Financing Multinationals*

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Abstract

We develop, validate, and quantify a tractable model of multinational firms that connects multinational production (MP) with foreign direct investment (FDI). Firms choose where to produce and how to finance the production. They can access external finance, but capital market imperfections prevent them from relying exclusively on it for affiliate production, giving rise to FDI. The model rationalizes the three-way relationship between MP, FDI, and financial market conditions that we document and leads to novel welfare implications. Quantification of the model highlights the relevance of these welfare implications and the importance of financial factors in shaping the activities of multinationals.

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1 Introduction

By mobilizing technological and financial capital across borders, multinational enterprises (MNEs) exert increasing influence on the world economy. A growing literature (e.g., Burstein and Monge-Naranjo, 2009; Ramondo and Rodríguez-Clare, 2013; Ramondo, 2014; Tintelnot, 2016; Cravino and Levchenko, 2016) has built quantitative models to explain MNEs' decisions and examine their global impacts. These models share the same central view: firms are owners of proprietary technologies (or 'blueprints', 'knowhow') that can be used in multiple locations within firm boundaries, and MNEs are the firms that deploy their technology abroad.[1] As the scale of a firm reflects the efficiency of its technology, in these models, the impact of foreign MNEs on the host economy often boils down to one statistic: the production by the affiliates of foreign MNEs (or 'multinational production', hereafter MP) as a share of host production.[2]

Guided by this insight, most studies viewing MNEs through the lens of technology focus on MP but overlook the financing decisions underlying MP, i.e., how investments in affiliates are financed. As such, these studies do not speak to foreign direct investment (FDI), a widely collected statistic and the subject of extensive empirical investigations.[3] This is an important disconnection for at least two reasons. First, the frictions that give rise to MNEs—impediments to the transfer of technology between firms—also incentivize parents to hold stakes in their affiliates, so MP rarely takes place without the company of FDI. To the extent that firms' allocation of internal capital depends on their use of external finance, a country's financial contracting institutions can be an important driver for FDI—hence MP, which are overlooked in existing studies. Second, as firms make FDI at least in part out of their retained earnings, which are shaped by past MP, the interplay between FDI and MP leads to a dynamic impact of MP that is absent in existing studies.

In this paper, we build a dynamic model of multinational firms that integrates MP and FDI in a unified framework. We show that financing factors are quantitatively important in driving the activities of MNEs and that the interplay between production and financing plays a central role in shaping workers' gains from these activities. Thus, viewing MNEs solely through the technological lens misses a crucial determinant of their activities and leads to biased welfare assessments.

Several descriptive facts connecting MP and FDI to countries' financial market conditions motivate our analysis. Existing research has documented a strong positive correlation between the activities of MNEs and the financial market conditions of host and home countries (e.g., Klein et al., 2002; Antras et al., 2009; Desbordes and Wei, 2017; Bilir et al., 2019). However, most of the literature either focuses only on MP (or closely related outcomes such as employment at foreign

[1]This view dates back to Hymer (1960) and permeates not only the quantitative models but also the entire modern approach to multinational firms; see Antràs and Yeaple (2014) for a review.

[2]For example, the MP share is a sufficient statistic for the impacts of foreign firms on the host output, productivity, and wage in Ramondo (2014) and Cravino and Levchenko (2016); it is also a sufficient statistic in the static baseline model of Burstein and Monge-Naranjo (2009) and McGrattan and Prescott (2009), and the non-trade special cases of Ramondo and Rodríguez-Clare (2013), Arkolakis et al. (2018), and (up to the first order) Tintelnot (2016).

[3]FDI is a balance-of-payment item that measures within-firm movement of capital from the parent to the affiliate. As an important economic indicator, it is collected by national governments and multilateral agencies such as the OECD. See Alfaro et al. (2004) and the references therein for the empirical literature devoted to FDI.

affiliates) or focuses on FDI, regarding it as a proxy for MP. Our analysis differentiates between MP and FDI. Using bilateral data, we show that host countries with better financial institutions attract more inward FDI and, conditional on the FDI stock, more inward MP. Home countries with better financial institutions send more outward FDI, but conditional on FDI, *not* more outward MP. These results are not confounded by other host and home characteristics, such as their income, sizes, and tax rates. Leveraging a firm-level panel from Orbis, we document similar patterns using the within-firm, *time changes* in financial market conditions. These asymmetric patterns highlight the distinction as well as the connection between the production and financing aspects of MNEs.

We rationalize these patterns by jointly modeling firms' internal capital market and their use of external finance. In the model, firms from a country are heterogeneous in productivity, which follows exogenous processes, and in their (endogenous) retained earnings, or net worth. Firms decide in which country to deploy their technology; when a firm deploys its technology abroad, an MNE emerges. MNEs combine their technology with capital and labor for production. Besides using their own net worth, they can finance capital investment by raising debt in the home country and by partnering with investors in the host country. Both forms of external finance are impeded by contractual frictions: the debt financing of the parent hindered by a limited enforcement friction, and the financing from host investors hindered by a moral hazard problem in technology transfer, which implies that affiliate operation must be financed at least in part by the parent.[4] These frictions lead to dynamic and static interactions in firms' decisions. Dynamically, through their influence on firms' net worth, firms' past operations shape future activities. Statically, the scale of an affiliate is constrained by the capital brought to the host by its parent firm, namely FDI.

Our model is consistent with the empirical patterns. Conditioning on FDI, improvements in host financial institutions can affect MP because they enable foreign firms to scale up on their direct investment with local financing. On the other hand, improved home financial institutions facilitate the expansion of firms with high productivity. In the short run, this drives up the home wage and pushes firms to invest abroad; in the long run, this leads to faster growth of productive firms, which are more likely to become MNEs. These forces increase both outward FDI and outward MP, but they affect MP primarily through FDI. We discuss additional implications of the model and connect them to empirical evidence.

Our model sheds new light on the welfare implications of MP. Taking the size and productivity distributions of firms as given, we derive the *static* wage gains of a host from *inward* MP as a formula of two statistics: the MP share, and the capital use of domestic firms which depends on FDI. The MP share captures the importance of foreign affiliates in local production. Conditioning on the MP share, higher inward FDI reduces the dependence of foreign affiliates on host financing, thus alleviating the crowd-out effect on domestic firms and bringing larger gains. This formula

[4] Despite having different micro-foundations, both types of impediments arise from imperfections in financial contracting institutions, so they are more severe where the quality of financial institutions is lower. Over time, both impediments tend to be more relaxed when the domestic capital market is relatively slack and more tightened during a credit crunch. In the quantitative exercise, we discipline the severity of these two forms of imperfections using different data and find they are indeed correlated across countries and over time.

encompasses two existing views of FDI. Compared to the neoclassical view that centers on capital flows (e.g., Mundell, 1957), our model highlights the importance of the technology embedded in FDI and potentially implies higher gains. Compared to the technology-based view of MNEs in which the MP share is a sufficient statistic (e.g., Ramondo, 2014), our model identifies a crowd-out effect in the capital market summarized by the capital use of host firms and implies lower gains.

By forging a link between FDI and MP, our model also identifies a dynamic mechanism of the welfare effects. Opening up a host to inward MP raises its wage but shifts the profits from local firms to foreign firms. As firms differ in their future productivity and the propensities to invest in the host country, such a shift can have first-order effects on future wages. We prove, in a special case of the model, that past openness tends to increase the future wage of a country if foreign firms are more likely to invest in the host economy than local firms, or if they invest like local firms but have higher future productivity. Conversely, past openness tends to decrease the future wage; in this case, the decrease in a period's wage due to past MP *can* outweigh the increase due to current MP, so openness brings net wage losses.

This mechanism is important for inferring the *dynamic* gains from MP. Compared to technology-based MP models in which FDI does not play a role, when calibrated to the same MP shares, our model might infer higher or lower (and possibly negative) wage gains because it incorporates the impact of past MP on firms' current size and productivity distributions. As such impact depends on firms' saving rates, their abilities to scale up internal savings (which are affected by a country's financial institution quality), and their propensities to invest internationally, the biases from the omission of these forces are also heterogeneous across host countries.

We implement the model quantitatively to examine the importance of financing factors in MNEs' decisions and the welfare implications of MP. Dynamic effects of the sort discussed above imply that past shocks matter for current MP and welfare. With countries connected by MNEs, openness in one country affects all others through third-country effects. To incorporate these forces, we derive two theoretical results: analytical characterizations for firm-level decisions, and tractable aggregation for country-level outcomes. This allows us to calibrate the *transitional dynamics* of the model to the multi-country data typical of studies on MP and international trade, capturing both the dynamic effects and the cross-country interactions.

We assemble a panel of bilateral FDI between 36 major countries over the period of 2001-2012, which we supplement with country-specific time series on GDP, domestic credit market conditions (proxied by the aggregate credit volume), investment rates, and the share of affiliate assets financed by foreign parents. Our calibration follows a wedge-accounting approach (see e.g., Eaton et al., 2016). Specifically, we introduce to the model country-specific wedges for investment efficiencies and bilateral wedges for FDI returns. We calibrate these wedges, as well as the structural parameters that determine credit market conditions and firms' productivity dynamics, so that the transitional dynamics of the model agree with all the data series described above. We then change model parameters to conduct three counterfactual exercises.

In the first exercise, using a gravity-like equation for bilateral MP derived from the model, we decompose the variation in cross-sectional MP into five terms, capturing respectively country size, geography, factors related to technology (including factor prices as well as fundamental productivities), host and home finance and their interaction with other factors, and a residual term arising from firm heterogeneity. Unsurprisingly, size and geography explain most of the variation (75%). Technological factors explain 7.4% of the variation, and financing factors account for 9.4%. While less prominent than size and geography, financing factors have about the same order of importance as the technological factors emphasized in existing models of MP.

In the second exercise, we quantify the role of technology and finance in the *time changes* of FDI. Our sample period saw a surge in global FDI (2001-2007) and a subsequent growth slowdown (2008-2012). The calibration reveals that, until 2007, many countries experienced gradually easing credit market conditions for both parent firms and foreign affiliates. This trend was reversed by the Great Recession starting in 2008. Through counterfactuals we find that, had the credit market conditions of all countries stayed at their 2001 levels, the *cumulative* global FDI flows during 2002-2007 would have fallen by 30%. On the other hand, if throughout the Great Recession, countries' credit markets had stayed at the peak level of 2007, the cumulative global FDI flows during 2008-2012 would have been 35% above the actual values. The changes in the fundamental productivity of countries also contribute to FDI growth and its slowdown, but their impacts are modest. Together, the first two exercises suggest that financing factors play a central role in shaping the activities of MNEs both cross-sectionally and over time.

In the last exercise, we examine the normative implications of the model. We focus on how European Union (EU) membership, by eliminating the restrictive policies of host member states on FDI from other members, affects the wage of the host. We measure the stringency of such policies by mapping the calibrated FDI return wedges to the OECD index of policy restrictions on foreign investment. We then solve for the 'non-EU member' counterfactual, separately for each member state, assuming that it imposes the same restrictions on inward FDI from within the EU that it has in place for FDI from other countries. We find that, averaging across member states and the sample period, EU membership raises inward FDI stock by 7.5%. This brings about an average wage increase of 0.37%. The technology component is important for the wage gains: evaluations in the neoclassical tradition that focus on capital only underestimate the gains by 30% on average. The dynamics arising from the FDI-MP link also plays a key role: when calibrated to match the same data, a technology-based model of MP without FDI, extended suitably to incorporate capital accumulation, could bias the estimates upward by one-half or downward by one-seventh. These findings highlight the value of using a unified model of FDI and MP for welfare assessments.

This paper is related to several strands of the literature. First and foremost, we contribute to the quantitative studies on the impacts of MNEs on the aggregate economy (e.g., Burstein and Monge-Naranjo, 2009; Ramondo and Rodríguez-Clare, 2013; Fillat and Garetto, 2015; Alviarez, 2019; Tintelnot, 2016; Cravino and Levchenko, 2016; Arkolakis et al., 2018; Alviarez et al., 2021). Our contribution is to develop a tractable framework that connects the technology view emphasized in existing studies with firms' financing decisions that give rise to FDI. With the model, we establish that financing factors are a first-order determinant for the activities of MNEs and that for a full understanding of the effects of these activities, a unified model of FDI and MP is needed.

The premise of our model builds on the findings of recent studies—that affiliate operation depends on financing from both the host financial market (Bilir et al., 2019) and the parent firm (Alfaro and Chen, 2012), and that credit crunches at home lead to sharp declines in outward FDI (e.g. Peek and Rosengren, 2000; Klein et al., 2002). Our specific mechanism linking host finance to inward FDI and MP is closely related to Antras et al. (2009), who show that the quality of host financial institutions can affect the financing of the affiliates, and hence the scale of their operation. Our contribution relative to Antras et al. (2009) is two-folds. First, we embed this mechanism into a dynamic general equilibrium model and quantify its aggregate implications. Second, we use comprehensive firm-level data to paint a complete picture of how FDI shapes the relationship between both host and home financial institutions and MP, complementing their evidence on the role of host financial institutions using the data of U.S. multinationals.

By connecting MP with FDI, this paper engages the literature on the impacts of international capital flows (e.g. Mundell, 1957; Gourinchas and Jeanne, 2006; Bai and Zhang, 2010). We differ from the bulk of this literature by focusing on a key feature of FDI—that it is a within-firm capital flow embedded with technology. Of course, we are not the first to incorporate this feature in a multi-country model. In a study of how MP shapes international risk sharing, Ramondo and Rappoport (2010) also emphasize the role of FDI in transferring technology. Fillat et al. (2018) model internal capital flows in a specific type of multinationals—global banks. We differ from these works in both the model and the research question.

Finally, our application on the effect of EU membership on FDI and wages connects with quantitative investigation of EU enlargement (e.g., Caliendo et al., 2021). While Caliendo et al. (2021) study integration in the labor and goods markets, we focus on the free movement of capital and business, which are also the cornerstone of the EU common market. The multi-country structural accounting exercise we have adopted is similar in spirit to Eaton et al. (2016) in that we first use the model to fully rationalize the data, before proceeding to counterfactual experiments. Different from their work, however, our model incorporates dynamic decisions in a setting of incomplete markets. To the best of our knowledge, this is the first paper to perform a wedge accounting exercise of an incomplete-markets model in a multi-country setting.

The rest of this paper proceeds as follows. Section 2 provides descriptive evidence on the three-way relationship between financial market conditions, MP, and FDI. Section 3 presents the model. In Sections 4 and 5, we implement the model quantitatively. Section 6 concludes.

2 Motivating Facts on MP, FDI, and Financial Market Conditions

In this section, we document the three-way relationship between MP, FDI, and the financial market conditions of host and home countries, by exploiting cross-sectional variation from bilateral data and time variation from a firm-level panel. We describe our main data and empirical findings below; additional details about the data and robustness results can be found in the Appendix.

2.1 Data and Sample Countries

Bilateral MP and FDI. We obtain the bilateral MP and FDI data from Ramondo et al. (2015). MP is defined as the total sales by the affiliates of foreign firms located in a host country, and FDI is defined as the *stock* of capital that parent firms invest in their overseas affiliates in equity or intra-company loans.[5] Both measures are averaged over 1996-2001. We supplement these two measures with additional information on countries, including their income, tax rates, an index of the restrictiveness of their policies on inward FDI, and indices on the quality of their financial institutions, all averaged over the same period. We use this dataset to examine the cross-sectional relationship between the quality of financial institutions and MP, and the role of FDI in mediating this relationship.

