complete revenue decentralization nor centralization is optimal.

In the third chapter, we provide a novel approach of estimating a regime-switching nonlinear and non-Gaussian state space model based on a particle learning scheme. In particular, we extend the particle learning method in Liu and West (2001) by constructing a new proposal distribution for the latent regime index variable that incorporates all available information contained in the current and past observations. The Monte Carlo simulation result implies that our approach categorically outperforms a popular existing algorithm. To demonstrate the model, the proposed algorithm is used to analyze the underlying dynamics of U.S. excess stock return.

Chapter 1

Bilateral Foreign Direct Investment, Economic Growth, and Income Convergence: A North-Emerging South-South Analysis

The motivation for trade and investment between high-income countries is well documented in the Linder [1961] hypothesis. That is, a similar willingness to pay for higher quality goods, where products from high-income countries are of higher unit values, drives up the trade volume between rich countries [e.g., Hallak, 2006, Feenstra and Romalis, 2012, Dingel, 2016]. Moreover, Fajgelbaum et al. [2014] contend that the Linder hypothesis also holds for the multilateral foreign direct investment (FDI) flows, where the product quality and income level relationship that affects high trade volumes between rich countries also affects dynamics of foreign investment. This implies that FDI flows between high-income countries dominates the volume of multinational investment. According to this theory, thus, the trade and financial exchanges between two high-income countries (i.e., North-North) must be high and prevalent.[1]

Since the era of capital account liberalization starting from the 1980s and 1990s, however, bilateral FDI flows from a southern country to a northern country and vice versa have deepened the asymmetry in global financial transactions. For instance, FDI flows from Sweden to South Korea (i.e., North-South FDI) increased from 0% in 2003 to 2.43% in 2012 as a share of Korea's total FDI inflows (UNCTAD, 2013). Similarly, the share of FDI flows from China to the United States (i.e., South-North FDI) in US's total FDI inflows increased from 2.3% in 2003 to 4.6% in 2012. Moreover, the traditional method of bifurcating income levels into North and South is insufficient: the surge of emerging South markets has significantly increased the range of income levels within the South which requires a more refined categorization of the North-South. The North consists of high-income OECD countries, whereas the South includes underdeveloped or developing nations. However, numerous countries have transitioned from the South to an Emerging South category, where income and development levels are much different. Thus, we divide countries into three regimes based on income levels: North, Emerging South, and South (i.e., NES framework).

Within the NES framework, we analyze the impact of bilateral FDI flows on income growth and business cycle synchronization. Whereas there is evidence that FDI flows may have a quantifiable impact on growth [e.g., Borensztein et al., 1998], the relationship is not strictly homogeneous. The efficacy of FDI as a

[1] Empirically, the North is defined as high-income OECD nations, and North-North refers to the direction of investment from a northern country to another northern country.

growth enhancing factor can vary for several reasons: the country of origin's investment motivation, the destination country's absorptive capacity, types of FDI (e.g., Greenfield versus M & A or horizontal versus vertical) and the sector of investment. We are particularly interested in the conditional impact of FDI on income growth related to the investment motivation and the absorptive capcaity. We also examine the association between bilateral FDI flows and business cycle synchronization. This has been overlooked in the literature even though foreign investment is as important of a convergence factor as trade due to an increased global financial integration.

The motivation for FDI versus trade flows can be quite different as technological progress in response to the exposure to new ideas and opportunities from diverse foreign investors is a main motivation of FDI flows, whereas geographic proximity or physical transportation costs are common determinants of trade flows. For instance, Disdier and Head [2008] show a highly persistent evidence that the volume of intensity of trade between two countries is lower when their geographic distance is further. Moreover, Hsu et al. [2011] contend that bilateral FDI flows tend to replace trade volumes when the physical cost of transportation is a major concern.

To analyze the heterogeneous relationship between bilateral FDI flows and income growth and business cycle synchronization, we use a sample of 9,591 country-pairs over the period 1990-2012. It is important to acknowledge that the volume of FDI flows between country-pairs is not randomly determined, a classic example of sample selection bias. Financial transactions between high-income countries are more frequently observed and the transactions have higher intensive margins than between countries with high and low income levels. Therefore, we apply a Heckman-style two-stage sample selection model to address the sample selection bias. Furthermore, the relationship between bilateral FDI flows and income growth or business cycle synchronization is highly endogenous. Endogeneity bias can occur if countries with similar income levels are more likely to invest in each another, and reverse causality can occur if fast growing countries receive more FDI flows. We mitigate endogeneity with instrumental variables (IV) and two-step system generalized method of moments (GMM) approaches.

Our analysis contributes to the literature in three major ways. First, we examine a long-run relationship between bilateral FDI flows and economic growth through an alternative empirical approach. Empirical specifications in the existing literature often examine the short-run dynamics of FDI flows. Changes in technological progress and human capital of host countries in response to increased capital flows are, however, a long term process. Second, we establish the relationship between bilateral FDI flows and business cycle synchronization which has been overlooked in the literature. Third, we account for heterogeneity in parameters between the North and the South, while decomposing the South into Emerging South and non-emerging South (i.e., NES framework) in response to numerous fast-growing developing countries.

1.1 Related Literature

1.1.1 Motivations for North-North Flows

The Linder [1961] hypothesis provides an explanation for the high volume of trade between high-income countries. An intensive trade volume between two high-income countries are motivated by their similar levels of per capita income and similar demand structures given that the demands for goods are non-homothetic.

Analogously, Krugman [1980] posits that countries with similar local consumption patterns intensively trade with one another through the home-market effects.[2] A large literature, including Bergstrand [1990], partially confirms a Linder-type hypothesis for trade through a synthesized framework.

While the motivation for the high volume of trade between high-income countries is widely analyzed, only recently has there been attempts to explain the high volume of FDI between high-income countries. Applying the concept of non-homotheticity in local demands and the home-market effects used in the trade literature, Fajgelbaum et al. [2014] show that the same relationship can also explain the trend in FDI flows. Firm-level data on multinational activities show that more extensive and intensive FDI flows are common between countries with a similar per capita income level if the local demand structures are similar. Accordingly, bilateral FDI country-pairs are symmetric in each region such that North-North FDI flows are prevalent. Similarly, Markusen and Venables [2000] develop a model in which firms operating in a capital-intensive industry have an incentive to open foreign production facilities in countries where the cost of capital is cheap. A large volume of North-North FDI flows exists in the aggregate level when multinationals in the capital-intensive industry are most prevalent in capital-abundant countries. The symmetry also holds for the quality of goods that each region produces. Alfaro and Charlton [2009] show that multinational firms from high-income countries specialize in producing high-quality goods. Conversely, multinational firms from low-income countries specialize in producing low-quality goods. They conclude that South-South FDI flows occur mostly in labor-intensive industries.

[2] The home-market effects refer to the concentration of certain industries in markets with lower transportation costs in relation to returns to scale.

1.1.2 Motivations for North-South Flows

Explaining the increased flows between asymmetric regions is a formidable task because economic variables other than income levels and factor endowments play a role in determination of foreign capital transactions. Similar to an argument in Helpman et al. [2007], one possible reason for an increase in North-South FDI flows is that multinationals from the North are searching for a higher expected return when investing in developing countries, away from the already capital-saturated industrialized countries. A recent surge in competition among host countries to attract more foreign investments through legislative changes and bilateral investment treaties may have also contributed to the rapid growth of FDI flows. On the other hand, an increase in South-North FDI flows can be partially attributed to multinationals in a southern country investing more in northern countries which have financial and political stability. Transportation costs heavily affect the volume of bilateral trade, bilateral FDI flows are not necessarily restricted by the physical moving cost. Thus investors can allocate their assets outside of the borders with less restrictions.

1.1.3 Economic Effects of FDI Flows

The symmetry and asymmetry in bilateral investments have several economic implications, including long-run economic growth in the host country and business cycle synchronization between the capital origin and host countries. Within the endogenous growth framework, FDI flows can have a long-run effect on economic growth of a host country through spillover effects, technology transfers, and knowledge diffusion [e.g., Borensztein et al., 1998]. The diversity of capital goods such as a FDI-led capital accumulation can positively affect technological progress through a capital deepening process [e.g., Shell, 1966]. Since the endogenous models regard technological progress as the main factor of long-run growth, an increase in FDI flows has a permanent effect on per capita income growth. Investments from multinational enterprises of northern countries, for instance, pave the way for introducing cutting-edge technology in the host country at a lower cost, resulting in more efficient technology spillovers. Consequently, the effectiveness of FDI flows would depend on the host country's level of human capital [e.g., Borensztein et al., 1998] and absorptive capacity [e.g., Durham, 2004, Girma, 2005].

1.1.4 North-South FDI Flows

Positive Effects

There are both positive and negative effects from North-South FDI flows. Dahi and Demir [2017] provide a comprehensive review of a such effect. We point out some of the major effects of the North-South FDI transactions. Regarding the positive effects, FDI flows from the North to the South can facilitate a transfer of cutting-edge technology and result in productivity spillovers to the South. The spillovers include adoption of more sophisticated management techniques of the North and an exposure to international markets, allowing the South to "catch-up" with the technological level of the North. These spillovers are expected to be significant considering the large productivity gap between the North and the South [e.g., Panagariya, 2000].

The high potential for the technological diffusion can result from the exploitation of economies of scale and faster upgrading in productivity and skills [e.g., Schiff and Wang, 2008]. That is the Southern producers have additional benefits via improvements in efficiency and the quality supplied. The South has an advantage in adopting technologies from the North more efficiently and less costly because of a variety of technologies in the North that the South can utilize. Furthermore, Krugman et al. [1995] show that the catching-up effect is magnified when there is an opportunity for vertical specialization and value-chain fragmentation. Similarly, Hallak [2006] and several others suggest that the improvements in productivity and product quality are possible when the importers' incomes are higher. That is, the exported products from the South to the North will be of a higher quality than the products from the South to the South.

The North-South integration can also have a positive impact on institutional quality. The North-South FDI flows can improve the institutional quality of the South as the North requires stricter investment binding agreements. Conditional requirements such as anti-corruption laws and demands for better rule of law are channels through which the North-South integration can have a positive effect on the South's institutional quality. Similarly, investors from the North can lobby and put pressure the policy-makers from the South to impose measures to improve the institutional quality of the South to ensure a sound investment environment [e.g., Kwok and Tadesse, 2006].[3]

Negative Effects

Because the levels of human capital and absorptive capacity are insufficient in most developing countries, Amsden [2001] contends that the benefits of foreign investments are only marginal. Several other studies are also skeptical of the effectiveness of North-South FDI. A substantial fraction of investment flows is low quality: investment is of low quality when the majority of investment flows

[3] See Demir [2016] for a further review on the topic.

is related to raw materials and intermediate goods [e.g., Alfaro and Charlton, 2009]. Furthermore, Nunn [2007] shows that countries with an incomplete contract environment are more likely to receive foreign investments of low quality since they require less relationship-specific capitals. Similarly, Alfaro et al. [2008] attribute low-income countries' arm's-length trade and high-income countries' relationship-specific activities as the main determinants of quality differentiation in FDI flows. Countries with good institutional qualities receive more sophisticated and specialized inputs. Better governance is positively correlated with high quality FDI flows. In the same way, Alfaro and Charlton [2009] show that a significant share of ownership of firms that control final or penultimate stages of production is located in northern countries, whereas the production of raw materials and intermediate goods is situated in southern countries. Often, the host country's effort to establish an extra binding agreement by signing bilateral investment treaties is ineffective because the agreement does not often apply to low quality FDI inflows.

Burgstaller and Saavedra-Rivano [1984] also emphasize concerns over profit repatriation or capital flight. Multinationals from the North taking the profits earned in southern countries back to their home countries, correlated with the South's limited ability to levy taxes on capital earnings of foreign investments. If the frequency and the amount of the capital leaving the host country is high and large, this type of behavior could have a detrimental consequence on the host country due to its unstable financial foundation. Consequently, Dutt [1996] and many others suggest that the North-South relationship can result in uneven development in the South, favoring only the terms of trade and skill-biased technological changes in the North.[4] A majority of the South's industry would

[4] See Darity and Davis [2005] for a further review.

specialize in primary and labor intensive products, resulting in slow economic growth. Moreover, a strong dependency on the North's economy is detrimental and not sustainable to the economic growth of the South.

The colonial ties between the North and the South, where the structure favors the activities of the North, prevent a freer and more efficient movements in capital flows. Due to a systematically higher entry barriers, investors from the South are restricted with a fruitful investment opportunities. Acemoglu et al. [2001] suggest that these long-standing colonial ties have a negative and significant effect on institutional quality of a Northern country. The residual effects of the Northern colonialism prevents proper institutional developments, democratic process, and human capital growth. Therefore, the North-South integration needs a consideration merely more than the volume of the capital flows.

1.1.5 South-South FDI Flows

Positive Effects

Given the grave consequence associated with profit repatriation, Aleksynska and Havrylchyk [2013] argue that South-South FDI flows may be more appropriate for creating an economic space in which technological transfers and adoptions for the host country is more stable. Cuervo-Cazurra and Genc [2008] and Demir and Hu [2016], for instance, present evidence that multinationals from the less developed countries have an advantage when investing in other southern markets because they are already accustomed to poor governance and bad institutions. Prior experiences with poor economic environments can help them compete and operate in any adverse environments.

In addition to the benefits from the comparative advantage of the Southern investors, the South-South relationship can increase economic stability, away from the business cycles of the North [e.g., Darity and Davis, 2005]. Instead, similarities in domestic demands, preferences, incomes, endowments, cultural characteristics, and institutional components between two Southern countries can facilitate income growth and convergence [e.g., Bergstrand and Egger, 2013]. Consequently, these similarities allow for product upgrading and export diversification by serving the markets with a relatively homogeneous preference as the South's home [e.g., Amighini and Sanfilippo, 2014]. Moreover, because of the smaller differences in investment leverages and bargaining power, the South-South preferential trade agreements and bilateral investment treaties are more balanced in terms of negotiation power and terms of trade Dahi and Demir [2013].

Negative Effects

Despite numerous benefits of the South-South integration, many have faulted the increasing South-South FDI flows for undermining the North's effort to enhance investment environments for the South.[5] Particularly, the dominant role that Chinese FDI outflows plays in the rest of the South has been a major concern. Scoones et al. [2016], for instance show that numerous African countries have experienced de-industrialization and returned back to commodity focused economies due to the rise of China. There is also a growing evidence that a few Emerging South dominates the volume and terms of FDI to the rest of the South, jeopardizing investment stability and economic growth of the host countries [e.g., Ros, 2013]. Furthermore, some of the Chinese investments in Africa resemble a neo-colonial behavior of resource extraction and exploitation [e.g., Jauch, 2011].

The most critical implication of the South-South relationship is the limitation

[5] For a detailed discussion, see Demir [2016].

and ineffectiveness of the South-South FDI flows. The South-South integration may not result in a fruitful outcome because the volume and quality of FDI flows of the South are marginal and low. The lack of absorptive capacity and insufficient adaptive capabilities of the South still applies even if another Southern country tries to improve technological progress. Demir and Duan [2018], for instance, find no substantial effect of South FDI flows affecting TFP of other Southern countries.

The negative effects are often magnified when the South-South FDI flows contain uneven elements. In particular, the uneven development between the Emerging South and South create problems for the development in the South. The most prime example of such a phenomenon is the China-Africa FDI relationship. Labor exploitation and neocolonialism-type practices by Chinese investors in many African countries is one of main problems that was pointed out for having an adverse impact on economic growth [e.g., Jauch, 2011].[6] Similarly, Cabral et al. [2016] show that investors from Brazil, an Emerging South, heavily invest in Africa but the outcome on growth is minimal because the Brazilian investors also face the same type of constraint as a typical Northern investors would.[7]

1.1.6 FDI Flows and Economic Growth

Despite the recent concern over the efficacy of FDI flows, the traditional view concerning the effects of FDI flows on economic growth has been favorable in that a large influx of foreign investment can augment private savings and relax capital constraints of developing countries, resulting in positive growth. Lucas [2000], for instance, argues that investment flows from high-income coun-

[6]See Dahi and Demir [2016] for a further discussion.
[7]For further discussion on the China-Africa FDI flows, see Dahi and Demir [2017].

tries to low-income countries may be favored over investments among low-income countries since knowledge spillovers and advanced technology transfers from the high-income countries can act as a catalyst for permanent economic growth in low-income countries. As an empirical evidence, Borensztein et al. [1998] find positive growth effects of FDI flows on several developing countries. The most notable implication is that the levels of human capital and technological diffusion of host countries are critical factors in enhancing positive growth. In addition, Li and Liu [2005] confirm Borensztein et al. [1998]'s findings that the benefits of FDI flows are maximized when the host country's level of human capital development is sufficient enough to absorb foreign investments. Theoretic models of endogenous growth have motivated empirical studies estimating impacts of FDI flows on long run economic performances of the host countries. Examining 46 developing countries from 1970-1985, Balasubramanyam et al. [1996] find that FDI flows have positive effects on export-oriented countries, and negative impacts on import-oriented countries.

In most studies, an instrumental variables (IV) approach is used to address endogeneity between FDI and economic growth. De Mello [1999] applies a dynamic GMM approach in a panel setting for a group of OECD members and non-OECD countries. The regression estimates imply that FDI flows have a positive effect on increasing GDP per capita growth for OECD nations, whereas FDI flows have a negative effect on non-OECD countries. Similarly, Nair-Reichert and Weinhold [2001] use the GMM approach to investigate whether the effects of FDI flows on economic growth are causal. Due to the inability to fully address the endogeneity issue, however, no causal relationship is found. Carkovic and Levine [2002] compare estimates from OLS and GMM regressions and find no significant effects of FDI flows on economic growth of the host countries. Carstensen and

Toubal [2004] examine the bilateral FDI relationship between G7 nations, as well as among Central and Eastern European Countries (CEECs). Numerous multinational enterprises from the G7 nations make a large volume of investments in foreign markets, while the multinationals from CEECs are on the receiving end of the investments. FDI flows are found to have partial but positive impacts on economic growth of CEECs. Moreover, Alfaro et al. [2004] find evidence that financially stable nations are more likely to benefit from FDI inflows than countries with unstable financial markets. These findings are seminal by being among the first in the literature to empirically show that the positive effects of FDI flows are most prominent in well-developed financial markets.

Regarding heterogeneity in parameters, Dabla-Norris et al. [2010] divide the sample countries by their income levels and geographical regions. The findings indicate that there is a strong positive correlation between economic growth and FDI flows for middle- and low-income countries. Doytch and Uctum [2011] dissect the aggregate FDI flows into manufacturing and service FDI flows. These estimates imply that the type of FDI flows by each industry exhibits heterogeneity itself. Manufacturing FDI has positive impacts, whereas service FDI flows have negative impacts on economic growth. Suleiman et al. [2013] examine countries in Southern Africa Custom Union (SACU) using dynamic ordinary least squares and find that there is a positive and statistically significant impact of FDI flows on economic growth of SACU member nations.

1.1.7 FDI Flows and Income Convergence

Empirical studies examining the relationship between bilateral trade and income convergence are abundant. There is, however, a dearth of literature studying the effects of bilateral FDI flows on business cycle synchronization. The literature investigating the association between trade and business cycle synchronization is the closest to our endeavor. Imbs [2004], for instance, shows that intra-industry trade has a significant impact on business cycle synchronization between two countries, whereas inter-industry trade has no consistent effects. The patterns of specialization in trade are the major factor in affecting the relationship since economies with similar economic structures grow concurrently through the evolving stages of diversification. Evidence show that bilateral trade and business cycles are positively correlated but the effects are significantly bigger among industrial countries than developing countries when using annual observations for 147 countries during 1960-1999.

With the surge of multinationals from high-income countries investing in low-income countries, and vice versa, a form of bilateral integration may occur between two countries. Co-movements in output between the North and the South from the increased volume of bilateral FDI flows may be possible since bilateral financial integration has an impact on business cycle synchronization. For instance, Imbs [2004] finds that financially integrated regions are more likely to be synchronized with one another, implying that coordination of international capital flows is a vital part of business cycle co-movements. Calderon et al. [2007] also show that patterns in bilateral trade have a substantial impact on responsiveness of business cycle synchronization with having heterogeneous impacts on industrial and developing countries. Similarly, Kalemli-Ozcan et al. [2013] examine the relationship between international capital flows and output co-movement, finding heterogeneity. Our paper appends to this strand of the literature to show the heterogeneous effects of bilateral FDI flows on business cycle synchronization is a substantial issue.

Income convergence between North-North is expected because of similarities in technology process, infrastructure, and demand preferences. Perhaps the same case could be true for the Emerging South-Emerging South and South-South pairs where their similarities in managerial skills and technology know-how can nurture a smoother transition of technology. The potential for productivity gains are higher for these groups as there is more room for growth with the existing older and underdeveloped technologies.

The introduction of the Emerging South group complicates the North-South relationship because it has characteristics of both groups. Emerging Southern countries are fast approaching the income and development levels of the North while still copying characteristics of the South on institutional and physical capital development. Emerging South markets have sufficient absorptive capacity and infrastructure to host foreign capital from the North. At the same time, they can also nurture FDI flows from the South because they have a similar demand preferences, as well as cultural and economical characteristics as the South.

1.2 Empirical Analysis

1.2.1 Bilateral FDI Flows and Economic Growth: Specifications

Our first specification involves the association between bilateral FDI flows and economic growth. We normalize investment flows from country j (source) to country i (host) by country i's economic size (GDP). The share of (log) bilateral FDI flow from country j to country i at time t is denoted by $fdi_{ij,t}$. Our dynamic panel consists of observations over the period of 1990-2012 with a linear regression model as in equation (1.1):

$$y_{i,t} - y_{i,t-1} = (\phi - 1)y_{i,t-1} + \beta^{'} X_{i,t} + \eta_i + \epsilon_{i,t} \tag{1.1}$$

, where $y_{i,t}$ is the log of real GDP per capita of country i at time t; $y_{i,t-1}$ is the lag of $y_{i,t}$; $X_{i,t}$ is the vector of explanatory variables, including FDI flows; η_i is the unobservable individual country-specific effect; and $\epsilon_{i,t}$ is the error term. Equation (1.1) can be rewritten as:

$$y_{i,t} = \phi y_{i,t-1} + \beta^{'} X_{i,t} + \eta_i + \epsilon_{i,t} \tag{1.2}$$

To eliminate the country-specific effects, we take the first-difference of equation (1.2):

$$y_{i,t} - y_{i,t-1} = \phi(y_{i,t-1} - y_{i,t-2}) + \beta^{'}(X_{i,t} - X_{i,t-1}) + \epsilon_{i,t} - \epsilon_{i,t-1} \tag{1.3}$$

Since the new error term, $\epsilon_{i,t} - \epsilon_{i,t-1}$, is correlated with the lagged dependent variable, we apply a dynamic panel approach to address the issue of serial correlations [e.g., Blundell and Bond, 2000]. We include the year fixed effect, δ_t, to account for international political and economic shocks that have a ubiquitous effect on all economies but is independent of the evolution of FDI flows and the country-pair fixed effect, δ_{ij}, to address the various unobservable factors that are unique to each country pair such that:

$$\Delta y_{i,t} = \phi \Delta y_{i,t-1} + \beta^{'} \Delta X_{i,t} + \delta_t + \delta_{ij} + \Delta\epsilon_{i,t} \tag{1.4}$$

, where $\Delta y_{i,t}$ and $\Delta y_{i,t-1}$ are the current and lagged growth rate of GDP per capita.

We allow one or more lagged values of real GDP per capita and bilateral FDI flows. This is similar to using an autoregressive distributed lag (ADL) model to address the possibility of bilateral FDI flows affecting the real GDP per capita growth over time because the capital flows may not have an immediate impact on economic growth. A generalized version of the autoregressive moving-average (ARMA) process of an ADL(p, q) model can be derived from equation (1.2) by adding a lag length p for y_i and a lag length q for $fdi_{ij,t}$ with a non-stationary process, $\delta_{i,t}$. Then

$$y_{i,t} = \phi_1 y_{i,t-1} + \phi_2 y_{i,t-2} + \cdots + \phi_p y_{i,t-p} + \theta_0 fdi_{ij,t} + \theta_1 fdi_{ij,t-1} + \cdots + \theta_q fdi_{ij,t-q} + \eta_i + \delta_{i,t} + \epsilon_{i,t} \quad (1.5)$$

The non-stationary process determines the long-run growth rate of real GDP per capita which combines the business cycle fluctuation and the general equilibrium of long-run growth paths of a transitional growth model such that

$$\delta_{i,t} = \alpha + \beta fdi_{ij,t} + \gamma_i + \varepsilon_t + \nu_{i,t} \quad (1.6)$$

, where γ_i accounts for the time-invariant country-specific heterogeneity in the growth rate; ε_t allows for time-varying global shocks; and $\nu_{i,t}$ refers to country-specific time-varying common shocks. When $\beta > 0$, there exists a long-run relationship between bilateral FDI flows and income growth. Combining the non-stationary process in equation (1.6) with the first-difference ADL model in equation (1.5),

$$\Delta y_{i,t} = \alpha + \beta fdi_{ij,t} + \phi_1 \Delta y_{i,t-1} + \phi_2 \Delta y_{i,t-2} + \cdots + \phi_p \Delta y_{i,t-p} + \theta_0 \Delta fdi_{ij,t} + \theta_1 \Delta fdi_{ij,t-1} + \cdots + \theta_q \Delta fdi_{ij,t-q} + \gamma_i + \varepsilon_t + \nu_{i,t} + \Delta\epsilon_{i,t} \tag{1.7}$$

Given some level of $\Delta\delta_{i,t}$, we can compute the cumulative level effect as $\beta/(1-\phi_1-\phi_2-\cdots-\phi_p)$ and the cumulative growth effect as $(\theta_0+\theta_1+\cdots+\theta_q)/(1-\phi_1-\phi_2-\cdots-\phi_p)$. The level effect is the initial impact of bilateral FDI inflows on the cumulative GDP growth rate. The growth effect is the cumulative effect of FDI growth on the cumulative GDP growth rate. Furthermore, we can test the significance of the long-run relationship between FDI and GDP growth in the following way: the null hypothesis assumes that there is no long-run relationship between economic growth and bilateral FDI flows. The p-values of the hypothesis test present the statistical significance of the long-run association.

Based on equation (1.7), we can determine our short-run and long-run baseline specifications. The short-run baseline specification is one-time effect of bilateral FDI flows on economic growth, $\Delta y_{i,t} = \alpha + \phi_1 \Delta y_{i,t-1} + \beta fdi_{ij,t} + \theta_1 \Delta fdi_{ij,t} + \gamma_i + \varepsilon_t + \nu_{i,t} + \Delta\epsilon_{i,t}$. The long-run baseline specification pertains to multi-period effect of FDI flows. We choose the lag length of three because any lags longer than three is not jointly significant. Specifically, $\Delta y_{i,t} = \alpha + \beta fdi_{ij,t} + \phi_1 \Delta y_{i,t-1} + \theta_0 \Delta fdi_{ij,t} + \theta_1 \Delta fdi_{ij,t-1} + \theta_2 \Delta fdi_{ij,t-2} + \theta_3 \Delta fdi_{ij,t-3} + \gamma_i + \varepsilon_t + \nu_{i,t} + \Delta\epsilon_{i,t}$ is our long-run specification. Due to concerns of simultaneity bias, we also use a lagged values of bilateral FDI flows in each of the short-run and long-run specifications.

1.2.2 Bilateral FDI Flows and Business Cycle Synchronization: Specifications

The dependent variable in the growth equation is GDP per capita growth rate. The main explanatory variable is the (log) level of bilateral FDI flows normalized by nominal GDP of host economies in current US dollars. The one-directional analysis may not be adequate to capture the efficacy of bilateral flows since the participation and the volume of FDI flows are also determined by the economic and political characteristics of the source countries. Consequently, we turn our attention to the income convergence literature as in Barro and Sala-i Martin [1992], Ben-David [1993], Sala-i Martin [1996], and Rey and Montouri [1999]. The theory predicts that the increased foreign capital transactions and trade volumes may lead to output co-movement among open economies. We consider the following specification for estimating the impact of bilateral FDI flows on business cycle synchronization:

$$Convergence_{ij,t} = \alpha_t + \alpha_{ij} + \beta_0 Convergence_{ij,t-1} + \beta_1 ln((FDI_{ij} + FDI_{ji})/(Y_i + Y_j))_{t-1} + X'_{ij,t-1}\Psi + \epsilon_{ij,t} \tag{1.8}$$

, where $Convergence_{ij,t}$ is the income convergence rate between investment partner countries i and j at time t; α_t is the year fixed effect; α_{ij} is the country-pair fixed effect; $ln((FDI_{ij} + FDI_{ji})/(Y_i + Y_j))_{t-1}$ is the (log) sum of bilateral FDI flows as a share of sum of each country's economic size at time $t-1$; $X'_{ij,t-1}$ is the set of variables that may affect the synchronization process (e.g., government spending as a share of GDP, inflation, productivity, and interest rate); and $\epsilon_{ij,t}$ is the bilateral error term. The dependent variable, $Convergence_{ij,t}$, is constructed in the following way: the absolute value of the difference of GDP per capita growth between two countries is the income divergence rate. Multiplying the income divergence rate by negative one gives us the absolute income convergence rate. That is, $Convergence_{ij,t} = -|(y_{i,t} - y_{i,t-1}) - (y_{j,t} - y_{j,t-1})|$, where $(y_{i,t} - y_{i,t-1})$ and $(y_{j,t} - y_{j,t-1})$ are the GDP per capita growth rate of country i and j at time t.

It is important to note the expected signs of β_1 and β_2 in equation (1.8) in relation to the dependent variable. If $\beta_1, \beta_2 > 0$, then a rise in bilateral FDI and trade flows increases income convergence between two countries. Although we expect that $\beta_2 > 0$ [e.g., Imbs, 2004], the sign of β_1 is the coefficient of interest. The explanatory variables are constructed in the manner where the vector of $X'_{ij,t-1}$ is the absolute difference of each explanatory variable. For instance, $|Inflation_i - Inflation_j|_{t-1}$ measures the absolute inflation divergence rate between two countries, and therefore a negative coefficient implies that a lower divergence in inflation rate may lead to more similarity in incomes between two countries.

Furthermore, we adopt the ADL model proposed in equation (1.7) to the analysis of the association between bilateral FDI and business cycle synchronization to examine the cumulative effect of β_1. Accordingly,

$$Convergence_{ij,t} = \alpha + \beta_1 ln((FDI_{ij} + FDI_{ji})/(Y_i + Y_j))_{t-1} + \phi_1 Convergence_{ij,t-1} + \cdots + \phi_p Convergence_{ij,t-p} + \phi_0 \Delta ln((FDI_{ij} + FDI_{ji})/(Y_i + Y_j))_t + \cdots + \phi_q \Delta ln((FDI_{ij} + FDI_{ji})/(Y_i + Y_j))_{t-q} + \gamma_{ij} + \varepsilon_t + \nu_{ij,t} + \Delta\epsilon_{ij,t} \tag{1.9}$$

, where γ_{ij} accounts for time-invariant country-pair-specific heterogeneity in income convergence and $\nu_{ij,t}$ is the country-pair-specific time-varying common shocks.

Based on equation (1.9), we derive the baseline specification for the long-run association between bilateral FDI flows and income convergence as the following:

$$Convergence_{ij,t} = \alpha + \beta_1 ln((FDI_{ij} + FDI_{ji})/(Y_i + Y_j))_{t-1} + \phi_1 Convergence_{ij,t-1} + \cdots + \phi_p Convergence_{ij,t-p} + \phi_0 \Delta ln((FDI_{ij} + FDI_{ji})/(Y_i + Y_j))_t + \cdots + \phi_q \Delta ln((FDI_{ij} + FDI_{ji})/(Y_i + Y_j))_{t-q} + \gamma_{ij} + \varepsilon_t + \nu_{ij,t} + \Delta\epsilon_{ij,t}$$

1.2.3 Data

We use a unique data on non-resident bilateral FDI flows, compiled from UNCTAD, OECD, and statistical offices of individual countries over the period of 1990-2012. Approximately 18,000 country pairs are available for analysis among 240 host and home countries. Merging observations from the UNCTAD and OECD data sources can be cumbersome since each country has different missing values over the sample period. We take the following steps to mitigate the inconsistency in the data when merging observations. First, we give priority to OECD data over UNCTAD data since OECD often has more complete and reliable observations on FDI flows. Similarly, if the host country is non-OECD but the home country is OECD then we use the home country data. Second, we give priority to the host country's data over home country's data when there is an inconsistency between bilateral FDI inflows and outflows. For instance, if the United States reports an inflow of $US 28.14 billion from United Kingdom in 2004, but United Kingdom reports an outflow of $US 10.49 billion to the United States in 2004, then, we use the United States' reported inflow value. Third, we mirror the home country's data for the full period if the host country's inflow data has missing observations but the home country's outflow data is available for a longer time period.

Real GDP per capita is measured in constant-price international dollars in 2005 and obtained from World Bank's World Development Indicators (WDI, 2015). Human capital, which measures the average years in schooling for each country, and total factor productivity (TFP), which measures the productivity levels of each country relative to the U.S. productivity (i.e., USA = 1) are retrieved from PWT 8.1. Inflation rate is calculated as the log difference of the consumer price index and obtained from IMF's International Financial Statistics (IFS, 2015). Total government expenditure and total investment rate are normalized as a share of GDP. Trade openness is calculated as the sum of exports and imports as a share of GDP. Total government expenditure, total investment rate, and trade openness are retrieved from Penn World Table (PWT) 8.1 and WDI (2015). Moreover, we obtain bilateral trade volumes from Feenstra et al. [2005] and its updated version from the Observatory of Economic Complexity (OEC) to range the observation periods from 1990-2012. Geographic information and gravity model variables, such as distance between two countries, common languages, and colonial ties are retrieved from CEPII's database. These are relevant control variables when examining income convergence between two partnering countries. Geographical distance heavily affects trade volumes while cultural ties may affect foreign investment decisions. Substantial trade volumes between European countries [e.g., Imbs, 2004] and the importance of migrant networks on FDI flows [e.g., Javorcik et al., 2011] are apparent reasons why we may need geographic variables when investigating the convergence story.

Table 1.1 presents the summary statistics of relevant variables. For our benchmark specification and for the values shown here, we exclude the top and bottom one percentile of observations of bilateral FDI share. The average (both mean and median) economic growth is around 2.1%. For examining the relationship between bilateral FDI flows and economic growth of country i (i.e., the host country), we use the (log) FDI flows from country j to country i as a share of country

i's GDP, denoted by $fdi_{ij,t}$. Due to extreme outliers, we remove the bottom 1^{th} and top 99^{th} of our raw data. Some FDI flows are negative if the net FDI outflow exceeds the net inflow. To account for negative values, we add an intercept (i.e., a positive integer of 1) to all observations such that all values are positive.[8] The mean of $fdi_{ij,t}$ is 0.035 with the standard deviation of 0.159, which indicates that there is a high variation in the cross-country observations. The growth rate of bilateral FDI flows is computed as the difference of $fdi_{ij,t}$, which is simply the log differenced growth rate. The average growth rate of the bilateral FDI flows, $\Delta fdi_{ij,t}$, is around 0.1% with the standard deviation of 0.066.

