Essays on International Capital Flows

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Abstract

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This dissertation consists of three essays on international capital flows. The first chapter documents the accumulation of foreign exchange reserves and the simultaneous increase in the foreign direct investment (FDI) for emerging market economies. The second chapter discusses the performance of FDI firms and domestic firms in creating jobs using firm-level data from Orbis. The third chapter studies the proper exchange rate and monetary policy when emerging market economies denominate their external debt in foreign currencies.

In Chapter 1, I study why emerging market economies hold high levels of foreign exchange reserves. I argue that foreign exchange reserves help emerging markets attract foreign direct investment. This incentive can play an important role when analyzing central banks' reserve accumulation. I study the interaction between foreign exchange reserves and foreign direct investment to explain the level of reserves using a small open economy model. The model puts the domestic entities and international investors in the same picture. The optimal level of the reserve-to-GDP ratio generated by the model is close to the level observed in East Asian economies. Additionally, the model generates positive co-movement between technology growth and the current account. This feature suggests that high technology growth corresponds to net capital outflow, because of the outflow of foreign exchange reserves in attracting the inflow of foreign direct investment, thus providing a rationale to the 'allocation puzzle' in cross-economy comparisons. The model also generates positive co-movement between foreign exchange reserves and foreign debt, thus relating to the puzzle of why economies borrow and save simultaneously.

In Chapter 2, joint work with Sakai Ando, we study whether FDI firms hire more employees than domestic firms for each dollar of assets. Using the Orbis database and its ownership structure

information, we show that, in most economies, domestic firms tend to hire more employees per asset than FDI firms. The result remains robust across individual industries in the case study of the United Kingdom. The analysis shows that an ownership change itself (from domestic to foreign or vice versa) does not have an immediate impact on the employment per asset. This result suggests that different patterns of job creation seem to come from technological differences rather than from different ownership structures.

In Chapter 3, I investigate how the devaluation of domestic currency imposes a contractionary effect on small open economies who have a significant amount of debt denominated in foreign currencies. Economists and policymakers express concern about the "Original Sin" situation in which most of the economies in the world cannot use their domestic currencies to borrow abroad. A devaluation will increase the foreign currency-denominated debt measured in the domestic currency, which will lead to contractions in the domestic economy. However, previous literature on currency denomination and exchange rate policy predicted limited or no contractionary effect of devaluation. In this paper, I present a new model to capture this contractionary devaluation effect with non-financial firms having foreign currency-denominated liabilities and domestic currency-denominated assets. When firms borrow from abroad and keep part of the asset in domestic cash or cash equivalents, the contractionary devaluation effect is exacerbated. The model can be used to discuss the performance of the economy in interest under exchange rate shocks and interest rate shocks. Future directions for empirically assessing the model and current literature are suggested. This assessment will thus provide policy guidance for economies with different levels of debt, especially foreign currency-denominated debt.

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To my beloved family,

Yuying Liu, Fagang Wang, Xiao Xu

You make everything possible.

Chapter 1: Foreign Direct Investment and Foreign Reserves Accumulation

1.1 Introduction

In recent decades, there has been rapid growth in foreign exchange reserves (RX)[1] held by emerging market (EM) economies. The average level of foreign exchange reserves for EM economies has increased from below 10% of GDP in the 1980s to more than 20% of GDP in recent years.

The widely accepted traditional motives for reserve accumulation are to cushion exchange rate volatility and prevent extreme events, for example, the 1994 Mexico peso crisis and the 1997 Asian Crisis. These motives have been explored in multiple strands of literature, for instance, Jeanne and Rancière (2008) and Obstfeld, Shambaugh and Taylor (2009). However, although the literature finds that reserves help stabilize the exchange rate and reduce the probability of a crisis, the general conclusion is that certain economies, such as the East Asian economies, hold excessive RX. In other words, based on the existing traditional motives, the probability of a crisis needs to be unrealistically high to justify the reserve level observed in some economies. Because reserve assets are liquid and pay low returns, holding reserves incurs a substantial opportunity cost. Whether we can explain the large accumulation of foreign reserves for some economies remains a puzzle.

In this paper, I study a novel channel to rationalize the accumulation of foreign exchange reserves and discuss the macroeconomic implications. My argument is based on the idea that reserves can reduce an economys perceived risk among foreign investors and thus have first-order effects in attracting foreign investment, specifically in the form of foreign direct investment (FDI). In other words, both foreign investors and recipient economies know that reserves can serve as a buffer against a currency crisis or exchange rate movement. Provided that foreign investors have limited information on private firms in EM economies, which is common for EM economies with under-

[1] Foreign exchange reserves refer to cash or cash equivalents, liquid assets held by economies' central banks, mostly denominated in USD or EURO.

developed financial markets and less transparent regulations, reserves can be a tool that central banks can employ to send positive signals to foreign investors and thus impact the latters investment decisions. Central banks choose to place domestic resources in low-yield assets and attract external investment because they value the productivity gain provided by foreign investors, which is a commonly discussed feature of FDI.

I first present a set of stylized facts regarding the relationships connecting reserves and FDI. I show that reserve assets and FDI liabilities have both increased tremendously for EM economies in recent decades. Reserve assets have grown to be the most significant component of the external asset position of EM economies, and FDI liabilities have risen to be the most significant component of their external liability position. There are robust positive correlations between reserves and FDI across different measures.

I then build a small open economy model to specifically study the incentive of holding reserves to attract FDI inflow in explaining the level of foreign exchange reserves. The model features a two-way interaction between domestic recipient firms seeking foreign investment and foreign investors seeking yield. Since foreign investors do not have complete information on the recipient economies, they expect a high level of reserves to reduce the volatility of the risk of the economy, which I show is present in the data by using reserve levels and stock returns. The inflow of foreign investment contributes to a higher level of domestic productivity. The information conveyed by the reserve assets to foreign investors and the benefits of foreign investment provide central banks incentives to allocate a large amount of domestic resources to reserve assets. I calibrate the model to the average level of EM economies and show that the optimal reserves generated by this incentive can be more than 20% of GDP, suggesting that this incentive can make up for the gap between the reality and the optimal level of reserves reported in the previous literature.

Another key feature of this mechanism described in this paper is that it can speak to an international macroeconomics puzzle called the 'allocation puzzle' identified by Gourinchas and Jeanne (2013). The allocation puzzle refers to the empirical observation of a negative correlation between the net flow of capital into countries and the technology growth of economies. Economies with higher average technology growth over the 1980-2000 period experienced lower average net capital inflows, which contradicts the standard neoclassic growth model. However, this phenomenon can be explained by the incentive for accumulating reserve assets and attracting foreign investment. Given a technology improvement, there is indeed larger capital inflows into an economy for the purpose of accumulating capital stock. However, there is simultaneously an outflow coming from the accumulation of reserve assets to encourage more private capital inflow. The public capital outflow and private capital inflow yield a net negative correlation between net capital inflow and technology growth. This is also observed in the data if I decompose the capital flows into FDI inflow and reserve outflow. The key mechanism in the model can generate the same pattern as cited in the allocation puzzle, both at the aggregate level and after decomposing the capital flows.

In the following sections of the chapter, I first review the status quo of the research on foreign reserves and FDI in section 1.2. Then, I present empirical motivations for this work in section 1.3, where I examine the relationships between foreign reserves and FDI in the data. Next, I present the model in section 1.4 and provide evidence for the model's key mechanism. The calibration of the model is explained in section 1.5. The equilibrium level of reserves and its relationship with the key mechanism in the model are discussed in section 1.6. Section 1.7 provides the dynamics generated by the model following shocks. Section 1.8 discusses the allocation puzzle in detail by comparing the pattern generated in the model and the pattern in the data. Finally, section 1.9 discusses the general business cycle moments of the model.

1.2 Literature review

This paper mainly relates to the strands of literature on foreign exchange reserves, FDI, and the correlations between capital flows in open economies. I will briefly summarize each strand of research and discuss their connections with this paper.

The literature on foreign reserves has focused on the precautionary saving motive, reducing the probability of a currency crisis and a capital flow crisis and stabilizing the exchange rate. Reducing the probability of a crisis and precautionary saving are often intertwined and examined jointly in the literature. Frankel and Saravelos (2010) claim that reserve accumulation and past movements in the real exchange rate were the two leading indicators of the varying incidence of the Global Financial Crisis. Adopting a broader focus, Gourinchas and Obstfeld (2011) use panel analysis across countries and across time to conclude that higher foreign reserves are associated with a reduced probability of crisis in EMs. Obstfeld, Shambaugh and Taylor (2009) documents that having reserves in excess of predicted levels is associated with smaller subsequent nominal exchange rate depreciation after 2008. Jeanne and Rancière (2008) uses a model to discuss the optimal level of international reserves for a small open economy that is vulnerable to sudden stops in capital flows. Reserves allow a country to smooth domestic absorption in response to sudden stops. They conclude that existing theory can explain the level of reserves observed in many countries, but the trend of accumulating reserves observed in EM economies appears excessive. The purpose of my paper is to propose a new explanation of holding reserves for EM economies, in an effort to reconcile the optimal reserve level predicted by theory and that observed in the data, and simultaneously explain other patterns of capital flows in the data.

Another strand of literature focuses on the question of why countries save through reserves while simultaneously accumulating external debt. Although previous works argue that high levels of reserve reduce the risk of crisis, EM economies can naturally avoid the risk of potential sudden stops and insolvent situations by reducing the level of debt instead of holding reserves. Alfaro and Kanczuk (2009) constructs a model in which both debt and reserves are imperfect substitutes to shift resources from repayment states to default states. However, the optimal strategy in that model is not to hold reserves at all. Bianchi, Hatchondo and Martinez (2018) add borrowing through long-term debt to the former model. In this setup, the country has incentives to borrow when the borrowing cost is low and deleverage when the borrowing cost is high. In my model, I show that without resorting to long-maturity debt, there is co-movement between external debt and reserves. The central bank has the incentive to finance the accumulation of reserves through high-spread external debt because of the reserves' impact on private capital flows.

The paper further relates to the literature on reserves and exchange rate volatility. The signaling effect of reserves in reducing investment risk in EM economies can work through stabilizing the exchange rate, which leads to less volatile returns. There is vast literature suggesting that reserves stabilize the exchange rate. Nowak, Hviding and Ricci (2004) study the role of an increase in foreign exchange reserves in reducing currency volatility for EM countries. Their results provide support for the proposition that holding adequate reserves reduces exchange rate volatility. The effect is nonlinear and appears to operate through a signaling effect. Cady and Gonzalez-Garcia (2007) find that reserve adequacy is significant in determining exchange rate volatility for both EM and industrialized countries. Aizenman and Riera-Crichton (2008) observe that international reserves cushion the impact of terms-of-trade shocks on the real exchange rate and that this effect is essential for developing but not for industrialized countries. Eichler and Littke (2018) find that country pairs with higher levels of foreign exchange reserves exhibit less exchange rate volatility.

This paper relates to the FDI literature by addressing one of the main characteristics studied by that literature: FDI increases the productivity of recipient countries. Aitken and Harrison (1999) finds that foreign equity participation is positively correlated with plant productivity for small enterprises. There is a productivity gain from foreign ownership but the little spillover effect. Blonigen and Wang (2004) and Melitz, Helpman and Yeaple (2004) find that export platform FDI may have a potentially larger effect on growth. Bloom, Sadun and Van Reenen (2012) study US multinationals operating in the EU in sectors that intensively use information technology (IT). These sectors in the EU experienced the same level of productivity growth as the US. In general, the literature has observed an increase in productivity from FDI due to the transfer of the investors' technology to the firms of the recipient economies.

There is little literature on the interaction of FDI and RX. Matsumoto (2018) builds on Benigno and Fornaro (2012) in modeling that accumulating reserves depreciates the real exchange rate, which leads to a shift in domestic production to the tradable sector. This will attract FDI into the tradable sector, which leads to higher productivity gains. My paper does not rely on the distinction between the tradable and non-tradable sectors and focuses more on the signaling gain due to reserves without relating it to the first-order effect of devaluating the exchange rate. I isolate the channel of the potential second-order effect by stabilizing the return on investment for foreign investors through reserve accumulation. Huang (2018) discusses the joint impact of a high level of reserves and a high level of FDI stock in China from the perspective of the investment return of the country. He gathered data from top banks in China and stock market information to calculate the market value of reserve assets and FDI liability. He then showed that the return on equity in China is higher than the return from reserve asset investment. My paper argues that reserves do not serve as an investment device but rather as a signaling device.

This paper also speaks to the research on capital flows of EMs, mainly the 'allocation puzzle', and can provide an explanation for that puzzle based on the main mechanism of the model. Gourinchas and Jeanne (2013) discuss the phenomenon of a negative correlation between the net flow of capital into an economy and its technology growth, which they call the 'allocation puzzle'. Alfaro, Kalemli-Ozcan and Volosovych (2014) further documents the public and private flows and demonstrates that sovereigntosovereign transactions account for upstream capital flows and global imbalances. Dooley, Folkerts-Landau and Garber (2004) describes how international reserves can be interpreted as a form of collateral for FDI flows to less developed economies. This causes the outflow of capital for EMs in the form of reserve assets and the inflow of capital in the form of FDI liability, which is called the 'Bretton Woods 2' system. The Bretton Wood 2 system is not quantified and is based only on the rough description of potential channels. However, it can be falsified by decomposing the reserve assets flowing into a certain economy and the FDI liabilities coming from a certain economy to see if they match each other proportionally, that is, whether the economies that receive larger reserve inflows provide more FDI. My paper differs from the Bretton Woods 2 concept in that it does not impose the insurance role of reserve assets but models reserves as a coordinating device for both investors and recipient economies and provides evidence for this mechanism. The signals do not work by directly providing collateral to a certain economy but generally indicate the economic conditions of the recipient country. Aguiar and Amador (2011) adopts a political economy setup that can also speak to the allocation puzzle in which there is a limited commitment from the governments' debt. Foreign investors would only let capital flow to countries with lower debt levels. Since political parties prefer spending to occur when they are in office to reduce the chance of losing their positions, there is a trade-off between borrowing to consume today and paying off external debt to let capital flow into the country and allow higher consumption in the future. This gives rise to the phenomenon whereby economies that grow rapidly tend to increase their net foreign asset position to encourage other forms of capital inflow. Thus, there is a net reduction in public debt combined with an inflow of private capital in fast-growing economies and the reverse in shrinking economies. My paper differs in that an increased net asset position means higher reserve accumulation instead of a lower debt level. Borrowing is used to accumulate reserves to encourage more FDI instead of more consumption.

1.3 Empirical analysis

In this section, I will show some empirical evidence on the status quo of the levels of reserves and levels of FDI liabilities for emerging market economies. I will also put the two capital flows in the same pictures and show the connections between the two.

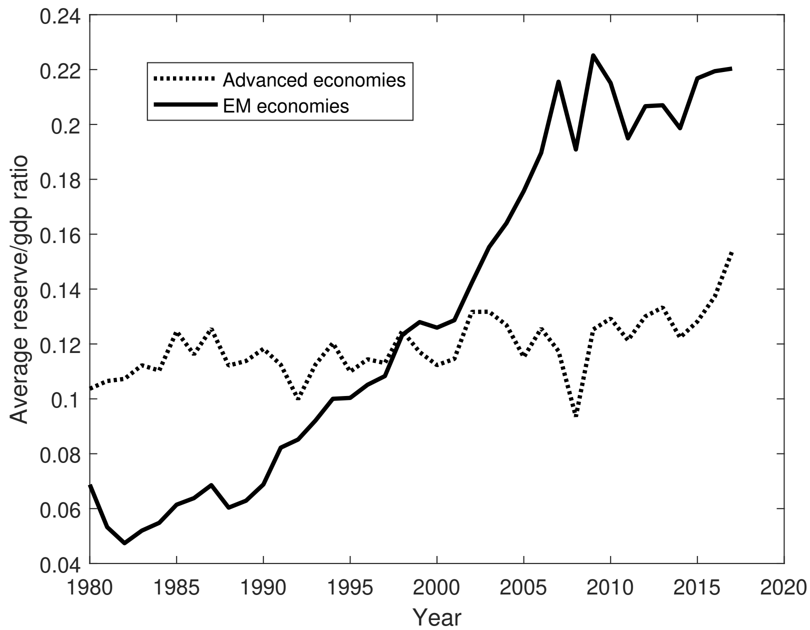
1.3.1 Aggregate trend of reserves and FDI

The amount of foreign reserves held by EM economies has grown in the past 30 years. Figure 1.1 shows the average reserves-to-GDP ratio[2] for EM economies and advanced economies over the period 1980-2017. The average reserves-to-GDP ratio for EM economies tripled in recent decades, from below 0.1 in the early 1980s to more than 0.2 in recent years. The ratio has remained relatively stable for advanced economies, with an average of approximately 0.1-0.15 in recent years.

Another indicator that reveals the adequacy of EM economies' reserves is the short-term-debt-to-reserves ratio. Although policymakers have long discussed the optimal amount of reserves that EM economies should hold, there is no consensus on this question. The IMF has rule-of-thumb guidelines for reserve holdings according to which a country should hold foreign reserves in an amount equal to their short-term debt liability. This rule can ensure that the economies are able

[2] The average for 33 EM economies and 47 advanced economies. The full set of countries is listed in the appendix

Figure 1.1: Reserves-to-GDP ratio, average for advanced economies and EM economies

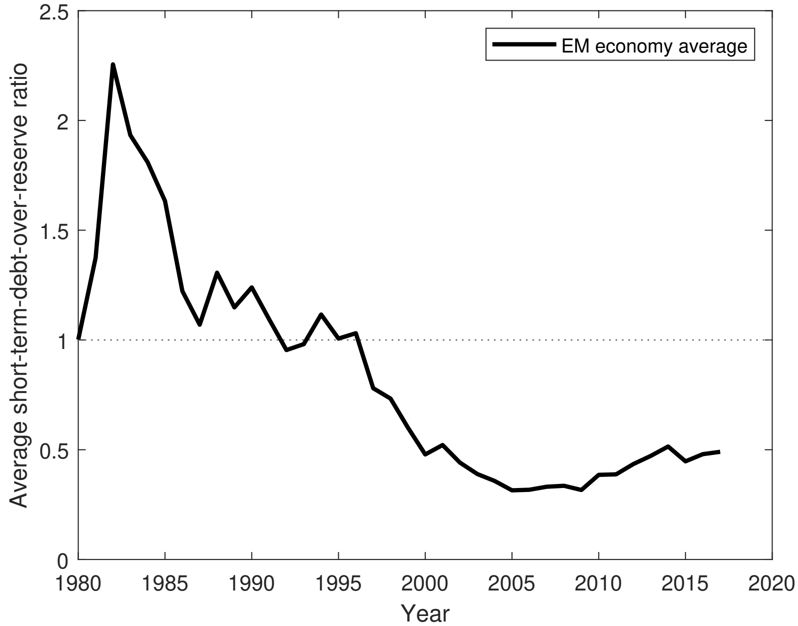


Note: This figure plots the average reserves-to-GDP ratio for 33 EM economies and 47 advanced economies from 1980 to 2017
Source: World Bank WDI

to repay their short-term debt and avoid insolvency when facing sudden stops in financing. These sudden stops refer to periods when economies are not able to secure capital inflow or roll over debt. However, the amount of reserves held by EM economies has far exceeded their short-term debt. Their average level of reserves is nearly four times that of their total short-term external debt. Figure 1.2 plots the average short-term debt-to-reserves ratio for EM economies. A value greater than one indicates that the short-term debt exceeds the amount of reserves, while a value smaller than one value indicates the opposite. Short-term debt exceeded reserves before 2000. By contrast, reserves have exceeded short-term debt for the past ten years, and the ratio suggests that the amount of reserves is three times that of short-term debt.

As reserves have grown to become a large proportion of the assets of EM economies, FDI has become their most significant form of liability. Figure 1.3 plots the components of the gross liability and gross asset positions of EM economies in recent decades. The positive y-axis plots the decomposition of the gross asset position. It has been growing in size since the late 1990s. Meanwhile,

Figure 1.2: Short-term-debt-to-reserves ratio, average for all EM economies



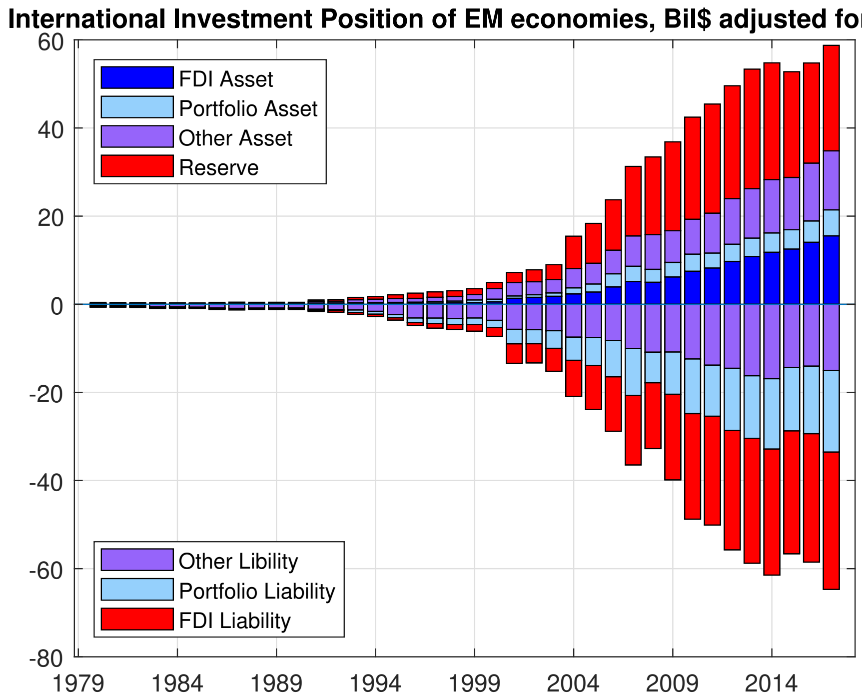
Note: This figure plots the average short-term debt as a percentage of foreign reserves for EM economies from 1980 to 2017.
Source: World Bank WDI

reserve assets have taken up an increasing share of the gross asset position, suggesting that EM economies mainly save through reserves. The negative y-axis plots the decomposition of the total liability position, of which FDI liability is the major component. FDI has in conjunction with the size of the liability of EM economies and has constituted half of their external liability in recent years. This suggests that FDI inflow has been the main form of capital inflow into EM economies. This graph indicates that as these economies gradually build up their balance sheets, both reserves and FDI have become significant parts. When analyzing the behavior of capital inflows and outflows of EM economies, it is important to closely examine to the most significant asset (reserves) and the most significant liability (FDI).

1.3.2 Correlation between foreign exchange reserves and FDI

Having examined the trends in the RX and FDI series in recent decades, I can put them in a single analysis and explore the interactions between them. A positive correlation between reserves and

Figure 1.3: Asset and liability decomposition of emerging market economies



Note: This figure plots the gross asset and gross liability decomposition for EM economies.
Source: IMF International Financial Statistics (IFS)

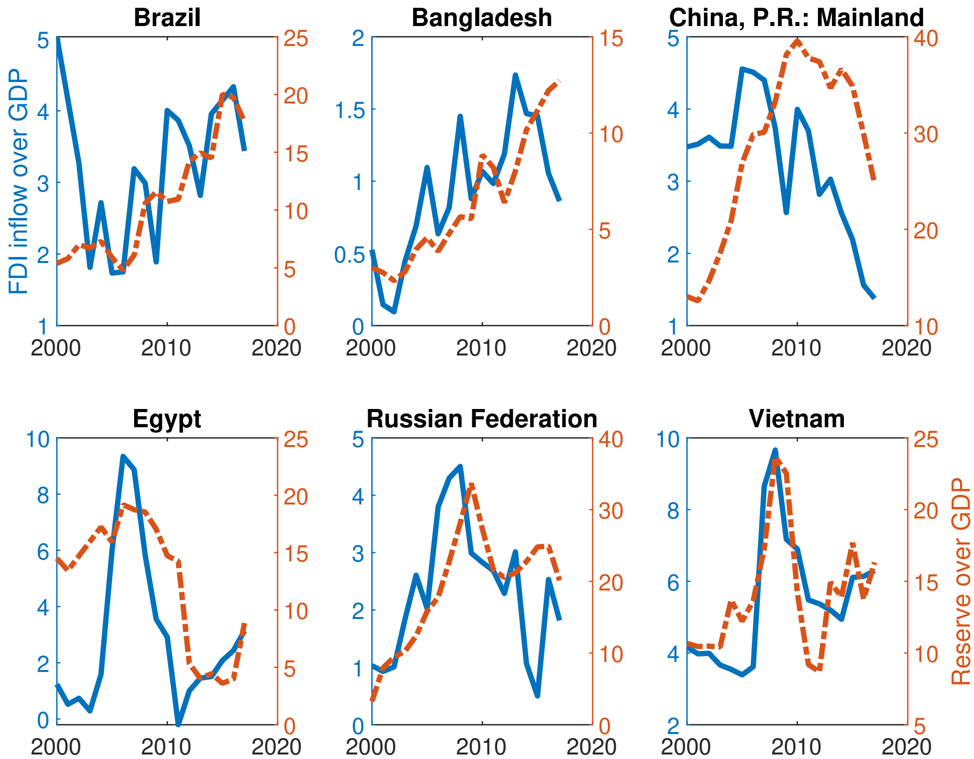
FDI can be established through different specifications and definitions of variables. This relationship is robust across all analyses. The five different specifications showing the positive correlation between FDI and reserves are summarized below.

Co-movement of reserves and FDI inflow in major EM economies

Figure 1.4 plots the co-movement of the reserves-to-GDP ratio[3] and FDI-inflow-to-GDP ratio for six major EM economies. These economies have high levels of the reserves-to-GDP ratio, ranging from 20% to 50% in recent years. The inflow of FDI in each year is also substantial, ranging from 0.5% to 10% of GDP. Within each economy, the periods with a high reserves-to-GDP ratio are also the periods with a high FDI-inflow-to-GDP ratio.

[3]Unless otherwise stated, all the empirical analyses take the reserves-to-GDP ratio to be the lagged reserves divided by current GDP.

Figure 1.4: Co-movement between FDI inflow and reserves



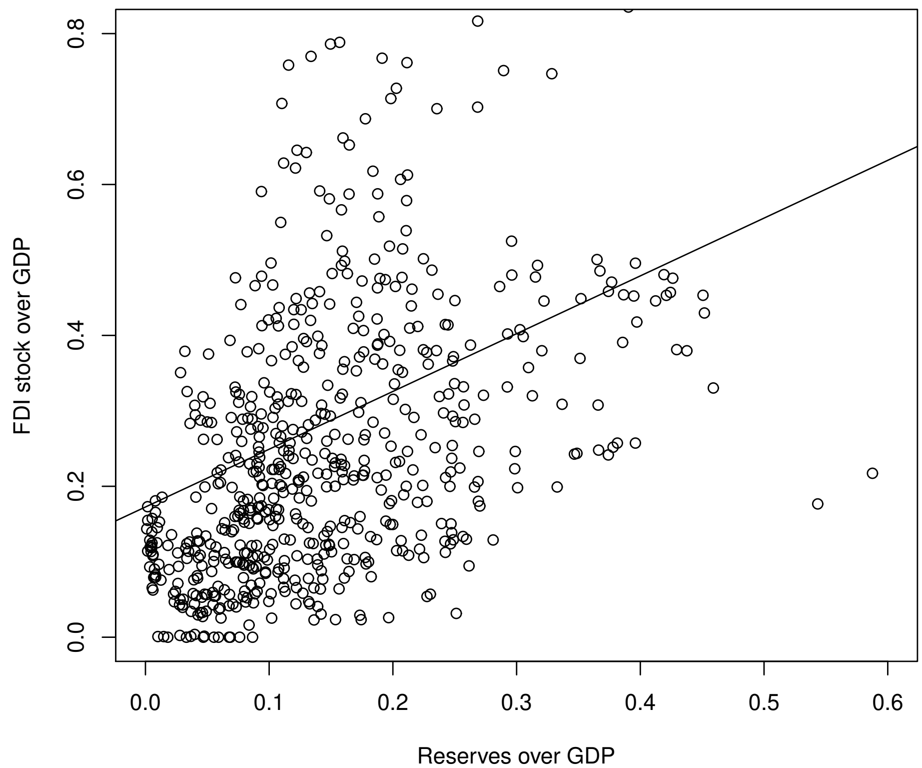
Note: This figure plots the reserve-to-GDP ratio and FDI-inflow-to-GDP ratio for six major EM economies.
Source: IMF IFS and World Bank WDI

Cross-economy and cross-time analysis of the FDI-stock-to-GDP ratio and reserve-to-GDP ratio

I can apply this analysis to a broader set of economies by examining the correlation between the reserves-to-GDP ratio and FDI-stock-to-GDP ratio across economies and years. Figure 1.5 plots the FDI-stock-to-GDP ratio on the y-axis and the reserves-to-GDP-ratio on the x-axis for all EM economies in the sample. Each dot represents a country-year combination. The figure suggests a robust positive correlation between the two variables; across economies and over time, higher savings in foreign reserves correspond to higher 'borrowing' in FDI.

There are analyses in other dimensions to show the positive correlation between to two variables, for example, the economies with larger changes in reserves asset position correspond to the ones

Figure 1.5: Positive correlation between FDI stock and reserves



Note: This scatter plot shows the reserves-to-GDP ratio and FDI-stock-to-GDP ratio for 33 EM economies for the period 1980-2017. Each dot represents a economy-year combination
Source: IMF IFS and World Bank WDI

with larger changes in FDI liability position. They are included in the Appendix A.1.2 for further reference.

Strong positive correlation between RX/GDP and FDI/GDP

This positive correlation between FDI and reserves can be further illustrated with a reduced-form regression by specifying the following model:

$$\frac{FDI_{it}}{GDP_{it}} = \beta_1 + \beta_2 \frac{RX_{it-1}}{GDP_{it}} + a_t + c_i + u_{it}$$

Table 1.1 reports the results of regressing the FDI-stock-to-GDP ratio on the one-period-lagged reserves-to-GDP ratio. The four specifications correspond to no fixed effects, time fixed effects, economy fixed effects and both fixed effects. The table suggests that across all specifications, the FDI-stock-to-GDP ratio and reserves-to-GDP ratio have strong positive correlations. A 1 unit increase in the reserves-to-GDP ratio correlates significantly with a 0.4-1 unit increase in the FDI-stock-to-GDP ratio, depending on the specification.

Table 1.2 reports the corresponding analysis by taking the FDI-inflow-to-GDP ratio as the dependent variable in the empirical specification. A 1 unit increase in the reserves-to-GDP ratio correlates significantly with a 0.02-0.076 unit increase in the FDI-inflow-to-GDP ratio. These observations will also be discussed later in the model calibration part of the paper.

As robustness checks, other factors that are commonly considered to be determinants of FDI liabilities are included in the regression equation. The full set of results is reported in the Appendix A.1.3. The results suggest that this positive correlation is robust to the inclusion other control variables. I also include one empirical specification in which the dependent variable is changed to the FDI-stock-to-total-liability ratio. The positive and significant correlation suggests that a high level of the reserves-to-GDP ratio also correlates with a high FDI liability as a percentage of total liability, suggesting that a larger fraction of the 'borrowing' of the economy is in the form of FDI.

Table 1.1: Regression of FDI stock/GDP on Reserves/GDP

	Dependent variable: FDI stock/GDP			
	(1)	(2)	(3)	(4)
$\text{Res}_{it-1}/GDP_{it}$	0.552***	0.369***	1.097***	0.417***
	(0.054)	(0.033)	(0.100)	(0.056)
Time fixed effect	No	Yes	No	Yes
Country fixed effect	No	No	Yes	Yes
Observations	618	618	618	618
R^2-Standard	0.144	0.292	0.695	0.834

Note: Standard errors are clustered at the economy and time levels **p<0.05; ***p<0.01

Table 1.2: Regression of FDI inflow/GDP on Reserves/GDP

	Dependent variable: FDI inflow/GDP			
	(1)	(2)	(3)	(4)
$\text{Res}_{it-1}/GDP_{it}$	0.076***	0.054***	0.043***	0.020**
	(0.017)	(0.012)	(0.013)	(0.009)
Time fixed effect	No	Yes	No	Yes
Country fixed effect	No	No	Yes	Yes
Observations	998	998	998	998
R^2-Standard	0.101	0.221	0.384	0.487

Note: Standard errors are clustered at the country and time levels **p<0.05; ***p<0.01

All empirical investigations consistently suggest positive co-movement between the level of FDI stock/inflow and the level of reserves. This positive correlation is the feature that will be built into the model to explain the high level of reserves held by EM economies.

1.4 The model

1.4.1 Households

The economy is assumed to be populated by a large representative family with a continuum of members. Consumption is identical across family members. Household preferences are defined over per capita consumption, c_t, and are described by the utility function

$$E_0\{\sum_{t=0}^{\infty}\beta^t U(c_t)\} \tag{1.1}$$

where $\beta \in (0,1)$ represents a subjective discount factor, and U is a period utility index assumed to be strictly increasing and strictly concave.

Households have access to a bond issued by central bank, b_t^H, which pays the gross interest rate R_{t-1}^H when held from $t-1$ to t. The household can hold positive or negative quantities of this bond. When the quantity is positive, the household is lending to the central bank. When the quantity is negative, the household is borrowing from the central bank. The household also receives dividends from the ownership of producing firms, denoted Π_t. The household's period-by-period budget constraint is given by:

$$c_t + b_t^H = R_{t-1}^H b_{t-1}^H + \Pi_t \tag{1.2}$$

Households take R_t^H and Π_t as given. In the model, households do not have access to the international financial market, and their only access to borrowing and saving is through b_t^H.

The household chooses processes for c_t and b_t^H to maximize the utility function (1.1) subject to (1.2). The Lagrangian associated with this maximization problem is

$$L = E_0(\sum_{t=0}^{\infty} \beta^t \{U(c_t)) + \lambda_t^{1d}(R_{t-1}^H b_{t-1}^H + \Pi_t - c_t - b_t^H)\}$$

where λ_t^{1d} represent the Lagrangian multiplier of equation (1.2). The first-order conditions with respect to c_t and b_t^H are,respectively, given by

$$U'(c_t) - \lambda_t^{1d} = 0 \tag{1.3}$$

$$\lambda_t^{1d} = \beta E_t\{\lambda_{t+1}^{1d} R_t^H\} \tag{1.4}$$

1.4.2 Firms

The economy is also populated by a representative firm that makes investment and production decisions. The production technology is given by

$$y_t = A_t k_t^{\alpha} \tag{1.5}$$

where A_t is an exogenous technology process, k_t denotes physical capital and the parameter $\alpha \in (0, 1)$. Capital depreciates at rate δ and firms will invest to build capital for the next period, so that

$$k_{t+1} = (1-\delta)k_t + i_t \tag{1.6}$$

where i_t denotes investment.

Firms need to decide whether to finance the investment through equity, which is FDI i_t^F, or debt, which is domestic investment i_t^H. Total investment is a function of both i_t^F and i_t^H. The investment aggregator $F(i_t^H, i_t^F)$ is increasing and concave in both elements.

$$i_t = F(i_t^H, i_t^F) \tag{1.7}$$

If the firm uses domestic investment, it needs to borrow from the central bank at an interest rate R_t^i and will need to repay the principal and interest in the next period. If the firm uses foreign investment i_t^F, it correspondingly needs to sell a new share $\frac{i_t^F}{k_{t+1}}$ to foreign investors and repay a share of the profit to foreign investors in the next period. The total share of the firm x_t owned by foreign investors also depreciates at rate δ, the depreciation rate of capital. The evolution of the shares held by foreign investors is thus given by

$$x_t = (1-\delta)x_{t-1} + \frac{i_t^F}{k_{t+1}} \tag{1.8}$$

To capture the advantage of using FDI i_t^F over domestic investment i_t^H, the productivity A_t is modeled as an increasing function of the existing FDI inflow from last period i_{t-1}^F

$$A_t = F(i_{t-1}^F) = A_{t,3} + A^1 (\frac{i_{t-1}^F}{i_{ss}^F})^{A_{t,2}} \tag{1.9}$$

where A_1 is a parameter and A_t^2 and A_t^3 are two exogenous processes. i_{ss}^F refers to the steady-state level of foreign investment. The firm also pays a proportional tax on its foreign investment i_t^F in each period at rate τ_t and receives a lump-sum transfer from the government T_t

Under these assumptions, the profit of the firm after paying dividends to the foreign investors in period t is given by

$$\Pi_t = (1 - x_{t-1})(A_t k_t^{\alpha}) - R^i_{t-1} i^H_{t-1} + T_t - \tau_t i^F_t \tag{1.10}$$

where the firm pays dividends to the foreign investors $x_{t-1} A_t k_t^{\alpha}$, repays the debt $R^i_{t-1} i^H_{t-1}$ from borrowing from the central bank in the previous period $t-1$, is subject to a tax/transfer T_t from the government and pays a proportional tax for inducing foreign investment $\tau_t i^F_t$.