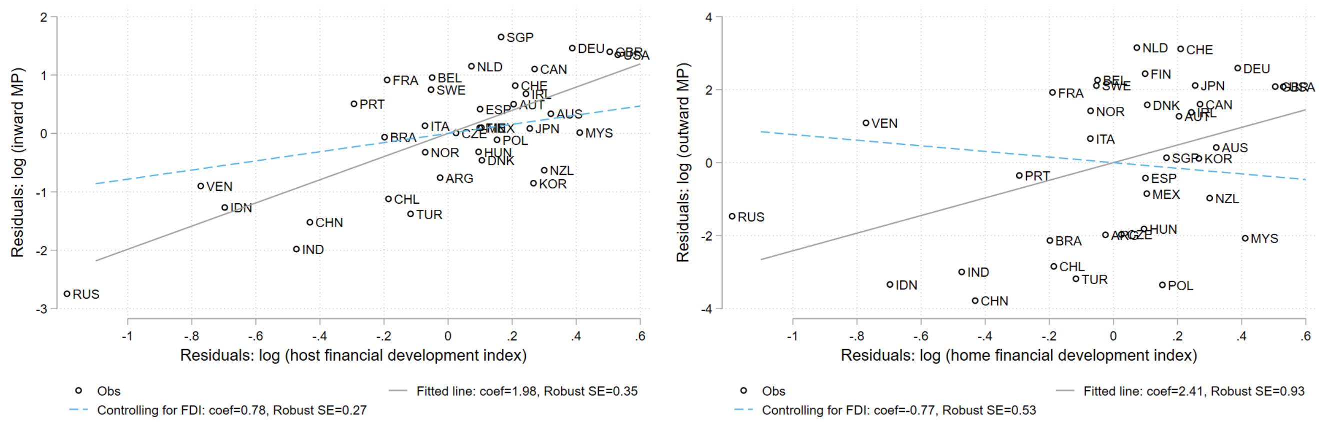
Firm-level MP. Our firm-level evidence is based on a panel dataset covering the period of 2001-2012, extracted from the Orbis database. In addition to standard accounting items such firms' total sales and assets, our data also include firms' ownership networks, which allow us to link firms to their 'global ultimate owner' (i.e., their parent firm). After the cleaning procedures detailed in Appendix A.2, we arrive at a firm-level panel of MNEs and their affiliates in different hosts.

This firm-level panel allows us to examine how the output of an affiliate (i.e., firm-level MP) responds to changes in the financial market conditions of home and host countries. To account for the role of the parent's finance, we also need to construct the measure of firm-level FDI. A shortcoming of the Orbis database, however, is that its coverage of firms' balance sheet *compositions* is not detailed enough for this purpose: in most cases, we observe only the majority owner of a firm, but not the exact number of shares it owns. We also cannot separate the loans extended to an affiliate by its parent from those by other sources. To make progress, we will construct two proxies for firm-level FDI in the spirit of the 'shift-share' instrumental variable, leveraging a newly assembled dataset on bilateral FDI stocks between 2001 and 2012.

Measures of financial market conditions. Our empirical analysis exploits cross-sectional and over-time differences in financial market conditions. Across countries, differences in contractual frictions and the protection of investors lead to variation in the difficulty of accessing external finance (La Porta et al., 1997). Following Desbordes and Wei (2017), we use the logarithm of the financial development index as a proxy for the quality of financial institutions. This index is created by the World Bank through a review of a country's laws and regulations by legal practitioners (Djankov et al., 2007). It is the sum of two separate measures, of the depth of information for the credit market and the legal rights of creditors, respectively. In some specifications, we will assess the impact of each individual component.

Over time, a country's quality of financial institutions is likely to remain stable. However, short-term factors such as monetary policies or investor sentiments could still affect firms' access to external finance. Following a macroeconomic literature on the real effect of financial market

[5] Ramondo et al. (2015) provide both raw and imputed MP data. Our empirical exercises use only the raw data.



(a) Host Financial Institution Quality

(b) Home Financial Institution Quality

Figure 1: The Relationship Between the Quality of Financial Institutions, FDI, and MP

Notes: The left panel plots the relationship between the quality of host financial institutions and inward MP, with (the dashed line) and without (circles and the solid line) controlling for inward FDI. The right panel plots the relationship between the quality of home financial institutions and outward MP, with (the dashed line) and without (circles and the solid line) controlling for outward FDI. Both the fitted line and the circles are after netting out the effect of country size.

conditions (e.g., Buera et al., 2015), we use the variation in total credit made to the domestic private sector, obtained from the World Bank, as a proxy for the time changes in this access.

Sample countries. Our empirical and quantitative exercises focus on a sample of 36 countries. This sample includes most high-income countries, which send out the majority of FDI in the world, and major developing countries. Appendix A.1 describes the sample selection.

2.2 Cross-Sectional Evidence

We start by examining the cross-sectional data. Figure 1 visualizes the data. The left panel plots the quality of *host* financial institutions against *inward* MP. The circles indicate the residuals of the two variables after the effect of host size (log GDP) is partialled out. The solid line is the fitted line, which shows a strong positive correlation between the two variables. The 1.98 slope means that a one-standard-deviation increase in the index is associated with a 73-log-point increase in inward MP. The dashed line is the best fitted line when the logarithm of inward FDI stock is further controlled for. The dashed line has a smaller slope than the solid line, consistent with better financial institutions increasing MP in part by attracting more inward FDI. However, the slope is still positive, suggesting that the higher MP in hosts with good financial institutions cannot be entirely accounted for by higher FDI toward these countries.

The right panel plots the quality of home financial institutions against outward MP. As before, the circles are the residuals of the two variables after partialling out the logarithm of home GDP, the solid line is the line that fits the circles, and the dashed line is the fitted line when the logarithm of outward FDI stock is also controlled for. These two fitted lines show that the quality of home financial institutions is strongly correlated with outward MP, but the correlation vanishes once outward FDI is accounted for.

The literature has documented a robust positive correlation between FDI/MP and the financial development of both host and home countries, treating FDI or MP as synonymous measures of MNE activities (see Di Giovanni, 2005; Desbordes and Wei, 2017 and the references therein). In addition to affirming these findings using our sample, Figure 1 also points to an important asymmetry: while MP is correlated with both host and home financial development, the correlation of MP with the latter is only through FDI. This asymmetry highlights the distinction between FDI and MP and calls for a model that jointly incorporates MNEs' financing and operation decisions.

Summary of regression results. In Appendix A.3, we report the results from regressions using the bilateral data. We show that the patterns in Figure 1 are robust to the inclusion of confounding factors such as a country's productivity, restrictions on inward FDI, proximity to other countries, and tax rate and status as a tax haven.

We also conduct three additional exercises that shed light on the mechanism in Appendix A.4. First, we separate our proxy for the quality of financial institutions into its two components and show that it is the protection of creditors' legal rights, rather than the depth of credit information, that drives both the correlation and its asymmetry. This finding is reassuring because, as MNEs tend to be well known, their ability to raise capital is unlikely to be severally hindered by the lack of credit information. On the other hand, the protection conferred to creditors by the legal system might help MNEs as well as local firms secure finances from external investors. Second, we show that the same patterns hold when wage bill is used to measure affiliate production, using the U.S. Bureau of Economic Analysis (BEA) public-use data covering American MNEs operating abroad and foreign firms operating in the U.S. This alleviates the concern that our finding is contaminated by the mis-reporting of sales due to e.g., the tax avoidance motive. Third, we use the BEA data to show that the asymmetric correlation between MP and financial market conditions operates through affiliates' balance sheet size and composition of external finance, as it would be if it is indeed the financial factors that are at play.

2.3 Firm-Level Evidence

The results based on the bilateral data demonstrate both a strong connection of the quality of financial institutions and the activities of MNEs, and the central role of FDI in mediating this connection. To strength the identification, we now turn to the firm-level panel. The time dimension of the data allows us to purge unobserved time-invariant country characteristics. The granularity of the data means that we can control for shocks and firm characteristics that are common to all affiliates within a firm through firm-year fixed effects.

Specification. We estimate several variants of the following specification:

$$y_{it} = \text{FE}_i + \beta_1 \text{credit}_{o(i)t} + \beta_2 \text{credit}_{d(i)t} + \beta_3 \log \widehat{\text{FDI}}_{i,t} + \gamma_1 X_{1,o(i)t} + \gamma_2 X_{2,d(i)t} + \gamma_3 X_{3,f(i)t} + \epsilon_{it}. \quad (1)$$

The dependent variable y_{it} is the logarithm of the sales of affiliate i in year t. The primary variables of interest are $\text{credit}_{o(i)t}$ and $\text{credit}_{d(i)t}$, which capture the overall credit market conditions in year

t in the origin country $o(i)$ and the host country $d(i)$ of affiliate i. In the absence of direct measures of the overall credit availability, we use the logarithm of total credit extended to private enterprises as a proxy. Although this proxy is widely used, a natural concern is that the total private credit is an equilibrium outcome that captures not only firms' access to, but also their demand for, external finance. The latter would be a confounding factor if it responds to shocks that are correlated with credit market conditions. For example, country-wide productivity shocks can influence the demand for credit by all firms; specific to our focus, the willingness of a foreign affiliate to borrow may be affected by fluctuations in the exchange rate or other conditions of their home country. We will purge these demand-side factors through firm- and country-level controls.

Our third variable of interest is $\log \widehat{\text{FDI}}_{i,t}$, a proxy for the stock of direct investment in affiliate i from its parent. As discussed earlier, the balance sheet information from Orbis is not detailed enough for measuring the amount of parent finance in an affiliate. We construct two proxies in the spirit of the 'shift-share' design. To this end, in a process detailed in Appendix C.1, we assemble annual bilateral FDI stock between the sample countries over 2001-2012 from the publications of the United Nations Conference on Trade and Development (UNCTAD). Denote $\text{FDI}_{o(i)d(i),t}$ the bilateral FDI stock from country $o(i)$ to country $d(i)$ at period t. Our first proxy for direct investment in an affiliate i is constructed as:

$$\log \widehat{\text{FDI}}_{i,t} = \log \left(\frac{K_{i,t-1}}{\sum_{j \in \{o(j)=o(i),\, d(j)=d(i)\}} K_{j,t-1}} \cdot \text{FDI}_{o(i)d(i),t} \right).$$

In this measure, $K_{i,t-1}$ is the total assets of affiliate i at $t-1$, and $\sum_{j \in \{o(j)=o(i),\, d(j)=d(i)\}} K_{j,t-1}$ is the total assets of *all* affiliates from home country $o(i)$ to host country $d(i)$. This formula essentially proportionally distributes the aggregate FDI from $o(i)$ to $d(i)$ to an affiliate in $d(i)$ according to its asset size.[6] In the Appendix, we also report results based on an alternative proxy of $\log \widehat{\text{FDI}}_{i,t}$, constructed as a nonparametric function of $\log(K_{i,t-1})$ and $\log(\text{FDI}_{o(i)d(i),t})$.

FE_i in equation (1) denotes affiliate fixed effects. By including FE_i in all specifications, we account for any invariant characteristics of the parent firm and the affiliate—and hence also those of origin and destination countries. To the extent that some time-varying characteristics might be correlated with shocks that affect both the credit market and affiliate production, we directly control for them in $X_{1,o(i)t}$, $X_{2,d(i)t}$, and $X_{3,f(i)t}$, which represent origin country, destination country, and firm-level controls, respectively.

Results. Columns 1 through 4 of Table 1 report the relationship between home country credit shocks and affiliate sales. The first column reports their correlation after controlling for affiliate fixed effects and host-year fixed effects. We find the elasticity of affiliates sales in home country credit volume to be 0.08, an economically meaningful estimate.

As discussed earlier, changes in home credit market conditions may be correlated with other home shocks that affect affiliates' demand for external finance. Likely candidates for these shocks

[6] All results are similar if we use the contemporary size instead of the lagged size.

Table 1: Financial Shocks and Affiliate Sales: Firm-Level Evidence

	Home Credit and Affiliate Sales				Host Credit and Affiliate Sales		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
dependent var:	log (affiliate sales)						
$\text{credit}_{o(i)t}$	0.081***	0.086***	0.102***	0.023			
	(0.023)	(0.023)	(0.024)	(0.031)			
log (parent $\text{sales}_{f(i),t}$)			0.028***	0.026***			
			(0.003)	(0.003)			
$\log \widehat{\text{FDI}}_{i,t}$				0.188***			0.179***
				(0.008)			(0.007)
$\text{credit}_{d(i)t}$					0.460***	0.299***	0.218***
					(0.063)	(0.066)	(0.057)
Observations	715183	715183	413068	393579	399430	399430	378750
R^2	0.902	0.902	0.891	0.899	0.908	0.908	0.917
Affiliate FE	yes	yes	yes	yes	yes	yes	yes
Host-year FE	yes	yes	yes	yes	-	-	-
Home economic shocks	-	yes	yes	yes	-	-	-
Firm-year FE	-	-	-	-	yes	yes	yes
Host economic shocks	-	-	-	-	-	yes	yes

Columns (1) to (4) estimate the impacts of home country credit shocks on affiliate sales. Columns (5) to (7) estimate the impacts of host country credit shocks on affiliate sales. Host and home economic shocks in the control include TFP and terms of trade from the Penn World Table. Standard errors (in parenthesis) are clustered two-way, by host-year and home-year. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

include shocks to home TFP and terms of trade. Column 2 controls for these two shocks and shows that the estimate does not change materially. In Column 3, we further include the sales of the parent firm in the regression. This control serves two purposes. First, to the extent that there are still other home shocks that can affect affiliate performance, these shocks likely affect the parent firm as well. Parent sales thus serves as a proxy for these shocks. Second, this control also captures the direct impact of parent's own productivity shock on affiliate sales (e.g., Cravino and Levchenko, 2016). The coefficient of home credit shock, if any, increases slightly with this control.

In Column 4, we include the proxy for firm-level FDI. The proxy has a positive and statistically significant coefficient, and the coefficient of home credit shocks shrinks to zero, in accord with the aggregate evidence documented in Figure 1b, suggesting that the positive impact of home credit on affiliate sales is likely mediated via parent's investment.

Columns 5 through 7 of Table 1 report the relationship between *host* country credit shocks and affiliate sales. Since the variation is at the host level, in addition to affiliate fixed effects, we are able to control for firm-year fixed effects, absorbing all shocks that affect all affiliates of a firm. Column 5 shows that even with these controls, host credit shock is strongly correlated with affiliate sales. Column 6 controls for host TFP and terms of trade. These controls do not change our finding qualitatively. Finally, Column 7 includes the proxy for direct investment to affiliate i in period t. The coefficient of host credit shocks is diminished but remains sizable, echoing the findings in Figure 1a.

Robustness. In Appendix A.5, we report several robustness exercises. First, we show that the results are similar when we use flexible functions of lagged firm capital stock and bilateral

FDI as a non-parametric proxy for direct investment. Second, we add interaction terms between credit market conditions and a post-crisis dummy variable, which takes a value of one for years after 2007. We find coefficients of these interaction terms to be small, indicating that the patterns documented above are not specifically driven by the impact of the financial crisis. Third, we show that the results are robust when wage bill is used to measure affiliate production.

Summary. Taking stock, we have shown that although both host and home credit market conditions are positively correlated with MP, once FDI is controlled for, only host country financial market condition is correlated with MP. Such a three-way relationship holds in the time changes within individual firms as well as in the cross section of countries. In the rest of this paper, we develop a quantitative model to interpret these patterns and to conduct counterfactual experiments.

3 Model

In this section, we describe the model and the theoretical results. Proofs, extensions, and microfoundations of the model are delegated to Appendix B.