For investigating the association between bilateral FDI flows and income convergence between two countries, we use (log) FDI flows from country j to country i plus FDI flows from country i to country j as a share of both country i and j's economic sizes. Thus, $ln((FDI_{ij} + FDI_{ji})/(Y_i + Y_j))_t$ denotes the bilateral FDI flows for the income convergence regression. The average value of the bilateral FDI flows for income convergence is 1.4% with the standard deviation of 0.114. Since the share variable is natural logs, we can obtain the growth rate of bilateral FDI flows, $\Delta ln((FDI_{ij} + FDI_{ji})/(Y_i + Y_j))_t$, as the difference of $ln((FDI_{ij} + FDI_{ji})/(Y_i + Y_j))_t$. The average value of the growth rate of bilateral FDI flows is .2% with the standard deviation of 0.113.

1.2.4 Trends in Bilateral FDI Flows

Our main data source for bilateral FDI flows is UNCTAD and OECD which requires a secondary examination. Garrett [2016] presents evidence that using the missing, zero, and positive FDI observations in bilateral FDI data can lead to

[8]This is a common practice in the literature. For instance, Borensztein et al. [1998] add the intercept to the black market premium values when examining the association between FDI flows and economic growth.

Table 1.1: Summary Statistics

	(1) Obs	(2) Mean	(3) S.D.	(4) Min	(5) Max	(6) P25	(7) P50	(8) P75
$\Delta y_{i,t}$	108,771	.021	.035	-.093	.121	.003	.021	.042
$Convergence_{ij,t}$	101,563	-.039	.043	-1.194	-1.00e-06	-.053	-.029	-.013
$fdi_{ij,t}$	108,771	.035	.159	-.329	2.882	0	0	.003
$\Delta fdi_{ij,t}$	108,771	.001	.066	-.418	.432	-4.77e-07	0	0.00002
$ln((FDI_{ij} + FDI_{ji})/(Y_i + Y_j))_t$	58,916	.014	.114	-3.125	14.307	0	0	.002
$\Delta ln((FDI_{ij} + FDI_{ji})/(Y_i + Y_j))_t$	56,023	.002	.113	-3.275	14.046	-.0001	0	.0003
$ln(\sum_{k=1}^{12} ICRG_{i,t}^k)$	85,593	4.269	.197	3.45	4.533	4.136	4.299	4.445
$ln(GovExp_{i,t}/GDP_{i,t})$	101,512	2.796	.332	.716	4.242	2.55	2.888	3.025
$ln(Trade_{i,t}/GDP_{i,t})$	102,254	-.369	1.193	-7.548	5.623	-.625	-.295	.091
$ln(Inflation_{i,t})$	97,662	-.014	.807	-5.384	6.971	-.333	.012	.378
$ln(Credit_i/GDP_i)$	95,399	4.044	.901	-.711	5.767	3.414	4.256	4.715
$HumanCapital_{i,t}$	86,955	1.013	.195	.121	1.286	.939	1.062	1.153
$\|TFP_{i,t} - TFP_{j,t}\|$	53,917	.34	.25	0	2.514	.134	.301	.502
$\|Inflation_{i,t} - Inflation_{j,t}\|$	76,752	.699	.737	0	7.262	.214	.48	.913
$\|Interest_{i,t} - Interest_{j,t}\|$	52,363	.789	.641	0	6.113	.312	.651	1.103
$\|GovExp_{i,t} - GovExp_{j,t}\|$	84,606	.394	.319	0	2.509	.142	.321	.577

Notes: The sample is based on the period 1990-2012. $\Delta y_{i,t}$ refers to economic growth of country i; $Convergence_{ij,t}$ refers to the absolute income convergence between countries i and j; $fdi_{ij,t}$ is the log share of bilateral FDI flows normalized by the host economy; and $\Delta fdi_{ij,t}$ is difference of $fdi_{ij,t}$. $ln(\sum_{k=1}^{12} ICRG_{i,t}^k)$ refers to the log sum of all twelve of ICRG index; $ln(GovExp_{i,t}/GDP_{i,t})$ is the log of government expenditure as a share of GDP; $ln(Trade_{i,t}/GDP_{i,t})$ is the log of openness to trade; $ln(Inflation_{i,t})$ is the log of inflation; $ln(Credit_i/GDP_i)$ is the log of domestic credit available in country i as a share of GDP; and $HumanCapital_{i,t}$ is the human capital index measuring education levels. $|TFP_{i,t} - TFP_{j,t}|$ is the absolute difference between two country's TFP levels; $|Inflation_{i,t} - Inflation_{j,t}|$ is the absolute difference between two country's inflation rate; $|Interest_{i,t} - Interest_{j,t}|$ is the absolute difference between two country's interest rate; and $|GovExp_{i,t} - GovExp_{j,t}|$ is the absolute difference between the two country's government expenditures as a share of each respective country's GDP. P25 refers to the first quartile of the distribution; P50 is the median; and P75 is the third quartile.

biased estimates if the sample selection problem is not addressed. As of 2012, we find that over 60% of the country-pairs still have not established a foreign investment partnership. As a further analysis, we provide a trend in the bilateral FDI relationship in Table 1.2, categorizing the investment volume into four different types: missing, zero (i.e., presumably recorded but the value is zero), negative (i.e., the total volume of outflows exceeds the total volume of inflows), and positive FDI flows. While we separated the missing and zero observations, the zero observations are technically missing, meaning there are no FDI flows. The investment balance of zero is very rare for any given country-pair.

Of the 379,186 observations possible for all country pairs between 1990 and 2012, 63.13% are missing and 18.36% are zero observations. Thus roughly 81.49% of the total observations are either unobservable or non-existent. Despite the recent evidence that the total volume of bilateral FDI flows has increased over the years, Table 1.2 shows that the number of new country-pairs has not necessary increased by the same magnitude. Only a few selective country pairs account for the total global financial activities. Of the non-missing and non-zero observations, approximately one-fourth of them are negative and three-fourth of them are positive, implying a majority of the realized bilateral FDI flows are greater than zero. We also analyze the trend in bilateral FDI flows by income group, the North and the South. Whether the host is the North or the South, more than 60% of the total possible observations are missing and approximately 20% of them are zero observations. One notable difference between the North and the South, however, is that the ratio of positive to negative bilateral FDI flows of the South (host) is higher than that of the North (host).

When we examine the bilateral FDI flows *between* the North (i.e., North-North), there is a stark difference in the percentage of missing and zero observations. Only 26.01% and 3.95% of all possible North-North pairs are either missing or zero observations, which is significantly lower than any other income groups. Most of the realized FDI flows within the North is attributed to a positive direction (i.e., inflows exceed outflows, both by non-residents), a trend that is consistent with the increased North-North financial transaction volume. On the other hand, when we examine the North-South or the South-North group, the missing and zero observations ratios are analogous to the ratios in all countries. The trend in the South-South flows is worth mentioning as the ratio of positive to negative FDI flows is almost one. This implies an investment imbalance in global financial transactions as most capital is flowing into developing countries with less outflows.

1.2.5 Addressing Sample Selection Bias

As evident from Table 1.2, the decision regarding the participation and the volume of bilateral FDI flows are not randomly determined. Eicher et al. [2012] also find that bilateral FDI data suffers from sample selection bias. Given strong evidence for a systematic pattern of FDI flows, we apply the Heckman [1979] two-step sample selection approach to address the possibility of sample selection bias in the following ways:

1. First stage: estimate a probit model to obtain the probability of participation in bilateral FDI relations.

Step 1. We generate an indicator variable, I_{ij}, for observing non-zero and non-missing bilateral FDI flows from country j to country i:

$$I_{ij} = \begin{cases} 1, \text{ if } FDI_{ij} > 0 \text{ or } FDI_{ij} < 0 \\ 0, \ otherwise \end{cases}$$

where FDI_{ij} is the latent variable of bilateral FDI flows.

Step 2. Estimate a probit model for the indicator variable, I_{ij}. In our probit model, we include exogenous variables that may affect selection. The exogenous determinants of bilateral FDI flows include the economic size of both host and source countries, geographic contiguity, common language, and colonial ties.

Step 3. Generate an inverse Mill's ratio (IMR) from the previous step. The IMR is the fraction of the probability density function over cumulative density function.

2. Second stage: IV regression

Step 1. Include the generated IMR in the regression equation. The generated IMR can be one of the instrumental variables for the endogenous growth regression.

Step 2. Estimate the two-stage IV regression. The sample selection bias adjusted and endogeneity bias addressed estimates are obtained in the final step.

1.2.6 Addressing Endogeneity

The use of an instrumental variables approach is indispensable since the endogenous relationship between bilateral FDI flows and economic growth is inevitable.

Reverse causality presents a significant challenge when estimating the effects of FDI flows on economic growth. Countries with a higher rate of output growth may receive more FDI flows than slow growing economies. It is unclear, therefore, if FDI flows promote growth or fast-growing countries are more likely to receive FDI flows. The reverse causality issue is also apparent for the association between bilateral FDI flows and business cycle synchronization: it is highly possible that the multinationals may decide to invest in countries with similar income levels and similar development conditions as their home countries. In this case, the direction of the impact is confounding, making it difficult to isolate the actual impacts of bilateral FDI flows on business cycle synchronization.

To address reverse causality, we use a set of instrumental variables in both the growth and convergence regressions. The validity of the instrument set can be assessed with the exogeneity condition and the relevancy condition. We check the exogeneity condition using an over-identification restrictions test of Sargan-Hansen (SH) and the relevancy condition with an under-identification test of Kleibergen-Paap (KP). The null hypothesis of SH test is that the instrument set as a group is exogenous, where the orthogonality test checks whether the instrument set is correlated with the endogenous variable. Hence, an instrument set is said to be valid when we fail to reject the null. Similarly, the null hypothesis of KP test is that the instrument set is not correlated with the endogenous variable, where the KP statistics determine the under-identification of the instrument set as a whole when more than one regressor is endogenous.

1.2.7 Addressing Cross-Sectional Dependency

Foreign direct investment and the real GDP per capita are known to have a unit root problem. When investigating the long-run relationship between bilateral FDI flows and economic growth, addressing the unit root issue and the co-integration issue is crucial since the estimates are inconsistent when a non-stationary time series variables are used in the regression model. To test for a unit root, we first compute the sample mean for each year such that $\bar{y}_1 = (1/N)\Sigma_{i=1}^{N} y_{i1}$ for the log of real GDP per capita and $F\bar{D}I_1 = (1/N)\Sigma_{i=1}^{N} FDI_{i1}$ for FDI flows.[9] We subtract these sample mean values for each year from the original observations to eliminate the common trend. The purpose of the subtraction is to reduce the possibility of cross-sectional dependency when examining time-series properties.

After testing each of the individual sample countries for both the level and the first-difference of real GDP per capita and bilateral FDI flows using the augmented Dickey-Fuller test, we determine that both variables are an integrated order of one. Moreover, we test each variable separately with a trend option to account for an upward time trend in the observations, but the fact that FDI flows and real GDP per capita are $I(1)$ does not change. Since the main explanatory variable and the dependent variable are both $I(1)$, we also test whether there is a co-integrating relationship between the two. Using heterogeneous panel co-integration tests (e.g., Im-Pesaran-Shin test), we find no co-integrating relationship between FDI flows and real GDP per capita.[10]

[9] We aggregate the FDI flows by each country such that $FDI_{it} = \Sigma_{ij=1}^{n} FDI_{ij}$.
[10] The findings are robust to the number of lag lengths up to 8.

1.2.8 North-Emerging South-South Framework

The changes in the origin and destination of foreign capitals can complicate the FDI and business cycle synchronization relationship because bilateral FDI flows between northern and southern countries lead to mixed results in output co-movements. Due to a dissimilarity in patterns of specialization, FDI flows from the North to South may not have any effects on output co-movement. A negative correlation between FDI flows and business cycle synchronization is possible if a significant share of FDI flows from the North to South consists of agricultural sector investments while the economies of the North focus mainly on manufacturing and financial sector. On the other hand, bilateral FDI flows can lead to synchronization in business cycle if the South catches up to the technology level of the North given it has sufficient absorptive capacity. FDI flows from southern countries to northern countries may have an insignificant impact since the volume of FDI flows is relatively marginal and the quality of FDI flows are often low. Our predictions are similar to Kalemli-Ozcan et al. [2013], which makes two possible theoretical predictions when examining the relationship between international capital flows and output co-movement. First, bilateral financial integration and business cycle synchronization are positively associated when there are dominant shocks to the financial sector. Second, the relationships are negatively associated when there are dominant shocks to the real sector's productivity and collateral.[11]

Dividing countries by two income groups, the North and the South, is no longer sufficient for capturing the heterogeneity in parameters because of the increasing variation between fast-growing and slow-growing developing countries.

[11] Since the second effect dominates the first effect, Kalemli-Ozcan et al. [2013] find that financial integration and business cycle synchronization are often negatively correlated, particularly for the global banking sector.

Within the South group, treating China, a fast-growing country, and Kenya, a relatively slow-growing country as the same economy would be invalid. Consequently, we further divide the South into two different income groups—Emerging Southern and non-Emerging Southern countries. In all, our analysis focuses on the heterogeneity in the coefficients of interest within the North-Emerging South-South framework. The traditional definition of the North includes high-income OECD countries, making the rest of the world as the South; however, in our paper, the South group does not include the Emerging Southern countries.[12] Table 1.3 lists the countries by their income groups.

In Table 1.4, we analyze the mean and standard deviation of (log) GDP per capita and (log) FDI flows (not normalized by the economic size) from 1990-2012 to emphasize the importance of dividing the South into Emerging South and non-Emerging South. For the full sample, the mean and standard deviation of (log) GDP per capita are 9.153 and 1.467, respectively. The mean value for the North (i.e., 10.477) is much higher than the full sample average, whereas the North's standard deviation of 0.322 is substantially lower than that of the full sample. The implication is that the sample countries in the North are of similar income characteristics and comprise a relatively homogeneous group. On the other hand, the traditional South (i.e., Emerging South and non-Emerging South) has a standard deviation of 1.318, which is more than four times larger than the standard deviation of the North. Considering the lower value of average (log) GDP per capita of the South, the South's coefficient of variation (CV) of 15.7% (i.e., 1.318/8.388) is much larger than the North's CV of 3% (i.e.,

[12] The list of countries can be robust in that an inclusion or exclusion of certain countries does not significantly change the overall outcome. However, there is a core group of countries that must be included in the Emerging Southern country group, namely China due to their fast-growing economies.

0.322/10.477), implying a greater variability in parameters within the South. Due to a substantial difference in income levels among the South, therefore, obtaining a single coefficient is inadequate for any sub-sample analysis. When we decompose the traditional South into Emerging South and non-Emerging, the composition of the Emerging South group is relatively more homogeneous than the non-Emerging South as the CV of Emerging South is 10% (i.e., 0.891/8.9) and 19.2% (i.e., 1.532/7.974) for the South. The high variation within the ES group is largely due to a high variation in the South group as the standard deviation for the Emerging South group decreases to 0.891 while the standard deviation of the non-Emerging South increases to 1.532.

After dividing the full sample by income levels, we can analyze the three-by-three multi-directional FDI flows of the North, Emerging South, and the South. For instance, North-North refers to the FDI flowing from a northern country to another northern country. Emerging-North refers to the FDI flowing from an Emerging Southern country to a northern country. South-North refers to a southern country investing in a northern country. As expected, North-North has the highest mean value of the nominal (log) level of FDI of 4.872 compared to any other investment directions, suggesting that the foreign investment between high-income countries has the highest intensive margin. The most extensive margin of the bilateral FDI flows, on the other hand, exists between North-Emerging with 7,695 observations. North-South has an average (log) FDI of 2.285 and a standard deviation of 2.158. This implies that the South receives the lowest amount of FDI from an average northern investor and this trend is quite normal among the North-South pair.

The average volume of intra-regional FDI flows is the highest for the North and the South as North-North and South-South have the highest average log (FDI) value out of all investment from each region. However, the average log (FDI) of Emerging-Emerging is not the highest for all investment originating from the Emerging South. Rather, Emerging-North has the highest intensive margin of 2.311, meaning investors from the Emerging Southern countries mainly allocate a relatively larger share of capital into high-income countries on average. However, this does not imply that these investors are risk-averse as the volume of Emerging-South is higher than the volume of Emerging-Emerging. The overall implication is that the investors from the Emerging Southern countries are aggressively searching for lucrative investment opportunities regardless of the income levels of the host countries. This emphasizes the vitality of decomposing the traditional definition of the South into Emerging South and non-Emerging Southern countries.

Table 1.5 reports the sub-sample summary statistics for the main variables used in the baseline regression. North-North has the highest average volume of $fdi_{ij,t}$ out of all country pairs. On the other hand, North-Emerging has the highest average growth rate of bilateral FDI share, $\Delta fdi_{ij,t}$ among all country pairs. This implies that while the volume of FDI flows between two northern countries is often large, more northern investors are depositing foreign capital in Emerging Southern markets at a faster rate.

Comparing the investment destinations from the North, the average value of $fdi_{ij,t}$ of North-Emerging is higher than that of North-South. This implies that the Emerging South receives a higher volume of FDI flows from northern investors on average. The growth rate of GDP per capita is also higher for the Emerging Southern country than the non-Emerging South, meaning that the Emerging economy is growing at a faster rate.

For the investment from the Emerging South (i.e., Emerging-North, Emerging-

Emerging, and Emerging-South), the Emerging-South pair has the highest average volume of FDI share. This trend is different than the Northern home country where the North-North flows were the highest. For the Emerging South, the Emerging-Emerging flows are not as prevalent as the Emerging-South flows. The implication is that the investors from the Emerging Southern markets may seek a higher investment return from the less developed South, away from the already capital saturated North.

For the investors from the South, the South-South FDI flows dominate their global capital transactions. Their average of 4% is much higher than the average values of the South-North and South-Emerging flows. The South-South sample has the highest rate of economic growth as well compared to the South-North and South-Emerging groups. The evidence suggest that there may be a positive association between the South-South FDI flows and economic growth.

1.3 Empirical Results

1.3.1 Bilateral FDI and Economic Growth: Long-run Association

In Table 1.6 we analyze the relationship between FDI flows and economic growth for the full sample using the empirical specification from equation (1.7), correcting for cross-sectional dependency and endogeneity by using demeaned variables (i.e., demeaned by aggregate mean values) and the 2SLS IV approach.[13] The regression results are from the annual observations between 1990-2012. The endogenous variables are $\Delta y_{i,t-1}$ and $fdi_{ij,t}$ or $fdi_{ij,t-1}$, as well as $\Delta fdi_{ij,t}$. The correspond-

[13]Throughout our regression analysis, we use the code *ivreg2* in Stata 14.

ing instrument set includes $\Delta y_{i,t-3}$, $fdi_{ij,t-2}$, $\Delta log((Export_{ij} + Export_{ji})/(Y_i + Y_j))_{t-2}$, and IMR, where using lagged variables of the endogenous variables as an instrument is a standard practice, the inclusion of outside instrument needs more justification. Adding IMR to the instrument set is justifiable as IMR is the inverse Mill's ratio generated from the sample selection model, making it relevant to the endogenous variables but not directly affecting the dependent variable.[14] $\Delta log((Export_{ij} + Export_{ji})/(Y_i + Y_j))_{t-2}$ is the growth rate of bilateral trade flow between two countries at time $t-2$, where the bilateral trade relationship is relevant to the endogenous variables but the lag 2 of bilateral trade growth does not directly affect the current level of economic growth. In addition to intuitively making sensing, the instrument set passes the validity tests of over- and under-identification. The p-values of SH and KP tests are reported at the bottom of each column. We fail to reject the null of SH test and we reject the null of KP test, both tests indicate validity of the instrument set. Moreover, whereas we include both year and host country fixed effect in all specifications, we explore various number of lag lengths and the inclusion of both host and home country fixed effects to test for robustness.

The first two columns show the 2SLS IV estimates from the short-run specification of one lag length of each the level and growth rate of bilateral FDI flows. Column (2) which has the lagged values is the baseline regression specification for the short-run. The coefficient of $fdi_{ij,t}$ is positive and statistically significant. The interpretation is that a one percent increase in bilateral FDI share increases the growth rate of GDP per capita by 0.01 percent. Quantitatively, if we change bilateral FDI share by 100 percent, we would expect economic growth to change

[14] We run a probit model for observing non-zero (i.e., positive and negative) and non-missing observations between country-pairs on different combinations of exogenous variables that are determinants of bilateral FDI flows.

by 1 percent. The growth rate of bilateral FDI share also has a positive effect on economic growth with the coefficient of 0.016. Quantitatively, a 100 percent increase in the growth rate of bilateral FDI share would lead to an increase of 1.6 percentage points in economic growth.

The findings from columns (1) and (2) show the short-run effect. The findings in columns (3)-(6) are new and alternative ways to examine the *long-run* relationship between bilateral FDI flows and income growth. The difference between columns (3) and (4) versus columns (5) and (6) is that the latter include home fixed effects while the former does not. We find that including both the host country and source country fixed effects is crucial for capturing the bilateral relationship: the explanatory variables in columns (3) and (4) are statistically insignificant for longer lags, whereas the ones in columns (5) and (6) are statistically significant. This difference implies that the unobservable factors that are unique to home countries are important in determining the efficacy of bilateral FDI flows on growth. Thus our finding supports the argument that the source country's motivation and other relevant unobserved variables play a role in the bilateral growth relationship.

The results from the baseline long-run specification are reported in column (6). The initial (lag) impact of the share of FDI flows (i.e., $fdi_{ij,t-1}$) is positive with the coefficient of 0.015. The magnitude of the level effect is higher than the short-run specification result in column (2). The cumulative level effect value is calculated as $0.015/(1-0.092) = 0.016$, which is also higher than the cumulative level effect in column (2).[15] To statistically examine the validity of the long-run relationship, we present a p-value for the null hypothesis that assumes no long-

[15] Refer to the last paragraph in Section 1.2.1 for how to calculate the cumulative long-run effects.

run relationship between bilateral FDI flows and economic growth. In rejecting the null, we find a strong evidence of a long-run association between the share of FDI flows and economic growth.

Moreover, we analyze the long-run relationship between the growth rate of FDI flows and economic growth. The intuition is that a continuous and steady foreign investment relationship is as vital for sustainability of economic growth as an initial increase in the share of FDI flows. That is, positive growth in FDI flows over the years can be a good indicator of the durability of the long-run relationship. Continuing with the working example in column (6), we find estimates of four different lags of FDI growth from time t to $t-3$.[16] Individually, each coefficient has a positive and statistically significant impact on economic growth, with values ranging from 0.005 to 0.123. To aggregate the growth effect over the multiple periods, we obtain a cumulative growth effect as $(0.123+0.03+0.013+0.005)/(1-0.092) = 0.189$. We reject the null hypothesis of no long-run relationships. When combined, the effect of FDI flows on economic growth is substantial and economically significant in the long run.

Using the long-run baseline specification of column (6) in Table 1.6, we independently include one period lagged values of government spending as a share of GDP, trade openness (i.e., exports and imports as a share of GDP), inflation, domestic debt as a share of GDP), human capital, and total factor productivity, as well as their lagged growth rate. This robustness test determines whether our empirical specification is sensitive to additional explanatory variables. $Z_{i,t-1}$ is the level of each additional variable and $\Delta Z_{i,t-1}$ is the first differenced values. Table 1.7 reports the robustness analysis results. All of year, host, and source

[16]We choose $p = 1$ and $q = 3$ for the ADL model since any higher lag lengths are jointly insignificant.

fixed effects are included in each specification. Focusing on the sensitivity of the cumulative long-run effects, we find that the main result of positive and statistically and economically significant impacts of FDI flows on growth is robust to the inclusion of additional control variables. High inflation and domestic debt have a negative and significant impact on growth, whereas more trade openness and better human capital have a positive effect. The long-run level effects range from 0.012 to 0.017 and the long-run growth effects range between 0.139 and 0.201, with the highest effects observed in a regime with high openness to trade.[17]

We also examine whether our main results are sensitive to the inclusion of the host country's political and economic environment. Multinational investors assess risk in foreign countries to determine the intensiveness and extensiveness of FDI volumes based on the host country's level of political development. Consequently, we adopt the International Country Risk Guide (ICRG) political risk index to measure the efficacy of FDI flows as a growth enhancing variable in the presence of various political and economic factors. ICRG reports twelve measures associated with investment risk. Scores range from 0 to 6 or 0 to 12, where a more politically stable country has a higher score.[18] It follows that a higher ICRG index value of the host country means that the country has a relatively more stable environment for investment.

Table 1.9 reports results from the 2SLS IV estimates, using the same instrument set as our long-run baseline specification and including year, host, and home fixed effects. To assess the impact of a comprehensive investment risk environment on growth, we calculate the total ICRG index by adding up each

[17] We also include all of the explanatory variables in one regression. Table 1.8 reports the results, and the results are consistent with the main findings.

[18] The ICRG variables are government stability, socioeconomic conditions, investment profile, internal conflict, external conflict, corruption, military in politics, religious tensions, law and order, ethnic tensions, democratic accountability, and bureaucracy quality.

ICRG index, k, for each host country i at time t as $ln(\sum_{k=1}^{12} ICRG_{i,t}^{k})$ and report the estimation result in column (1).[19] As expected, political stability and economic growth are positively associated. Under a politically stable regime, the cumulative level and growth effects of FDI flows are 0.02 and 0.276, respectively. Furthermore, we individually introduce eight of the twelve ICRG variables that are closely related with foreign investment decision into the regression model to determine whether risk assessments, political environments, and socioeconomic circumstances have a substantial impact on the relationship between FDI and growth. The cumulative level effects of FDI flows range between 0.016 and 0.018 and the cumulative growth effects range between 0.187 and 0.213. The highest values are observed when the investment profile index is included.

Once we find that the long-run relationship between bilateral FDI flows and economic growth for the full sample is positive and statistically significant and robust to additional explanatory variables, we can examine the heterogeneity in parameters by decomposing the sample by the income groups of North, Emerging South, and South. Following the short-run baseline specification of column (2) in Table 1.6, we report the sub-sample analysis of three-by-three multilateral directional FDI flows in Table 1.10. The first three columns consist of country groups that receive FDI flows from the North. As predicted by the theory and observed in the literature, FDI flows from the North have a positive and statistically significant impact on growth of another Northern country, whereas the same flows do not have any impact on growth in the South. On the other hand, our new finding suggests that FDI flows from the North may have an impact in enhancing economic growth of Emerging Southern countries as the coefficient of $(\Delta(fdi_{ij}/Y_i))_{t-1}$ is positive and statistically significant. We further explore this

[19]Using a lagged value of the total ICRG index generates a similar result.

relationship in the long-run specification.

When we examine the effect of FDI flows from Emerging Southern countries to the rest of the world which are reported in columns (4)-(6), we find striking evidence of a positive association conditional on the direction of flows. Although weak evidence of positive growth in Emerging-North is not uncommon, the strong and positive association between FDI flows and growth of Emerging-South and Emerging-Emerging is a new finding. In particular, FDI flows from the Emerging South has an initial level effect of 1.5% and the growth effect of 2.1% in enhancing growth of the South. These effects are approximately twice as high for the Emerging-Emerging pair where the level effect is 2.9% and the growth effect is 4.6%. The aggregate effects in Emerging-Emerging can be partially explained by the Linder Hypothesis where countries with similar income levels engage in more foreign transactions with each other, which in turn results in a higher growth effect. However, the same parallel explanation does not directly apply to the effects of FDI flows from the South to the rest of the world as reported in columns (7)-(9). Both the Emerging South and the South experience positive economic growth when there is a positive level of FDI flows is present, meaning an initial injection of foreign capital is enhancing the economic system of both regimes. Unfortunately, the growth effect is only statistically significant for the recipients of the Emerging South. One possible explanation for the phenomenon is that the Emerging South has the necessary absorptive capacity for growth compared to a poor investment-thriving environment in the South. The South does not have any noticeable impact in enhancing growth of the North because either the investment volume is too small or of low quality and their income differences are too far apart.

Given the evidence of short-run relationship in bilateral FDI flows and economic growth, we further analyze the long-run relationship to determine the cumulative impact of FDI flows on growth. Using the baseline long-run specification of column (6) from Table 1.6, we report the long-run sub-sample estimates in Table 1.11. Columns (1)-(3) present the estimates of FDI flows from the North to the rest of the world. The North-North flows has a positive and significant level effect on economic growth. However, the growth rate of bilateral FDI flows is insignificant. This implies that while an initial level of capital has a short-run effect, the cumulative growth effect is marginal. The long-run association between the level and growth rate of bilateral FDI flows and economic growth are positive and statistically significant for the North-Emerging pair. The North-South pair also has a significant level effect, but there is no evidence of capital accumulation (i.e., insignificant growth effects) between two countries.

When investigating the effects of the Emerging South FDI flows (columns (4)-(6)), it is also evident that the recipients of the Emerging South is the only regime that most benefits from the influx of foreign investment. That is, both the cumulative level and growth effects for the Emerging-Emerging pair are positive and statistically significant. Other groups, Emerging-North and Emerging-South, have positive relationships, but their associations are statistically and economically weak.

The case for FDI flows from the South (columns (7)-(9)) is the same where the Emerging South has a positive and statistically significant long-run association with the cumulative level effect of 0.056 and the growth effect of 0.273. Combining the evidence from the North-Emerging South-South framework, it can be inferred that the positive and significant impacts of FDI flows on economic growth seen in the full sample are driven by the North-North and mainly by the positive growth from the Emerging Southern countries regardless of the origin of the FDI flows. The Emerging South has the income level that is not so distinctly apart from either the North or the South while having a sufficient enough political stability to attract investment from the North and enough absorptive capacity to nurture investment from the South. Our finding contributes to the literature by emphasizing the importance of heterogeneity within the South. For instance, using the same dataset, Demir and Duan [2018] do not find any significant relationship between South-South FDI flows and TFP. This is partly due to not dividing the South into Emerging and non-Emerging.

The following analysis examines the sensitivity of findings from our North-Emerging South-South framework in Table 1.11. First, we re-estimate the first-stage of the probit model using different combinations of exogenous variables that determine the participation and the intensity (in terms of volume) of bilateral FDI flows. In particular, Table 1.12 reports the estimates when colonial ties are removed. The estimation result does not change. Second, we eliminate the outliers and re-estimate the 2SLS IV regression to examine whether the outliers are driving the results. Thus, we drop the 5^{th} and the 95^{th} percentile observations of bilateral FDI flows and re-estimate the results. Table 1.13 reports the estimates and the overall conclusion of our analysis does not change. Third, we use the two-step system GMM approach to examine whether the results are robust to different econometric tools. Table 1.14 reports the estimation result from the GMM estimation.[20].

[20]Furthermore, the robust test results for using the GMM approach in each empirical table are reported in the following tables

1.3.2 Bilateral FDI and Business Cycle Synchronization

Because we find evidence that bilateral FDI flows and economic growth have an economically and statistically significant relationship, we examine whether the two country-pairs experience business cycle synchronization. The starting point of our empirical analysis is equation (1.8), where the dependent variable, $Convergence_{ij,t} = -|(y_{i,t} - y_{i,t-1}) - (y_{j,t} - y_{j,t-1})|$, measures the convergence in income levels of two countries. Since $Convergence_{ij,t-1}$ and $ln((FDI_{ij} + FDI_{ji})/(Y_i + Y_j))_{t-1}$ are endogenously determined, we use the instrument set of $ln((FDI_{ij} + FDI_{ji})/(Y_i + Y_j))_{t-2}$, $ln((Export_{ij} + Export_{ji})/(Y_i + Y_j))_{t-2}$, $ln((Export_{ij} + Export_{ji})/(Y_i + Y_j))_{t-3}$, $ln((FDI_{ij} + FDI_{ji})/(Y_i + Y_j))_{t-3}$, and IMR, where IMR is the inverse Mill's ratio from the first stage and included in the second stage IV regression to account for sample selection bias. Using the annual observations between 1990-2012, we report the 2SLS IV results for the full sample in Table 1.21.

Column (1) shows the estimation results from the short-run specification with only one lag of the level and growth rate of bilateral FDI share. The coefficients are both positive and statistically significant, meaning that a high share of bilateral FDI flows between two countries lead to a similarity in income levels. These effects are quantitatively significant as the cumulative level and growth effects are 0.284 and 0.783, respectively. That is, the growth effect has a synergy effect on income convergence as both $ln((FDI_{ij} + FDI_{ji})/(Y_i + Y_j))_{t-1}$ and $(\Delta(fdi_{ij} + fdi_{ji})/(Y_i + Y_j))_{t-1}$ are positive and statistically significant. We add a longer lag of $\Delta ln((FDI_{ij} + FDI_{ji})/(Y_i + Y_j))_t$ to analyze a relatively longer effect, where column (2) has a lag length up to 2 and column (3) has a lag length up to 3 following equation (1.9). The estimates in column (3) show that the cumulative level and growth effects are 0.218 and 0.812, respectively.

It is important to note that a larger difference in interest rate between countries leads to a higher income convergence. And this effect is shown to be the only control variable that has a significant impact in income convergence. Columns (4)-(6) repeat the estimation specifications in columns (1)-(3) except only include the interest differences as the control variable. This does not mean that other control variables are insignificant. Rather, it implies that the bilateral FDI share absorbs the differences in government expenditure, inflation, and total factor productivity. The estimates in columns (4)-(6) are similar to the findings in columns (1)-(3). In all, regardless of the lag lengths and the inclusion of different control variables, the overall finding is that FDI flows have a positive and significant long-run effect on the convergence of two countries' income levels.

Given we have evidence of positive associations between income convergence and FDI flows for the full sample, we can decompose the effects within the North-Emerging South-South framework. The sub-sample analysis using the specification of column (6) in Table 1.21 is reported in Table 1.22.

North-North experiences income convergence and this association is statistically and quantitatively significant throughout all lags. A similar trend is observed in North-Emerging where the initial share of bilateral FDI share increases income convergence between the two income groups. However, the coefficients of contemporaneous and lagged growth effect are statistically insignificant. Conversely, there is some evidence of income convergence between Emerging-North as a result of a positive growth in bilateral FDI share. Unfortunately, this is only a weak relationship. These findings imply that the FDI flows from the North may lead to income convergence with another North or Emerging Southern countries. On the other hand, there is no evidence of income convergence for all other groups. The reason for such a phenomenon could be that the income levels among the South are so apart that FDI flows are insufficient for enhancing income convergence considering the intensity of FDI flows are marginal.

The following analysis examines the sensitivity of findings from our North-Emerging South-South framework in Table 1.22. First, we re-estimate the first-stage of the probit model excluding exogenous variables that determine the participation and the intensity (in terms of volume) of bilateral FDI flows one at a time. The exogenous variables that we exclude are common language, contiguity, and colonial ties. The estimation result does not change. Second, we eliminate the outliers and re-estimate the 2SLS IV regression to examine whether the outliers are driving the results. Thus, we drop the 5^{th} and the 95^{th} percentile observations of bilateral FDI flows and re-estimate the results. The overall conclusion of our analysis does not change. Third, we use the two-step system GMM approach to examine whether the results are robust to different econometric tools. The results do not change.

1.4 Conclusion

The composition of foreign investment has been evolving since the era of capital liberalization which introduced numerous Emerging Southern countries as both a key source and recipient of international financial transactions. We propose a three regime framework in which the North, Emerging South, and South all engage in multilateral FDI flows in response to an increasing income variations within developing countries. We find that Emerging Southern countries' income growth dominates the positive, statistically, and economically significant effects of FDI flows on growth for the full sample analysis. Having sufficient political stability for luring investments from the North and an adequate absorptive capacity for nurturing investments from the South are critical factors driving income growth in Emerging Southern countries. Also we contend that the income level of the Emerging South is not too far apart from the income levels of neither the North nor the South, enabling a Linder-type trend in international capital transactions.