The firm thus chooses processes for k_{t+1}, i_t, x_t, i^H_t, i^F_t to maximize the present discounted value of dividends, subject to equations (1.6)–(1.9), replaces A_t with equation (1.9), and takes τ_t, T_t, R^i_t as given.

$$max_{\{i_t, k_{t+1}, x_t, i^H_t, i^F_t\}} E_0 \sum_{t=0}^{\infty} M_{0,t} \Big((1 - x_{t-1}) A_t k_t^{\alpha} - R^i_{t-1} i^H_{t-1} + T_t - \tau_t i^F_t \Big)$$

where $M_{0,t}$ is the stochastic discount factor between time 0 and t for firms. Since the profit is rebated to the household, $M_{0,t} \equiv \beta^t \frac{\lambda^{1d}_t}{\lambda^{1d}_0}$. Lagrangian is given by

$$L = \sum_{t=0}^{\infty} E_0 \{ M_{0,t} \Big((1 - x_{t-1}) A_t k_t^{\alpha} - R^i_{t-1} i^H_{t-1} + T_t - \tau_t i^F_t + \\ \lambda^{2d}_t ((1-\delta) k_t + i_t - k_{t+1}) + \lambda^{3d}_t (F(i^H_t, i^F_t) - i_t) + \lambda^{4d}_t ((1-\delta) x_{t-1} + \frac{i^F_t}{k_{t+1}} - x_t) \Big) \}$$

where $\lambda^{2d}_t - \lambda^{4d}_t$ corresponds to the Lagrangian multipliers of equations (1.6) - (1.8), with equation (1.9) substituted into the objective function. The first-order conditions with respect to i_t, k_{t+1}, x_t, i^H_t and i^F_t are

$$M_{0,t} (\lambda^{2d}_t - \lambda^{3d}_t) = 0 \tag{1.11}$$

$$E_t \{ M_{0,t+1} (1 - x_t) A_{t+1} k_{t+1}^{\alpha - 1} \alpha + M_{0,t+1} \lambda^{2d}_{t+1} (1 - \delta) - M_{0,t} \lambda^{2d}_t - M_{0,t} \lambda^{4d}_t \frac{i^F_t}{k^2_{t+1}} \} = 0 \tag{1.12}$$

$$E_t \{ -M_{0,t+1} A_{t+1} k_{t+1}^{\alpha} + M_{0,t+1} (1 - \delta) \lambda^{4d}_{t+1} \} = \lambda^{4d}_t M_{0,t} \tag{1.13}$$

$$E_t\{M_{0,t+1}R^i_t\} = M_{0,t}\lambda^{3d}_t F_{i^H_t} \tag{1.14}$$

$$E_t\{M_{0,t+1}(1-x_t)\frac{\partial A_{t+1}}{\partial i^F_t}k^{\alpha}_{t+1}\} + M_{0,t}\lambda^{3d}_t F_{i^F_t} + M_{0,t}\lambda^{4d}_t\frac{1}{k_{t+1}} - M_{0,t}\tau_t = 0 \tag{1.15}$$

1.4.3 Central bank and government

The central bank makes decisions on the interest rate of lending/borrowing from the households R^H_t and the interest rate of lending to firms R^i_t. The central bank's budget constraint is given by the following equation

$$\underbrace{b^H_t - b^H_{t-1}R^H_{t-1}}_{\text{Household}} - \underbrace{(i^H_t - i^H_{t-1}R^i_{t-1})}_{\text{Firms}} = \underbrace{rx_t - rx_{t-1}R^r_{t-1}}_{\text{Reserves}} - \underbrace{(b^F_t - b^F_{t-1}R^f_{t-1})}_{\text{External Debt}} \tag{1.16}$$

The interest rate on reserves R^r_t and the interest rate on foreign debt R^f_t follow two exogenous processes.

The central bank can choose to finance the accumulation of foreign reserves rx_t through foreign debt b^F_t or by suppressing domestic consumption by borrowing from households b^H_t. This is the cost of holding foreign reserves for EM economies in the model. The economy will experience temporary loss in consumption or borrow from the rest of the world at a higher interest rate than the safe interest rate paid on holding foreign reserves.

The government collects a proportional tax from the firms and then rebates it back to the firms as a lump-sum transfer

$$\tau_t i^F_t = T_t \tag{1.17}$$

1.4.4 Foreign investors

Foreign investors are the shareholders in domestic firms because they invest in the firms through FDI inflow i^F_t and obtain a share of the firm's output in the subsequent periods. An investor decides in every period how much to invest in the firms. Foreign investors do not have perfect information on the economic conditions of the recipient EM economies. According to the investors' beliefs, the level of reserves rx_t affects the volatility of the return on their investment.[4]. This is the key assumption in the model: the expected volatility of the return on FDI is a decreasing function of the level of reserves. Some empirical evidence on this assumption will be provided in the next section.

Let us assume that foreign investors face two choices of assets in each period. One is the risky asset FDI i_t^F, which foreign investors believe will pay a stochastic return, and the volatility of which depends on the level of reserves. The other is a global safe asset that always pays a constant interest rate. Then, this is an infinite-horizon portfolio allocation problem between risky and riskless assets. Allow me to deviate from the main setup of the investors' problem by assuming for the present that the FDI asset is a one-period risky asset for the foreign investors to characterize the problem and provide the explicit solution of the investors' demand for FDI.

Suppose that a foreign investor at the beginning of every period has wealth W_t; he or she needs to decide how much to consume and how much to invest in a risky asset, which is FDI in EM economies, or a risk-free asset. Let R_1 denote the gross return on the risk-free asset. Let G_t^f denote the gross risky return on the FDI asset. Investors expect lnG_t^f to follow a normal distribution $N(d_t, \sigma_t^2)$. The utility function of the investors follows a constant relative risk aversion utility function with γ being the risk-aversion parameter. a_t represents the share of wealth that investors invest in the risky FDI asset. The budget constraint and maximization function of the foreign investors are thus as follows:

$$\sum \beta^t U(C_t^i)$$

subject to

$$W_{t+1} = a_t(W_t - C_t)G_{t+1}^f + (1 - a_t)(W_t - C_t)R_1$$

[4] A simple micro-foundation of this belief is provided in the Appendix

Here, I follow the same setup as the Merton-Samuelson discrete-time portfolio allocation model. I obtain the solution that C_t^i is a constant fraction of W_t, bW_t. a_t is an explicit function of the other variables in the model:

$$a_t = \frac{E_t G_{t+1}^f - R_1 + \frac{\sigma_{t+1}}{2}}{\gamma \sigma_{t+1}}$$

The share of wealth that the investors will invest in the risky FDI asset depends on two key factors. The first is the spread between the expected return and the safe asset. The second is the volatility of the demand for the FDI investment under the assumption that FDI is a one-period asset:

$$i_t^F = a_t(W_t - C_t) = (1-b)W_t \frac{E_t G_{t+1}^f - R_1 + \frac{\sigma_{t+1}}{2}}{\gamma \sigma_{t+1}}$$

However, it is unrealistic to assume that the FDI asset only pays a one-period return. To keep the model tractable and incorporate the features of FDI, I take the functional form from the single-period payment case and apply it to the multi-period payment of FDI, which yields the following investment decision for the foreign investors:

$$i_t^F = W_t E_t \left(\frac{G_{t+1}^f}{\gamma} r x_t^{\zeta}\right) \tag{1.18}$$

where σ_{t+1} explicitly takes the form of $rx^{-\zeta}$, which is a decreasing function of the level of reserves. W_t represents the wealth of the foreign investors. G_{t+1}^f represents the return on the asset. γ is the risk aversion of the investors in their power utility function

The share owned by the investors for the newly invested i_t^F in the firm is defined as $\frac{i_t^F}{k_{t+1}}$. This share will remain in the recipient firm. Investors can obtain a series of returns for every period in the future, but the share will depreciate at the depreciation rate of capital, δ. The expected payoff is the share owned $\frac{i_t^F}{k_{t+1}}$ times the output of the firm $A_{t+1}k_{t+1}^{\alpha}$ from the next period, and the resale value takes into account the devaluation in the next period $p_{t+1}^i(1-\delta)$ over the investment made in this period i_t^F. Thus, the expected return on FDI asset G_{t+1}^f is characterized as follows:

$$E_t(G_{t+1}^f) = \frac{E_t(\frac{i_t^F}{k_{t+1}}(A_{t+1}k_{t+1}^{\alpha} + p_{t+1}^i(1-\delta)))}{i_t^F} \tag{1.19}$$

The price for the firm is the production in next period plus the discounted price of next period.

$$p_t^i = E_t(A_{t+1}k_{t+1}^{\alpha} + \beta^i p_{t+1}^i) \tag{1.20}$$

where β^i represents the discount factor for foreign investors and is endogenously given. The evolution of the wealth of investors is given by

$$W_{t+1} = (1-b)W_t - i_t^F + x_{t-1}A_t k_t^{\alpha} \tag{1.21}$$

1.4.5 What is FDI?

The setup in the model of modeling FDI liability is obviously a reduced form of modeling of the real activities related to FDI. However, I argue that this modeling captures the critical features of FDI that are of interest in this paper and its relationship linking foreign and domestic entities. I also attempt to evaluate the effect of this simplification on the main mechanism that I capture in the model.

The model simplifies the forms of private inflow into domestic firms. FDI is, in reality, defined as foreign residents owning more than 10% (voting power) of domestic firms, both directly and indirectly. Firms can take on foreign investment through portfolio investment in the form of an equity acquisition of less than 10% and through private debt flow. In the model, FDI is modeled as a foreign investment in the domestic firm via equity acquisition. The private inflow is also simplified to consist only of FDI inflow, not other equity inflows or debt instruments. This simplification is a fair representation of private inflows into EM economies in recent years. Most of the private investment in EM economies is through a direct investment relationship. I use the data from IFS to demonstrate that FDI is indeed the main form of private capital inflow into firms. IFS has decomposed the net international liability position of the economies into Direct investment, Portfolio investment and Other investment. Under Portfolio investment and Other investment, there are three subcategories of private corporations' liabilities. I calculate the share of the direct investment over the sum of direct investment and these three other corporate liability categories. The results suggest that FDI liability has increased to approximately 85% of total liabilities in recent years. This justifies my modeling choice of only including FDI liabilities for the firms.

The model also differs from the actual accounting value of FDI stocks and inflows. Based on IMF standard BPM6 and OECD standard BMD4, the recommendation for reporting FDI statistics, both stocks and flows, is that they be based on market value. However, it is challenging to produce market values of FDI positions because the equity of many direct investment enterprises is not listed. Often, the only information available to compilers is the book value available on either the books of the direct investor or the target enterprise. Thus, if market values are unavailable, FDI data at book value should be adjusted or imputed to estimate the market value. The main purpose of using market value is to enable the comparison of different forms of accounting items for the economy/firms. Due to the complexity of market value accounting and the irrelevancy of using market value to the main mechanism of the model, I do not use the market value of the firms to represent FDI inflows and stocks.

The FDI inflow into the model economy is defined as i_t^F, or the inflow of foreign investment, which is in the unit of domestic and foreign consumption goods. Since the units of reserves and foreign debts in terms of consumption goods are also one, one can compare the current account component of the economy, including the reserve flow, the debt flow and the FDI flow in the model.

The FDI stock in the model is defined as the claim on the firm's capital instead of the claim on the market value of the firm. This is to simplify the net investment position of domestic firms. Given the definition of FDI inflow in the model, the claim on domestic capital enables us to decompose the change in investment position from the change in foreign-owned FDI stock into the new inflow i_t^F and the depreciation of the claim $-\delta x_{t-1} k_{t+1}$, such that one would have $(x_t - x_{t-1})k_{t+1} = i_t - \delta x_{t-1} k_{t+1}$, which is precisely equation (1.8).

These deviations from the standard accounting of FDI do not jeopardize our main channel and the correlation analysis between different forms of capital flows.

These deviations from the standard accounting for FDI do not jeopardize our main channel or the correlation analysis between different forms of capital flows.

There are several features of FDI that the model captures and are critical for the mechanism in the model. The first is that the inflow of FDI is influenced by the reserve level. This is to capture the advantages of foreign investment over domestic investment. The second feature is the equity payment of the FDI investment. This is to capture the riskiness of FDI, namely, that the return on FDI depends on the return on capital and the unknown production within the economy. The feature of the risky return contributes to explaining why, in reality, the investors care about the stability of the country and why, in the model, the reserve serves as a signaling device. The third feature captured by the model is that FDI pays multi-period returns, which ensures that there will be a reasonable measure of the FDI stock in the economy. There are obviously other features pf FDI and reserves in reality that are not captured by the model. However, they are not central to our analysis, and adding them would complicate the model without offering further insights.

1.4.6 Competitive equilibrium

A stationary competitive equilibrium is a set of stationary processes c_t, y_t, b_t^H, Π_t, k_{t+1}, x_t, i_t^H, i_t^F, i_t, λ_t^{1d}, λ_t^{2d}, λ_t^{3d}, λ_t^{4d}, A_t, G_{t+1}^f, p_t^i, W_t, R_t^H, R_t^i, rx_t, b_t^F, and T_t that satisfies equations (1.2)-(1.17), given a central bank policy on R_t^i and R_t^H, τ_t, exogenous stochastic processes on technology A_t^2, A_t^3 and interest rate R_t^r, R_t^f.

1.4.7 The social planner

Let us solve the benevolent social planners' problem in choosing the stochastic processes c_t, rx_t, k_{t+1}, i_t, b_t^F, x_t, i_t^H, and i_t^F that maximize

$$\sum_{t=0}^{\infty} E_0(\beta^t U(c_t))$$

subject to the constraints

$$i_t^H + c_t + rx_t - rx_{t-1}R_{t-1}^r = (1 - x_{t-1})A_t(i_{t-1}^F)k_t^\alpha + b_t^F - b_{t-1}^F R_{t-1}^f \tag{1.22}$$

$$k_{t+1} = (1 - \delta)k_t + i_t \tag{1.23}$$

$$i_t = F(i_t^H, i_t^F) \tag{1.24}$$

$$x_t = (1 - \delta)x_{t-1} + \frac{i_t^F}{k_{t+1}} \tag{1.25}$$

$$i_t^F = W_t \frac{E_t(G_{t+1}^f)}{\gamma} rx_t^\zeta \tag{1.26}$$

Equation (1.22) is the aggregate economy-wide resource constraint. The output of the economy, after the dividend payment to foreign investors, is used to consume c_t, invest i_t^H, accumulate/decumulate foreign reserves rx_t and accumulate/decumulate external debt b_t^F. It is the combination of household budget constraint equation (1.2), central bank budget constraint equation (1.16), government budget constraint (1.17) and the definition of profit Π_t equation (1.10).

If I let λ_t^1, λ_t^2, λ_t^3, λ_t^4 and λ_t^5 correspond to the Lagrangian multipliers of the above five constraints respectively, the Lagrangian associated with the maximization problem is given by

$$\begin{aligned} L = \sum_{t=0}^{\infty} \beta^t E_0 \{ U(c_t) + \lambda_t^1 \big((1 - x_{t-1}) A_t k_t^\alpha + b_t^F - b_{t-1}^F R_{t-1}^f - i_t^H - c_t - rx_t + rx_{t-1} R_{t-1}^r \big) \\ + \lambda_t^2 \big((1-\delta) k_t + i_t - k_{t+1} \big) + \lambda_t^3 \big(F(i_t^H, i_t^F) - i_t \big) + \lambda_t^4 \big((1-\delta) x_{t-1} + \frac{i_t^F}{k_{t+1}} - x_t \big) \\ + \lambda_t^5 \big(W_t \frac{E_t(G_{t+1}^f)}{\gamma} rx_t^\zeta - i_t^F \big) \} \end{aligned}$$

The first-order conditions with respect to c_t, rx_t, b_t^F, i_t k_{t+1}, x_t, i_t^H, i_t^F in that order is

$$U'(c_t) = \lambda_t^1 \tag{1.27}$$

$$E_t(\beta\lambda_{t+1}^1 R_t^r) = \lambda_t^1 - \lambda_t^5 \frac{\partial i_t^F}{\partial rx_t} \tag{1.28}$$

$$\lambda_t^1 = E_t(\beta\lambda_{t+1}^1 R_t^f) \tag{1.29}$$

$$\lambda_t^2 - \lambda_t^3 = 0 \tag{1.30}$$

$$E_t(\beta\lambda_{t+1}(1-x_t)A_{t+1}\alpha k_{t+1}^{\alpha-1} + \beta(1-\delta)\lambda_{t+1}^2) = \lambda_t^2 + \lambda_4 \frac{i_t^F}{k_{t+1}^2} \tag{1.31}$$

$$E_t(-\beta\lambda_{t+1}^1 A_{t+1} k_{t+1}^{\alpha} + \beta\lambda_{t+1}^4(1-\delta)) = \lambda_t^4 \tag{1.32}$$

$$-\lambda_t^1 + \lambda_t^3 F_{i_t^H} = 0 \tag{1.33}$$

$$E_t(\beta\lambda_{t+1}^1(1-x_t)\frac{\partial A_{t+1}}{\partial i_t^F} k_{t+1}^{\alpha}) + \lambda_t^3 F_{i_t^F} + \lambda_t^4 \frac{1}{k_{t+1}} - \lambda_t^5 = 0 \tag{1.34}$$

The Ramsey equilibrium is thus defined as a series of stochastic processes c_t, rx_t, k_{t+1}, i_t, b_t^F, x_t, i_t^H, i_t^F, λ_t^1, λ_t^2, λ_t^3, λ_t^4, λ_t^5, W_t, G_{t+1}^f, and p_t^i that satisfies condition equations (1.22) - (1.34) and equations (1.19) - (1.21), given the same exogenous stochastic processes on technology A_t^2, A_t^3 and interest rate R_t^r, R_t^f as in the competitive equilibrium, which will be discussed later in terms of the specific functional form.

1.4.8 Social planners and the competitive equilibrium

I argue that by choosing the optimal policy variables, the central bank and government can replicate the social planner's optimal solution under competitive equilibrium.

Suppose that we have the solution from the social planner's problem. The variables λ_t^1-λ_t^5, c_t, rx_t,k_{t+1}, i_t, b_t^F, x_t, i_t^H, and i_t^F are already pinned down by the social planner's equilibrium conditions. Now, we need to pin down the other corresponding variables by letting them satisfy all the competitive equilibrium conditions. Then, I argue that by satisfying equation (1.22) to equation (1.34) and equations (1.19) to (1.21), the competitive equilibrium conditions (1.2)-(1.17) are also satisfied.

Let us first consider the firm's problem in the competitive equilibrium. Given the definition of $M_{0,t} \equiv \frac{\beta^t \lambda_t^{1d}}{\lambda_0^{1d}}$, if I let $\lambda_t^1 = \lambda_t^{1d}$, $\lambda_t^{2d} = \frac{\beta^t \lambda_t^2}{M_{0,t}\lambda_0^1}$, $\lambda_t^{3d} = \frac{\beta^t \lambda_t^3}{M_{0,t}\lambda_0^1}$, $\lambda_t^{4d} = \frac{\beta^t \lambda_t^4}{M_{0,t}\lambda_0^1}$, $\tau_t = \frac{\lambda_t^5}{M_{0,t}} \frac{\beta^t}{\lambda_0^1}$, $R_t^i = \frac{\lambda_t^1}{\beta E_t(\lambda_{t+1}^1)}$, this replicates the first-order conditions in the social planner's problem. Specifically, the equations for the firm's problem under competitive equilibrium (1.6) (1.7) (1.8) and (1.11) to (1.15), given the value of the variables discussed above, are exactly equal to equations (1.23) (1.24) (1.25) and equations (1.30) to (1.34). The former sets of equations hold as long as the latter sets hold. Equation (1.5) is satisfied automatically by defining the output level. Equation (1.10) is satisfied automatically by defining the profit level. Equation (1.9) is satisfied automatically by defining the technology level.

Let us then match the household problem under the competitive problem and the social planner's equilibrium. Equation (1.3) corresponds to equation (1.27), as is satisfied by the equivalence of $\lambda_t^{1d} = \lambda_t^1$. Equation (1.4) pins down the level of R_t^H. $R_t^H = \frac{\lambda_t^1}{\beta E_t(\lambda_{t+1}^1)}$. Note that this is the same as the interest rate of borrowing from abroad R_t^f by equation (1.29)

In the foreign investors' problem, (1.18) to (1.21) are also included in the social planner's problem, so they are automatically satisfied.

The only equations left in the competitive equilibrium are equations (1.2), (1.16) and (1.17). Since everything else is pinned down, (1.2) pins down the level of domestic borrowing/saving b_t^H. Then, (1.16) is automatically satisfied by subtracting (1.2) from (1.22). Equation (1.17) pins down the level of T_t

This completes the proof that competitive equilibrium. Equations (1.2)-(1.17) are also satisfied once we have the social planner's optimal solution and the corresponding optimal interest rate and optimal tax rate on FDI.

1.5 Model parametrization

1.5.1 Households and preferences

I use the following standard functional forms for utility

$$U = log(c_t)$$

The household discount factor β is pinned down by the interest rate on foreign debt to ensure the existence of steady state.

1.5.2 Foreign investors

ζ is the key parameter in the analysis of foreign investors and is central to the mechanism of the model. As first shown in equation (1.18), ζ measures the reserves' ability to reduce the volatility of the expected return on FDI and thus increase FDI inflow. Therefore, I calibrate ζ by directly measuring its impact on the volatility of stock market returns from the data. The procedures for doing so will be explained in section 1.6.1. It is set to 0.1 in the baseline analysis. I also compare it to the result from directly assessing reserves' impact on increasing FDI inflow from the data. These two empirical measures are compatible with one another, although the analysis with FDI inflow provides a wider region for pinning down the parameter. The detailed discussion on this parameter is provided in both the empirical findings discussed in section 1.3.2 and the analysis on the effect of the critical parameters in section 1.6

β^i is the discount factor for foreign investors and is calibrated using the empirical fact that the return on FDI is on average approximately 10% as documented by Bosworth, Collins and Chodorow-

Reich (2007)

γ is the risk-aversion parameter for foreign investors and set to 4, which is a standard value in the literature

b is the fraction of wealth consumed by investors. It is pinned down by the steady-state level of the consumption-to-wealth ratio for US households, which is 0.7

1.5.3 Firms and production

The aggregation function for total investment (i_t) composed of foreign investment (i_t^F) and domestic investment (i_t^H) is modeled as taking a constant elasticity of substitution form.

$$i_t = H(\phi i_t^{F\rho} + (1-\phi) i_t^{H\rho})^{\frac{1}{\rho}}$$

where H is a constant and ϕ measures the share of domestic and foreign investment in total investment. ρ measures the elasticity of substitution between domestic and foreign investment.

ρ is set to 0.1 in the benchmark analysis, and I will discuss the model's robustness to different values of ρ. In the benchmark case, the elasticity is $1/(1-0.1) = 1.11$, which is slightly higher than in the Cobb-Douglas case, in which $\rho \to 0$ and the elasticity is 1. However, it will be shown that the level of ρ does not affect our result of interest.

ϕ and $1-\phi$ are calibrated to match the empirical observation that $\frac{i_t^F}{i_t} = 0.15$, which is calculated using the average FDI inflow over the fixed capital formation for the EM economies in the sample.

H is chosen to match the steady-state domestic investment share in total investment and set to 0.85, $\frac{i_t^H}{i_t} = 0.85$. Thus, total investment in the steady state is equivalent to the summation of domestic and foreign investment. The price of total investment in terms of consumption/investment goods is exactly 1 in the steady state.

In the production function, $y = Ak^\alpha$, the Cobb-Douglas parameter α is set to 0.3, which is a common value in the literature.

1.5.4 Technology process and shocks

The technology process takes the following functional form

$$A_t = A_{t,3} + A_1 (\frac{i_t^F}{i_{ss}^F})^{A_{t,2}} \tag{1.35}$$

The technology level A increases when there is an increase in FDI inflow i_t^F. $A_{t,3}$ is the level of technology when foreign investment (FDI inflow) is 0, in which case total investment consists solely of domestic capital. $A_{t,2}$ measures the ability of FDI inflow to increase technological development. A_1 is a constant to adjust for the share of the technology level that is affected by FDI inflow. A_t^3 and A_t^2 follow an exogenous process subject to shocks in the economy

$$lnA_{t+1,2} - lnA_2 = \rho_A (lnA_{t,2} - lnA_2) + \epsilon_{t+1}^{A_2} \tag{1.36}$$

$$lnA_{t+1,3} - lnA_3 = \rho_A (lnA_{t,3} - lnA_3) + \epsilon_{t+1}^{A_3} \tag{1.37}$$

where $\epsilon_{t+1}^{A_2} \sim N(0, \sigma_{A_2})$, $\epsilon_{t+1}^{A_3} \sim N(0, \sigma_{A_3})$

A_1, A_2, and A_3 are calibrated using the following three conditions.

- A_3 is set at 57.9% of the level of A, which matches the average technology level in 1980 relative to the technology level in 2017 for 33 EM countries. The technology level in 1980 is assumed to represent the condition when bilateral FDI flows are 0.
- In steady state, the investment-to-output ratio is the average investment-to-output ratio for the 33 EM countries in the sample, which is 0.24.
- The standard percentage deviation from the trend of the reserves-to-GDP ratio in the data is 14.32 %

The persistence of both shocks is taken to be the same, $\rho_A = 0.9$. This is taken from Eichenbaum (1991), where different values of the quarterly persistence level between 0.863 and 0.986 are considered.

The standard deviations σ_{A_2} and σ_{A_3} are taken to be the same to match the standard deviation of technology A over the mean of technology in the data, which is a 5.3% deviation from the trend. The technology level is calculated using the residual from capital and labor input in EM countries. I follow the method of Gourinchas and Jeanne (2013). The precise steps are explained in detail in Appendix A.4

The other two shocks in the economy come from exogenous processes R_t^r and R_t^f, the return on reserve assets and the borrowing cost of external debt, respectively. I assume that both of them follow an AR(1) process with persistence levels of ρ_{R^r} and ρ_{R^f}, respectively:

$$R_{t+1}^r - R^r = \rho_{R^r}(R_t^r - R^r) + \epsilon_{t+1}^r \tag{1.38}$$

$$R_{t+1}^f - R^f = \rho_{R^f}(R_t^f - R^f) + \epsilon_{t+1}^f \tag{1.39}$$

The level of R^r is calibrated using the US Federal Funds rate, the level of R_f is calibrated using the EMBI sovereign spread index, and their corresponding standard deviations are σ_{R^f} and σ_{R^r}. The persistence levels of the shocks ρ_{R^r} and ρ_{R^f} are taken from Neumeyer and Perri (2005), where the persistence level of world interest rate shock is estimated to be 0.81, and that of emerging economies is 0.78. The full set of parameters and their corresponding values are summarized in Table 1.3 below.

Table 1.3: Parameter values after calibration

Parameter	Description	Value
Household		
β	Household discount factor	0.9434
Firm		

α	Cobb-Douglas parameter	0.3
ϕ	foreign investment share in total investment	0.0925
ρ	elasticity of substation between foreign and domestic investment	0.1
H	scale parameter of investment	1.3647
δ	capital depreciation rate	0.1
Foreign investors		
ζ	reserves ability in attracting FDI inflow	0.1
γ	risk aversion parameter or investors	4
b	investors' share of consumption in total wealth	0.7
β^i	investors' discount factor	0.4512
Exogenous		
R_r	steady state return on reserve assets	1.015
R_f	steady state borrowing cost of external debt	1.06
A_1	parameter in A	0.1941
A_2	steady state of $A_{t,2}$, FDI technology	0.52
A_3	steady state of $A_{t,3}$	0.27
ρ_A	persistence level of the shock process	0.9
ρ_{r1}	persistence level of the shock process	0.81
ρ_{r2}	persistence level of the shock process	0.78
σ_{R_r}	sd of R_r	0.0063

σ_{R_f}	sd of R_f	0.0259
σ_A	sd of A_2 and A_3	2.15%

Note: The table summarizes the parameter values taken in the model

1.6 Equilibrium level of foreign reserves and key parameters

Given the parameter values discussed above, the model predicts that the reserves-to-GDP ratio is 23% in steady-state value.

This prediction is much larger than those in the previous literature. It is closer to the average in recent years, as I show in the graphs in the empirical section 1.3.2, and closer to the average level of the reserves-to-GDP ratio for the East Asian economies. This suggests that by incorporating the incentives for attracting FDI inflow for reserve holding, I can explain the larger amount of reserves held by EM economies.

However, this result is sensitive to the parameter values I assign to the two main mechanisms in the model: the parameter that measures reserves' ability to increase FDI, ζ, and the parameter that represents the level of FDI inflow to increase the technology level, A_2. I next discuss in detail some empirical evidence on these parameters, how I calibrate them and what the economic meanings of the values of the these parameters are.

1.6.1 The value of ζ

Recall that ζ governs the inflow of FDI with respect to the level of reserves:

$$i_t^F = W_t \frac{E(G_{t+1}^f)}{\gamma} r x_t^{\zeta} \tag{1.40}$$

This equation is a reduced-form equation taken from a simpler case when letting FDI be a one-period asset for foreign investors.

$$i_t^F = a_t(W_t - C_t) = (1-b)W_t \frac{E_t G_{t+1}^f - R_1 + \frac{\sigma_{t+1}}{2}}{\gamma \sigma_{t+1}}$$

where I assume that rx_t reduces the volatility of the return σ_{t+1} by letting $\sigma_{t+1} = rx^{-\zeta}$.

I first show that there is indeed a negative correlation between the volatility of returns and the level of reserves in the data, and I then measure how large the parameter ζ is.

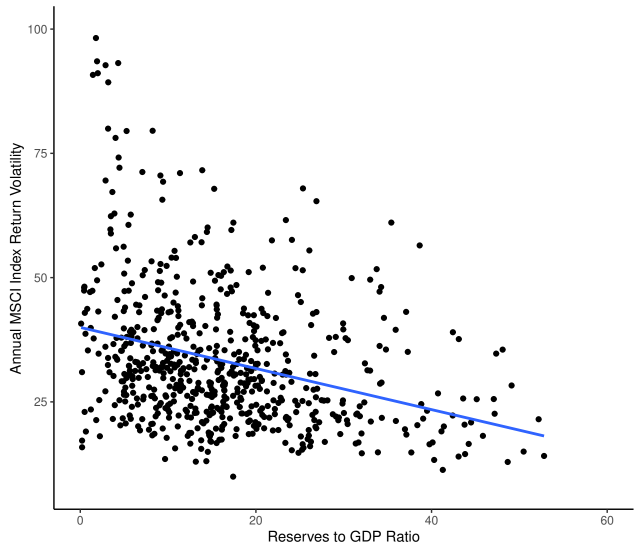
I use stock market volatility as a proxy for the volatility of the expected return on risky FDI assets for foreign investors. There are two reasons that I select this proxy. The first is that there is no good measure of the precise return on FDI from investing in each of the EM economies. The stock market return is relatively more accessible and comparable across economies. The MSCI country index has a good coverage of 30 economies out of the 33 economies in my sample. The similar standard in picking stocks to ensure a fair representation of the underlying local equity markets make it more comparable across economies. The second reason is that since engaging in FDI aims to buy a share of a firm, it is reasonable to assume that it pays the same return as other portfolio investment, which is represented in general by the economies' stock market returns.

The stock market return index, MSCI country index,[5] covers all the EM economies in my sample except Iran, Indonesia, and Saudi Arabia. I take the monthly data from 1980-present and calculate each month's return based on the index. The volatility of the return in each year is calculated as the past three years of volatility and then annualized.

I plot the volatility against the reserves-to-GDP ratio across economies and over time in figure 1.6. As the figure shows, high return volatility is correlated with a lower level of the reserves-to-GDP ratio, and this negative relationship is very significant. The negative relationship is also robust to grouping the observations by economy or by date, as shown in Appendix A.3.

[5] The data are obtained from Factset

Figure 1.6: Return volatility and reserve-over-GDP ratio



Note: This figure plots the stock market return volatility again the reserves-to-GDP ratio for the EM economies in the sample.
Source: World Bank WDI, Factset MSCI

To pin down the level of ζ in $\sigma_{t+1} = rx_t^{-\zeta}$, I run the following empirical regression.

$$log(\sigma_{it}) = \beta + \beta_1 log(rx_{it-1}) + \beta_2 log(gdp_{it-1}) + a_i + b_t + \epsilon_{it} \tag{1.41}$$

where a_i refer to time fixed effects and b_t refers to economy fixed effects

The result of this empirical analysis on parameter ζ is presented in table 1.4. Because I assume that $\sigma_{t+1} = rx_t^{-\zeta}$, the parameter in front of the variable $log(rx)$ is the empirical measure of ζ. The number ranges from -0.08 to -0.136. I employ -0.1 in the baseline analysis in the model, which means that $\zeta = 0.1$

I also compare this number with the empirical analysis on FDI inflow and reserve levels to determine whether the level of ζ also conforms with the empirical evidence corresponding to equation 1.40.

The empirical regression I present in table 1.2 suggests that a 1% increase in the reserves-to-GDP ratio corresponds to a 0.02%-0.076% increase in the FDI-inflow-to-GDP ratio. In essence, if we take GDP as constant across all cases and recognize that the reserve level is five times that of

Table 1.4: Correlation between stock market volatility and reserve level

	Dependent variable: Stock market volatility (3-year moving window)			
	(1)	(2)	(3)	(4)
Log(rx)	-0.136***	-0.085***	-0.098***	-0.087***
	(0.051)	(0.029)	(0.037)	(0.027)
Log(gdp)	0.094	-0.182***	0.112**	-0.213**
	(0.063)	(0.042)	(0.055)	(0.085)
Time fixed effect	No	No	Yes	Yes
Country fixed effect	No	Yes	No	Yes
Observations	643	643	643	643
R^2	0.107	0.467	0.418	0.694

Note: *p<0.1; **p<0.05; ***p<0.01

FDI inflow, this indicates that a 1% increase in the reserve level corresponds to a 0.1%-–0.35% increase in the FDI inflow level. I further run a similar regression of equation 1.41 by regressing $log(FDI\ inflow)$ on $log(rx)$, which yields an estimate of ζ in the range $0.16 - 0.28$. This evidence suggests that $\zeta = 0.1$ is a reasonable and conservative measure for how reserves reduce the volatility of the return and provide a lower bound in the data on how reserves increase FDI inflow. I employ $\zeta = 0.1$ in the benchmark analysis if not otherwise stated and relax the number in the robustness checks in Appendix A.5

1.6.2 The level of A_2

The change in the level of parameter A_2 also changes the steady-state level of the reserves-to-GDP ratio. As in equations (1.9) and (1.36), A_2 is the steady state of $A_{t,2}$, which measures the ability of FDI inflow to increase the technology level. Since it is not feasible to obtain a direct measure of this effect, I calibrate it to match the percentage deviation from the trend of the reserves-to-GDP ratio in the model with the data. The interpretation of A_2, combined with the level of A_3 as a fraction of A, is the percentage increase in FDI inflow for increasing the technology level. In steady state, A_3

is calibrated to be 0.58, and A_2 is calibrated to be 0.4. This approach gives the interpretation that a 1% increase in FDI inflow over GDP yields a 0.22% increase in the technology level.

This value of A_2 is also a reasonable and conservative estimation based on the empirical evidence in this study. To provide an empirical justification for the level of A_2, I calculate the technology process of the 33 EM economies in the sample by calculating the Solow residuals based on the information on GDP, employment, and capital level. The detailed steps of calculation are described in Appendix A.4. Then I run the following regression between productivity level A across economies and the FDI inflow across economies.

$$lnA_{it} = \beta lnFDIinflow_{it} + a_i + \epsilon_{it}$$

To account for the reverse causality that investors will invest more when the productivity level is higher, I use the risk-free rates taken from the Kenneth R. French Library to instrument for the level of FDI inflow. The intuition is that when using the risk-free rates to instrument for FDI inflows, we are utilizing the variations in FDI inflows due to the changes in the risk-free rates. When risk-free rates are higher, the investors have lower incentives to invest in risky FDI assets. However when the interest rates are lower, investors seek yields and thus invest more in the risky FDI assets, leading to more FDI inflows for EM economies. On the other hand, the change in the risk-free rates should not affect the variations in technology levels. I further add economy fixed effects to the regression to account for potential difference across economies.

