Financing Multinationals*

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Abstract

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

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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 the decisions of MNEs 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 impacts of foreign MNEs on the host economy often boil 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 the investment in affiliates is financed. As such, they 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' internal allocation of capital depends on their access to external finance, the financial conditions of countries that are overlooked in existing studies can be an important driver for FDI—hence MP. Second, as firms make FDI at least in part out of their retained earnings, which are shaped by the past MP, the interplay between FDI and MP also leads to dynamic impacts of MP absent in existing studies.

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

Several descriptive facts connecting FDI and MP to the conditions of financial markets motivate our analysis. Existing research has documented strong a positive correlation between 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 the employment of 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 being collected by national governments and multilateral agencies such as the OECD. See Alfaro et al. (2004) and the references thereto for the large empirical literature devoted to FDI.

affiliates) or focus on FDI, regarding it as a proxy for MP.[4] Our analysis differentiates between MP and FDI. Using bilateral data, we show that hosts with better financial institutions attract more inward FDI and, conditional on the *stock* of FDI, more inward MP. Home countries with better financial institutions send more outward FDI, but conditional on the *stock* of FDI, *not* more outward MP. These results are not confounded by other host and home characteristics, such as income, size, and tax rates. Leveraging a firm-level panel from Orbis, we document similar patterns for the within-firm, *time changes* in financial market conditions. These asymmetric patterns highlight the distinction as well as the connection between the operating and financing aspects of MNEs.

We rationalize these patterns by jointly modeling firms' internal capital market and their access to 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 own net worth, they can finance capital investment by raising debt in the home country and by partnering up with investors in the host country. Both forms of external finance are impeded by contractual frictions: the debt financing capacity 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. These frictions manifest themselves as financial constraints in firms' decisions: the total debt of a parent firm is constrained by its net worth, whereas the scale of an affiliate is constrained by the capital brought to the host by its parent firm, namely FDI.[5]

Our model is consistent with the data. 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. Improved home financial institutions facilitate the expansion of the most productive firms. 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. Both channels increase outward FDI but 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, the *static* wage gains of a host from *inward* MP depend on 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 it, 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. Our model encompasses two existing views

[4]In an important exception, Antras et al. (2009) show that U.S. multinational firms have larger affiliates in host economies with better financial institutions, but finance a smaller fraction of activities via FDI in these affiliates.

[5]Despite having different micro-foundations, both constraints arise due to imperfections in financial contracting, so they are more severe in countries with worse financial institutions. Over time, both constraints tend to be more relaxed when the domestic credit market is relatively slack and more tightened during times of 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.

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 (e.g., Ramondo, 2014), in which the MP share is a sufficient statistic, our model identifies a crowd-out effect in the credit market summarized by the capital use of host firms and implies lower gains.

The link between FDI and MP also leads to a new mechanism that shapes the dynamic wage gains. Opening up of a host to inward MP raises its wage but also shifts the profits from local to foreign firms. As firms differ in future productivity and the propensities to invest in the host country, such a shift can have first-order effects on the future wage of the country. 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.[6] In the latter scenario, the decrease in a period's wage due to past openness *can* outweigh the increase due to the current inward MP, so openness brings dynamic wage losses.

This dynamic mechanism has important implications for the ex-post measurement of the gains from MP. Compared to static technology-based MP models, when calibrated to the same MP shares, our model might infer higher or lower (and possibly negative) wage gains for the same period, because it incorporates the impacts of past MP on the distribution of profits which shape the size and productivity distributions of firms across countries. As such impacts depend on firms' internal saving rates, their abilities to scale up internal savings which is affected by the financial constraints, and the propensities to invest internationally, the biases due to the omission of these impacts are also heterogeneous across countries.

We implement the model quantitatively to examine the importance of financing factors in the decisions of MNEs and the welfare implications of MP. Dynamic effects of the sort discussed above imply that past changes can affect the current MP. With countries connected by MNEs, openness in one country can affect all others through third-country effects. To incorporate these forces, we derive two theoretical properties of the model: analytical characterizations for firm-level decisions and tractable aggregation for country-level outcomes. These properties allow 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 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 and bilateral wedges for FDI returns. We calibrate these wedges, as well as the structural parameters that determine

[6] This mechanism is similar in spirit to the one identified in the studies on the secondary burden of international transfers (e.g., Dekle et al., 2008)—that due to the home bias in consumption, international transfers can lead to secondary impacts by altering the demands for the products of countries. Our mechanism differs in that it operates dynamically through the interaction of investment and the endogenous size and productivity distribution of firms.