Moreover, we suggest a new way of examining the long-run association between bilateral FDI and economic growth using a unique dataset between 1990-2012 to better capture the asymmetric dynamics in global economy. We find that the cumulative growth effect of FDI flows is vital for sustainable income growth, emphasizing the importance of maintaining a stable financial relationship to avoid an ephemeral effect. To validate our findings, we address sample selection bias using a Heckman-style approach, address endogeneity using either a 2SLS IV or two-step system GMM approach, address non-stationarity using first-differenced variables, and address cross-sectional dependency using demeaned values.

Perhaps the most important contribution of this paper is investigating the relationship between business cycle synchronization and bilateral FDI flows. We offer a novel investigation of this relationship. We find evidence of a positive association for the full sample. When examining within the North-Emerging South-South framework, however, we find that the positive effect is mainly originated from the North & North or Emerging & Emerging pair, whereas the South & South pair has no significant impact.

Future studies can include dissecting the FDI flow data even further into sectoral or firm level analysis to capture the specific channels that lead to heterogeneous outcomes of economic growth and income convergence in response to bilateral FDI flows. Moreover, analyzing the relationships between the multinationals from the Emerging South or Southern countries can help us better understand the dynamics of bilateral FDI flows and the outcome variables, such as economic growth. The ways to which technological progress and productivity gains are retained in an Emerging Southern or Southern country when other countries invest should provide some guidance on how to improve the absorptive capacity of some Emerging Southern and Southern countries to maximize the benefits of bilateral FDI relations.

Table 1.2: Trend in Bilateral FDI Inflow by Income Group

Income Group	(1) Missing	(2) Zero	(3) Negative	(4) Positive
All (N=379,186)	63.13%	18.36%	4.47%	14.04%
North (host) (N=122,743)	60.84%	20.86%	5.59%	12.71%
South (host) (N=256,443)	64.23%	17.16%	3.94%	14.67%
North-North (N=11,650)	26.01%	3.95%	17.27%	52.77%
North-South (N=111,372)	64.49%	13.04%	5.21%	17.26%
South-North (N=111,093)	64.49%	22.63%	4.37%	8.51%
South-South (N=145,071)	64.03%	20.32%	2.96%	12.69%

Notes: The sample observations are from 1990-2012 using the UNCTAD FDI dataset. All refers to all country-pairs available in our data. High-income OECD countries are defined as North and the rest of world is defined as South. The percentage values are the share of missing, zero, negative, and positive FDI in total observations of FDI flows in each sample. North-South refers to FDI flows from North to South.

Table 1.3: Sample Countries

Income Level	Country list
North (N=23)	Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Israel, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States
Emerging South (N=38)	Argentina, Brazil, Bulgaria, Chile, China, Colombia, Czech Republic, Egypt, Hong Kong, Hungary, India, Indonesia, Iran, Ireland, Korea (South), Malaysia, Mexico, Morocco, Oman, Pakistan, Paraguay, Peru, Philippines, Poland, Romania, Russian Federation, Singapore, Slovakia, Slovenia, South Africa, Taiwan, Thailand, Tunisia, Turkey, Ukraine, Uruguay, Venezuela, Vietnam
South (N=144)	Afghanistan, Albania, Algeria, Andorra, Angola, Anguilla, Antigua & Barbuda, Armenia, Aruba, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belize, Benin, Bermuda, Bhutan, Bolivia, Bosnia & Herzegovina, Botswana, British, Virgin, Islands, Brunei Darussalam, Burkina Faso, Burundi, Cape Verde, Cambodia, Cameroon, Cayman Islands, Central African Republic, Chad, Comoros, Congo, Congo,D.R., Cook Islands, Costa Rica, Cote d'Ivoire, Croatia, Cuba, Cyprus, Czechoslovakia, Djibouti, Dominica, Dominican Republic, Ecuador, El Salvador, Equatorial Guinea, Eritrea, Estonia, Ethiopia, Fiji, French Polynesia, Gabon, Gambia, Georgia, Ghana, Greenland, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Iraq, Jamaica, Jordan, Kazakhstan, Kenya, Kiribati, Kuwait, Kyrgyzstan, Laos, Latvia, Lebanon, Lesotho, Liberia, Libya, Lithuania, Macao, Macedonia, Madagascar, Malawi, Maldives, Mali, Malta, Marshall Islands, Mauritania, Mauritius, Federated States of Micronesia, Moldova, Mongolia, Montenegro, Montserrat, Mozambique, Myanmar, Namibia, Nauru, Nepal, Netherlands Antilles, New Caledonia, Nicaragua, Niger, Nigeria, Palau, Palestinian Territory, Panama, Papua New Guinea, Paraguay, Rwanda, Samoa, San Marino, Sao Tome and Principe, Saudi Arabia, Senegal, Serbia, Seychelles, Sierra Leone, Solomon Islands, Somalia, Sri Lanka, St.Kitts and Nevis, St.Lucia, St.Vincent and the Grenadines, Sudan, Suriname, Swaziland, Syrian Arab Republic, Tajikistan, Tanzania, Timor-Leste, Togo, Tonga, Trinidad and Tobago, Turkmenistan, Turks and Caicos Islands, Tuvalu, Uganda, United Arab Emirates, Uzbekistan, Vanuatu, Yemen, Zambia, Zimbabwe

Table 1.4: North-Emerging South-South Framework

	log of (GDP per capita)			log (level of FDI)		
	(1)	(2)	(3)	(4)	(5)	(6)
	N	Mean	Std. Dev.	N	Mean	Std. Dev.
Full	108,771	9.153	1.467	39,992	2.647	2.792
North	39,826	10.477	0.322	13,070	3.149	3.002
Emerging & South (ES)	68,945	8.388	1.318	26,922	2.403	2.65
Emerging	36,849	8.9	0.891	15,960	2.541	2.949
South	34,884	7.974	1.532	11,715	2.141	2.191
North-North	6,968	10.393	0.324	5,081	4.872	2.72
North-Emerging	10,138	8.419	1.03	7,695	3.642	2.417
North-South	19,171	7.81	1.489	6,741	2.285	2.158
Emerging-North	8,136	10.449	0.338	3,842	2.311	2.306
Emerging-Emerging	7,761	8.757	0.942	3,977	1.434	2.791
Emerging-South	11,541	7.91	1.522	3,101	1.702	2.458
South-North	25,267	10.509	0.31	4,479	1.853	2.848
South-Emerging	19,573	9.195	0.643	4,614	1.528	3.203
South-South	5,899	8.609	1.525	2,139	2.067	1.961

Notes: The sample period ranges between 1990-2012. North refers to high-income OECD countries. Emerging refers to Emerging Southern countries and South refers to non-Emerging Southern countries. See Table 1.3 for the list of countries for each group. The country group left of a dash is the home country, while the country group right of a dash is the host country. For instance, North-South refers to foreign investment from the North to the South.

Table 1.5: Summary Statistics by Income Group

	(1) Obs	(2) Mean	(3) S.D.	(4) Min	(5) Max	(6) P25	(7) P50	(8) P75
North-North								
$\Delta y_{i,t}$	6,968	.012	.023	-.082	.064	.002	.016	.027
$Convergence_{ij,t}$	6,953	-.017	.016	-.111	-2.86e-06	-.023	-.013	-.006
$fdi_{ij,t}$	6,968	.086	.236	-.329	2.843	0	.008	.082
$\Delta fdi_{ij,t}$	6,968	.001	.114	-.418	.432	-.022	0	.021
North-Emerging								
$\Delta y_{i,t}$	10,138	.032	.036	-.091	.12	.015	.036	.054
$Convergence_{ij,t}$	10,110	-.034	.026	-.176	-.00001	-.049	-.029	-.014
$fdi_{ij,t}$	10,138	.079	.208	-.31	2.842	.00002	.009	.065
$\Delta fdi_{ij,t}$	10,138	.003	.095	-.416	.431	-.012	0	.016
North-South								
$\Delta y_{i,t}$	19,171	.024	.037	-.093	.121	.001	.024	.046
$Convergence_{ij,t}$	19,080	-.035	.028	-.194	-9.54e-07	-.051	-.028	-.013
$fdi_{ij,t}$	19,171	.068	.247	-.327	2.882	0	0	.021
$\Delta fdi_{ij,t}$	19,171	.001	.089	-.418	.43	-.00002	0	.0002
Emerging-North								
$\Delta y_{i,t}$	8,136	.01	.024	-.082	.064	.001	.015	.025
$Convergence_{ij,t}$	7,961	-.036	.03	-.307	-.00001	-.05	-.029	-.014
$fdi_{ij,t}$	8,136	.006	.051	-.316	1.886	0	0	.001
$\Delta fdi_{ij,t}$	8,136	0	.033	-.41	.4	-.0003	0	.0005
Emerging-Emerging								
$\Delta y_{i,t}$	7,761	.03	.037	-.091	.12	.015	.036	.053
$Convergence_{ij,t}$	7,709	-.035	.032	-.334	-9.06e-06	-.048	-.027	-.012
$fdi_{ij,t}$	7,761	.014	.085	-.286	2.842	0	1.28e-06	.002
$\Delta fdi_{ij,t}$	7,761	0	.043	-.392	.43	-.0002	0	.0003
Emerging-South								
$\Delta y_{i,t}$	11,541	.024	.037	-.091	.121	.002	.025	.047
$Convergence_{ij,t}$	11,533	-.039	.031	-.245	-1.91e-06	-.056	-.032	-.015
$fdi_{ij,t}$	11,541	.041	.177	-.323	2.784	0	0	.0004
$\Delta fdi_{ij,t}$	11,541	.001	.065	-.413	.429	0	0	0
South-North								
$\Delta y_{i,t}$	25,267	.007	.027	-.082	.064	-.002	.013	.023
$Convergence_{ij,t}$	21,403	-.044	.059	-1.116	-9.54e-07	-.057	-.031	-.014
$fdi_{ij,t}$	25,267	.003	.036	-.329	1.329	0	0	0
$\Delta fdi_{ij,t}$	25,267	0	.028	-.414	.431	0	0	0
South-Emerging								
$\Delta y_{i,t}$	19,573	.025	.041	-.091	.119	.009	.033	.05
$Convergence_{ij,t}$	16,792	-.048	.059	-1.194	-1.91e-06	-.063	-.035	-.017
$fdi_{ij,t}$	19,573	.009	.074	-.326	2.695	0	0	0
$\Delta fdi_{ij,t}$	19,573	0	.032	-.411	.426	0	0	0
South-South								
$\Delta y_{i,t}$	5,899	.03	.043	-.091	.121	.003	.033	.061
$Convergence_{ij,t}$	5,419	-.051	.049	-1.053	-6.68e-06	-.07	-.041	-.019
$fdi_{ij,t}$	5,899	.04	.154	-.327	2.835	0	0	.014
$\Delta fdi_{ij,t}$	5,899	.001	.072	-.418	.432	0	0	0

Notes: The sample is based on 1990-2012. S.D. refers to standard deviation; P25 refers to the first quartile of the distribution; P50 is the median; and P75 is the third quartile. For other variable definitions, refer to Table 1.1.

Table 1.6: Bilateral FDI and Economic Growth: Annual, Full sample, 2SLS IV

Dependent variable: $\Delta y_{i,t}$						
	Short-run		Long-run			
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta y_{i,t-1}$	0.202***	0.209***	0.120***	0.121***	0.092***	0.092***
	(0.023)	(0.021)	(0.026)	(0.026)	(0.028)	(0.028)
$fdi_{ij,t}$	0.008**		0.008***		0.015***	
	(0.004)		(0.003)		(0.003)	
$fdi_{ij,t-1}$		0.010***		0.009***		0.015***
		(0.003)		(0.003)		(0.003)
$\Delta fdi_{ij,t}$	0.243**		0.067*	0.077*	0.104***	0.123***
	(0.124)		(0.037)	(0.040)	(0.030)	(0.034)
$\Delta fdi_{ij,t-1}$		0.016***	0.021**	0.021**	0.030***	0.030***
		(0.005)	(0.010)	(0.010)	(0.009)	(0.009)
$\Delta fdi_{ij,t-2}$			0.009	0.009	0.013***	0.013***
			(0.006)	(0.006)	(0.005)	(0.005)
$\Delta fdi_{ij,t-3}$			0.003	0.003	0.005**	0.005**
			(0.003)	(0.003)	(0.003)	(0.003)
Observations	67,350	65,933	48,277	48,277	48,277	48,277
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Host F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Home F.E.	Yes	Yes	No	No	Yes	Yes
KP test	0.060	0.000	0.000	0.000	0.000	0.000
SH test	0.724	0.835	0.426	0.420	0.797	0.805
Level Effect	0.009	0.012	0.010	0.010	0.016	0.016
Level p-value	0.040	0.001	0.009	0.009	0.000	0.000
Growth Effect	0.305	0.020	0.114	0.126	0.169	0.189
Growth p-value	0.052	0.001	0.070	0.061	0.001	0.000

Notes: The sample observations observed annually over the period 1990-2012. The covariance matrix in each column allows for heteroscedasticity and the MA(1) errors. See the text for the instrument set. Robust standard errors are in parentheses whereas ***, **, and * represent marginal significance levels of 1%, 5%, and 10%, respectively. P-values are reported for the Kleibergen-Paap (KP) and Sargan-Hansen (SH) tests. The level effect is computed as $\beta/(1-\phi_1-\phi_2)$ and the growth effect as $(\theta_0+\theta_1+\theta_2+\theta_3)/(1-\phi_1-\phi_2)$. The p-values of the hypothesis tests for the long-run effects are reported, where the null hypothesis assumes no long-run relationships between economic growth and bilateral FDI flows.

Table 1.7: Bilateral FDI and Economic Growth: Annual, Full Sample, 2SLS IV, Robustness

Dependent variable: $\Delta y_{i,t}$	(1) Government Spending	(2) Trade Openness	(3) Inflation Rate	(4) Domestic Debt	(5) Human Capital	(6) Productivity (USA=1)
$\Delta y_{i,t-1}$	0.095***	0.133***	0.060*	0.096***	0.085***	0.272***
	(0.029)	(0.028)	(0.031)	(0.029)	(0.032)	(0.029)
$fdi_{ij,t-1}$	0.014***	0.014***	0.016***	0.012***	0.011***	0.011***
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)
$\Delta fdi_{ij,t}$	0.121***	0.124***	0.132***	0.094***	0.090***	0.090***
	(0.033)	(0.034)	(0.036)	(0.031)	(0.032)	(0.033)
$Z_{i,t-1}$	0.00002	0.024***	-0.001***	-0.023***	0.128***	0.001
	(0.002)	(0.001)	(0.000)	(0.001)	(0.008)	(0.001)
$\Delta Z_{i,t-1}$	-0.001	0.003	0.001***	0.024***	0.018*	0.014***
	(0.002)	(0.002)	(0.000)	(0.001)	(0.011)	(0.003)
$\Delta fdi_{ij,t-1}$	0.030***	0.031***	0.032***	0.023***	0.023***	0.024***
	(0.008)	(0.008)	(0.009)	(0.008)	(0.008)	(0.008)
$\Delta fdi_{ij,t-2}$	0.014***	0.014***	0.014***	0.011***	0.010**	0.010**
	(0.004)	(0.005)	(0.005)	(0.004)	(0.004)	(0.005)
$\Delta fdi_{ij,t-3}$	0.005**	0.005**	0.006**	0.004	0.004	0.004
	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)
Observations	47,412	47,604	44,016	42,413	40,878	35,024
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Host F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Home F.E.	Yes	Yes	Yes	Yes	Yes	Yes
KP test	0.000	0.000	0.000	0.000	0.000	0.000
SH test	0.711	0.786	0.143	0.527	0.910	0.581
Level Effect	0.016	0.017	0.017	0.014	0.012	0.014
Level p-value	0.000	0.000	0.000	0.000	0.000	0.001
Growth Effect	0.188	0.201	0.195	0.145	0.139	0.175
Growth p-value	0.000	0.000	0.000	0.003	0.006	0.008

Notes: The sample observations observed annually over the period 1990-2012. Year, host, and home fixed effects are included. The covariance matrix in each column allows for heteroscedasticity and the MA(1) errors. See the text for the instrument set. Robust standard errors are in parentheses whereas ***, **, and * represent marginal significance levels of 1%, 5%, and 10%, respectively. P-values are reported for the Kleibergen-Paap (KP) and Sargan-Hansen (SH) tests. The level effect is computed as $\beta/(1-\phi_1)$ and the growth effect as $(\theta_1+\theta_2)/(1-\phi_1)$. The p-values of the hypothesis tests for the long-run effects are reported, where the null hypothesis assumes no long-run relationships between economic growth and bilateral FDI flows.

Table 1.8: Bilateral FDI and Economic Growth: Annual, Full Sample, IV and GMM, Robustness

	(1) IV	(2) GMM
$\Delta y_{i,t-1}$	0.226***	0.226***
	(0.035)	(0.027)
$fdi_{ij,t-1}$	0.010***	0.010***
	(0.003)	(0.003)
$\Delta fdi_{ij,t}$	0.072**	0.072**
	(0.033)	(0.033)
$\Delta fdi_{ij,t-1}$	0.018**	0.018**
	(0.008)	(0.008)
$\Delta fdi_{ij,t-2}$	0.008*	0.008*
	(0.005)	(0.004)
$\Delta fdi_{ij,t-3}$	0.003	0.003
	(0.003)	(0.003)
$Gov_{i,t-1}$	0.005*	0.005**
	(0.003)	(0.002)
$\Delta Gov_{i,t-1}$	0.001	0.001
	(0.004)	(0.003)
$Trade_{i,t-1}$	0.020***	0.020***
	(0.001)	(0.001)
$\Delta Trade_{i,t-1}$	0.004**	0.004**
	(0.002)	(0.002)
$Inflation_{i,t-1}$	-0.002***	-0.002***
	(0.000)	(0.000)
$\Delta Inflation_{i,t-1}$	0.002***	0.002***
	(0.000)	(0.000)
$Debt_{i,t-1}$	-0.020***	-0.020***
	(0.001)	(0.001)
$\Delta Debt_{i,t-1}$	0.025***	0.025***
	(0.002)	(0.001)
$HumanCapital_{i,t-1}$	0.011	0.011
	(0.008)	(0.007)
$\Delta HumanCapital_{i,t-1}$	0.009	0.009
	(0.011)	(0.012)
$TFP_{i,t-1}$	0.002**	0.002**
	(0.001)	(0.001)
$\Delta TFP_{i,t-1}$	0.013***	0.013***
	(0.004)	(0.004)
Observations	28,605	28,605
KP test	0.000	0.000
SH test	0.561	0.452
Level Effect	0.013	0.013
Level p-value	0.004	0.003
Growth Effect	0.131	0.131
Growth p-value	0.037	0.036

Notes: The sample observations observed annually over the period 1990-2012. Year, host, and home fixed effects are included. The covariance matrix in each column allows for heteroscedasticity and the MA(1) errors. See the text for the instrument set. Robust standard errors are in parentheses whereas ***, **, and * represent marginal significance levels of 1%, 5%, and 10%, respectively. P-values are reported for the Kleibergen-Paap (KP) and Sargan-Hansen (SH) tests. The level effect is computed as $\beta/(1-\phi_1)$ and the growth effect as $(\theta_1+\theta_2)/(1-\phi_1)$. The p-values of the hypothesis tests for the long-run effects are reported, where the null hypothesis assumes no long-run relationships between economic growth and bilateral FDI flows.

Table 1.9: Bilateral FDI and Economic Growth: Annual, Full Sample, 2SLS IV, Robustness

Dependent variable: $\Delta y_{i,t}$	(1) $ln(\sum_{k=1}^{12} ICRG_{i,t}^k)$	(2) Bureaucratic Quality	(3) Corruption	(4) External Conflicts	(5) Government Stability	(6) Internal Conflicts	(7) Investment Profile	(8) Military in Politics
$\Delta y_{i,t-1}$	0.105***	0.105***	0.092***	0.129***	0.046	0.080***	0.069**	0.124***
	(0.032)	(0.029)	(0.029)	(0.028)	(0.031)	(0.030)	(0.030)	(0.028)
$fdi_{ij,t-1}$	0.018***	0.015***	0.015***	0.016***	0.016***	0.015***	0.017***	0.014***
	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)
$\Delta fdi_{ij,t}$	0.169***	0.126***	0.122***	0.130***	0.133***	0.125***	0.143***	0.118***
	(0.048)	(0.034)	(0.034)	(0.034)	(0.035)	(0.034)	(0.036)	(0.034)
$ICRG_{i,t}$	0.157***	0.008***	0.005***	0.003***	0.003***	0.003***	0.004***	0.003***
	(0.012)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\Delta fdi_{ij,t-1}$	0.046***	0.031***	0.030***	0.032***	0.033***	0.031***	0.035***	0.029***
	(0.013)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
$\Delta fdi_{ij,t-2}$	0.022***	0.013***	0.013***	0.014***	0.014***	0.013***	0.015***	0.012***
	(0.007)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$\Delta fdi_{ij,t-3}$	0.010***	0.005**	0.005**	0.006**	0.005**	0.005**	0.006**	0.005*
	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Observations	40,982	45,071	45,071	45,071	45,071	45,071	45,071	45,071
KP test	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SH test	0.693	0.950	0.869	0.996	0.941	0.882	0.615	0.955
Level Effect	0.020	0.017	0.016	0.018	0.017	0.016	0.018	0.017
Level p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Growth Effect	0.276	0.195	0.187	0.208	0.194	0.188	0.213	0.188
Growth p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001

Notes: The sample observations observed annually over the period 1990-2012. Year, host, and home fixed effects are included. The covariance matrix in each column allows for heteroscedasticity and the MA(1) errors. See the text for the instrument set. Robust standard errors are in parentheses whereas ***, **, and * represent marginal significance levels of 1%, 5%, and 10%, respectively. P-values are reported for the Kleibergen-Paap (KP) and Sargan-Hansen (SH) tests. The level effect is computed as $\beta/(1-\phi_1)$ and the growth effect as $(\theta_1+\theta_2+\theta_3)/(1-\phi_1)$. The p-values of the hypothesis tests for the long-run effects are reported, where the null hypothesis assumes no long-run relationships between economic growth and bilateral FDI flows.

Table 1.10: Bilateral FDI and Economic Growth: Annual, North-Emerging South-South, 2SLS IV, Short-run

Dependent variable: $\Delta y_{i,t}$	(1) North-North	(2) North-Emerging	(3) North-South	(4) Emerging-North	(5) Emerging-Emerging	(6) Emerging-South	(7) South-North	(8) South-Emerging	(9) South-South
$\Delta y_{i,t-1}$	0.475***	0.645***	0.025	0.411***	0.731***	0.590***	0.423***	0.684***	0.452***
	(0.028)	(0.087)	(0.063)	(0.036)	(0.031)	(0.026)	(0.039)	(0.020)	(0.031)
$fdi_{ij,t-1}$	0.004**	0.002	0.001	0.009	0.016**	0.010***	0.004	0.013*	0.033***
	(0.002)	(0.003)	(0.003)	(0.010)	(0.007)	(0.004)	(0.014)	(0.007)	(0.010)
$\Delta fdi_{ij,t-1}$	0.004*	0.008**	-0.000	-0.003	0.033**	0.017*	0.008	0.008	0.013
	(0.002)	(0.004)	(0.004)	(0.011)	(0.017)	(0.010)	(0.008)	(0.018)	(0.016)
Observations	5,531	7,431	9,318	5,482	5,283	5,563	10,706	9,042	2,058
KP test	0.000	0.000	0.000	0.093	0.000	0.000	0.000	0.000	0.000
SH test	0.328	0.129	0.139	0.293	0.181	0.739	0.310	0.170	0.289
Level Effect	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
Level p-value	0.012	0.425	0.620	0.371	0.035	0.006	0.763	0.070	0.001
Growth Effect	0.007	0.023	0.000	-0.005	0.124	0.042	0.014	0.024	0.023
Growth p-value	0.092	0.084	0.997	0.795	0.055	0.081	0.320	0.668	0.435

Notes: The sample observations observed annually over the period 1990-2012. The covariance matrix in each column allows for heteroscedasticity and the MA(1) errors. See the text for the instrument set. Robust standard errors are in parentheses whereas ***, **, and * represent marginal significance levels of 1%, 5%, and 10%, respectively. P-values are reported for the Kleibergen-Paap (KP) and Sargan-Hansen (SH) tests.

Table 1.11: Bilateral FDI and Economic Growth: Annual, North-Emerging South-South, 2SLS IV, Long-run

Dependent variable: $\Delta y_{i,t}$	(1) North-North	(2) North-Emerging	(3) North-South	(4) Emerging-North	(5) Emerging-Emerging	(6) Emerging-South	(7) South-North	(8) South-Emerging	(9) South-South
$\Delta y_{i,t-1}$	0.491***	0.831***	0.653***	0.378***	0.693***	0.588***	0.587***	0.399***	0.798***
	(0.031)	(0.041)	(0.024)	(0.060)	(0.032)	(0.031)	(0.034)	(0.049)	(0.063)
$fdi_{ij,t-1}$	0.008***	0.009*	0.013**	0.003	0.039*	0.010	0.017	0.033***	0.008
	(0.003)	(0.005)	(0.006)	(0.011)	(0.021)	(0.007)	(0.016)	(0.008)	(0.015)
$\Delta fdi_{ij,t}$	0.010*	0.028**	0.031**	0.037	0.083*	0.014	0.024	0.034*	0.011
	(0.006)	(0.011)	(0.015)	(0.037)	(0.044)	(0.017)	(0.015)	(0.020)	(0.035)
$\Delta fdi_{ij,t-1}$	0.012	0.039**	0.033	0.068	0.147	0.015	0.027	0.081***	-0.020
	(0.008)	(0.019)	(0.024)	(0.069)	(0.090)	(0.036)	(0.017)	(0.031)	(0.066)
$\Delta fdi_{ij,t-2}$	0.005	0.018	0.014	0.054	0.055	-0.000	0.011	0.037**	-0.029
	(0.005)	(0.011)	(0.012)	(0.050)	(0.043)	(0.017)	(0.012)	(0.015)	(0.029)
$\Delta fdi_{ij,t-3}$	0.002	0.010*	0.003	0.032	0.030	-0.001	0.005	0.012	-0.006
	(0.003)	(0.005)	(0.005)	(0.026)	(0.023)	(0.008)	(0.007)	(0.011)	(0.011)
Observations	4,964	6,537	7,411	4,085	4,571	4,423	8,913	7,818	1,507
KP test	0.000	0.000	0.000	0.088	0.000	0.000	0.000	0.000	0.000
SH test	0.256	0.167	0.230	0.968	0.905	0.953	0.717	0.815	0.528
Level Effect	0.016	0.055	0.036	0.005	0.128	0.024	0.041	0.056	0.037
Level p-value	0.010	0.072	0.041	0.799	0.048	0.131	0.292	0.000	0.587
Growth Effect	0.058	0.565	0.236	0.307	1.025	0.068	0.162	0.273	-0.216
Growth p-value	0.148	0.027	0.126	0.294	0.098	0.705	0.148	0.023	0.750

Notes: The sample observations observed annually over the period 1990-2012. The covariance matrix in each column allows for heteroscedasticity and the MA(1) errors. See the text for the instrument set. Robust standard errors are in parentheses whereas ***, **, and * represent marginal significance levels of 1%, 5%, and 10%, respectively. P-values are reported for the Kleibergen-Paap (KP) and Sargan-Hansen (SH) tests. The level effect is computed as $\beta/(1-\phi_1)$ and the growth effect as $(\theta_0+\theta_1+\theta_2+\theta_3)/(1-\phi_1)$. The p-values of the hypothesis tests for the long-run effects are reported, where the null hypothesis assumes no long-run relationships between economic growth and bilateral FDI flows.

Table 1.12: Bilateral FDI and Economic Growth: Annual, North-Emerging South-South, 2SLS IV, Long-run (without colonial ties)

Dependent variable: $\Delta y_{i,t}$	(1) North-North	(2) North-Emerging	(3) North-South	(4) Emerging-North	(5) Emerging-Emerging	(6) Emerging-South	(7) South-North	(8) South-Emerging	(9) South-South
$\Delta y_{i,t-1}$	0.491***	0.831***	0.653***	0.378***	0.693***	0.588***	0.588***	0.399***	0.798***
	(0.031)	(0.041)	(0.024)	(0.060)	(0.032)	(0.031)	(0.034)	(0.049)	(0.063)
$fdi_{ij,t-1}$	0.008***	0.009*	0.013**	0.003	0.039*	0.010	0.017	0.033***	0.008
	(0.003)	(0.005)	(0.006)	(0.011)	(0.021)	(0.007)	(0.016)	(0.008)	(0.015)
$\Delta fdi_{ij,t}$	0.010*	0.028**	0.031**	0.037	0.083*	0.014	0.024	0.034*	0.011
	(0.006)	(0.011)	(0.015)	(0.037)	(0.044)	(0.017)	(0.016)	(0.020)	(0.035)
$\Delta fdi_{ij,t-1}$	0.012	0.039**	0.033	0.068	0.147	0.016	0.027	0.081***	-0.020
	(0.008)	(0.019)	(0.024)	(0.069)	(0.090)	(0.035)	(0.017)	(0.031)	(0.066)
$\Delta fdi_{ij,t-2}$	0.005	0.018	0.014	0.054	0.055	0.000	0.011	0.037**	-0.029
	(0.005)	(0.011)	(0.012)	(0.050)	(0.043)	(0.017)	(0.012)	(0.015)	(0.029)
$\Delta fdi_{ij,t-3}$	0.002	0.010*	0.003	0.032	0.030	-0.001	0.005	0.012	-0.006
	(0.003)	(0.005)	(0.005)	(0.026)	(0.023)	(0.008)	(0.007)	(0.011)	(0.011)
Observations	4,964	6,537	7,411	4,085	4,571	4,423	8,913	7,818	1,507
KP test	0.000	0.000	0.000	0.088	0.000	0.000	0.000	0.000	0.000
SH test	0.256	0.167	0.230	0.968	0.905	0.944	0.548	0.815	0.528
Level Effect	0.016	0.055	0.036	0.005	0.128	0.025	0.041	0.056	0.037
Level p-value	0.010	0.072	0.041	0.799	0.048	0.123	0.291	0.000	0.587
Growth Effect	0.058	0.565	0.236	0.307	1.025	0.072	0.162	0.273	-0.216
Growth p-value	0.148	0.027	0.126	0.294	0.098	0.687	0.147	0.023	0.750

Notes: The sample observations observed annually over the period 1990-2012. The covariance matrix in each column allows for heteroscedasticity and the MA(1) errors. See the text for the instrument set. Robust standard errors are in parentheses whereas ***, **, and * represent marginal significance levels of 1%, 5%, and 10%, respectively. P-values are reported for the Kleibergen-Paap (KP) and Sargan-Hansen (SH) tests. The level effect is computed as $\beta/(1-\phi_1)$ and the growth effect as $(\theta_0+\theta_1+\theta_2+\theta_3)/(1-\phi_1)$. The p-values of the hypothesis tests for the long-run effects are reported, where the null hypothesis assumes no long-run relationships between economic growth and bilateral FDI flows.

Table 1.13: Bilateral FDI and Economic Growth: Annual, North-Emerging South-South, 2SLS IV, Long-run (bottom 5^{th} and top 95^{th}) removed

Dependent variable: $\Delta y_{i,t}$	(1) North-North	(2) North-Emerging	(3) North-South	(4) Emerging-North	(5) Emerging-Emerging	(6) Emerging-South	(7) South-North	(8) South-Emerging	(9) South-South
$\Delta y_{i,t-1}$	0.487***	0.885***	0.677***	0.391***	0.706***	0.612***	0.595***	0.374***	0.772***
	(0.036)	(0.046)	(0.029)	(0.061)	(0.031)	(0.030)	(0.035)	(0.053)	(0.067)
$fdi_{ij,t-1}$	0.019	0.088*	0.073	0.165**	0.095*	0.050	0.030	0.157***	0.065
	(0.012)	(0.045)	(0.050)	(0.070)	(0.056)	(0.062)	(0.038)	(0.051)	(0.073)
$\Delta fdi_{ij,t}$	0.021	0.115**	0.098	0.166**	0.102	0.067	0.052	0.175**	0.074
	(0.016)	(0.055)	(0.063)	(0.072)	(0.073)	(0.090)	(0.046)	(0.075)	(0.109)
$\Delta fdi_{ij,t-1}$	0.004	0.030*	0.020	0.076**	0.044	0.024	0.023	0.095***	-0.011
	(0.006)	(0.017)	(0.016)	(0.032)	(0.032)	(0.028)	(0.020)	(0.036)	(0.047)
$\Delta fdi_{ij,t-2}$	-0.002	0.010	0.006	0.073***	-0.009	0.003	0.005	0.063***	-0.028
	(0.004)	(0.010)	(0.010)	(0.021)	(0.021)	(0.017)	(0.016)	(0.022)	(0.028)
$\Delta fdi_{ij,t-3}$	0.000	-0.003	-0.005	0.037***	-0.002	0.009	0.008	0.022	-0.014
	(0.002)	(0.005)	(0.005)	(0.012)	(0.016)	(0.009)	(0.010)	(0.015)	(0.017)
Observations	3,557	5,085	5,771	3,857	4,272	3,964	8,618	7,555	1,314
KP test	0.000	0.000	0.000	0.013	0.000	0.000	0.000	0.000	0.000
SH test	0.653	0.192	0.334	0.552	0.929	0.884	0.657	0.441	0.532
Level Effect	0.037	0.769	0.226	0.270	0.323	0.128	0.075	0.251	0.285
Level p-value	0.103	0.059	0.129	0.025	0.086	0.420	0.423	0.001	0.354
Growth Effect	0.045	1.328	0.371	0.576	0.457	0.265	0.216	0.569	0.089
Growth p-value	0.372	0.064	0.171	0.010	0.300	0.442	0.290	0.009	0.914

Notes: The sample observations observed annually over the period 1990-2012. The covariance matrix in each column allows for heteroscedasticity and the MA(1) errors. See the text for the instrument set. Robust standard errors are in parentheses whereas ***, **, and * represent marginal significance levels of 1%, 5%, and 10%, respectively. P-values are reported for the Kleibergen-Paap (KP) and Sargan-Hansen (SH) tests. The level effect is computed as $\beta/(1-\phi_1)$ and the growth effect as $(\theta_0+\theta_1+\theta_2+\theta_3)/(1-\phi_1)$. The p-values of the hypothesis tests for the long-run effects are reported, where the null hypothesis assumes no long-run relationships between economic growth and bilateral FDI flows.