Table 1.5 reports the result of the IV regression using three different periods. The earliest record for FDI inflow for the 33 EM economies in the sample is from 1968, which is presented in column 1. I also check the periods corresponding to the main period of empirical analysis in section 1.3, from 1980 to 2017, in column 2. Then I check the periods using the same length as the calibration to ζ, from 1987 to 2017, in column 3. The three regressions by including different periods suggest that β is between 0.21-0.32. The interpretation of β is the percentage increase in A when there is a 1% increase in FDI inflow. The regression results suggest that that number used in the baseline

Table 1.5: Correlation between technology level and FDI inflow

	1968-2017	1980-2017	1987-2017
	lnA	lnA	lnA
lnfdi	0.217^{***}	0.230^{***}	0.319^{***}
	(0.0128)	(0.0137)	(0.0223)
_cons	7.839^{***}	7.703^{***}	6.903^{***}
	(0.106)	(0.116)	(0.194)
N	1079	1002	867

Note: Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

model 0.22 is a conservative and reasonable estimation also based on empirical evidence. The robustness checks for the equilibrium and dynamic movements of the model by varying A_2 are discussed in the Appendix A.5

The two key parameters also suggest an explanation for the heterogeneity in reserve holding behavior across EM economies. The crucial impacts that these parameters have on the steady-state level of the reserves-to-GDP ratio suggest that exploring the exact levels of these parameters can be used to explain the heterogeneity in the levels of reserves across economies. The average level of Latin American economies' reserves-to-GDP ratio is approximately 10%, which can be explained by motives such as precautionary savings. However, the average level of the reserves-to-GDP ratio for Asian economies is over 20%, which requires a high probability of crisis to justify under the precautionary saving motive. However, using the possible incentive of attracting FDI inflow by holding reserves can account for the gap between the optimal level of reserves in past theories and the data. To better estimate the magnitude of this channel and its relative significance compared to other reserve holding incentives, we need to obtain more precise measures from the data for different economies of interest. This will be an essential aspect of future research on this channel if more micro-level data become available.

1.7 Technology shock

After discussing the equilibrium level of the reserves-to-GDP ratio, we can examine the dynamics of the variables of interest after technology shocks.

There are two kinds of technology shocks in the model based on the technology process specified in the model.

$$A_t = A_{t,3} + A^1 (i^F_{t-1})^{A_{t,2}}$$

where A^3_t and A^2_t follow two exogenous processes:

$$lnA_{t+1,2} - lnA_2 = \rho_A (lnA_{t,2} - lnA_2) + \epsilon^{A_2}_{t+1}$$

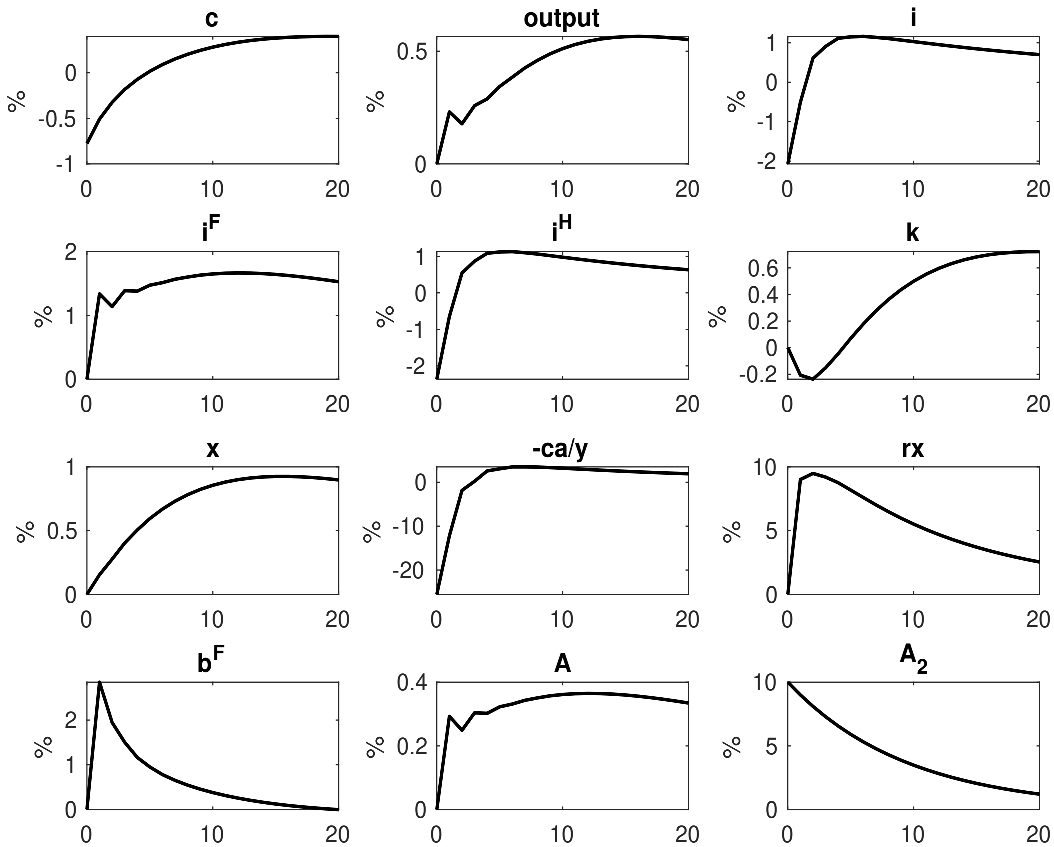
$$lnA_{t+1,3} - lnA_3 = \rho_A (lnA_{t,3} - lnA_3) + \epsilon^{A_3}_{t+1}$$

We call the shock to $A_{t,2}$ the FDI technology shock and the shock to $A_{t,3}$ the classical technology shock. An increase in $A_{t,2}$ means that an increase in FDI inflow is more capable of increasing the technology level of the economy. This can be regarded as a better absorption of the advanced technology of the parent economy through better training or the presence of more high-skilled workers. An increase in $A_{t,3}$ is similar to standard technology shocks, where productivity is higher, which has nothing to do with the level of FDI inflow. It is reasonable to assume that both kinds of technology shock vary along the business cycle. FDI inflow sometimes contributes more to technology and sometimes contributes less. The classic technology shock also experiences booms and busts.

1.7.1 The FDI technology shock A_2

Figure 1.7 plots a 10% increase in the FDI technology $A_{t,2}$. We can see that $A_{t,2}$ increases by 10% following the shock and gradually returns to the steady state. The increase in $A_{t,2}$ increases in the marginal benefit of FDI inflow and thus the marginal benefit of holding reserves. We hence observe an increase in reserves after the shock. The FDI inflow correspondingly increases, so we

Figure 1.7: 10% increase in A_2



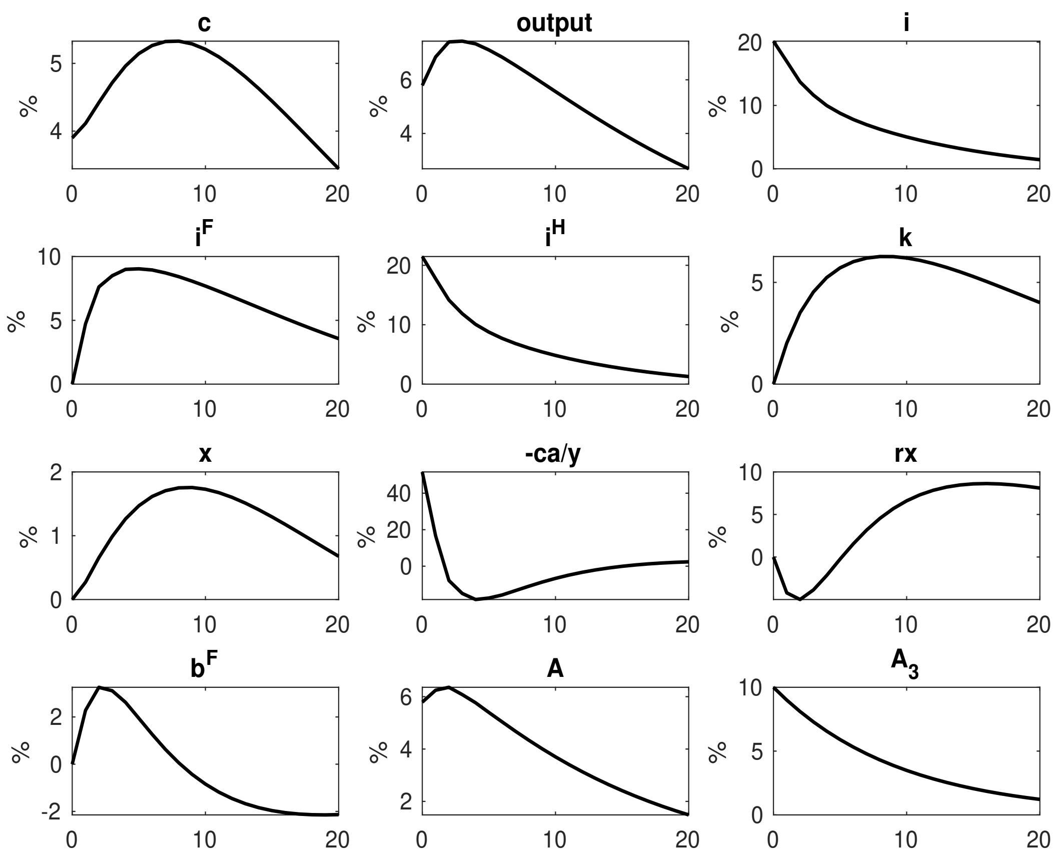
Note: This graph plots the impulse responses for a 10 % FDI technology shock on $A_{t,2}$

observe an increase in i_t^F. The increase in reserves is financed by an increase in the foreign debt level b_t^F, a temporary decrease in the consumption level c, and a temporary decrease in domestic investment i_t^H. These are the costs of holding reserves. The simultaneous increase in the marginal cost and marginal benefit of holding reserves generates the co-movement between external debt and the reserve level. This explains why the economy simultaneously borrows and saves.

1.7.2 The classic technology shock A_3

Figure 1.8 plots a 10% increase in the classic technology $A_{t,3}$. We can see that $A_{t,3}$ increases by 10% following the shock and gradually returns to the steady state. The increase in the classic technology shock increases the expected return on capital. One key reason that foreign investors invest in the domestic economy is the expected return. Following the increase in the classic tech-

Figure 1.8: 10% increase in A_3



Note: This graph plots the impulse responses for a 10 % classic technology shock on $A_{t,3}$

nology shock, foreign investors become more interested in investing in the economy for a given reserve level. The increase in the capital stock decreases the marginal productivity of capital and thus reduces the marginal benefit of holding reserves to attract one additional unit of capital. We can thus observe an initial decrease in the reserve level. The economy also allocates resources to domestic investment to make use of high technology. We can see that there is an increase in i_t^H, and the economy is borrowing more from the rest of the world b_t^F. These behaviors are the same as in the classic RBC model, which predicts that a positive technology shock leads to more investment, less saving and more borrowing. The FDI inflow is higher following the shock because of the high expected return. As the shock gradually vanishes, we observe that the economy begins to accumulate more reserves to slow the process of FDI inflow converging back to the steady state. The difference between the increases in A_3 and A_2 is the change in the marginal benefit of holding reserves, which can be decomposed into two parts: the marginal benefit of investment and the marginal increase in investment due to a unit increase in the reserve level. An increase in the FDI technology shock does not significantly affect the level of technology but increases the marginal benefit of foreign investment. In contrast, an increase in classic technology shock substantially affects the level of technology and causes an increase in foreign investment. This increase in foreign investment significantly lowers the marginal benefit of the investment. The different directions of the movements in the marginal benefit of investment cause reserve levels to move differently following the two technology shocks.

$$E_t\Big(\underbrace{(\beta\lambda^1_{t+1}(1-x_t)\frac{\partial A_{t+1}}{\partial i^F_t}k^{\alpha}_{t+1}+\lambda^3_t F_{i^F_t}+\lambda^4_t\frac{1}{k_{t+1}})}_{\text{marginal benefit of investment}}\underbrace{\frac{\partial i^F_t}{\partial rx_t}}_{\text{change in investment}}\Big)=\underbrace{\beta E_t\lambda_{t+1}(R^f_t-R^r_t)}_{\text{marginal external cost}} \tag{1.42}$$

1.8 Allocation puzzle

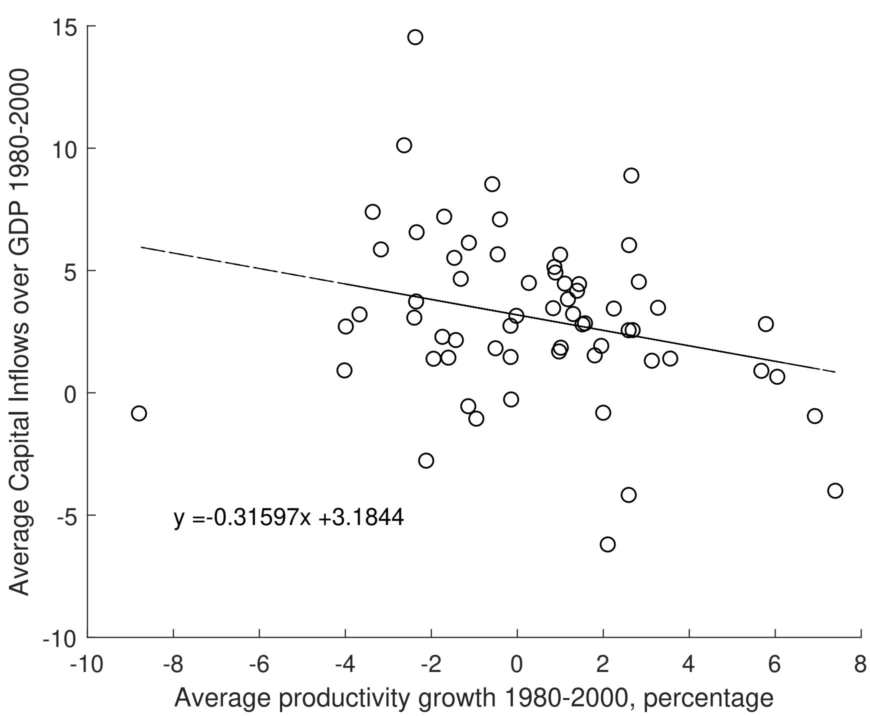
The allocation puzzle refers to the empirical observation that there is a negative correlation between economies' net inflows of capital and productivity growth and was initially highlighted by Gourinchas and Jeanne (2013). It is considered a puzzle since one would expect that according to the classical real business cycle model, capital would flow to economies with higher technology growth. This means that if we compare economies in recent decades, we would expect those with higher average productivity growth to be those with higher capital inflow. However, empirically, as I show below, the pattern is the opposite: economies with higher average productivity growth are those with lower capital inflow. The model discussed in this paper can generate the pattern described in the puzzle. The short explanation is that following technology shocks, there is public capital outflow (reserves) intended to attract private capital inflow (FDI inflow). On net, we observe a negative correlation between net capital inflow and technology growth.

I first provide empirical evidence of this phenomenon by replicating the result of Gourinchas and Jeanne (2013). I then present the empirical counterpart in this paper by showing that the puzzle is resolved if we only consider the empirical FDI flow. However, the foreign reserve outflow is also higher in economies with higher technology growth. The last step is to simulate the model and demonstrate that it generates the same pattern as we observe in the data, and the explanation for the puzzle is precisely the mechanism proposed in the model.

1.8.1 Empirical observations

The empirical observation of the allocation puzzle is summarized in Figure 1.9. I plot the average productivity growth over the period 1980-2000 for 66 economies on the x-axis, and the average capital inflow is represented by the negative of the current-account-to-GDP ratio $\frac{CA_t}{GDP_t}$ on the y-axis. The details of the data construction can be seen in Appendix A.4. The graph suggests that among the 66 developing economies in the sample, economies with higher average productivity growth over the period 1980-2000 experience less net capital inflow on average.

Figure 1.9: Allocation puzzle, net capital inflow and productivity growth



Note: Author's calculation. Due to the lack of current account data for some economies, there are 59 observations in this figure. The calculations of the technology growth and net capital inflow are described in Appendix A.4.
Source: Penn World Table and World Bank WDI.

Gourinchas and Jeanne (2013) further divides the net capital inflow into private flows and public flows and concludes that there is no puzzle if we only consider private flows. Economies with higher productivity growth are indeed associated with higher net private capital inflow. However, public flows show that economies with higher productivity growth are associated with less net public inflow.

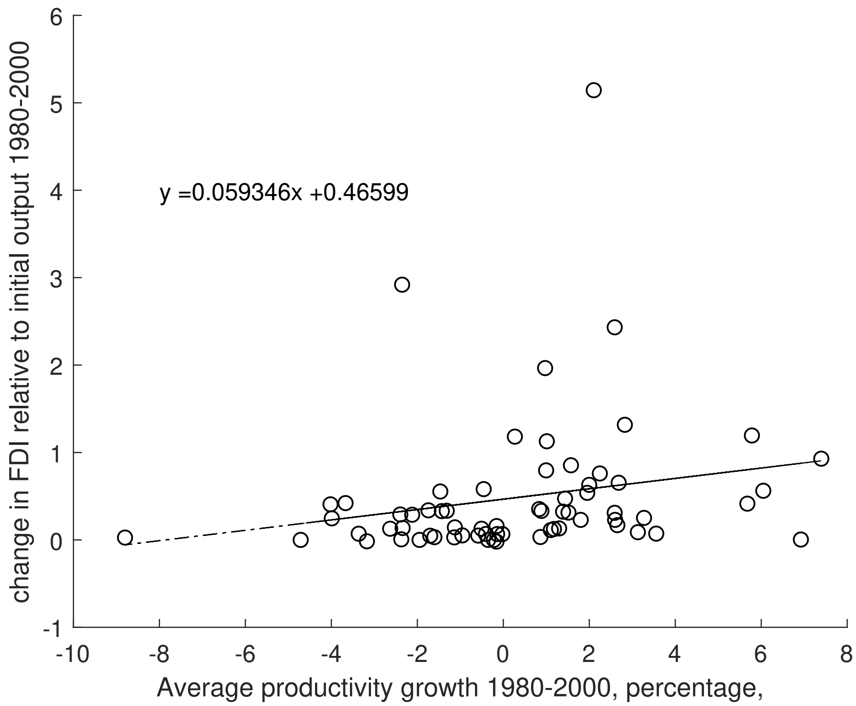
When describing the motivation for this study, I noted that the liabilities of emerging economies are mainly composed of FDI liability (private capital inflow) and that their assets are mainly composed of RX (public capital outflow). When FDI inflow and reserve assets are plotted against productivity growth, we observe the pattern that generates the allocation puzzle. The private FDI inflow correlates positively with productivity growth, as does the public reserve outflow.

Figure 1.10 shows the positive correlation between FDI inflow and productivity growth. On the x-axis, I have the same productivity growth for the 66 countries shown in Figure 1.9. On the y-axis, I plot the change in FDI between 1980 and 2000 by summing all the FDI inflows during the 20-year period and scale each year's FDI inflow by the investment price level in that year. The details of the data are described in Appendix A.4. Figure 1.10 suggests that when considering private FDI flows, countries with higher technology growth indeed attract higher FDI inflow.

Figure 1.11 shows the positive correlation between the increase in reserve position and productivity growth. I have the same x-axis as in the previous two figures. The y-axis plots the change in reserve position over the period 1980-2000. The construction of the reserve outflow is analogous to that of the FDI inflow. Figure 1.11 suggests that when considering public reserve outflow, economies with higher technology growth also experience larger reserve outflows.

To summarize, the empirical evidence suggests a negative correlation between capital inflow and technology growth. However, if I decompose the inflow into public and private, specifically reserve outflow and FDI inflow, there is a positive correlation between FDI inflow and technology growth and a positive correlation between reserve outflow and technology growth. This causes a negative correlation between net inflow and technology growth.

Figure 1.10: FDI inflows and productivity growth



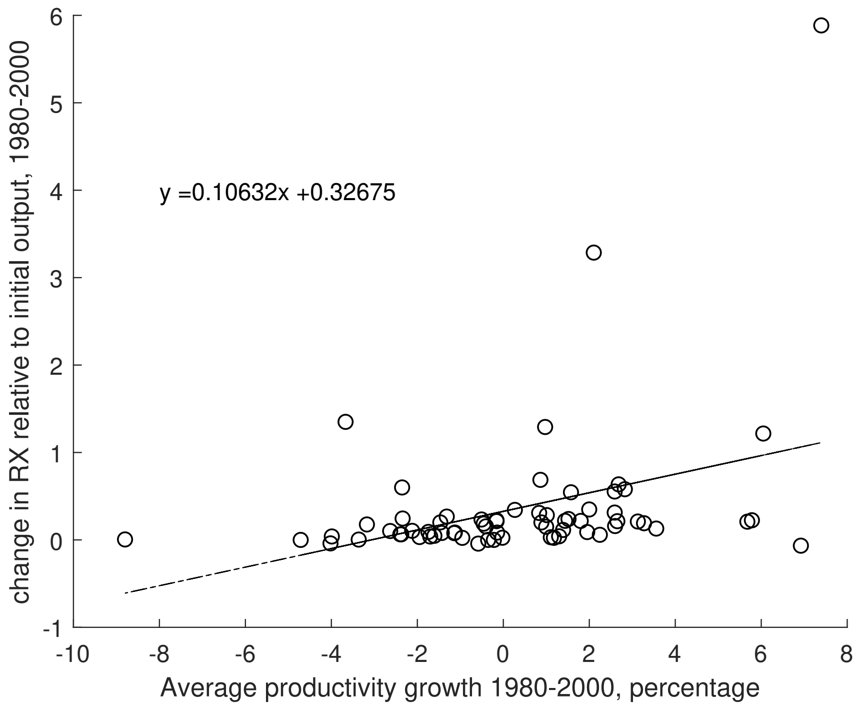
Note: Author's calculation. There are 66 observations in the figure. The calculations of the technology growth and FDI inflow are described in Appendix A.4
Source: Penn World Table and IMF International Financial Statistics

1.8.2 Model simulations

The model can generate the same correlations we see in the empirical observations. The model indicates that higher productivity growth correlates with less net capital inflow, larger FDI inflow, and larger reserve accumulation. To mimic the same technology growth process we observe in the data, I use the technology growth inferred from the data to feed into the shock processes in the model.

There are four shock processes in the model, namely, equations (1.36) to (1.39). Since the technology shocks in the model affect the components of A_t, $A_{t,2}$ and $A_{t,3}$, I do not have direct observations of the processes of $A_{t,2}$ and $A_{t,3}$ in the data. The only observation I have from the data is on the aggregate technology growth A_t. Thus, I feed into the simulation process the same technology growth rate as in the data to both $A_{t,2}$ and $A_{t,3}$. If the observed growth rate of technology in a

Figure 1.11: Reserve outflows and productivity growth



Note: Author's calculation. There are 66 observations in the figure. The calculation of technology growth and the change in reserves assets are described in the Appendix A.4
Source: Penn World Table and IMF International Financial Statistics

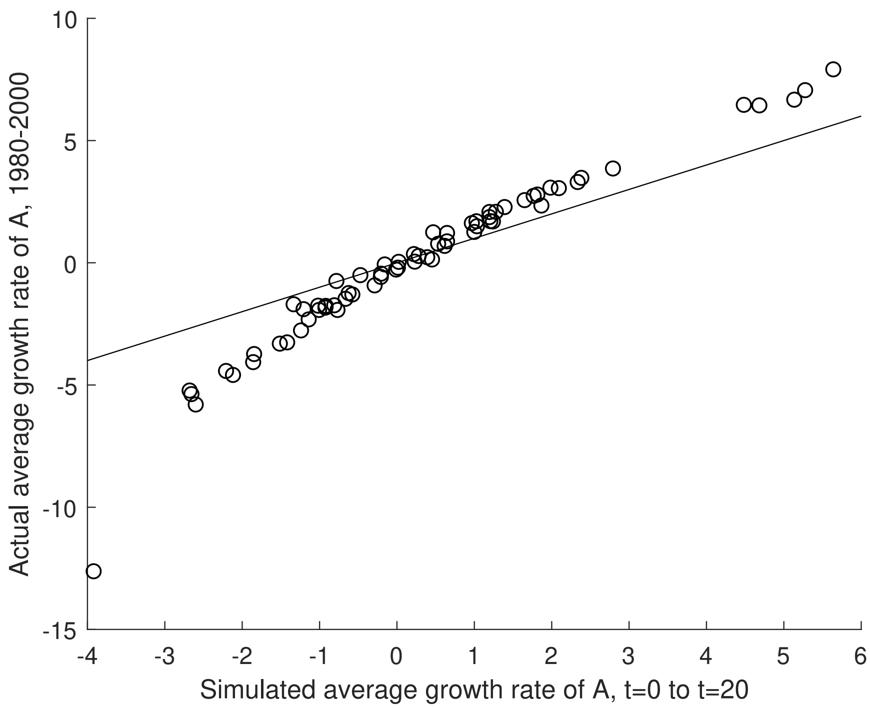
specific year is 3%, then I let $A_{t,2}$ and $A_{t,2}$ experience the same percentage shock in that year. The interest rate shocks on R_t^r and R_t^f are shut down in the simulation. The simulation is performed for the technological progress of all 66 countries used in the empirical analysis.

I begin the simulation from the steady state, treating that as t=0. The persistence parameter ρ_A is changed to 1 so I can more easily match the actual technology growth. The actual data I have are a series of technology growth observations from 1980 to 2000 for 66 economies, where each number represents the growth rate between two consecutive years, e.g., g_t^{data}. Each period's technology shock is calculated from the actual series by

$$\epsilon_t^A = \prod_{i=1}^{t} g_i^{data} - \prod_{i=1}^{t-1} g_i^{data}$$

Under this construction, the percentage change in A_t^2 and A_t^3 from the steady state in the model is the same as the percentage change in A from the initial period in the data. Although this setup does not necessarily generate the same average productivity growth in the model as in the data, the two are quite similar. In Figure 1.12, I have the simulated average productivity growth for 20 periods plotted on the x-axis and the actual average productivity growth from the data plotted on the y-axis. The simulated average technology growth is calculated by using the last period's technology level A^i_{20} and taking the geometric average. The dots almost align on a 45-degree line, suggesting that the simulated productivity growth is close to the actual productivity growth.

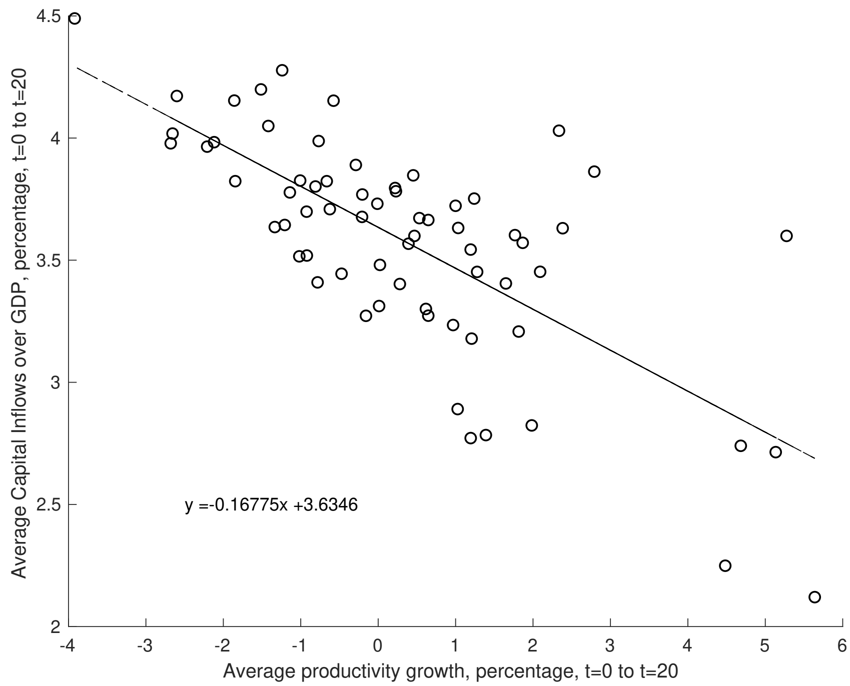
Figure 1.12: Model simulated productivity growth and actual productivity growth



Note: The x-axis depicts the simulated technology growth. The y-axis depicts the actual technology growth. The straight line is a 45-degree line, suggesting $y = x$.

Figure 1.13 depicts the model simulated version of the allocation puzzle. The y-axis plots the average net capital inflow over the initial output. The x-axis plots the average technology growth. There is a clear negative correlation between technology growth and average capital inflow. After I simulate the model with the shocks described above, I calculate the average current-account-to-GDP ratio (ca/y) as the average over the 20 periods and take the negative of it as the net capital inflow. The average productivity growth is the same as discussed above.

Figure 1.13: Model simulation of the allocation puzzle

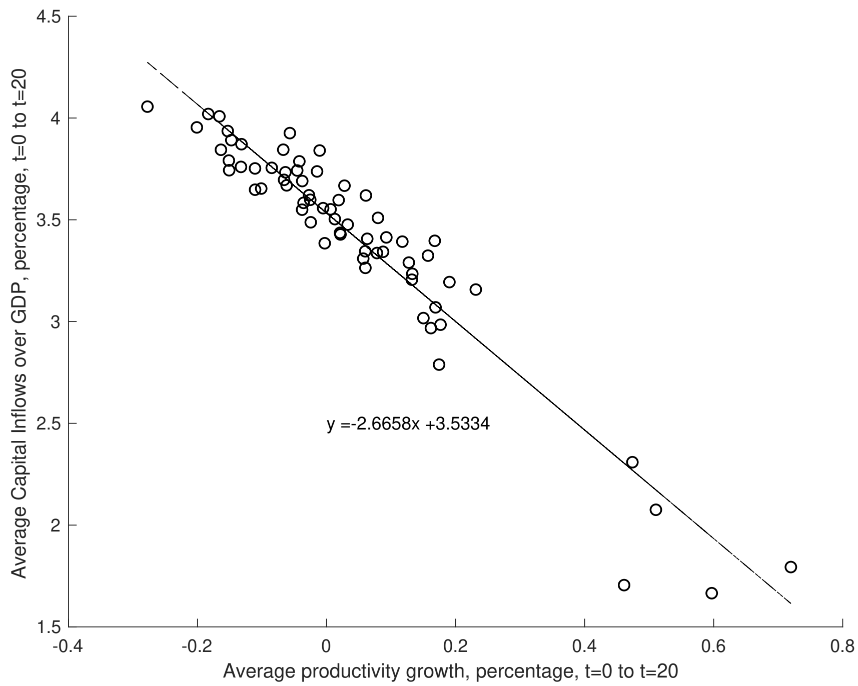


Note: Model simulation of the allocation puzzle.

Note that the negative correlation in Figure 1.13 is the combination of the effect of the FDI technology shock, $A_{t,2}$, and the classic technology shock $A_{t,3}$. The FDI technology $A_{t,2}$ shock increases the marginal benefit of FDI inflow, since now one unit of FDI inflow can contribute more to the technology level. The increase in the marginal benefit of FDI inflow needs to be accompanied by a decrease in the marginal increase in FDI inflow per unit increase in reserves to equalize equation (1.42). The decrease in the marginal increase in FDI inflow can be achieved by an increased level of reserves. The increase in FDI inflow cannot compensate for the increase in reserve level, and we see a strong negative correlation between technology growth and capital inflow under $A_{t,2}$, which is shown in Figure 1.14

The classic technology shock $A_{t,3}$ generates a consistent result with what we would expect from a neoclassic growth model. Higher technology growth corresponds to larger capital inflows, which is shown in Figure 1.15. The graph is plotted by only feeding in the model the classic technology

Figure 1.14: Model simulation with only FDI technology shock $A_{t,2}$



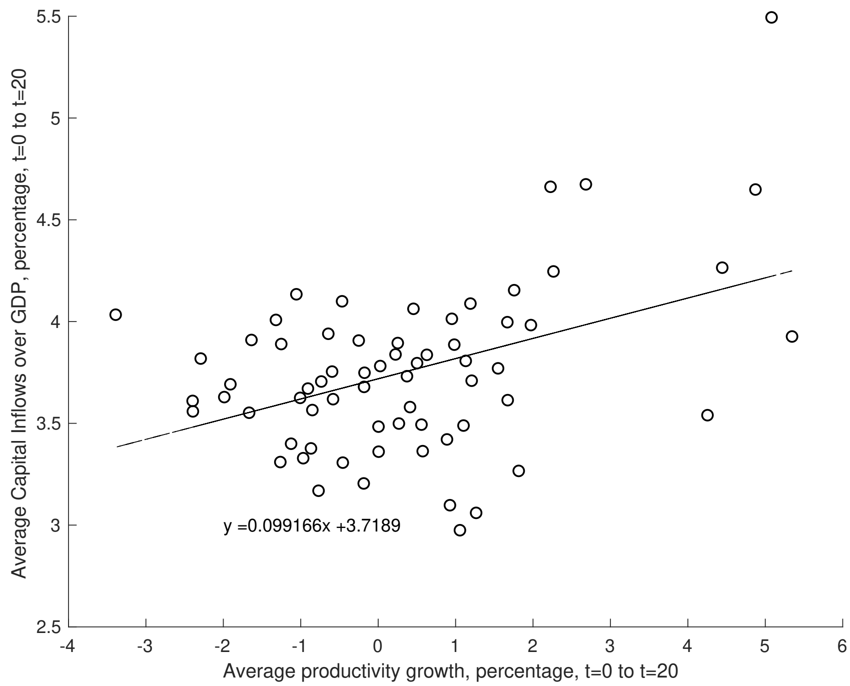
Note: Model simulation of the allocation puzzle, with only the FDI technology shock.

shock $A_{t,3}$ and shutting down the FDI technology shock $A_{t,2}$. The classic technology shock induces a sizable increase in foreign investment in the first place but not the marginal benefit of foreign investment. This significant increase in FDI inflow reduces the marginal benefit of FDI inflow. Thus, it needs to be compensated by a reduction in reserve levels, that is, to make the marginal increase in FDI inflow larger for a unit increase in the reserve level, to make equation (1.42) equalized. The increase in the FDI inflow and the reduction in the reserve level together contribute to the positive correlation of technology growth and capital inflow.

Overall, with both shocks in $A_{t,2}$ and $A_{t,3}$, the combination suggests that the $A_{t,2}$ overturns the positive correlation arising from the $A_{t,3}$ shock and gives us the negative correlation of the allocation puzzle with both shocks in the model.

Figure 1.16 shows the model-simulated version of the positive correlation between technology growth and the change in reserve position. The change in reserve position is taken as the deviation of the last period's reserve from the steady state. When productivity growth is high, there is also

Figure 1.15: Model simulation with only FDI technology shock $A_{t,3}$



Note: Model simulation of the allocation puzzle, with only the classic technology shock.

more substantial reserve outflow.

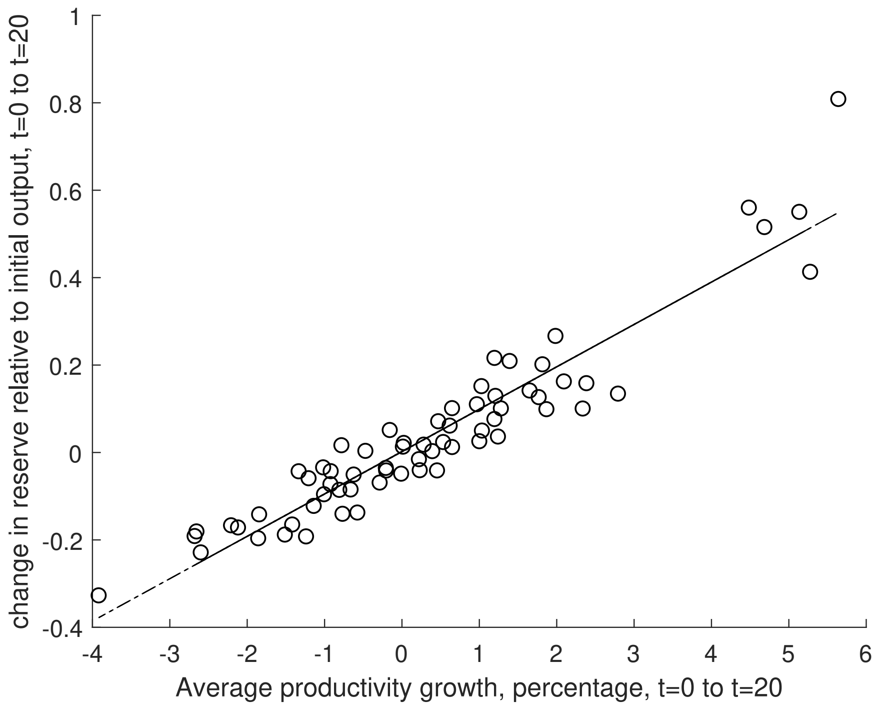
Figure 1.17 shows the model-simulated version of the positive correlation between technology growth and FDI inflow. The FDI inflow is calculated as the total FDI inflow for all periods relative to the initial output. When productivity growth is high, there is a larger FDI inflow.