3.1 Endowments, Preferences, and Technology

Time t is discrete and goes from 0 to infinity. There are N countries, indexed by i. All fundamentals can be time-varying and so are equilibrium variables; to simplify the notation, time subscripts of variables are omitted when there is no prospect of confusion. Each country is endowed with an exogenous number of workers, denoted by L_i. Workers are immobile, each supplying one unit of labor inelastically and consuming all their labor income.

Each country has a continuum of firms. Following a growing literature of firm dynamics in imperfect financial markets (Buera et al., 2011; Midrigan and Xu, 2014; Moll, 2014), we assume that firms are owned by entrepreneurs with the following preference:

$$\mathbb{E}\sum_{t=0}^{\infty}\beta^t u(c_t), \tag{2}$$

where c_t is the entrepreneurs' private consumption at period t. Entrepreneurs make operational decisions to maximize their personal utility. Of course, most MNEs are large corporations owned by shareholders instead of individual entrepreneurs. In this case, we can either think of the entrepreneur as the CEO of a company and interpret c_t as the compensation of the CEO,[7] or think of c_t as dividend payouts and the curvature in $u(c_t)$ as capturing the dividend smoothing motive.

Firms differ in their idiosyncratic productivity $z \in \mathcal{Z} \subseteq (0, \infty)$, which follows Markov pro-

[7] CEOs of large corporations are usually incentivized through stock options and bonuses. For example, Google CEO Sundar Pichai made \$100.5 million in 2015, 99% of which was in the form of restricted stock. Given this, how much a CEO is being paid depends heavily on shareholders' wealth gains. If the CEO's compensation is proportional to total dividends to shareholders, then the incentives of the CEO would be largely aligned with those of shareholders, in which case we can think of $u(c_t)$ as utility of the shareholders. In particular, when u takes the log form, CEOs being paid a fixed fraction of total dividends will act in the same way as if they were maximizing shareholders' utility.

cesses with country-specific transition probability density functions $f_i(z'|z)$. Firms can operate affiliates in different countries—including their home country—to produce a homogeneous good.[8] An *affiliate* in host h of a firm from country i uses l units of labor and k units of capital to produce y units of output:

$$y = (z_{ih}k)^{\alpha} l^{1-\alpha},\ \alpha \in (0,1).$$

z_{ih} is the productivity of the affiliate. An affiliate's productivity increases with the productivity of its parent but also depends on the country in which it operates. We assume $\forall h \neq i, z_{ih} = \tilde{z}_{ih}(z)$, with $\tilde{z}_{ih}(\cdot)$ being an increasing function. As normalization, $\tilde{z}_{ii}(z) = z$, so the productivity of an affiliate in the home country is also the productivity of its parent.

3.2 Affiliate Finance and Production

Affiliates hire workers in competitive host labor markets and finance their production with funds from the internal capital market of their parent and external investors at the host. When the cost of host finance is lower than the shadow value of internal capital, firms have the incentive to use more host finance, via either local debt or equity. Regardless of the instruments used, however, imperfections in the capital market might limit the degree to which firms can rely on host finance.

Given our focus on aggregate FDI and MP, we wish to capture this force in a simple environment. We specify that to raise each unit of capital in the host country, an exogenous minimum level of parent investment must be made. Letting e_h be the investment made by a parent company in its affiliate in host country h and b_h^F be the amount of external funding raised in host h, formally, the assumption states that $b_h^F \leq \mu_h \cdot e_h$, with $\mu_h > 0$ determining the maximum leverage that the affiliate can obtain in the host country.

Denote the wage and net interest rate in host h by w_h and r_h^b, respectively. For given e_h, affiliate financing and production decisions solve Problem (3) to maximize the return $\tilde{R}_{ih}(z, e_h)$:

$$\begin{aligned} \tilde{R}_{ih}(z, e_h) = \max_{b_h^F, k, l, y}\ & y + (1-\delta)k - w_h l - (1 + r_h^b) b_h^F, \qquad (3) \\ s.t. \quad & y = [\tilde{z}_{ih}(z)k]^{\alpha} l^{1-\alpha} \\ & 0 \leq b_h^F \leq \mu_h e_h \\ & 0 \leq k \leq e_h + b_h^F. \end{aligned}$$

Micro-foundations. Although parsimonious, inequality $b_h^F \leq \mu_h \cdot e_h$ in (3) encompasses three views on why the access of an affiliate to external finance can be constrained by e_h, the investment it receives from the parent. The first view, also our preferred view, is to see the constraint as from

[8] Since output is homogeneous, there is no scope for trade in our model. Appendix B.5 shows that our setup is isomorphic to an environment with CES preference and monopolistic competition, if capital stock is introduced as the fixed cost for the production of horizontally differentiated varieties and if this fixed cost increases with host total production. In that model, it is possible to explore the interaction between trade and FDI policies. Since this interaction is not the focus of the present paper, we stay with the homogeneous good setting throughout.

the moral hazard problem in the transfer of production technology from the parent to the affiliate. We provide a micro-foundation to this setup in Appendix B.4.1. In the micro-foundation, as the owner of production technology, the parent firm needs to exert non-contractible efforts to ensure the success of affiliate operations. For such efforts to be incentive compatible, the parent needs to have sufficient stake in the affiliates, i.e., $\frac{e_h}{e_h+b_h^F}$ cannot be too low. Thus, the exact reason MNEs arise in the first place—contracting frictions associated with the transfer of technologies across firms—also means affiliates scale is constrained by parent investment.[9]

The second view of the setup recognizes that FDI often takes the form of the acquisition of a local firm by a foreign firm, which results in a joint venture receiving technology and capital inputs from both partners. In Appendix B.4.3, we develop a model of merger and acquisition that highlights a key tradeoff the foreign firm faces between its control over and the size of the joint venture. Intuitively, given e_h, an increase in the stake of the local partner b_h^F dilutes the control of the foreign parent, so the productivity of the joint venture is lower than when the foreign parent has full control. We show that, in a special case of the M&A model, this tradeoff leads to a constraint on the stake of the local partner in the form of $b_h^F \leq \mu_h \cdot e_h$.

Lastly, this setup can also be viewed as the conventional collateral constraint in the macro literature. Under this view, b_h^F is the total debt of the affiliate, and it is constrained by the assets that the parent brings to the host country due to a limited enforcement problem in debt repayment.

Despite having different micro-foundations, all three views imply that the frictions to external finance will be less severe in hosts with better financial contracting institutions, and that within a host, the tightness of the credit market can lead to time changes in firms' access to external finance. When there is no confusion, we will refer to b_h^F as the debt from the host, but we interpret it more broadly as capturing the total financial stake of local investors—be they debt or equity investors—and will pin down μ_h using data that cover both debt and equity financing.

International frictions. Cross-border investment is characterized by significant frictions, such as the barriers to the transfer of knowledge (Keller and Yeaple, 2013), and the risk of either extortion by corrupt foreign officials (Wei, 2000) or expropriation by foreign governments (Thomas and Worrall, 1994). To capture these frictions, we assume that the parent receives only a fraction of the return, denoted by $\eta_{ih} \cdot \tilde{R}_{ih}(z, e_h)$, with the remaining 'melt' in the repatriation process like in the iceberg trade cost specification.[10] We further assume $\eta_{ih} = \bar{\eta}_{ih} \cdot \zeta_h$, where $\bar{\eta}_{ih}$ is the deterministic component common to all firms from i operating in h, and ζ_h is the idiosyncratic component that is drawn i.i.d. across parents and affiliates, capturing the 'fit' between hosts and a firm's technology. The literature has documented an MNE productivity premium and rationalized it with a fixed cost of setting up affiliates so that the average return from opening foreign affiliates increases in pro-

[9] This view of the constraint is closely related to that of Antras et al. (2009). They show that because of the foreign parent's moral hazard in monitoring local managers, who might steal profits from the firm in the presence of capital market imperfections, firms' FDI and MP can vary with host financial market conditions.

[10] We specify η_{ih} as a return wedge rather than a productivity wedge because when calibrated to match the observed level of MP, the latter specification implies that foreign affiliates are less productive than the average local firm, which is inconsistent with the data. Although productivity and return wedges are isomorphic in many models of MP, this is not the case in our model because affiliates' operation decisions are not a homogeneous function of productivity.

ductivity (Helpman et al., 2004). In quantification, we incorporate this channel by allowing $\bar{\eta}_{ih,\ i \neq h}$ to be an increasing function of z, which we discipline using firm-level data, but we suppress z as an argument for now.

3.3 Parent Firm Finance and Investment

Each period, after learning the current productivity z and the realization of the return shocks from all potential hosts, $\boldsymbol{\eta} = (\eta_{i1}, \eta_{i2}, ..., \eta_{iN})$, firms decide whether to be idle or active. Idle firms loan out their net worth a in the bond market. Active firms choose whether to scale up on their net worth through borrowing and in which host (including the country they are from) to invest.

Denote r_i^b the interest rate for lending and borrowing in country i. For active firms, the amount they can borrow, b^H, is subject to the following constraint

$$b^H \leq \lambda_i a,$$

which says that the external funds raised cannot exceed λ_i fraction of the parent firm's net worth. As elaborated in the micro-foundation in Appendix B.4.2, this constraint arises in an environment of endogenous bond pricing in the presence of limited enforcement in repayment, and can be alleviated by improvements in both the financial contracting environment and the credit market condition. The total funds of the parent, $a + b^H$, will then be allocated to affiliates to maximize the per-period return, after which consumption and saving decisions are made.

Denote $v_i(z, \boldsymbol{\eta}, a)$ the expected discounted utility of firm owners from country i with characteristics $(z, \boldsymbol{\eta}, a)$. The Bellman equation for $v_i(z, \boldsymbol{\eta}, a)$ reads:[11]

$$\begin{aligned} v_i(z, \boldsymbol{\eta}, a) = & \max_{c, a', \{e_h\}_{h=1}^N, b^H} u(c) + \beta_i \mathbb{E}\left[v_i(z', \boldsymbol{\eta}', a') \middle| z\right] \\ s.t. \quad & \sum_h e_h = a + b^H \\ & -a \leq b^H \leq \lambda_i \cdot a \\ & c + a' = \sum_h \tilde{R}_{ih}(z, e_h)\eta_{ih} - (1 + r_i^b) b^H. \end{aligned} \tag{4}$$

The first constraint says that the funds allocated to affiliates should sum to net worth plus external funds raised in the home country. The second constraint says that, (1) an idle parent firm can loan out all but not more than its net worth; and (2) funds raised by an active parent firm cannot exceed what the constraint allows. $\tilde{R}_{ih}(z, e_h)\eta_{ih}$ in the third constraint, with $\tilde{R}_{ih}(z, e_h)$ defined in (3), denotes the returns from investing in host country h, net of wages, payments to *host* country investors, and the component that is melt during repatriation. The third constraint says that total repatriated investment returns from affiliates are split among financing costs, the payout for

[11] We describe here the Bellman equation associated with the stationary equilibrium and omit the time subscript. Our main quantitative exercise focuses on transitional paths and allows for time-varying equilibrium variables. The related sequential competitive equilibrium with explicit time dependence is defined in Appendix B.1.

current consumption, and future net worth a'.

Problem (4) describes the joint decision of capital accumulation and investment allocation among hosts. The incomplete-market setting, while natural, means that one needs to solve the problems of firms in each country at all possible states $(z, \boldsymbol{\eta}, a)$ and then aggregate the decisions, which is in general challenging. Below, we first characterize affiliate- and firm-level decisions analytically, and then establish aggregation results with the aid of two additional assumptions.

3.4 Characterizing Affiliate- and Firm-level Decisions

We start by solving for the return and policy functions at the affiliate level, specified in Problem (3). Lemma 1 summarizes the solution.

Lemma 1. *The return function from affiliate operation, defined in (3), satisfies* $\tilde{R}_{ih}(z, e_h) = R_{ih}(z)e_h$, *with*

$$R_{ih}(z) = \max_{\hat{b}_h^F, \hat{k}, \hat{l}, \hat{y}} \hat{y} + (1-\delta)\hat{k} - w_h \hat{l} - (1 + r_h^b)\hat{b}_h^F, \tag{5}$$

$$\begin{aligned} s.t. \quad & \hat{y} = [\tilde{z}_{ih}(z)\hat{k}]^{\alpha}\hat{l}^{1-\alpha} \\ & 0 \leq \hat{b}_h^F \leq \mu_h \\ & 0 \leq \hat{k} \leq 1 + \hat{b}_h^F. \end{aligned}$$

Correspondingly, the solution to (3) satisfies $X_{ih}(z, e_h) = \hat{X}_{ih}(z)e_h$, *for* $X \in \{b^F, k, l, y\}$, *where* $\hat{X}_{ih}(z)$ *is the solution to (5) and given below:*

$$\begin{aligned} \hat{b}_{ih}^F(z) &= \begin{cases} \mu_h, & \forall \tilde{z}_{ih}(z) \geq z_{ih}^* \\ 0, & \forall \tilde{z}_{ih}(z) < z_{ih}^* \end{cases} \\ \hat{k}_{ih}(z) &= [1 + \hat{b}_{ih}^F(z)] \\ \hat{l}_{ih}(z) &= \tilde{z}_{ih}(z)\hat{k}_{ih}(z)\left(\frac{1-\alpha}{w_h}\right)^{1/\alpha} \\ \hat{y}_{ih}(z) &= \tilde{z}_{ih}(z)\hat{k}_{ih}(z)\left(\frac{1-\alpha}{w_h}\right)^{(1-\alpha)/\alpha}. \end{aligned}$$

The cutoff value z_{ih}^* *in* $\hat{b}_{ih}^F(z)$ *is determined implicitly by* $\pi_h(z_{ih}^*) = 1 + r_h^b$, *with* $\pi_h(z_{ih})$ *defined as:*

$$\pi_h(z_{ih}) = \alpha z_{ih}\left(\frac{1-\alpha}{w_h}\right)^{(1-\alpha)/\alpha} + 1 - \delta.$$

At the solution, $R_{ih}(z) = \pi_h\big(\tilde{z}_{ih}(z)\big)[1 + \hat{b}_{ih}^F(z)] - (1 + r_h^b)\hat{b}_{ih}^F(z)$.

This lemma exploits the fact that both the objective function and the constraints in Problem (3) are homogeneous of degree one in e_h. The first part of the lemma states that the solution to (3) is linear in e_h, so the total returns at the *affiliate* level are simply the unit return to investment multiplied by the size of investment, with the unit return given by the solution to Problem (5).

The second part of the lemma shows that, first, affiliate decisions are linear in e_h. Second, affiliate decisions follow a cutoff rule in productivity: affiliates with productivity above the threshold z_{ih}^* will leverage external funding from local investors and produce at full capacity; affiliates with productivity below the threshold will choose not to use any funding from the host country. The cutoff is given by the equality condition between the cost of external financing, $1 + r_h^b$, and the return from an additional unit of capital, $\pi_h(z_{ih})$. A selection channel akin to that in the Melitz model operates here: as wage or interest rate in the host country goes up, the cutoff increases, so fewer affiliates will seek finance from host investors for expansion.

Lemma 1 gives an explicit expression for $\tilde{R}_{ih}(z, e_h)$, the investment returns, which are used in defining the parent firm's problem in (4). To characterize the firm's dynamic decisions, we make the following assumption on the utility function:

Assumption 1. *$u(c) = \log(c)$.*

Under Assumption 1, we characterize the solution to Problem (4) in Lemma 2.