Table 1.14: Bilateral FDI and Economic Growth: Annual, North-Emerging South-South, GMM, Long-run

Dependent variable: $\Delta y_{i,t}$	(1) North-North	(2) North-Emerging	(3) North-South	(4) Emerging-North	(5) Emerging-Emerging	(6) Emerging-South	(7) South-North	(8) South-Emerging	(9) South-South
$\Delta y_{i,t-1}$	0.491***	0.832***	0.653***	0.378***	0.693***	0.588***	0.587***	0.399***	0.798***
	(0.029)	(0.030)	(0.022)	(0.046)	(0.032)	(0.028)	(0.034)	(0.049)	(0.063)
$fdi_{ij,t-1}$	0.008**	0.009	0.013***	0.003	0.039*	0.010*	0.017	0.033***	0.008
	(0.003)	(0.006)	(0.005)	(0.007)	(0.021)	(0.006)	(0.016)	(0.008)	(0.015)
$\Delta fdi_{ij,t}$	0.010*	0.028**	0.031***	0.037	0.083*	0.014	0.024	0.034*	0.011
	(0.006)	(0.012)	(0.011)	(0.023)	(0.044)	(0.013)	(0.015)	(0.020)	(0.035)
$\Delta fdi_{ij,t-1}$	0.012	0.039*	0.033*	0.068	0.147	0.015	0.027	0.081***	-0.020
	(0.008)	(0.021)	(0.019)	(0.045)	(0.090)	(0.028)	(0.017)	(0.031)	(0.066)
$\Delta fdi_{ij,t-2}$	0.005	0.018	0.014	0.054*	0.055	-0.000	0.011	0.037**	-0.029
	(0.005)	(0.012)	(0.010)	(0.032)	(0.043)	(0.014)	(0.012)	(0.015)	(0.029)
$\Delta fdi_{ij,t-3}$	0.002	0.010	0.003	0.032*	0.030	-0.001	0.005	0.012	-0.006
	(0.003)	(0.006)	(0.004)	(0.018)	(0.023)	(0.007)	(0.007)	(0.011)	(0.011)
Observations	4,964	6,537	7,411	4,085	4,571	4,423	8,913	7,818	1,507
KP test	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SH test	0.334	0.177	0.089	0.968	0.905	0.927	0.717	0.815	0.528
Level Effect	0.016	0.055	0.036	0.005	0.128	0.024	0.041	0.056	0.037
Level p-value	0.012	0.113	0.007	0.680	0.048	0.066	0.292	0.000	0.587
Growth Effect	0.058	0.559	0.236	0.307	1.025	0.068	0.162	0.273	-0.216
Growth p-value	0.144	0.051	0.051	0.102	0.098	0.628	0.148	0.023	0.750

Notes: The sample observations observed annually over the period 1990-2012. The covariance matrix in each column allows for heteroscedasticity and the MA(1) errors. See the text for the instrument set. Robust standard errors are in parentheses whereas ***, **, and * represent marginal significance levels of 1%, 5%, and 10%, respectively. P-values are reported for the Kleibergen-Paap (KP) and Sargan-Hansen (SH) tests. The level effect is computed as $\beta/(1-\phi_1)$ and the growth effect as $(\theta_0+\theta_1+\theta_2+\theta_3)/(1-\phi_1)$. The p-values of the hypothesis tests for the long-run effects are reported, where the null hypothesis assumes no long-run relationships between economic growth and bilateral FDI flows.

Table 1.15: Bilateral FDI and Economic Growth: Annual, Full sample, GMM

Dependent variable: $\Delta y_{i,t}$						
	Short-run		Long-run			
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta y_{i,t-1}$	0.202***	0.209***	0.120***	0.121***	0.092***	0.092***
	(0.018)	(0.017)	(0.021)	(0.021)	(0.023)	(0.023)
$fdi_{ij,t}$	0.008***		0.008***		0.015***	
	(0.003)		(0.003)		(0.003)	
$fdi_{ij,t-1}$		0.010***		0.009***		0.015***
	(0.003)		(0.003)		(0.003)	
$\Delta fdi_{ij,t}$	0.243***		0.067*	0.077*	0.104***	0.123***
	(0.086)		(0.036)	(0.040)	(0.029)	(0.032)
$\Delta fdi_{ij,t-1}$		0.016***	0.021**	0.021**	0.030***	0.030***
		(0.005)	(0.010)	(0.010)	(0.008)	(0.008)
$\Delta fdi_{ij,t-2}$			0.009*	0.009*	0.013***	0.013***
			(0.005)	(0.005)	(0.004)	(0.004)
$\Delta fdi_{ij,t-3}$			0.003	0.003	0.005**	0.005**
			(0.003)	(0.003)	(0.002)	(0.002)
Observations	67,350	65,933	48,277	48,277	48,277	48,277
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Host F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Home F.E.	Yes	Yes	No	No	Yes	Yes
KP test	.000	0.000	0.000	0.000	0.000	0.000
SH test	0.624	0.825	0.390	0.385	0.763	0.774
Level Effect	0.009	0.012	0.010	0.010	0.016	0.016
Level p-value	0.009	0.001	0.008	0.008	0.000	0.000
Growth Effect	0.305	0.020	0.114	0.126	0.169	0.189
Growth p-value	0.005	0.001	0.065	0.057	0.000	0.000

Notes: The sample observations observed annually over the period 1990-2012. The covariance matrix in each column allows for heteroscedasticity and the MA(1) errors. See the text for the instrument set. Robust standard errors are in parentheses whereas ***, **, and * represent marginal significance levels of 1%, 5%, and 10%, respectively. P-values are reported for the Kleibergen-Paap (KP) and Sargan-Hansen (SH) tests. The level effect is computed as $\beta/(1-\phi_1-\phi_2)$ and the growth effect as $(\theta_0+\theta_1+\theta_2+\theta_3)/(1-\phi_1-\phi_2)$. The p-values of the hypothesis tests for the long-run effects are reported, where the null hypothesis assumes no long-run relationships between economic growth and bilateral FDI flows.

Table 1.16: Bilateral FDI and Economic Growth: Annual, Full Sample, GMM, Robustness

Dependent variable: $\Delta y_{i,t}$						
	(1) Government Spending	(2) Trade Openness	(3) Inflation Rate	(4) Domestic Debt	(5) Human Capital	(6) Productivity (USA=1)
$\Delta y_{i,t-1}$	0.095***	0.133***	0.060**	0.096***	0.085***	0.272***
	(0.024)	(0.023)	(0.025)	(0.023)	(0.025)	(0.024)
$fdi_{ij,t-1}$	0.014***	0.014***	0.016***	0.012***	0.011***	0.011***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta fdi_{ij,t}$	0.121***	0.124***	0.132***	0.094***	0.090***	0.090***
	(0.032)	(0.032)	(0.033)	(0.031)	(0.031)	(0.033)
$Z_{i,t-1}$	0.000	0.024***	-0.001***	-0.023***	0.128***	0.001
	(0.002)	(0.001)	(0.000)	(0.001)	(0.007)	(0.001)
$\Delta Z_{i,t-1}$	-0.001	0.003*	0.001***	0.024***	0.018*	0.014***
	(0.002)	(0.002)	(0.000)	(0.001)	(0.011)	(0.003)
$\Delta fdi_{ij,t-1}1$	0.030***	0.031***	0.032***	0.023***	0.023***	0.024***
	(0.008)	(0.008)	(0.008)	(0.007)	(0.008)	(0.008)
$\Delta fdi_{ij,t-2}$	0.014***	0.014***	0.014***	0.011***	0.010**	0.010**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
$\Delta fdi_{ij,t-3}$	0.005**	0.005**	0.006**	0.004*	0.004	0.004*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Observations	47,412	47,604	44,016	42,413	40,878	35,024
KP test	0.000	0.000	0.000	0.000	0.000	0.000
SH test	0.666	0.748	0.083	0.460	0.899	0.497
Level Effect	0.016	0.017	0.017	0.014	0.012	0.014
Level p-value	0.000	0.000	0.000	0.000	0.000	0.001
Growth Effect	0.188	0.201	0.195	0.145	0.139	0.175
Growth p-value	0.000	0.000	0.000	0.003	0.005	0.007

Notes: The sample observations observed annually over the period 1990-2012. Year, host, and home fixed effects are included. The covariance matrix in each column allows for heteroscedasticity and the MA(1) errors. See the text for the instrument set. Robust standard errors are in parentheses whereas ***, **, and * represent marginal significance levels of 1%, 5%, and 10%, respectively. P-values are reported for the Kleibergen-Paap (KP) and Sargan-Hansen (SH) tests. The level effect is computed as $\beta/(1-\phi_1)$ and the growth effect as $(\theta_1+\theta_2)/(1-\phi_1)$. The p-values of the hypothesis tests for the long-run effects are reported, where the null hypothesis assumes no long-run relationships between economic growth and bilateral FDI flows.

Table 1.17: Bilateral FDI and Economic Growth: Annual, Full Sample, GMM, Robustness

Dependent variable: $\Delta y_{i,t}$	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$ln(\sum_{k=1}^{12} ICRG_{i,t}^k)$	Bureaucratic Quality	Corruption	External Conflicts	Government Stability	Internal Conflicts	Investment Profile	Military in Politics
$\Delta y_{i,t-1}$	0.105***	0.105***	0.092***	0.129***	0.046*	0.080***	0.069***	0.124***
	(0.025)	(0.023)	(0.023)	(0.023)	(0.025)	(0.024)	(0.024)	(0.023)
$fdi_{ij,t-1}$	0.018***	0.015***	0.015***	0.016***	0.016***	0.015***	0.017***	0.014***
	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
$\Delta fdi_{ij,t}$	0.169***	0.126***	0.122***	0.130***	0.133***	0.125***	0.143***	0.118***
	(0.044)	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)
$ICRG_{i,t}$	0.157***	0.008***	0.005***	0.003***	0.003***	0.003***	0.004***	0.003***
	(0.011)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\Delta fdi_{ij,t-1}$	0.046***	0.031***	0.030***	0.032***	0.033***	0.031***	0.035***	0.029***
	(0.011)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
$\Delta fdi_{ij,t-2}$	0.022***	0.013***	0.013***	0.014***	0.014***	0.013***	0.015***	0.012***
	(0.006)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
$\Delta fdi_{ij,t-3}$	0.010***	0.005**	0.005**	0.006**	0.005**	0.005**	0.006***	0.005**
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Observations	40,982	45,071	45,071	45,071	45,071	45,071	45,071	45,071
KP test	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SH test	0.608	0.941	0.846	0.995	0.930	0.861	0.535	0.947
Level Effect	0.020	0.017	0.016	0.018	0.017	0.016	0.018	0.017
Level p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Growth Effect	0.276	0.195	0.187	0.208	0.194	0.188	0.213	0.188
Growth p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: The sample observations observed annually over the period 1990-2012. Year, host, and home fixed effects are included. The covariance matrix in each column allows for heteroscedasticity and the MA(1) errors. See the text for the instrument set. Robust standard errors are in parentheses whereas ***, **, and * represent marginal significance levels of 1%, 5%, and 10%, respectively. P-values are reported for the Kleibergen-Paap (KP) and Sargan-Hansen (SH) tests. The level effect is computed as $\beta/(1-\phi_1)$ and the growth effect as $(\theta_1+\theta_2+\theta_3)/(1-\phi_1)$. The p-values of the hypothesis tests for the long-run effects are reported, where the null hypothesis assumes no long-run relationships between economic growth and bilateral FDI flows.

Table 1.18: Bilateral FDI and Economic Growth: Annual, North-Emerging South-South, GMM, Short-run

Dependent variable: $\Delta y_{i,t}$	(1) North-North	(2) North-Emerging	(3) North-South	(4) Emerging-North	(5) Emerging-Emerging	(6) Emerging-South	(7) South-North	(8) South-Emerging	(9) South-South
$\Delta y_{i,t-1}$	0.475***	0.645***	0.025	0.411***	0.731***	0.590***	0.423***	0.684***	0.452***
	(0.026)	(0.067)	(0.055)	(0.030)	(0.030)	(0.024)	(0.035)	(0.020)	(0.031)
$fdi_{ij,t-1}$	0.004**	0.002	0.001	0.009	0.016*	0.010***	0.004	0.013***	0.033***
	(0.002)	(0.003)	(0.002)	(0.009)	(0.008)	(0.004)	(0.014)	(0.005)	(0.010)
$\Delta fdi_{ij,t-1}$	0.004*	0.008*	-0.000	-0.003	0.033*	0.017*	0.008	0.008	0.013
	(0.002)	(0.005)	(0.004)	(0.010)	(0.018)	(0.010)	(0.006)	(0.016)	(0.016)
Observations	5,531	7,431	9,318	5,482	5,283	5,563	10,706	9,042	2,058
KP test	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SH test	0.350	0.219	0.126	0.193	0.236	0.638	0.356	0.168	0.289
Level Effect	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
Level p-value	0.021	0.502	0.608	0.325	0.053	0.008	0.750	0.005	0.001
Growth Effect	0.007	0.023	0.000	-0.005	0.124	0.042	0.014	0.024	0.023
Growth p-value	0.095	0.103	0.997	0.777	0.068	0.083	0.218	0.630	0.435

Notes: The sample observations observed annually over the period 1990-2012. The covariance matrix in each column allows for heteroscedasticity and the MA(1) errors. See the text for the instrument set. Robust standard errors are in parentheses whereas ***, **, and * represent marginal significance levels of 1%, 5%, and 10%, respectively. P-values are reported for the Kleibergen-Paap (KP) and Sargan-Hansen (SH) tests.

Table 1.19: Bilateral FDI and Income Convergence: Annual, Full Sample, GMM, Long-run

Dependent variable: $Convergence_{ij,t}$	(1)	(2)	(3)	(4)	(5)	(6)
$Convergence_{ij,t-1}$	0.303***	0.314***	0.269***	0.312***	0.347***	0.306***
	(0.030)	(0.038)	(0.042)	(0.027)	(0.032)	(0.033)
$ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-1}$	0.050***	0.038***	0.026***	0.041***	0.026***	0.019**
	(0.009)	(0.009)	(0.008)	(0.009)	(0.009)	(0.008)
$\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_t$	0.098***	0.085***	0.059**	0.067***	0.043**	0.025
	(0.021)	(0.023)	(0.025)	(0.018)	(0.020)	(0.021)
$\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-1}$	0.011**	0.019**	0.006	-0.001	0.003	-0.005
	(0.005)	(0.007)	(0.008)	(0.003)	(0.005)	(0.005)
$\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-2}$		0.013***	0.009		0.005	-0.002
		(0.005)	(0.007)		(0.004)	(0.006)
$\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-3}$			0.001			-0.005
			(0.004)			(0.004)
$\lvert Interest_{i,t-1} - Interest_{j,t-1}\rvert$	0.002***	0.002***	0.002***	0.001	0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
$\lvert GovExp_{i,t-1} - GovExp_{j,t-1}\rvert$	-0.002**	-0.005***	-0.004**			
	(0.001)	(0.001)	(0.002)			
$\lvert Inflation_{i,t-1} - Inflation_{j,t-1}\rvert$	-0.001***	-0.001*	-0.000			
	(0.000)	(0.000)	(0.000)			
$\lvert TFP_{i,t-1} - TFP_{j,t-1}\rvert$	-0.005***	-0.005**	-0.006***			
	(0.002)	(0.002)	(0.002)			
Observations	15,248	12,648	10,275	23,545	19,365	15,449
KP test	0.000	0.000	0.000	0.000	0.000	0.000
SH test	0.006	0.000	0.003	0.000	0.000	0.000
Level Effect	0.072	0.056	0.036	0.060	0.039	0.027
Level p-value	0.000	0.000	0.001	0.000	0.002	0.024
Growth Effect	0.157	0.171	0.103	0.096	0.077	0.019
Growth p-value	0.000	0.000	0.060	0.000	0.051	0.669

Notes: The sample observations observed annually over the period 1990-2012. The covariance matrix in each column allows for heteroscedasticity and the MA(1) errors. The endogenous variables are $Convergence_{ij,t-1}$, $ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-1}$, and $\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_t$. The instrument set is $ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-2}$, $ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-3}$, $(log(Export_{ij}+Export_{ji})/(Y_i+Y_j))_{t-2}$, $(log(Export_{ij}+Export_{ji})/(Y_i+Y_j))_{t-3}$, grbifidsh4, and IMR. Robust standard errors are in parentheses whereas ***, **, and * represent marginal significance levels of 1%, 5%, and 10%, respectively. P-values are reported for the Kleibergen-Paap (KP) and Sargan-Hansen (SH) tests. The level effect is computed as $\beta/(1-\phi_1)$ or $\beta/(1-\phi_1-\phi_2)$ and the growth effect as $(\theta_0+\theta_1+\cdots+\theta_q)/(1-\phi_1)$ or $(\theta_0+\theta_1+\cdots+\theta_q)/(1-\phi_1-\phi_2)$. The p-values of the hypothesis tests for the long-run effects are reported, where the null hypothesis assumes no long-run relationships between income convergence and bilateral FDI flows.

Table 1.20: Bilateral FDI and Income Convergence: Annual, North-Emerging South-South, GMM

Dependent variable: $Convergence_{ij,t}$	(1) North-North	(2) North-Emerging	(3) North-South	(4) Emerging-North	(5) Emerging-Emerging	(6) Emerging-South	(7) South-North	(8) South-Emerging	(9) South-South
$Convergence_{ij,t-1}$	-0.000	0.321**	0.769***	0.330***	0.509***	1.378	0.471***	0.515***	-0.033
	(0.087)	(0.146)	(0.103)	(0.123)	(0.086)	(2.033)	(0.039)	(0.152)	(0.146)
$ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-1}$	0.016***	0.197*	-0.041	0.066	0.001	0.575	-0.001	0.004	0.035
	(0.005)	(0.102)	(0.046)	(0.083)	(0.028)	(1.446)	(0.030)	(0.123)	(0.038)
$\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t}$	0.039***	0.645*	-0.156	0.093	0.109	-4.384	-0.135	-0.323	-0.004
	(0.013)	(0.347)	(0.119)	(0.098)	(0.304)	(12.807)	(0.086)	(0.553)	(0.042)
$\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-1}$	0.005	0.140	0.002	-0.002	0.050	-1.308	-0.084**	-0.207	-0.017
	(0.004)	(0.089)	(0.032)	(0.015)	(0.163)	(3.824)	(0.041)	(0.256)	(0.035)
$\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-2}$	0.007*	0.036	-0.023	0.001	0.045	-1.605	-0.039	-0.160	0.001
	(0.004)	(0.034)	(0.035)	(0.014)	(0.096)	(4.613)	(0.025)	(0.202)	(0.022)
$\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-3}$	0.005*	0.017	-0.043*	-0.022	0.019	-0.374	-0.043**	0.012	0.014
	(0.003)	(0.019)	(0.022)	(0.016)	(0.047)	(1.034)	(0.020)	(0.099)	(0.027)
$\lvert Interest_{i,t-1} - Interest_{j,t-1}\rvert$	0.000	-0.001	-0.000	-0.000	0.002	-0.004	0.002*	0.001	0.005**
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.019)	(0.001)	(0.003)	(0.002)
Observations	2,609	1,608	2,267	2,027	1,302	1,220	2,996	1,342	4,093
KP test	0.000	0.030	0.000	0.000	0.066	0.936	0.000	0.316	0.000
SH test	0.000	0.143	0.072	0.847	0.097	0.817	0.447	0.865	0.032
Level Effect	0.016	0.290	-0.176	0.099	0.003	-1.524	-0.003	0.008	0.034
Level p-value	0.001	0.112	0.413	0.453	0.964	0.758	0.962	0.973	0.336
Growth Effect	0.057	1.234	-0.953	0.104	0.455	20.316	-0.570	-1.400	-0.005
Growth p-value	0.013	0.148	0.310	0.463	0.706	0.726	0.053	0.514	0.927

Notes: The sample observations observed annually over the period 1990-2012. The covariance matrix in each column allows for heteroscedasticity and the MA(1) errors. The endogenous variables are $Convergence_{ij,t-1}$, $ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-1}$, and $\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_t$. The instrument set is $ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-2}$, $ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-3}$, $(log(Export_{ij}+Export_{ji})/(Y_i+Y_j))_{t-2}$, $(log(Export_{ij}+Export_{ji})/(Y_i+Y_j))_{t-3}$, grbifidsh4, and IMR. Robust standard errors are in parentheses whereas ***, **, and * represent marginal significance levels of 1%, 5%, and 10%, respectively. P-values are reported for the Kleibergen-Paap (KP) and Sargan-Hansen (SH) tests. The level effect is computed as $\beta/(1-\phi_1)$ or $\beta/(1-\phi_1-\phi_2)$ and the growth effect as $(\theta_0+\theta_1+\cdots+\theta_q)/(1-\phi_1)$ or $(\theta_0+\theta_1+\cdots+\theta_q)/(1-\phi_1-\phi_2)$. The p-values of the hypothesis tests for the long-run effects are reported, where the null hypothesis assumes no long-run relationships between income convergence and bilateral FDI flows.

Table 1.21: Bilateral FDI and Income Convergence: Annual, Full Sample, 2SLS IV, Long-run

Dependent variable: $Convergence_{ij,t}$	(1)	(2)	(3)	(4)	(5)	(6)
$Convergence_{ij,t-1}$	0.347***	0.369***	0.297***	0.308***	0.338***	0.295***
	(0.045)	(0.056)	(0.062)	(0.041)	(0.050)	(0.051)
$ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-1}$	0.186***	0.176***	0.153***	0.206***	0.195***	0.170***
	(0.041)	(0.041)	(0.040)	(0.038)	(0.042)	(0.040)
$\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t}$	0.463***	0.458***	0.435***	0.513***	0.512***	0.494***
	(0.109)	(0.115)	(0.124)	(0.102)	(0.117)	(0.126)
$\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-1}$	0.049***	0.069***	0.081***	0.050***	0.078***	0.096***
	(0.016)	(0.022)	(0.029)	(0.013)	(0.022)	(0.029)
$\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-2}$		0.027**	0.043**		0.037***	0.059***
		(0.012)	(0.018)		(0.014)	(0.021)
$\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-3}$			0.017			0.027**
			(0.012)			(0.014)
$\lvert Interest_{i,t-1}-Interest_{j,t-1}\rvert$	0.003***	0.003***	0.003***	0.001**	0.001*	0.001*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$\lvert GovExp_{i,t-1}-GovExp_{j,t-1}\rvert$	-0.000	-0.002	-0.001			
	(0.001)	(0.002)	(0.002)			
$\lvert Inflation_{i,t-1}-Inflation_{j,t-1}\rvert$	-0.001***	-0.000	-0.000			
	(0.000)	(0.000)	(0.000)			
$\lvert TFP_{i,t-1}-TFP_{j,t-1}\rvert$	-0.003	-0.002	-0.004			
	(0.002)	(0.003)	(0.003)			
Observations	13,956	11,479	9,259	21,513	17,576	13,948
KP test	0.000	0.000	0.000	0.000	0.000	0.000
SH test	0.895	0.587	0.817	0.695	0.371	0.488
Level Effect	0.284	0.278	0.218	0.298	0.295	0.241
Level p-value	0.000	0.000	0.000	0.000	0.000	0.000
Growth Effect	0.783	0.878	0.821	0.812	0.946	0.958
Growth p-value	0.000	0.000	0.000	0.000	0.000	0.000

Notes: The sample observations observed annually over the period 1990-2012. The covariance matrix in each column allows for heteroscedasticity and the MA(1) errors. The endogenous variables are $Convergence_{ij,t-1}$, $ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-1}$, and $\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_t$. The instrument set is $ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-2}$, $ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-3}$, $(log(Export_{ij}+Export_{ji})/(Y_i+Y_j))_{t-2}$, $(log(Export_{ij}+Export_{ji})/(Y_i+Y_j))_{t-3}$, grbifidsh4, and IMR. Robust standard errors are in parentheses whereas ***, **, and * represent marginal significance levels of 1%, 5%, and 10%, respectively. P-values are reported for the Kleibergen-Paap (KP) and Sargan-Hansen (SH) tests. The level effect is computed as $\beta/(1-\phi_1)$ or $\beta/(1-\phi_1-\phi_2)$ and the growth effect as $(\theta_0+\theta_1+\cdots+\theta_q)/(1-\phi_1)$ or $(\theta_0+\theta_1+\cdots+\theta_q)/(1-\phi_1-\phi_2)$. The p-values of the hypothesis tests for the long-run effects are reported, where the null hypothesis assumes no long-run relationships between income convergence and bilateral FDI flows.

Table 1.22: Bilateral FDI and Income Convergence: Annual, North-Emerging South-South, 2SLS IV

Dependent variable: $Convergence_{ij,t}$	(1) North-North	(2) North-Emerging	(3) North-South	(4) Emerging-North	(5) Emerging-Emerging	(6) Emerging-South	(7) South-North	(8) South-Emerging	(9) South-South
$Convergence_{ij,t-1}$	-0.144	0.209*	0.787***	0.305**	0.538***	0.783***	0.387***	0.480***	0.140
	(0.131)	(0.117)	(0.115)	(0.132)	(0.104)	(0.303)	(0.035)	(0.140)	(0.343)
$ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-1}$	0.116***	0.219*	0.075	0.106	0.041	-0.155	0.142	0.106	0.106
	(0.031)	(0.119)	(0.115)	(0.093)	(0.046)	(0.564)	(0.106)	(0.177)	(0.177)
$\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t}$	0.305***	0.857*	0.240	0.340	0.260	-0.753	0.412	0.061	0.187
	(0.082)	(0.476)	(0.341)	(0.226)	(0.498)	(1.348)	(0.337)	(0.647)	(0.889)
$\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-1}$	0.054***	0.155	0.015	0.099*	0.133	-0.269	0.061	-0.006	0.069
	(0.019)	(0.110)	(0.043)	(0.060)	(0.302)	(0.360)	(0.065)	(0.315)	(0.431)
$\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-2}$	0.040***	0.045	0.013	0.070	0.101	-0.152	0.014	-0.008	0.064
	(0.015)	(0.041)	(0.033)	(0.044)	(0.205)	(0.235)	(0.033)	(0.288)	(0.334)
$\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-3}$	0.021*	0.021	-0.009	0.003	0.051	0.090	0.020	0.007	0.057
	(0.012)	(0.023)	(0.035)	(0.023)	(0.098)	(0.352)	(0.030)	(0.170)	(0.150)
$\|Interest_{i,t-1} - Interest_{j,t-1}\|$	0.001	0.001	0.000	0.000	0.002	0.002	0.003***	0.004**	0.003
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.003)
Observations	2,139	1,539	2,150	1,879	1,182	1,138	2,729	1,171	3,651
KP test	0.000	0.032	0.000	0.003	0.029	0.054	0.000	0.001	0.587
SH test	0.606	0.830	0.380	0.583	0.897	0.269	0.001	0.797	0.423
Level Effect	0.101	0.277	0.353	0.152	0.088	-0.714	0.231	0.203	0.124
Level p-value	0.000	0.072	0.538	0.301	0.349	0.833	0.178	0.516	0.443
Growth Effect	0.367	1.362	1.210	0.735	1.182	-5.009	0.825	0.103	0.439
Growth p-value	0.001	0.092	0.553	0.177	0.595	0.690	0.251	0.969	0.820

Notes: The sample observations observed annually over the period 1990-2012. The covariance matrix in each column allows for heteroscedasticity and the MA(1) errors. The endogenous variables are $Convergence_{ij,t-1}$, $ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-1}$, and $\Delta ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_t$. The instrument set is $ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-2}$, $ln((FDI_{ij}+FDI_{ji})/(Y_i+Y_j))_{t-3}$, $(log(Export_{ij}+Export_{ji})/(Y_i+Y_j))_{t-2}$, $(log(Export_{ij}+Export_{ji})/(Y_i+Y_j))_{t-3}$, grbifidsh4, and IMR. Robust standard errors are in parentheses whereas ***, **, and * represent marginal significance levels of 1%, 5%, and 10%, respectively. P-values are reported for the Kleibergen-Paap (KP) and Sargan-Hansen (SH) tests. The level effect is computed as $\beta/(1-\phi_1)$ or $\beta/(1-\phi_1-\phi_2)$ and the growth effect as $(\theta_0+\theta_1+\cdots+\theta_q)/(1-\phi_1)$ or $(\theta_0+\theta_1+\cdots+\theta_q)/(1-\phi_1-\phi_2)$. The p-values of the hypothesis tests for the long-run effects are reported, where the null hypothesis assumes no long-run relationships between income convergence and bilateral FDI flows.

Chapter 2

Differential Effects of Fiscal Decentralization: Local Revenue Share vs. Local Fiscal Autonomy

The allocation of expenditure and revenue responsibilities between the central and sub-national governments is the fundamental concern of the fiscal decentralization research. Despite the popularity and significance of the topic, however, only recently has the literature noticed the fundamental distinction between taxes collected at the *federal* level versus taxes collected at the *sub-national* level.[1] Hatfield [2015], in particular, theoretically shows that fiscal decentralization is beneficial for growth only when revenues are generated at the sub-national level. Examining the differential effects of fiscal decentralization based on which level of government that taxes are collected requires an adequate measure of fiscal decentralization. Unfortunately, the existing measures of fiscal decentralization

[1] We use the terms local and sub-national governments interchangeably throughout the paper.

are insufficient for drawing such a comparison.

Local revenue share, which is a proxy for taxes collected at the central government level, is the most commonly used measure of fiscal decentralization. We contribute to the literature by proposing a new measure of fiscal decentralization, *local fiscal autonomy*, to serve as a proxy for taxes collected at the sub-national level. Theoretically, there is a distinction between local revenue share and local fiscal autonomy: an increase in local revenue share does not necessarily translate to a proportional increase in budgetary autonomy. Local governments commonly receive block grants with strings attached from the central government with little to no discretion over the federal funding. On the other hand, a rise in local fiscal autonomy implies that more local jurisdictions have the freedom to choose their preferred tax instruments. Each sub-national government adopts a tax policy that can accumulate more capital (i.e., lowering capital tax or providing investment incentives), which in turn maximizes regional growth.

Using a maximum panel of 121 countries over the period 1985-2012, we find that local fiscal autonomy has a positive, statistically, and quantifiable impact on economic growth, while local revenue share has only a marginally significant relationship . In addition to proposing a new measure of fiscal decentralization, our empirical analysis contributes to the literature by introducing a long-run analysis, incorporating heterogeneity in parameters, identifying different sources of growth-enhancing revenue channels, and considering nonlinearity. The long-run specification is crucial since the association between fiscal decentralization and economic growth is a gradual process; heterogeneity in parameters is inevitable considering different federalism status and income levels across our sample countries; determining the efficacy of each tax revenue source—property, income, or sales—is vital for policy implication; and recognizing the quadratic relationship is indispensable because neither complete centralization nor decentralization is optimal.

2.1 Related Literature

2.1.1 A Theoretical Relationship

Musgrave [1959] introduces the concept of fiscal federalism to explain the role of different tiers of government. Subsequent analyses by Oates [1972] and others [e.g., Berglas, 1976, Wooders, 1978, Berglas and Pines, 1981, Henderson, 1985, Hochman et al., 1995] examine the extent to which local governments are granted autonomy over tax revenues and expenditures. Laying out the foundation of the theory, Tiebout [1956] argues that people can "vote with their feet" and move to a desired jurisdiction based on their preference for public goods. The Tiebout-style literature explains the trend in fiscal decentralization and shows that a sub-national entity can allocate its expenditures better than the central government. In light of heterogeneity of resources and preferences for public goods, Oates [1993] argues that the ability of local governments to invest in projects based on the demands of local residents improves productivity and efficiency of the targeted policy. This suggests that fiscal decentralization could be associated with factors that affect growth outcomes.

An issue that is overlooked in the Tiebout-style literature is intergovernmental interactions that may create spillovers between different sub-national jurisdictions. Spillovers in intergovernmental interactions occur when local representatives learn from a neighboring jurisdiction's policy and make utility maximizing decisions regrading public goods accordingly. This process is possible only when the decision-making power is decentralized [e.g., Besley and Case, 1995]. Such learning could lead to a more efficient policy, resulting in a positive impact on economic growth. On the other hand, fierce intergovernmental competition could create countervailing forces, negating the effects of positive spillovers. For instance, a negative-sum game or a race to the bottom outcome could occur if local governments lower tax rates at the expense of public goods [e.g., Zodrow and Mieszkowski, 1986] or ignore environmental issues to lure investment from others [e.g., Oates and Schwab, 1988].[2] Thus, intensive intergovernmental competition could cause inefficient resource management and have an adverse impact on growth.

Exploring the effects of fiscal decentralization on economic growth directly, Brueckner [2004] argues that such effects depend on whether or not the growth benefits from Tiebout sorting dominate the costs from tax competition among sub-national entities. The costs of inter-jurisdictional tax competition increase when a distortionary capital tax subsidizes public goods. Concerns about capital flight could distort the decision-making process regarding public goods. A jurisdiction with more opportunistic behaviors for hosting foreign investments may have higher economic output, resulting in more dispersion across jurisdictions. Zodrow and Mieszkowski [1986], for instance, suggest that public goods are under-provided to local residents when welfare maximizing local governments engage in inter-jurisdiction tax competition. This in turn discourages economic growth. Similarly, Janeba and Wilson [2011] explore the optimal level of revenue allocation among different tiers of governments. A high level of regional autonomy is inefficient because each jurisdiction competes for capital by lowering

[2] Similar analyses include Mintz et al. [1986], Wildasin [1988], Bucovetsky [1991]. See Wilson [1999] for a more extensive review of the literature.

capital tax rates which consequently reduces the appropriate level of expenditures on public goods. A high level of centralization is also never optimal due to inefficient in legislative process. Therefore, the optimal level of revenue allocation should be derived from the trade-off between the two inefficiencies.

2.1.2 An Empirical Relationship

The empirical literature examines fiscal decentralization and economic growth using both single country and cross-country analysis. Whereas we contribute to the cross-country literature, conclusions from the single country studies are relevant. The single country literature finds an ambiguous relationship between fiscal decentralization and economic growth within and across countries. For instance, Zhang and Zou [1998]'s findings of negative and statistically insignificant impacts on economic development contrast those of Lin and Liu [2000] and Feltenstein and Iwata [2005] who find that China's regional autonomy enhances growth. Similarly, mixed results are found for the United States: Akai and Sakata [2002] find a positive and significant effect of fiscal decentralization on economic growth, whereas Xie et al. [1999] conclude that further decentralization may be harmful for growth since the existing level of regional fiscal autonomy has already reached the growth capacity. In other words, a further deepening of decentralization will not lead to positive economic growth.

Studies in the cross-country literature commonly measure fiscal decentralization with local revenue share or local expenditure share in total revenue with a typical study using an OLS or GLS regression with year and country fixed effects. A few studies go beyond the common approach: Iimi [2005], Vázquez and McNab [2006], and Gemmell et al. [2013] use an instrumental variables (IV) approach to address endogeneity between fiscal decentralization and economic growth. In particular, there is a positive association between fiscal decentralization and growth when using local revenue share, but a negative association when using local expenditure share. To address the concern that common measures of fiscal decentralization may overestimate the true level of fiscal autonomy of sub-national governments, Thornton [2007] utilizes the OECD tax autonomy dataset to measure fiscal decentralization. The association between economic growth and decentralization is inconclusive when the OECD tax autonomy data is used.

The ambiguity in the relationship is also pervasive in the cross-country literature. For instance, Davoodi and Zou [1998], Rodríguez-Pose and Krøijer [2009], Rodríguez-Pose and Ezcurra [2011], and Baskaran et al. [2014] find a negative association between fiscal decentralization and economic growth, whereas Yilmaz [1999], Thiessen [2003], and Iimi [2005] find a positive and significant association. The association may even be insignificant as shown in Woller and Phillips [1998]. Heterogeneity in parameters is also documented based on the federalism status, development level, and the use of government expenditure or revenue as the measure of fiscal decentralization. Yilmaz [1999], for example, finds that the positive effect is more growth enhancing for unitary states. Vázquez and McNab [2006] show that the impact of fiscal decentralization is positive for developing countries, whereas the effect is negative for industrialized countries. Gemmell et al. [2013] contend that the impact of fiscal decentralization on growth is negative when the share of government expenditure is used as a measure of fiscal autonomy of sub-national governments, whereas the impact is positive when the share of government revenue is used.