Overall, the model matches the observations in the data. The explanation for the allocation puzzle based on the model is precisely the mechanism of the model, in which the public capital outflow is used to incentivize private capital inflow.

1.9 Reserves correlation with other variables

In this section, I compare the model's unconditional moments to the data. To do so, I conduct a three-million-period simulation of the model by drawing a sequence of $\epsilon_t^{R^r}$, $\epsilon_t^{R^f}$, $\epsilon_t^{A_2}$, and $\epsilon_t^{A_3}$ and feed them into the policy functions to obtain the time-series for all other variables.

Figure 1.16: Model simulation of reserve outflows and productivity growth

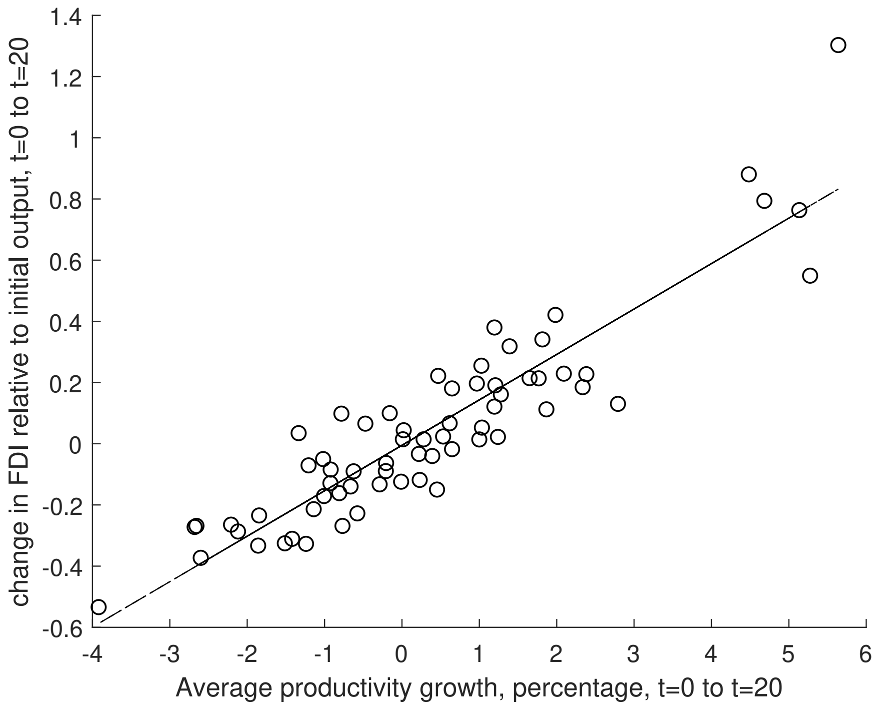


Note: Model simulation of the allocation puzzle between reserves and technology growth.

Table 1.6 shows the moments and correlations of reserves and other macro variables, providing a comparison between the data and model. I report the comparison of the data to the model both under all shocks and one shock at a time.

In general, I can reproduce the correlations between reserves and other variables. The model predicts a similar level of volatility of the current-account-to-GDP ratio as observed in the data. The correlations between the reserves-to-GDP ratio and FDI-inflow-to-GDP ratio are close to the actual moments from the data. The correlation between the reserves-to-GDP ratio and FDI-stock-to-GDP is more substantial than the data, probability due to the lack of adjustment cost for both variables. The correlation between the reserves-to-GDP ratio and GDP is positive, as in the data. The correlation between the reserves-to-GDP ratio and the external-debt-to-GDP ratio for the full model is slightly negative compared to what we see in the data. However, we do observe positive co-movement between the two series following specific shocks (A_2, R_t^f, R_t^r). The negative correlation is dominated by the classical technology shock A_3, due to the restriction that the sizes of the two

Figure 1.17: Model simulation of FDI inflows and productivity growth



Note: Model simulation of the allocation puzzle between FDI inflow and technology growth.

shocks be equal.

Comparing the model's performance under specific shocks, we can see that the model under the classical technology shock indicates that the reserves-to-GDP ratio has negative correlations with the FDI-inflow-to GDP ratio, the output level and the external-debt-to-GDP level. These are of the opposite directions from the observations in the data.

The model predicts a higher level of the reserves-to-GDP ratio for EMs than observed in the data, suggesting that countries are under-accumulating reserves on average. However, the predicted level of the reserves-to-GDP ratio is closer to the level of Asian economies, which are the economies that are accused of over accumulating reserves to an extent that is difficult to justify using classical incentives. The result from the model shows that, by allowing for the incentive of attracting FDI inflows into the country, one can generate a much larger level of the equilibrium reserves-to-GDP ratio.

Table 1.6: Business Cycle Moments

Variable	Data	Model	Model (A2)	Model (A3)	Model (R1)	Model (R2)
Targeted						
$\sigma_{rx/y}$	14.37%	14.63%	5.64%	7.48%	13.09%	17.3%
Non-Targeted						
$\mu_{rx/y}$	13%	23%	23%	23%	23%	23%
$\sigma_{ca/y}$	80%	89.34%	6.37%	14.75%	20.38%	76.49%
$\rho(rx/y, i_t^F/y)$	0.52	0.53	0.61	-0.28	0.73	-0.38
$\rho(rx/y, k_t^F/y)$	0.43	0.89	0.52	0.41	0.39	0.35
$\rho(rx/y, y)$	0.10	0.57	0.61	-0.24	0.54	0.72
$\rho(rx/y,, bf/y)$	0.35	-0.11	0.34	-0.15	0.59	0.89

1.10 Conclusion

Why do we observe large accumulations of reserves? This paper answers this question from a novel perspective: public capital outflow is intended to attract more private capital inflow. This explanation also speaks to the co-movements of capital flows observed in the data on EM economies. It is important to emphasize that I abstract from some important features of foreign exchange reserves as analyzed in the literature, including precautionary savings and reducing the probability of a crisis. Including these features would unambiguously lead to an increase in the optimal level of reserves. However, the aim of this paper is not to provide policy guidance regarding the optimal level of reserves. It should instead be used to understand the unexplored incentives for reserve-holding behavior. If there were policy coordination between investor economies and the recipient economies on other signals instead of foreign exchange reserves, the cost of attracting private investment will be significantly reduced for EM economies. Such policy discussions regarding optimal reserve-holding behavior could be further pursued by multilateral institutions such as the IMF and central banks around the world as an important area for future research.

Chapter 2: Do FDI firms create more jobs than domestic firms for each dollar of assets?

This chapter is coauthored with Sakai Ando. We thank colleagues in IMF for constructive discussion. The paper does not reflect the view of the IMF, its Executive Board, or IMF management. All errors are ours

2.1 Introduction

Foreign direct investment (FDI) brings many different benefits, but the most wanted benefit might differ depending on the recipient economies. For example, some economies might be most interested in the tax revenue generated by foreign-participated companies. The economies that aim to catch up with advanced economies may find knowledge transfer to be the main benefit. For other economies (for instance, those already at the technology frontier), job creation can be the benefit of interest.

Among the various dimensions of FDI, this paper specifically focuses on job creation. The job-creation benefits that FDI may generate in recipient economies is usually underscored by both the firms engaged in FDI and policy makers. For example, large MNEs that are often subject to the accusation of tax avoidance use job creation to justify their business in the local economies.[1] Policy makers often accolade FDI by quoting the total value of the investment and the jobs it creates.[2] Despite its relevance, the aspect of job creation has been under-explored in the literature.

This paper is an attempt to fill the gap by studying whether, for each dollar of assets, FDI firms hire more employees than domestic firms. To answer the question, we use the firm-level data of Orbis

[1]For example, Apple Inc. has websites to advertise the total number of jobs it creates in each economy. https://www.apple.com/uk/job-creation/

[2]U.S. president Donald Trump mentioned in his 2017 tweet "Toyota & Mazda to build a new $ 1.6B plant here in the U.S.A. and create 4K new American jobs. A great investment in American manufacturing!"

by Bureau van Dijk to construct a unique dataset of FDI and domestic firms. Specifically, we use the ownership structure data to classify each firm into FDI or domestic and use the financial statement to construct its employment per asset ratio. To prevent "phantom FDI" from contaminating the analysis, we also remove special purpose entities (SPEs) from the main specification.

As the main result, we show that, in most economies, domestic firms create more jobs than FDI firms for each dollar of assets. Specifically, in 2016, in 41 out of 51 economies in the sample, the mean of the log employment per asset for domestic firms is significantly higher than that for FDI firms. This result is robust to alternative definitions of FDI and SPEs.

To understand the structure of the aggregate result, the paper compares FDI and domestic firms not just for each economy but also for each industry. The case study of the United Kingdom shows that domestic firms create significantly more jobs per asset in 9 out of 11 industries. This result suggests that the main result is not driven by a particular industry but is a common feature across different industries.

The analysis at the industry level also explores the cross-country relationship between industry composition and the difference in job creation between FDI and domestic firms. It is shown that domestic firms tend to create more jobs per asset if a higher fraction of domestic firms is in construction, wholesale trade, or services. The result suggests the driving industries that help predict the difference in job creation between FDI and domestic firms at the aggregate level.

Finally, we leverage the time-series dimension of the data by tracing the firms that change ownership from FDI to domestic and vice versa as well as those with stable ownership. The sample from 2011 to 2016 reveals that (1) the ownership change itself does not have an immediate impact on the behavior of employment per asset and (2) the always-domestic firms hire significantly more employees per asset than the switchers and always-FDI firms. These results suggest that the behavior of job creation is not so much driven by the ownership structure itself as by the technological characteristics of the firms that are owned or traded by foreign investors.

The interpretation and the resulting policy implications of the analysis need to be understood with care. On the one hand, the fact that domestic firms create more jobs compared with FDI firms with similar asset sizes suggests that attracting FDI firms may not be the best policy for the purpose of job creation in the short run. On the other hand, the fact that firms with similar asset sizes can be operated with a smaller number of employees is consistent with more efficient operation, which can contribute to longer-run productivity gains.

2.2 Literature

There is a strand of literature focusing on the labor market effects of FDI, but the data tend to be limited to a particular industry or a specific economy. Harrison and Scorse (2005) use data on firms in Indonesia to find that the wage premium paid by foreign establishments during the 1990s were robust to the inclusion of workers characteristics, suggesting that the higher wage premiums may be due to a foreign firm's higher spending for training, partly in order to retain workers. Harrison and McMillan (2011) use U.S. MNEs data and study the impact of U.S. MNEs offshore jobs on domestic employment. They show that the effect of job shifting to offshore on the domestic labor market is limited. Lundin et al. (2007) study the impact of FDI on employment in the Chinese manufacturing industry, suggesting that the FDI entry into China has positive effects on employment growth in the manufacturing industry.

Although the job creation aspect of FDI has been under-explored, other gains from FDI have been studied extensively. For example, there is a large literature on the productivity gain and technology spillover of FDI. Aitken and Harrison (1999) use panel data on Venezuelan plants and suggest that foreign equity participation is positively correlated with plant productivity, but the spillover effect is small. Smarzynska (2004) uses firm-level data from Lithuania and shows that spillovers are associated with projects with shared domestic and foreign ownership but not with fully owned foreign investments. Matthew (2007) use the plant-level panel data of the United Kingdom and find a significantly positive correlation between a domestic plant's TFP and the foreign-affiliate share of activity in that plant's industry. Alfaro et al. (2003) relates inward FDI to the local financial market and finds that economies with well-developed financial markets gain significantly from FDI.

2.3 Data

This section describes the Orbis database and the cleaning process. Regarding the data cleaning process, we introduce three layers of cleaning in addition to dropping missing values, *i.e.*, (1) dropping the data related to consolidated financial statements, (2) classifying firms into FDI and domestic firms, (3) dropping Special Purpose Entities (SPEs). Appendix B.1 presents the table of summary statistics of the cleaning process.

The Orbis database used in this paper is a commercial database compiled by Bureau van Dijk (BvD). It reports the information of firms financial statements collected from administrative sources and its coverage extends to more than 300 million firms across the world. Orbis is one of the most comprehensive firm-level databases that cover both listed and unlisted firms across the world, although some quality concerns have already been known in the literature as discussed by Kalemli-Ozcan et al. (2015) and Tørsløv, Wier and Zucman (2018).

The main analysis of this paper uses the 2016 data of each firms (1) number of employees, (2) total asset, (3) nationality of shareholders, and (4) direct and total percentages of shares held by the shareholders. We choose 2016 as the benchmark since 2016 data is the most complete recent data due to the reporting lags of Orbis as of 2019. The four variables are taken from the financial historical database and historical ownership database of Orbis, which are then matched using the unique BvD firm identifier.[3]

We implement three more steps to filter out the data suitable for the analysis, in addition to the standard data cleaning process to keep the non-missing observations. The first step is to drop the observations of the consolidated data in Orbis. Consolidated data aggregate up the information of all the subsidiaries into the group total, including those incorporated abroad. As a result, the number of employees in the consolidated data does not necessarily reflect the employment in the economy where the parent firm is incorporated.[4]

[3] The analysis at industry level in section 2.5 and that of the switching firms in section 2.6 further restrict the observations to those that have industry information and those that can match past data respectively. The number of the observations in each analysis will be reported in each section.

[4] The parent firm is often incorporated in a tax heaven with small population, in which case the number of employees

The second step is to classify firms into FDI and domestic firms. Ideally, the identification of FDI firms should follow the definition of the direct investment enterprises in *the Balance of Payments Manual 6th edition* (BPM6). In practice, however, the information in Orbis is not sufficient to directly apply BPM6. The next section explains the issue and describes the definition adopted in this paper.

2.3.1 Classifying firms into FDI and domestic firms

BPM6 defines a direct investment enterprise as an entity subject to control or a significant degree of influence by a nonresident entity. The definition of control or influence is further divided into (1) the immediate direct investment relationship where a nonresident entity directly owns more than 10 percent equity with voting power and (2) the indirect direct investment relationship where a nonresident entity can exercise more than 10 percent voting power through a chain of direct investment relationships.

Figure 2.1 describes an example of both the immediate and indirect direct investment relationships, where firm A is a nonresident entity and firm B , C , and D are resident entities in the economy. The percentage indicates the equity share with voting power and the vertical line represents the boundary of economic territories. In this example, firm B and C are the direct investment enterprises of firm A since firm A directly owns more than 10 percent equity of firm B and C . Firm D is also a direct investment enterprise of firm A , even though firm A has no equity of firm D , because A has an influence of 10 percent voting power on firm D through firm B and C .

Similar to BPM6, the ownership structure data in Orbis are also divided into two types, direct and total percentage, although the definitions have subtle differences. Table 1 illustrates an example similar to Figure 1 that shows how Orbis records such a situation, assuming that firm A is incorporated in the United States and firm B , C , and D are in China. Each firm and shareholder has a 2-digit identifier of the location of the economy at the beginning of their ID. The ownership share is reported in either direct percentage or total percentage.

in the consolidated data can exceed the population of the economy.

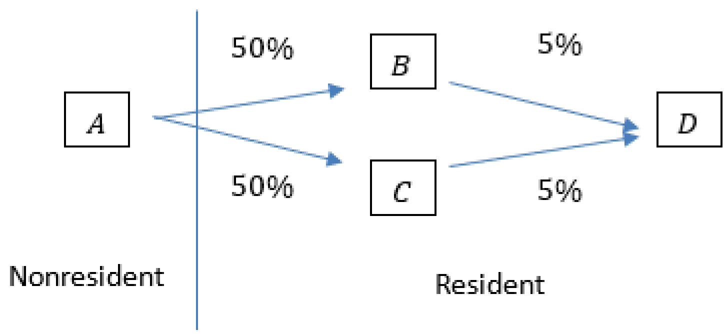


Figure 2.1: Firm B, C, and D are all direct investment enterprises of firm A

Firm ID	Shareholder ID	Direct percentage	Total percentage
CN000B	US000A	50	NA
CN000C	US000A	50	NA
CN000D	US000A	NA	5
CN000D	CN000B	5	NA
CN000D	CN000C	5	NA

Table 2.1: Format of shareholder information in Orbis

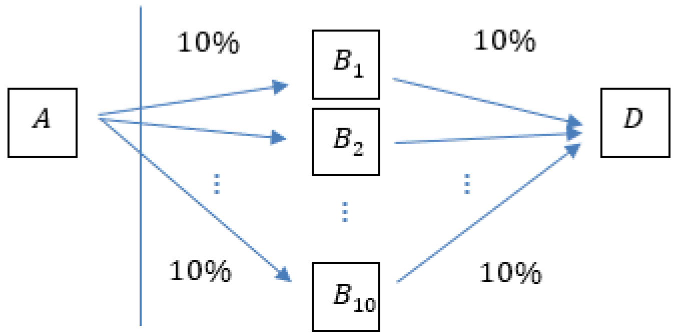


Figure 2.2: Total percentage in Orbis overestimates indirect direct investment enterprises

Note that the total percentage of A on D is $5 = (0.5 \times 0.05 + 0.5 \times 0.05) \times 100$ instead of 10 . This is because the total percentage in Orbis is calculated by summing up the multiplication of the shares throughout the chains. In contrast, BPM6 counts the voting power using only the last legs, i.e., $5+5 = 10$. The rest of the chains are used only to make sure that every investment relationship is chained by more than 50 percent equity share so that the parent firm has control over the voting decision of the last legs.

Using the total percentage in Orbis to estimate the direct investment enterprises in BPM6 can end up with both under- and over-estimation. Figure 2.1 is an example of under-estimation. Over-estimation can also happen if the number of firms in the middle increases. Suppose that, instead of firm B and C , firm A has 10 percent equity shares of firm $B_1, \ldots, B_{10}$ and each of them has 10 percent shares of firm D as in Figure 2.2. The total percentage in Orbis is 10 , but the voting power in BPM6 is 0 since firm A does not have control of firm $B_1, \ldots, B_{10}$.

The patterns of the existing and missing data add further complications to the identification of direct investment enterprises. In some cases, the direct percentage of all the shareholders of a firm does not sum up to 100, implying the possibility of either missing shareholder information or the possibility that the direct percentage is recorded in the total percentage column. In other cases, only the names of the shareholders are reported without any information on the direct or total percentage.

Given these difficulties in identifying direct investment enterprises, this paper adopts a simpler definition than BPM6 by restricting FDI firms to those with at least one foreign shareholder owning more than 10 percent share in either direct or total percentage. To demonstrate the robustness of the analysis based on this definition, Appendix B.3 shows that the main result in section 2.4 remains similar after replacing 10 by 50 so that firms are restricted to those that are under the control of foreign parent companies.

2.3.2 Treatment of Special Purpose Entities

The last step of the data cleaning is to drop the Special Purpose Entities (SPEs) from the sample. SPEs refer to the legal entities that are used to fulfill the special purpose of firms, such as isolating financial risks and tax avoidance by multinational firms. As discussed by Damgaard, Elkjaer and Johannesen (2019), SPEs are often considered to be pass-through entities and do not reflect the real activities that FDI statistics intend to capture. The existence of SPEs can change the FDI data significantly as discussed in IMF (2018).

To prevent SPEs from driving the result, this paper excludes SPEs from the analysis. Following the definition proposed by IMF (2018), FDI firms with less than 5 employees are defined as SPEs and dropped from the main analysis. To ensure that the result is not driven by domestic shell companies, the main analysis also excludes domestic firms with less than 5 employees.

Although the threshold of 5 employees is a crude definition, it turns out that the results of the main analysis are robust to alternative definitions. Appendix B.4 and B.5 discuss the robustness by using two alternative definitions of SPEs. The first one is to keep all the domestic firms but drop the FDI firms with less than 5 employees. The second one is to use the lower 5 percentile of the employment distribution instead of 5 employees.

In summary, the definition of FDI and domestic firms used in this paper is as follows.

Definition. *Fix a firm in Orbis identified by the unique BvD firm ID. The firm is an FDI firm if (1) it reports an unconsolidated financial statement, (2) it has at least one foreign shareholder owning more than* 10 *percent share in either direct or total percentage, and (3) it has at least* 5 *employees. The firm is a domestic firm if it satisfies (* 1 *), (* 3 *), and (* 4 *) all the foreign shareholders hold less* *than* 10 *percent share in both direct and total percentage.*

2.4 Main analysis

This section analyzes whether FDI firms create more jobs than domestic firms for each dollar of assets. We describe our approach and show that, in many economies, domestic firms create more jobs for each dollar of assets. The main analysis at the aggregate level motivates more disaggregated analysis at the industry and individual firm level in the following sections.

The comparison of the FDI firms and domestic firms is based on the number of employees divided by the total asset. Given the fat tail distribution of the financial statement variables, we take the log as is suggested by Willett (2015). Thus, each firm is represented by

$$e = log_{10}\left(\frac{Number\ of\ employees}{Total\ assets}\right) \tag{2.1}$$

There can be multiple legitimate interpretations for employment per asset e . One interpretation is how efficiently the firm can create jobs given the same size of the asset. Another is how efficiently the firm can operate using the employees. Since the interpretation can depend on the specific context of the readers, this paper avoids the evaluative term "efficiently" and just neutrally call e employment per asset.

Note that the measure of employment per asset e may not have a direct connection with the productivity of the firm. The productivity of a firm usually refers to the ratio of output to inputs. The total asset, however, is not necessarily a measure of the output but can include both the value of the capital used for production and other activities including investment in financial instruments. Therefore, the two concepts do not necessarily have a one-to-one mapping with each other. The asset serves as the normalization tool to compare different firms.

The comparison between FDI and domestic firms in each economy is based on hypothesis testing. Specifically, the null and alternative hypotheses are

$$H_0\text{: E}\left[e^{Dom}\right] = E\left[e^{FDI}\right]$$

$$H_1\text{: E}\left[e^{Dom}\right] \neq E\left[e^{FDI}\right]$$

where e^{Dom} and e^{FDI} are the random variables drawn from the distributions of domestic and FDI firms. The t-statistic of the test is

$$t = \frac{\bar{e}^{Dom} - \bar{e}^{FDI}}{\sqrt{\hat{V}(\bar{e}^{Dom} - \bar{e}^{FDI})}}$$

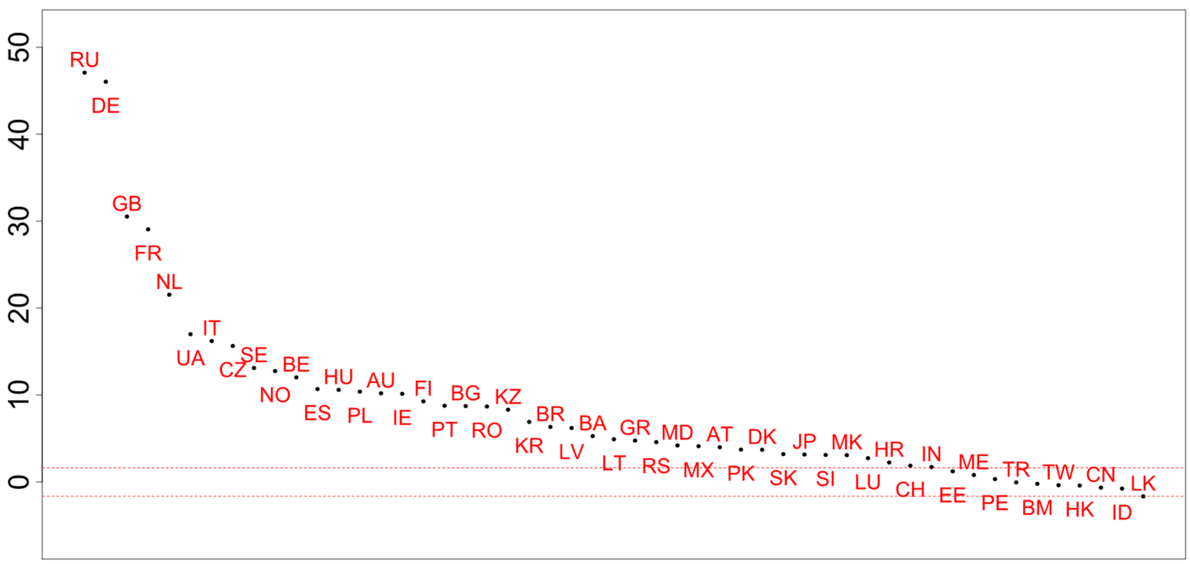
where $\overline{e}^{Dom}$ and $\overline{e}^{FDI}$ are the sample means of the employment per asset for domestic and FDI firms, and $\hat{V}$ is the estimated variance. The observations are assumed to be *i.i.d.*, so the estimated variance is the sum of the sample variances. Since the hypothesis testing is based on the large sample theory, we drop the economies with either the number of FDI or domestic firms less than 50 .

The main result is plotted in Figure 2.3. Each dot corresponds to the t-statistic of an economy. The red dashed line is the 10 percent acceptance region of the null hypothesis. The figure is ordered by the t-statistic and a larger t-statistic suggests that it is more likely that on average domestic firms create more jobs than FDI firms for each dollar of assets.

Figure 2.3 suggests that, in most economies, domestic firms tend to create more jobs than FDI firms for each dollar of assets. One can see that some economies exhibit large positive t-statistics, but no economies exhibit large negative t-statistics. In this sense, there is not much qualitative heterogeneity across economies.

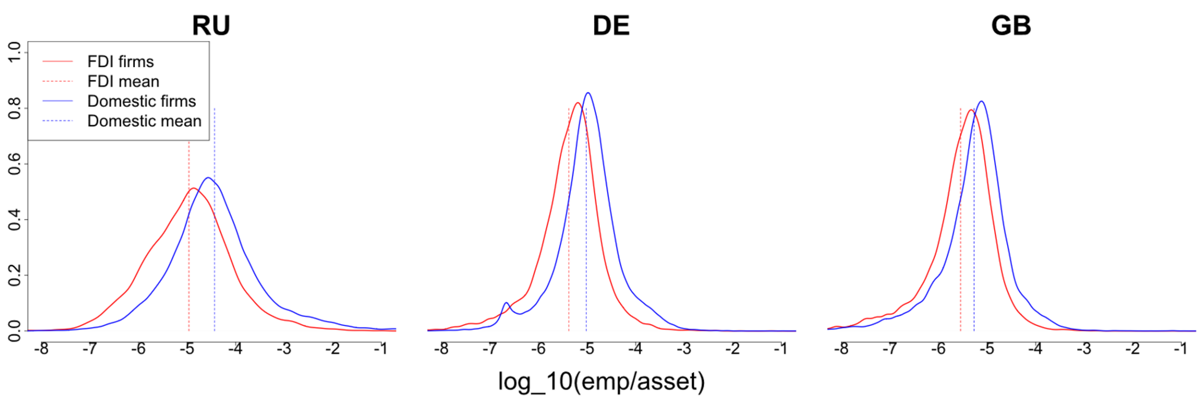
Figure 2.4 suggests that the large t-statistics for some of the economies are not driven by outliers. It shows the density of FDI firms and domestic firms for the three largest t-statistic economies. One can see that, although the fatness of the densities are different across economies, they all have larger t-statistics because the densities of FDI firms are shifted to the left side of those of domestic firms and is not because of outliers.

Figure 2.3: Domestic firms create more jobs per asset in most economies



Note: Y-axis denotes the t-statistics. A larger number suggests that it is more likely that on average domestic firms create more jobs than FDI firms for each dollar of assets. The number of observations can be found in Table B.1.

Figure 2.4: The largest t-statistics economies are not driven by outliers

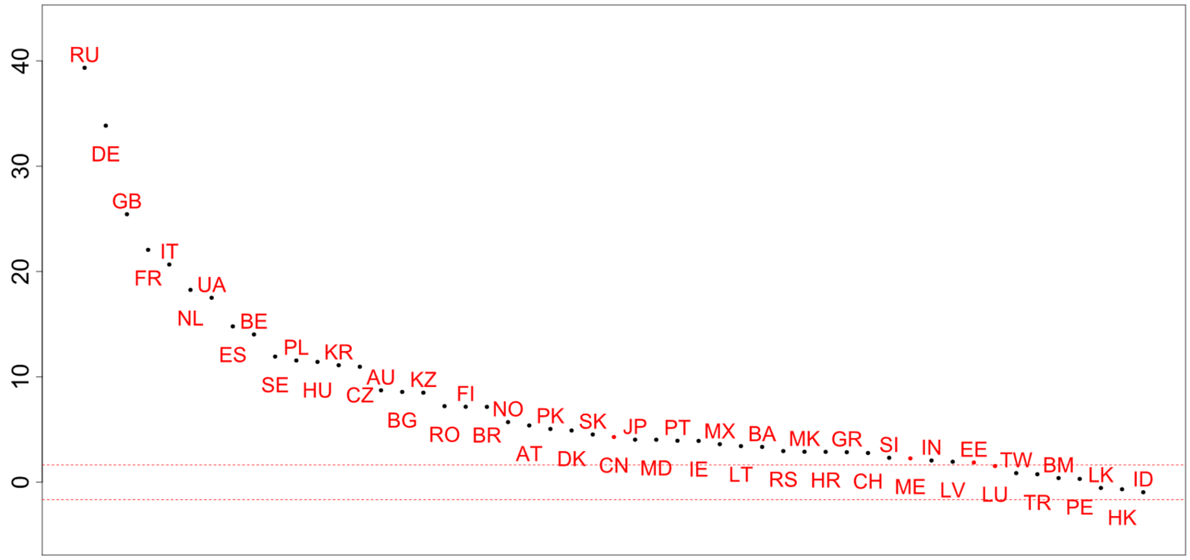


2.4.1 Discussion about the main result

One natural question is whether the result in Figure 2.3 is robust to alternative specifications of FDI and domestic firms. Figure 2.5 shows that the qualitative result survives even if all firms with less than 100 employees are dropped. Thus, dropping small- and medium-sized enterprises (SMEs) does not change the insight.

In the appendix, we show additional results about the robustness of Figure 2.3. Specifically, the

Figure 2.5: The result survives if all firms with less than 100 employees are dropped



Note: Y-axis denotes the t-statistics. A larger t-statistic suggests that it is more likely that on average domestic firms create more jobs than FDI firms for each dollar of assets. Red dots correspond to those whose result of the hypothesis test changed from Figure 2.3.

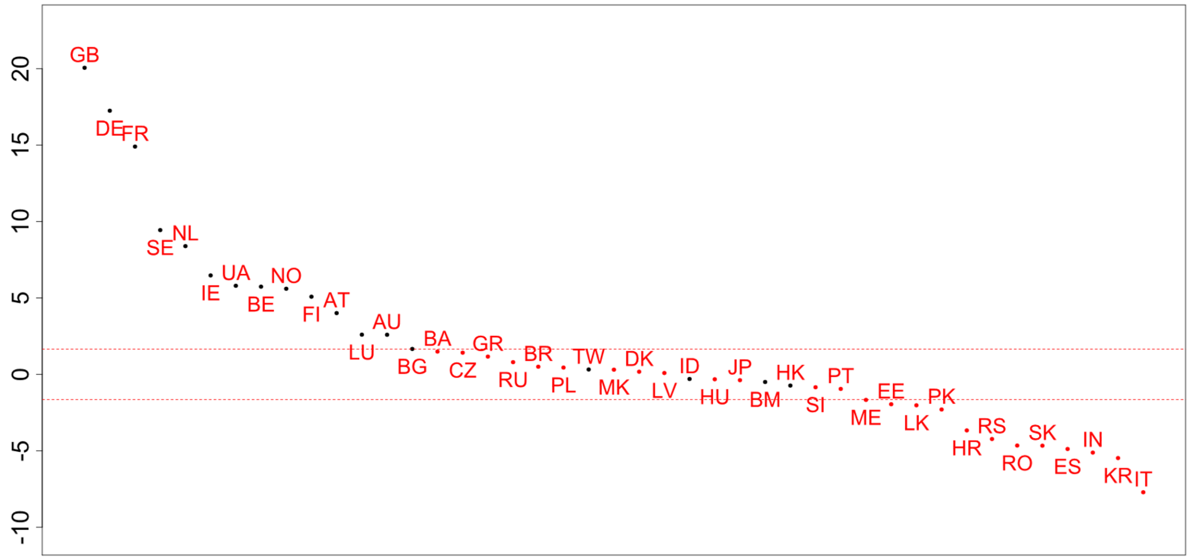
qualitative result remains similar if (1) the total assets are replaced by shareholders funds (Appendix B.2), (2) the 10 percent threshold in the definition of FDI firms is replaced by 50 percent (Appendix B.3), (3) the definition of SPEs is restricted to FDI firms and all domestic firms are included in the exercise (Appendix B.4), and (4) the 5 employee threshold in the definition of SPE is replaced by 5 percentile (Appendix B.5). These robustness checks suggest that the main result does not so much hinge on the details of the FDI-related concepts as represents the overall pattern of the data at the aggregate level.

Another natural question is whether Figure 2.3 implies that domestic firms pay a larger amount of wage and other financial benefits for the employees. For this question, we can use the information about the cost of employees in Orbis and conduct the same exercise.

$$e^{cost} = \log_{10}\left(\frac{Cost\ of\ employees}{Total\ assets}\right)$$

Figure 2.6 shows that, in the majority of the economies, domestic firms spend more on the cost of employees than FDI firms for each dollar of assets, although more economies than Figure 3 exhibit

Figure 2.6: Heterogeneity increases if the number of employees is replaced by their cost



Y-axis denotes the t-statistics. A larger t-statistic suggests that it is more likely that, on average, domestic firms spend more on the cost of employees than FDI firms for each dollar of assets. Red dots correspond to those whose result of the hypothesis test changed from Figure 2.3.

the opposite pattern. Note that this does not necessarily mean that the wage for each employee is higher in domestic firms. What it means is that domestic firms not only create more jobs but also generate more total income for workers than FDI firms for each dollar of assets in many economies.

2.5 Analysis at the industry level

Section 2.4 has studied job creation at the aggregate level by comparing all the FDI and domestic firms. This section explores further granularity of the data at the industry level. Specifically, we dig deeper into two aspects of the main result in section 2.4.

The first aspect is the industry fixed effect. It is of natural interest to see whether the aggregate result holds in the individual industry. We show that, for the case of the United Kingdom, domestic firms create more jobs than FDI firms for each dollar of assets in all industries.

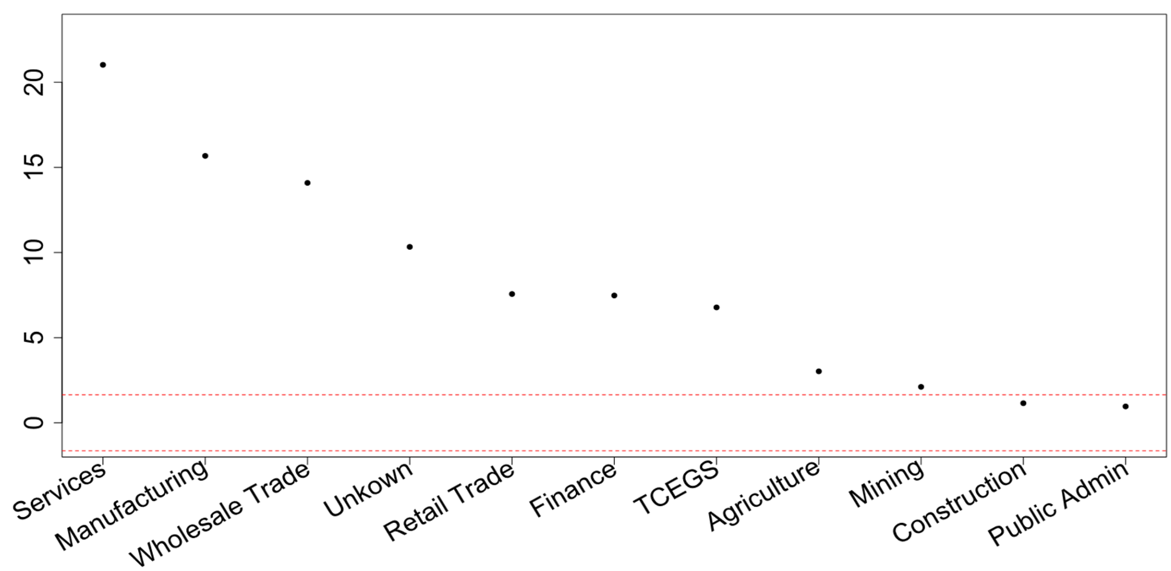
The second aspect is the cross-sectional relationship between the aggregate result and industry composition. Whether higher t-statistic comes from a larger share of certain industries in the economy is an intriguing question. We show that a larger share of domestic firms in construction, wholesale trade, and services is associated with a higher t-statistic of domestic firms creating more jobs than FDI firms for each dollar of assets at the aggregate level.