Lemma 2. *The policy function for borrowing and lending satisfies*

$$b_i^H(z, \boldsymbol{\eta}, a) = \begin{cases} \lambda_i \cdot a, & \text{if } \max_{h'} R_{ih'}(z)\eta_{ih'} \geq 1 + r_i^b \\ -1 \cdot a, & \text{if } \max_{h'} R_{ih'}(z)\eta_{ih'} < 1 + r_i^b, \end{cases} \tag{6}$$

with $R_{ih}(z)$ characterized in Lemma 1. The policy functions for consumption and investment satisfy

$$\begin{aligned} c_i(z, \boldsymbol{\eta}, a) &= (1 - \beta_i) R_i^a(z, \boldsymbol{\eta}) \cdot a \\ a_i'(z, \boldsymbol{\eta}, a) &= \beta_i R_i^a(z, \boldsymbol{\eta}) \cdot a, \end{aligned}$$

$$\text{where} \qquad R_i^a(z, \boldsymbol{\eta}) = \begin{cases} [\max_{h'} R_{ih'}(z)\eta_{ih'}](1 + \lambda_i) - (1 + r_i^b)\lambda_i, & \text{if } \max_{h'} R_{ih'}(z)\eta_{ih'} \geq 1 + r_i^b \\ (1 + r_i^b), & \text{if } \max_{h'} R_{ih'}(z)\eta_{ih'} < 1 + r_i^b, \end{cases} \tag{7}$$

The first part of the lemma characterizes the lending/borrowing decision. If $\max_{h'} R_{ih'}(z)\eta_{ih'} \geq 1 + r_i^b$, i.e., the shadow return on capital is greater than the interest rate in the home bond market, the firm borrows to scale up; otherwise, it stays idle and lends out its net worth. The shadow return, which equals the return from the most productive affiliate, could be large due to either productivity (z) or luck ($\boldsymbol{\eta}$). Because the unit shadow return is scale-independent (see Lemma 1), when a firm chooses to scale up, it will max out the available credit $\lambda_i \cdot a$.

$R_i^a(z, \boldsymbol{\eta})$ in the second part of the lemma denotes the return to net worth a, which depends on whether a firm is active and whether it levers up over a. Thus, according to the policy functions characterized in the lemma, firms reinvest a fixed fraction β of their end-of-period total returns $R_i^a(z, \boldsymbol{\eta}) \cdot a$ and use the remainder for consumption.

3.5 Aggregation

Lemmas 1 and 2 express firms' decisions as functions of their states $(z, \boldsymbol{\eta}, a)$ after the uncertainty about idiosyncratic draws $(\zeta_h)_{h=1}^N$ has resolved (recall $\eta_{ih} = \bar{\eta}_{ih} \cdot \zeta_h$). Deriving aggregate FDI between each country pair requires integrating across firms with all possible realizations of $(\zeta_h)_{h=1}^N$. For tractable aggregation, we make the following assumption:

Assumption 2. *The cumulative distribution function (CDF) for $(\zeta_h)_{h=1}^N$ is given by:*

$$G(\zeta_1, ..., \zeta_N) = 1 - \sum_h \frac{1}{N} [\zeta_h^{-\theta}], \textit{ for } \zeta_h \geq 1, \forall h.$$

This distribution is the special case (when $\rho = 0$) of the multivariate distribution in Arkolakis et al. (2018).[12] An attractive feature of this distribution is that $\max_h (\zeta_h)_{h=1}^N$ has a Pareto-shaped tail. This feature ensures tractability even as firms in our model make extensive-margin entry decisions based on the realization of $(\zeta_h)_h$.[13]

To see this, define the wedge-adjusted investment return for firm $(z, a, \boldsymbol{\eta})$ from i as

$$\Xi_i(z, (\zeta_h)_h) \equiv \max_{h'} \eta_{ih'} R_{ih'}(z) = \max_{h'} \bar{\eta}_{ih'} \zeta_{h'} R_{ih'}(z).$$

The CDF for $\Xi_i(z, (\zeta_h)_h)$ conditional on (i, z), denoted $H_i(x|z)$, is then given by:

$$H_i(x|z) \equiv Pr\Big(\Xi_i(z, (\zeta_h)_h) \leq x \Big| i, z\Big) = \begin{cases} 1 - \left(\frac{x}{\tilde{R}_i(z)}\right)^{-\theta}, \text{ for } x \geq \overline{R}_i(z) \\ 0, \text{ for } x < \overline{R}_i(z), \end{cases}$$

$$\text{where } \overline{R}_i(z) \equiv \max_{h'} \bar{\eta}_{ih'} R_{ih'}(z), \text{ and } \tilde{R}_i(z) \equiv \left(\frac{1}{N} \sum_{h'} [\bar{\eta}_{ih'} R_{ih'}(z)]^{\theta}\right)^{\frac{1}{\theta}}.$$

Because all ζ_h draws are no smaller than 1, the support of $\Xi_i(z, (\zeta_h)_h)$ is $[\overline{R}_i(z), \infty)$, with $\overline{R}_i(z)$ being the worst-case (i.e., all ζ_h draws equal to one) return for a firm from i with productivity z. Above $\overline{R}_i(z)$, the distribution of $\Xi_i(z, (\zeta_h)_h)$ agrees with a Pareto distribution with a scale parameter of $\tilde{R}_i(z)$, the CES aggregated value of host-specific returns.[14] At $\overline{R}_i(z)$ is a mass point with measure $1 - \left(\frac{\tilde{R}_i(z)}{\overline{R}_i(z)}\right)^{-\theta}$. This measure is zero if and only if $\bar{\eta}_{ih'} R_{ih'}(z) = \bar{\eta}_{ih} R_{ih}(z), \forall (h, h')$.

With $H_i(x|z)$, we can aggregate the investment decisions and the average return to net worth by firms' productivity, under two separate scenarios. The first is for firms whose productivity z

[12] In their general specification, parameter $\rho \in (0, 1)$ governs correlation among $(\zeta_h)_{h=1}^N$, with $\rho \to 0$ corresponding to the lowest correlation. Because our model incorporates the correlation in productivity among affiliates of the same parent through $\tilde{z}_{ih}(z)$, we think of ζ_h as capturing solely the residual idiosyncratic 'match quality' between the parent's technology and a host country, thereby setting $\rho = 0$.

[13] A commonly used alternative in international trade for aggregation is to assume that $(\zeta_h)_{h=1}^N$ are drawn from the Frechet distribution (see Eaton and Kortum, 2002). The Frechet assumption loses tractability in our setting unless the idiosyncratic draws also apply to the return from being inactive, which is at odds with the interpretation of $(\zeta_h)_{h=1}^N$ as the fit of technology between the firm and host countries and the bond return being risk-free.

[14] $\text{Prob}(\Xi_i(z, (\zeta_h)_h) \leq x | i, z) = \text{Prob}(\zeta_1 \leq \frac{x}{\bar{\eta}_{i1} R_{i1}(z)}, \zeta_2 \leq \frac{x}{\bar{\eta}_{i2} R_{i2}(z)}, ..., \zeta_N \leq \frac{x}{\bar{\eta}_{iN} R_{iN}(z)})$. When $x \geq \overline{R}_i(z) \equiv \max_{h'} \bar{\eta}_{ih'} R_{ih'}(z)$, we have $\frac{x}{\bar{\eta}_{ih'} R_{ih'}(z)} \geq 1$, which is in the support of G. Applying the definition of G gives the result.

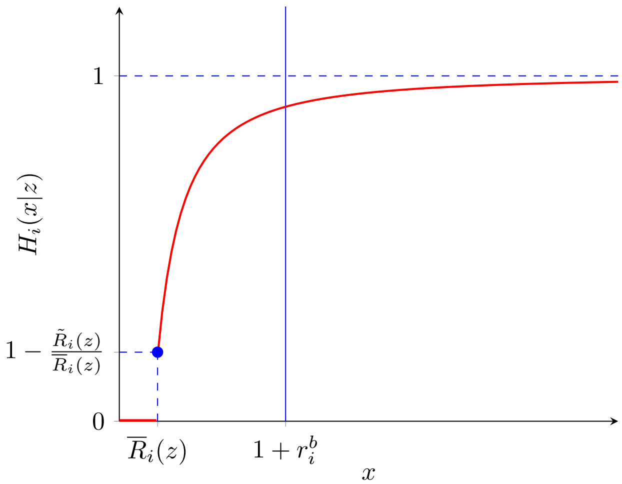


Figure 2: The conditional CDF for $\Xi_i(z,(\zeta_h)_h)$

is such that $\overline{R}_i(z) < 1 + r_i^b$. This is the case illustrated in Figure 2. Firms will be active if the realization of $\Xi_i(z,(\zeta_h)_h)$ falls to the right of the vertical line. The Pareto tail allows us to derive the probability of being active and of choosing each destination, and the associated expected returns. The second is for when $\overline{R}_i(z) \geq 1 + r_i^b$, in which case firms will always be active and we need to account for the firms at the mass point.[15] We summarize the characterizations in Lemma 3.

Lemma 3. *Among the set of firms from home country i with productivity z,*

(i) *if $\overline{R}_i(z) < 1 + r_i^b$, the share of these firms being active is*

$$[\tilde{R}_i(z)/(1+r_i^b)]^\theta.$$

The share of firms investing in host h, denoted by $\hat{e}_{ih}(z)$, is

$$\hat{e}_{ih}(z) = [\tilde{R}_i(z)/(1+r_i^b)]^\theta \cdot \frac{1}{N}\left(\frac{\bar{\eta}_{ih}R_{ih}(z)}{\tilde{R}_i(z)}\right)^\theta.$$

The expected return to net worth among these firms is

$$\begin{aligned}\mathbb{E}[R_i^a(z,\boldsymbol{\eta})|z] = &\left(1-[\tilde{R}_i(z)/(1+r_i^b)]^\theta\right)(1+r_i^b)\\ &+[\tilde{R}_i(z)/(1+r_i^b)]^\theta\left(\frac{\theta}{\theta-1}(1+r_i^b)(1+\lambda_i)-(1+r_i^b)\lambda_i\right).\end{aligned}$$

(ii) *If $\overline{R}_i(z) \geq 1 + r_i^b$, the share of active firms among them is one. Expressions for $\hat{e}_{ih}(z)$ and $\mathbb{E}[R_i^a(z,\boldsymbol{\eta})|z]$ can be derived analogously (see Appendix B.2.3).*

[15] In existing studies with Assumption 2 (see Arkolakis et al. (2018) and the reference thereto), researchers assume the model parameters are such that only the first scenario arises. This assumption is not suitable here because the variables governing firms' choice of whether to be active are equilibrium outcomes in our model. Our analytical characterization of the decisions under the second scenario enables the machineries to handle settings where the extensive-margin decisions are governed by endogenous outcomes.

Because $\boldsymbol{\zeta}$ are i.i.d over time, Lemma 3 reduces the aggregate state of a country from a distribution over $(z, \boldsymbol{\eta}, a)$ to a distribution over firms' beginning-of-period states (z, a). Since firms' decisions are linear in net worth, we can further reduce the aggregate state into a distribution of net worth over z, which enables us to take the dynamics of the model to multi-country data.[16] Let $\Phi_i(z, a)$ be the joint probability density of firms' productivity and net worth in country i, and define

$$\phi_i(z) \equiv \int_0^\infty a \cdot \Phi_i(z, a) da. \tag{8}$$

$\phi_i(z)$ is essentially the (density of) total net worth held by firms with productivity z, which will be hereafter referred to as the *wealth density function*. The transition from current $\phi_i(z)$ to future $\phi_i'(z)$ is governed by the exogenous productivity process and firms' investment and saving decisions. As shown in Appendix B.2.4, it satisfies the following equation:

$$\phi_i'(z') = \int_0^\infty \phi_i(z) \beta \mathbb{E}[R_i^a(z, \boldsymbol{\eta})|z] f_i(z'|z) dz, \tag{9}$$

where $\mathbb{E}[R_i^a(z, \boldsymbol{\eta})|z]$, characterized in Lemma 3, is the expected return to net worth for parents with productivity z. For convenience, we also define the aggregate net worth across all parent firms in a country, W_i, and the *wealth share* density function, $\hat{\phi}_i(z)$, as

$$W_i \equiv \int_0^\infty \phi_i(z) dz, \quad \hat{\phi}_i(z) \equiv \frac{\phi_i(z)}{W_i}.$$

The (density of) total investment made by firms with productivity z from home i to host h is then:

$$\psi_{ih}(z) \equiv (1 + \lambda_i) \hat{e}_{ih}(z) \phi_i(z).$$

This total investment takes into account the fact that active parent firms can borrow in the home country for investment, as characterized in Lemma 2.

In the model, FDI emerges as the investment from the parent firms to the affiliates. With the policy functions derived in Lemma 1 and Lemma 2, the aggregate FDI stock from i to h is

$$[\text{FDI}]_{ih} = \int_0^\infty \psi_{ih}(z) dz.$$

Similarly, the total production by multinational firms (MP) from i in host h is

$$Y_{ih} = \int_0^\infty \hat{y}_{ih}(z) \psi_{ih}(z) dz.$$

[16]The log utility function (Assumption 1) is *not* crucial for this result. We show in Appendix B.6.2 that the reduction—hence the tractability of our model—generalizes to the utility function with constant relative risk aversion, although in that case the firm-level investment decisions and expected return to net worth do not admit closed-form solutions.

The total capital *used* in production in a host h, aggregated across domestic and foreign firms, is

$$K_h = \sum_i K_{ih}, \quad K_{ih} = \int_0^\infty \hat{k}_{ih}(z)\psi_{ih}(z)dz.$$

The total output in a host h is $Y_h = \sum_i Y_{ih}$.

3.6 Definition of Equilibrium

Given the initial densities of parent firms in each country, $(\Phi_{i,t=0}(z,a))_{i\in I}$, a sequential competitive equilibrium is a sequence of (a) wages and interest rates in each country, (b) parent firm value and policy functions, affiliate return and policy functions, and (c) densities of parent firms, such that at every period (i) value, return and policy functions solve the firm's problem; (ii) goods and labor markets clear by country, and bond markets clear;[17] (iii) the densities of firms are consistent with the transition implied by firms' policy functions and the exogenous productivity processes. A stationary equilibrium is a sequential competitive equilibrium with time-invariant equilibrium objects. See Appendix B.1 for a formal definition.

3.7 FDI, MP, and the Quality of Financial Institutions

We now discuss how financing factors shape the activities of multinational firms. In the following proposition, we connect the two aspects of the activities by multinational firms—FDI and MP—with each other and with the quality of financial institutions at home and aboard.

Proposition 1. *Assume firms' expected investment returns are higher at home than abroad, then for every (i,h) at any period t*

$$[FDI]_{ih} \propto W_i \times (1+\lambda_i) \times \left(\frac{R_{ih}(\bar{\bar{z}}_i)}{R_{ii}(\bar{\bar{z}}_i)}\right)^\theta \times \bar{\eta}_{ih}^\theta \times [\epsilon_{ih}^{FDI}]^\theta. \tag{10}$$

In equation (10), W_i is the total net worth of country i; $R_{ih}(\bar{\bar{z}}_i)$, characterized in Lemma 1, is the return on parent investment in h for the 'average firm' from country i whose productivity is given by $\bar{\bar{z}}_i \equiv \int_0^\infty z\hat{\phi}_i(z)dz$; and ϵ_{ih}^{FDI} is a measure of heterogeneity in financing among affiliates from i to h, which equals one if all affiliates have the same productivity. Furthermore,

$$Y_{ih} \propto [FDI]_{ih} \times \tilde{z}_{ih}(\bar{\bar{z}}_i) \times (1+\overline{lev}_{ih}^F) \times w_h^{-\frac{1-\alpha}{\alpha}} \times \epsilon_{ih}^Y, \tag{11}$$

where $\tilde{z}_{ih}(\bar{\bar{z}}_i)$ is the productivity of the affiliate of the average firm; $(1+\overline{lev}_{ih}^F)$ is the average leverage of all affiliates from i to h; and ϵ_{ih}^Y is a measure of heterogeneity in production among these affiliates, which equals one if all affiliates have the same productivity.