It is important to note that the application of fiscal decentralization is not limited to its impact on economic growth. Martinez-Vazquez et al. [2016] provide an excellent literature survey on the various outcome variables that are affected by the degree of fiscal autonomy in sub-national governments. Recent studies explore the effects of fiscal decentralization on education quality [e.g., Falch and Fischer, 2012], natural disasters [e.g., Escaleras and Register, 2012], citizens' trust in government institutions [e.g., Ligthart and van Oudheusden, 2015], government corruption [e.g., Dell'Anno and Teobaldelli, 2015], tax morale [e.g., Lago-Peñas and Lago-Peñas, 2010], and party systems [e.g., Harbers, 2010]. These studies indicate that fiscal decentralization has a considerable effect on numerous outcomes, and therefore has important public policy implications.

2.2 Measuring Fiscal Decentralization

The traditional measure of fiscal decentralization, local revenue share, is defined as the share of local government tax revenue in total central government tax revenue. By definition, local revenue share is a proxy of fiscal decentralization for taxes collected at the central government level. Equation (2.1) represents local revenue share, $Share_{i,t}$, for country i at year t as:

$$Share_{i,t} = \sum Revenue^{s}_{i,t} / \sum Revenue^{f}_{i,t} \tag{2.1}$$

, where s and f refer to sub-national (local) governments and the federal (central) government, respectively. Simply put, the sum of all local revenue over the sum of all central revenue is the traditional measure of fiscal decentralization. For the United States in 2011, for instance, total local government revenue was around US$2.515 trillion while the central government general revenue was US$4.5 trillion, resulting in a local revenue share of 55.73%.

Notably, a rise in local revenue share does not translate to a rise in fiscal autonomy. This measure overestimates the autonomy of local governments because local governments have the limited ability to set tax rates on their revenue sources in most countries. Nor do local governments have full autonomy over their expenditure because central governments give block grants which have strings attached. Consequently, this commonly used measure of fiscal decentralization can be problematic.

For this reason, Hatfield [2015] contends that local revenue share or taxes collected at the central government level is inadequate for capturing the true relationship between fiscal decentralization and economic growth. Instead, fiscal decentralization is beneficial for growth only when revenues are generated at the sub-national level. Why is this the case? Hatfield [2015] uses an endogenous growth model to show that local governments choose the capital tax rate that maximizes growth, where local districts compete for capital via various tax policies. Therefore, only when local governments have the ability to set tax rates do they choose the tax policy that maximizes growth. In the same way, Brueckner [2006] uses an endogenous growth model and over-lapping generation (OLG) approach to show that there is an extra incentive to save under federalism because local governments are able to make choices that better suit heterogeneous demands of the young and old. This incentive increases human capital investments which in turn enhances growth.

The hypothesis implies that tax rates have a significant impact on technological progress and long-term growth because tax competition under a fiscally decentralized government with free capital mobility could lead to higher economic growth. Local governments may be pressured to create a financially favorable environment for businesses by lowering tax rates, which may encourage investment activities and in turn promote economic growth. Particularly, fiscal decentralization increases economic growth in a model that includes provision of both productive public goods and efficient savings behavior. Benefits from Tiebout sorting are maximized when voters have heterogeneous preferences for public goods and head taxes are feasible.[3]

As shown in the theory, distinguishing between the level of government imposing taxes is important because a mere increase in sub-national governments revenue as a share of total government revenue is not directly linked to sub-national governments' discretion over their revenue stream. We empirically test the validity of the hypothesis. To our knowledge, we are first to take on such an endeavor. Comparing the effect of taxes collected at different levels of the government requires a new measure of fiscal decentralization. We borrow from Gadenne and Singhal [2014] who propose a measure called fiscal gap, which is the difference between total local government revenue and total local government tax revenue as a share of total local government revenue. Total local government general revenue includes intergovernmental and block grants, whereas the local tax revenue includes its own source revenues and fees such as the waste, utility, and water bills.

In the spirit of the construction of fiscal gap, we propose *local fiscal autonomy* as a measure of fiscal decentralization. Assuming sub-national governments have the ability to collect taxes, local fiscal autonomy can be measured as one minus the share of tax revenues in total sub-national government general revenue. Equation (2.2) represents local fiscal autonomy for country i at year t:

$$Autonomy_{i,t} = 1 - \left(\sum Revenue^{s}_{i,t} - \sum TaxRevenue^{s}_{i,t}\right) / \sum Revenue^{s}_{i,t} \quad (2.2)$$

[3]Head taxes refer to uniformly imposed taxes on each individual.

In other words, local fiscal autonomy is the local government's tax revenue autonomy. A smaller local fiscal autonomy value indicates less fiscal decentralization because grants from other governments reduce local fiscal autonomy. In an extreme case, where local governments receive 100% of their revenue from outside sources, the fiscal autonomy variable becomes 0. On the other hand, a larger local fiscal autonomy implies that more revenues are financed through locally imposed taxes. For instance, the total U.S. local government general revenue in 2011 was approximately US$2.515 trillion and tax revenue was US$1.371 trillion, resulting in local fiscal autonomy of 54.52%.

There are two important caveats to our proposed measure. First, we focus on the revenue share instead of the expenditure share because the revenue share is a more conservative measure of fiscal autonomy of sub-national governments. For instance, Gadenne and Singhal [2014] show that the local tax revenue systems (or lack thereof) drive fiscal decentralization differences in developing and developed countries. Developing countries are less fiscally decentralized than developed countries because local governments have limited taxing autonomy and depend heavily on centralized revenue sources. The ability to set tax rates and collect tax revenues is more difficult for sub-national governments in developing countries. Second, our measure is fundamentally disparate from any existing measures of fiscal decentralization. For instance, Thornton [2007] attempts to measure decentralization in a similar way, by using a discrete variable that is observed every five years for selective OECD nations only. Our measure, local fiscal autonomy, is observed annually for various OECD and non-OECD countries, which allows us to use a dynamic cross-country panel model and account for heterogeneity in parameters.

An important assumption in our measure of local fiscal autonomy is that sub-national governments have the ability to collect taxes. Local fiscal autonomy may overestimate the true extent of fiscal decentralization if sub-national governments do not have control over their tax revenues. Local governments, in fact, do not have complete fiscal autonomy over all of their tax revenue because sales and income taxes collected at the sub-national level are often levied by the central government. For instance, sub-national governments in China can collect taxes and make decisions on local expenditures at their discretion. However, the central government still determines the local tax rates. In such a case, the fiscal gap measure would overestimate fiscal autonomy of Chinese sub-national governments. For this reason, we consider sources of tax autonomy. Notably, property tax is an integral part of local governments revenue in many countries. Sub-national governments in the United States receive a substantial amount of revenue from levying property taxes, which varies by state. Property taxes are the major source of the revenue for local governments in Australia and Great Britain as well. Similar to equation (2.1), we define local revenue share from property tax revenue for country i at year t as:

$$Share_{i,t}^{Property} = PropertyTaxRevenue_{i,t}^{s} / \sum TaxRevenue_{i,t}^{s} \tag{2.3}$$

Recognizing that a single share variable may not be appropriate for capturing the true extent of fiscal decentralization, we use local fiscal autonomy from property tax revenue as an alternative measure when property taxes are the major source of local government revenue. Equation (2.4) represents local fiscal autonomy from property taxes for country i at year t:

$$Autonomy_{i,t}^{Property} = 1-(\sum Revenue_{i,t}^{s}-PropertyTaxRevenue_{i,t}^{s})/\sum Revenue_{i,t}^{s} \tag{2.4}$$

For the U.S., local property tax revenue was US$ 449.1 billion and total local tax revenue was US$ 1.371 trillion in 2011. Consequently, local revenue share from property taxes was 32.76%. With U.S. local government revenue of approximately US$ 2.515 trillion, local fiscal autonomy from property taxes was 17.86%.

Property taxes are often not an integral part of local government revenues for non-OECD countries. Property taxes in China, for instance, are essentially non-existent. Recently, some provinces in China have started to impose local property taxes, but their economic significance is marginal. Therefore, we repeat the same data generating process for revenues from the income tax and sales tax. Local revenue share from income taxes, $Share_{i,t}^{Income}$, equals $IncomeTaxRevenue_{i,t}^{s}/\sum TaxRevenue_{i,t}^{s}$, and local fiscal autonomy share from income taxes, $Autonomy_{i,t}^{Income}$, is calculated as $1-(\sum Revenue_{i,t}^{s} - IncomeTaxRevenue_{i,t}^{s})/\sum Revenue_{i,t}^{s}$. In the same way, local revenue share from sales taxes, $Share_{i,t}^{Sales}$, is calculated as $SalesTaxRevenue_{i,t}^{s}/\sum TaxRevenue_{i,t}^{s}$ and local fiscal autonomy from sales taxes, $Autonomy_{i,t}^{Sales}$, is calculated as $1-(\sum Revenue_{i,t}^{s} - SalesTaxRevenue_{i,t}^{s})/\sum Revenue_{i,t}^{s}$.

2.3 Empirical Specifications

2.3.1 Baseline Regression Model

Our sample consists of a maximum of 121 countries over the period of 1985-2012. To motivate the empirical study of the relationship between fiscal decentralization and economic growth, we adopt an endogenous growth model following Barro [1990] where government spending plays a vital role in determining the level of private investment through tax rates. Central governments use taxation as the main instrument for financing public goods, and the tax rates are affected by intergovernmental tax competition from fiscal decentralization. Private investment decisions by firms and savings behavior by consumers are sensitive to changes in tax rates. The starting point of our dynamic panel regression model with country fixed effects, α_i, and year fixed effects, α_t is:

$$\Delta lny_{i,t} = \alpha_i + \alpha_t + \phi_1 \Delta lny_{i,t-1} + \beta_1 Decentralization_{i,t-1} + X^{'}_{i,t-1}\Psi + \epsilon_{i,t} \quad (2.5)$$

, where $y_{i,t}$ is GDP per capita measured in constant-price international dollars of country i at year t, making $\Delta lny_{i,t}$ the per capita rate of economic growth. $Decentralization_{i,t-1}$ refers to the level of fiscal decentralization at year $t-1$. We measure fiscal decentralization with either local revenue share or local fiscal autonomy to compare the efficacy of fiscal decentralization in improving economic growth when revenues are collected at the central level versus the sub-national level. Vector $X_{i,t}$ is a set of control variables and $\epsilon_{i,t}$ is the error term. The control variables include consumer price inflation rate and openness to trade (measured as the sum of exports and real imports as a share of GDP).

In addition to the impact of *level* of fiscal decentralization, we are also interested in the current and lagged values of *growth* of fiscal decentralization. Using a distributed lag model as in Bond et al. [2010], we obtain our baseline regression model as

$$\Delta lny_{i,t} = \alpha_i + \alpha_t + \phi_1 \Delta lny_{i,t-1} + \beta_1 Decentralization_{i,t-1} + \theta_1 Decentr\hat{a}lization_{i,t} + \theta_2 Decentr\hat{a}lization_{i,t-1} + X'_{i,t-1}\Psi + \epsilon_{i,t} \quad (2.6)$$

, where $Decentr\hat{a}lization_{i,t}$ is the growth rate of fiscal decentralization calculated as $(Decentralization_{i,t} - Decentralization_{i,t-1})/Decentralization_{i,t-1}$. Equation (2.6) allows us to examine the cumulative impact of both the level and growth of fiscal decentralization as $l_{FD} = \beta_1/(1-\phi_1)$ and $g_{FD} = (\theta_1 + \theta_2)/(1-\phi)$, respectively. To statistically determine the long-run association between fiscal decentralization and economic growth, we report the p-value for a hypothesis test that has the null of no long-run relationships. Therefore, rejecting the null hypothesis indicates that the cumulative level and growth effects, l_{FD} and g_{FD}, are statistically significant.

2.3.2 Addressing Endogeneity: Two-step System GMM Approach

Reverse causality presents major empirical challenges for cross-country regressions. As Bardhan [2002] states, fiscal decentralization is not the only factor that affects growth: other political and economic variables, such as elections and business cycle fluctuations, have confounding impacts on the economy. Furthermore, countries with more stable political structures and advanced democratic systems are inclined to adopt policies that grant more fiscal autonomy to sub-national governments. Political stability and economic soundness correlate with the income levels, which in turn affect economic growth. Accordingly, it is unclear if fiscal decentralization encourages growth or if more wealthy countries have a decentralized government: a classic example of reverse causality. Furthermore, simultaneity bias could skew the estimation results when examining the effects of fiscal decentralization on economic growth. If fast economic growth causes the level of fiscal decentralization to behave differently, then it would be difficult to determine the direction of the impact. To address reverse causality and simultaneity bias, we use a two-step system of generalized method of moments (GMM) estimators for the dynamic panel regression model. The endogenous variables in equation (2.6) are $\Delta lny_{i,t-1}$, $Decentralization_{i,t-1}$, and $\Delta Decentralization_{i,t}$. The instrument set we use is $lny_{i,t-2}$, $Decentralization_{i,t-2}$.

The two-step system GMM estimator can reduce the potential biases and imprecision associated with an usual two-stage least squares difference estimator since there could be conceptual and statistical shortcomings with the difference estimator. Conceptually, we would like to study the cross-country relationship between fiscal decentralization and economic growth, which is eliminated in the difference estimator. Statistically, when the explanatory variables are persistent over time, the lagged levels of these variables are weak instruments for the regression equation in differences. Instrument weakness influences the asymptotic and small-sample performance of the difference estimator. Asymptotically, the variance of the coefficients rises. In small samples, the weak instrument influences can bias the coefficients. To mitigate the conceptual and statistical problems and to generate consistent and efficient parameter estimates, we use the moment conditions and use instruments lagged two periods (t-2) to employ a two-step system GMM procedure.

The validity of the instruments used in the two-step system GMM estimation depends on the relevancy and exogeneity conditions. The instrument set meets the relevancy condition since it consists of lagged values of the endogenous variables. For testing the exogeneity condition, we use the Sargan-Hansen test. The null hypothesis of Sargan-Hansen test is that the instrument set as a group is exogenous, where the orthogonality test checks whether the instrument set is correlated with the endogenous variable. Hence, an instrument set is said to be valid when we fail to reject the null.

2.3.3 Data and Trends

Data Source

Constructing local revenue share and local fiscal autonomy requires information on the aggregated government revenue and revenue sources by each tier of the government. IMF's Government Finance Statistics (IMF_{GFS}) provides the most comprehensive observations for each country: the dataset dissects the revenues into tax and non-tax, cash and non-cash, and their respective sources. In addition, we use OECD's Revenue Statistics ($OECD_{RS}$) data if there are missing observations. In instances where both IMF_{GFS} and $OECD_{RS}$ have missing observations, we use OECD's observations because their data often has longer periods and fewer missing values. Moreover, the RS dataset provides expansive observations for non-OECD members, such as Brazil. If non-OECD members have missing observations from IMF_{GFS} but non-missing values from $OECD_{RS}$, then we append the dataset using $OECD_{RS}$.

Our dependent variables are either the growth rate of real GDP per capita (i.e., economic growth) or the growth rate of real GDP per worker (i.e., labor productivity). Both variables are measured in constant-price international dollars and retrieved from Penn World Table 8.0. The main control variables, the inflation rate (measured as the log difference of consumer price index) is retrieved from Penn World Table 8.0 and (log) openness to trade (exports plus imports as a share of GDP) is obtained from the World Bank's World Development Indicators (WDI). Other explanatory variables, such as government expenditure as a share of GDP, (gross) fixed capital formation as a share of GDP, and (gross) domestic investment share of GDP (measured in constant-price international dollars) are also obtained from Penn World Table 8.0. Furthermore, we use political risk rating variables, including government stability and bureaucratic quality from the International Country Risk Guide (ICRG) database. To determine whether a country is federal or unitary, we refer to the CIA World Fact Book.

Summary Statistics

Table 2.1 presents the summary statistics for the full sample. Our main dependent variable, the growth rate of real GDP per capita, has a mean of 2% and the median of 2.3%. The other dependent variable, the average growth rate of real GDP per worker (i.e., labor productivity growth), has a mean of 1.5% with the median of 1.7%. Our main control variables, (log) inflation (i.e., $ln(Inflation)_{i,t-1}$) and (log) openness to trade (i.e., $ln(Openness)_{i,t-1}$) have relatively high standard deviations since some countries have experienced a hyperinflation during the sample period and some economies are heavily export-driven. Government expenditures (i.e., $GovExp_{i,t-1}$) account for 21.4% of the total economic size, on average, with the median value of 18.5%. Besides some outliers where almost all GDP is accounted by the government expenditure, a 20% of a typical country's GDP is consisted of government spending. Fixed capital formation refers to new additions of fixed assets (instead of being consumed) to the economy, whereas domestic investment refers to all additions of physical investment, including fixed and financial assets. Since domestic investment incorporates fixed capital formation, the average value of $Investment_{i,t-1}$ is higher than the mean of $FixedCapital_{i,t-1}$.

We also provide the summary statistics for each measure of fiscal decentralization in their levels and growth rates. Local revenue share, $Share_{i,t}$, has the mean of 33.9% with the median value of 27.6%, meaning that extreme values skew the distribution of local revenue share. On the other hand, local fiscal autonomy, $Autonomy_{i,t}$, has very similar mean and median values of 53.7% and 53.2%, respectively. The quartile values are vital when interpreting the effects of fiscal decentralization on the dependent variables. Each measure of fiscal decentralization has a range between 0 and 1, so it unclear what it means to have an "one unit" increase or decrease. Quantitatively, a movement from the first quartile (p25) to the median (p50) of the sample distribution is equivalent to the one unit increase. When we discuss the economic effect of one unit increase in $Share_{i,t}$, for instance, we refer to the increase from 13.4% to 27.6%. Similarly, the change from 34.3% to 53.2% in $Autonomy_{i,t}$ is considered when we interpret the quantitative effect of local fiscal autonomy.

Focusing on the source of tax revenues, an obvious trend is that local property tax revenue share, $Share_{i,t}^{Property}$, has a substantially higher mean value than that of local fiscal autonomy from property taxes, $Autonomy_{i,t}^{Property}$. The fact that the average values of the share variables are higher than the autonomy variables is consistently observed in our sample. This suggests that the share variables may overestimate the true extent of fiscal autonomy. The distribution of each share and autonomy variable is skewed to the right as the median values are always smaller than the mean values. The distribution has a right-skewness because most sample countries have a relatively lower share or autonomy value while the shape of the distribution is driven by the some of the high share, autonomy

Table 2.1: Summary Statistics (Full Sample)

	(1) Obs	(2) Mean	(3) S.D.	(4) Min	(5) Max	(6) p25	(7) p50	(8) p75
Real GDP per Capita Growth								
$\Delta lny_{i,t}$	4,279	.02	.044	-.198	.156	0	.023	.044
$\Delta lny_{i,t-1}$	4,257	.019	.056	-.699	.637	0	.023	.045
Real GDP per Worker Growth (Labor Productivity Growth)								
$\Delta ln\tilde{y}_{i,t}$	4,061	.015	.046	-.197	.174	-.006	.017	.04
$\Delta ln\tilde{y}_{i,t-1}$	3,898	.015	.058	-.697	.642	-.006	.017	.04
Control variables								
$ln(Inflation)_{i,t-1}$	4,685	1.914	1.419	-4.605	10.195	1.099	1.853	2.604
$ln(Openness)_{i,t-1}$	3,740	-.434	.751	-5.878	1.693	-.826	-.4	.038
$GovExp_{i,t-1}$	4,523	.214	.116	.021	.983	.138	.185	.256
$FixedCapital_{i,t-1}$	3,611	.218	.092	.003	.957	.172	.208	.249
$Investment_{i,t-1}$	2,232	.684	.242	.004	1	.533	.746	.876
$ln(\sum_{k=1}^{12} ICRG_{i,t-1}^{k})$	3,609	4.471	.295	2.597	4.941	4.326	4.51	4.682
Fiscal Decentralization (Level)								
$Share_{i,t}$	1,708	.339	.269	.001	1	.134	.276	.436
$Autonomy_{i,t}$	2,458	.537	.259	0	1	.343	.532	.752
$Share_{i,t}^{Property}$	1,600	.307	.299	0	1	.078	.181	.47
$Autonomy_{i,t}^{Property}$	1,542	.098	.099	0	.624	.035	.071	.125
$Share_{i,t}^{Income}$	1,959	.421	.284	0	1	.212	.362	.611
$Autonomy_{i,t}^{Income}$	1,906	.243	.168	0	.94	.127	.224	.343
$Share_{i,t}^{Sales}$	2,315	.328	.24	0	1	.114	.313	.483
$Autonomy_{i,t}^{Sales}$	2,256	.188	.167	0	.892	.044	.158	.285
Fiscal Decentralization (Growth)								
$\Delta Share_{i,t}$	1,568	.01	.115	-.408	.688	-.03	0	.035
$\Delta Autonomy_{i,t}$	2,230	.004	.116	-.472	.695	-.035	0	.035
$\Delta Share_{i,t}^{Property}$	1,438	.032	.295	-.766	3.151	-.052	0	.049
$\Delta Autonomy_{i,t}^{Property}$	1,378	.03	.291	-.819	2.746	-.063	-.003	.061
$\Delta Share_{i,t}^{Income}$	1,670	.005	.137	-.706	.655	-.04	.002	.052
$\Delta Autonomy_{i,t}^{Income}$	1,628	.007	.175	-.718	1.128	-.064	.002	.07
$\Delta Share_{i,t}^{Sales}$	2,086	.022	.208	-.674	1.379	-.05	0	.057
$\Delta Autonomy_{i,t}^{Sales}$	2,024	.023	.241	-.716	1.728	-.066	-.001	.071

Notes: Data ranges from 1985-2012 for a maximum of 121 countries. Median is equal to p50. Observations are retrieved from IMF's Government Finance Statistics, OECD's Revenue Statistics, Penn World Table 8.0, and World Bank's World Development Indicators. *Share* is equal to total local government revenue divided by total central government revenue. *Autonomy* is equal to one minus the difference between total local revenue and local tax revenue as a share of total local revenue. $\Delta Share$ and $\Delta Autonomy$ refer to the growth rates of *Share* and *Autonomy*, respectively.

sample countries.

Regarding the annual growth rate of fiscal decentralization, there is about 1% growth in $\Delta Share_{i,t}$ and 0.4% growth in $\Delta Autonomy_{i,t}$. The annual growth rate is marginal since the median value is zero. Considering the small yearly changes in the growth rate, it is reasonable to use a distributed lagged model where the estimates of the current and lagged of the growth rates are combined to examine the quantitative effect of growth in fiscal decentralization. On the other hand, the increase is substantially bigger for the growth in local property tax share, $\Delta Share_{i,t}^{Property}$, and local fiscal autonomy from property taxes, $Autonomy_{i,t}^{Property}$, with the average of 3%. Moreover, the growth rate from income and sales taxes are bigger for the autonomy variables, implying an increasing trend in fiscal autonomy from these revenue sources.

The full sample reveals heterogeneity in fiscal decentralization among different regimes. The specific regimes we focus on are the income groups and federation status. Income levels are bifurcated by the North and the South, where the North is defined as high-income OECD countries. The federation status is divided into federal versus unitary states according to the CIA World Fact Book. The intuition behind the sub-sample analysis is that there may be a strong correlation between economic development and fiscal decentralization. Treating the estimate of the North as the same for the South would be inadequate because their true parameter values are disparate. Furthermore, it is reasonable to suspect that countries that adopt a constitution of federalism are more likely to be fiscally decentralized than unitary states because a federal state allows divisions of power between the central and sub-national governments.[4] Table 2.2 lists the sample

[4]We acknowledge the limitation of our sub-sample analysis. The federalism categorization is rudimentary since the local government in India (a federal state) may have less fiscal autonomy than the local government in China (a unitary state). In other words, a federal state does

countries by income level and federation status. There are 7 countries which are in the North and federal, and the list suggests that they are all economically and politically developed countries, including the United States. On the other hand, a majority of our sample countries (88 out of 121) belongs to the South group and have a unitary *and* regime.

Table 2.3 presents the summary statistics of the measures of fiscal decentralization by income and federal states. Columns (1)-(4) report the values for the South and columns (5)-(8) report them for the North. The median value of $Share_{i,t}$ for the North (i.e., 29.1%) is higher than that of the South (i.e., 25.9%), suggesting that high-income OECD countries generally have a higher local revenue share. Moreover, the coefficient of variation (CV) of $Share_{i,t}$ for the North is 49.5% (i.e., 0.145/0.293), which is lower than the South's CV (0.314/0.364=86.3%). This implies that degree of variation of the North group is lower than the variation of the South group. All told, the North has a higher local revenue share and this trend is more consistently observed for the North than the South. Similarly, the breakdown of local fiscal autonomy for the South and the North also indicates that the North derives a higher fiscal autonomy from taxes on property and income: the mean and median values of $Autonomy_{i,t}^{Property}$ and $Autonomy_{i,t}^{Income}$ are higher for the North than the South. On the other hand, the mean and median values of $Autonomy_{i,t}$ and $Autonomy_{i,t}^{Sales}$ are higher for the South than the North. This implies that the high value of autonomy in the South originates from the fiscal autonomy in the sales tax or taxes other than property and income.

Columns (9)-(12) report the summary statistics of the measures of fiscal de-

not always maintain a high level of fiscal decentralization. Despite being a unitary state, for instance, China is often considered as a highly fiscally decentralized country since some Chinese provinces have the authority to set tax rates and levy taxes.

Table 2.2: List of Sample Countries

	Federal (N=17)
North (n=7)	Australia, Austria, Belgium, Canada, Germany, Switzerland, United States
South (n=10)	Argentina, Bosnia and Herzegovina, Brazil, India, Malaysia, Mexico, Nepal, Nigeria, Pakistan, Russia
	Unitary (N=104)
North (n=16)	Denmark, Finland, France, Greece, Iceland, Israel, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, United Kingdom
South (n=88)	Angola, Armenia, Republic of Azerbaijan, Bahamas, The Bahrain, Bangladesh, Belarus, Bhutan, Bolivia, Botswana, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Cape Verde, Central African Republic, Chile, China, Colombia, Republic of Congo, Costa Rica, Cote d'Ivoire, Croatia, Cyprus, Czech Republic, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Estonia, Fiji, The Gambia, Georgia, Ghana, Guatemala, Honduras, Hong Kong, Hungary, Indonesia, Iran, Ireland, Jordan, Kazakhstan, Kenya, Republic of Korea, Kyrgyz Republic, Latvia, Lesotho, Lithuania, Macao, Madagascar, Maldives, Mali, Mauritius, Moldova, Mongolia, Morocco, Namibia, Oman, Panama, Paraguay, Peru, Philippines, Poland, Romania, Rwanda, Senegal, Serbia, Sierra Leone, Singapore, Slovakia, Slovenia, South Africa, Sri Lanka, Syrian Arab Republic, Tajikistan, Tanzania, Thailand, Togo, Trinidad and Tobago, Turkey, Uganda, Ukraine, Venezuela, Zambia, Zimbabwe

Notes: A total of 121 countries exists in the full sample. Federal refers to countries that have a federalist system according to the CIA World Fact Book, whereas unitary refers to countries that do not have the federalist system. North refers to high-income OECD countries, whereas the South is the rest of the countries.

Table 2.3: Summary Statistics (Sub-sample)

	South				North				Unitary				Federal			
	(1) Obs	(2) Mean	(3) S.D.	(4) p50	(5) Obs	(6) Mean	(7) S.D.	(8) p50	(9) Obs	(10) Mean	(11) S.D.	(12) p50	(13) Obs	(14) Mean	(15) S.D.	(16) p50
$Share_{i,t}$	1,098	.364	.314	.259	610	.293	.145	.291	1,380	.311	.269	.248	328	.454	.237	.403
$Autonomy_{i,t}$	1,830	.575	.271	.592	628	.425	.181	.454	2,067	.532	.271	.523	391	.56	.186	.549
$Share_{i,t}^{Property}$	984	.282	.292	.154	616	.348	.306	.256	1,271	.335	.317	.2	329	.201	.179	.136
$Autonomy_{i,t}^{Property}$	942	.081	.076	.065	600	.125	.123	.088	1,226	.102	.107	.071	316	.082	.061	.07
$Share_{i,t}^{Income}$	1,438	.381	.255	.319	521	.53	.33	.493	1,623	.42	.29	.347	336	.425	.256	.401
$Autonomy_{i,t}^{Income}$	1,393	.237	.159	.22	513	.258	.188	.259	1,588	.244	.174	.223	318	.238	.13	.226
$Share_{i,t}^{Sales}$	1,729	.358	.246	.339	586	.239	.196	.216	1,909	.312	.232	.289	406	.401	.261	.385
$Autonomy_{i,t}^{Sales}$	1,686	.219	.175	.186	570	.099	.098	.056	1,863	.179	.166	.14	393	.233	.164	.226
$\Delta Share_{i,t}$	991	.011	.134	0	577	.007	.071	.001	1,263	.01	.117	0	305	.006	.103	.001
$\Delta Autonomy_{i,t}$	1,630	.005	.124	0	600	.003	.091	-.001	1,863	.004	.121	0	367	.006	.088	.003
$\Delta Share_{i,t}^{Property}$	862	.044	.353	0	576	.015	.174	0	1,130	.037	.32	0	308	.015	.173	.001
$\Delta Autonomy_{i,t}^{Property}$	819	.041	.357	-.009	559	.014	.148	.001	1,082	.036	.315	-.004	296	.011	.175	-.002
$\Delta Share_{i,t}^{Income}$	1,230	.008	.151	.006	440	-.002	.083	0	1,377	.005	.138	.001	293	.006	.128	.006
$\Delta Autonomy_{i,t}^{Income}$	1,195	.008	.191	.004	433	.004	.118	.001	1,339	.006	.173	0	289	.008	.181	.005
$\Delta Share_{i,t}^{Sales}$	1,524	.025	.213	.002	562	.013	.191	-.003	1,703	.022	.218	0	383	.019	.156	-.002
$\Delta Autonomy_{i,t}^{Sales}$	1,480	.025	.251	.002	544	.017	.209	-.004	1,654	.025	.256	-.001	370	.011	.157	0

Notes: Data ranges from 1985-2012 for a maximum of 121 countries. Median is equal to p50. *Share* is equal to total local government revenue divided by total central government revenue. *Autonomy* is equal to one minus the difference between total local revenue and local tax revenue as a share of total local revenue. $\Delta Share$ and $\Delta Autonomy$ refer to the growth rates of *Share* and *Autonomy*, respectively. North refers to high-income OECD countries, whereas the South is the rest of the countries. Federal refers to countries that have a federalist system according to the CIA World Fact Book, whereas unitary refers to countries that do not have the federalist system.

centralization for the unitary states and columns (13)-(16) report the values for the federal states. As expected, countries that constitutionally adopt federalism have a higher local revenue share than the unitary states. However, there is almost no discernible difference between the unitary and the federal states in the average local fiscal autonomy both are over 50%. The implication of these two findings is that while having a federalist system results in a higher local revenue share, there is no guarantee that this leads to higher local fiscal autonomy. Thus, local fiscal autonomy may not dependent on federalism. A similar conclusion can be drawn from the comparison between the unitary and federal states in terms of $Autonomy_{i,t}^{Property}$.

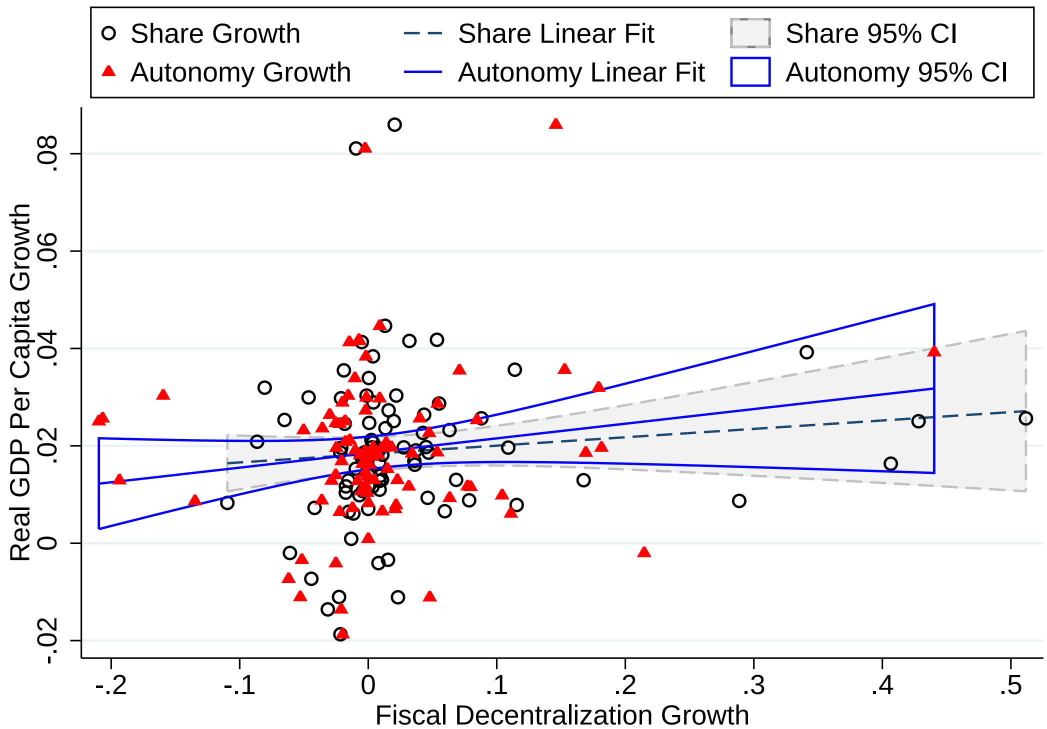
2.4 Results

2.4.1 Main results

To visualize the differential effects of taxes collected at the central level and the local level on economic growth, we plot the relationship between economic growth and the growth rate of fiscal decentralization based on different measures. The hollow circle depicts the distribution of local revenue share growth and economic growth whereas the triangle depicts the distribution of local fiscal autonomy. A majority of fiscal decentralization growth is concentrated between 0 and 0.1 with a few outliers ranging from -.2 to 0.5.[5] Drawing the fitted values for both local revenue share and local fiscal autonomy reveals the differential effects on economic growth. The dashed line is the fitted value for local revenue share and economic growth whereas the solid line is the fitted value for local fiscal autonomy

[5]The representation is similar even when removing more outliers.

Figure 2.1: Fiscal Decentralization and Economic Growth: Differential Effects of Local Revenue Share versus Local Fiscal Autonomy



Notes: The sample period ranges from 1985-2012 for a maximum of 121 countries.

and economic growth. The 95% confidence intervals are also presented. The slope of local fiscal autonomy trend is steeper than the slope of local revenue share, implying a stronger positive correlation between local fiscal autonomy and economic growth.