2.5.1 Comparison of FDI and domestic firms at the industry level

The industry level comparison of this section focuses on the United Kingdom. The United Kingdom is the economy with the highest t-statistic in Figure 3 among those that have industry information for more than 90 percent of the firms. Thus, the United Kingdom is the most informative economy in the sample for the exploration of the driving industries behind the difference in job creation between FDI and domestic firms.

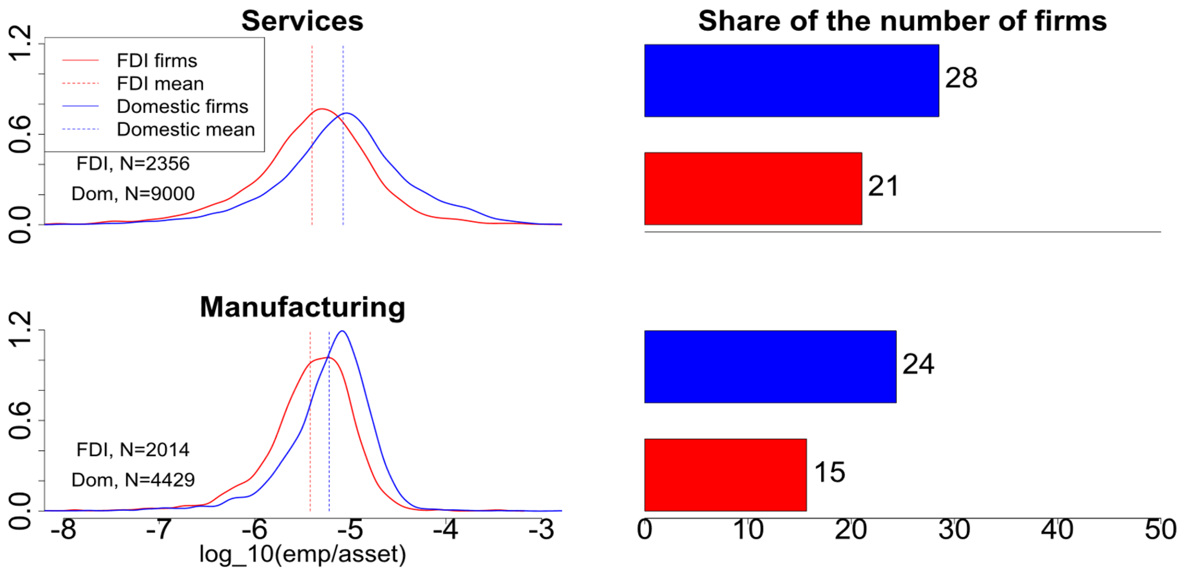
Figure 2.7 suggests that domestic firms create more jobs per asset than FDI firms in all industries in the United Kingdom. It shows the same exercise of t-statistics as Figure 3 except that the x-axis is the individual industry in the United Kingdom instead of the economies. One can see that all t-statistics are positive, although some of them are statistically insignificant.

Figure 2.7: Domestic firms create more jobs per asset in all industries of the United Kingdom



Y-axis denotes the t-statistics. A larger t-statistic in y-axis suggests that domestic firms are likely to create more jobs than FDI firms for each dollar of assets. X-axis denotes industries based on US-SIC where TCEGS represents transportation, communications, electric, gas and sanitary service and Unknown represents the firms without industry information.

Figure 2.8: Services and manufacturing are the two highest t-statistics industries



The left column shows the densities of the employment per asset for services and manufacturing industries. The first row of the right column shows the percentage of the firms in the services industry within FDI firms (blue) and domestic firms(red). The second row of the right column shows the corresponding shares for the manufacturing industry.

To see further details, Figure 2.8 presents the distributions of employment per asset for the two highest t-statistics industries. The left column shows the densities of the employment per asset for services and manufacturing industries. One can see that the distributions of domestic firms are more right-shifted than FDI firms in both industries. The first row of the right column shows the share of the services industry within FDI firms and domestic firms, while the second row shows the shares for the manufacturing industry. One can see that, in terms of the number of firms, the two industries have large shares in both groups of FDI and domestic firms.

The high aggregate t-statistics in Figure 2.3 for the United Kingdom is, therefore, not a result of a few outlier industries or firms but is a general behavior of the FDI and domestic firms. Interestingly, the services sector that constitutes the largest share in both the FDI and domestic firms exhibit the sharpest contrast between the two groups of the firms. In the next subsection, we study whether there is a relationship between the structure of the industry and the difference in job creation between FDI and domestic firms.

2.5.2 Industry composition and cross-sectional pattern of job creation

The analysis so far has focused on the comparison between FDI and domestic firms within the same economies. Whether the cross-sectional differences in job creation can be predicted by different economic structure is of natural interest.

Figure 2.9: Sectors whose larger shares are positively associated with FDI-domestic difference

Y-axis denotes the same t-statistics as Figure 2.3 with ISO2 label for top 5 economies. A higher t-statistic suggests that it is more likely that domestic firms create more jobs than FDI firms per asset. X-axis denotes the share of the number of firms in the industry within domestic firms. A larger share in the above three industries is associated with a larger aggregate difference between domestic and FDI firms.

Figure 2.9 presents the cross-sectional pattern of differences in job creation against the industry structure measured by the share of the number of firms in the industry within domestic firms. One can see that a larger share in construction, wholesale trade, and services predicts is associated with a higher likelihood that domestic firms create more jobs than FDI firms for each dollar of assets.[5] The pattern does not hold as clearly as the above three industries when it comes to other industries. For example, the financial industry can exhibit low employment per asset in both FDI and domestic firms due to the nature of the business, but as in Appendix B.6, it turns out that the size of the financial industry is not correlated with the difference in job creation between the two groups of firms.

[5]Note that the regression cannot be interpreted as causality since both axes are endogenous variables and should be interpreted as prediction based on correlation.

2.6 Analysis of switchers

The previous sections have studied the data of a single year. This section explores the time series dimension by analyzing the firms that switch ownerships between domestic and FDI firms. Although focusing on switchers implies that the sample is limited to a subset of brownfield FDI firms, and thus excludes greenfield FDI firms, the analysis has the advantage of controlling some of the firms fixed effects.

The analysis focuses on the firms that have changed ownership status between FDI and domestic from 2013 to 2014. As in section V.A., we use the United Kingdom as an example to visualize the exercise. The switchers are compared with non-switchers with 2 years lag and forward. Although the non-switchers are natural candidates for control groups, switchers may possess their own unique characteristics that drove them into the switchers in the first place, so the result needs to be interpreted with care. Specifically, we study the following four groups of firms.

1. Firms that are domestic firms from 2011 to 2016.

2. Firms that are domestic firms from 2011 to 2013 and FDI firms from 2014 to 2016.

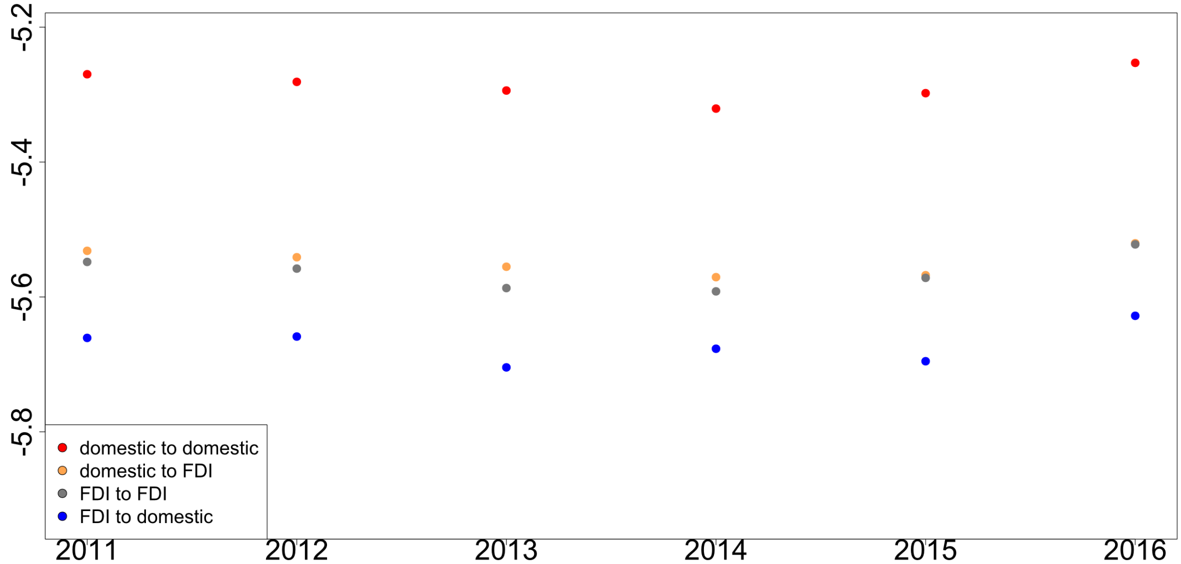
3. Firms that are FDI firms from 2011 to 2016.

4. Firms that are FDI firms from 2011 to 2013 and domestic firms from 2014 to 2016.

Figure 2.10 shows the time series of employment per asset ratio in Eq. 2.1 for the four groups of the firms. One can see that the ownership change from 2013 to 2014 does not have an obvious impact on the employment per asset in itself. Rather, the always-domestic firms have higher employment per asset ratio uniformly over time. An interesting observation is that always-FDI firms do not necessarily exhibit the lowest employment per asset ratio, although the FDI-to-domestic group is based on a small sample size of 44. The same chart is plotted for Russia, Germany, and all firms in the world in Appendix B.7, exhibiting similar stable patterns as the United Kingdom.

The result suggests that the behavior of job creation is not so much driven by the ownership structure itself as by the technological characteristics of the firms that are owned or traded by foreign

Figure 2.10: The four groups do not exhibit obvious patterns of change in the United Kingdom



Y-axis denotes the mean of the log employment per asset ratio for the four groups of firms. There is no obvious change of pattern after the ownership change from 2013 to 2014.

investors. In other words, the image of foreign vulture funds taking over firms and laying off employees for cost-cutting is not what the data show. Rather, the firms that receive cross-border investment possess certain production technologies in the first place. One policy implication is that, although domestic firms create more jobs per asset, policies to force changes of ownership from FDI to domestic firms do not necessarily lead to immediate job creation, unless the underlying production technology also changes.

A regression-based analysis can be conducted using the difference-in-difference framework. Appendix B.8 applies the regression with firm and time fixed effects to all the firms in all economies. Consistent with the analysis in the current section, it is shown that there is no systematic difference before and after the ownership change.

2.7 Conclusion

This paper has shown that, in most economies, domestic firms create more jobs than FDI firms for each dollar of assets. In the industry level analysis of the United Kingdom, it is shown that the aggregate result is not driven by certain industries, and instead, domestic firms tend to create more jobs per asset than FDI firms in all industries. The switchers analysis suggests that the change of ownership itself does not have immediate impacts on the behavior of job creation, and therefore, the difference between FDI and domestic firms may rather reflect the technological difference of the firms owned by foreign investors rather than the ownership structure itself. The analysis implies that policies to attract FDI firms might not be the most effective instrument for the purpose of job creation, and therefore, it might be more effective to put other aspects including technological transfer at the center of the discussion of FDI-promotion policies.

Chapter 3: Liability Dollarization and Contractionary Devaluation: A model based evaluation

3.1 Introduction

Emerging markets borrow from international borrowers not only in their domestic currencies but also in foreign currencies. A large fraction of the external debt in emerging markets is not denominated in their own currencies. According to the World Bank, in 2016, Brazil has 94% of the public debt denominated in USD, Argentina has 70%, and Mexico has 55%. Many other countries have similar situations.

International investors prefer dollar-denominated assets to avoid exchange rate fluctuation risk. This situation forces emerging markets borrowers to issue dollar-denominated debt instead of their own currency-denominated debt. The existing amount of foreign currency debt would pose policy concern to domestic central banks. The conventional monetary policy that requires devaluation to boost the domestic economy might not be suitable for a highly indebted country with foreign currency debt. The substantial debt burden brought by devaluation might overturn the benefits of being able to move the exchange rate freely.

Economists and policymakers have been trying to examine the detrimental effects of having liabilities in foreign currencies. The existence of foreign currency-denominated debt might give rise to a completely different optimal monetary policy. If this concern is not taken into account, devaluation predicted by the standard New Keynesian model will do more harm than benefits when a small open economy faces negative external shocks.

To fully address this problem, we need first to address directly the channel of devaluation that leads to output and investment contraction if the economy has full autonomy of its exchange rate policy. There are two sides to a devaluation policy. On the positive side, the world's demand for domestic goods will be greater if the depreciation in the exchange rate leads to a decrease in the price of domestic exportable goods in terms of foreign currency. The export will be stimulated due to the relatively lower domestic goods price. If we further assume domestic consumption is also composed of domestically produced goods and foreign goods, then this relative price change can also increase the demand for domestic goods from the domestic side. The decrease in the relative price of domestic goods leads to a demand increase both from domestic consumers and foreign consumers. But on the negative side, if the economy has a certain amount of debt denominated in foreign currencies, upon devaluation, the nominal amount of debt will be larger in terms of the domestic currency. By intuition, this is a channel that cannot be neglected when modeling monetary policy for a small open economy.

This paper revisits the foreign currency liability problem by proposing a simple model that speaks directly to the mechanism of the detrimental effect of liabilities denominated in foreign currencies of emerging markets. The model adds borrowing friction to the small open economy when borrowing from foreign lenders. When entrepreneurs, the owner of the firms, borrow from the international lenders to finance domestic investment, they are facing a working capital constraint, that a fraction of the borrowed debt has to be held in domestic currency risk-free assets. This can be interpreted as setting aside a certain fraction of the resources for paying wages to workers, or as a potential carry trade that the firms are exploiting the domestic high interest rate compared to the world interest rate. The model further features nominal rigidity, that the price of the domestically produced goods is rigid.

The asset holding constraint and the domestic nominal rigidity lead to the contractionary effect of devaluation that the model can generate. When there is a devaluation of the domestic currency, due to the price rigidity, the income of the firm shrinks compared to its foreign currency debt. Due to the asset holding constraint, the entrepreneurs can not fully smooth away the relative larger debt burden. These then transfer to a lower investment level, and thus a lower output and capital stock. The model can also provide quantitative evaluation and thus policy guidance based on this contractionary devaluation effect, and can speak specifically to each country with different levels of debt.

The rest of the paper is organized as follows. In section 3.2, I summarize the literature on this question by discussing their channels of frictions in international borrowing, potential drawbacks, and contradictions. In section 3.3, I introduce the model. In section 3.4, I explain the primary mechanism that the model delivers, which is used to address the specific liability dollarization problem and provide calibrations of the key parameters in the model. In section 3.5, I discuss the results and provide policy guidance. In section 3.6, I briefly discuss the welfare loss of the business cycle and summarize my thoughts on future directions of research in section 3.7.

3.2 Literature Review

My research relates to two strands of literature, the currency mismatch, and the exchange rate policy. Gertler, Gilchrist and Natalucci (2007), discuss the currency mismatch problem for Korea. In the paper, they use a model with the financial accelerator mechanism. The key assumption is that borrowing cost depends on the leverage ratio for a small open economy, which can be directly affected by the exchange rate regime. The higher the leverage ratio is, the higher the borrowing cost is. This financial accelerator mechanism is the main mechanism that the paper uses to compare different monetary policies, the Taylor rule and the exchange rate peg, under the world interest rate shock. The paper's conclusion is that the decrease in asset price under the exchange rate peg is more detrimental than the increase in the debt burden due to the devaluation under the Taylor rule. However, Cook (2004) uses the same mechanism but has opposite results. In his paper, he discovers that the distribution of the profit of firms matters to the response to shocks. It determines who bears the loss or the gain of the shock. Another aspect that affects the different responses is how sensitive export depends on the relative price change. Different combinations of parameter values will give different results to the model. Céspedes, Chang and Velasco (2004) use a simple tractable model with the financial accelerator to explore the conditions for different results. They find that under some parameter values, the world interest rate increase in this model will lead to a real appreciation and thus output boom in both flexible and fixed exchange rate regimes. Under other conditions, there will be a real depreciation after world interest rate shock. Some financially robust economies will experience a decrease in the borrowing cost, and the financially fragile economy will experience an increase. But both will suffer less loss from a flexible exchange rate compared to a fixed one. These three papers use the same mechanism but reach different and some non-intuitive results. Galí and Monacelli (2005) discuss in general the trade-off of the exchange rate in monetary policy between stabilizing terms of trade /exchange rate, and stabilizing output gap/inflation. They conclude that domestic inflation based Taylor rule is still the optimal monetary policy.

My research adds to the literature of closing the gap between different results of the devaluation policies on foreign currency debt. I demonstrate the key parameters in the model that affect the conclusion of either contractionary or expansionary devaluation. I start from only focusing on the model's response to exogenous exchange rate movement to discussing exchange rate policies upon other adverse external shocks. The results will provide some policy guidance and point out the direction for empirical validation.

3.3 Model

The model is populated by three players, the household, the firms and the entrepreneur. I will describe them one by one.

3.3.1 Household

The economy is assumed to be populated by a large representative family with a continuum of members. Consumption is identical across family members. Household preferences are defined over per capita consumption, C_t, and are described by the utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, L_t) \tag{3.1}$$

Household gains utility from consumption and loses utility by providing labor, with the specific GHH utility form

$$U(C_t, L_t) = \frac{(C_t - \frac{L_t^{\omega}}{\omega})^{1-\sigma} - 1}{1-\sigma}$$

The sequential budget constraint of the household is given by

$$Q_t C_t + S_t B_t^h (1 + r_t) = W_t L_t + S_t B_{t+1}^h \tag{3.2}$$

Where

$$r_t = \rho_t + F(\hat{B}_t^h)$$

Q_t is the price of consumption good domestically, S_t is the exchange rate and ρ_t denotes the world interest rate level. $\hat{B}_t^h$ denotes the average cross-sectional level of household debt. Thus $F(.)$ is the country-specific interest rate premium for households. Households take the evolution of $\hat{B}_t^h$ as given. Because agents are assumed to be identical, in equilibrium, the average cross-sectional level of debt must be equal to the individual level of debt. $\hat{B}_t^h = B_t^h$

The functional form of $F(.)$ is $F(B_t^h) = e^{\tilde{B}_t{}^h - BH} - 1$, where BH is the steady-state level of household debt. Household in this case is allowed to borrow dollars and their borrowing cost depends on the economy's average household's external borrowing. The higher this external borrowing is, the larger the premium over international interest rate. There is no domestic credit market for household, household can only borrow foreign currency denominated debt. The debt elastic interest rate is for technical reason so that the model has a unique steady state.

Household choose process $\{C_t, L_t, B_{t+1}^h\}_{t=0}^{\infty}$ to maximize the utility function (1) subject to sequential budget constraint (2). The Lagrangian corresponding to the household problem is

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta^t \{U(C_t, L_t) + \lambda_t (W_t L_t + S_t B_{t+1}^h - Q_t C_t - S_t B_t^h (1 + r_t))\}$$

where $\beta^t \lambda_t$ denotes the Lagrange multiplier associated with the sequential budget constraint (2). The first order conditions with respect to $\{C_t, L_t, B_{t+1}^h\}$ associated the household's problem are thus

$$(C_t - \frac{L_t^{\omega}}{\omega})^{-\sigma} = \lambda_t Q_t \tag{3.3}$$

$$\lambda_t S_t = E_t\{\lambda_{t+1} S_{t+1} \beta (1 + \rho_{t+1} + F(B_{t+1}^h))\} \tag{3.4}$$

$$L_t^{\omega-1} = \frac{W_t}{Q_t} \tag{3.5}$$

3.3.2 Firms

The domestic goods are produced with a continuum of varieties of intermediate inputs via the technology

$$Y_t = (\int_0^1 Y_{it}^{\nu} di)^{\frac{1}{\nu}} \tag{3.6}$$

Firms produce the final good operate in a perfectly competitive environment. Profit is given by

$$P_t Y_t - \int_0^1 P_{it} Y_{it} di$$

So the first order condition associated with it is thus

$$Y_{it} = (\frac{P_{it}}{P_t})^{\frac{1}{\nu-1}} Y_t \tag{3.7}$$

for $i \in \{0, 1\}$. Using (7) to eliminate Y_{it} from (6), we would have the corresponding aggregate price for final good is

$$P_t = (\int_0^1 P_{it}^{\frac{\nu}{\nu-1}} di)^{\frac{\nu-1}{\nu}} \tag{3.8}$$

Intermediate goods are produced by monopolistic competitive firms using labor L_{it}, and capital K_{it}^d. Firms pay wage W_t to labor and rental rate R_t to entrepreneurs, who own the capital. The production function is Cobb-Douglas

$$Y_{it} = (K_{it}^d)^{\theta_d} L_{it}^{1-\theta_d} \tag{3.9}$$

where Y_{it} denotes the quantity of intermediate good i produced in period t. Firm i face a demand for intermediate good i given by (7). Production is demand determined.

Price is sticky in the model. The firms set prices according to Calvo set up. Specifically, with exogenous probability $\kappa \in (0,1)$, a firm cannot reset its price in period t. It then must charge the same price as in the previous period, and with probability, $1-\kappa$, can adjust price freely. Consider the pricing decision of a firm that can reoptimize its price in period t. Let P_{it}^c denote the price chosen in period t. Then, with probability κ the price will continue to be P_{it}^c in period $t+1$. With probability κ^2 the price will continue to be P_{it}^c in period $t+2$ and so on.

The present discounted value of profits associated with P_{it}^c is given by

$$maxE_t \sum_{s=0}^{\infty} \kappa^s Q_{t,t+s}(P_{it}^* - MC_{i,t+s})Y_{i,t+s}$$

Where $Q_{t,t+s}$ is a state-contingent nominal discount factor that converts nominal payments in period $t+s$ into a nominal payment in period t. The firm take $Q_{t,t+s}$ as given. The firm picks P_{it}^* to maximize the above expression. The corresponding first-order condition is

$$E_t \sum_{s=0}^{\infty} \kappa^s Q_{t,t+s} Y_{i,t+s} (\frac{P_{it}^*}{P_{i,t+s}})^{\frac{1}{\nu-1}} (\nu P_{it}^* - MC_{i,t+s}) = 0$$

Since all intermediate goods producers face the same rental rate and wage, their input ratio of labor and capital are the same. In the aggregate level, the factor input and optimal conditions regarding price can be written in the following forms by eliminating the subscript i

$$E_t \sum_{s=0}^{\infty} \kappa^s Q_{t,t+s} Y_{t+s} (\frac{P_t^*}{P_{t+s}})^{\frac{1}{\nu-1}} (\nu P^* - MC_{t+s}) = 0 \tag{3.10}$$

$$R_t^d = MC_t \theta_d \frac{Y_t}{K_t^d} \tag{3.11}$$

$$W_t = MC_t(1-\theta_d)\frac{Y_t}{L_t} \tag{3.12}$$

Here we assume that the firms are risk neutral; they choose the optimal price P^* to maximize the lifetime dollar profit taking into account that they might not be able to change the price in the following periods. The risk-neutral discount factor is thus $Q_{t,t+s} = \beta^s \frac{S_t}{S_{t+s}}$. Marginal cost MC_t is In the aggregate level, with the individual price-setter's behavior and equation (8), the price of domestic produced good is given as

$$P_t^{\frac{v}{v-1}} = \kappa P_{t-1}^{\frac{v}{v-1}} + (1-\kappa)P_t^*$$

Log-linearize equation (10) and combine it with the above price dynamics, we can have the following linearized dynamics of inflation.

$$\hat{\pi}_{t+1}\frac{\beta\kappa}{1-\kappa} = \frac{\kappa}{1-\kappa}\hat{\pi}_t + (1-\beta\kappa)(\hat{p}_t - \hat{mc}_t) \tag{3.13}$$

3.3.3 Entrepreneurs

Entrepreneurs are the owner of the firms, and they bare the profit and loss of the firms. Entrepreneurs are in charge of investment in the economy. They can borrow in foreign currency, here in the paper denoted as dollar, from foreign investors. Entrepreneurs face a normal budget constraint and a working capital constraint, that a fraction of their borrowed debt has to be held in domestic currency risk-free asset. Here I use cash as a convenience, but it can be substituted for deposits, domestic currency bonds, etc. Their constraints are given as follows

$$S_t B_{t+1}^d + (P_t - MC_t)Y_t + R_t K_t + M_t = Q_t I_t + \frac{1}{2}Q_t \frac{I_t^2}{K_t} + Q_t C_t^d + S_t B_t^d(1+r_t^d) + M_{t+1} \tag{3.14}$$

$$M_{t+1} \geq \eta S_t B^d_{t+1} \tag{3.15}$$

$$K_{t+1} = \delta K_t + I_t \tag{3.16}$$

In equation (14), S_t, B^d_{t+1} denote exchange rate and borrowed foreign currency debt in period t, that will be carried over to the next period. $(P_t - MC_t)Y_t$ denotes the firms' profit that is distributed to entrepreneurs., R_t, K_t refer to the rental rate of capital and the capital stock in period t. M_t is the domestic asset that is required to be held by the entrepreneurs from period $t-1$. Q_t, I_t refer to the price of capital goods, which is also the price of domestically produced goods, and the new investment that will add on to the current stock, $\frac{1}{2}Q_t\frac{I_t^2}{K_t}$ refers to the adjustment cost of investment. C^d_t is the consumption of entrepreneurs. B^d_t is the liability carried over from the last period. $1 + r^d_t$ refers to the interest rate paid on B^d_t to the foreign investor. Here I model the interest rate to be debt elastic, $r_t = \rho_t + G(\tilde{B}_t)$. ρ_t is the world interest rate, and $G(\tilde{B}_t)$ is an increasing function on the average cross-sectional debt taken on by each entrepreneur. This means entrepreneurs will need to pay a higher interest rate if they have more outstanding debt. This technical assumption is the same as the household side, will give a unique equilibrium to the debt evolvement. The last term, M_{t+1} is the new requirement on domestic asset holdings that need to be satisfied due to the new debt.

Equation (15) describes the cash holding requirement, η fraction of the borrowed debt has to be held in domestic currency. In equilibrium, entrepreneur borrows the same amount of debt in each period, and use the old asset held in domestic currency to satisfy the new requirement in each period, such that all the newly borrow debt can be used to invest. The asset holding requirement does not affect how much the borrowed resource entrepreneur can use to invest. It provides a way to model more dynamics in terms of exchange rate shock. Equation (16) describes the capital evolvement. Capital depreciates at a rate of δ.

With the above described constraints, entrepreneurs maximize the following utility function by choosing $C_t^d, B_{t+1}^d, I_t, K_{t+1}, M_{t+1}$

$$U = E_0 \sum \beta_e^t log(C_t^d) \tag{3.17}$$

The Lagrangian corresponding to the entrepreneurs' maximization problem is

$$\mathcal{L} = E_0 \sum \beta_e^t \Bigg(log(C_t^d) + v_t \Bigg(S_t B_{t+1}^d + (P_t - MC_t)Y_t + R_t K_t + M_t$$

$$-Q_t I_t - Q_t \frac{I_t^2}{K_t}\frac{1}{2} - Q_t C_t^d - S_t B_t^d (1 + \rho_t + G(\tilde{B_t^d})) - M_{t+1} + q_t(\delta K_t + I_t - K_{t+1})$$

$$+\varphi_t (M_{t+1} - \eta B_{t+1}^d)) \Bigg)$$

v_t is the Lagrangian multiplier of equation (14), $v_t q_t$ is the Lagrangian multiplier of equation (15), $v_t \phi_t$ it the Lagrangian multiplier of equation (16)

The first order conditions correspond to $C_t^d, B_{t+1}^d, K_{t+1}, M_{t+1}, I_t$, are as follows

$$\frac{1}{C_t^d} = v_t Q_t \tag{3.18}$$

$$v_t S_t (1 - \varphi_t \eta) = \beta_e E_t \big(v_{t+1} S_{t+1} (1 + \rho_{t+1} + G(\tilde{B}_{t+1}^d)) \big) \tag{3.19}$$

$$v_t q_t = \beta_e E_t \big(v_{t+1} (\delta q_{t+1} + R_{t+1} + Q_t \frac{1}{2} (\frac{I_{t+1}}{K_{t+1}})^2) \big) \tag{3.20}$$

$$v_t (1 - \varphi_t) = \beta_e E_t \big(v_{t+1} \big) \tag{3.21}$$

$$Q_t + \frac{Q_t I_t}{K_t} = q_t \tag{3.22}$$

Note that from equation (21) and equation (19), we can get the discount factor β_e, assuming that in steady state the borrowing premium $G(\tilde{B}^d)$ is 0

$$\beta_e = \frac{1-\eta}{1+\rho-\eta}$$

which is smaller than $\beta = \frac{1}{1+\rho}$, the household discount factor. This suggests entrepreneurs are less patient than household

3.3.4 Aggregate in the Economy

Domestic absorption A_t consists of both domestic produced goods D_t and foreign produced goods F_t. Domestic absorption is constitute of household consumption C_t^h, entrepreneur consumption C_t^d, entrepreneur investment I_t, and adjustment cost $\frac{1}{2}\frac{I_t^2}{K_t}$

$$A_t = C_t^h + I_t^d + C_t^d + \frac{1}{2}\frac{I_t^2}{K_t} = \frac{D_t^\gamma F_t^{1-\gamma}}{\gamma^\gamma(1-\gamma)^{1-\gamma}} \tag{3.23}$$

The composition of the domestic final goods A_t gives the composition of price index Q_t, where the domestic price of the foreign goods is taken to be the exchange rate S_t,

$$Q_t = P_t^\gamma S_t^{1-\gamma}$$

The cost minimization condition of constructing A_t gives the breakdown of D_t and F_t

$$D_t = \gamma A_t(\frac{S_t}{P_t})^{1-\gamma}$$

$$F_t = (1-\gamma)A_t(\frac{P_t}{S_t})^\gamma$$

Symmetrically, I assume export (foreign demand of domestic goods) given by

$$EX_t = (1-\gamma_x)(\frac{S_t}{P_t})^{\gamma_x} A_t^W$$

where A_t^W is the world demand, γ_x is the export elasticity, both are endogenously given.

The market clearing condition suggests that the domestic output Y_t is either domestically absorbed or exported

$$D_t + EX_t = Y_t$$

3.3.5 Model in real variables

The model is solved in real variables. Below I write all variables and equations that characterize the model in foreign goods. This is done by dividing all nominal variables by the exchange rate S_t, e.g. $p_t = \frac{P_t}{S_t}$, $w_t = \frac{W_t}{S_t}$, $p_t^\gamma = \frac{P_t^\gamma S_t^{1-\gamma}}{S_t} = \frac{Q_t}{S_t}$, $\epsilon_{t+1} = \frac{S_{t+1}}{S_t}$

Then a competitive equilibrium is a set of process

$$C_t^h, L_t, w_t, mc_t, Y_t, p_t, D_t, F_t, EX_t, A_t, r_t^d, C_t^d, la_t, \pi_t$$

$$B_{t+1}^h, K_{t+1}^d, B_{t+1}^d, s_t, m_t, v_t^r, \varphi_t, I_t, q_t^r$$

satisfying

1. $$(C_t^h - \frac{L_t^\omega}{\omega})^{-\sigma} = la_t p_t^\gamma$$

   where $la_t = \lambda_t S_t$, the Lagrangian multiplier based on the budget constraint of household written in real variables

2. $$la_t = E_t(la_{t+1}\beta(1 + r_{t+1}))$$

   where

   $$r_{t+1} = \rho_{t+1} + exp(B_{t+1}^h - BH) - 1$$

   and BH is SS level of household debt

3. Labor supply from the GHH utility function

$$L_t^{\omega-1} = \frac{w_t}{p_t^\gamma}$$

4. Household budget constraint

$$p_t^\gamma C_t^h + B_t^h(1 + r_t) = w_t L_t + B_{t+1}^h$$

5. Real rental rate of capital

$$r_t^d = mc_t \theta_d \frac{Y_t}{K_t^d}$$

6. Real wage

$$w_t = mc_t(1 - \theta_d)\frac{Y_t}{L_t}$$

7. Output

$$Y_t = s_t^{-1}(K_t^d)^{\theta_d} L_t^{1-\theta_d}$$

8. Price dispersion

$$s_t = \kappa s_{t-1}\pi_t^{\frac{1}{1-\nu}} + (1 - \kappa)p_t^{*\frac{1}{\nu-1}}$$

Price dynamics to substitute out p^*

$$\kappa\pi_t^{\frac{\nu}{1-\nu}} + (1 - \kappa)(p_t^*)^{\frac{\nu}{\nu-1}} = 1$$

9. Linearized optimal pricing behavior

$$\frac{\beta\kappa}{1-\kappa}\frac{\pi_{t+1} - \pi_{ss}}{\pi_{ss}} = \frac{\kappa}{1-\kappa}\frac{\pi_t - \pi_{ss}}{\pi_{ss}} + (1 - \beta\kappa)(\frac{p_t - p_{ss}}{p_{ss}} - \frac{mc_t - mc_{ss}}{mc_{ss}})$$

$$\hat{\pi}_{t+1}\frac{\beta\kappa}{1-\kappa} = \frac{\kappa}{1-\kappa}\hat{\pi}_t + (1 - \beta\kappa)(\hat{p}_t - \hat{mc}_t)$$

10. Relative price and depreciation

$$p_t = p_{t-1}\frac{\pi_t}{\epsilon_t}$$

11. Consumption of entrepreneur, v_t is the Lagrangian

$$\frac{1}{C_t^d} = v_t p_t^{\gamma}$$

12. Entrepreneur's borrowing,

$$v_t^r(1 - \varphi_t\eta) = \beta_e E_t\big(v_{t+1}^r(1 + \rho_{t+1} + G(\tilde{B}_{t+1}^d))\big)$$

where $v_t^r = v_t S_t$, $v_{t+1}^r = v_{t+1}S_{t+1}$, the Lagrangian multiplier corresponding to the budget constraint written in real variables

13. Entrepreneur's capital construction

$$v_t^r q_t^r = \beta_e E_t\big(v_{t+1}^r(\delta q_{t+1}^r + r_{t+1} + p_{t+1}^{\gamma}\frac{1}{2}(\frac{I_{t+1}}{K_{t+1}})^2)\big)$$

where $q_t^r = \frac{q_t}{S_t}$, the Lagrangian multiplier corresponding to the real budget constraint

14. Working capital constraint

$$v_t^r \epsilon_{t+1}(1 - \varphi_t) = \beta_e E_t\big(v_{t+1}^r\big)$$

15. Investment

$$p_t^{\gamma} + \frac{p_t^{\gamma} I_t}{K_t} = q_t^r$$

16. Debt dynamics dollar, ϵ_{t+1} exist because divide both side by S_t, $\frac{M_{t+1}}{S_t} = m_{t+1}\epsilon_{t+1}$

$$B_{t+1}^d + (p_t - mc_t)Y_t + r_t K_t + m_t = p_t^{\gamma} I_t + p_t^{\gamma}\frac{1}{2}\frac{I_t^2}{K_t} + p_t^{\gamma} C_t^d + B_t^d(1 + \rho_t + G(\tilde{B}_t^d)) + m_{t+1}\epsilon_{t+1}$$

17. Working capital constraint

$$m_{t+1}\epsilon_{t+1} \geq \eta B^d_{t+1}$$

18. Capital accumulation

$$K_{t+1} = \delta K_t + I_t$$

19. Aggregate domestic absorption

$$C^h_t + C^d_t + I^d_t + \frac{1}{2}\frac{I^2_t}{K_t} = A_t$$

20. Demand of domestic goods in domestic absorption

$$D_t = \gamma A_t p_t^{\gamma-1}$$

21. Demand of foreign goods in domestic absorption

$$F_t = (1-\gamma)A_t p_t^{\gamma}$$

22. Export

$$EX_t = (1-\gamma_x)A^w_t p_t^{-\gamma_x}$$

23. Aggregate domestic output

$$D_t + EX_t = Y_t$$

Given the exogenous process $A^w_t, \rho_t, \epsilon_t$, initial condition $B^h_0, K^d_0, B^d_0, s_{-1}, p_{-1}, m_0$

24. World Interest rate

$$\rho_t = (1-\phi^r)\rho + \phi^r \rho_{t-1} + \sigma^r_t \tag{3.24}$$

25. World demand

$$lnA_t^W = (1 - \phi^A)A^W + \phi^A A_{t-1}^W + \sigma_t^A \tag{3.25}$$

26. Exchange rate policy

$$\epsilon_{t+1} = 1 \tag{3.26}$$

3.4 Mechanism and Calibrations

3.4.1 Parameter values

In the household utility function, σ and ω are taken to be 2 and 1.45 respectively, from Uribe and Schmitt-Grohé (2017) Chapter 4. In the firm side, capital share θ_d is taken to be 0.32, from the same source. The substitution parameter between intermediate goods $\nu = 0.9$, taken from Uribe and Schmitt-Grohé (2017) Chapter 9. κ is taken to be 0.75, 75% of the firms cannot adjust the price in a certain period, which is a standard parameter for Calvo model. In the aggregate level, γ is taken to be 0.5; the household has equal demand for domestic and foreign goods. γ_{ex} is taken to be 0.1, the world demand for domestic good is not as sensitive as domestic demand for foreign good.