Equation (10) articulates the relationship between bilateral FDI and the quality of host and

[17] Bond supply in a country is from inactive parent firms; bond demand is from both active parent firms and affiliates. Our setup allows the bond market to either clear by country (i.e. autarky bond market) or be fully integrated globally.

home financial institutions. An increase in μ_h, due to either financial development or a credit boom in h, increases the return from investing there ($R_{ih}(\bar{\bar{z}}_i)$), which leads to an increase in $[\text{FDI}]_{ih}$.

An increase in λ_i affects outward FDI through four channels. First, holding constant the distribution of firms over (z, a), a larger λ_i increases the average leverage of firms in i, captured in the term $(1 + \lambda_i)$. Second, in the presence of firm heterogeneity, it also triggers reallocation of market shares toward more productive firms, who are more likely to become MNEs. The effect of this reallocation on outward FDI is captured in ϵ_{ih}^{FDI}. Third, both the increase in the average leverage and the reallocation push up the wage and interest rate in country i, which reduce $R_{ii}(\bar{\bar{z}}_i)$ and push firms to invest abroad. Finally, with better access to external finance, productive firms will be able to accumulate capital faster. If productivity is persistent, such a reallocation increases *future* aggregate wealth (W_i), resulting in a higher level of outward FDI in the future.

Equation (11) links FDI and other fundamentals to MP. Conditional on $[\text{FDI}]_{ih}$, an improvement in host financial market conditions μ_h increases Y_{ih} by allowing affiliates to scale up more on the investment from the parent. On the other hand, an improvement in home financial market conditions does not directly affect Y_{ih}. Both predictions are consistent with the facts in Section 2.

Aside from clarifying the mechanisms, Proposition 1 provides a basis for a static decomposition of bilateral MP into financing and other factors, an exercise we will pursue in Section 5.

3.8 Static and Dynamic Gains from MP

We now turn to the implications of our model for the wage gains from MP for a host country.

The static wage gains from MP. Consider first the static effect of MP, taking as given the distribution of firms in each country over (z, a). As shown in Appendix B.2.6, the ex-post effect of any change in fundamentals on the real wage can be decomposed into:

$$\Delta \log(w_h) = \alpha \Delta \log(A_h) + \alpha \Delta \log(K_h), \tag{12}$$

where $A_h \equiv \sum_i \int_0^\infty \frac{\hat{k}_{ih}(z)\psi_{ih}(z)}{K_h} \tilde{z}_{ih}(z) dz$ is the capital-weighted productivity of all firms active in host h, K_h is the total capital used in production in h, and Δ denotes the differences in variables between the equilibria before and after the change. Thus, in our model, the openness of a host h to inward FDI can benefit workers through two channels: by improving the productivity distribution of the country, and by increasing the capital stock.

These two channels encompass two views on what the entry of foreign firms embodies. Compared to the neoclassical view of FDI as just one particular form of international capital flow (Mundell, 1957; Feldstein, 1995), in which the benefit from inward FDI accrues exclusively through the increase in domestic capital use captured by $\Delta \log(K_h)$, our model incorporates an extra productivity channel that captures the technology embedded in FDI. The importance of this channel depends on the efficiency of foreign firms relative to domestic firms and the extent to which foreign entrants improve domestic allocative efficiency by pushing up domestic factor prices.

Our model also connects to the technology-based models of multinational firms, in which the

MP share (the share of production by foreign firms) is often the sufficient statistic for the ex-post evaluation of wage gains. To facilitate the comparison, we characterize wage gains as a function of the MP share under the Pareto assumption on firms' productivity distribution, a widely adopted assumption in international trade (e.g., Chaney, 2008).

Proposition 2. *Assume that the wealth share density function in period t for host country h (i.e., $\hat{\phi}_h(z)$ defined in Section 3.5) is a Pareto density function with a tail index $\gamma > 1$ and that outward FDI from country h is restricted (i.e., $\eta_{ih} = 0$ for $i \neq h$ and $\eta_{hh} = 1$).*[18] *Then, the contemporaneous change in workers' wage in country h in response to a change in inward FDI policy is:*

$$\Delta \log(w_h) = -\alpha \Delta \log\left(\frac{Y_{hh}}{Y_h}\right) + \alpha \frac{\gamma - 1}{\gamma} \Delta \log\left(\frac{K_{hh}}{W_h}\right), \tag{13}$$

where $\frac{Y_{hh}}{Y_h}$ is the share of production conducted by domestic firms of h and $\frac{K_{hh}}{W_h}$ is the share of domestic wealth used by domestic firms.[19]

Equation (13) links the wage gains from inward MP to two statistics. The first, $\frac{Y_{hh}}{Y_h}$ (one minus the MP share), measures the importance of foreign firms in host production. This statistic captures the *direct* effect of foreign technology on host labor productivity. Conditional on the MP share, the dependence of foreign affiliates on parent versus host external finance also matters, as it determines the magnitude of the crowd-out effects from foreign firms in the host credit market. This force is reflected in $\Delta \log\left(\frac{K_{hh}}{W_h}\right)$. Intuitively, if a large part of affiliate production is financed through FDI, or if foreign firms achieve their production through superior technologies that use little domestic capital, then more of the host country's wealth will be retained for host firms. In this case, the decrease in $\log\left(\frac{K_{hh}}{W_h}\right)$ due to openness would be smaller, implying larger wage gains. Conversely, if foreign production relies heavily on the host country for external financing, the wage gains would be lower.

In Appendix B.2.7, we further derive $\Delta \log\left(\frac{K_{hh}}{W_h}\right)$ as a function of factor prices and obtain

$$\Delta \log(w_h) = -\frac{\alpha}{1 - (1-\gamma)(1-\alpha)} \Delta \log\left(\frac{Y_{hh}}{Y_h}\right) - \frac{\alpha(\gamma - 1)}{1 - (1-\gamma)(1-\alpha)} \Delta \log(r_h^b + \delta). \tag{14}$$

The first term captures both the *direct* and *indirect* (through labor reallocation) impacts of inward MP on the host wage holding constant the interest rate, and the second term captures the effect due to the change in the interest rate. As the effect of inward MP on the interest rate is usually positive, equation (14) shows that focusing only on the MP share leads to an overestimation of the wage gains. Only for small open economies (i.e., when the interest rate is constant) is the MP

[18] A sufficient condition for $\hat{\phi}_h(z)$ to be the density of a Pareto distribution is that the productivity process is i.i.d. and follows a Pareto distribution (Itskhoki and Moll, 2014).

[19] This thought experiment is between two equilibria with different degrees of *inward* openness, which could be the result of an increase of $\bar{\eta}_{ih}, i \neq h$ for country h. Although the restriction on outward FDI is strong, it serves as a natural benchmark to clarify the mechanism. The thought experiment does not impose whether the credit market in country h is integrated with the rest of the world, or whether the integration is different between the two equilibria.

share sufficient for inferring the wage changes. In this case, as long as the appropriate elasticity for the MP share is used, technology-based models of MP can measure the wage gains correctly.[20]

The dynamic versus static gains. By shifting market shares and profits among firms from different countries and with different productivity, current openness policies can affect future wages. We illustrate the mechanism in a two-period special case of the model, with the focal host country h and $N-1$ other symmetric countries, denoted by $i = 1, ...N-1$. To be explicit about the dynamic effects, we also add back time subscripts of variables in the analysis below.

Countries have time-varying fundamentals and share an integrated bond market. The productivity of firms in a country is drawn i.i.d. from a Pareto distribution with the location parameters (i.e., the lower bounds of support) of the focal country h and the remaining $N-1$ countries denoted $\bar{z}_{h,t}$ and $\bar{z}_{i,t}$, respectively. In this environment, we consider $\frac{d \log w_{h,2}}{d\bar{\eta}_{ih,1}}$, the impact on the second period wage in country h of its opening up to FDI at period 1, modeled as an increase in $\bar{\eta}_{ih,1}$. $\frac{d \log w_{h,2}}{d\bar{\eta}_{ih,1}}$ thus captures the dynamic effect of the openness policy. To isolate the mechanism from the host country's perspective, we further assume that the policy change is relatively small and the labor supply in foreign countries are perfectly elastic, so the world interest rate and foreign wages do not respond to the policy. We have the following:

Proposition 3.

1. *Holding fixed all other fundamentals,*[21] *if β_h, $\lambda_{h,2}$, $\bar{z}_{h,2}$, are sufficiently large, or if β_i, $\lambda_{i,2}$, $\bar{z}_{i,2}$, $\bar{\eta}_{ih,2}$ are sufficiently small, then $\frac{d \log w_{h,2}}{d\bar{\eta}_{ih,1}} < 0$; conversely, $\frac{d \log w_{h,2}}{d\bar{\eta}_{ih,1}} > 0$.*[22]

2. *Hold fixed all other fundamentals and consider a permanent openness policy in country h that raises $\bar{\eta}_{ih,1}$ and $\bar{\eta}_{ih,2}$ by a common level $\Delta\bar{\eta}_{ih} > 0$. While the wage gains of country h at period 1 are always positive, the wage gains at period 2 can be negative if β_h, $\lambda_{h,2}$, $\bar{z}_{h,2}$ are sufficiently large or if β_i, $\lambda_{i,2}$, $\bar{z}_{i,2}$ are sufficiently small.*

The first part of Proposition 3 suggests that openness can either increase or decrease the future wage. Intuitively, openness in the first period shifts the market shares in host h from domestic to foreign firms, so at the end of the first period, foreign firms make more profits at the expense of domestic firms.[23] Whether such a shift increases or decreases the second period wage depends on two forces: the marginal propensities of firms to invest their first-period profits in country h, and, conditional on their investment, the relative productivity of domestic versus foreign firms. If domestic firms invest a sufficiently higher proportion of their past profits in h than foreign firms, which could happen because of a higher domestic saving rate (high β_h or low β_i), better domestic financial institutions (high $\lambda_{h,2}$ or low $\lambda_{i,2}$), or geography (low $\bar{\eta}_{ih,2}$), or if domestic firms

[20] In our model, the elasticity for MP depends on both the capital share and the Pareto parameter that governs the joint distribution of productivity and net worth. This is different from a purely technology-based model of MP, in which the elasticity is determined by parameters governing heterogeneity in technology. This observation echoes the finding in international trade that different models might yield the same ex-post gains but imply different theory-consistent ways of estimating the trade elasticity. See, e.g., Arkolakis et al. (2012) and Melitz and Redding (2015).

[21] The economy's fundamentals include all parameters as well as aggregate net worths in all countries at the beginning of period 1. The wealth share densities are not important as firm productivities are assumed to be i.i.d.

[22] Appendix B.2.8 characterizes the conditions that define parameters to be sufficiently large or small.

[23] Openness also shifts market shares from less to more productive domestic firms. Since firm productivity is independent across periods *in this special case*, such within-country shifts do not affect the second period outcomes.

are sufficiently more productive in the second period, then such a shift tends to reduce the second period wage. Conversely, it can increase the second period wage.

The second part of the proposition considers a *permanent* policy change that opens up h to foreign firms in *both* periods. The policy unambiguously increases the wage of host h at period 1, but its impact on the second period wage is more involved. To unpack the impact, we can view the policy as a combination of two changes: an increase in $\bar{\eta}_{ih,2}$ and a simultaneous increase in $\bar{\eta}_{ih,1}$ of the same magnitude. The first change unambiguously increases the wage at period 2, whereas the second change might increase or decrease the wage at period 2, according to the first part of the proposition. Therefore, the net effect of the policy on the second period wage is ambiguous and depends on the fundamentals of the economy.

Remarks. This last result might at first appear surprising—from the perspective of host workers, the openness policy is akin to an improvement in the productivity of foreign firms in both periods. How can such a seemingly positive change reduce the wage?

Two central features of our model, motivated by the nature of FDI as within-firm movement of capital, drive this result. First, because of capital market imperfections, MP cannot take place without FDI. Since FDI is at least in part financed by firms' retained earnings, changes in the current market shares can affect future MP. This feature also gives room for restrictions on FDI to be a second-best policy for addressing capital market imperfections.

Second, for firms making direct investment, different hosts are imperfect substitutes, with the elasticity of substitution governed by the dispersion of idiosyncratic investment efficiencies (parameter θ). This feature captures an important difference between FDI and portfolio investment: while the latter only seeks to maximize a simple return, FDI is embedded with technology and hence governed by the 'fit' between a firm's technology and a host country, embodied in the idiosyncratic draws of η_{ih}. Such a feature implies a finite elasticity of inward FDI with respect to the host investment return. To see the importance of this feature, consider an alternative setup where FDI is treated as portfolio investment. In that setup, the decline in domestic investment led by a past openness policy would be entirely compensated for by the inflow of foreign investment, so openness to foreign investment will never reduce the wage.

Proposition 3 has important implications for the ex-post evaluation of the gains from MP. To infer the gains from MP over a period of time, we can calibrate our baseline model to the observed sequence of MP shares and conduct a dynamic counterfactual experiment. Alternatively, we can view the data through the lens of a purely technology-based MP model in which FDI does not play a role, extended to incorporate capital accumulation. The above discussion suggests that, by overlooking the dynamic effect arising from the connection of FDI and MP, the estimates from the second exercise would be biased and may have the wrong sign, with both the sign and the size of the bias varying by countries' fundamentals. We will evaluate this bias in Section 5.

3.9 Discussion of Model Assumptions and Extensions

Before proceeding to quantification, we discuss the rationales for some model assumptions and the implications if they are relaxed. One of the key assumptions is that firms face financial contracting frictions in the short run, so the shadow return on capital differs from the cost of external financing. This allows the model to speak to the empirical relationship between home financial development and outward MP documented in this paper and elsewhere.

Despite ample evidence from firm and aggregate data, one might still be skeptical of whether MNEs, typically large conglomerates, can still be affected by financial frictions. In reality, even though these firms can borrow from banks or issue bonds, as their leverage increases, the default risk and agency cost usually lead to a higher cost of borrowing (see e.g., Corbae and D'Erasmo, 2021 for a recent quantitative model with this mechanism). Our parent-firm financing model block, which arises as the equilibrium outcome of a model with defaultable bonds and endogenous bond pricing (Appendix B.4.2), captures this idea parsimoniously. We also wish to note that the financial frictions only restrict the short-term debt-equity ratio. Productive firms can still expand by accumulating equity and leveraging it to acquire more external financing. Ultimately, our mechanism will be active, as long as firms make some investment out of their retained earnings.

While somewhat ad hoc, the way we introduce the financial contracting frictions has received empirical support. For example, Peek and Rosengren (2000) and Klein et al. (2002) show that the decrease in collateral value leads to a collapse in Japanese overseas investment via reduced bank lending; Chaney et al. (2012) document a decrease in activities among U.S. listed companies whose collateral values were hit during the Great Recession. Moreover, this setup has been widely used in quantitative models to examine the role of financial shocks in accounting for business cycle fluctuations (Buera et al., 2015).

An additional implication of the model, arising from the two-stage financing decision, is that the financial shocks in home and host countries affect affiliate output in a log linear manner (see Proposition 1), implying that, when estimating the specification for affiliate sales in logarithm, we should not see a first-order interaction effect between host and home financial market conditions. We show in Appendix A.5 that it is indeed the case empirically, further validating the model setup.