The differential effects are hypothesized in Hatfield [2015] but have never been empirically uncovered in the literature because an adequate measure for a comparison was non-existent. Our proposed measure of local fiscal autonomy enables us to compare its effect with that of local revenue share. The steeper slope of the fitted value for local fiscal autonomy indicates that the ability of local jurisdictions to set tax rates, lure outside investments, and increase saving has a potentially synergistic effect. This effect is much stronger than a mere revenue allocation between the federal and local governments. Given the clear motivation for analyzing the heterogeneous effects of local revenue share and local fiscal autonomy, we delve into a more precise examination of different magnitudes of impacts on our dependent variables.

Using a two-step system GMM approach, Table 2.4 reports the estimates from our baseline specification of dynamic panel in equation (2.6). Fiscal decentralization can be measured in two different ways: local revenue share and local fiscal autonomy. As discussed before, local revenue share is well used in the literature and mostly represents revenues collected at the central level. On the other hand, fiscal autonomy is our proposed measure of fiscal decentralization to represent revenues collected at the sub-national level. We compare the estimates of local revenue share and local fiscal autonomy to gauge the efficacy of fiscal decentralization on economic growth depending on the difference of revenue autonomy. Columns (1) and (3) show the estimates from local revenue share, whereas columns (2) and (4) are from local fiscal autonomy. The baseline results that we will use throughout the paper are from columns (3) and (4). The p-values for the Sargan-Hansen test indicate that the instrument set satisfies the exogeneity condition for each specification.

First two columns show the contemporaneous effects of level and growth of fiscal decentralization. The coefficients of $Decentralization_{i,t-1}$ indicate that maintaining a high local revenue share does not promote economic growth, whereas fiscal autonomy has a positive and statistically significant impact on economic growth. A similar finding can be shown with fiscal decentralization growth, where an increase in local revenue share has no effects, whereas an increase in fiscal autonomy has a positive and statistically significant impact on enhancing economic growth. One major concern with the specification in columns (1) and (2) is that the association between fiscal decentralization and economic growth is a long-run process, where the changes in fiscal decentralization do not have an immediate impact in the current growth rates. Also as shown in the summary statistics, the magnitude of the growth rate of fiscal decentralization is small for each year. Therefore, we use columns (3) and (4) as the baseline specification.

As shown in columns (3) and (4), the level of fiscal decentralization, whether measured by local revenue share or local fiscal autonomy, has a positive and statistically significant impact in economic growth. The discussion of the economic significance of these estimates is necessary since it is unclear what it means to have one unit increase in fiscal decentralization when each variable ranges between 0 and 1. Quantitatively, an increase from the first quartile of local revenue share (i.e., 13.4%) to the sample median (i.e., 27.6%) has a permanent increase in economic growth of 1.2 percentage point. The economic effect is even greater for local fiscal autonomy with an 1.8 percentage point increase. However, the growth rate of fiscal decentralization has a positive effect on economic growth only when measured with local fiscal autonomy. To further examine the cumulative effects of fiscal decentralization we turn our attention to the level and growth effects. The cumulative level effect is 2.3 % and 3.4% for local revenue share and local fiscal autonomy. However, there is no long-run relationship between local revenue share and economic growth. The p-value of 0.111 indicates that we fail to reject the null of no long-run associations. On the other hand, we reject the null of no long-run associations between local fiscal autonomy and economic growth. The same trend also holds for the cumulative growth effect where there is a long-run relationship between the growth rate of local fiscal autonomy and economic growth only and not between local revenue share and economic growth.

We test the robustness of our baseline specification (i.e., columns (3) and (4) of Table 2.4) by adding extra explanatory variables. Derived from equation (2.6), the following equation provides a basis for the robustness analysis:

$$\Delta lny_{i,t} = \alpha_i + \alpha_t + \phi_1 \Delta lny_{i,t-1} + \beta_1 Decentralization_{i,t-1} + \theta_1 Decentr\hat{a}lization_{i,t} + \theta_2 Decentr\hat{a}lization_{i,t-1} + \gamma_1 ln(Inflation)_{i,t-1} + \gamma_2 ln(Openness)_{i,t-1} + \gamma_3 Z_{t-1} + \epsilon_{i,t} \quad (2.7)$$

, where Z_{t-1} individually refers to government expenditure, fixed capital formation, and domestic investment all as a share of GDP, as well as $ln(\sum_{k=1}^{12} ICRG_{i,t}^{k})$. The last variable is the (log) weighted sum of each of the ICRG index. A total of 12 ICRG indexes are available, so we aggregate each index k for country i at time t. The score of an index ranges either from 0 to 12, 0 to 6, or 0 to 4. We multiply the second and third categories by 2 and 3, respectively to be compatible with the 0 to 12 category. The aggregated scores indicate the overall bureaucratic, political, and economic stability of each country, where the higher the index, the more stable the country is in terms of these indexes.

Table 2.5 reports the robust analysis results. Adding government expenditure as a share of GDP (i.e., columns (1) and (2)) does not change the main result: the level of fiscal decentralization has a positive and statistically significant effect (although the economic effect of local fiscal autonomy is much higher than the economic effect of local revenue share). Notably, the growth rate of fiscal decentralization enhances economic growth only when measured using the local fiscal autonomy measure. The statistically insignificant coefficients of government expenditure do not mean that spending from government has no effect in economic growth. Instead, when controlling for local revenue share and local fiscal autonomy, fiscal decentralization sufficiently captures the effects of govern-

Table 2.4: Fiscal Decentralization and Economic Growth: Baseline Specification: Annual, Two-step System GMM, Full sample

	(1) Share	(2) Autonomy	(3) Share	(4) Autonomy
$\Delta lny_{i,t-1}$	0.497***	0.480***	0.490***	0.481***
	(0.048)	(0.049)	(0.053)	(0.050)
$Decentralization_{i,t}$	0.010	0.019*		
	(0.008)	(0.010)		
$Decentralization_{i,t-1}$			0.012*	0.018*
			(0.007)	(0.009)
$\Delta Decentralization_{i,t}$	-0.001	0.006***	0.003	0.008***
	(0.005)	(0.002)	(0.002)	(0.003)
$\Delta Decentralization_{i,t-1}$			0.000	0.001
			(0.003)	(0.002)
$ln(Inflation)_{i,t-1}$	-0.017***	-0.025***	-0.019***	-0.024***
	(0.005)	(0.005)	(0.005)	(0.004)
$ln(Openness)_{i,t-1}$	-0.018***	-0.018***	-0.018***	-0.018***
	(0.006)	(0.007)	(0.007)	(0.007)
Level Effect	0.0202	0.0359	0.0230	0.0339
	[0.224]	[0.0611]	[0.111]	[0.0647]
Growth Effect	-0.00274	0.0112	0.00528	0.0173
	[0.765]	[0.00153]	[0.397]	[0.0610]
Year Fixed Effects	Yes	Yes	Yes	Yes
Host Fixed Effects	Yes	Yes	Yes	Yes
Observations	1,223	1,510	1,223	1,510
Number of Countries	88	121	88	121
Sargan-Hansen	0.926	0.244	0.905	0.228

Notes: The sample period ranges from 1985-2012. The covariance matrix in each column allows for heteroscedasticity and moving-average order of 1 or MA(1) errors. Robust standard errors are in parentheses whereas ***, **, and * represent respectively marginal significance levels of 1%, 5%, and 10%. Endogenous variables are $\Delta lny_{i,t-1}$, $Decentralization_{i,t}$ (or $Decentralization_{i,t-1}$), and $\Delta Decentralization_{i,t}$. The instrument set includes $\Delta lny_{i,t-2}$ and $Decentralization_{i,t-2}$. Level effect is calculated as $\beta_1/(1-\phi_1)$ and growth effect is calculated as $(\theta_1+\theta_2)/(1-\phi)$ from equation (2.6). The p-values of level and growth effects are reported in the brackets. The p-values are reported for the Sargan-Hansen test.

ment spending on economic growth. This is consistent with the theory which states that there is a growth-maximizing level of fiscal decentralization when public spending is carried out by different tiers of governments. The same trend can be observed when we add fixed capital (columns (3) and (4)) and domestic investment as a share of GDP (i.e., columns (5) and (6)) as extra explanatory variables.

When the aggregated ICRG index is included as an additional control variable (i.e., columns (7) and (8)), however, coefficients of both the level and growth rate of local revenue share and local fiscal autonomy become statistically significant. Accordingly, the cumulative level effect of 1.6% for local revenue share and of 4% for local fiscal autonomy are shown to have long-run impacts on economic growth. When we examine the cumulative growth effects, however, the p-value of 0.6 of local revenue share indicates that there is no long-run association between the growth rate of local revenue share and economic growth. On the contrary, the growth rate of local fiscal autonomy and economic growth has a long-run relationship with the magnitude of 1.89%. Focusing on local fiscal autonomy (i.e., column (8)), the aggregated ICRG has a positive and statistically significant impact on growth. The interpretation of this finding is that maintaining a stable political and economical environment leads to economic growth and has a substantial impact even when controlling for fiscal decentralization.

As another robustness test, we check the sensitivity of estimates to different instruments, particularly to different lags of fiscal decentralization measurements. Recall that the instrument set includes $\Delta lny_{i,t-2}$ and $Decentralization_{i,t-2}$. We introduce IVs of the third and fourth lags of *Decentralization* to see if a longer lag of the instrument set has any effects on the outcome of the main result. Columns (1) and (2) of Table 2.6 use the instruments $\Delta lny_{i,t-2}$ and $Decentralization_{i,t-3}$,

Table 2.5: Robust Analysis to Columns (3) and (4) in Table 2.4: Additional Explanatory Variables

	Government Expenditure as a share of GDP		Fixed Capital Formation as a share of GDP		Domestic Investment as a share of GDP		$ln(\sum_{k=1}^{12} ICRG_{i,t}^{k})$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Share	Autonomy	Share	Autonomy	Share	Autonomy	Share	Autonomy
$\Delta lny_{i,t-1}$	0.508***	0.518***	0.532***	0.522***	0.538***	0.528***	0.513***	0.509***
	(0.063)	(0.056)	(0.068)	(0.058)	(0.067)	(0.059)	(0.006)	(0.001)
$Decentralization_{i,t-1}$	0.014**	0.024**	0.015*	0.022**	0.011	0.022**	0.008***	0.020***
	(0.007)	(0.010)	(0.008)	(0.011)	(0.008)	(0.011)	(0.001)	(0.001)
$\Delta Decentralization_{i,t}$	0.003	0.009***	0.002	0.009***	0.003	0.009***	0.001***	0.009***
	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.000)	(0.000)
$\Delta Decentralization_{i,t-1}$	-0.002	0.000	-0.003	0.000	-0.001	0.000	-0.001***	0.000***
	(0.002)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.000)	(0.000)
$ln(Inflation)_{i,t-1}$	-0.015**	-0.025***	-0.014**	-0.025***	-0.013**	-0.024***	-0.023***	-0.026***
	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)	(0.005)	(0.001)	(0.000)
$ln(Openness)_{i,t-1}$	-0.009	-0.008	-0.005	-0.010	-0.013*	-0.008	-0.022***	-0.018***
	(0.007)	(0.007)	(0.008)	(0.009)	(0.007)	(0.006)	(0.001)	(0.001)
$Z_{i,t-1}$	-0.041	-0.011	-0.073	0.015	0.028	0.009	-0.064***	0.003**
	(0.084)	(0.073)	(0.083)	(0.084)	(0.030)	(0.024)	(0.004)	(0.001)
Level Effect	0.0294	0.0500	0.0324	0.0465	0.0241	0.0457	0.0160	0.0400
	[0.0379]	[0.0238]	[0.0664]	[0.0570]	[0.185]	[0.0566]	[0.000]	[0.000]
Growth Effect	0.00215	0.0190	-0.00135	0.0195	0.00431	0.0196	-0.000530	0.0189
	[0.765]	[0.0443]	[0.874]	[0.0611]	[0.610]	[0.0554]	[0.600]	[0.000]
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Host Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,057	1,303	1,038	1,274	1,057	1,303	1,165	1,404
Number of countries	82	111	81	109	82	111	81	104
Hansen	0.928	0.498	0.930	0.494	0.922	0.541	0.959	0.533

Notes: The sample period ranges from 1985-2012. The covariance matrix in each column allows for heteroscedasticity and moving-average order of 1 or MA(1) errors. Robust standard errors are in parentheses whereas ***, **, and * represent respectively marginal significance levels of 1%, 5%, and 10%. Endogenous variables are $\Delta lny_{i,t-1}$, $Decentralization_{i,t}$ (or $Decentralization_{i,t-1}$), and $\Delta Decentralization_{i,t}$. The instrument set includes $\Delta lny_{i,t-2}$ and $Decentralization_{i,t-2}$. Level effect is calculated as $\beta_1/(1-\phi_1)$ and growth effect is calculated as $(\theta_1+\theta_2)/(1-\phi)$ from equation (2.6). The p-values of level and growth effects are reported in the brackets. The p-values are reported for the Sargan-Hansen test.

and columns (3) and (4) use the set of $\Delta lny_{i,t-2}$ and $Decentralization_{i,t-4}$. The overall conclusion that local fiscal autonomy has positive and statistically significant effects on economic growth is robust to using different instrument sets.

Given the robustness of our baseline specification, we further examine whether the effects of local revenue share and local fiscal autonomy from property, income, and sales taxes have the same impact as the total government revenue. Columns (1) and (2) of Table 2.7 report our baseline specification estimation results (i.e., the same as columns (3) and (4) of Table 2.4) as a reference point. Recall that the main conlcusion from the baseline regression result is that only local fiscal autonomy has a positive, statistically and quantitatively significant impact on economic growth, whereas local revenue share has only a marginal impact. When we compare the effects of local revenue share of property taxes and local fiscal autonomy of property taxes, the level of fiscal decentralization does not have any discernible impacts on economic growth. The same trend is true of both the income and sales taxes. The results make sense considering a marginal degree of the fiscal decentralization level of these revenue sources.

On the contrary, the growth rate of local fiscal autonomy appears to have some measurable impacts on economic growth whereas the growth rate of local revenue share does not. The coefficients of the current and lag growth rates of local fiscal autonomy from property taxes in column (4) are positive and significant. The economic significance is small considering the corresponding cumulative growth effect of 0.6%. A similar trend is also observed for local fiscal autonomy from income and sales taxes (i.e., columns (6) and (8)) with the cumulative growth effects of 1.48% and 0.85%, respectively. Taken together, the findings suggest that local fiscal autonomy from property, income, and sales taxes has a positive effect on economic growth, but the magnitude of the impact may be negligible.

Table 2.6: Robust Analysis to Columns (3) and (4) in Table 2.4: Additional Instruments

	(1) Share	(2) Autonomy	(3) Share	(4) Autonomy
$\Delta lny_{i,t-1}$	0.511***	0.472***	0.511***	0.517***
	(0.056)	(0.052)	(0.058)	(0.056)
$Decentralization_{i,t-1}$	0.014	0.018**	0.014**	0.024**
	(0.009)	(0.009)	(0.007)	(0.010)
$\Delta Decentralization_{i,t}$	0.005***	0.007***	0.003	0.009***
	(0.002)	(0.002)	(0.002)	(0.003)
$\Delta Decentralization_{i,t-1}$	-0.000	-0.000	-0.002	0.000
	(0.003)	(0.002)	(0.002)	(0.002)
$ln(Inflation)_{i,t-1}$	-0.020***	-0.023***	-0.015***	-0.025***
	(0.006)	(0.004)	(0.006)	(0.005)
$ln(Openness)_{i,t-1}$	-0.015**	-0.012*	-0.010*	-0.008
	(0.007)	(0.007)	(0.006)	(0.007)
Level Effect	0.0283	0.0344	0.0282	0.0499
	[0.132]	[0.0453]	[0.0427]	[0.0218]
Growth Effect	0.0104	0.0138	0.00232	0.0200
	[0.233]	[0.0608]	[0.755]	[0.0503]
Year Fixed Effects	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes
Observations	1,134	1,400	1,057	1,303
Number of Countries	84	115	82	111
Sargan-Hansen	0.918	0.350	0.940	0.431

Notes: The sample period ranges from 1985-2012. The covariance matrix in each column allows for heteroscedasticity and moving-average order of 1 or MA(1) errors. Robust standard errors are in parentheses whereas ***, **, and * represent respectively marginal significance levels of 1%, 5%, and 10%. Endogenous variables are $\Delta lny_{i,t-1}$, $Decentralization_{i,t}$ (or $Decentralization_{i,t-1}$), and $\Delta Decentralization_{i,t}$. The instrument set includes $\Delta lny_{i,t-2}$ and $Decentralization_{i,t-3}$ (columns (1) and (2)) or $Decentralization_{i,t-4}$ (columns (3) and (4)). Level effect is calculated as $\beta_1/(1-\phi_1)$ and growth effect is calculated as $(\theta_1+\theta_2)/(1-\phi)$ from equation (2.6). The p-values of level and growth effects are reported in the brackets. The p-values are reported for the Sargan-Hansen test.

Table 2.7: Fiscal Decentralization and Economic Growth: Annual, Two-step System GMM, Full sample, Different Tax Revenue Sources

	Total Tax		Property Tax		Income Tax		Sales Tax	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Share	Autonomy	Share	Autonomy	Share	Autonomy	Share	Autonomy
$\Delta lny_{i,t-1}$	0.490***	0.481***	0.486***	0.457***	0.459***	0.439***	0.459***	0.474***
	(0.053)	(0.050)	(0.056)	(0.054)	(0.057)	(0.052)	(0.054)	(0.053)
$Decentralization_{i,t-1}$	0.012*	0.018*	-0.000	0.000	-0.000	-0.000	-0.000	0.000
	(0.007)	(0.009)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
$\Delta Decentralization_{i,t}$	0.003	0.008***	0.001	0.002*	0.002	0.003	0.001	0.003**
	(0.002)	(0.003)	(0.001)	(0.001)	(0.003)	(0.003)	(0.001)	(0.002)
$\Delta Decentralization_{i,t-1}$	0.000	0.001	0.001	0.001**	0.003	0.005*	0.000	0.001
	(0.003)	(0.002)	(0.001)	(0.001)	(0.002)	(0.003)	(0.001)	(0.001)
$ln(Inflation)_{i,t-1}$	-0.019***	-0.024***	-0.013**	-0.013**	-0.017***	-0.018***	-0.009	-0.019***
	(0.005)	(0.004)	(0.005)	(0.006)	(0.006)	(0.005)	(0.007)	(0.008)
$ln(Openness)_{i,t-1}$	-0.018***	-0.018***	-0.011	0.014	-0.010	-0.003	-0.014	-0.019*
	(0.007)	(0.007)	(0.008)	(0.013)	(0.009)	(0.009)	(0.011)	(0.011)
Level Effect	0.0230	0.0339	-0.000132	0.000749	-3.69e-05	-6.37e-06	-2.74e-05	0.000739
	[0.111]	[0.0647]	[0.469]	[0.136]	[0.469]	[0.968]	[0.905]	[0.592]
Growth Effect	0.00528	0.0173	0.00404	0.00624	0.00868	0.0148	0.00190	0.00847
	[0.397]	[0.0610]	[0.211]	[0.0410]	[0.229]	[0.0925]	[0.505]	[0.0696]
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,223	1,510	1,139	1,085	1,033	1,003	1,399	1,347
Number of Countries	88	121	79	79	90	90	114	114
Sargan-Hansen	0.905	0.228	0.973	0.593	0.794	0.879	0.325	0.354

Notes: The sample period ranges from 1985-2012. The covariance matrix in each column allows for heteroscedasticity and moving-average order of 1 or MA(1) errors. Robust standard errors are in parentheses whereas ***, **, and * represent respectively marginal significance levels of 1%, 5%, and 10%. Endogenous variables are $\Delta lny_{i,t-1}$, $Decentralization_{i,t}$ (or $Decentralization_{i,t-1}$), and $\Delta Decentralization_{i,t}$. The instrument set includes $\Delta lny_{i,t-2}$ and $Decentralization_{i,t-2}$. Level effect is calculated as $\beta_1/(1-\phi_1)$ and growth effect is calculated as $(\theta_1+\theta_2)/(1-\phi)$ from equation (2.6). The p-values of level and growth effects are reported in the brackets. The p-values are reported for the Sargan-Hansen test.

As discussed in Table 1.5, heterogeneity in parameters based on the federation status and the income level, meaning the findings from the full sample analysis. Using the baseline specification (i.e., columns (3) and (4) in Table 2.4) we divide our samples into federal, unitary, South, and North. Table 2.8 reports the sub-sample estimation results. Using local revenue share as a measure of fiscal decentralization, a higher local revenue share has a positive effect in growth only for the unitary states as shown in columns (1) and (2). The growth rate of local revenue share is also growth-enhancing for the unitary states: the coefficient of $\Delta Decentralization_{i,t}$ is significant only for the unitary states. However, the growth effect found in local revenue share does not have a long-run impact as the p-value for the cumulative growth is 0.553. On the other hand, local fiscal autonomy of a unitary state has a quantifiable impact on economic growth. Comparing the estimates between columns (3) and (4), only the unitary state's local fiscal autonomy has significant effects in both the level and growth rates. The p-values of the cumulative level and growth effects also indicate that the level effect of 4.5% and the growth effect of 1.9% have a permanent impact in economic growth.

Regarding heterogeneity in income levels, estimates from column (5) suggests that maintaining a high level of local revenue share can be detrimental for economic growth of the North as the coefficients are negative and statistically significant. For the South, the cumulative level and growth effects suggest that local revenue share and economic growth does not have any long-run association for the low-income countries either. When measured with local fiscal autonomy, the cumulative estimation results indicate that only in the South does local fiscal autonomy have a long-run association with economic growth.

To explain why fiscal decentralization creates positive impacts only for unitary

Table 2.8: Fiscal Decentralization and Economic Growth: Annual, Two-step System GMM, Sub-sample

	Federalism				Income Level			
	Share		Autonomy		Share		Autonomy	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Federal	Unitary	Federal	Unitary	North	South	North	South
$\Delta lny_{i,t-1}$	0.174	0.511***	0.314***	0.499***	0.321***	0.409***	0.440***	0.444***
	(0.192)	(0.056)	(0.109)	(0.054)	(0.077)	(0.015)	(0.032)	(0.000)
$Decentralization_{i,t-1}$	0.052	0.015*	0.015	0.023**	-0.034**	0.001	-0.008	0.002
	(0.057)	(0.008)	(0.088)	(0.011)	(0.016)	(0.001)	(0.007)	(0.001)
$\Delta Decentralization_{i,t}$	-0.130	0.004***	0.060	0.009***	-0.097*	0.001***	0.012	0.005***
	(0.108)	(0.001)	(0.077)	(0.003)	(0.058)	(0.000)	(0.022)	(0.000)
$\Delta Decentralization_{i,t-1}$	-0.042	-0.002	-0.062	0.001	-0.054	-0.001***	-0.009	-0.000***
	(0.061)	(0.003)	(0.129)	(0.003)	(0.043)	(0.000)	(0.016)	(0.000)
$ln(Inflation)_{i,t-1}$	-0.000	-0.020***	-0.002	-0.029***	-0.013***	-0.021***	-0.015***	-0.027***
	(0.010)	(0.006)	(0.009)	(0.005)	(0.003)	(0.001)	(0.002)	(0.000)
$ln(Openness)_{i,t-1}$	-0.012	-0.027***	-0.002	-0.028***	-0.028***	-0.030***	-0.026***	-0.037***
	(0.017)	(0.009)	(0.008)	(0.008)	(0.004)	(0.001)	(0.004)	(0.000)
Level Effect	0.0633	0.0297	0.0215	0.0452	-0.0496	0.00116	-0.0143	0.00393
	[0.364]	[0.0778]	[0.868]	[0.0526]	[0.0156]	[0.326]	[0.224]	[0.109]
Growth Effect	-0.209	0.00438	-0.00287	0.0188	-0.222	0.000418	0.00470	0.00878
	[0.165]	[0.553]	[0.980]	[0.0724]	[0.0681]	[0.489]	[0.940]	[0.000]
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	242	981	287	1,223	492	731	511	999
Number of Countries	14	74	17	104	23	65	23	98
Sargan-Hansen	0.999	0.993	0.999	0.502	0.999	0.999	0.999	0.653

Notes: The sample period ranges from 1985-2012. The covariance matrix in each column allows for heteroscedasticity and moving-average order of 1 or MA(1) errors. Robust standard errors are in parentheses whereas ***, **, and * represent respectively marginal significance levels of 1%, 5%, and 10%. Endogenous variables are $\Delta lny_{i,t-1}$, $Decentralization_{i,t}$ (or $Decentralization_{i,t-1}$), and $\Delta Decentralization_{i,t}$. The instrument set includes $\Delta lny_{i,t-2}$ and $Decentralization_{i,t-2}$. Level effect is calculated as $\beta_1/(1-\phi_1)$ and growth effect is calculated as $(\theta_1+\theta_2)/(1-\phi)$ from equation (2.6). The p-values of level and growth effects are reported in the brackets. The p-values are reported for the Sargan-Hansen test. Federal refers to countries that have a federalist system according to the CIA World Fact Book, whereas unitary refers to countries that do not have the federalist system. North refers to high-income OECD countries, whereas the South is the rest of the countries.

states, we examine whether the North and unitary (see Table 2.2) countries, such as Denmark and Finland are driving the results found in columns (2) and (4) of Table 2.8. However, we do not find any evidence that the high-income OECD countries with a unitary system alter the findings. This suggests that the South and unitary states (a total of 88 countries in the sample) may benefit the most from a high degree of local fiscal autonomy. Similarly, to identify the finding from the North-South framework is purely from the South and not from the federation status, we exclude the countries that are categorized as the South and federal. However, we do not find any evidence that the federalism alters the estimates in columns (6) and (8). The most reasonable explanation for such an insignificant result is due to the noise in the data. It is possible that a few outliers may be driving the result.

The findings from the sub-sample analysis indicate that the revenue-sharing structure of a country has significant implications for its development, especially for low-income countries. Fiscal decentralization may reduce the likelihood of planning errors by the central government, resulting in more efficient public expenditures. Chaudhury et al. [2006], for instance, show that the management of social programs by sub-national governments is essential for schooling and health improvements in developing countries because centralization of education and health services is likely to increase the absence rate of teachers and doctors. At the same time, we do not claim that this positive effect always holds because unsupervised fiscal decentralization can be detrimental to growth. For example, if sub-national governments mismanage their revenues and expenditures, this misallocation of resources can cause a significant underdevelopment.

If fiscal decentralization leads to more efficient public expenditures on schooling and health improvements, then we may see a positive impact on labor productivity. Denoted by $\Delta ln\tilde{y}_{i,t-1}$, the growth rate of GDP *per worker* measures the growth rate of labor productivity. Using the same framework as equation (2.6) except changing the dependent variable from economic growth to labor productivity, we can examine the long-run relationship between fiscal decentralization and labor productivity. Columns (3) and (4) of Table 2.9 report the estimation results.

The results suggest that when measured with local revenue share, the level of fiscal decentralization does not have a significant impact on labor productivity growth. The coefficient of $Decentralization_{i,t-1}$ for local revenue share is statistically insignificant. On the other hand, a high level of local fiscal autonomy has a positive and significant impact on labor productivity growth. Quantitatively, an increase from the first quartile of local revenue share (i.e., 34.3%) to the sample median (i.e., 53.2%) has a permanent increase in labor productivity growth by 2.2 percentage point. The growth rates of local revenue share and local fiscal autonomy have positive effects in the short-run. The magnitude of the impact is more than two times bigger for local fiscal autonomy. When examining a longer run framework, the p-values of the cumulative effects indicate that only local fiscal autonomy has a permanent relationship with labor productivity growth.

Based on the baseline regression model of labor productivity growth, we determine how each of the revenue sources have different effects on the growth path. Table 2.10 reports the estimates using different revenue sources. Columns (1) and (2) are identical from the main result in Table 2.9 and repeatedly shown here as a point of reference. As shown in column (3), neither the level nor the growth rate of local revenue share has a significant impact on enhancing labor productivity growth. On the other hand, the coefficients of local fiscal autonomy have both positive and statistically significant effects on labor productivity

Table 2.9: Fiscal Decentralization and Labor Productivity: Annual, Two-step System GMM, Full sample

	(1) Share	(2) Autonomy	(3) Share	(4) Autonomy
$\Delta ln\tilde{y}_{i,t-1}$	0.432***	0.415***	0.427***	0.417***
	(0.046)	(0.048)	(0.045)	(0.047)
$Decentralization_{i,t}$	0.011	0.020**		
	(0.008)	(0.010)		
$Decentralization_{i,t-1}$			0.011	0.022**
			(0.007)	(0.010)
$\Delta Decentralization_{i,t}$	0.001	0.006***	0.004***	0.009***
	(0.003)	(0.002)	(0.001)	(0.003)
$\Delta Decentralization_{i,t-1}$			-0.000	0.000
			(0.004)	(0.002)
$ln(Inflation)_{i,t-1}$	-0.015***	-0.024***	-0.016***	-0.024***
	(0.005)	(0.005)	(0.004)	(0.004)
$ln(Openness)_{i,t-1}$	-0.015**	-0.016**	-0.014***	-0.016***
	(0.006)	(0.006)	(0.006)	(0.006)
Level Effect	0.0188	0.0343	0.0193	0.0371
	[0.172]	[0.0448]	[0.143]	[0.0313]
Growth Effect	0.000929	0.0104	0.00663	0.0159
	[0.870]	[0.00202]	[0.293]	[0.0177]
Year Fixed Effects	Yes	Yes	Yes	Yes
Host Fixed Effects	Yes	Yes	Yes	Yes
Observations	1,195	1,482	1,195	1,482
Number of countries	88	121	88	121
Hansen	0.854	0.346	0.810	0.330

Notes: The sample period ranges from 1985-2012. The covariance matrix in each column allows for heteroscedasticity and moving-average order of 1 or MA(1) errors. Robust standard errors are in parentheses whereas ***, **, and * represent respectively marginal significance levels of 1%, 5%, and 10%. Endogenous variables are $\Delta lny_{i,t-1}$, $Decentralization_{i,t}$ (or $Decentralization_{i,t-1}$), and $\Delta Decentralization_{i,t}$. The instrument set includes $\Delta lny_{i,t-2}$ and $Decentralization_{i,t-2}$. Level effect is calculated as $\beta_1/(1-\phi_1)$ and growth effect is calculated as $(\theta_1+\theta_2)/(1-\phi)$ from equation (2.6). The p-values of level and growth effects are reported in the brackets. The p-values are reported for the Sargan-Hansen test.

growth. The cumulative level and growth effects also concur with this finding. For income and sales taxes, the effects are almost negligible for either measure of fiscal decentralization.

So far we have shown that local fiscal autonomy has a positive and substantial impact on economic growth and labor productivity growth. This means that fiscal decentralization is growth enhancing only when taxes are collected at the sub-national levels. As theory suggests, we empirically show that the local government's decision-making regarding savings and investment becomes more aggressive when it has the ability to levy taxes and set the tax rates. This movement affects positive savings and investment behavior, which in turn impacts growth. A natural question follows as to what should be the policy implication considering the positive and permanent association between local fiscal autonomy and economic growth and labor productivity growth. That is, how much autonomy should be relegated to sub-national government?

To answer this crucial question, we introduce nonlinearity to the baseline regression estimation and refrain from the linearity assumption. Thiessen [2003] and Thornton [2007], for instance, find a nonlinear relationship between fiscal decentralization and economic growth. Failing to consider the nonlinearity may result in insignificant estimates. Furthermore, Faguet and Pöschl [2015] suggest that although sub-national governments are better at fulfilling local demands and preferences, central governments still play an integral part in redistributing wealth and implementing broader-based tax programs. This implies a limited role for local governments in affecting economic growth: an extremely high level of local revenue share may not be ideal beyond a certain threshold. Another implication is that, perhaps, the government budgets affecting the entire nation, such as the military spending and social welfare, should be not determined at the

Table 2.10: Fiscal Decentralization and Labor Productivity: Annual, Two-step System GMM, Full sample, Different Tax Revenue Sources

	Total Tax		Property Tax		Income Tax		Sales Tax	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Share	Autonomy	Share	Autonomy	Share	Autonomy	Share	Autonomy
$\Delta ln\tilde{y}_{i,t-1}$	0.427***	0.417***	0.386***	0.383***	0.402***	0.403***	0.348***	0.383***
	(0.045)	(0.047)	(0.062)	(0.066)	(0.056)	(0.049)	(0.048)	(0.047)
$Decentralization_{i,t-1}$	0.011	0.022**	-0.000	0.001***	-0.000	-0.000	0.000*	0.001
	(0.007)	(0.010)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
$\Delta Decentralization_{i,t}$	0.004***	0.009***	0.001	0.003*	0.002	0.004	0.001	0.004***
	(0.001)	(0.003)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
$\Delta Decentralization_{i,t-1}$	-0.000	0.000	-0.000	0.001	0.004**	0.006***	0.002	0.003
	(0.004)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
$ln(Inflation)_{i,t-1}$	-0.016***	-0.024***	-0.007*	-0.014**	-0.015***	-0.017***	-0.007	-0.016**
	(0.004)	(0.004)	(0.004)	(0.007)	(0.006)	(0.005)	(0.005)	(0.006)
$ln(Openness)_{i,t-1}$	-0.014***	-0.016***	-0.007	0.033**	-0.007	-0.003	0.000	-0.012
	(0.006)	(0.006)	(0.006)	(0.013)	(0.008)	(0.009)	(0.008)	(0.009)
Level Effect	0.0193	0.0371	-7.00e-05	0.00126	-3.24e-05	-3.56e-05	0.000233	0.000909
	[0.143]	[0.0313]	[0.554]	[0.00183]	[0.433]	[0.789]	[0.0477]	[0.396]
Growth Effect	0.00663	0.0159	0.00120	0.00567	0.00854	0.0162	0.00364	0.0102
	[0.293]	[0.0177]	[0.551]	[0.0619]	[0.113]	[0.0135]	[0.314]	[0.0309]
Observations	1,195	1,482	1,117	1,065	1,021	993	1,375	1,326
Number of Countries	88	121	79	79	90	90	114	114
Sargan-Hansen	0.810	0.330	0.966	0.438	0.876	0.863	0.246	0.349

Notes: The sample period ranges from 1985-2012. The covariance matrix in each column allows for heteroscedasticity and moving-average order of 1 or MA(1) errors. Robust standard errors are in parentheses whereas ***, **, and * represent respectively marginal significance levels of 1%, 5%, and 10%. Endogenous variables are $\Delta lny_{i,t-1}$, $Decentralization_{i,t}$ (or $Decentralization_{i,t-1}$), and $\Delta Decentralization_{i,t}$. The instrument set includes $\Delta lny_{i,t-2}$ and $Decentralization_{i,t-2}$. Level effect is calculated as $\beta_1/(1-\phi_1)$ and growth effect is calculated as $(\theta_1+\theta_2)/(1-\phi)$ from equation (2.6). The p-values of level and growth effects are reported in the brackets. The p-values are reported for the Sargan-Hansen test.

local level.