World interest rate ρ is taken as 1%, which is a conservative level of the world interest rate environment. Discount factor for household β is then take to be $\frac{1}{1+\rho}$. Asset holding constraint η is taken to be 0.6 unless otherwise stated. Discount factor for entrepreneurs is then calculated from equation (3.19) and (3.21) to be $\frac{1-\rho}{1+\rho-\eta}$

3.4.2 Mechanism

Before I present the dynamics of the variables in the model upon shocks, I first discuss the mechanism that the model can generate on contractionary devaluation. The key mechanism requires both the asset holding constraint and the nominal rigidity.

The existence of nominal rigidity guarantees that the domestic price level will not catch up with the foreign price level upon devaluation so that there is a loss in terms of the asset side of the entrepreneurs. The existence of the asset holding constraint suggests that the entrepreneurs cannot fully offset the negative effect by borrowing from international lenders.

If there is no nominal rigidity and asset holding requirement in the model, the domestic price will adjust along with the devaluation. Firms can set prices freely in each period, so the domestic price level will catch up with the exchange rate, leaving the relative price unchanged. When entrepreneurs make their investment decisions, since there is no asset holding requirement, both the asset and liability side expand after the devaluation. There is no increase in the debt burden, and thus the entrepreneurs will make similar investment decisions as they would before the devaluation. So we would not observe contractionary devaluation if no price stickiness and no asset holding requirement exist. When there is no price stickiness, with the asset holding requirement alone, the wealth effect after devaluation still exists, but inflation can quickly pick up since price is flexible, which helps to alleviate the negative effect of the wealth shock. When there is no asset holding requirement, even if the domestic goods price is not flexible, entrepreneurs can also smooth consumption by borrowing more from abroad after the shock. In this way, the effect on domestic output is also limited.

So the two conditions, the nominal rigidity and the asset holding requirement, should both exist for a heavier debt burden after the devaluation. The heavier debt burden then transfers to a lower investment level. The lower investment level has two effects. One is that since investment goods is part of the output, lower investment level thus means lower demand for domestic good, which affect current period output. The decrease in investment also means the next period capital stock is below the steady state. So it also directly affects the next period output. The lower level of the capital stock decreases labor productivity, and thus real wage; this will lead to the decrease in labor input, thus affects output.

3.5 Result

3.5.1 Contractionary devaluation

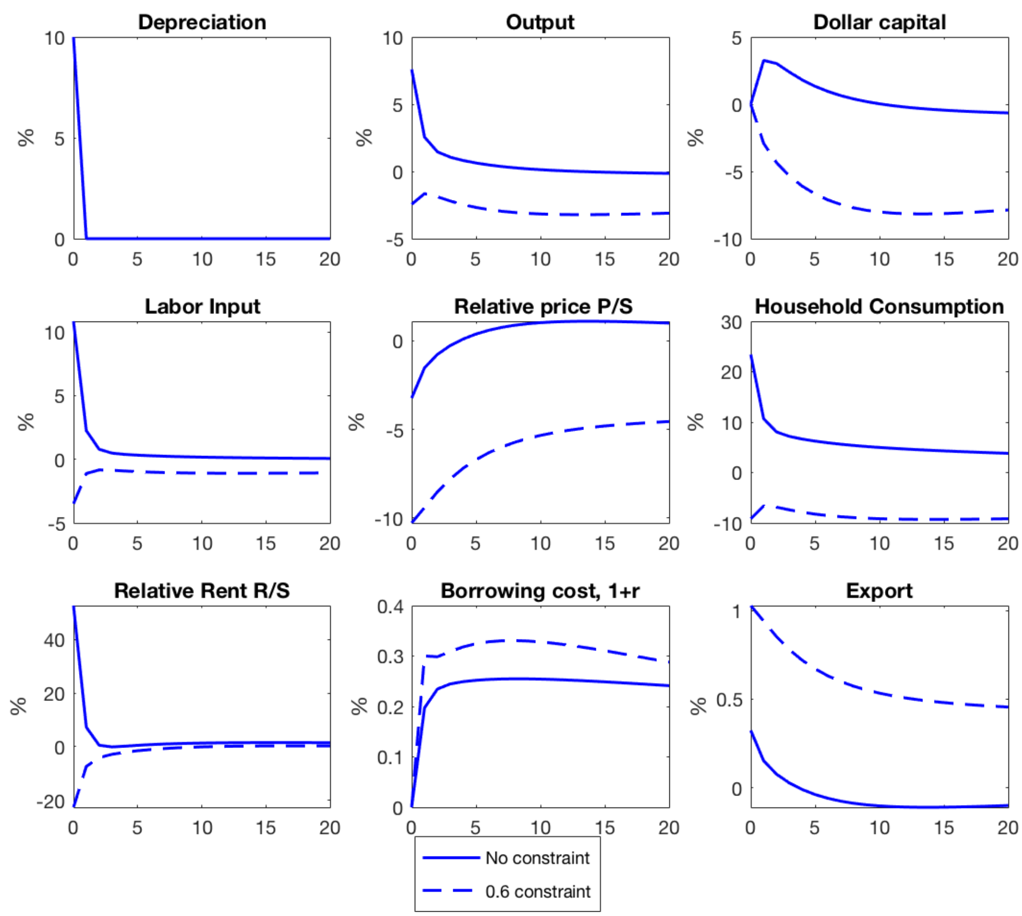
Here I discuss the response of a devaluation shock of 10%. Following the conventional intuition that if the economy has too much foreign currency-denominated debt, devaluation will cause an increase in debt burden and thus become contractionary. Here I show how this channel is reflected in the model.

Figure 3.1 plots the impulse response of the variables in the model upon a 10% devaluation shock. That is, the country maintains a fixed exchange rate regime up to period t, then the country suddenly depreciates the exchange rate by 10% and maintain the exchange rate fixed at the new level thereafter.

I contrast two cases in the model, one with a domestic asset holding requirement described as in the entrepreneur's section, one without such asset holding requirement. Without the constraint, where there is a devaluation, domestic goods become relatively cheaper; entrepreneurs have the incentive to borrow more to invest. The debt burden does not become larger since they can always borrow the same amount of real foreign debt B_{t+1}, to repay the real debt B_t from the last period. The exchange rate does not affect the real debt amount. The increase in borrowing is used to purchasing more investment goods, which also drives up the level of the output, since capital goods is a part of the output. This is the channel, combined with the boost in export due to the relative price change, that devaluation is expansionary.

The case with constraint shows how devaluation is contractionary. Due to part of the borrowed foreign currency held in the domestic currency asset, sudden devaluation causes a large wealth effect on the entrepreneurs. Now they have to use part of the newly borrowed foreign currency debt to satisfy the new asset holding requirement $S_t B_{t+1}$, where the old asset holding is $S_{t-1} B_t$ and the increase in exchange rate S_t making $S_t > S_{t-1}$. This wealth effect means that not all the borrowed foreign currency goes into investment activity. Investment decreases and drags down the output concurrently. The output is also below the steady-state level in the following period because the investment is below the steady-state level causing the capital stock for production being smaller. The decrease in capital stock causes labor productivity to decease and thus lowers the wage level. Household consumption is also smaller due to the lower wage income. This further decreases the demand for domestic goods. Although export increases more in the case with constraint because of the lower relative price, this cannot compensate for the decrease in the domestic demand.

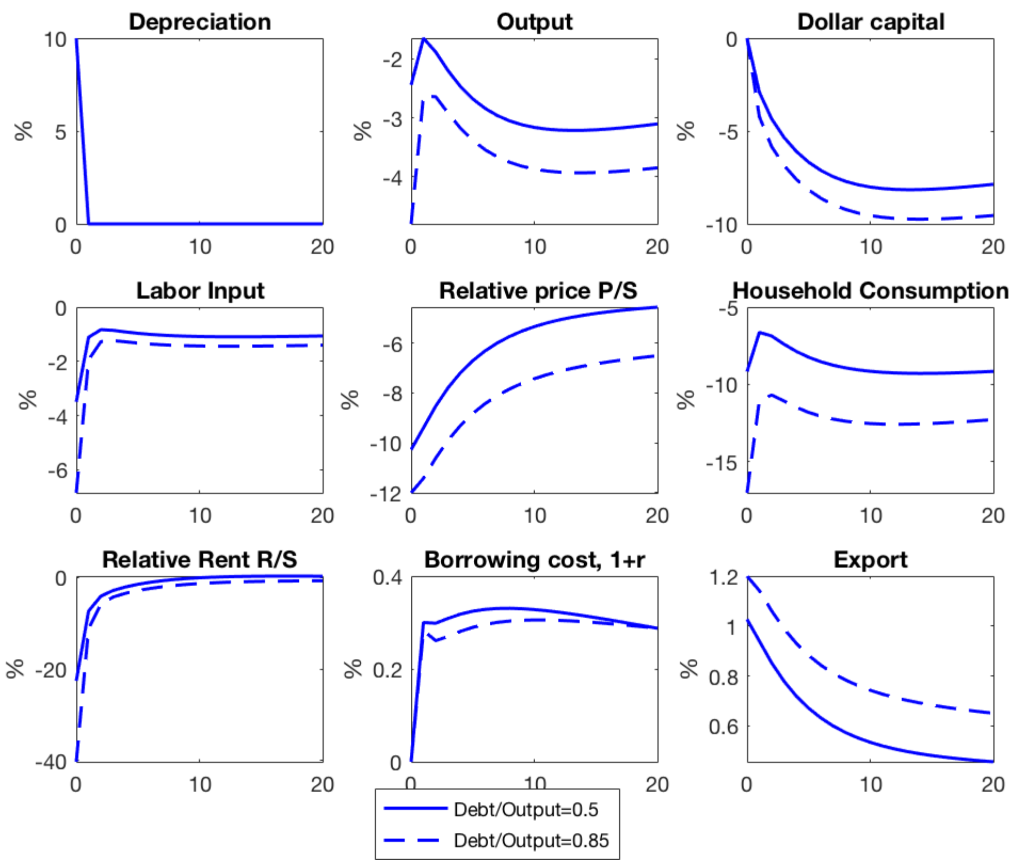
Figure 3.1: 10 % devaluation shock, with and without asset holding constraint



Note: The figure plots the impulse responses of variables upon a 10% devaluation shock, with the asset holding constraint and without the asset holding constraint, corresponding respectively to the contractionary and expansionary devaluation.

The magnitude of the effect obviously depends on the level of the outstanding debt and how large is the constraint on the asset holding requirement. Figure 3.2 addresses this magnitude with respect to the outstanding external debt level, where it plots the comparison of the impulse responses of variables upon a 10% devaluation for different debt-to-output ratios in the steady state. The contractionary effect is larger for the debt-to-output ratio being 0.85 compared to the debt-to-output ratio being 0.5. The contractionary effect also depends on the magnitude of the asset holding con-

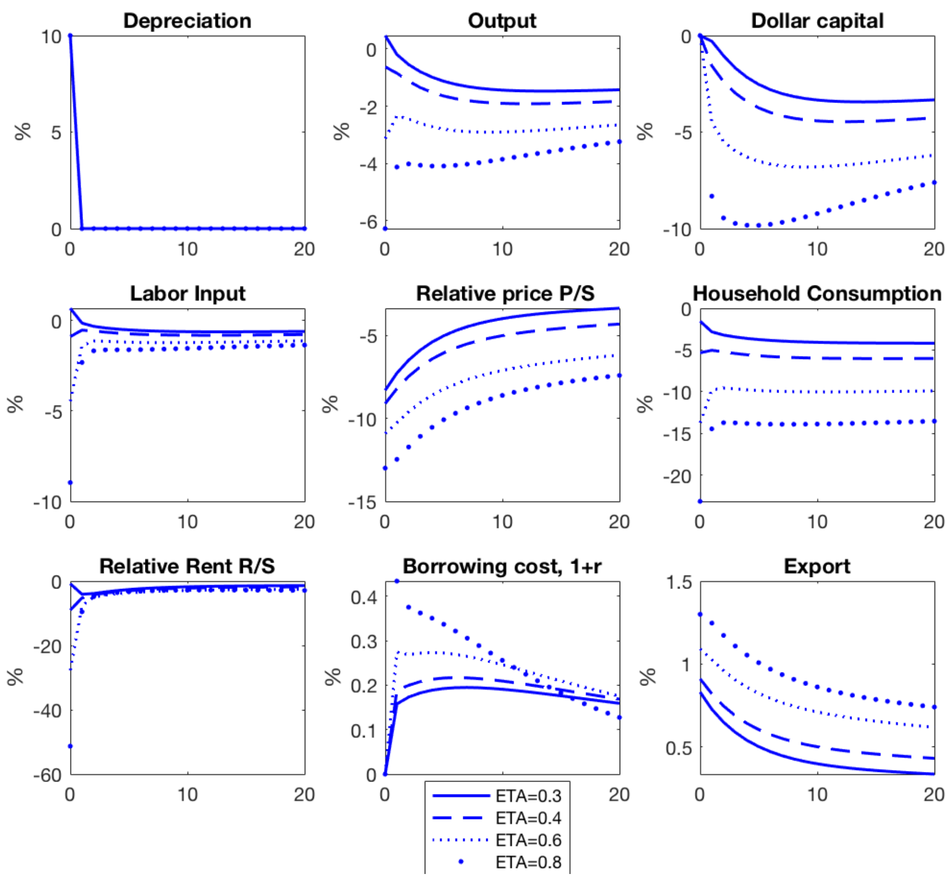
Figure 3.2: 10 % devaluation shock, different debt levels



Note: The figure plots the impulse responses of variables upon a 10% devaluation shock, with different debt-to-output levels in the steady state. The contractionary effect is larger when there is a higher external debt level, meaning more foreign-currency denominated debt.

straint, which is governed by the parameter η. Figure 3.3 plots the comparison between different values of this parameter, with the debt-to-output ratio fixed to be 0.5. The higher η is, the larger fraction of the borrowed foreign currency has to be held in the domestic asset, thus a larger wealth effect upon potential exchange rate change. As from the graph, η being 0.3 to 0.4 is the threshold that investment is below the steady-state level, and the capital stock starts to fall upon the devaluation. The output does not fall on impact for $\eta = 0.3$ because the wealth effect on impact is not large enough to counteract the expansion in export. But soon as price picks up, the export advantage gradually disappears, and the output starts to fall.

Figure 3.3: 10 % devaluation shock, different magnitude of the asset holding requirement



Note: The figure plots the impulse responses of variables upon a 10% devaluation shock, with different magnitude of the asset holding requirement. The contractionary effect is larger when η is higher

3.5.2 Exogenous Shocks

Apart from the exchange rate shock, another relevant question is how should the exchange rate change upon negative external shock. In this section I compare different exchange rate regimes upon an increase in world interest rate.

To impose different exchange rate regimes, I need to add an interest rate policy to the model. In this section I assume that the household is allowed to borrow in the domestic market with domestic currencies. The household's budget constraint is thus changed to

$$Q_t C_t + S_t B_t^h (1 + r_t) + B_t^{hd}(1 + i_t) = W_t h_t + S_t B_{t+1}^h + B_{t+1}^{hd}$$

The first order condition with respect to B_{t+1}^{hd} gives the equilibrium interest rate for domestic market

$$\lambda_t = E_t(\beta\lambda_{t+1}(1 + i_t)) \tag{3.27}$$

This combined with equation (4) gives the relationship between domestic interest rate and the exchange rate

$$1 + i_t = \epsilon_{t+1}(1 + r_t) \tag{3.28}$$

For a fixed exchange rate regime, i_t moves one for one with the exchange rate according to equation (28). For a flexible exchange rate regime, I adopt two different inflation targeting rules on interest rates from Cook (2004), Gertler Gilchrist and Natalucci (2003)(Below denoted as GGN), to compare my results with their conclusions.

Cook monetary policy

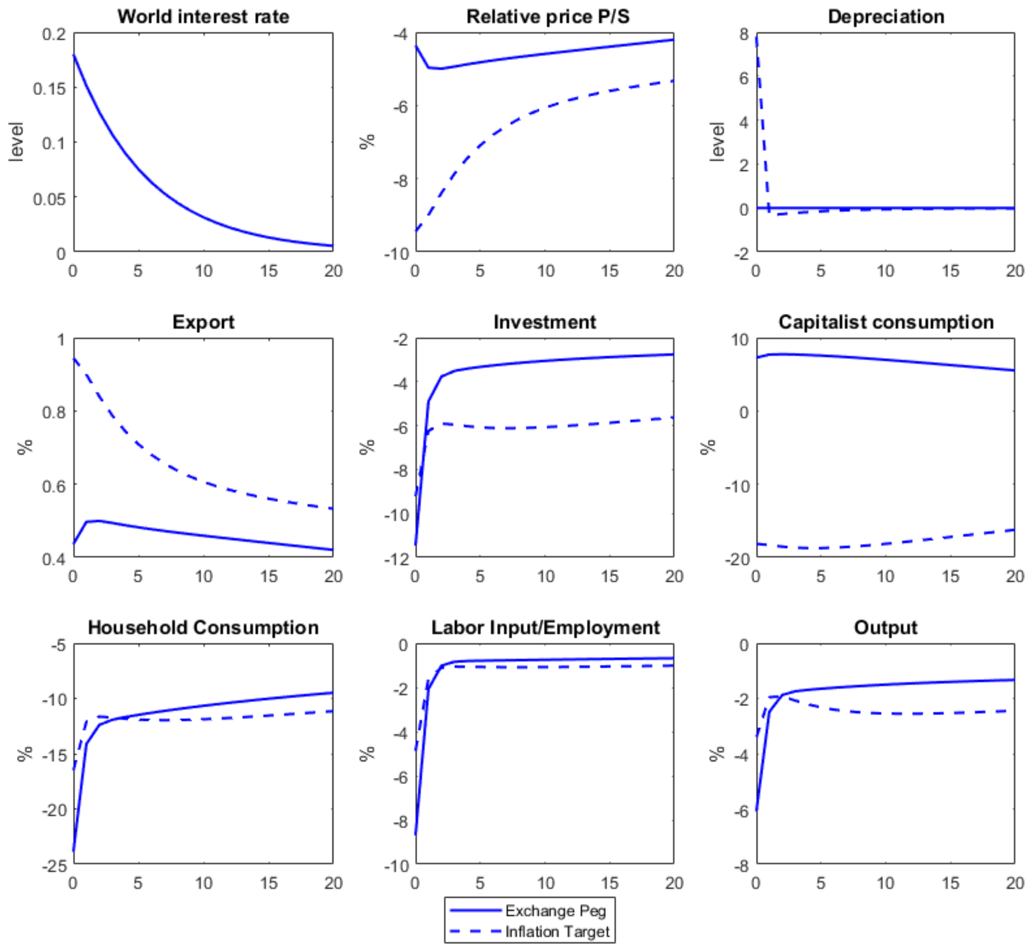
$$i_t - i^{ss} = \varphi^i(i_{t-1} - i^{ss}) + \varepsilon^p(\pi_t - \pi^{ss}) + \epsilon_t^i, \quad E_{t-1}\epsilon_t^i = 0 \tag{3.29}$$

This follows the form of inflation targeting interest rate policy from Cook (2014). The parameter values also follow Cook's calibration. The interest rate has a persistent parameter $\varphi^i = 0.9$. The interest rate responds to inflation when inflation deviates from the steady state, with the sensitivity being $\varepsilon^p = 0.1$. The debt-to-output ratio is also calibrated to be 0.315 to match Cook's paper.

Below I show the impulse response of a 0.0018 increase in world interest rate ρ_t, where the exogenous world interest rate follows equation (24), with AR(1) parameter for the persistence level equals to 0.84

Under the inflation targeting interest rate regime, there is a devaluation upon the world interest rate

Figure 3.4: World interest rate shock, under the policies of exchange rate peg or inflation targeting

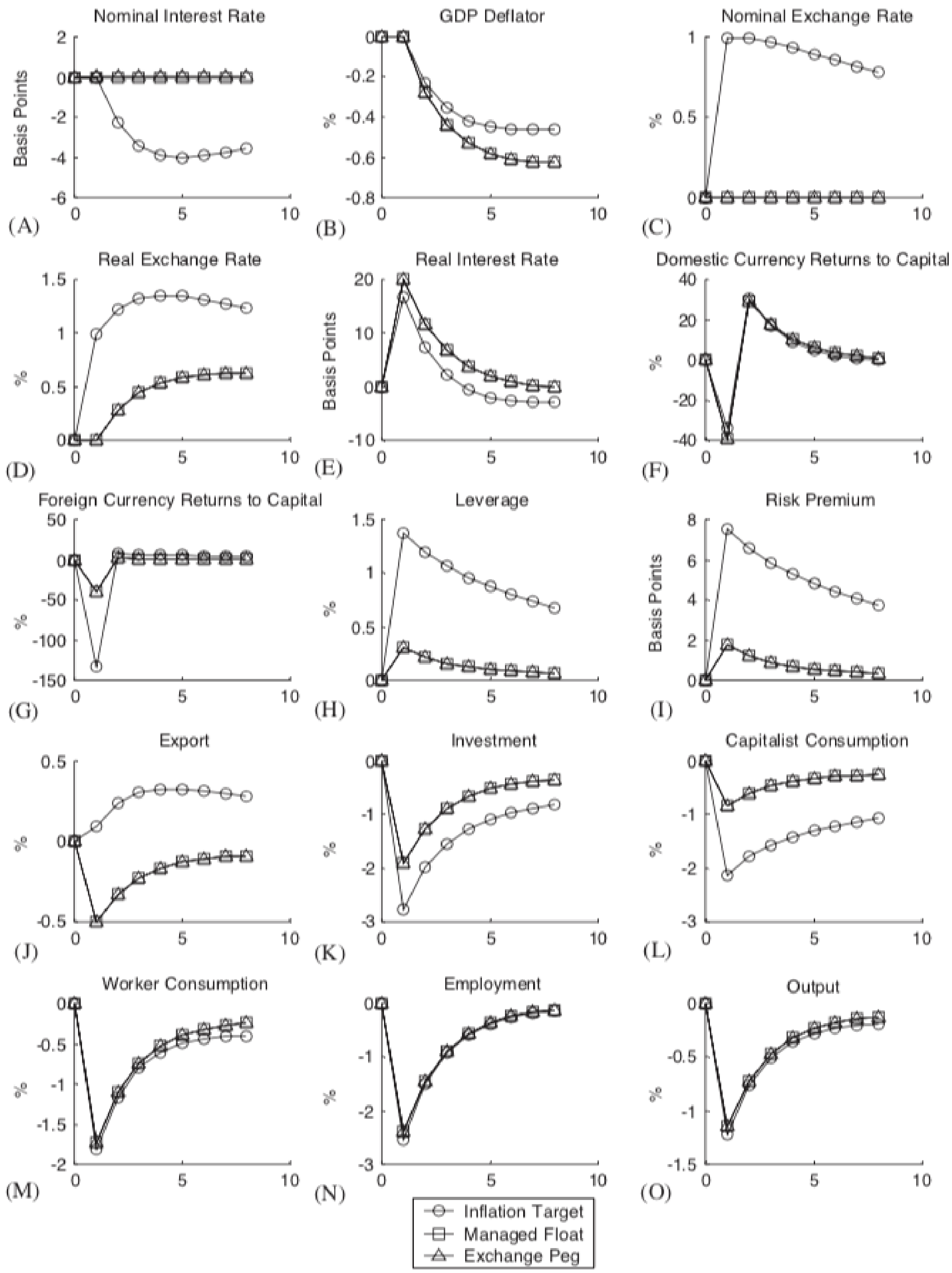


Note: This figure plots the impulse responses of variables upon world interest rate increase, under two different exchange rate policies, the exchange rate peg and the inflation targeting interest rate

increase. The effect of this devaluation is the same as discussed in the contractionary devaluation effect. Entrepreneurs will borrow more to invest when there is depreciation. Because the relative domestic price is lower, so investment does not decrease as much as the case under exchange rate peg on impact. But because of the extra external borrowing, the burden on the debt level will hurt investment and output in the following periods compared to the exchange rate peg regime. In this case, the exchange rate peg regime causes worse adverse effects on the output and investment on impact compared to the inflation targeting regime but performs better in the following periods after the shock, due to the lack of extra debt burden. The peg causes domestic investment and output to fall by a large amount on impact. Households and entrepreneurs consume very little on impact. But there is not too much over-borrowing, thus the economy can get back to the right track quicker than the inflation targeting induced devaluation.

This conclusion is consistent with Cook's result, but the advantage of exchange rate peg is more prominent in my result. Figure 3.5 is the main result of Cook's paper. The difference in output and household consumption is not significant between the exchange rate peg regime and the inflation targeting regime. The consumption of entrepreneurs is larger under the exchange rate peg regime, and so is the investment.

Figure 3.5: Main result from Cook(2004), impulse responses upon world interest rate increase under different exchange rate regimes



GGN monetary policy

$$i_t = i^{ss} + \gamma_\pi(\pi_t - \pi_{ss}) + \gamma_y(y_t - y_{ss}) \tag{3.30}$$

The monetary policy in GGN suggests that the interest rate responds to the inflation gap and the output gap from the steady state. γ_π and γ_y is taken as 2 and 0.75 respectively.

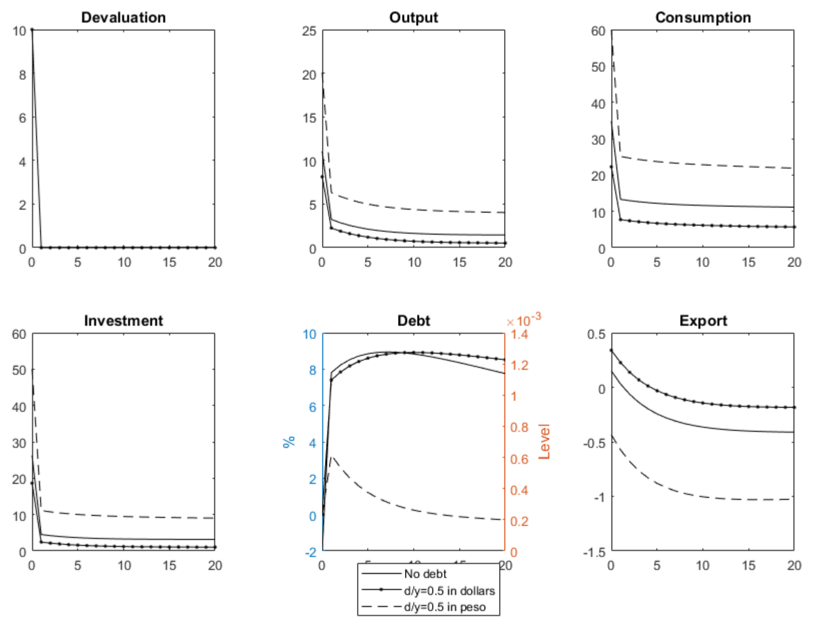
If this Taylor rule is imposed in the model, the model generates an appreciation of the exchange rate after an increase in the world interest rate. This lead to an output boom. This is an interesting result given the context of the set up of the model. The appreciation upon an increase in the world interest rate is an unconventional response based on common expectations. However, this is reasonable in the setting of the model. Since I allow the channel for contractionary devaluation, the model naturally contains the channel for expansionary appreciation. But I do not discuss this response in depth, since the paper focuses on devaluation. This response can be left for future discussion to consider optimal monetary policy under this setup.

3.5.3 Turning off the friction

As I discussed before, the contractionary devaluation effect would not hold without the mechanisms in the model. This section shows the result of shutting down the new channel of asset holding requirement, but keep the nominal rigidity.

If we turn off the asset holding requirement, the contractionary devaluation effect is minimal, which is shown in the graph below. This is because consumption-smoothing agents in the economy will smooth the increase in debt burden by increasing international borrowing to pay back the increase in debt, and there is no friction in doing so. The aggregate effect of the increase in the nominal amount of debt measured in domestic currency does not have a large effect on the economy. The graph below compares three conditions, no debt in equilibrium, debt denominated in foreign currency, and debt denominated in domestic currency. When there is a sudden 10% devaluation shock, all three conditions have an output boom due to the positive channel of the relative price change on the export. The output increase when debt is denominated in domestic currency is the largest since domestic investors and consumers have wealth effects on the debt being relatively cheaper in terms of foreign currencies after devaluation. The degree of the increase in output under the condition when there is no external debt, and when external debt is denominated in foreign currencies are similar. This proves that the contractionary effect from foreign currency debt, as we described above, is minimal when there is no friction in borrowing. This channel is not easily captured because the previous literature does not adequately detect the friction on external borrowing.

Figure 3.6: Impulse responses upon devaluation when there is no asset holding requirement



3.6 Welfare analysis

In order to compare numerically different exchange rate regimes, there has to be a well-defined welfare measure that can measure the loss of each exchange rate regime after exogenous shock. Following the welfare analysis in Gali (2008), I define the welfare losses as follows. The welfare loss for each agent in the economy can be expressed as a fraction of its steady-state consumption.

$$Loss = \frac{W_t - W_{ss}}{U_c C_{ss}}$$

where W_t is the welfare of the business cycle after exogenous shock. W_{ss} is the welfare if the economy is always in the steady state.

Since there are two kinds of consumers in the economy, household and entrepreneurs, I weight the total loss by their consumption in steady state.

$\tau_h = \frac{C_{ss}^h}{C_{ss}^h + C_{ss}^e}$, $\tau_e = 1 - \tau_h$

On the household side, each period utility and the steady state marginal utility are given by

$$U_t^h = \frac{(C_t - \frac{L_t^\omega}{\omega})^{1-\sigma} - 1}{1-\sigma}, \quad U_{ss}^h = \frac{(C_{ss} - \frac{L_{ss}^\omega}{\omega})^{1-\sigma} - 1}{1-\sigma}$$

$$U_c^h = (C_{ss} - \frac{L_{ss}^\omega}{\omega})^{-\sigma}$$

On the entrepreneur side

$$U_t^e = log(C_t^d), \quad U_t^e = log(C_{ss}^d)$$

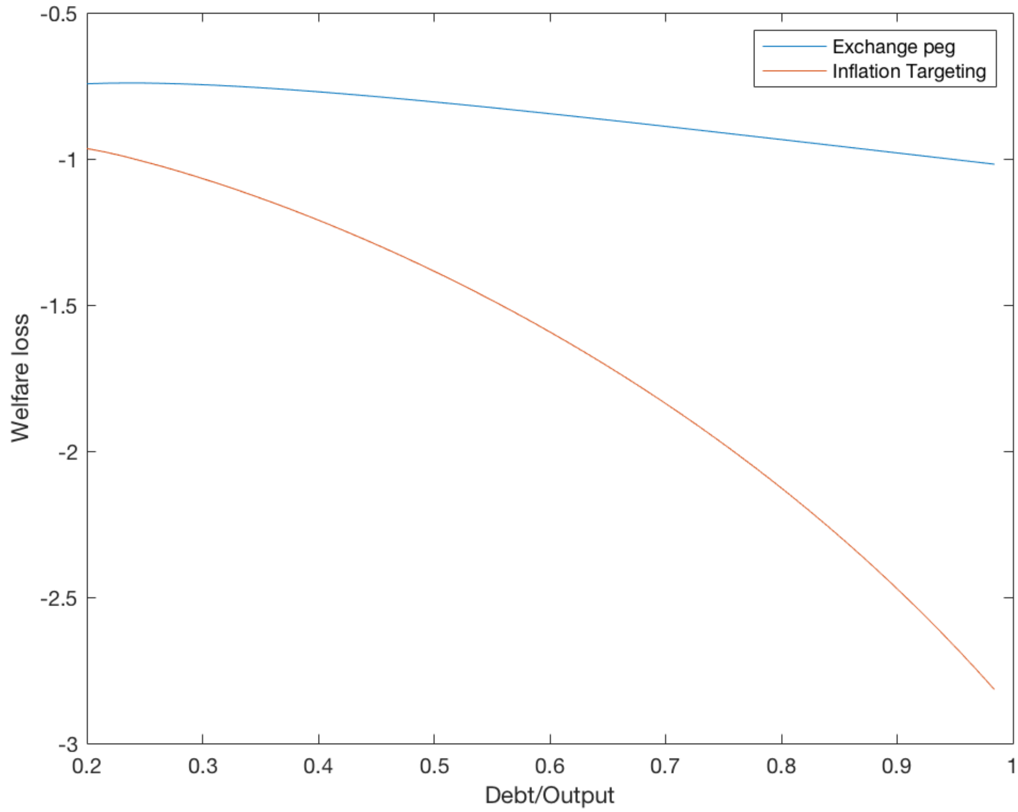
$$U_c^e = \frac{1}{C_{ss}^d}$$

Then the measure for welfare loss in the economy is

$$WL = \tau_c \sum_{t=1}^{k} \beta^t \frac{U_t^h - U_{ss}^h}{U_c^h C_{ss}^h} + \tau_e \sum_{t=1}^{k} \beta_e^t \frac{U_t^e - U_{ss}^e}{U_c^e C_{ss}^e}$$

Figure 3.7 corresponds to the welfare loss of the exchange rate peg regime and the inflation targeting regime under the specification of section 5.2.1 with varying debt-to-output ratio. The welfare loss for the exchange rate peg regime is always smaller than that for the inflation targeting regime. When the debt-to-output ratio is small, the difference is not as large. But as the debt-to-output ratio increases, the difference in the two exchange rate regimes becomes prominent.

Figure 3.7: Welfare loss under two regimes for different levels of debt-to-output ratio



3.7 Future Works

3.7.1 Empirical validation

There are two aspects I would like to look into regarding the empirical evidence of the paper and the currency mismatch literature in general. The first one is to estimate the parameter of asset holding η. This is to measure what fraction of the external liability of a firm is held in domestic currency-denominated assets. Bruno and Shin (2017) discuss the usage of dollar credit to the firms. They conclude that firms use dollar credit to conduct carry trade to some extent. Those firms who already have a large amount of cash holding are the ones who tend to borrow from abroad and add on to their cash holding in domestic banks. This is consistent with the balance sheet mismatch channel, that when firms borrow in foreign currency, they register the asset in domestic currency. To estimate the parameter, I plan to get data of the balance sheets of the firms in small open economy and then estimate the destination of dollar credit flow. All the money that flows into domestic asset holding, including bank deposit, inter-firm loan should be counted into the calculation for η.

The second one is to estimate the borrowing cost of firms in a small open economy. Once I have the balance sheet data, combined with dollar bond issuance data for firms in a small open economy, I would be able to know the determinants of firms' borrowing cost. This is another aspect of the empirical evidence for the currency mismatch literature. It would be interesting to know whether the country macro and political conditions affect the firms borrowing cost more or the firms' specific aspects like size and leverage ratio.

3.7.2 Optimal monetary policy

After estimating the asset holding parameter, I would like to see the policy implications of the model. Based on the current welfare analysis, it's possible to compare welfare losses of different exchange rate regimes. I would then be able to answer the question of what is the optimal monetary policy corresponding to varying levels of external dollar debt positions to conduct economy specific analyses.

3.8 Conclusion

This paper models a channel of contractionary devaluation, which directly addresses the firms' balance sheet mismatch channel, by adding an asset holding requirement to the firms' external debt. This is reasonable, especially considering countries like China that impose compulsory foreign exchange settlement from private entities. Thus the firms are more exposed to currency risks. The level of the contractionary effect mainly depends on the strictness of the asset holding requirement and also on the level of the external foreign currency debt. I then compare different exchange rate regimes upon negative global shocks. The exchange rate peg regime has a smaller welfare loss compared to the inflation targeting regime which induces devaluation.

The model provides a framework for further discussion of the optimal exchange rate policy for small open economies. By analyzing the assumptions of the model and existing literature empirically, the model is also able to generate policy guidance with empirical implications. These directions are worth exploring in terms of fully understanding the balance sheet mismatch channel for the small open economies.

Bibliography

Aguiar, Mark, and Manuel Amador. 2011. "Growth in the Shadow of Expropriation." *The Quarterly Journal of Economics*, 126(2): 651–697.

Aitken, Brian J., and Ann E. Harrison. 1999. "Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela." *American Economic Review*, 89(3): 605–618.

Aizenman, Joshua, and Daniel Riera-Crichton. 2008. "Real Exchange Rate and International Reserves in an Era of Growing Financial and Trade Integration." *The Review of Economics and Statistics*, 90(4): 812–815.