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 groups of parameters to conduct three sets of counterfactual exercises.

In the first exercise, we decompose the variation in cross-sectional bilateral MP into country size, geography, factors related to technology (capturing factor prices as well as the fundamental productivity), host and home finance and their interaction with other factors, and a residual term arising from firm heterogeneity. Unsurprisingly, size and geography explains most of the variation (75%). Technological factors explains 7.4% of the variation; financing factors account for 9.4%. While less prominent than size and geography, financing factors have about the same order of importance as the technology-related factors emphasized in the 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 many countries experienced improving access to credits until 2007 in the form of gradually easing credit market conditions for both parent firms and 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 fall by 30%; on the other hand, if throughout the Great Recession, countries' credit markets had stayed at the peak level of 2007, then the cumulative global FDI flows during 2008-2012 would have been 35% higher than 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.

In the last set of exercises, we study the static and dynamic wage gains from inward FDI. To this end, we move each country from the calibrated transition path over 2001-2012 to a counterfactual transitional path without inward FDI. We highlight two main findings. First, both technology and capital components of FDI are important in accounting for the wage gains. In our static decomposition, of the average 9% wage gains from inward FDI among the sample countries, about half realizes through the increase in capital stock in production, while the remaining is due to the improvement in technology. Second, because foreign firms make the majority of their investment at home, the dynamic wage gains are lower than the static wage gains. Heterogeneity across countries notwithstanding, the average of the dynamic wage gains over 2001-2012 for a typical country is around half of its period-by-period static wage gains calculated using the static version of our model, pointing to a sizable bias due to the omission of the dynamic mechanism. 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 for most, 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; Garetto, 2013; Ramondo, 2014; Fillat and Garetto, 2015; Alviarez, 2016; Cravino and Levchenko, 2016; Tintelnot, 2016; Arkolakis et al., 2018; Alviarez et al., 2021). Our contribution is to develop a tractable framework that combines 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 dynamic effects of these activities, a unified model of FDI and MP is needed.

The premise of our model builds on the findings of existing studies—that affiliate operation depends on financing from both the host financial market (Bilir et al., 2019) and the parent (Alfaro and Chen, 2012), and that a crunch in the home credit provision leads to a sharp decrease in outward FDI (e.g. Peek and Rosengren, 2000; Klein et al., 2002). The specific mechanism of our model linking host finance to inward FDI and MP is most closely related to Antras et al. (2009), who show theoretically and empirically that the quality of host financial institutions can affect the financing of the affiliates and, through it, 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 touches on 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 structural accounting exercise is similar in spirit to Eaton et al. (2016) and Kehoe et al. (2018) in that we first use the model to fully rationalize the data, before proceeding to counterfactual experiments. Different from these works, 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 wedge accounting exercise of an incomplete market 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 Relationship Between MP, FDI, and Financial Market Conditions

In this section, we document three-way relationship between MP, FDI, and the financial market conditions of host and home countries, exploiting cross-sectional variation from bilateral data and time variation from a firm-level panel. We describe our main data sources 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 FDI and MP 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.[7] Both measures are averaged over 1996-2001. We supplement the data with a number of country characteristics, such as their income, business tax rate, policy restrictions on FDI, and the indices for the quality of financial institutions, all averaged over the same period. We use this dataset to document cross-sectional relationship between the quality of financial institutions and MP, and the role of FDI in mediating this relationship.