Lastly, our setup abstracts from the sunk costs of setting up foreign affiliates, so it does not feature the firm-level hysteresis emphasized in some empirical studies. Relatedly, by assuming each affiliate is an independent producer of a homogeneous good, the model does not allow for the interaction between affiliates through demand cannibalization (Tintelnot, 2016). On the other hand, the model incorporates the cannibalization between affiliates in competing for the scarce internal factor (capital). Given the goal of the paper in explaining aggregate FDI and MP and in examining their implications for aggregate welfare, we choose to abstract from trade and firm-level hysteresis. Nevertheless, we show that the tractability of our model extends to the inclusion of differentiated goods (Appendix B.5) and firm-level switching costs (Appendix B.6.1), so it can be the basis for answering other questions in which such features play a central role.

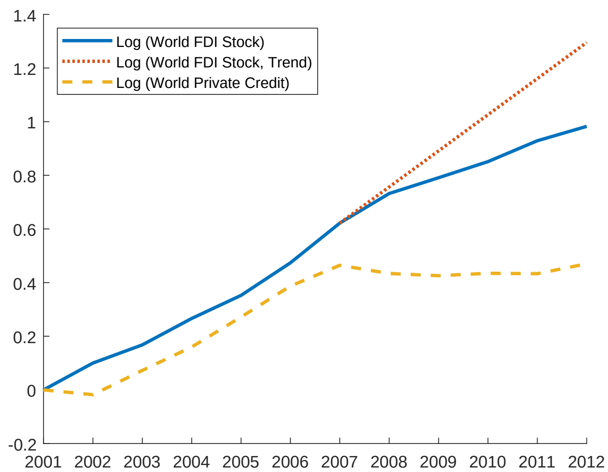


Figure 3: Private Credit and the Dynamics of World FDI

Note: The solid line is the aggregate FDI stock in the sample of 36 countries. The dashed line is the total stock of credit issued to domestic private sectors in the same countries. Values in 2001 are normalized to 1. Source of data: UNCTAD and the World Bank.

4 Quantitative Implementation

To shed light on the importance of model mechanisms, we implement the model quantitatively. We focus on the same 36 countries as in the empirical section (see Figure 1) over the period 2001-2012. We will calibrate the model and use it to assess the role of various fundamental factors, including financial market conditions, in shaping the activities of multinational firms.

With this goal in mind, we inspect the dynamics of financial market conditions and FDI in Figure 3. The solid line depicts the logarithm of total FDI stock among the sample countries. As is well known, the past few decades saw increasing activity by MNEs. This trend shows up in our sample. The growth in total FDI stock, however, has slowed since 2008. The actual world FDI stock is 20% lower by 2012 than the linear extrapolation of the pre-crisis trend. The dashed line depicts the logarithm of total stock of credit to the private sector among the sample countries. It shows a credit boom during 2001-2007 and a subsequent credit crunch.

Although the structural breaks of these two series largely coincided, our previous discussion suggests that the changes in FDI capture the impacts of past as well as current fundamentals. To disentangle these forces, instead of calibrating the steady state of the model to the average features of the data, we apply a wedge accounting procedure to the transitional dynamics of the model. Specifically, we pick the series of model fundamentals (λ_i, μ_h, $\bar{z}_i$) and the bilateral investment return wedges ($\bar{\eta}_{ih}$), all of which are time varying, so that the sequential equilibrium of the model matches the data for all countries. If we feed the sequences of these fundamentals into the model, it will produce the time series of GDP, domestic and bilateral foreign investment, private credit, etc., exactly as in the data. We then alter different groups of fundamentals either to assess their respective contribution to the aggregate FDI or to evaluate a country's wage gains from FDI. In both the calibration and counterfactuals, we assume that the world credit market is fully integrated, so every period, there is a world interest rate that clears the global bond market.[24]

Below, we first discuss the targets that identify each parameter and then describe the numerical procedures. Additional information on the data used in this section and computational algorithms are provided in Appendix C.

4.1 Targets and Numerical Procedures

Parameters calibrated independently. The model is calibrated at annual frequency. We start with the parameters that are calibrated independently. The entrepreneurs' discount factor, β_i, determines the saving rate. We set $\beta_i = 0.9$ following Buera et al. (2011). We set the capital share $\alpha = 0.4$ and the depreciation rate $\delta = 4.5\%$ based on the average estimates for our sample countries from the Penn World Table. The dispersion parameter of the multivariate Pareto distribution, θ, determines the elasticity of firms' investment in host-specific investment return (see characterizations of $\hat{e}_{ih}(z)$ in Lemma 3). Using cross-country variation in taxes, Wei (2000) estimates this elasticity to be 4.6, which is also around the median value in a recent meta-analysis (De Mooij and Ederveen, 2003). We set $\theta = 5$.[25]

We next parameterize firms' productivity process. We assume that the productivity of firm z from home country i is governed by the following process:

$$\log(z') - \log(\bar{z}_i') = \rho_z \big[\log(z) - \log(\bar{z}_i)\big] + \sigma_\epsilon \varepsilon(z),$$

in which $\log(z)$ and $\log(z')$ are the current and future productivities of the firm, and $\log(\bar{z}_i)$ and $\log(\bar{z}_i')$ are the current and future *fundamental productivity* of country i. $\varepsilon(z)$ is a firm-specific i.i.d. shock that follows the standard normal distribution. According to this specification, a firm's productivity fluctuates around the fundamental productivity of a country, with the deviation following an AR(1) process. $\rho_z \in (0, 1)$ determines the persistence and $\sigma_\varepsilon > 0$ determines the dispersion of the deviation. We set $\rho_z = 0.85$ and $\sigma_\epsilon^2 = 0.69$, which are the median values among the estimates of Asker et al. (2014) for an AR(1) productivity process of many developed and developing countries. Through time-varying $\bar{z}_i$, our specification accommodates changes in the country-level productivity. We will pin down $\bar{z}_i$ to match the aggregate output of countries, as described below.

We specify the productivity of an affiliate in host country h of firm z from i as:

$$\tilde{z}_{ih}(z) = [\tilde{z}_h(z)]^{1-\gamma}[\tilde{z}_i(z)]^{\gamma}$$

in which $\tilde{z}_h(z)$ and $\tilde{z}_i(z)$ represent the host and the parent components of the affiliate productivity, respectively. Both components fluctuate around the country's fundamental productivity following

[24] Alternatively, we can either assume that the credit market is closed in each country, which is clearly counterfactual, or that each country has a specific spread, which requires us to take a stand on the size of the spread and which investors are paid with the spread. We view an integrated world credit market as a more appealing benchmark.

[25] Wei (2000) estimates θ as the aggregate FDI elasticity. In our model, θ governs firm-level elasticity, which is not identical to the aggregate elasticity in presence of extensive margin decisions. However, in the simulation we find the difference to be small so we directly use the external calibration of θ.

the same AR(1) process (i.e., $\log(\tilde{z}_k(z)) - \log(\bar{z}'_k) = \rho_z\left[\tilde{z}_k(z) - \log(\bar{z}_k)\right] + \sigma_\epsilon \varepsilon(z)$, which is also consistent with the normalization that $\tilde{z}_{ii}(z) = z$). Following the recent estimate of the parent and host component in affiliate productivity by Cravino and Levchenko (2016), we set $\gamma = 0.228$.

Parameters calibrated in equilibrium. The remaining parameters are allowed to change over time and disciplined using time-varying targets in equilibrium. Parameter λ_i determines the accessibility of external finance for parents. In the long run, this parameter depends on the quality of financial institutions, but in the short run, it is also shaped by the availability of credit in a country. We therefore use λ_i to match the time series of credit to domestic private sectors in each sample country, interpreting its over-time change as capturing evolving credit market conditions.

Parameter μ_h determines the extent to which affiliates can rely on local partners for financing. While μ_h likely also depends on the availability of credit in h, its level and sensitivity to credit market conditions need not be the same as λ_i.[26] To allow for this possibility, we discipline μ_h using a different time series. Recall that μ_h determines the fraction of the balance sheet of an affiliate that is financed by its parent. We use the BEA data to construct the empirical counterpart of this object. Specifically, the BEA reports annually the total external finance of U.S. affiliates in each country and these affiliates' finance from their U.S. parents, which allows us to construct the ratio of parent finance in total external finance. For the U.S. as a host, we construct the same ratio for foreign affiliates that operate in the U.S. We then pin down the time-series of μ_h by matching the model-implied ratios and the data.

The domestic and international investment wedges determine the evolution of domestic investment and FDI, respectively. We set the capital stock in each country (K_h) at the beginning of our sample period to the data and then use the sequence of $\bar{\eta}_{ii}$ to match the evolution of domestic investment. For international investment, the literature has documented that more productive firms are more likely to become MNEs. We capture this pattern in a reduced-form way by assuming that the investment return wedge has a component that depends on z:

$$\bar{\eta}_{ih}(z) = \bar{\eta}_{ih} z^{\eta_z}, h \neq i. \tag{15}$$

Under this specification, the probability that a firm finds it optimal to open an affiliate overseas is an increasing function of z. We pin down η_z through indirect inference. Based on a representative survey of manufacturing firms in a number of countries (Bloom et al., 2012), we estimate a Logit specification, regressing whether a firm is an MNE on its productivity. We then determine η_z so that in the model, this regression specification yields the same estimate when performed on the firms from the same set of countries as in the empirical analysis. This finds $\eta_z = 0.03$.[27] Given η_z,

[26] On the one hand, affiliates of foreign firms are backed by the reputation of their overseas parents; on the other hand, they may not be as connected to the local financial institutions as local firms.

[27] As elaborated in Appendix C.2.1, in the special case with $\tilde{R}_i(z) = \bar{R}_i(z)$, the Logit specification can be derived as a structural equation of the model. Although the premise is generally not satisfied, the relationship between a firms' productivity and whether it is an MNE is still informative about η_z. Note also that when estimating the specification using model-simulated data, we need to have calibrated the rest of the model, so our indirect inference proceeds in a nested fashion, as described below.

Table 2: Model Parameterization

Parameter	Description	Target/Source	Value
A: Parameters Calibrated Independently			
Parameter	Description	Target/Source	Value
α	Capital share	PWT	0.4
δ	Capital depreciation rate	PWT	4.5%
θ	Elasticity of FDI w.r.t. return	Wei (2000)	5
ρ_z	Firm productivity autocorrelation	Asker et al. (2014)	0.85
σ_ϵ^2	Firm productivity innovation variance	Asker et al. (2014)	0.69
γ	Parent weight in affiliate productivity	Cravino and Levchenko (2016)	0.4
$\{L_{i,t}\}$	Effective employment	PWT	-
B: Parameters Calibrated in Equilibrium			
Parameter	Description	Target/Source	Value
$\{\lambda_{i,t}\}$	Credit market conditions for parent companies	Total private credit	Figure 4
$\{\mu_{h,t}\}$	Credit market conditions for affiliates	Shares of affiliates' assets financed by parents	Figure 4
$\{\bar{\eta}_{ih,t}\}$	Return wedge for domestic and foreign direct investment	Capital/GDP ratios; bilateral FDI stocks/host capital	
$\{\bar{z}_{i,t}\}$	Fundamental TFP	GDP per worker	-
η_z	Relationship between MNE status and productivity	Estimated using Bloom et al. (2012) data	0.03

we then use the sequence of $\bar{\eta}_{ih}, h \neq i$ to match bilateral FDI over time. This procedure ensures that the model exactly matches the evolution of each country's capital stock and distribution of direct investment across host countries.

The sequence of labor endowments in each country, L_i, is set to the effective employment from the Penn World Table, which incorporates changes in population, labor force participation, and the human capital of the labor force.

With the above parameterization, our model matches the aggregate capital and labor input in each period. For any sequence of fundamental parameters, it also implies a joint distribution of firms over size and productivity, which determines the allocative efficiency of the economy. We pick the fundamental TFP of countries, denoted by $\bar{z}_i$, as the residual so that the model matches the data on output per worker for all countries and periods.

Table 2 summarizes how the parameters are determined (see Table C.1 for key parameters and data statistics by country). Parameters in Panel A are pinned down externally. Parameters in Panel B are determined jointly in equilibrium. Importantly, in addition to these parameters, the dynamics of the model also depends on the joint distribution of firms' net worth and productivity in the initial period. Ideally, we would like to measure this distribution directly. Without access to a representative firm-level dataset that covers all countries for the early 2000s, we assume that the wealth share density function ($\hat{\phi}_i(z)$ defined in Section 3.5) in each country in the initial period is the same as the one from the stationary equilibrium calibrated to the data in 2001.[28]

Numerical algorithm. The calibration works as follows. In the first step, given Panel-A parameters and for a guess of η_z, we calibrate the stationary equilibrium by finding values of parameters in Panel B, such that the listed moments in Panel B match their data counterparts in 2001. These moments include each country's credit/GDP ratios, shares of affiliates' assets financed by parents, GDP per efficient unit of labor, and bilateral FDI stocks as shares of receiving countries' capital stock. We then check if the model implies the same relationship between whether a firm is

[28]Note that we only assume the *wealth share* densities start from those of the stationary equilibrium, not the aggregate net worth. Our calibration matches aggregate capital stock and aggregate output for all countries and periods along the transition.

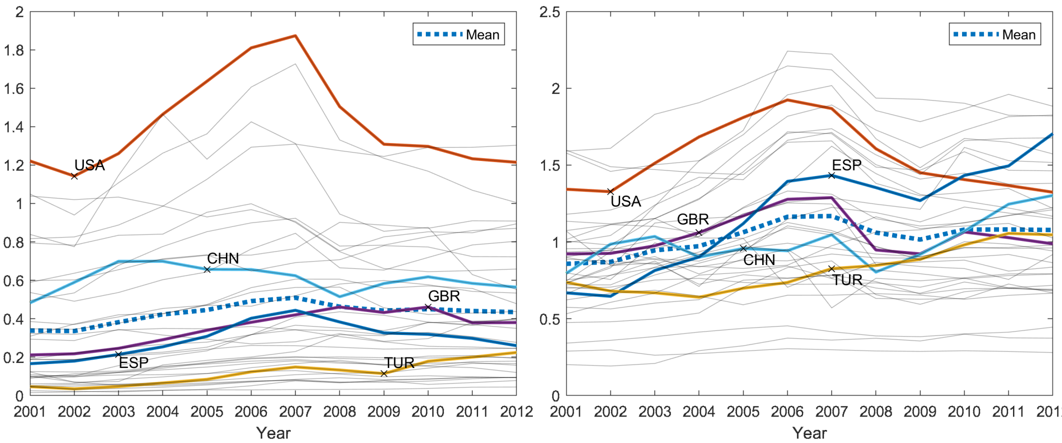


Figure 4: Inferred λ_i and μ_h

Note: The left panel is the calibrated λ_i; the right panel is the calibrated μ_h. The dotted line is the average across the sample countries.

an MNE and its productivity as in the data and, if not, update η_z and repeat the procedure.

In the second step, starting from the wealth share density functions of the stationary equilibrium, we choose the time-varying parameters along the transition path, so that the moments of the model equal their data counterparts listed in Panel B over 2001-2012. Since the number of moments equals the number of parameters, the parameters are just-identified.

The above procedure requires computing the wealth share density functions and the transition of the density functions numerous times. We describe an efficient numerical algorithm for this purpose in Appendix C.2.2.

4.2 The Dynamics of Financial Market Conditions

Figure 4 plots the calibrated sequences of λ_i and μ_h. The solid lines highlight selected countries and the dotted line denotes the mean value across all countries.