Alfaro, Laura, and Fabio Kanczuk. 2009. "Optimal reserve management and sovereign debt." *Journal of International Economics*, 77(1): 23 – 36.

Alfaro, Laura, Areendam Chanda, Sebnem Kalemli-Ozcan, and Selin Sayek. 2003. "FDI and Economic Growth: The Role of Local Financial Markets." 64: 89–112.

Alfaro, Laura, Sebnem Kalemli-Ozcan, and Vadym Volosovych. 2014. "Sovereigns, Upstream Capital Flows, and Global Imbalances." *Journal of the European Economic Association*, 12(5): 1240–1284.

Benigno, Gianluca, and Luca Fornaro. 2012. "Reserve Accumulation, Growth and Financial Crises." , (dp1161).

Bianchi, Javier, Juan Carlos Hatchondo, and Leonardo Martinez. 2018. "International Reserves and Rollover Risk." *American Economic Review*, 108(9): 2629–70.

Blonigen, Bruce A, and Miao Wang. 2004. "Inappropriate Pooling of Wealthy and Poor Countries in Empirical FDI Studies." , (10378).

Bloom, Nicholas, Raffaella Sadun, and John Van Reenen. 2012. “Americans Do IT Better: US Multinationals and the Productivity Miracle.” *American Economic Review*, 102(1): 167–201.

Bosworth, Barry, Susan M Collins, and Gabriel Chodorow-Reich. 2007. “Returns on FDI: Does the U.S. Really Do Better?” , (13313).

Bruno, Valentina, and Hyun Song Shin. 2017. “Global Dollar Credit and Carry Trades: A Firm-Level Analysis.” *The Review of Financial Studies*, 30(3): 703–749.

Cady, John, and Jesus Gonzalez-Garcia. 2007. “Exchange Rate Volatility and Reserves Transparency.” *IMF Staff Papers*, 54(4): 741–754.

Cook, David. 2004. “Monetary policy in emerging markets: Can liability dollarization explain contractionary devaluations?” *Journal of Monetary Economics*, 51(6): 1155–1181.

Céspedes, Luis Felipe, Roberto Chang, and Andrés Velasco. 2004. “Balance Sheets and Exchange Rate Policy.” *American Economic Review*, 94(4): 1183–1193.

Damgaard, Jannick, Thomas Elkjaer, and Niels Johannesen. 2019. “What Is Real and What Is Not in the Global FDI Network?”

Dooley, Michael P, David Folkerts-Landau, and Peter M Garber. 2004. “The US Current Account Deficit and Economic Development: Collateral for a Total Return Swap.” , (10727).

Eichenbaum, Martin. 1991. “Technology shocks and the business cycle.” *Economic Perspectives*, , (Mar): 14–31.

Eichler, Stefan, and Helge C.N. Littke. 2018. “Central bank transparency and the volatility of exchange rates.” *Journal of International Money and Finance*, 89: 23 – 49.

Frankel, Jeffrey A, and George Saravelos. 2010. “Are Leading Indicators of Financial Crises Useful for Assessing Country Vulnerability? Evidence from the 2008-09 Global Crisis.” , (16047).

Galí, Jordi, and Tommaso Monacelli. 2005. "Monetary Policy and Exchange Rate Volatility in a Small Open Economy." *The Review of Economic Studies*, 72(3): 707–734.

Gertler, Mark, Simon Gilchrist, and Fabio M. Natalucci. 2007. "External Constraints on Monetary Policy and the Financial Accelerator." *Journal of Money, Credit and Banking*, 39(23): 295–330.

Gourinchas, Pierre-Olivier, and Maurice Obstfeld. 2011. "Stories of the Twentieth Century for the Twenty-First." , (17252).

Gourinchas, Pierre-Olivier, and Olivier Jeanne. 2013. "Capital Flows to Developing Countries: The Allocation Puzzle." *The Review of Economic Studies*, 80(4 (285)): 1484–1515.

Harrison, Ann, and Margaret McMillan. 2011. "Offshoring Jobs? Multinationals and U.S. Manufacturing Employment." 93: 857–875.

Harrison, Ann E., and Jason Scorse. 2005. "Do foreign-owned firms pay more? : evidence from the Indonesian manufacturing sector 1990-99."

Huang, Yi. 2018. "From the World's Factory to a World Creditor: China's External Wealth and Excess Returns, 1997-2016." *HKIMR Working Paper No. 8/2018*.

IMF. 2018. "Final Report of the Task Force on Special Purpose."

Jeanne, Olivier, and Romain Rancière. 2008. "The Optimal Level of International Reserves For Emerging Market Countries: A New Formula and Some Applications." , (6723).

Kalemli-Ozcan, Sebnem, Sorensen Bent, Carolina Villegas-Sanchez, Vadym Volosovych, and Yesiltas. Sevcan. 2015. "How to Construct Nationally Representative Firm Level data from the ORBIS Global Database."

Lundin, Nannan, Fredrik Sjöholm, Ping He, and Jinchang Qian. 2007. "FDI, Market Structure and R& D Investments in China."

Matsumoto, Hidehiko. 2018. "Reserve Accumulation, Foreign Direct Investment, and Economic Growth."

Matthew, Haskel Jonathan Pereira C. Sonia Slaughter J. 2007. "Does Inward Foreign Direct Investment Boost the Productivity of Domestic Firms?" 89: 482–496.

Melitz, Marc, Elhanan Helpman, and Stephen Yeaple. 2004. "Export Versus FDI with Heterogeneous Firms." *American Economic Review*, 94: 300–316.

Neumeyer, Pablo A., and Fabrizio Perri. 2005. "Business cycles in emerging economies: the role of interest rates." *Journal of Monetary Economics*, 52(2): 345 – 380.

Nowak, M., Ketil Hviding, and Luca A Ricci. 2004. "Can Higher Reserves Help Reduce Exchange Rate Volatility?" , (04/189).

Obstfeld, Maurice, Jay C Shambaugh, and Alan M Taylor. 2009. "Financial Instability, Reserves, and Central Bank Swap Lines in the Panic of 2008." , (14826).

Smarzynska, Javorcik Beata. 2004. "Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers Through Backward Linkages." 94: 605–627.

Tørsløv, R. Thomas, S. Ludvig Wier, and Gabriel Zucman. 2018. "The Missing Profits of Nations."

Uribe, M., and S. Schmitt-Grohé. 2017. *Open Economy Macroeconomics.* Princeton University Press.

Willett, Roger. 2015. "Logarithmic Transformations in Cross Section Regression Models of the Long Run Relation between Market and Accounting Values."

Appendices

Appendix A: Appendix to chapter 1

A.1 Empirical analysis

A.1.1 Sample of countries

Emerging Market Economies

In the empirical analysis, the sample of EM economies is taken by using the union of the definitions from MSCI, IMF and Brics+Next eleven. The three definitions include the 33 economies listed below:

Argentina, Bangladesh, Brazil, Bulgaria, China, Chile, Colombia, Czech Republic, Egypt, Greece, Hungary, India, Indonesia, Iran, Malaysia, Mexico, Nigeria, Pakistan, Peru, Philippines, Poland, Qatar, Romania, Russian Federation, Saudi Arabia, South Africa, South Korea, Thailand, Turkey, United Arab Emirates, Ukraine, Vietnam, Venezuela.

Advanced Economies

The sample of advanced economies follows the definition of IMF, covering 47 economies:

Andorra, Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Faroe Islands, Finland, France, Germany, Greece, Guernsey, Holy See, Iceland, Ireland, Italy, Jersey, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Netherlands, Norway, Portugal, San Marino, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, Hong Kong, Israel, Japan, Macau, Singapore, South Korea, Taiwan, Bermuda, Canada, Puerto Rico, United States, Australia, New Zealand

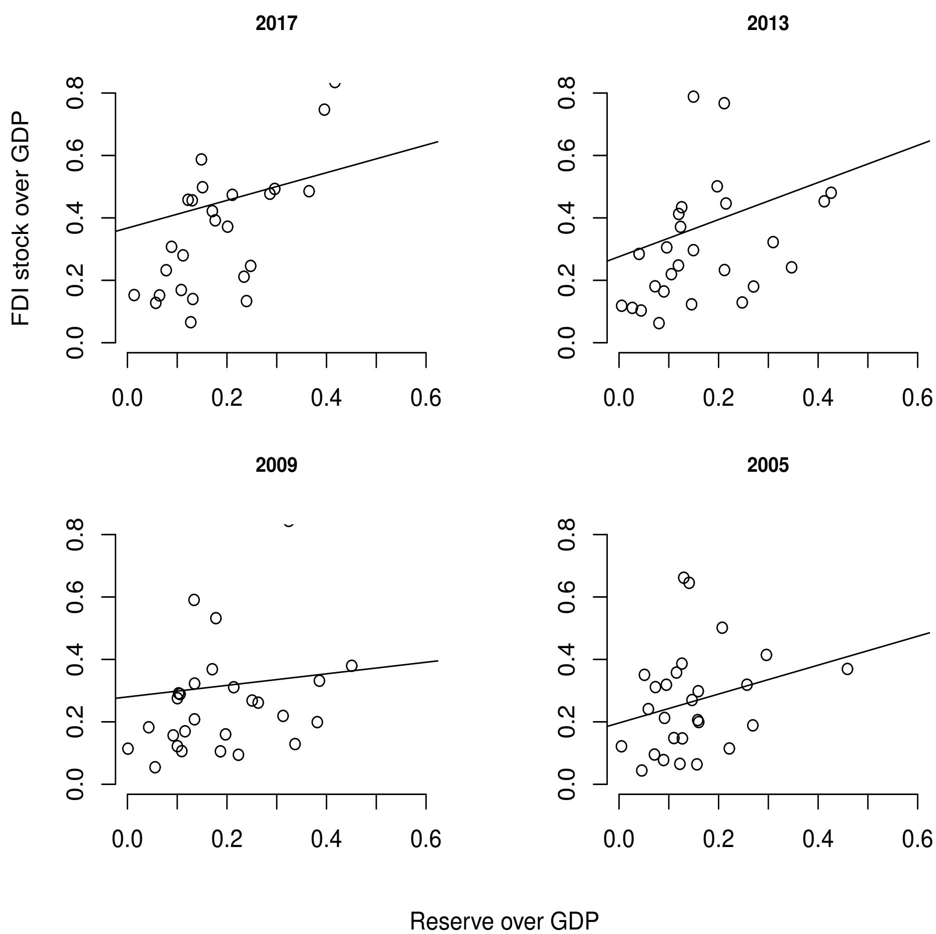
A.1.2 Other empirical evidences of co-movements

This section describe further empirical observations of the co-movement between reserve levels and FDI levels, supplementing section 1.3

Yearly snapshot of FDI-stock-to-GDP ratio and reserves-to-GDP ratio

Figure A.1 is composed of multiple yearly snapshots of Figure 1.5. I plot, within each year, the FDI-stock-to-GDP ratio against the reserves-to-GDP ratio for all the economies in the sample[1] for the years 2017, 2013, 2009, and 2005. The positive correlation still holds when I restrict the economies to these individual years. Economies with a high reserves-to-GDP ratio are also economies with a high FDI-stock-to-GDP ratio.

Figure A.1: FDI stock/GDP and Reserve/GDP, yearly snapshot



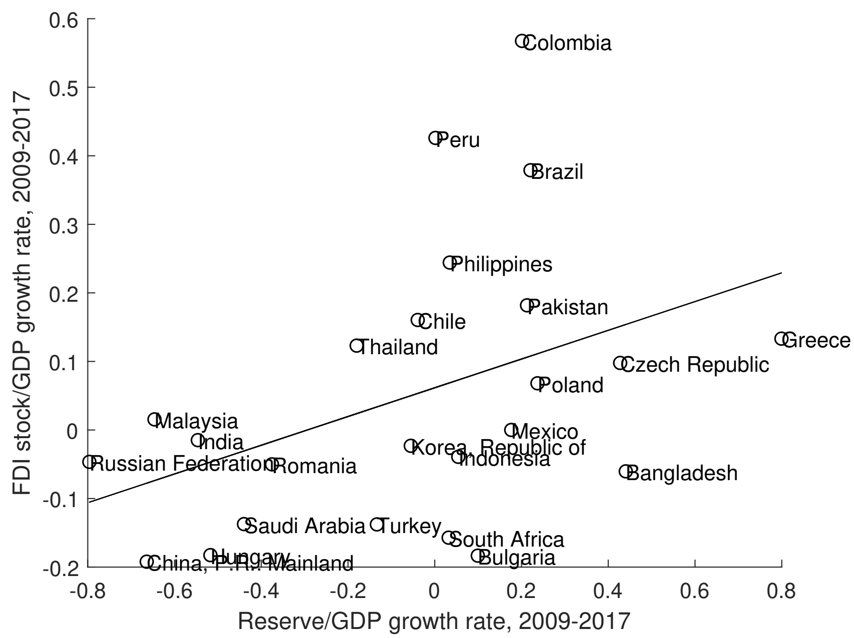
Note: This scatter plot shows the reserves-to-GDP ratio and FDI-stock-to-GDP ratio for 33 major EM economies in four years.
Source: IMF IFS and World Bank WDI

[1]Depending on data availability, the years have slightly different samples.

The change in the reserves-to-GDP ratio and FDI-stock-to-GDP ratio

Figure A.2 plots the percentage change in the reserves-to-GDP ratio and FDI-stock-to-GDP ratio for the period 2009-2017. Economies that have a higher growth rate of the reserves-to-GDP ratio also have a higher growth rate of the FDI-stock-to-GDP ratio.

Figure A.2: Change in reserves and FDI from 2009 to 2017



Note: This scatter plot shows the change in reserve stock and the change in FDI stock from 2009 to 2017 for major EM economies
Source: IMF IFS and World Bank WDI

A.1.3 Regression with control variables

The empirical model with other control variables is specified as follows

$$\frac{FDI_{it}}{GDP_{it}} = \beta_1 + \beta_2 \frac{Res_{it-1}}{GDP_{it}} + Z_{it}\Gamma_{it} + a_i + c_t + u_{it}$$

FDI_{it} refers to the FDI variable of interest; it can be FDI stock or FDI inflow as in section 1.3.

Res_{it-1} is the amount of RX lagged by one period.

Z_{it} are the control variables employed in the literature that are expected to affect the level of FDI. I include GDP growth, the interest rate, the depreciation rate, financial market accessibility, financial market efficiency, trade openness and the external debt level.

GDP growth is directly taken from the World Bank WDI. The interest rate is operationalized as the deposit rate for economies from the World Bank WDI. Trade openness is operationalized as the gross imports and gross exports over the GDP level of the economy by using the corresponding series from World Bank WDI. External debt is calculated as the external-debt-to-GDP ratio by using the corresponding series from World Bank WDI.

The depreciation rate is calculated using the local currency and dollar exchange rate from the IMF IFS. Financial market accessibility and financial market efficiency are taken from the IMF Financial Development Index Database (FDID). Financial market accessibility compiles data on large companies' percent of market capitalization and total number of issuers of debt per 10,000 adults. Financial market efficiency compiles data on the stock market turnover ratio for each economy.

c_t is a time fixed effect, which controls for the world interest rate, investor appetites, risk-taking features, etc.

a_i is the economy fixed effect, which controls for the geographic features and economy-specific characteristics.

Table A.1 uses the FDI-stock-to-GDP ratio as the dependent variable. Table A.2 employs the FDI-flow-to-GDP ratio as the dependent variable. Table A.3 employs the FDI-liability-to-total-liability ratio as the dependent variable

Table A.1: Regression of the FDI-stock-to-GDP ratio on reserves and other controls

	Dependent variable: FDI stock/GDP			
	(1)	(2)	(3)	(4)
$\text{Res}_{it-1}/GDP_{it}$	0.556***	0.507***	0.496***	0.405***
	(0.042)	(0.071)	(0.070)	(0.047)
GDP Growth_{it}	-0.001	-0.001*	0.0001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Deposit rate_{it}	-0.010	-0.009***	-0.010***	-0.010***
	(0.002)	(0.001)	(0.001)	(0.001)
Devaluation rate_{it}	0.068	0.107***	0.066*	0.074*
	(0.049)	(0.037)	(0.039)	(0.043)
Financial $\text{Accessibility}_{it}$	-0.358***	-0.431***	-0.392***	-0.395***
	(0.043)	(0.047)	(0.073)	(0.043)
Financial openness_{it}	-0.197***	-0.219***	-0.081	-0.099***
	(0.032)	(0.068)	(0.084)	(0.030)
Trade/GDP_{it}	-0.002	-0.002***	-0.0001	-0.001***
	(0.0003)	(0.0003)	(0.0005)	(0.0002)
Debt/GDP_{it}	0.466	0.392***	0.217	0.112
	(0.237)	(0.149)	(0.169)	(0.230)
Constant	0.413***			
Time fixed effect	No	Yes	No	Yes
Country fixed effect	No	No	Yes	Yes
Observations	277	277	277	277

Note: Data come from World Bank WDI, IMF IFS and IMF FDID

Table A.1 suggests that after controlling for the commonly used control variables for FDI, reserves still have a positive and significant impact on the level of the FDI-stock-to-GDP ratio. Financial market accessibility and openness have a negative impact on the level of FDI, suggesting that economies with more developed financial markets might borrow more from the stock market and debt market. This is in line with our defined characteristics for EM economies, in that they have less developed financial markets and need to finance through FDI to fund their private firms. These characteristics give reserves the opportunity to play a signaling role.

Table A.2: Regression of the FDI-inflow-to-GDP ratio on reserves and other controls

	Dependent variable: FDI inflow/GDP			
	(1)	(2)	(3)	(4)
$\text{Res}_{it-1}/GDP_{it}$	0.100***	0.090***	0.015	0.006
	(0.015)	(0.011)	(0.010)	(0.015)
GDP Growth_{it}	0.0001	0.00001	0.0002	0.00004
	(0.0004)	(0.0003)	(0.0003)	(0.0003)
Deposit rate_{it}	-0.0004	-0.0004	-0.0002	-0.0004
	(0.0004)	(0.0002)	(0.0003)	(0.0003)
Devaluation rate_{it}	0.001	0.008	-0.004	0.004
	(0.012)	(0.009)	(0.009)	(0.011)
Financial $\text{Accessibility}_{it}$	-0.034***	-0.042***	-0.004	-0.026***
	(0.007)	(0.013)	(0.012)	(0.007)
Financial openness_{it}	-0.007***	-0.009**	0.016***	0.008*
	(0.005)	(0.005)	(0.005)	(0.005)
Trade/GDP_{it}	-0.0001	-0.0001***	0.0001	0.0001***
	(0.00004)	(0.00004)	(0.00004)	(0.00004)
Debt/GDP_{it}	0.284	0.275***	0.249***	0.242***
	(0.079)	(0.069)	(0.069)	(0.081)
Constant	0.028*			
Time fixed effect	No	Yes	No	Yes
Country fixed effect	No	No	Yes	Yes
Observations	372	372	372	372

Note: See note to Table A.1

Table A.2 suggests that when we account for the control variables, the effect of the reserves-to-GDP ratio has a weaker impact on the FDI-inflow-to-GDP ratio, but the positive correlation persists. This could be because the control variables are highly correlated with the level of reserves and because both reserves and FDI inflow are somewhat driven by the control variables.

Table A.3: Regression of the FDI-stock-to-total-liability ratio on reserves and other controls

	Dependent variable: FDI stock/Total Liability			
	(1)	(2)	(3)	(4)
$\text{Res}_{it-1}/GDP_{it}$	0.509***	0.427***	0.657***	0.396***
	(0.060)	(0.076)	(0.092)	(0.070)
GDP Growth_{it}	0.001	0.002***	0.0001	0.001**
	(0.001)	(0.001)	(0.001)	(0.001)
Deposit rate_{it}	-0.008	-0.004***	-0.015***	-0.010***
	(0.002)	(0.001)	(0.002)	(0.002)
Devaluation rate_{it}	-0.016	0.002	0.028	-0.023
	(0.056)	(0.037)	(0.029)	(0.063)
Financial $\text{Accessibility}_{it}$	-0.039***	-0.153***	-0.210***	-0.323***
	(0.041)	(0.049)	(0.064)	(0.044)
Financial openness_{it}	-0.088***	-0.106	0.016	0.018
	(0.015)	(0.068)	(0.060)	(0.021)
Trade/GDP_{it}	-0.001	-0.001***	0.001***	-0.0003
	(0.0002)	(0.0004)	(0.0004)	(0.0002)
Debt/GDP_{it}	0.058	-0.047	0.214***	0.114
	(0.098)	(0.104)	(0.080)	(0.098)
Constant	0.423***			
Time fixed effect	No	Yes	No	Yes
Country fixed effect	No	No	Yes	Yes
Observations	277	277	277	277

Note: See note to Table A.1

Table A.3 suggests that the reserves-to-GDP ratio has a positive and significant impact on the FDI-liability-to-total-liability ratio. The higher the level of reserves-to-GDP ratio is, the larger the fraction of external liability is in the form of FDI. The financial market variables have a negative impact on this ratio, also suggesting that the more open and efficient an economy's financial market is, the more likely the economy is to self-finance through debt and the stock market. The deposit rate has a significant and negative impact on this ratio and could be preliminary evidence of a possible carry trade in economies with high deposit rates.

A.2 Micro-foundations of investor behavior

A.2.1 Investment decision rule of foreign investors

In the main formulation of the model, I let b represent the constant share of wealth that is consumed by foreign investors and, without loss of generality, model the gross safe asset interest rate R_1 as 1. In the multi-period case, I model investors in an overlapping generations setup to avoid accounting for multiple shareholders of the firm and mimicking the results discussed above. Suppose that each investor lives for two periods, young and old. The young investor in period t is endowed with $(1-b)W_t$. He or she buys the share x_{t-1} from the previous generation using $(1-\delta)p_t^x$. He or she also obtains the proceeds that the previous generation had from selling the asset. He or she then makes an investment decision regarding the FDI asset in period t i_t^F based on the return that the next generation will obtain. He or she also receives a dividend payment from the domestic firms $x_{t-1}A_t^k{}_t^\alpha$. At the end of the period, he or she becomes old, consumes $(1-b)W_{t+1}$ of the total wealth, endows the rest of his or her wealth and sells his or her shares in firm to the next young generation. In this way, I derive an investor wealth process that is similar to that in the single-period return case:

$$W_{t+1} = (1-b)W_t - i_t^F + x_{t-1}A_t^\alpha k_t^\alpha - (1-\delta_x)x_{t-1}p_t^x + (1-\delta_x)x_{t-1}p_t^x$$

$$= (1-b)W_t - i_t^F + x_{t-1}A_t^\alpha k_t^\alpha$$

A.2.2 Reserves and volatility of return

In the previous section and throughout the model, I assume that the volatility of returns is affected by the level of reserves. This correlation could operate through multiple channels. The reserves could serve as insurance held by the central bank whereby when firms seek to exit the country, the central bank can guarantee the repayment of investments made in them. The reserves can also serve as insurance for investors through the traditional role of maintaining exchange rate stability if the profit of the firms is denominated in local currency but the dividend is paid in USD. Although there is a large empirical literature on the ability of reserves to stabilize the exchange rate, as discussed in the literature review, there is no theoretical model of this mechanism.

I do not intend to limit the analysis to a specific channel, and I would argue that the reality is a mixture of these possible channels. However, I provide here a simple micro-foundation for the exchange rate channel.

Apart from the players described in the main model, suppose that all decisions are made for period t and that there is a certain amount of bonds held by traders. This means that in addition to holding reserve assets, the central bank is borrowing in domestic currency from the rest of the world, which pays interest rate R. The traders can decide whether to hold the bond or exchange it for dollars, depending on their expectation of future devaluation. The payoff is as follows

	Devaluation	No devaluation
Dollar	1-g(rx)	0
Bond	r	r

If the central bank devalues, the return on devaluation is equal to a function of reserve level. $g(rx)$ is an increasing function of the reserve level. The intuition is that when the reserve level is high, the devaluation rate will be lower since more reserves would stabilize more movement. The return in the no-devaluation case is 0 for dollar holders. The returns for bond holders are r, which is the predetermined interest rate in the two cases considered here. The central bank's decision to devalue the currency depends on its loss of reserves, L/rx. A measures the total amount withdrawn by traders. The net value of maintaining a fixed exchange rate is given by θ-$\frac{L}{rx}$, where θ is exogenous and refers to the value of a peg without any reserve loss. The central bank will devalue if and only if

$$\theta < \frac{L}{rx}$$

In the first stage of the game, nature selects θ from an improper uniform distribution over the entire real line. Then, each trader observes an idiosyncratic signal about θ, which is x_i and $x_i \sim N(\theta, \sigma^{-1})$. The cumulative distribution function of the private signal is given by $\Phi(\sqrt{\sigma}(x-\theta))$, which also equals the fraction of traders who observe a signal $x_i \leq x$. In stage 2, the traders chose whether to exchange their bonds for dollars with the central bank. The traders submit bid $a_i(x_i, r)$ to the central bank if they wish to exchange their bonds for dollars. The amount of reserve loss is equal to the total demand for dollars:

$$L(\theta, r) = \int a(x, r)\sqrt{\sigma}\phi(\sqrt{\sigma}(x-\theta))$$

Suppose that the solution is a threshold rule for both central banks and traders. Traders demand dollars whenever their private signal satisfies $x_i \leq x^*(r)$, and the central bank devalues if $\theta \leq \theta^*(r)$. The expected payoff when observing $x^*(r)$ should be equalized across the two cases; let $p(x^*(r), r)$ refer to the expected probability of devaluation:

$$p(x^*(r), r)(1-g(rx)) = r = p(\theta \leq \theta^*|x^*) = \Phi(\sqrt{\sigma}(\theta^*(r) - x^*(r)))$$

$$\theta^*(r) = \frac{L(\theta^*(r), r)}{rx} = \frac{\Phi(\sqrt{\sigma}(x^*(r) - \theta^*(r))}{rx}$$

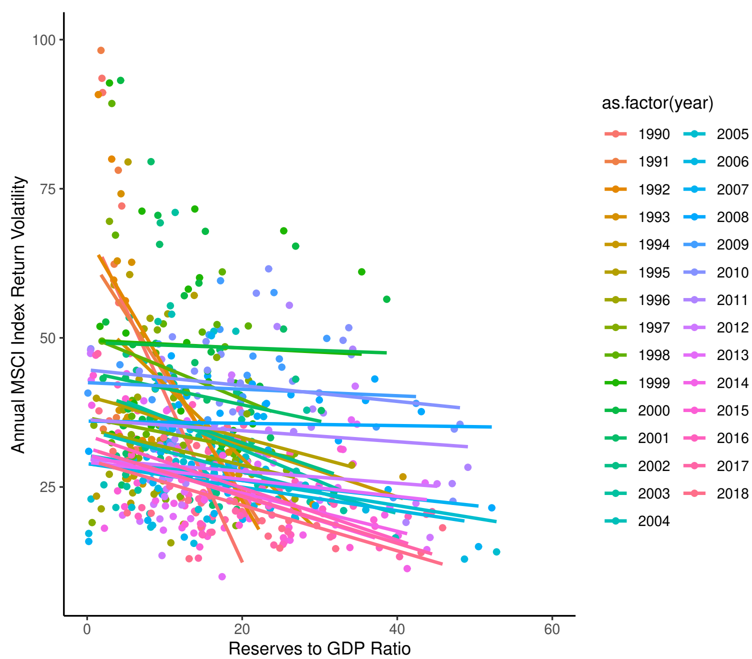
The levels of $\theta(r)$ and $x^*(r)$ for the corresponding r can be solved using the above equations. A higher level of reserves means a lower level of $\theta^*(r)$ for any r, which reduces the probability of devaluation, leading to the conclusion that reserves decrease the volatility of the exchange rate. On the equilibrium path, the central bank does not devalue with a deterministic θ but knowns that there is a possibility that θ will be subject to a shock and drawn from the distribution noted above.

This provides one micro-foundation for the level of reserves affecting the volatility of the return on assets through exchange rate stability.

A.3 Return volatility and reserve levels by economy and by date

Figure A.3 plots the same observations as presented in figure 1.6 but separates the observations by year. Within any given year, an economy with a larger return volatility has to a lower reserves-to-GDP ratio. The negative correlation persists even if we consider a single year.

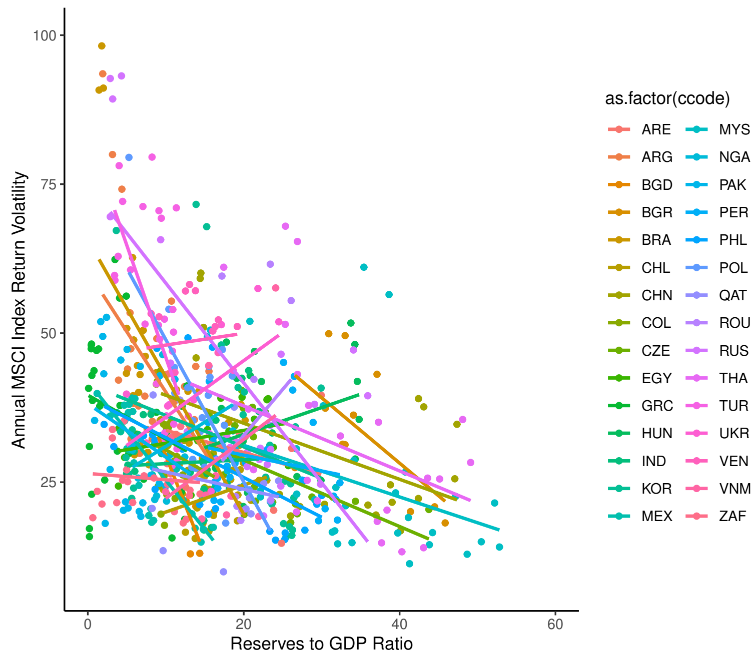
Figure A.3: Return volatility and the reserves-to-GDP ratio by date



Note: This figure plots the stock market return volatility again the reserves-to-GDP ratio for the EM economies in the sample.
Source: World Bank WDI, Factset MSCI

Figure A.4 plots the same observations as presented in figure 1.6 but separates the observations by country. Of the 30 EM economies in my sample, most show negative correlations. Overall, this negative correlation is quite robust across economies and over time.

Figure A.4: Return volatility and the reserves-to-GDP ratio by economy



Note: This figure plots the stock market return volatility against the reserves-to-GDP ratio for the EM economies in the sample.
Source: World Bank WDI, Factset MSCI

A.4 Data construction for allocation puzzle

The construction of the data used in the allocation puzzle follows the method used by Gourinchas and Jeanne (2013). The raw data come from the latest version of the Penn World Table Version 9.1, termed PWT hereafter, and the IMF's International Financial Statistics, termed the IFS hereafter Figure 1.9 suggests a negative correlation between the average net capital inflow and average technology growth. The data are constructed as follows:

1. Technology growth is measured using the Cobb-Douglas production function $Y_t = K_t^\alpha (A_t L_t)^{1-\alpha}$; α is set to 0.3. The country-specific output Y_t and L_t are directly taken from the PWT.

2. K_t in the above equation is measured by constructing the times-series of real investment $K_t = (1 - \delta)K_{t-1} + I_t$. Real investment I_t in each period is calculated using the series Real

domestic absorption and Real consumption in the PWT.

$$I_t = \text{Real domestic absorption - Real consumption}$$

The initial level of capital K_0 is constructed using the standard accounting method, where $K_0 = \frac{I_0}{\delta+\bar{g}}$. I_0 is the first observation of capital, and $\delta = 0.06$ is the depreciation rate employed in the paper. $\bar{g}$ is the geometric average growth rate of investment for the first ten observations of investment data. Then, I can obtain the series of capital levels K_t in recursive order.

3. Average productivity growth is measured using the series of productivity A calculated above and taking the geometric average.

4. Average capital inflow is calculated as the arithmetic average of the current account balance $-\frac{CA_t}{GDP_t}$ for each year because a negative current account balance indicates capital inflow. The current account-to-GDP ratio is taken from IFS.

Figure 1.10 suggests that there is a positive correlation between FDI inflow and productivity growth.

- FDI inflow is calculated as the accumulation of all FDI inflow from 1980 to 2000. FDI inflow data are taken from the IFS balance of payment data at the country level.

- I adjust the inflow data from nominal USD to real USD by adjusting for the investment price level pl_i in the PWT. Then, I sum up all the real FDI inflows between 1980 and 2000 and divide it by the real GDP level in the initial year, 1980:

$$\frac{\sum_{1980}^{2000} \text{Real FDI inflow}_t}{\text{Real GDP}_{1980}}$$

Figure 1.11 suggests a positive correlation between RX assets (capital outflow) and productivity growth; countries with higher productivity growth also accumulate higher reserve assets, which is the capital outflow, which contributes to explaining the allocation puzzle. The construction of RX change is the same as the construction of FDI change, with the RX data coming from the IFS balance of payment data.

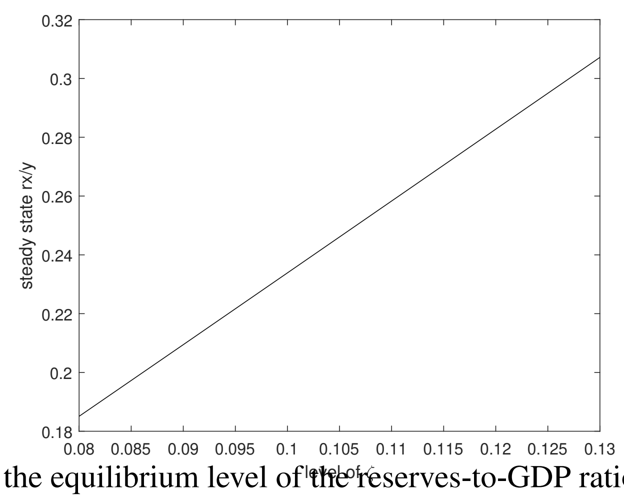
A.5 Robustness check

A.5.1 The parameter ζ

Parameter ζ measures the ability of reserves to attract FDI inflow and affect the equilibrium level of the reserves-to-GDP ratio. From the empirical analysis, I have pinned down the range of ζ as $0.08 - 0.13$, as discussed in section 1.6. In the main analysis, I set the level of ζ at 0.1, within the range of the empirical observations. Now, I can vary the value of ζ and examine how the main analysis changes with the change in ζ.

The application here is analogous to that for varying the parameter ρ described above, in that I change the value of ζ but fix the other parameters that I use in the main analysis to obtain comparative results on the equilibrium level of the reserves-to-GDP ratio

Figure A.5: Change in the level of ζ



Note: This graph plots the equilibrium level of the reserves-to-GDP ratio for different values of ζ

Figure A.5 suggests that the higher ζ is, the larger amount of reserves held by central banks in equilibrium. The interpretation is that a central bank would hold more reserves if one unit of reserves can attract more FDI inflow. One might expect that if the ability of reserves to attract

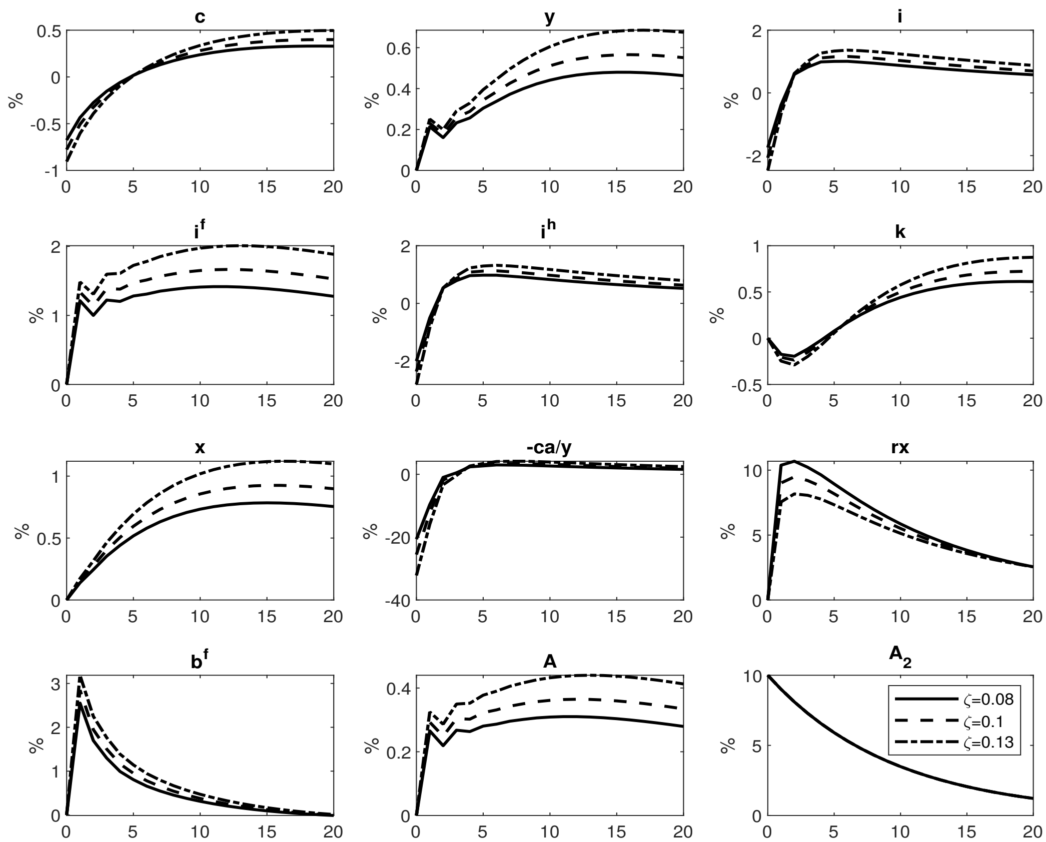
FDI inflow is very high, the central bank would not need to hold a high level of reserves to attract a given amount of FDI inflow. However, the equilibrium level of variables is pinned down by the optimal conditions, in which the marginal cost of holding reserves and the marginal benefit of holding reserves should be equalized. Since for any level of ζ, the marginal benefit of holding reserves is decreasing in the level of reserves, a large value of ζ corresponds to a high level of reserves provided that the cost is the same. This is because when the reserve level is very high, increasing reserves by one unit does not increase the benefit of holding reserves.