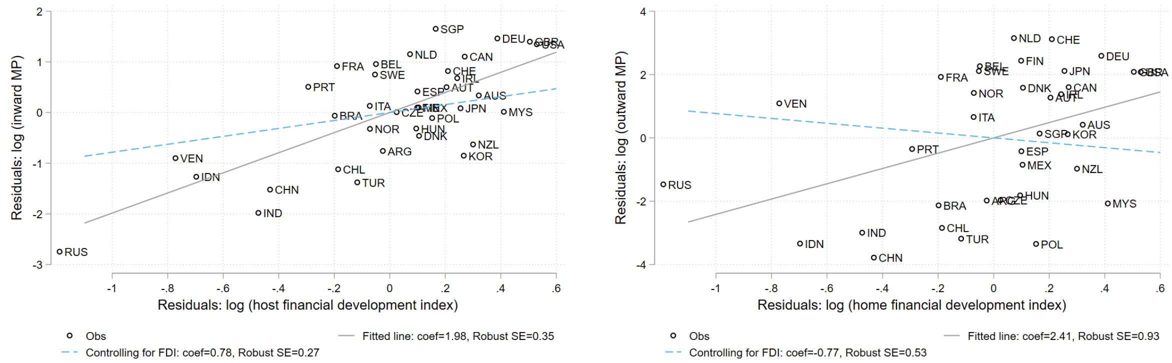
Firm-level MP. Our firm-level evidence is based on a panel dataset covering the period of 2001 to 2012, extracted from the Orbis database. Our data include standard accounting items such as the sales (turnover) and total asset of individual firms, and the ownership network that allows us to link these firms to their 'global ultimate owner', i.e., their parent firm. After standard cleaning procedures detailed in Appendix A.2, we arrive at a firm-level panel that contains information on MNEs and their affiliates in different hosts.

This firm-level panel allows us to examine how the sales 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 parent financing in the responses, we also need information on firm-level FDI. A shortcoming of the Orbis database, however, is that it does not contain detailed enough information on the *compositions* of firms' balance sheets for measuring firm-level FDI: in most cases, we observe only the majority owner of a firm, but not how many shares it owns; we also cannot separate the loans extended to an affiliate by its parent from those from other sources. To make progress, we will leverage a newly assembled dataset on bilateral FDI stock between 2001 and 2012 to construct two proxies—in the spirit of the 'shift-share' instrumental variable—for firm-level FDI.

Measures of financial market conditions. Our empirical analysis exploits cross-sectional and over-time differences in the condition of financial markets. Across countries, differences in contractual frictions and the protection of investors lead to the variation in the difficulty in 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 law and regulations by legal practitioners (Djankov et al., 2007). It is the sum of two separate measures, on 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 likely remains 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 conditions (e.g., Buera et al., 2015), we use the variation in the total credit made to the domestic private sector, obtained from the World Bank Database, as a proxy for the time changes in this access.

[7] Ramondo et al. (2015) provide both raw and imputed MP data. All our exercises use 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 (blue dashed line) and without (black dots 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 (blue dashed line) and without (black dots and the solid line) controlling for outward FDI. Both the fitted line and the circles are after netting out the effect of country size.

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 how we select this sample.

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 dots are the residuals in inward MP and host financial development index, respectively, netting out the effect of host size (log GDP). The solid line is the fitted line, which shows 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 blue dashed line is the best fitted line when the logarithm of inward FDI stock is 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. But its slope is still positive, suggesting that the higher MP in hosts with good financial institutions cannot be entirely accounted for by the FDI in these countries.

The right panel plots the quality of home financial institutions against *outward* MP. As before, the dots are the residuals of the two variables after netting out the logarithm of home GDP, the solid line is the line that fits the dots, 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 robust positive correlation between FDI/MP and the financial development of both host and home countries, treating FDI and 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 both host and home financial development is correlated with MP, the correlation of the latter is only through FDI. This asymmetry highlights the distinction between FDI and MP and calls for a model that incorporates jointly 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 key patterns in Figure 1 are robust to the inclusion of confounding factors such as a country's productivity, FDI polices, 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 the quality of financial institutions index into its two components and show that it is the protection of credits' legal right, 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 the credit information. On the other hand, the protection conferred to creditors by the legal system might help MNEs as well as local firms secure external finance. Second, using the U.S. Bureau of Economic Analysis (BEA) public-use data that cover American MNEs operating abroad and foreign firms operating in the U.S., we show that the same patterns hold when wage bill is used to measure affiliate production. This alleviates the concern that our estimate is contaminated by the mis-reporting of sales due to the tax avoidance motive. Third, we use the BEA data to show that the asymmetric correlation between MP and financial market conditions operates through the size of the affiliate balance sheet and affiliate 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 a strong connection between the quality of financial institutions and the activities of MNEs and the central role of FDI in mediating the relationship. However, with cross-sectional variation alone, identification requires strong assumptions. To strength the identification, we now turn to the firm-level panel. The time dimension of the data will allow us to purge out unobserved time-invariant country characteristics; the granularity of the data means we can control for firm characteristics and shocks that are common to all affiliates within a firm through firm-year fixed effects.