The left panel shows the great heterogeneity in calibrated λ_i across countries. With an average of 1.4, the U.S. is among the countries with the highest level of λ_i. Turkey is among the countries with the lowest, with an average value of around 0.1. This long-run difference across countries reflects the difference in credit over GDP ratios in the data, as shown in the first two columns of Table C.1. Although differing in levels, λ_i of many countries follow a similar trend. They are on an upward trend in the first half of the sample period, corresponding to a period of easy access to credit in many countries. Subsequently, the trend is met by a sharp downturn around 2008, mirroring the credit crunch shown in Figure 3. In some countries, this drop is severe—-the U.S., for example, sees its λ_i declining from the peak value of 1.8 to 1.2 within just two years.

The right panel of Figure 4 plots the evolution of μ_h for each host country. Again, there is substantial heterogeneity in host countries along this dimension. Columns 3 and 4 in Table C.1 show that, the calibrated μ_h is directly linked to the average leverage of foreign affiliates in a host country. Similar to λ_i, μ_h in many countries sees a decrease around 2008.

Table 3: Calibrated and External Measures of Financial Market Conditions

	(1) $\bar{\lambda}_i$	(2) $\bar{\mu}_i$	(3) $\bar{\mu}_i$	(4) $\Delta\mu_i$
log (financial development index)	0.448***	0.349**		
	(0.153)	(0.169)		
$\bar{\lambda}_i$			0.299*	
			(0.172)	
$\Delta\lambda_i$				0.584***
				(0.106)
Observations	36	36	36	396
R^2	0.201	0.111	0.081	0.122

Note: $\bar{\lambda}_i$ and $\bar{\mu}_i$ are the average of λ_i and μ_i over the sample period. $\Delta\lambda_i$ and $\Delta\mu_i$ are the yearly changes in λ_i and μ_i. Standard errors (clustered by country) are in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.3 Model Validation

We validate the model by comparing calibrated parameters to several external measures.

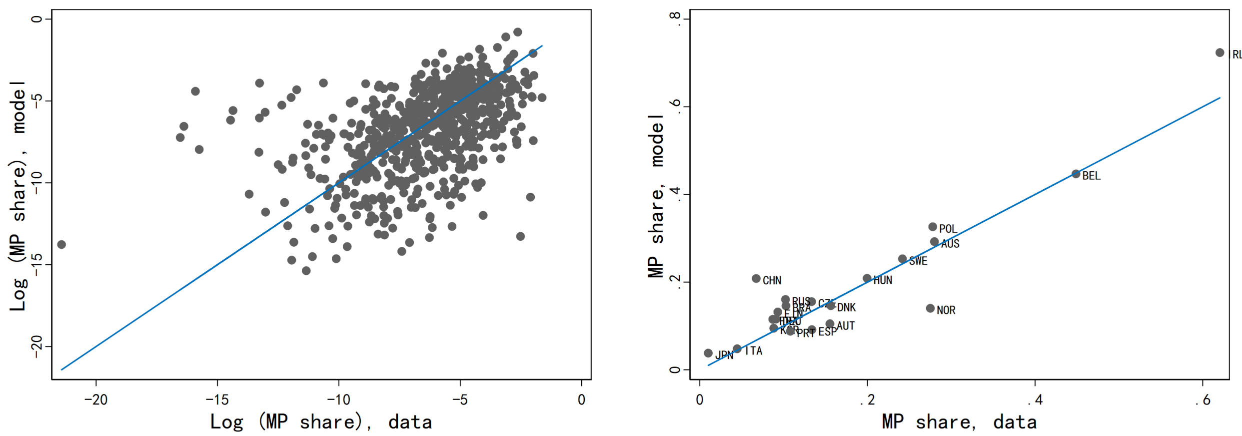
Financial market conditions. We first relate the calibrated values of λ_i and μ_h to external measures of the quality of financial institutions. Insofar as in countries with better financial institutions, parent firms can more easily borrow and affiliates of foreign firms can rely more on local finance, these two parameters should be correlated with each other and both with the proxy for the quality of financial institutions. In the short run, both parameters are influenced by the conditions in the credit market, so their fluctuations should also be correlated. Table 3 reports the test for these implications. The first three columns show that the average values of λ_i and μ_h for each country are correlated with each other and with the logarithm of the financial development index. The fourth column shows that the over-time variations of the two measures are also correlated.

Bilateral and aggregate inward MP. Due to the lack of comprehensive bilateral MP data over most of the sample period, we choose not to match the bilateral MP shares. Instead, we have used the newly collected bilateral FDI stock data as targets. As a validation of the model, we compare our model's implications on bilateral and aggregate inward MP shares to the data, focusing on the year 2012, when our firm-level sample has the best coverage.[29] Figure 5 shows that the model generates empirically consistent MP shares.

Cross-border investment return wedges. In our calibration, the return wedges $\bar{\eta}_{ih}$ are intended as catch-all for frictions and policy distortions to international investment. We examine whether they are correlated with measurable frictions and policies related to FDI in expected ways.

Table 4 reports the results. The dependent variable is the bilateral wedge for the year 2012. Column 1 shows that the return wedges are strongly correlated with common proxies for geographic frictions. Column 2 replaces host fixed effects with host characteristics. As expected, we find that hosts that are viewed as tax havens (low-tax countries) have higher return wedges, al-

[29]Despite the generally good coverage, the firm-level sample is tilted toward manufacturing, where MNEs are more active. On the other hand, our bilateral FDI stocks are originally reported by the government and presumably cover the entire economy. To adjust for difference due to sectoral compositions, we scale our model implied MP shares so that the model-implied share of capital stocks owned by foreign firms matches the share of assets owned by foreign firms in the Orbis data.



(a) Bilateral MP Shares

(b) Inward MP Shares

Figure 5: MP Shares, Model v.s Data

Note: Lines in the plots are the 45-degree lines. Bilateral MP shares (left) are calculated as the ratio of total turnovers of foreign affiliates in a host from a home country to total turnovers of all firms in that host. A host country's inward MP share (right) is calculated as the ratio of total turnovers of all foreign affiliates in that host to total turnovers of all firms there.

Table 4: FDI Return Wedges and Measurable Frictions

	(1)	(2)
	$\log \bar{\eta}_{ih}$	
Log(Distance)	-0.244***	-0.179***
	(0.014)	(0.018)
Common border	-0.064	-0.016
	(0.044)	(0.048)
Colonial tie	0.211***	0.226***
	(0.051)	(0.050)
Common language	0.159***	0.240***
	(0.035)	(0.056)
Low tax country		0.305***
		(0.086)
Profit tax		0.003
		(0.003)
FDI restrictiveness index		-0.603*
		(0.313)
Log(host financial development index)		0.164
		(0.152)
Observations	1134	1076
R^2	0.670	0.579
Home country FE	Yes	Yes
Host country FE	Yes	
Host country chars.	-	Yes

Note: The host country characteristics controlled in the second column include the log values of GDP and TFP. Robust standard errors for the first column and clustered (by host) standard errors for the second column are in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

though the coefficient of the profit tax itself is insignificant. Restrictive policies of the host country on inward FDI also have an economically and statistically significant effect on the return wedge, consistent with our interpretation of the wedges as the un-modeled variation in frictions. Last

Table 5: Cross-Sectional Decomposition

Size	Geography	Productivity	Factor price	Home fin.	Host fin.	Host fin. $\times$ others	Heterogeneity
0.153	0.593	0.070	0.004	0.021	0.019	0.054	0.087

but not least, we find the financial development index to be unimportant in explaining the return wedge. This is reassuring as it shows that the empirical relationship between the quality of host financial institutions and inward FDI is entirely accounted for by our model mechanisms.

5 Counterfactual Experiments

The preceding exercises show that our model generates consistent predictions in dimensions not directly targeted. We now use the model to conduct counterfactual experiments.

5.1 Financing Factors and the Cross Section of MP

Our first exercise decomposes the determinants of cross-sectional bilateral MP. Combining equations (10) and (11) gives us:

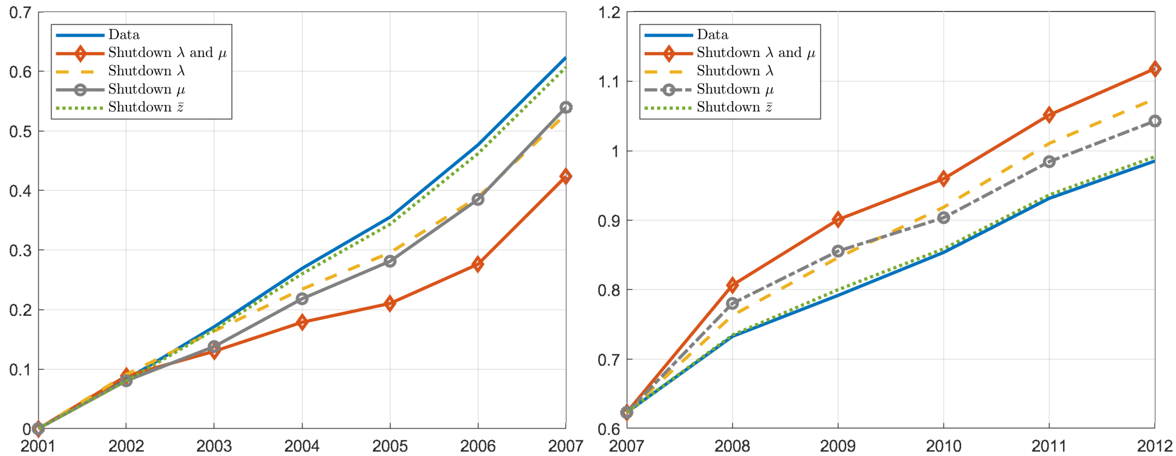
$$Y_{ih} \propto \underbrace{W_i}_{\text{size}} \times \underbrace{\bar{\eta}_{ih}^{\theta}}_{\text{geography}} \times \underbrace{\tilde{z}_{ih}(\bar{\bar{z}}_i)}_{\text{productivity}} \times \underbrace{w_h^{-\frac{1-\alpha}{\alpha}}}_{\text{factor price}} \times \underbrace{(1+\lambda_i)}_{\text{home finance}} \times \underbrace{(1+\overline{lev}_{ih}^{F})}_{\text{host finance}} \times \underbrace{\left(\frac{R_{ih}(\bar{\bar{z}}_i)}{R_{ii}(\bar{\bar{z}}_i)}\right)^{\theta}}_{\text{host finance}\times\text{other factors}} \times \underbrace{\epsilon_{ih}^{Y} \cdot [\epsilon_{ih}^{FDI}]^{\theta}}_{\text{heterogeneity}}.$$

This equation relates bilateral MP to a number of factors. With the log-linear structure, we can assess the importance of these factors in accounting for the variation of bilateral MP by regressing the logarithm of each of them on the logarithm of MP as in Eaton et al. (2011). The regression coefficients sum to one and each represents the importance of one factor.

Table 5 reports the result from this decomposition. Consistent with the existing literature, size and geography are the most important factors, together accounting for 75% of the variation in bilateral MP. Factors emphasized in traditional models of MP, such as firm productivity and factor prices, jointly account for 7.4% of the variation. Host and home financing factors directly account for 4.0%, and host finance further interacts with other host characteristics to account for an additional 5.4%. Thus, including the financing factor explains 9.4% of the variation. The remaining 8.7% is accounted for by firm heterogeneity. This decomposition exercise shows that although financing factors are less important than size and geography, they are in the same order of importance as technology-related factors emphasized in existing studies of MP.

5.2 Financing Factors and the Dynamics of FDI

The previous exercise is a partial equilibrium decomposition because it takes as given the wage and total net worth of countries, both of which are, however, shaped endogenously by countries' past fundamentals. To disentangle the effects of different fundamentals, we now move to a de-



(a) Log World FDI: 2002-2007

(b) Log World FDI: 2008-2012

Figure 6: Changes in World FDI Stock: Data and Counterfactuals

Note: The figures report the effects of the changes in λ_i, μ_h, and $\bar{z}_i$ on aggregate FDI. The vertical axis is the logarithm of FDI stock in year t minus the logarithm of FDI stock in 2001, or approximately, the cumulative world FDI flow between 2001 and year t as a share of initial FDI stock.

composition exercise based on counterfactuals along the dynamic transition path.[30] Motivated by Figure 3, which shows a clear trend break in both world FDI and credit market conditions around 2007, we split the counterfactuals into two periods: before and after 2007.

The boom in FDI before 2007. In the first exercise, we examine whether the easing access to credit in the lead-up to the financial crisis can account for the increase in FDI in this period. To this end, we set the time sequence of calibrated (λ_i, μ_h) to their values at the beginning of the sample (year 2001). Figure 6a plots the findings. The solid line indicates the actual evolution of world FDI stock over this period, which the model matches. The solid line with diamond markers indicates the counterfactual evolution of world FDI stock. Comparison between the two shows that, if the financial market conditions of all countries (reflected by λ_i and μ_h) had remained at the level of 2001, the increase in FDI stock during 2001-2007 would have decreased by around 30%. The dashed line and the solid line with circle markers indicate that the changes in λ_i and μ_h each account for about half of the effect. To investigate the role of changes in fundamental productivity, the dotted line plots the outcome when fundamental TFPs of all countries are kept at the level of 2001. The world FDI in this scenario decreases relative to the data, but only slightly. This reflects that over this period, the changes in fundamental TFPs among the major sending and recipient countries of FDI tend to be more modest than the changes in financial market conditions.

The slowdown in FDI growth since 2008. Our second dynamic exercise is similar in spirit but focuses on 2008-2012, a period of financial market disruptions and FDI growth slowdown. We

[30]In conducting these counterfactuals, we assume the economy starts with the same aggregate state as the benchmark but subsequently experience changes in fundamentals. In general, agents' expectation of these fundamentals matter for the counterfactual outcomes; in the case of log period utility function, agents make the same decisions regardless of whether they anticipate these changes.

feed in the calibrated sequence of parameters until 2007 and then 'freeze' the relevant fundamental parameters at their 2007 values for all subsequent years. Figure 6b depicts the main findings. The solid line is the data. The solid line with diamond markers shows that, had λ_i and μ_h of all countries remained at their peak values from 2007, the cumulative world FDI flow would have been around 35% higher. The dashed line and the dash-dotted line plots the individual effect of λ_i and μ_h, respectively. We find that both forces are quantitatively relevant, but the deteriorating access to credit for parent firms mattered more toward the end of the period. As before, the changes in fundamental TFPs have a negligible impact on aggregate FDI.

Together, these two exercises show that the changes in financial market conditions play a first-order role in explaining the dynamics of aggregate FDI over this period.

The role of general equilibrium effects and validation based on counterfactuals. In Appendix C.3, we conduct the above experiments by altering the fundamentals of one country at a time. These country-specific counterfactuals serve two goals. First, by comparing the predictions of country-specific experiments to those of experiments with simultaneous changes to all countries, we shed light on the importance of general-equilibrium forces in shaping the distribution of FDI. For example, an improvement in country A's domestic condition that leads to higher domestic factor prices and more outward FDI will suppress other countries' investment both toward country A and toward the main destinations of country A's outward FDI. We show that omitting these general equilibrium forces leads to an overestimation of the true aggregate effect, shown in Figures 6a and 6b, by two folds. This comparison highlights the value of using a multi-country general equilibrium model to evaluate the impact of shocks to fundamentals on FDI.

Second, using the outcomes from these country-specific experiments, we estimate a diff-in-diff specification for the impact of financial market conditions on outward FDI, which we compare to the empirical estimates based on the bilateral FDI panel. We find that the model can account for the empirical estimates both qualitatively and quantitatively. This lends strong support to the model as it shows that the model's *counterfactual* predictions also fit the empirical relationship.[31]

5.3 The Gains from FDI: A Case Study on the Effect of EU Membership

Our third exercise is a case study of countries' wage gains from inward FDI by being an EU member. Through the freedom of establishment and free movement of capital, the EU common market framework enables firms to move within the EU without facing discriminatory barriers from the host. We focus on this specific aspect of EU membership.