The different levels of ζ also produce different responses to shocks. The impulse response for different values of ζ for a given FDI technology shock A_2 is shown in Figure A.6, where ζ varies from 0.03 to 0.13. The direction and shape of the reactions of all variables to shocks are the same, but the magnitude differs. When ζ is small, the magnitude of the increase in the reserve level is large. This is because, for a given increase in the reserve level, a smaller ζ means less ability to attract FDI inflow. A large increase in reserves is need to raise the FDI inflow to the desired level. The increase in FDI inflow i^f under different specifications of ζ also differs. Specifically, a smaller ζ, which indicates a smaller impact of reserves on FDI inflow, is accompanied by both a larger increase in reserves and a smaller increase in FDI inflow. The increase in FDI inflow increases in ζ.

A.5.2 The parameter A_2

The parameter A_2 measures the ability of an increase in FDI inflow to increase productivity. I conduct similar exercises involving fixing other parameters in the model when varying the level of A_2 to compare the steady-state levels of the reserves-to-GDP ratio. The effect of a change in A_2 on the equilibrium level of the reserves-to-GDP ratio is similar to that of a change in parameter ζ. As suggested in Figure A.7, a larger value of A_2 yields a higher equilibrium reserves-to-GDP ratio. The interpretation is the same as discussed in the previous section. The impulse responses that correspond to different values of A_2 are shown in Figure A.8. A higher level of A_2 corresponds to a smaller increase in reserves and a larger increase in the FDI inflow.

Figure A.6: IRF for different values of ζ



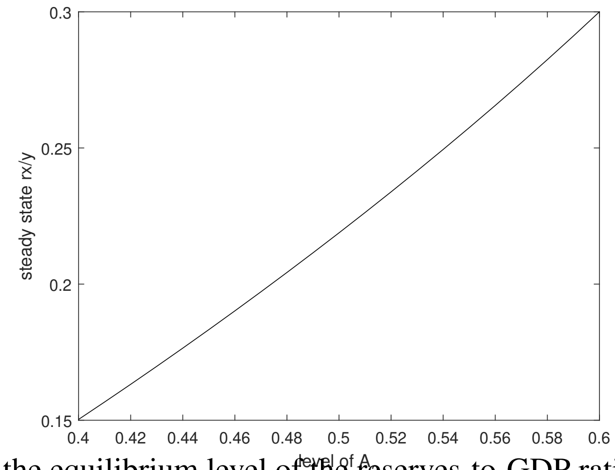
Note: This graph plots the impulse responses for a 10 % FDI technology shock on $A_{t,2}$ for different values of ζ

A.5.3 The elasticity of substitution, ρ

The parameter ρ, which governs the elasticity of substitution between domestic investment and foreign investment, seems to be an essential parameter for determining the level of foreign investment and thus the equilibrium level of reserves. However, it has little effect on the equilibrium level of the reserves-to-GDP ratio.

If I perform a similar exercise that involves holding the other parameters fixed from the baseline analysis and only varying the level of ρ from 0 to 0.5, meaning that the elasticity of substitution ranges from 1 to 2, the equilibrium level of the reserves-to-GDP ratio is always approximately 23%. The equilibrium level of foreign investment as a percentage of total investment decreases as

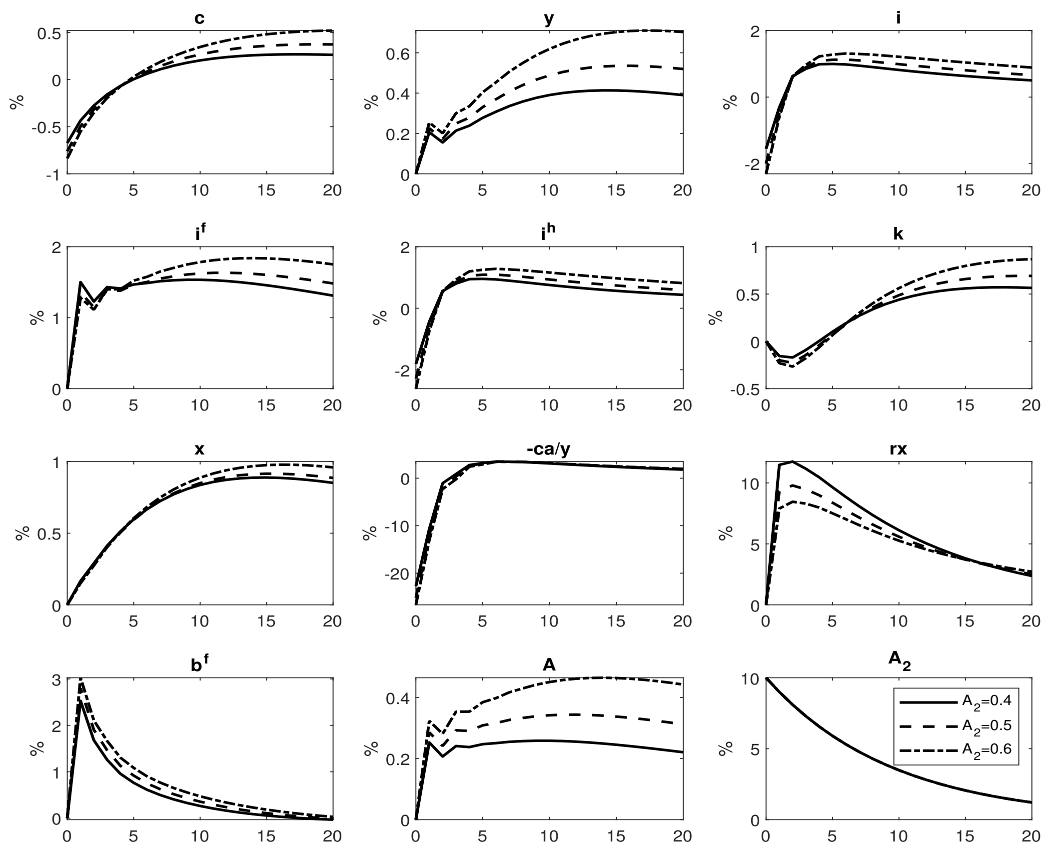
Figure A.7: Change in the level of A_2



Note: This graph plots the equilibrium level of the reserves-to-GDP ratio for different values of A_2

the elasticity of substitution increases. However, the decrease in i_t^F increases the marginal benefit of holding one more unit of i_t^F on the level of technology. Since the cost of holding reserves has not changed, the central bank would always want to hold reserves at the level that balances the costs and benefits of doing so. Therefore, we observe that the equilibrium level of reserves is does not appear to be significantly sensitive to a change in the elasticity of substitution.

Figure A.8: IRF for different values of A_2



Note: This graph plots the impulse responses for a 10 % FDI technology shock on $A_{t,2}$ for different values of A_2, the steady-state value of $A_{t,2}$

Appendix B: Appendix to chapter 2

B.1 Summary statistics of data cleaning

Table B.1: Reduction of observations due to lack of asset or number of employees

economy	# of obs before cleaning	# of obs after cleaning	survival rate	# of FDI firms	# of domestic firms
AU	10873	5053	0.464729	1307	3746
AT	13428	7034	0.523831	1612	5422
BE	18526	12683	0.684605	2240	10443
BM	684	280	0.409357	96	184
BA	1552	1202	0.774485	248	954
BR	5290	1374	0.259735	253	1121
BG	5614	3979	0.708764	846	3133
CN	56589	22378	0.395448	5071	17307
HR	2456	2107	0.857899	468	1639
CZ	19719	9586	0.48613	2857	6729
DK	9046	4796	0.530179	1100	3696
EE	1593	937	0.588198	370	567

Table B.1 – continued from previous page

economy	# of obs before cleaning	# of obs after cleaning	survival rate	# of FDI firms	# of domestic firms
FI	7530	4774	0.633997	968	3806
FR	74164	38764	0.522679	5391	33373
DE	116706	69166	0.592652	8673	60493
GR	3769	3490	0.925975	616	2874
HK	5289	401	0.075818	302	99
HU	6756	5140	0.760805	850	4290
IN	18062	1539	0.085207	249	1290
ID	550	524	0.952727	180	344
IE	7682	2472	0.321791	903	1569
IT	70652	54412	0.770141	5163	49249
JP	45313	31328	0.691369	425	30903
KZ	845	695	0.822485	99	596
KR	28835	19751	0.684966	1253	18498
LV	1691	1303	0.77055	498	805
LT	1923	1627	0.846074	468	1159
LU	3636	772	0.212321	341	431
MK	1235	722	0.584615	122	600

Table B.1 – continued from previous page

economy	# of obs before cleaning	# of obs after cleaning	survival rate	# of FDI firms	# of domestic firms
MX	1938	535	0.276058	54	481
MD	614	276	0.449511	33	243
ME	267	182	0.681648	57	125
NL	31084	7492	0.241024	1984	5508
NO	20423	11503	0.563238	1592	9911
PK	567	376	0.663139	64	312
PE	214	146	0.682243	70	76
PL	18590	5461	0.29376	1479	3982
PT	10981	8400	0.764958	1561	6839
RO	9453	7281	0.770232	2463	4818
RU	75713	66875	0.88327	7260	59615
RS	3760	2400	0.638298	523	1877
SK	4614	3574	0.774599	1349	2225
SI	2192	1599	0.729471	405	1194
ES	48148	33921	0.704515	4326	29595
LK	527	172	0.326376	44	128
SE	20405	13321	0.65283	2760	10561

Table B.1 – continued from previous page

economy	# of obs before cleaning	# of obs after cleaning	survival rate	# of FDI firms	# of domestic firms
CH	22143	310	0.014	87	223
TW	2169	1544	0.711849	57	1487
TR	4691	165	0.035174	46	119
UA	9242	7805	0.844514	1579	6226
GB	105246	35116	0.333656	8207	26909

B.2 An alternative measure of job creation based on shareholders funds

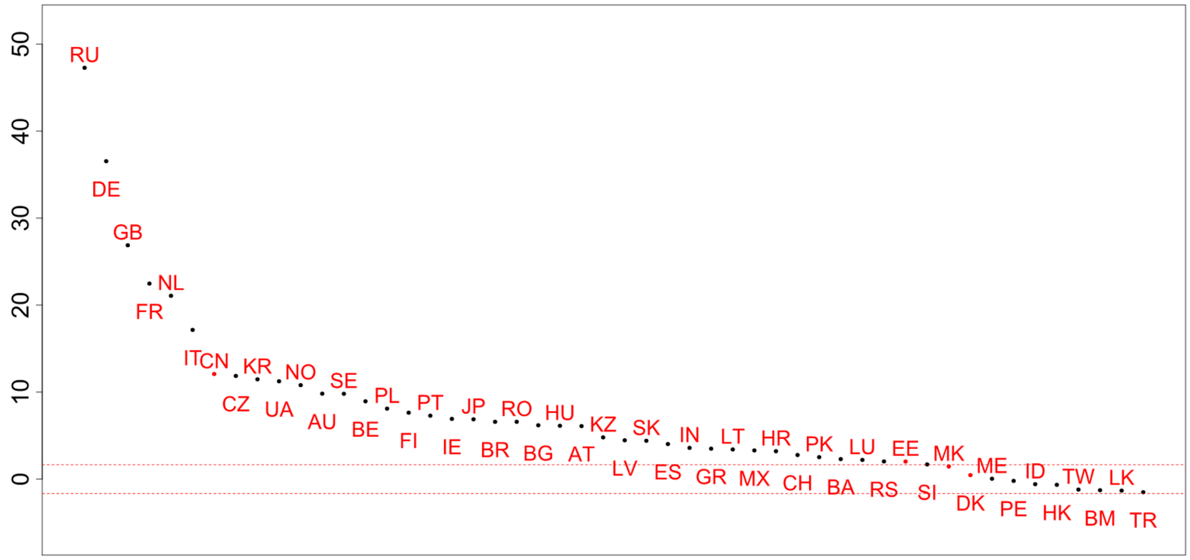
The main analysis in section 2.4 is based on the number of employees per asset, but there can be other ways to measure the financial resources used to operate the firm. For example, the same exercise can be conducted by replacing the total assets with shareholders funds

$$e^{equity} = log_{10}\left(\frac{Number\ of\ employees}{Shareholder's\ funds}\right) \tag{B.1}$$

One problem of this measure is that often the shareholders funds are negative. This can happen for example when the firm runs a deficit, but it gets loans from banks guaranteed by its parent company. We drop the observations with negative shareholders funds and conduct the same exercise as Figure 2.3.

Figure B.1 shows that the qualitative feature of the main analysis remains similar if the total asset is replaced by shareholders funds. The result can be interpreted as indicating the robustness of the main analysis, suggesting that domestic firms on average create more jobs than FDI firms for one of unit of financial resource.

Figure B.1: Domestic firms create more jobs in most economies for each dollar of equity



A larger t-statistic suggests that it is more likely that on average domestic firms create more jobs than FDI firms for each dollar of equity. Red dots correspond to those whose result of the hypothesis test changed from Figure 2.3

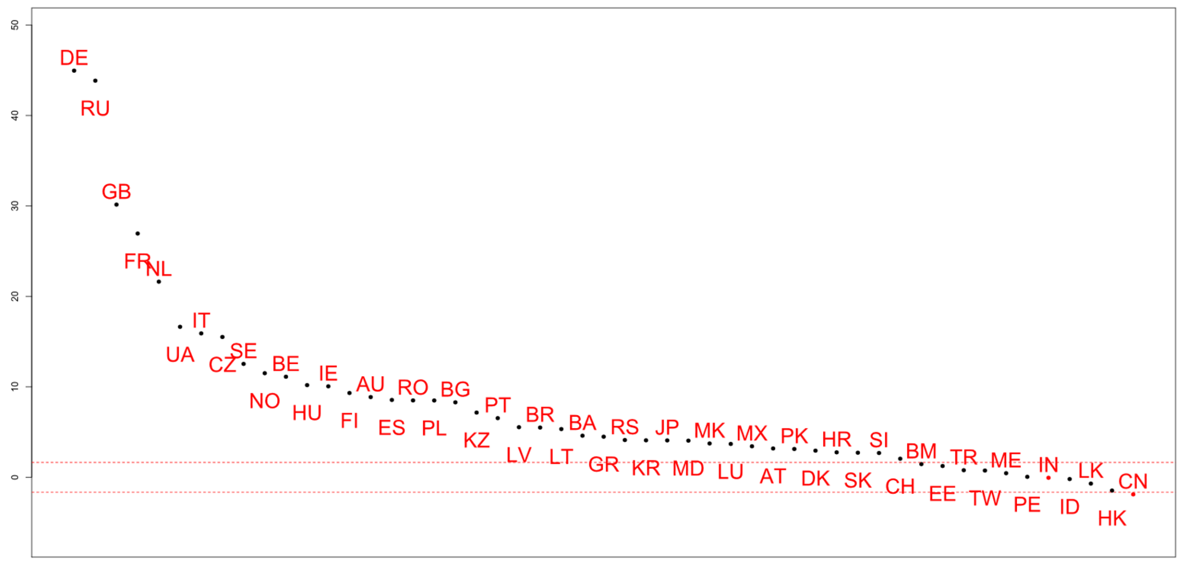
B.3 Alternative definition of FDI firms

The definition of FDI firms in the main analysis of section IV is based on the 10 percent threshold of foreign shareholders. Although the 10 percent threshold is the internationally accepted definition of BPM6, one might be concerned about whether the result survives when a different threshold is chosen.

One natural candidate for the threshold is 50. In BPM6, the shareholders with more than 50 percent share are defined as the investors who can exercise control, while those with 10 percent share are considered to be able to exercise a significant degree of influence but not control. Thus, the alternative threshold 50 narrows down the FDI firms to those controlled by foreign shareholders and extends the set of domestic firms by including those that are not controlled but are under the influence of foreign shareholders.

Figure B.2 shows that the qualitative result survives even if the definition of FDI firms adopts the 50 percent threshold instead of 10. Thus, the behavior of FDI firms is mostly driven by those that are controlled by foreign shareholders with more than 50 percent share. Table B.2 shows the number of firms by the share held by foreign investors. Indeed, one can see that the majority of FDI firms are controlled by foreign investors.

Figure B.2: Qualitative result survives if FDI firms are defined using 50 percent threshold



A larger t-statistic suggests that it is more likely that on average domestic firms create more jobs than FDI firms for each dollar of assets. Red dots correspond to those whose result of the hypothesis test changed from Figure 2.3

Table B.2: Number of firms by the share held by nonresident

Share held by foreigners	**[0,10)**	**[10,50)**	**[50,100]**
AU	3746	137	1169
AT	5422	165	1446
BE	10443	153	2087
BM	184	69	27
BA	954	62	186
BR	1121	67	186

Table B.2 – continued from previous page

Share held by foreigners	[0,10)	[10,50)	[50,100]
BG	3133	113	737
CN	17307	744	4337
HR	1639	55	413
CZ	6729	271	2579
DK	3696	56	1042
EE	567	48	322
FI	3806	64	904
FR	33373	582	4809
DE	60493	1324	7349
GR	2874	156	460
HK	99	50	252
HU	4290	48	802
IN	1290	143	106
ID	344	108	72
IE	1569	79	824
IT	49249	737	4426
JP	30903	256	169
KZ	596	32	66

Table B.2 – continued from previous page

Share held by foreigners	[0,10)	[10,50)	[50,100]
KR	18498	333	920
LV	805	77	421
LT	1159	75	393
LU	431	66	275
MK	600	19	103
MX	481	10	40
MD	243	10	23
ME	125	19	38
NL	5508	53	1931
NO	9911	137	1454
PK	312	27	37
PE	76	29	41
PL	3982	292	1187
PT	6839	220	1341
RO	4818	426	2037
RU	59615	1022	6100
RS	1877	70	453
SK	2225	157	1192

Table B.2 – continued from previous page

Share held by foreigners	[0,10)	[10,50)	[50,100]
SI	1194	53	352
ES	29595	521	3805
LK	128	26	18
SE	10561	226	2534
CH	223	10	78
TW	1487	41	16
TR	119	12	34
UA	6226	415	1164
GB	26909	468	7739

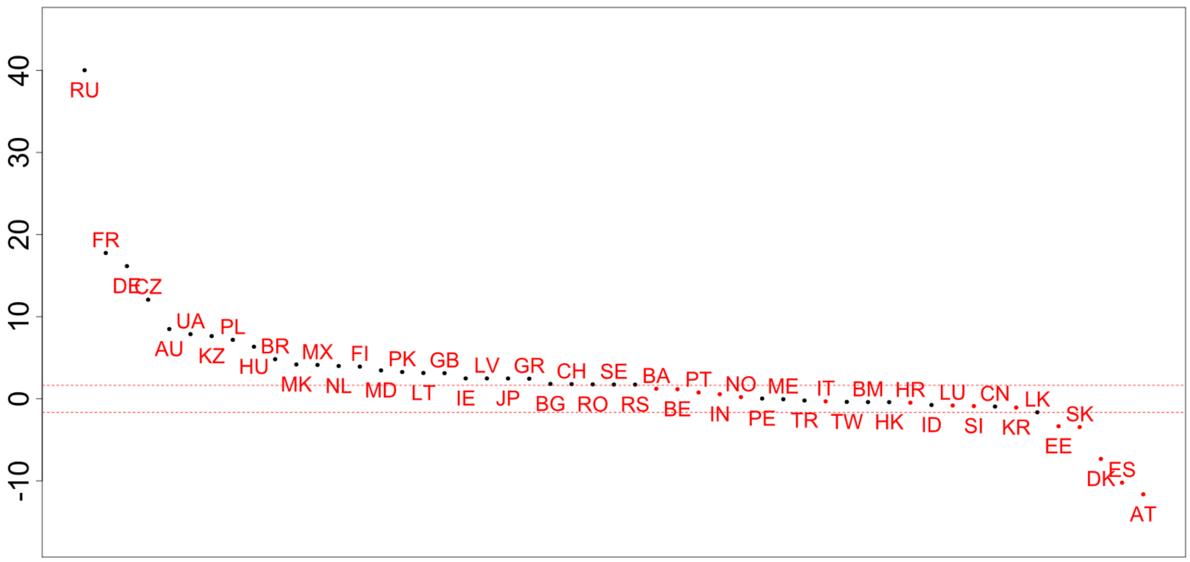
B.4 Alternative definition of SPEs: restrict SPEs to FDI firms

In the main analysis of section 2.4, we have dropped all the SPEs defined as the firms with less than 5 employees. Although the criteria follow the recommendation of IMF (2018) as discussed in section 2.3.2, the crude nature of the definition may raise concerns about the robustness of the main result.

One concern of defining all the firms with less than 5 employees as SPEs is that it might exclude many domestic firms that are engaged in real economic activities, such as self-employed and small and medium-sized enterprises (SMEs). Thus, this section defines SPEs to be the FDI firms with less than 5 employees and assume none of the domestic firms are SPEs.

Figure B.3 presents the result. One can see that the inclusion of domestic firms with less than 5 employees changes results for several economies, but the majority remains the same. One caveat is that Orbis may not have better coverage for larger firms, so the analysis of self-employment and SMEs may not be representative.

Figure B.3: The result changes for some but remains similar for most economies if SPEs are removed from only FDI firms

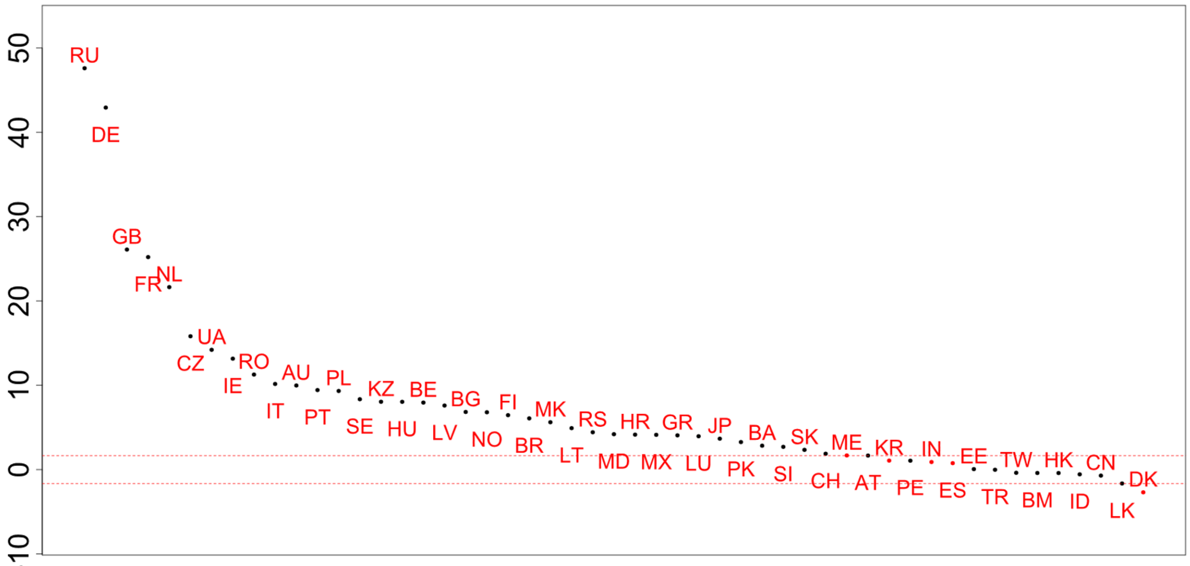


A larger t-statistic suggests that it is more likely that on average domestic firms create more jobs than FDI firms for each dollar of assets. Red dots correspond to those whose result of the hypothesis test changed from Figure 2.3

B.5 Alternative definition of SPE: lower 5 percentile of the employee distribution

The threshold of 5 employees in the main analysis of section 2.4 might exclude firms disproportionately from the sets of FDI and domestic firms since the employment distributions of the two groups might have different shapes. To address this concern, this section defines SPEs to be the firms in the lower 5 percentile of the employment distributions of the FDI and domestic firms. It turns out that, as shown in Figure B.4, the result is almost the same as the main analysis in Figure 2.3.

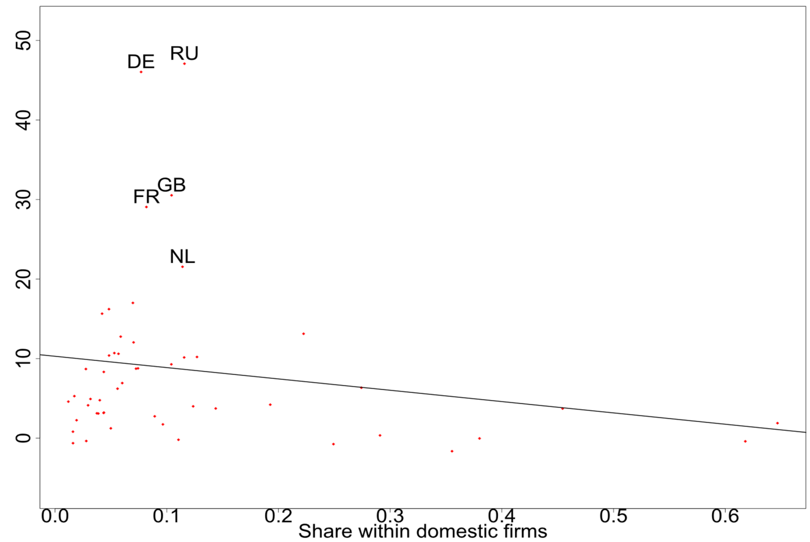
Figure B.4: The result remains similar for most economies if SPEs are defined as firms in lower 5 percentile of the number of employees



A larger t-statistic suggests that it is more likely that on average domestic firms create more jobs than FDI firms for each dollar of assets. Red dots correspond to those whose result of the hypothesis test changed from Figure 2.3

B.6 Industry structure and difference in job creation: finance industry

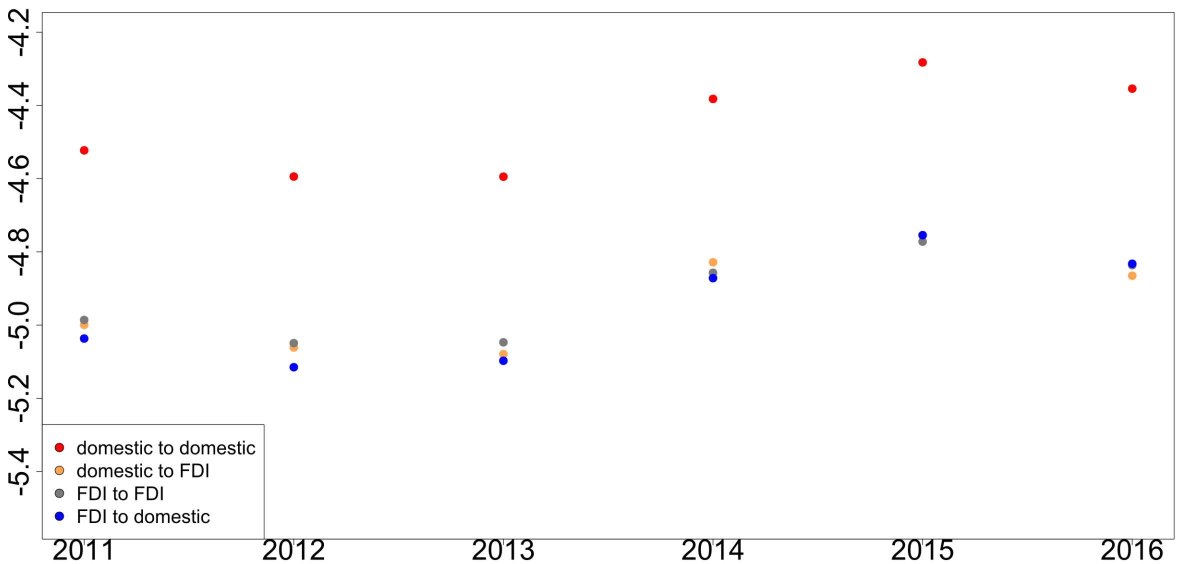
Figure B.5: The size of finance sector does not tell much about difference in job creation



A larger t-statistic suggests that it is more likely that on average domestic firms create more jobs than FDI firms for each dollar of assets. X-axis denotes the share of finance industry within domestic firms.

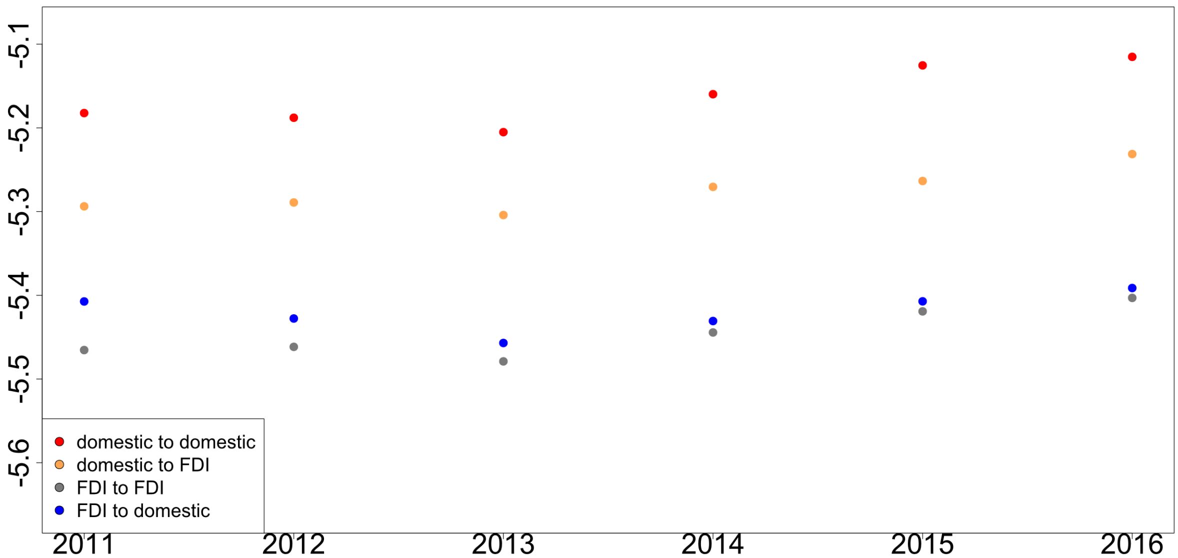
B.7 Switchers analysis: Russia, Germany, all firms in the sample

Figure B.6: Switchers analysis for Russia



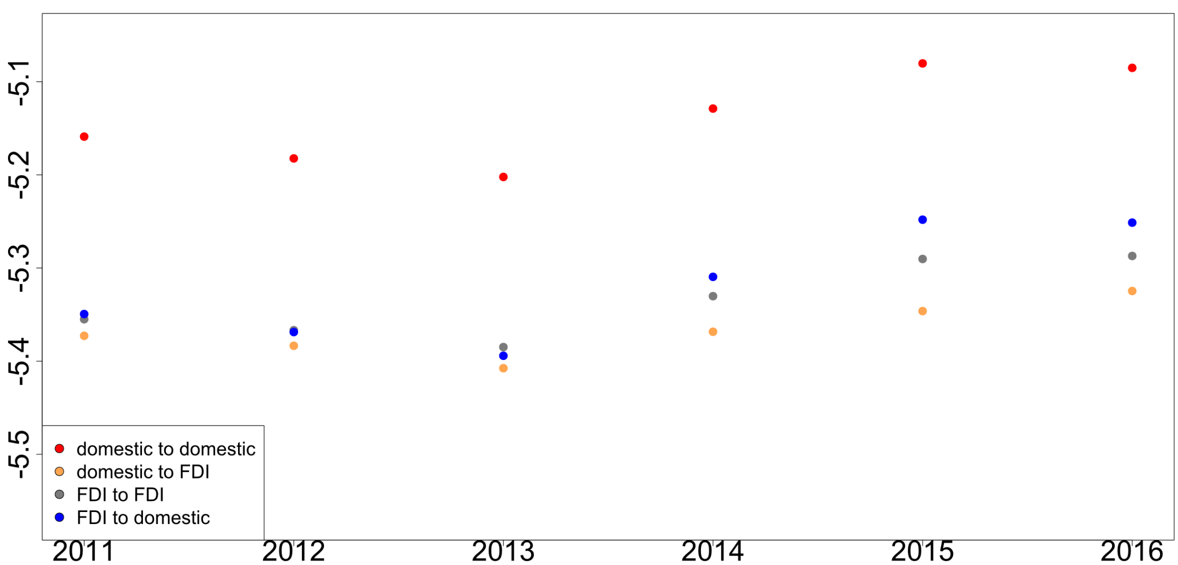
Y-axis denotes the mean of the log employment per asset ratio for the four groups of firms. There is no obvious change of pattern after the ownership change from 2013 to 2014.

Figure B.7: Switchers analysis for Germany



Y-axis denotes the mean of the log employment per asset ratio for the four groups of firms. There is no obvious change of pattern after the ownership change from 2013 to 2014.

Figure B.8: Switchers analysis for all firms in all the countries in the sample



Y-axis denotes the mean of the log employment per asset ratio for the four groups of firms. There is no obvious change of pattern after the ownership change from 2013 to 2014.

B.8 Switchers analysis: difference-in-difference

For each pair of (1) control group 1 and experimental group 2 and (2) control group 3 and experimental group 4 as defined in section VI, we run the following regression

$$e_{it} = \beta_i + \beta_t + treat_i + treat_i \left(\sum_{\tau=2011}^{2012} \beta_\tau 1_{t=\tau} + \sum_{\tau=2014}^{2016} \beta_\tau 1_{t=\tau} \right) + \epsilon_{it}$$

where e_{it} is the log employment per asset for firm i at year t , (β_i, β_t) represents the fixed effects for the firm and year, $treat_i$ is a dummy variable with 1 if firm i belongs to the experimental group that switches the ownership.

The interaction of year and the treatment dummy is included to test the pre-treatment parallel trend of the switcher and the non-switchers. The interaction term for 2013 is omitted so that the year 2013 serves as the baseline. The standard error is clustered at the firm level to allow correlations within-firm across observations in different years.

The switch of ownership has an effect if β_{2011} and β_{2012} are close to 0 and β_{2014} is not. In this case, the two groups have a similar trend before the treatment, but after the switch, there is a change in the employment per asset for the switchers compared to the non-switchers. β_{2015} and β_{2016} tell whether the effect of the ownership change increases or dies out.

Table B.3 below shows the results of the two regressions. The first one is the comparison between group 1 and group 2 firms. The second regression is the comparison between group 3 and group 4 firms. The p-values are put in the parentheses. All the coefficients are insignificant, suggesting that the difference between the two groups is not the consequence of ownership change but rather an endogenous behavior. The result is also consistent with the aggregate results in Figure 2.10 and section B.7.

Table B.3: Difference in difference analysis

Dependent variable: log of employment per asset		
Variable	*Group 1: dom-dom v.s.dom-fdi*	*Group 2: fdi-fdi v.s. fdi-dom*
β_{2011}	-0.0052	-0.0135
	(0.8259)	(0.6750)
β_{2012}	-0.0109	-0.0070
	(0.6365)	(0.8183)
β_{2014}	-0.0087	-0.0084
	(0.7280)	(0.7870)
β_{2015}	-0.0053	-0.0093
	(0.8220)	(0.7736)
β_{2016}	-0.0137	-0.0057
	(0.5818)	(0.8549)
Firm fixed effect	Yes	Yes
Time fixed effect	Yes	Yes
Observations	Balanced Panel: n = 206252, T = 6, N = 1237512	Balanced Panel: n = 29354, T = 6, N = 176124
R^2	4.5682e-07	1.474e-06