Specification. We estimate variants of the following specification:

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

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 condition in year t in the origin country $o(i)$ and host country $d(i)$ of affiliate i. In the absence of direct measures on the overall credit availability, we use the logarithm of the total credit extended to private enterprises as a proxy. Although this proxy is widely used in the literature, a natural concern with it is that the total private credit is an equilibrium outcome that captures not only firms' access to, but also their demand for, external finance, which can respond to the overall economic conditions that are potentially correlated with the shock to the credit market. 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 might also be influenced by the fluctuations in the exchange rates or the conditions in their home country. We will purge out these demand side factors through firm- and country-level controls.

Our third variable of interest is $\log \widehat{\mathrm{FDI}}_{i,t}$, a proxy for the stock of direct investment from the parent in affiliate i. 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 $FDI_{o(i)d(i),t}$ the bilateral FDI stock between country $o(i)$ in country $d(i)$ at period t. Our first proxy for direct investment in an affiliate i is constructed as:

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

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 of home country $o(i)$ located in host country $d(i)$. This formula essentially proportionally distributes the FDI between $o(i)$ and $d(i)$ to different affiliates in $d(i)$.[8] In the Appendix, we also report results based on an alternative proxy of $\log \widehat{\mathrm{FDI}}_{i,t}$, constructed as a nonparametric function of $\log(K_{i,t-1})$ and $\log(FDI_{o(i)d(i),t})$. This alternative has the advantage of allowing firm-level FDI to depend arbitrarily on affiliate size and bilateral FDI.

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—as well as those of origin and destination countries. To the extent that some time-varying characteristics might be correlated with both the shocks to the credit market and affiliate production, we directly control for them in $X_{1,o(i)t}$, $X_{2,d(i)t}$, and $X_{f(i)t}$, representing origin country, destination country, and firm-level controls, respectively.

Results. Columns 1 through 4 of Table 1 report the relationship between home country credit shock and affiliate sales. The first column reports the raw correlation after controlling for affiliate fixed effects and host-year fixed effects, which absorb time-invariant firm characteristics and time-varying host characteristics. We find the elasticity of affiliates sales in home country credit volume to be 0.08, a sizable and statistically significant estimate.

As discussed earlier, changes in home credit market conditions can be correlated with other

[8] All results are similar if we use instead the contemporary size.

Table 1: Credit 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. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

home country shocks that may directly affect affiliates' demand for external finance. Likely candidates for these shocks include the home TFP and terms of trade shock. Column 2 controls for these two shocks and shows that their inclusion does not change the estimated elasticity materially. In the third column, we further include the sales of the parent firm in the regression. This control serves two goals. 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—in fact, it is plausible that these shocks affect the affiliate through their impact on the parent. Parent sales thus serves as a proxy for these shocks. Second, this control can also capture the direct impact of parent's own productivity shock on affiliate sales (e.g. Cravino and Levchenko, 2016). If any, the coefficient of credit shock increases slightly with this control.

In the fourth column, we include the proxy for firm-level FDI. The proxy has a positive and statistically significant coefficient, whereas the coefficient for home credit shocks shrinks to zero, in accord with the aggregate evidence documented in Section 2.2. This is despite possible measurement errors in our proxy for the firm-level FDI, 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 reports 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 reports the result from a specification with these fixed effects as the only controls. Column 6 controls for host TFP and terms of trade. These controls do not change our finding qualitatively. Finally, we include the proxy for direct investment to affiliate i in period t. Doing so diminishes the coefficient of host credit shocks by one third, but it remains sizable and statistically significant.

Robustness. In Appendices 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 with a post-crisis dummy, which takes a value of one for years after 2007. We find that the interaction terms are very small, indicating that the patterns documented above are not due to the 2007 financial crisis alone. Third, we show 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, conditional on FDI, 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 discuss the main theoretical results. Proofs, extensions, and micro foundations 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 $i \in I$. 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 also 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 the company and interpret c as the compensation of the CEO,[9] or think of c_t as dividend payouts and the curvature in $u(c_t)$ as capturing the dividend smoothing motive.

[9] CEOs of large corporations are usually incentivized through stock options and bonus. For example, Google CEO Sundar Pichai made \$100.5 million in 2015, among which 99% 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 CEO would be largely aligned with that 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.