Building on equation (2.6), the following equation accounts for the nonlinear relationship between fiscal decentralization and economic growth or labor productivity growth.

$$\Delta lny_{i,t} = \alpha_i + \alpha_t + \phi_1 \Delta lny_{i,t-1} + \beta_1 Decentralization_{i,t-1} + \beta_2 Decentralization^2_{i,t-1} + \theta_1 Decentr\hat{a}lization_{i,t} + \theta_2 Decentr\hat{a}lization_{i,t-1} + X'_{i,t-1}\Psi + \epsilon_{i,t}. \tag{2.8}$$

Equation (2.8) implies that nonlinearity is introduced in the level of fiscal decentralization only because an extremely high value of fiscal decentralization (e.g., local revenue share or local fiscal autonomy close to 1) can be inefficient as shown in Janeba and Wilson [2011]. Consequently, the calculation for the cumulative level effect can be modified to $l_{FD} = (\beta_1 + \beta_2)/(1 - \phi_1)$.

Table 2.11 reports the estimation results from the nonlinear specification. The dependent variable of the first two columns is economic growth. As expected, local revenue share does not have any quantifiable effects on economic growth. On the other hand, the coefficient of the level of local fiscal autonomy has a positive sign, while its squared-term has a negative sign. This is a classic example of nonlinearity, where too much local fiscal autonomy can be harmful for growth. Using the cumulative level effect, the marginal effect of local fiscal autonomy is 3.45%. This magnitude is almost identical to the linear specification as the cumulative level effect of local fiscal autonomy is 3.39% (i.e., column (4) of Table 2.4). A similar finding can be shown with the association between fiscal decentralization and labor productivity growth. The estimates from columns (3) and (4) also suggest that only local fiscal autonomy has a measurable effect on the dependent variable. The nonlinear specification has the cumulative level effect of 2.67%, which is slightly lower than the cumulative level effect of 3.71% from the linear specification (i.e., column (4) of Table 2.9).

Focusing on the findings from local fiscal autonomy, we are interested in the net marginal effects of fiscal decentralization when the quadratic term is included in the regression analysis. To highlight our finding, we plot the net marginal effect of local fiscal autonomy on economic growth in Figure 2.2a and on labor productivity in Figure 2.2b. In both graphs, local fiscal autonomy is centered at the mean since a graph without centering will imply that the predicted economic growth rate is zero when the level of fiscal decentralization is zero. Therefore, local fiscal autonomy is centered at the mean such that zero on the x-axis corresponds to the average. That is, a value of 0 in the x-axis is equal to the mean of local fiscal autonomy, which is 0.537. Considering the minimum and maximum values of local fiscal autonomy, the values of -.5 and .5 on the x-axis correspond to 0 and 1 of local fiscal autonomy. The x-axis is in an increment of one standard deviation of the distribution, where -.1 and .1 refer to the one standard deviation from the mean.

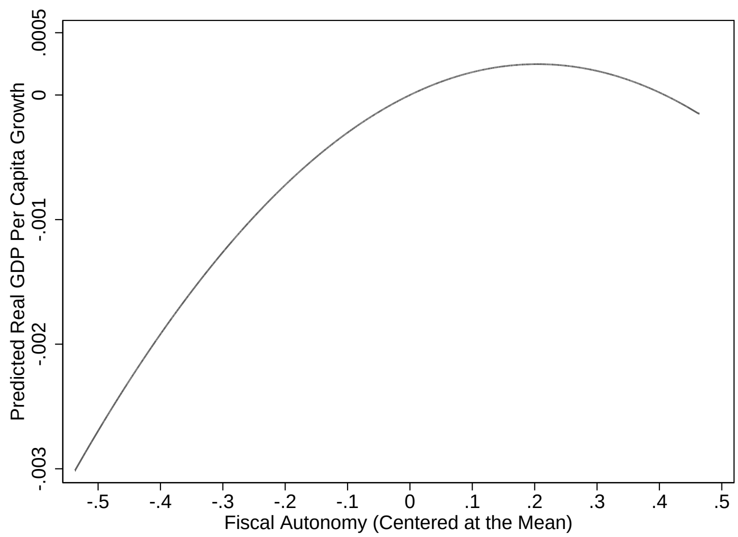
The nonlinear figures resemble an inverse-u shape, which implies that the net marginal effect of fiscal decentralization on economic growth or labor productivity is non-monotonic. The underlying implication from the figures is that extremely high levels of fiscal decentralization can have an adverse impact on growth. The findings make an intuitive sense: relegating “too much” fiscal autonomy to the local governments is harmful for the overall economy. For a typical country in our sample, the growth maximizing level of local fiscal autonomy occurs about two standard deviations to the right of the mean for economic growth. For labor productivity growth, that value is near the mean.

Table 2.11: Fiscal Decentralization and Economic Growth and Labor Productivity, Annual, Two-step System GMM, Full sample, Nonlinear

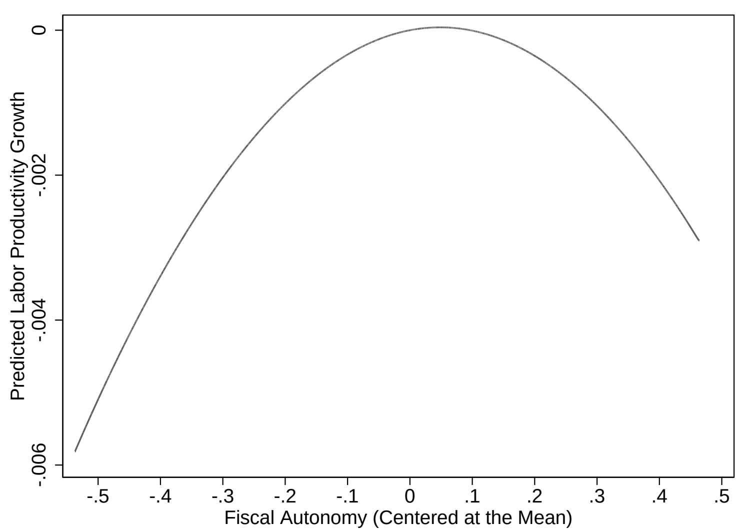
	Economic Growth		Labor Productivity	
	(1)	(2)	(3)	(4)
	Share	Autonomy	Share	Autonomy
$\Delta lny_{i,t-1}$	0.499***	0.450***		
	(0.050)	(0.056)		
$\Delta ln\tilde{y}_{i,t-1}$			0.429***	0.375***
			(0.045)	(0.054)
$Decentralization_{i,t-1}$	0.008	0.311*	-0.006	0.374**
	(0.010)	(0.183)	(0.030)	(0.185)
$Decentralization^2_{i,t-1}$	0.002	-0.292	0.018	-0.358*
	(0.003)	(0.181)	(0.027)	(0.187)
$\Delta Decentralization_{i,t}$	0.003	0.012***	0.004***	0.014***
	(0.002)	(0.004)	(0.002)	(0.004)
$\Delta Decentralization_{i,t-1}$	-0.001	0.001	-0.001	0.000
	(0.003)	(0.002)	(0.004)	(0.002)
$ln(Inflation)_{i,t-1}$	-0.019***	-0.024***	-0.016***	-0.023***
	(0.005)	(0.004)	(0.005)	(0.004)
$ln(Openness)_{i,t-1}$	-0.020***	-0.015*	-0.015**	-0.013*
	(0.007)	(0.008)	(0.006)	(0.008)
Level Effect	0.0198	0.0345	0.0202	0.0267
	[0.237]	[0.198]	[0.110]	[0.349]
Growth Effect	0.00297	0.0239	0.00641	0.0221
	[0.647]	[0.00895]	[0.350]	[0.00168]
Observations	1,223	1,510	1,195	1,482
Number of Countries	88	121	88	121
Sargan-Hansen	0.900	0.298	0.796	0.277

Notes: The sample period ranges from 1985-2012. The covariance matrix in each column allows for heteroscedasticity and moving-average order of 1 or MA(1) errors. Robust standard errors are in parentheses whereas ***, **, and * represent respectively marginal significance levels of 1%, 5%, and 10%. Endogenous variables are $\Delta lny_{i,t-1}$, $Decentralization_{i,t}$ (or $Decentralization_{i,t-1}$), and $\Delta Decentralization_{i,t}$. The instrument set includes $\Delta lny_{i,t-2}$ and $Decentralization_{i,t-2}$. Level effect is calculated as $(\beta_1 + \beta_2)/(1 - \phi_1)$ and growth effect is calculated as $(\theta_1 + \theta_2)/(1 - \phi)$ from equation (2.6). The p-values of level and growth effects are reported in the brackets. The p-values are reported for the Sargan-Hansen test.

Figure 2.2: The Nonlinear Association Between Fiscal Decentralization and Economic Growth (retrieved from Columns (2) and (4) in Table 2.11 using Local Fiscal Autonomy



(a) GDP Per Capita Growth



(b) Labor Productivity Growth

Notes: The sample period ranges from 1985-2012 for a maximum of 121 countries. The mean value of local fiscal autonomy for the full sample is 0.537.

2.5 Conclusions

We analyze the effects of fiscal decentralization on economic growth, highlighting the notion that fiscal decentralization itself is not sufficient for enhancing growth if taxes are collected at the central level. Instead, we find that the growth impact is magnified when tax autonomy is relegated to sub-national governments. To draw a such a comparison, we propose a new measure of fiscal decentralization, local fiscal autonomy, which approximates the ability of a local jurisdiction to set tax rates and control fiscal decision. Furthermore, we establish a long-run association between local fiscal autonomy and economic growth and labor productivity growth using a distributed lag model.

The long-run relationship varies by the federalism status and development levels. Unitary states and developing countries benefit most from the positive effects of local fiscal autonomy. The heterogeneous findings imply that growth in fiscal decentralization is vital for unitary and under-developed countries which currently have sub-optimal levels of local fiscal autonomy. There is also evidence of heterogeneity based on different tax instruments, particularly for property taxes. High-income countries benefit most from local fiscal autonomy in property taxes. In other words, the ability of sub-national governments in rich countries to set property tax rates is the most effective tool for enhancing regional growth. All of these heterogeneous findings imply that there is no universal threshold of local revenue share that maximizes economic growth given unique fiscal systems across countries.

Whereas a rise in fiscal decentralization is helpful for economic growth and labor productivity growth when taxes are collected at the local level, we emphasize that complete decentralization is never optimal. Our finding is consistent with Janeba and Wilson [2011] who show that some public goods and services should be provided by local governments. Even though economic growth can be enhanced when countries share fiscal autonomy with their local governments, the end goal of the policy should not be granting full fiscal autonomy to the local governments. Some fiscal items, such as the national defense budget, may not be suitable for the discretion of the local governments. Therefore, it is crucial to acknowledge the importance of revenue-sharing structure when policy-makers consider fiscal decentralization.

One practical policy implication from our findings is that central governments should restructure the revenue-sharing system such that it relegates more fiscal autonomy to sub-national governments via locally autonomous taxes. Block grants, intergovernmental transfers, and grants from international organizations will not necessary ensure that the revenue is allocated accordingly to the local needs. The fiscal decentralization process also involves other types of decentralization, such as political and administrative decentralization. If sub-national governments do not efficiently manage their revenues or if they abuse their autonomy, then fiscal decentralization may not enhance growth. We speculate that the coordination among different branches and levels of the governments would be an essential cornerstone of effective decentralization.

We have provided a comprehensive analysis on fiscal decentralization. There is however room for future to investigate specific channels through which local fiscal autonomy enhances growth. Furthermore, using our measure of fiscal decentralization, a related study can examine how local fiscal autonomy may affect political outcomes, such as government quality, corruption, and bureaucratic process. Moreover, as discussed in Treisman [2007], the interaction between the expenditure and revenue is an integral study of the political science literature. In particular, the relationship between the revenue raising capacity and the actual implementation of these revenues (i.e., authorized expenditure) given the market and political constraints is an important strand of future work.

Chapter 3

An Efficient Sequential Learning Algorithm in Regime-switching Environments

A linear state-space model with Markov switching is widely used in the application where a dramatic change in model parameters is prevalent. Kim [1994], for instance, estimates the model with a Kalman filter-based technique. The traditional linear model is no longer adequate, however, because of the presence of non-linearity in many modern day applications. Another feature of current time-series observations is a surge in real-time data, compounding at a rapid rate. A more refined model, consequently, requires two areas of improvement: first, consideration of non-linearity and non-Gaussian shocks in the state-space model under a regime-switching environment; and second, the inclusion of sequential parameter learning and state filtering methodology to accommodate the high rate of real-time data update. We propose a sophisticated sequential parameter learning algorithm that can be used in a generalized regime-switching environment. Then we test the estimation accuracy of our algorithm against a popular alternative method.

The foundations of our proposed approach are novel works of Liu and West [2001] and Carvalho and Lopes [2007]. In their seminal paper, Liu and West [2001] introduce a sequential parameter learning method by combining the auxiliary particle filter (APF) of Pitt and Shephard [1999][1] with a kernel smoothing approach that approximates the posterior distribution of model parameters. Extending the method of Liu and West [2001], Carvalho and Lopes [2007] develop a widely applicable and easily implementable particle learning algorithm to estimate a regime switching state space model. Our main contribution is improving the estimation performance of the algorithm in Carvalho and Lopes [2007], which is a culmination of several seminal works in the Sequential Monte Carlo (SMC) literature.

We improve the estimation accuracy and the computational efficiency by carefully designing a particle re-sampling procedure and a candidate generating distribution for a regime index variable (i.e., s_t). Under the framework of Carvalho and Lopes [2007], the particle re-sampling process and the candidate generating distribution are mainly determined by the regime transition probability. Specifically, a particular regime state that has the highest regime transition probability is selected at time t *given* the regime state at time $t-1$. Based on the chosen regime state at time t, the predictive density of the current data (i.e., y_t) is calculated. The predictive density, which is largely determined by the transition probability, is the main factor in the particle re-sampling step. Unfortunately,

[1] Gordon et al. [1993] introduce the bootstrap filter to draw samples from unobserved states based on a sampling importance re-sampling strategy. Building off the bootstrap filter, Pitt and Shephard [1999] construct the APF, which adopts a sequential importance sampling with re-sampling particle filters.

the existing approach cannot efficiently identify regime-switching because any regime transition probability higher than 0.5, for instance, would indicate that there is no change in regimes between the two time periods in the re-sampling step. Moreover, the existing approach can be inefficient since the regime transition probability is the only factor that determines particles of the regime index variable at time t.

To mitigate the strong dependence on the regime transition probability, we combine the re-sampling step and the particle drawing step of the regime index variable, while utilizing the information set available up to the current period. By using both the regime transition probability and the current data in the combined step, the estimation performance is no longer sensitive to the regime transition probability. Given a reasonable number of particles, the SMC simulation results indicate that the estimation accuracy in Carvalho and Lopes [2007] is greatly compromised when regimes are frequently changing, whereas our estimation strategy performs well regardless of the regime persistence.

For an empirical illustration, we apply the proposed algorithm to investigate the dynamics of U.S. excess stock market returns. In particular, we focus on whether a dramatic regime change exists in the leverage effect, the conditional mean, and the conditional variance process. Based on marginal likelihood values, we find that the model with a regime change in volatility can best explain the underlying dynamics of the process. Our finding suggests a regime change in volatility. We do not, however, find any evidence that a regime change also exists in the conditional mean. Moreover, we highlight that the leverage effect itself is an integral element of the stock return analysis even though the model with regime changes in both volatility and the leverage effect is not selected as the best model.

3.1 Sequential Estimation of Markov Switching State-Space Models

A nonlinear and non-Gaussian state-space model with regime-switching for a N-dimensional time series, y_t, and state vector, x_t, generally adopts the following specification:

$$y_t = h(x_t, s_t, \epsilon_t) \tag{3.1}$$

$$x_t = g(x_{t-1}, s_t, \eta_t) \tag{3.2}$$

, where the error terms ϵ_t and η_t are i.i.d. random variables and their means are assumed to be zeros. The measurement equation, $h(\cdot)$, relates the state vector x_t to the observed data, while the transition equation, $g(\cdot)$, shows the dynamics of x_t. Both the measurement and transition equations are determined by the parameter set, β_{s_t}, whose values depends on the regime state, $s_t \in \{0, 1, \ldots, K-1\}$. The dynamic system changes between K regimes over time, while the latent variable that determines the current regime, s_t, follows a first-order Markovian process as given below:

$$\pi_{k,j} = p(s_t = j | s_{t-1} = k) \tag{3.3}$$

, where $\prod_{j=0}^{K-1} \pi_{k,j} = 1$. Let π be the set of transition probabilities. The main goal of our proposed estimation strategy is to sequentially estimate the unknown model parameters, $\theta = [\beta'_0, \beta'_1, \ldots, \beta'_{K-1}, \pi]'$, and the latent states, $[s_t, x_t]$, by incorporating new observations at each time period.

Liu and West [2001] combine the auxiliary particle filter with kernel smoothing methods, which is the foundation of our sequential parameter learning approach. We summarize the Liu-West (LW) filter in *Algorithm* 1 with the inclusion of the distribution for s_t.[2]

Algorithm 1: Liu-West (LW) Filter for Markov Switching State Space Models

i. Generate $\{s_0^{(i)}, x_0^{(i)}, \theta_0^{(i)}\}$ with the importance weight, $\hat{\omega}_0^{(i)} = \frac{1}{N}$ for $i = 1, 2, \ldots, N$.

ii. Compute the re-sampling weight $\hat{\omega}_{t-1|t}^{(i)}$ for $i = 1, 2, \ldots, N$.

iii. Re-sample N particles $\{\hat{s}_{t-1}^{(i)}, \hat{x}_{t-1}^{(i)}, \hat{\theta}_{t-1}^{(i)}\}_{i=1}^{N}$ from $\{s_{t-1}^{(i)}, x_{t-1}^{(i)}, \theta_{t-1}^{(i)}\}_{i=1}^{N}$ and draw $\{s_t^{(i)}, x_t^{(i)}, \theta_t^{(i)}\}$ conditional on $\{\hat{s}_{t-1}^{(i)}, \hat{x}_{t-1}^{(i)}, \hat{\theta}_{t-1}^{(i)}\}$ for $i = 1, 2, \ldots, N$.

iv. Compute the normalized importance weight, $\hat{\omega}_t^{(i)}$, for the particle set $\{s_t^{(i)}, x_t^{(i)}, \theta_t^{(i)}\}$ for $i = 1, 2, \ldots, N$.

v. Iterate steps (ii), (iii), and (iv) at $t = 1, 2, \ldots, T$.

In *Algorithm* 1, N represents the number particles of the latent variables. At step (i) of *Algorithm* 1, the particle set $\{s_0^{(i)}, x_0^{(i)}, \theta_0^{(i)}\}$ is orderly drawn from $p(\theta_0^{(i)})$, $p(s_0^{(i)} \mid \theta_0^{(i)})$, and $p(x_0^{(i)} \mid s_0^{(i)}, \theta_0^{(i)})$. Note that $p(s_0^{(i)} \mid \theta_0^{(i)})$ and $p(x_0^{(i)} \mid s_0^{(i)}, \theta_0^{(i)})$ are the unconditional distribution of $s_0^{(i)}$ and $x_0^{(i)}$. To estimate the unknown parameter set $\theta = [\beta_0', \beta_1', \ldots, \beta_{K-1}', \pi]'$ at time $t-1$, the LW filter incorporates the following mixture of multivariate normal distributions:

$$p(\theta|y_{1:t-1}) \approx \sum_{i=1}^{N} \hat{\omega}_{t-1}^{(i)} f(\theta; m_{t-1}^{(i)}, h^2 V_{t-1}) \tag{3.4}$$

, where $f(\theta; m_{t-1}^{(i)}, h^2 V_{t-1})$ is a normal distribution with the mean, $m_{t-1}^{(i)}$, and the variance, $h^2 V_{t-1}$. Note that $m_{t-1}^{(i)} = \alpha\theta_{t-1}^{(i)} + (1-\alpha)\bar{\theta}_{t-1}$, where $\bar{\theta}_{t-1} = \sum_{i=1}^{N} \hat{\omega}_{t-1}^{(i)} \theta_{t-1}^{(i)}$. Also $h^2 V_{t-1} = h^2 \sum_{i=1}^{N} \hat{\omega}_{t-1}^{(i)} (\theta_{t-1}^{(i)} - \bar{\theta}_{t-1})(\theta_{t-1}^{(i)} - \bar{\theta}_{t-1})'$, where $h^2 = (1-\alpha^2)$. The tuning parameter, α, appears in the mean through $m_{t-1}^{(i)}$ (i.e., a shrinkage factor) and in the variance through h^2 (i.e., a smoothing factor).

[2] We have added the regime-switching state space model to the original work of Liu and West [2001].

Carvalho and Lopes [2007] extend the LW filter by including the regime-state, s_t. An important feature of their algorithm is that the estimation of s_t is heavily dependent on the previous state through the prior transition density. We modify Carvalho and Lopes [2007]'s approach in *Algorithm* 2. Notice that the derivation in *Algorithm* 2 starts from step (ii.1) because the first step is the same as step (i) of the LW filter derivation in *Algorithm* 1.

Algorithm 2: Carvalho and Lopes [2007]

1.21 Compute posterior mean and variance statistics, $m_{t-1}^{(i)}$ and $h^2 V_{t-1}$.

1.22 Generate $\tilde{s}_t^{(i)} = \text{argmax}_{k \in \{0,\ldots,K-1\}}\, p(s_t = k \mid s_{t-1}^{(i)}; m_{t-1}^{(i)})$ for $i = 1, 2, \ldots, N$.

1.23 Compute $\tilde{x}_t^{(i)} = g(x_{t-1}^{(i)}, \tilde{s}_t^{(i)}, \eta_t = 0; m_{t-1}^{(i)})$ for $i = 1, 2, \ldots, N$.

1.24 Compute the re-sampling importance weight, $\hat{\omega}_{t-1|t}^{(i)} = \frac{\omega_{t-1|t}^{(i)}}{\sum_{j=1}^{N} \omega_{t-1|t}^{(j)}}$ for $i = 1, 2, \ldots, N$, where $\omega_{t-1|t}{}^{(i)} \propto p(y_t | \tilde{x}_t^{(i)}, \tilde{s}_t^{(i)}; m_{t-1}^{(i)}) \hat{\omega}_{t-1}^{(i)}$, and $p(y_t | \tilde{x}_t^{(i)}, \tilde{s}_t^{(i)}; m_{t-1}^{(i)})$ is the conditional density of y_t given $\tilde{x}_t^{(i)}$, $\tilde{s}_t^{(i)}$, and $m_{t-1}^{(i)}$.

1.31 Re-sample the particle set, $\{\hat{s}_t^{(i)}, \hat{x}_t^{(i)}, \hat{s}_{t-1}^{(i)}, \hat{x}_{t-1}^{(i)}, \hat{\theta}_{t-1}^{(i)}, \hat{m}_{t-1}^{(i)}\}_{i=1}^{N}$ from $\{\tilde{s}_t^{(i)}, \tilde{x}_t^{(i)}, s_{t-1}^{(i)}, x_{t-1}^{(i)}, \theta_{t-1}^{(i)}, m_{t-1}^{(i)}\}_{i=1}^{N}$ using $\{\hat{\omega}_{t-1|t}^{(i)}\}_{i=1}^{N}$. Define $\tilde{s}_t^{(i)} = \hat{s}_t^{(i)}$; $\tilde{x}_t^{(i)} = \hat{x}_t^{(i)}$; $s_{t-1}^{(i)} = \hat{s}_{t-1}^{(i)}$; $x_{t-1}^{(i)} = \hat{x}_{t-1}^{(i)}$; $\theta_{t-1}^{(i)} = \hat{\theta}_{t-1}^{(i)}$; and $m_{t-1}^{(i)} = \hat{m}_{t-1}^{(i)}$ for $i = 1, 2, \ldots, N$.

1.32 Generate $\theta_t^{(i)}$ from $N(m_{t-1}^{(i)}, h^2 V_{t-1})$ for $i = 1, 2, \ldots, N$.

1.33 Generate $s_t^{(i)}$ from $p(s_t \mid s_{t-1}^{(i)}; \theta_t^{(i)})$ for $i = 1, 2, \ldots, N$.

1.34 Generate $x_t^{(i)}$ from $p(x_t \mid s_{t-1}^{(i)}, s_t^{(i)}, x_{t-1}^{(i)}; \theta_t^{(i)})$ for $i = 1, 2, \ldots, N$.

iv.1 Compute the importance weight $\hat{\omega}_t^{(i)} = \frac{\omega_t^{(i)}}{\sum_{j=1}^{N} \omega_t^{(j)}}$, where $\omega_t^{(i)} \propto \frac{p(y_t | x_t^{(i)}, s_t^{(i)}; \theta_t^{(i)})}{p(y_t | \tilde{x}_t^{(i)}, \tilde{s}_t^{(i)}; m_{t-1}^{(i)})}$.

It is important to note that $\tilde{s}_t^{(i)}$, which is solely determined by the regime transition probability, $p(s_t \mid s_{t-1}^{(i)})$, is used to generate $\tilde{x}_t^{(i)}$ and to compute the re-sampling weight $\hat{\omega}_{t-1|t}^{(i)}$. Moreover, the new particle, $s_t^{(i)}$, is generated from the same transition probability. Because of the heavy dependency of *Algorithm* 2 on the transition probability, we conjecture that its performance is substantially influenced by the degree of persistence in each regime. A small number of particles, in particular, would exacerbate the problem.

To mitigate the problem, we relax the restriction of relying on the regime transition probability as a main factor that determines the re-sampling weights and s_t in the proposal distribution. Instead, we utilize all of the available information set, including the current observation y_t in the merged process that combines the step for re-sampling particles at time $t-1$ with the step of generating new s_t particles. *Algorithm* 3 summarizes of our approach.[3] Notice that the derivation in *Algorithm* 3 starts from step (ii.1) because the first step is the same as step (i) of the LW filter derivation in *Algorithm* 1.

Algorithm 3: Proposed Algorithm

---

ii.1 Compute posterior mean and variance statistics, $m_{t-1}^{(i)}$ and $h^2 V_{t-1}$.

ii.2 Compute $\tilde{x}_{t|k}^{(i)} = g(x_{t-1}^{(i)}, s_t = k, \eta_t = 0; m_{t-1}^{(i)})$ for $k = 0, 1, \ldots, K-1$ and $i = 1, 2, \ldots, N$.

ii.3 Compute the importance weight $\hat{\omega}_{t-1|t,k}^{(i)} = \frac{\omega_{t-1|t,k}^{(i)}}{\sum_{k=0}^{K-1} \sum_{i=1}^{N} \omega_{t-1|t,k}^{(i)}}$ for $k = 0, 1, \ldots, K-1$ and $i = 1, 2, \ldots, N$, where $\omega_{t-1|t,k}^{(i)} \propto p(y_t \mid \tilde{x}_{t|k}^{(i)}, s_t = k; m_{t-1}^{(i)}) p(s_t = k | s_{t-1}^{(i)}; m_{t-1}^{(i)}) \hat{\omega}_{t-1}^{(i)}$.

iii.1 Draw $\{s_t^{(i)}\}_{i=1}^{N}$ and re-sample the particle set, $\{\hat{x}_{t|k}^{(i)}, \hat{s}_{t-1}^{(i)}, \hat{x}_{t-1}^{(i)}, \hat{\theta}_{t-1}^{(i)}, \hat{m}_{t-1}^{(i)}\}_{i=1}^{N}$ simultaneously using $\hat{\omega}_{t-1|t,k}^{(i)}$. The re-sampling is preformed on $\{\tilde{x}_{t|k}^{(i)}, s_{t-1}^{(i)}, x_{t-1}^{(i)}, \theta_{t-1}^{(i)}, m_{t-1}^{(i)}\}_{i=1}^{N}$. Define $\tilde{x}_{t|k}^{(i)} = \hat{x}_{t|k}^{(i)}$; $s_{t-1}^{(i)} = \hat{s}_{t-1}^{(i)}$; $x_{t-1}^{(i)} = \hat{x}_{t-1}^{(i)}$; and $\theta_{t-1}^{(i)} = \hat{\theta}_{t-1}^{(i)}$.

iii.2 Generate $\theta_t^{(i)}$ from $N(m_{t-1}^{(i)}, h^2 V_{t-1})$ for $i = 1, 2, \ldots, N$.

iii.3 Generate $x_t^{(i)}$ from $p(x_t \mid s_t^{(i)}, x_{t-1}^{(i)}; \theta_t^{(i)})$ for $i = 1, 2, \ldots, N$.

---

[3] The incremental target density of the proposed algorithm is given below:

$$p(x_t, s_t, \theta \mid y_{1:t}) \propto p(y_t \mid x_t, s_t; \theta) p(x_t \mid x_{t-1}, s_t; \theta) p(s_t \mid s_{t-1}; \theta) p(\theta | y_{1:t-1})$$

, where $y_{1:t} = [y_1, y_2, \ldots, y_T]'$.

iv.1 Compute the importance weight $\hat{\omega}_t^{(i)} = \frac{\omega_t^{(i)}}{\sum_{j=1}^{N} w_t^{(j)}}$,

where $\omega_t^{(i)} \propto \frac{p(y_t|x_t^{(i)}, s_t^{(i)}; \theta_t^{(i)}) p(s_t^{(i)}|s_{t-1}^{(i)}; \theta_t^{(i)})}{p(y_t|\tilde{x}_{t|s_t^{(i)}}^{(i)}, s_t^{(i)}; m_{t-1}^{(i)}) p(s_t^{(i)}|s_{t-1}^{(i)}; m_{t-1}^{(i)})}$.

The main difference between the existing particle learning algorithm in Carvalho and Lopes [2007] (i.e., *Algorithm* 2) and our proposed approach in *Algorithm* 3 lies on steps (ii), (iii), and (iv). Specifically, at step (iii.1) of *Algorithm* 3, we combine the re-sampling step for the existing particles at time $t-1$ and the sampling step for s_t. This step is the key to understanding how the proposed algorithm can overcome the aforementioned problem of the existing algorithm. First, our approach does not require the generation of deterministic $\tilde{s}_t^{(i)}$, which critically depends on the transition probability. Second, our approach employs more information contained in the current observation y_t in generating s_t compared to *Algorithm* 2.

3.2 Simulation Study

We consider a two-state (i.e., K=2) Markov Switching Stochastic Volatility (MSSV) model proposed in So et al. [1998] to evaluate the performance of the two described online estimation algorithms:

$$y_t = \beta + \exp(\frac{x_t}{2})\epsilon_t, \ \epsilon_t \sim N(0,1) \tag{3.5}$$

$$x_t = \alpha_{s_t} + \phi(x_{t-1} - \alpha_{s_{t-1}}) + \eta_t, \ \eta_t \sim N(0, \tau^2) \tag{3.6}$$

, where $\alpha_{s_t} = \alpha_0 + \alpha_d s_t$ and $s_t \in \{0, 1\}$ for $t = \{1, 2, \ldots, T\}$. Without loss of generality, regime 0 or $s_t = 0$ refers to a low-volatility state, whereas regime 1 or $s_t = 1$ refers to a high-volatility regime. Following the data generating process in equations (3.5) and (3.6), we use the parameter values of $\{\alpha_0 = 1, \alpha_d = 3, \phi = 0.5, \sigma^2 = 0.5\}$ with $T = 1,000$ over a set of 100 simulation studies. We explore two different sets of transition probabilities. Case 1 considers a volatility process that experiences a relatively frequent regime switch. The corresponding transition probability values are $\pi_{00} = 0.9$ and $\pi_{11} = 0.85$ with the expected regime duration of 10 and 7 for regimes 0 and 1, respectively.[4] On the other hand, Case 2 considers a volatility process that has a more persistent state and uses the probability values of $\pi_{00} = 0.99$ and $\pi_{11} = 0.9$. The corresponding expected regime duration is 100 for regime 0 and 10 for regime 1. For both cases, we generate the entire sequence of true values of s_t based on the computed expected regime duration.

To compare the estimation accuracy of the simulation results, we define the Mean Squared Error (MSE) for volatility as $MSE_V^{(j)} = \frac{1}{T}\sum_{t=1}^{T}(V_t - \hat{V}_t^{(j)})^2$, which represents the difference between the real volatility process (i.e., $V_t = exp(x_t)$) and the filtered process (i.e., $\hat{V}_t = exp(\hat{x}_t)$) in the j-th simulation. We compute the average volatility MSE (i.e., $M\bar{S}E_V = \frac{1}{100}\sum_{j=1}^{100} MSE_V^{(j)}$) to summarize all simulation results.

Moreover, to compare how well each algorithm is able to correctly capture a change in regimes and successfully recognize the current state, we define the Quadratic Probability Score (QPS) for the j-th simulation as $QPS^{(j)} = \frac{1}{T}\sum_{t=1}^{T}(s_t - \hat{P}r(s_t = 1)^{(j)})^2 \times 100$, where $\hat{P}r(s_t = 1)$ is the filtered probability of the high volatility regime (i.e., estimated state) and s_t is the true value. We can summarize the QPS by averaging over the repeated simulation number of 100 (i.e., $Q\bar{P}S = \frac{1}{100}\sum_{j=1}^{100} QPS^{(j)}$). The score ranges between 0 and 100. QPS is equal

[4]The expectation of regime duration is computed by $\frac{1}{1-\pi_{kk}}$ for $k = \{0, 1\}$. For the simulation purpose, when the computed regime duration is not an integer, we round it up to the nearest integer.

to 0 if the online estimation algorithm is able to perfectly capture and recognize the regime changes, while 1 being the other side of the extreme.

To compare the performance of the parameter estimation, we define the MSE for model parameters[5] as $MSE_P^{(j)} = \frac{1}{T}\sum_{t=1}^{T}(p - \hat{p_t}^{(j)})^2$ where p is the true parameter value and $\hat{p_t}$ is the estimated parameter path. Similar to the volatility MSE and QPS, the average MSE for each parameter can be written as $M\bar{S}E_P = \frac{1}{100}\sum_{i=j}^{100} MSE_P^{(j)}$.

We compare the performance of each algorithm under different regime frameworks based on the average values of MSE_V, QPS, and MSE_P in Table 3.1. For a direct comparison, each filter utilizes the same number of particles ($N = 5,000$). We use non-informative priors for the model parameters in the simulation.[6] Columns (1) and (3) are from Carvalho and Lopes [2007] and columns (2) and (4) are from our proposed algorithm.

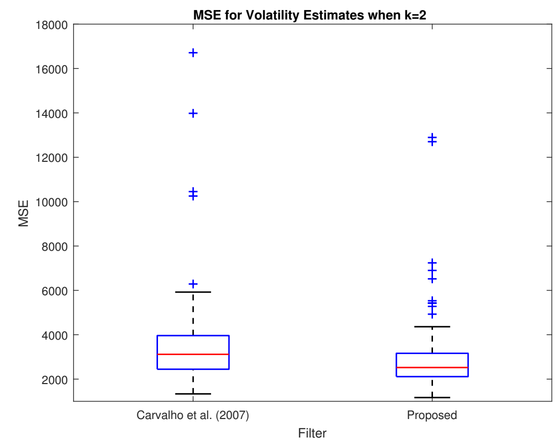
When there is a high turnover rate in regime-switching (i.e., Case 1), the proposed algorithm clearly outperforms the existing algorithm in estimation accuracy. The average MSE_V value is significantly lower for the proposed approach than the existing approach, which implies that the new approach can better estimate the volatility process given the same number of particles. Furthermore, The average QPS value of the proposed filter is nearly twice as small as that of the existing algorithm. Because a lower value of the average QPS equates to less erroneous state estimations, the proposed algorithm can better determine the position of the current state with the reasonable number of particles. On the other hand, when regime-switching is stagnant (i.e., Case 2), the average MSE_V

[5] The parameter set is $\theta = \{\alpha_0, \alpha_d, \phi_0, \sigma^2, \pi_{00}, \pi_{11}\}$.