We deduce how member states' openness toward foreign investment from other members may be affected by the common market framework using the OECD index on the restrictiveness of host FDI policies. This index ranges from 0 (no restriction) to 1 (most restrictive) and captures the stringency of host regulations on foreign firms. For EU members, who cannot discriminate

[31] By design, our calibration matches the panel of bilateral FDI and country financial market conditions. But for this exercise we construct the 'treatment effect' of financial market conditions on FDI through counterfactual experiments, so the model-implied effect is not baked in by the calibration process.

between domestic and other EU firms, the index is best viewed as describing their regulations on firms from *outside* the EU. Therefore, for the 'non-EU-member counterfactual', we assume that if not for being a member, a host would have applied these regulations to EU firms as well.

Concretely, recall that in the calibration we use investment return wedges $\bar{\eta}_{ih}$ to match the series of bilateral FDI. We model the counterfactual FDI policy of an EU member h as a decrease in $\log \bar{\eta}_{ih}$ by Δ_h for $i \in \text{EU}, i \neq h$. Loosely speaking, Δ_h is the 'ad-valorem equivalent' of country h's FDI regulations that would have been applied to FDI within the EU if h was not a member. We infer Δ_h from the estimate in Column 2 of Table 4, according to which an increase of the FDI restrictiveness index from 0 to 1 translates into a decrease of 0.603 log points in $\bar{\eta}_{ih}$. Therefore, if an EU member state h has an index of ind_h, its counterfactual inward wedges will be set to $\exp(\log \bar{\eta}_{ih} - 0.603 \times \text{ind}_h)$, for $i \in \text{EU}, i \neq h$. As the index is available for only a subset of the sample years and does not vary much over time, we use time-invariant ind_h from 2003, the year with the best coverage among the earlier part of our sample period.

Table 6 reports the main findings of this exercise. To isolate third-country effects, we conduct the experiments for one country at a time. Panel A is for the three countries in our sample that joined the EU in 2004; their inward FDI return wedges are altered as described above for 2004-2012. Panel B is for the countries that were in the EU throughout the period of 2001-2012; their inward FDI return wedges are altered for the entire period. The first and second columns report the increase in inward FDI stock and wage due to EU membership, respectively, averaged over 2004-2012 for countries in Panel A and over 2001-2012 for countries in Panel B.

On average, openness induced by EU membership increases the stock of inward FDI by 7.5%. The effect varies by how restrictive a country is toward foreign firms. For example, with a high restrictiveness index (0.15), Austria sees the biggest increase in FDI; the increase in the neighboring Czech Republic, which was quite open to begin with (with an index of 0.046), is more modest.

The inflow of foreign investment pushes up the local wage. The average wage gains among all countries are 0.37%. This estimate has the same order of magnitude as the welfare effect of the integration in goods and labor markets within the EU (Caliendo et al., 2021), so the increase in firm mobility is an important mechanism for EU to increase worker welfare.

Comparison to the neoclassical view of FDI. It is instructive to compare our estimates to those of alternative views of FDI. Since in quantification we have assumed a perfectly integrated world bond market, *ex-ante*, the neoclassical view of FDI centering on capital flows would predict that an increase in $\bar{\eta}_{ih}$ has no impact on the wage in host country h. Ex-post, if the increase in capital use in production due to the abolition of restrictions on EU firms can be measured, then equation (12) can be used to infer the effect on wage. However, without a measure for how openness affects the aggregate productivity, the inferred effect on wage would still be biased.

To gauge the size of this bias, we report the contribution of capital inflows to wage gains based on equation (12). On average, the change in capital use accounts for 70% of the wage gains. This share is lower in new member states, where the productivity gaps between domestic firms and foreign entrants are larger, and hence the host benefits more from the technological channel. On

Table 6: Inward FDI and the Wage Gains from EU Membership

	(1) Impact on FDI in stocks (%)	(2) Wage gains (%) Benchmark	(3) Contribution from changes in K_h (%)	(4) No-FDI – Benchmark as % of Benchmark
Panel A: Countries Joining the EU in 2004				
HUN	6.5	0.40	60.4	20.0
POL	14.7	1.09	38.4	11.7
CZE	2.4	0.08	42.1	15.6
Panel B: Countries in the EU before 2001				
AUT	24.7	0.56	73.9	24.1
BEL	7.8	0.78	91.2	-1.2
DNK	6.2	0.16	76.0	28.1
FIN	4.7	0.16	67.3	25.5
FRA	9.4	0.26	61.3	32.4
DEU	4.5	0.11	50.5	32.3
IRL	5.6	0.86	123.6	-2.1
ITA	10.4	0.10	70.2	49.6
NLD	2.4	0.44	106.8	-14.4
PRT	1.5	0.03	66.9	48.9
ESP	4.3	0.08	65.4	30.1
SWE	10.4	0.55	77.8	16.6
GBR	4.7	0.30	71.6	6.7
Mean	7.5	0.37	71.5	20.3

Note: The impact of EU accession on a country is calculated as the change from the counterfactual where the country imposes additional restrictions on FDI from within the EU. For countries that joined the EU in 2004 (Panel A), the impacts are averaged over 2004-2012; for countries that joined EU before 2001 (Panel B), the impacts are averaged over 2001-2012. Column 4 reports the difference in inferred wage gains between the no-FDI model and the benchmark as percentages of the benchmark gains (Column 2).

the other hand, in Ireland and the Netherlands, this share exceeds 100%. This can happen if the allocative efficiency of the host economy deteriorates due to the entry of foreign firms.

Comparison to technology-based MP models without FDI. We also compare our model to a technology-based model of MP, extended to incorporate capital accumulation. This alternative departs from the benchmark model in two main aspects: 1) λ_i and μ_h are set to infinite; 2) each firm chooses at most one host country,[32] and their production function, altered as below, features a return to scale of $1-\varphi$ in k and l, with φ being the share of firms' knowhow as a fixed input:

$$y = z_{ih}^{\varphi}(k^{\alpha}l^{1-\alpha})^{1-\varphi}, \varphi \in (0,1).$$

With the first departure and the maintained assumption of an integrated world bond market, the shadow prices of internal and external capital are equalized and FDI is no longer essential for affiliate production. In this sense, it is a model 'without FDI.' The second departure ensures a well-defined firm size distribution in this model.

As described in Appendix B.3, this model can be calibrated to the same bilateral MP and capital accumulation decisions as in the benchmark model. Moreover, with appropriately chosen

[32] In the benchmark model, firms choose optimally to produce in one host country; in this alternative model, this needs to be imposed as an assumption as there is no internal market that restricts the number of projects in a firm. This restriction ensures that the alternative model is statically isomorphic to the benchmark model.

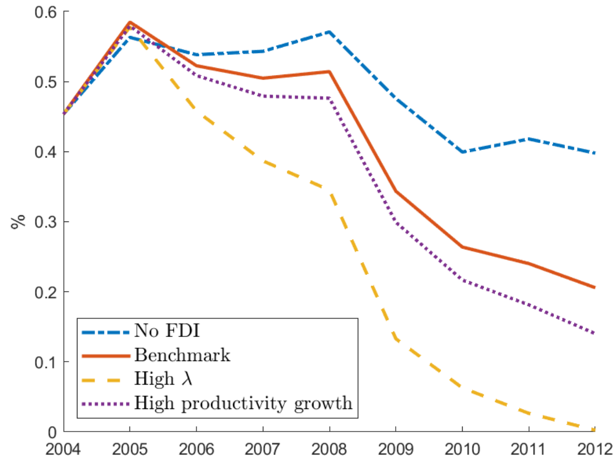


Figure 7: Wage Gains in Benchmark and Other Models: Hungary's Accession to the EU in 2004
Note: The figure depicts Hungary's wage gains from increasing inward FDI due to EU accession. 'Benchmark' refers to the benchmark model. 'No FDI' refers to the alternative model without FDI. 'High λ' refers to a different calibration of the benchmark that raises λ_{HUN} in every period by 2 s.d. of λ_i across countries (0.76); 'High productivity growth' refers to a different calibration of the benchmark that raises the annual productivity growth rate of Hungary in every period by 2 s.d. of the productivity growth rates across countries (5%). The change in inward wedges induced by EU accession in alternative calibrations are chosen so that alternative models imply the same wage gains in 2004 as the benchmark.

parameters, for counterfactual changes not big enough to affect the world interest rate, this calibration implies the same mapping from the change in MP share to the *static* wage gains as in the benchmark model. However, without an active role for the internal capital market, it does not feature the dynamic mechanisms via the MP-FDI nexus highlighted by Proposition 3. The difference between the two models, calibrated to the same data, therefore informs us the importance of such dynamic mechanisms in determining wage gains.

We report in the last column of Table 6 the differences in the inferred wage gains from the benchmark model to the alternative model as percentages of the benchmark wage gains. These differences vary widely across countries, ranging from -14% to $+50\%$ of the benchmark wage gains. For 13 of the 16 countries, the alternative model overestimates the gains. Such tendency to overestimate the gains stems mainly from the home bias in direct investment. In the presence of the home bias, a reshuffling of profits to foreign firms due to past openness can reduce current investment if internal capital is crucial for investment—as is the case of the benchmark model—but it would not have a dynamic effect in the alternative model in which firms can entirely rely on external finance for production. For most countries, this home bias effect is dominant and leads to a positive bias in wage gains inferred by the alternative model. For Belgium, Ireland, and the Netherlands, the home bias effect is dominated by other dynamic forces elaborated in Proposition 3, such as profits being reshuffled to foreign firms with higher productivity growth or better access to external finance, so the alternative model infers lower gains.

To more closely compare the models with and without FDI, Figure 7 depicts their dynamic

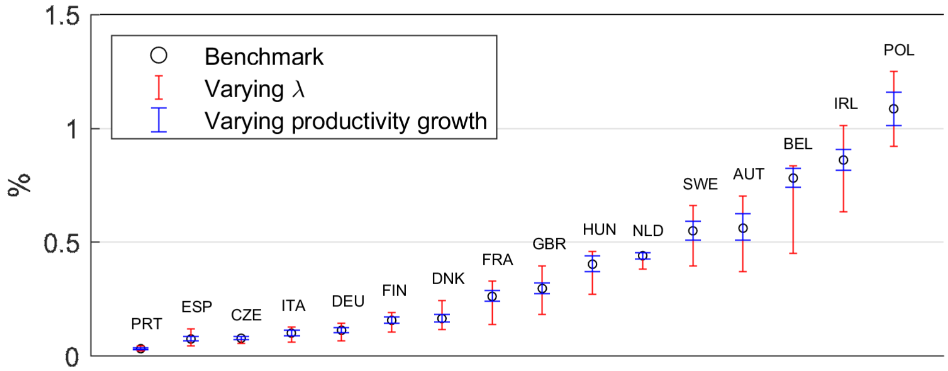


Figure 8: Wage Gains from EU Accession under Counterfactual Country Fundamentals

Note: 'Benchmark' refers to the average wage gains in the baseline calibration. 'Varying λ' refers to the range of average wage gains when host country h's financial development parameter λ_h varies by 2 s.d. (0.76) in both directions. 'Varying productivity growth' refers to the range when the host country's annual productivity growth rate varies by 2 s.d. (5%) in both directions.

implications, focusing on Hungary as an example. The solid line is the wage gains inferred by the benchmark model. Hungary's wage increased by 0.45% on impact due to the EU accession. This increase climbed to 0.6% in 2005, before it slowly gave way to the dynamic mechanisms we have discussed. The dash-dotted line depicts the wage gains in the alternative model. On impact, the two models make the same prediction by design. Over time, the alternative model predicts higher gains. By the end of the sample period, the alternative model overestimates the wage gains by almost 100%. This difference shows that it is important to account for the FDI-MP nexus in welfare evaluations.

The role of host countries' fundamentals. Finally, we examine how host countries' fundamentals affect the strength of these dynamic mechanisms. We focus on the quality of financial institutions and the productivity growth of countries.

Figure 7 illustrates the importance of these fundamentals for Hungary. The dashed line depicts the inferred gains in a re-calibrated model where λ_i of Hungary is increased by 0.76 (2 s.d. of the measure among sample countries).[33] Under the new parameterization, the model infers substantially lower dynamic gains than the benchmark model, with the gap increasing over time. The dotted line depicts the counterfactual wage gains in a re-calibrated model where the annual growth rate of Hungary's fundamental productivity, $\bar{z}_i$, is increased by 5% (2 s.d. of the measure across sample countries). As shown, the inferred dynamic wage gains are also lower than the benchmark, although the difference is more modest. These findings echo the characterizations in Proposition 3 that countries with faster-growing indigenous firms—either due to faster growing exogenous productivity or enabled by a better developed financial market—tend to see lower dynamic gains from FDI entry, highlighting an important tradeoff in the design of openness policies.

Figure 8 summarizes the variation in the dynamic wages gains of all EU members as we vary their productivity growth rate and quality of financial institutions. The circles denote the average

[33] We recalibrate the proportional change in inward FDI wedges so models with alternative fundamentals produce the same static wage gains as the benchmark.

dynamic wage gains in the benchmark, corresponding to Column 2 of Table 6. The intervals denote the range of dynamic wage gains as we vary host country h's parameter λ_h from $\max\{\lambda_h - 0.76, 0\}$ to $\lambda_h + 0.76$, and the growth rate of its fundamental productivity ($\bar{z}_h$) from the benchmark by $\pm 5\%$. As indicated by the wide intervals in the figure, the inferred wage gains can vary by a factor of two as the fundamental parameters vary within their distribution among the sample countries. This, again, suggests the crucial role of countries' fundamentals in determining the dynamic wage gains.

The main message from the exercises in this section is that modeling FDI as within-firm capital transfer embedded with technology leads to quantitatively important insights on the gains from MP. Focusing on the capital component underestimates the static gains; in our particular setting, focusing on the technological component can infer correctly the static gains if wage-MP elasticities are carefully chosen, but it would still miss the dynamic wage gains and their systematic relationship with countries' fundamentals.

6 Concluding Remarks

In this paper, we have documented new three-way relationships between MP, FDI, and the financial market conditions of host and home countries. Motivated by these patterns, we integrate two distinct approaches in the studies of MNEs—focusing on either MP or FDI—into a unified quantitative framework. Through a structural accounting exercise, we show that financing factors are as important as the technological factors emphasized in existing studies for explaining *cross-sectional* MP, and a first-order determinant of its *dynamics* over 2001-2012. We further show that our model, capturing the distinction and connection between MP and FDI, leads to new mechanisms shaping the gains from MNEs' activities.

The tractable quantitative framework developed here could be the basis for several future inquiries. In terms of modeling, we have chosen to abstract from a few interesting channels, such as technological spillovers from foreign to domestic firms, and firm-level distortions other than financial frictions which are salient in many developing countries. These elements could be conveniently incorporated in our model and, combined with increasingly available micro-data, for a more comprehensive understanding of FDI. In terms of policy implications, our model points to a potentially interesting second-best interaction between financial market conditions and the optimal path of FDI policies, which future research should investigate.

Our model incorporates both FDI and portfolio investment flows (in the form of bond), but we deliberately keep the household sector simple. Extending the model to incorporate household savings would allow it to simultaneously match the dynamics of FDI and portfolio investments of both firms and households. Such extensions can then be used to study the interaction between different types of capital flows and the effects of capital control policies that treat them differently.

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