Firms differ in their productivity $z \in (0, \infty)$, which follows Markov processes with country-specific conditional density $f_i(z'|z)$. Firms can operate affiliates in different countries—including their home country—to produce a homogeneous good.[10] 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 this affiliate. Affiliate productivity increases in the productivity of its parent but also depends on the host in which it operates. Formally, we assume $\forall h \neq i, z_{ih} = \tilde{z}_{ih}(z)$, with $\tilde{z}_{ih}(\cdot)$ being an increasing function. As normalization, $\tilde{z}_{ii}(z) = z, \forall i$, so z is the productivity of the affiliate operated in the home country.

3.2 Affiliate Finance and Production

Affiliates hire labor in competitive host country labor markets and finance their capital usage with the funds from both the parent firm and local investors. Because of the financial frictions at the corporate level, described below, when the shadow price of internal capital is higher than the local cost of finance, parents have the incentive to increase the use of the fund from the host country, via either local debts or equity. Regardless of the instruments used, however, imperfections in the financial market limit the extent to which a parent can rely on the host external finance.

Given our focus on the 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^F be the amount of external funding raised in host h, formally, the assumption states that $b^F \leq \mu_h \cdot e_h$, with $\mu_h > 0$ determining the maximum leverage that the affiliate can obtain in the host country.

Denoting the wage and net interest rate in host h by w_h and r^b_h respectively, for given e_h, the parent firm makes the affiliate financing and production decision to maximize the return from their investment:

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

Micro-foundations. Although parsimonious, inequality $b^F \leq \mu_h \cdot e_h$ in (3) encompasses three

[10] Since output is a homogeneous good, there is no scope for trade in our model. Appendix B.5.1 shows that our setup is isomorphic to an environment with the 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 development. In that alternative 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.

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, also our preferred, view, is to see the constraint as from the moral hazard problem in the transfer of the production technology from the parent to the affiliate. We micro-found this setup in Appendix B.3.1. In the model, as the owner of the technology, the parent firm needs to exert efforts, which are non-contractible, to ensure the success of affiliate operation. For such efforts to be incentive compatible, the parent needs to have sufficient stake in the affiliates, i.e., $\frac{e_h}{e_h+b_F}$ cannot be too low. Thus, the exact reason why 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.[11]

The second view of the setup recognizes the fact that FDI often takes the form of the acquisition of a local firm by a foreign firm, resulting in a joint venture receiving technology and capital inputs from both partners. In Appendix B.3.3, we develop a model of merger and acquisition that highlights a key tradeoff faced by the foreign firm between the size of the joint venture and its control over it. Intuitively, given e_h, an increase in the stakes of the local partner b_F dilutes the control of the foreign parent, so the productivity of the joint venture is lower than when the foreign parent has the full control. We show that in a special case of the M&A model, this tradeoff leads to a constraint on the stakes of the local partner in the form of $b^F \leq \mu_h \cdot e_h$.

Lastly, this setup can also been seen as the conventional collateral constraint in the macro literature. Under this view, b_F is the total debt of the affiliate, which is constrained by total asset the parent brings to the host country because of a limited enforcement problem in bankruptcy.

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 temporal changes in firms' access to external finance. When there is no confusion, we will refer to b^F as debt from the host country, but we will interpret it more broadly as capturing the total stakes held by the local partner—be it a bank or equity investor—and will pin down μ_h using data that include both equity and debt.

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 extortion by corrupted foreign officials (Wei, 2000) or expropriation by foreign governments (Thomas and Worrall, 1994). To capture these frictions, we assume that the parent receive 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.[12] 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

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

[12] We specify the iceberg wedges as for affiliate returns instead of affiliate productivity 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 in many heterogeneous firms models of MP, productivity and return wedges are isomorphic, in our model they are different since affiliates' operation decisions are not a homogeneous function of productivity.

that is i.i.d. across parents and affiliates. The literature has documented higher productivity for MNEs and rationalized this with a fixed cost of setting up affiliates so that the average return from opening up foreign affiliates increases in productivity (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 realizations of the return shocks from all potential hosts, $\boldsymbol{\eta} = (\eta_{i1}, \eta_{i2}, ..., \eta_{iN})$, firms decide whether to produce or stay idle. Idle firms loan out their net worth a at the market interest rate. Active firms further choose whether to scale up on their net worth through borrowing, and in which host country to invest.