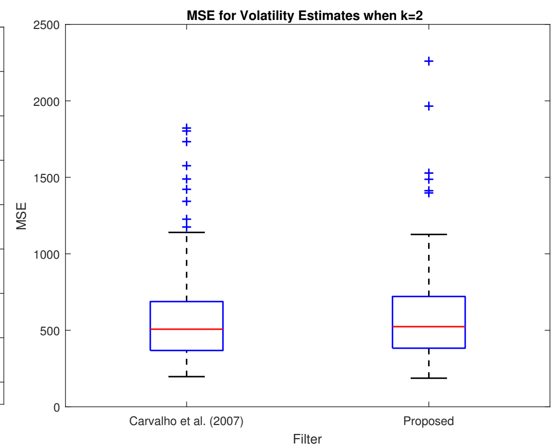
[6] The priors for α_0, α_d, and ϕ are normal distributions. The variance parameter τ^2 takes an inverse gamma distribution as a prior. For the transition probabilities, we assume beta distributions.

and the average QPS values of the proposed approach are not very different from those of the existing approach.[7]

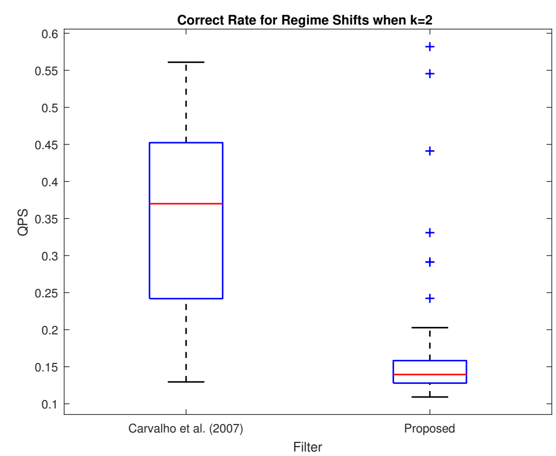
Figure 3.1: Top: Box plots of the MSE of the estimated volatility process compared to the real simulated volatility process for each filter. Bottom: Box plots of the QPS for each filter.



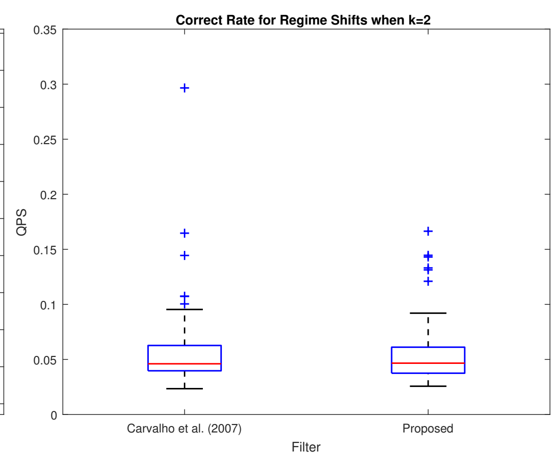
(a) Case 1: $\pi_{00} = 0.9, \pi_{11} = 0.85$



(b) Case 2: $\pi_{00} = 0.99, \pi_{11} = 0.9$



(c) Case 1: $\pi_{00} = 0.9, \pi_{11} = 0.85$



(d) Case 2: $\pi_{00} = 0.99, \pi_{11} = 0.9$

Notes: All plots present the results for the MSSV k=2 model with the parameter set of $\{\alpha_0 = 1, \alpha_1 = 3, \phi = 0.5, \sigma^2 = 0.5\}$. Case 1 uses the transition probability of $\{\pi_{00} = 0.9, \pi_{11} = 0.85\}$ and Case 2 uses $\{\pi_{00} = 0.99, \pi_{11} = 0.9\}$. The total simulation runs are 100. Each simulation uses 5,000 particles in 1,000 time periods.

[7] The average MSE and QPS for each algorithm can also be compared with a box plot representation. Figure 3.1 presents the distribution of observed MSE_V and QPS values obtained from 100 simulations.

Table 3.1: Averages of MSE_V, QPS, and MSE_P for the 2-state MSSV model.

	Case 1: $\pi_{00} = 0.9, \pi_{11} = 0.85$		Case 2: $\pi_{00} = 0.99, \pi_{11} = 0.9$	
	(1)	(2)	(3)	(4)
	Carvalho and Lopes [2007]	Proposed	Carvalho and Lopes [2007]	Proposed
$M\bar{S}E_V$	3,811	3,787	640.67	644.72
$Q\bar{P}S$	34.773	16.081	6.254	6.075
$M\bar{S}E_P$: α_0	1.535	0.974	0.0641	0.0636
$M\bar{S}E_P$: α_d	0.540	0.421	0.489	0.440
$M\bar{S}E_P$: ϕ_0	0.0231	0.0161	0.0238	0.0242
$M\bar{S}E_P$: σ^2	0.990	0.205	0.0369	0.0206
$M\bar{S}E_P$: π_{00}	0.00203	0.00108	0.00062	0.00059
$M\bar{S}E_P$: π_{11}	0.0124	0.0026	0.00110	0.00109

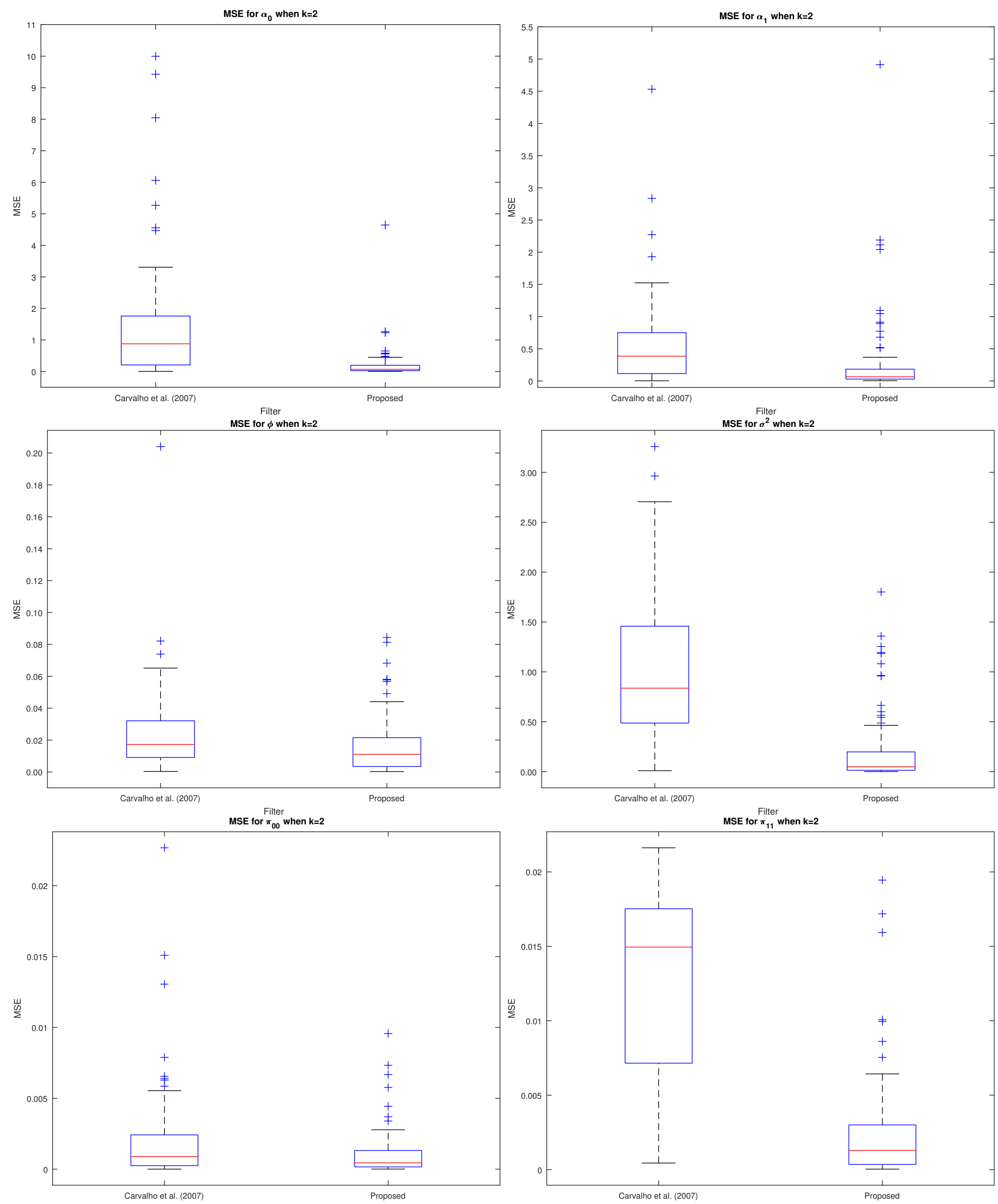
Notes: $M\bar{S}E_V$ refers to the average mean squared error for volatility. $Q\bar{P}S$ refers to the average quadratic probability score. The QPS index ranges between 0 and 100, with 0 being the case of correct assignment of the state variable for all time periods and 100 being the opposite case. $M\bar{S}E_P$ refers to the MSE of each parameter. The results are based on the 2-state MSSV model with $\alpha_0 = 1, \alpha_d = 3, \phi = 0.5, \sigma^2 = 0.5$ using 5,000 particles, averaged over 100 simulations.

The parameter estimation accuracy of the proposed approach is also significantly better than the existing algorithm given $N = 5,000$ in Case 1. For instance, regime-dependent volatility means (i.e., α_0 and α_d) are better estimated with the proposed approach with the average MSE value of 0.974 and 0.421 compared with values of 1.535 and 0.540 of the existing filter, respectively. Moreover, the existing filter produces a higher average MSE for σ^2. This result can be explained by the fact that *Algorithm* 2 often spuriously attributes variations in volatility to the shock, η_t, because it fails to capture regime changes in the mean of the volatility process. On the other hand, the values of average MSE for the model parameters under persistent regimes (i.e., Case 2) are similar between the two approaches.[8]

One important implication from the findings is that the existing algorithm performs very differently depending on time series characteristics of regimes. Notably the new algorithm constantly performs well. In many different empirical

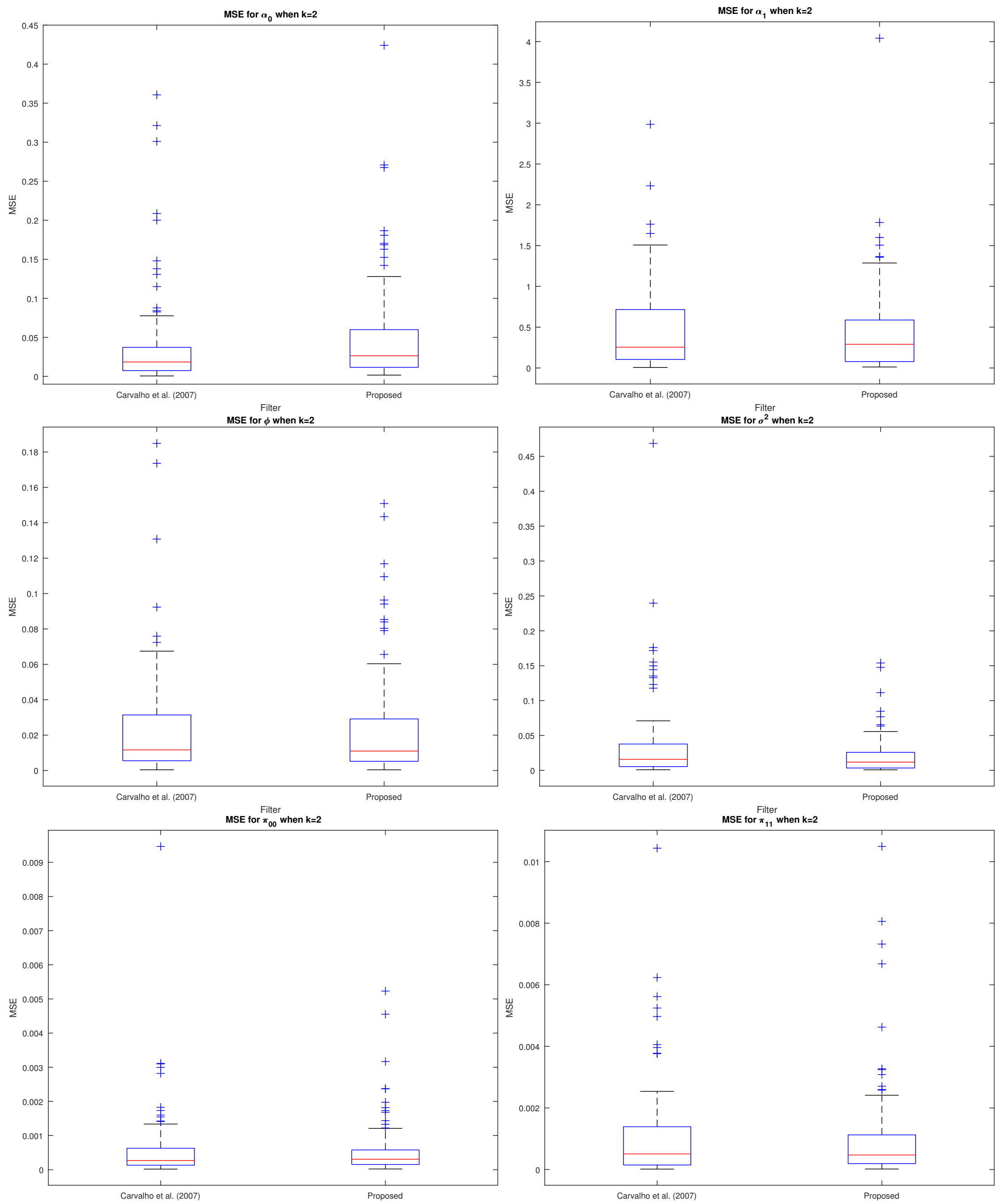
[8] We show box plots for the distribution of MSE for each parameter in Figures 3.2 and 3.3

Figure 3.2: Comparison of Parameter MSE: Case 1: Box plots of the MSE of each parameter for each filter



Notes: All plots present the results for the MSSV k=2 model with the parameter set of $\{\alpha_0 = 1, \alpha_d = 3, \phi = 0.5, \sigma^2 = 0.5\}$. The total simulation runs are 100. Each simulation uses 5,000 particles in 1,000 time periods.

Figure 3.3: Comparison of Parameter MSE: Case 2: Box plots of the MSE of each parameter for each filter



Notes: All plots present the results for the MSSV k=2 model with the parameter set of $\{\alpha_0 = 1, \alpha_d = 3, \phi = 0.5, \sigma^2 = 0.5\}$. The total simulation runs are 100. Each simulation uses 5,000 particles in 1,000 time periods.

analyses, we may observe various transition probabilities for regimes. The proposed algorithm will be useful in practice regardless of underlying persistence of regimes.

3.3 Application

3.3.1 Empirical Specification

For an empirical illustration, we apply the proposed algorithm to investigate whether the dynamics of U.S. stock market excess returns can be well characterized by a model with abrupt regime changes.[9] For our analysis, we employ the value-weighted portfolio returns of NYSE, AMEX, and NASDAQ firms minus the one-month Treasury bill rate.[10] The data are observed at the weekly level from the week of January 4, 1980 to the week of May 26, 2017, a total of 1,952 observations.

We consider the following model of excess stock returns:

$$r_t^e = \mu_t^r + \sigma_t \epsilon_t, \;\; \epsilon_t \sim NID(0,1) \tag{3.7}$$

, where the excess stock returns, r_t^e, are made up of the expected value of excess returns, μ_t^r, and an unexpected random shock, $\sigma_t \epsilon_t$. An economic agent forms her expectations of r_t^e at time $t-1$ using the information available up to time $t-1$. However, μ_t^r is assumed to be a latent variable and is estimated within the model because the information set available to a researcher is substantially smaller than the amount of information available to the economic agent. The unobserved (log)

[9]So et al. [1998], for instance, highlight the appropriateness of a time-varying stochastic volatility model with regime-switching using the Standard and Poor's 500 weekly return data.
[10]The data is retrieved from the CRSP database.

mean, m_t, and the (log) volatility, x_t, of excess returns are determined by the following latent vector autoregressive (VAR) process:

$$m_t = \mu^m_{s^m_t} + \phi_{11}(m_{t-1} - \mu^m_{s^m_{t-1}}) + \phi_{12}(x_{t-1} - \mu^x_{s^x_{t-1}}) + e^m_t, \tag{3.8}$$

$$x_t = \mu^x_{s^x_t} + \phi_{21}(m_{t-1} - \mu^m_{s^m_{t-1}}) + \phi_{22}(x_{t-1} - \mu^x_{s^x_{t-1}}) + \phi_{23,s^x_t}\epsilon_{t-1} + e^x_t, \tag{3.9}$$

$$\begin{bmatrix} e^m_t \\ e^x_t \end{bmatrix} \sim NID\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma^2_m & \rho\sigma_m\sigma_x \\ \rho\sigma_m\sigma_x & \sigma^2_x \end{bmatrix} \right) \tag{3.10}$$

, where $\mu^m_{s^m_t} = \mu^m_0 + \mu^m_d\ s^m_t$; $\mu^x_{s^x_t} = \mu^x_0 + \mu^x_d\ s^x_t$; $s^m_t \in \{0,1\}$; and $s^x_t \in \{0,1\}$.[11] Under the VAR representation, the conditional mean and volatility are specified as $\mu^r_t = \exp(m_t)$ and $\sigma^2_t = \exp(x_t)$. We are extending the latent VAR model in Brandt and Kang [2004] by incorporating abrupt but recurring regime changes in μ^m and μ^x with the regime indicator variables s^m_t and s^x_t.[12] The regime-dependent parameter, ϕ_{23,s^x_t}, plays an important role in capturing the leverage effect. For example, the leverage of a firm increases when negative news lowers the market value of the firm. An increase in leverage leads to a higher risk of holding the equity claims, which results in a rise in the volatility.[13] By allowing for the regime switching in ϕ_{23,s^x_t}, we can test for whether the magnitude of the leverage effect depends on the high and low volatility regimes.

[11] We also consider a case in which $\phi_{13}\epsilon_t$ is included in equation (3.8). However, the posterior distribution of ϕ_{13} is narrowly disperse around zero and the more general model is not preferred by our Bayesian model selection criterion. For the sake of brevity, we do not report the corresponding result.

[12] We have considered another comparable model in which all VAR coefficients, $\{\phi_{11}, \phi_{12}, \phi_{21}, \phi_{22}\}$ change according to regimes. We do not report the results here because the marginal likelihood of the model is too low compared to others.

[13] Christie [1982] provides a comprehensive analysis of the importance of the leverage effect.

The discrete state variables follow a first-order Markovian process of

$$\pi_{00}^m = p[s_t^m = 0 \mid s_{t-1}^m = 0], \quad \pi_{11}^m = p[s_t^m = 1 \mid s_{t-1}^m = 1], \tag{3.11}$$

$$\pi_{00}^x = p[s_t^x = 0 \mid s_{t-1}^x = 0], \quad \pi_{11}^x = p[s_t^x = 1 \mid s_{t-1}^x = 1] \tag{3.12}$$

For the purpose of identifying regimes, we assume that $\mu_\delta^m > 0$ and $\mu_\delta^x > 0$. Accordingly, $s_t^m = 0$ ($s_t^x = 0$) represents a state of low conditional mean (low volatility), whereas $s_t^m = 1$ ($s_t^x = 1$) represents a state of high conditional mean (high volatility). *Algorithms* 1 and 3 allow us to estimate the above nonlinear state space model with regime-switching. The priors that we employed are reported in Table 2.[14] In estimation, we use 100,000 particles to ensure that our method fully explores the parameters and state spaces.

3.3.2 Empirical Results

Our empirical analysis accounts for various possibilities of innovations under which the conditional mean and volatility may perform. In particular, the generalized environment can be categorized into three broad cases: a regime change in volatility, a regime change in the conditional mean, and a regime change in the leverage effect. Model A assumes no regime changes at all. All other cases assume regime-switching either in the conditional mean and volatility of the market excess return. For instance, Model B assumes a regime change in μ^s only; Model D assumes regime changes in both μ^s and μ^m; and Model C assumes regime changes in μ^s and ϕ_{23} to incorporate a possibility of a regime change in the leverage effect. To determine which model best fits with the data in a parsimonious model setup,

[14]We impose weakly informative priors for other parameters while using informative priors for regime transition probabilities following the literature.

we compute the log marginal likelihoods (log(ML)) at the terminal time period of each case.[15]

Comparing the log(ML) of Model A against Models B, C, D determines if a regime switching occurs and where it occurs in the excess return process. Table 3.2 presents the log(ML) values. The log(ML) value of -4,105.9 in Model A is smaller than other two models except Model D, which is evidence that the regime change exists only in the conditional volatility process. Comparing Model B (i.e., a change in volatility only) and Model D (i.e., changes in the conditional mean and the volatility) can identify which model can better estimate the underlying process of the excess return. The log(ML) value of -4,101.3 in Model B is higher than the log(ML) value of -4,107.2 in Model D. Again, this finding suggests that the regime change occurs only in the volatility process.

Given the evidence in favor of regime-switching in volatility, we can examine whether a regime-switching occurs in both the volatility process and the leverage effect. Comparing Model B (i.e., the leverage effect is constant) versus Model C (i.e., the leverage effect changes according to the volatility regimes) allows us to determine whether the leverage effect changes over time. The log(ML) of -4,101.3 in Model B is greater than the log (ML) of -4,105.5 in Model C, which implies that the regime switching in the leverage effect is not a main feature of the excess market return. However, this evidence does not discount the importance of the leverage effect in the model. Rather, the leverage effect itself is an integral element of the stock return analysis, as $\phi^x_{23,0}$ is significant across all model specifications.

[15] The marginal likelihood estimator of the auxiliary particle filter is defined by:

$$\hat{p}(y_{1:t}) = \hat{p}(y_1) \prod_{t=2}^{T} \hat{p}(y_t \mid y_{1:t-1})$$

, where $\hat{p}(y_t \mid y_{1:t-1}) = (\frac{1}{N} \sum_{i=0}^{N} \omega_t^{(i)})(\sum_{k=0}^{K-1} \sum_{i=1}^{N} \omega_{t-1|t,k}^{(i)})$.

Note that according to the model comparison criterion suggested by Kass and Raftery [1995] and Raftery [1995], Model B is strongly or very strongly preferred to other models.[16]

We depict the movements of the weekly excess return, the filtered stochastic volatility, $E[\sigma_t^2 \mid y_{1:t}]$, and the filtered probability of the high-volatility regime, $\Pr(s_t = 1 \mid y_{1:t})$, from the week of January 4, 1980 to the week of May 26, 2017 in Figure 3.4 using the specification from Model B, the best model. The weekly return (i.e., top graph) oscillates quite violently throughout the sample period. The degree of fluctuation is particularly large for periods between the years of '87-'89, -'99-'01, and '09-'11 (i.e., periods of the second oil shock, the dot-com boom, and the global financial crisis, respectively). When matching the weekly market return with the volatility graph (i.e., the mid graph), it is evident that the cycles with high fluctuations are closely associated with the periods that exhibit high volatility. The volatility is at its peak during the recent financial crisis. When we compare the volatility graph with the filtered regime state graph (i.e., the bottom graph), it is evident that the level of volatility and the probability of the high-volatility regime exhibit strong co-movements. Note that the volatility regime is not well identified in the early sample periods due to the insufficient number of observations. However, since the mid-1990s, when observations are accumulated, the volatility regime is more accurately estimated by incorporating more observations that contain regime switching signals.

Continuing from the working example of Model B, we compare the one year average excess return and the estimated μ_t^r in Figure 3.5. The red dotted line is

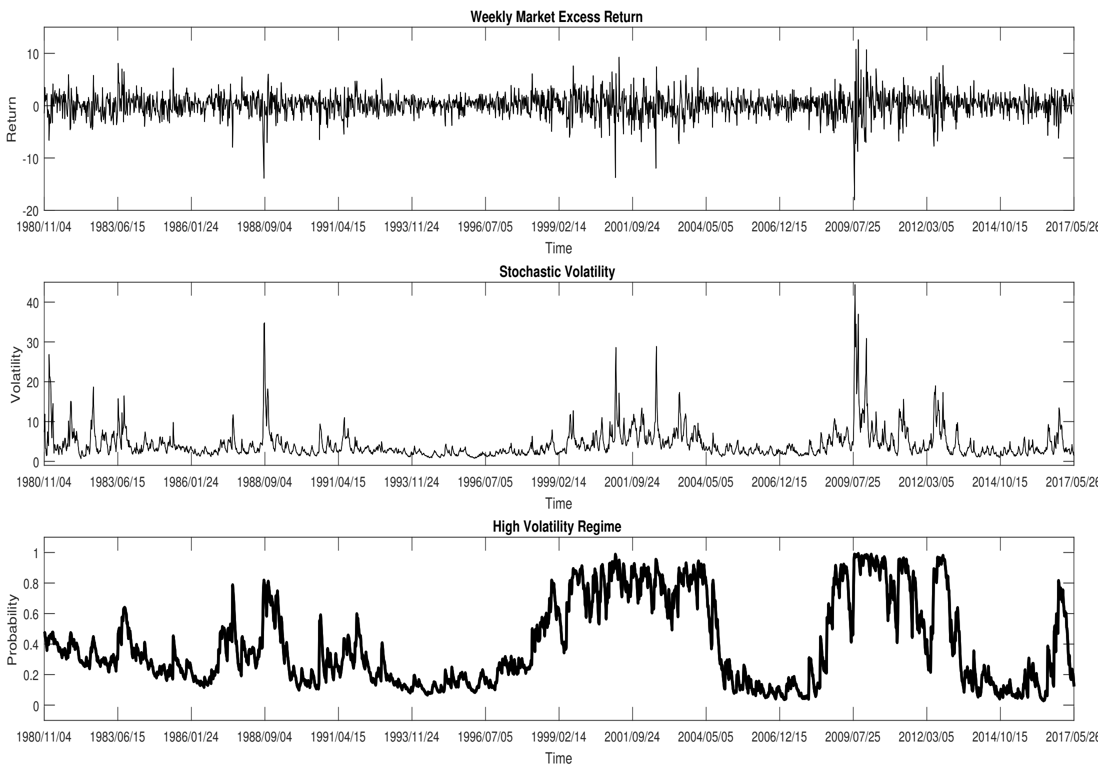
[16] The difference between the log(ML) value for the two compared models is multiplied by two to compute the model comparison criterion. When the value is between 6 and 10, the corresponding model is strongly preferred. When it is larger than 10, the model is very strongly preferred.

Table 3.2: Parameter Comparisons by Model Specification

		Model A		Model B		Model C		Model D	
	Regime Δ in Vol.	No	No	Yes	Yes	Yes	Yes	Yes	Yes
	Regime Δ in Mean	No	No	No	No	No	No	Yes	Yes
	Regime Δ in Leverage	No	No	No	No	Yes	Yes	No	No
	Prior	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
μ_0^m	$\mathcal{N}(ln\hat{M}-1,2^2)$	-2.314	0.376	-2.040	0.306	-2.022	0.325	-4.036	0.385
μ_d^m	$\mathcal{TN}(2,2^2)$	-	-	-	-	-	-	2.235	0.298
μ_0^x	$\mathcal{N}(ln\hat{V}-1,2^2)$	1.269	0.082	0.852	0.069	0.804	0.076	0.776	0.078
μ_d^x	$\mathcal{TN}(2,2^2)$	-	-	0.995	0.121	1.114	0.114	1.191	0.101
ϕ_{11}^m	$\mathcal{N}(0.9,0.5^2)$	0.528	0.131	0.502	0.113	0.827	0.042	0.859	0.034
ϕ_{12}^m	$\mathcal{N}(0,1^2)$	-0.218	0.090	-0.064	0.120	0.035	0.090	0.067	0.120
ϕ_{21}^x	$\mathcal{N}(0,1^2)$	-0.205	0.073	0.003	0.100	-0.063	0.086	-0.023	0.089
ϕ_{22}^x	$\mathcal{N}(0.9,0.5^2)$	0.830	0.052	0.838	0.046	0.876	0.026	0.814	0.044
$\phi_{23,0}^x$	$\mathcal{N}(0,0.1^2)$	-0.198	0.020	-0.245	0.024	-0.187	0.031	-0.255	0.024
$\phi_{23,1}^x$	$\mathcal{N}(0,0.1^2)$	-	-	-	-	-0.223	0.031	-	-
ρ	$\mathcal{TN}(0,1^2)$	-0.026	0.217	-0.195	0.258	-0.026	0.255	-0.085	0.298
${\sigma^2}_m$	$\mathcal{IG}(5,0.05)$	0.042	0.010	0.043	0.011	0.015	0.003	0.016	0.004
${\sigma^2}_x$	$\mathcal{IG}(5,0.05)$	0.068	0.013	0.054	0.013	0.015	0.005	0.013	0.004
π_{00}^m	$\mathcal{B}e(98,2)$	-	-	-	-	-	-	0.979	0.006
π_{11}^m	$\mathcal{B}e(98,2)$	-	-	-	-	-	-	0.980	0.006
π_{00}^x	$\mathcal{B}e(98,2)$	-	-	0.986	0.004	0.987	0.005	0.988	0.004
π_{11}^x	$\mathcal{B}e(98,2)$	-	-	0.982	0.005	0.983	0.005	0.978	0.006
log(ML)		-4,105.9		-4,101.3		-4,105.5		-4,107.2	

Notes: Refer to Eqs. (3.8), (3.9), (3.11), and (3.12). Model A assumes no regime changes. Model B assumes a regime change in μ^s only. Model C assumes regime changes in μ^s and ϕ_3^x. Model D assumes regime changes in μ^s and μ^m. The value of log(ML) refers to the log of marginal likelihood. The sample period ranges between the week of January 4, 1980 and the week of May 26, 2017. A total of 100,000 particles are used to obtain the estimates. The values of $ln\hat{M}$ and $ln\hat{V}$ represent the logs of the sample mean and variance of y_t. The truncated normal distributions for μ_d^m and μ_d^x are defined between 0 and infinity. The truncated normal distribution ρ is defined between -1 and 1.

Figure 3.4: Time series of the stock return, volatility, and regime probability



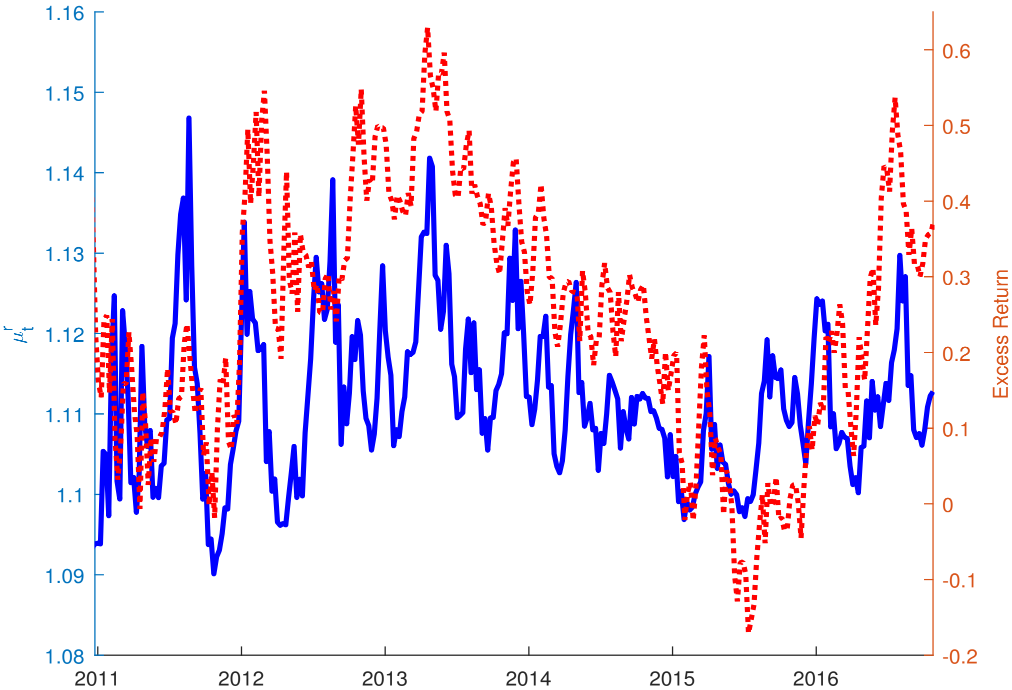
Notes: The sample period ranges from the week of 1980/01/04 and 2017/05/26. Stochastic volatility refers to the extracted $exp(x_t)$. High volatility regime depicts the probability of the estimated switches in regimes.

the average excess return, whereas the blue solid line is the extracted μ_t^r from the data. For a better comparison of the movements in the average excess return and the estimated μ_t^r, we report the result for the latter sample period from the week of August 12, 2011 to the week of May 26, 2017. Given that the sample period starts from 1980, we conjecture that there is sufficient information to accurately estimate μ_t^r by August of 2011. Using a slightly earlier or slightly later date than August 2011 does not substantially change our finding. Figure 3.5 shows that there is a similarity in the long-term movements between the two series. Even though the magnitude of fluctuation may be different, the overall vertical movements of these two series co-align with each other.[17] The overall comparison result indicates that the estimated μ_t^r can accurately capture the behaviors of the average excess return.

In addition, we report the posterior means and standard deviations of model parameters at the terminal time period in Table 3.2. While the parameters that represent persistence, ϕ_{11} and ϕ_{22}, are significant, other parameters that govern inter-temporal relationships between the conditional mean and volatility, ϕ_{12} and ϕ_{21}, are not significant. Even if the trade-off between risk and return is not our direct concern, the empirical result may be the consequence of the intrinsically inconclusive evidence on the risk-return relation in the return data, which has been actively discussed in the previous literature. For instance, Ghysels et al. [2005], Lundblad [2007], and Ludvigson and Ng [2007] show a positive risk-return trade-off, whereas Nelson [1991], Glosten et al. [1993], and Brandt and Kang [2004] present a negative risk-return trade-off.

[17] We also experiment with the monthly excessive return instead of the yearly, and the result does not change.

Figure 3.5: Comparison of Yearly Average Excess Return and Filtered μ_t^r



Notes: The solid blue line is for the estimated μ_t^r, while the red dashed line is the for the yearly average excess return. The graph depicts the periods between August 12, 2011 and May 26, 2017.

3.4 Conclusion

In this paper, we propose a novel online estimation method for regime-switching state space models. Particularly, we improve the estimation performance of the existing method developed by Carvalho and Lopes [2007] by utilizing all of the available and most recent information when re-sampling existing particles and generating new particles. Empirically, we apply the proposed method to understand the dynamics of the conditional mean and volatility of U.S. excess stock market returns under a regime switching framework. Our empirical findings indicate that the model that incorporates regime-switching (particularly in the volatility process) is the most viable candidate for correctly capturing the stock return movement.

Our new approach opens doors for future research. Namely, a combination of a full parameter learning approach (e.g., sufficient statistics) in Carvalho et al. [2010] with our proposed approach of handling the regime index variable may offer a more reliable estimation method for various regime switching models. Additionally, it would be interesting to merge more refined SMC smoothing methods of Yang et al. [2017] with our proposed algorithm.

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