The interest rate for lending and borrowing in country i is denoted by r_i^b. 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 cannot exceed λ_i fraction of the parent firm's retained earnings/net worth. As discussed in the micro-foundation in Appendix B.3.2, this constraint arises in an environment of endogenous bond pricing in the presence of limited enforcement in debt repayment, and could be alleviated by improvements in either the financial contracting environment or the credit market conditions. The total fund at the parent, $a + b^H$, will then be allocated to affiliates to maximize return.

Formally, the Bellman equation for the value function of firm owners from country i reads:[13]

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

The first constraint says that the funds allocated to affiliates should sum to net worth plus debt 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; (2) funds raised by an active parent firm cannot exceed the limit imposed by the collateral constraint. $\tilde{R}_{ih}(z, e_h)\eta_{ih}$ in the third constraint denotes the net return from investing in host country h, which is net of wages, payment to *host* country investors, and the component melt when repatriated. This constraint says that the total repatriated profits from

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

affiliates are split among financing costs, the current consumption, and the future net worth a'.

Problem (4) involves the joint decision of capital accumulation and investment allocation among host countries. The incomplete-market setting, while natural, means that we need to solve for the decisions of firms in each country at all possible $(z, \boldsymbol{\eta}, a)$ states and aggregate these decisions, which is in general a daunting task. Below we first characterize affiliate- and firm-level decisions analytically, and then prove some 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 for individual affiliates, specified in equation (3). Lemma 1 summarizes the results.

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

$$
\begin{aligned}
R_{ih}(z) = \max_{\hat{b}^F, \hat{k}, \hat{l}, \hat{y}} \; & \hat{y} + (1-\delta)\hat{k} - w_h \hat{l} - (1 + r_h^b)\hat{b}^F, \\
s.t. \quad & \hat{y} = [\tilde{z}_{ih}(z)\hat{k}]^\alpha \hat{l}^{1-\alpha} \\
& 0 \le \hat{b}^F \le \mu_h \\
& 0 \le \hat{k} \le 1 + \hat{b}^F.
\end{aligned} \tag{5}
$$

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

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

with the cutoff z^*_{ih} determined implicitly by $\pi_h(z^*_{ih}) = 1 + r_h^b$, and $\pi_h(z_{ih})$ defined as:

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

Under the solutions, $R_{ih}(z) = \pi_h(z_{ih})[1 + \hat{b}^F_{ih}(z)] - (1 + r_h^b)\hat{b}^F_{ih}(z)$.

This lemma exploits 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 Problem (3) is linear in e_h, so the *affiliate*-level total return is simply the return to each unit of investment times total investment, with the unit-investment return given by the solution to Problem (5). A direct implication of this result is that firms will only invest in their most profitable affiliates.

The second part of the lemma shows that, first, affiliate decisions are linear in e_h. Second, affiliate decisions follow a cutoff rule in the productivity: affiliates whose productivity are above the threshold z^*_{ih} will leverage the funding from local investors and produce at full capacity; affiliates whose productivity are 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 borrowing, $1 + r^b_h$, and the return from an additional unit of capital, given by $\pi_h(z_{ih})$. The selection channel as in the Melitz model operates here: as the wage goes up, the cutoff increases, so fewer active affiliates will seek finance from host investors for expansion.

Lemma 1 gives an explicit expression of $\tilde{R}_{ih}(z, e_h)$, the investment return in equation (4). To characterize firm's dynamic decisions, we make the following functional form assumption:

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*

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

with R_{ih} defined in Lemma 1. The policy functions for consumption and investment satisfy

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

$$\textit{where} \qquad R^a_i(z, \boldsymbol{\eta}) = \begin{cases} [\max_{h'} R_{ih'}(z)\eta_{ih'}](1 + \lambda_i) - (1 + r^b_i)\lambda_i, & \textit{if } \max_{h'} R_{ih'}(z)\eta_{ih'} \geq 1 + r^b_i \\ (1 + r^b_i), & \textit{if } \max_{h'} R_{ih'}(z)\eta_{ih'} < 1 + r^b_i, \end{cases} \tag{7}$$

The first part of the lemma characterizes the lending/borrowing decision. If $\max_{h'} R_{ih'}(z)\eta_{ih'} > 1 + r^b_i$, i.e., the shadow value of capital is greater than the interest rate, the firm borrows to scale up; otherwise, it stays idle and lends the net worth to other firms. The unit shadow value, which is the net return from the most productive affiliate, could be high either because the firm is productive or because it gets a lucky η_{ih} draw (recall $\eta_{ih} = \bar{\eta}_{ih}\zeta_h$ with ζ_h random). Because this unit shadow value is size-independent (see Lemma 1), when a firm chooses to scale up, it will max out the credit available, $\lambda_i \cdot a$.

$R^a_i(z, \boldsymbol{\eta})$ in the second part of the lemma denotes the return to net worth a, which depends on whether a firm is active. The return for an active firm takes into account the fact that the firm can lever up on a. The lemma then shows that firms reinvest a fixed fraction β of its end-of-period total earnings $R^a_i(z, \boldsymbol{\eta}) \cdot a$ and use the remaining 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 the idiosyncratic draws $(\zeta_h)_{h=1}^N$ has resolved. Keeping track of the 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:*

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

This distribution is the special case (when $\rho = 0$) of the multivariate distribution in Arkolakis et al. (2018).[14] 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 an extensive-margin entry decision that is dependent on the realization of $(\zeta_h)_{h=1}^N$.[15]

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

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

The CDF for $\Xi_i(z)$, denoted by $H_i(\xi|z)$, is then given by:

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

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

Because all ζ_h draws are no smaller than 1, the support of $\Xi_i(z)$ 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 $\Xi_i(z)$ is a Pareto distribution with a lower support of $\tilde{R}_i(z)$, the CES aggregated value of host-specific returns.[16] At $\overline{R}_i(z)$ is a mass point with measure $1 - \frac{\tilde{R}_i(z)}{\overline{R}_i(z)}$. This measure is zero if and only if $\bar{\eta}_{ih'} R_{ih'}(z) = \bar{\eta}_{ih} R_{ih}(z), \forall h, \ h'$.

With $H_i(\xi|z)$, we derive the *aggregate* investment decision and the return on net worth among firms with productivity z under two scenarios. The first is for firms whose productivity z is such

[14] 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 $\rho = 0$.

[15] That is, these shocks only matter if firms decide to be active; and firms only decide to be active, if the most profitable affiliate generates higher net return than risk-free bonds (see Lemma 2). A commonly used alternative in international trade for analytical aggregation is to assume that $(\zeta_h)_{h=1}^N$ are drawn from the Frechet distribution (see Eaton and Kortum, 2002). The cutoff in the policy function renders the Frechet assumption intractable.

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

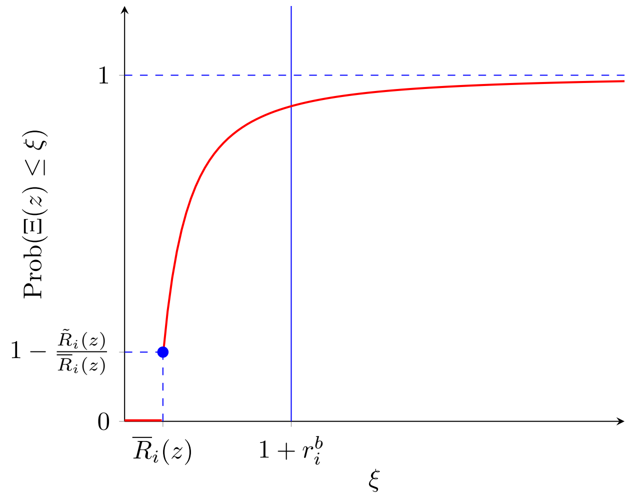


Figure 2: The CDF for $\Xi_i(z)$

that $\overline{R}_i(z) < 1 + r_i^b$. This is the case illustrated in Figure 2. Firms will stay active if and only if the realization of $\Xi_i(z)$ falls to the right of the vertical line. The Pareto tail allows us to derive the probability of engaging in active production and choosing each destination, and the associated expected returns. The second is for when $\overline{R}_i(z) \geq r_i^b$, in which case firms will always be active and we need to account for the firms at the mass point.[17] We have Lemma 3.

Lemma 3. *Among the set of firms with productivity z,*

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

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

The fraction 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 the net worth of 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 1. Expressions for $\hat{e}_{ih}(z)$ and $\mathbb{E}[R_i^a(z, \boldsymbol{\eta})|z]$ can be derived analogously (see Appendix B.2.4).*

[17] 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 option is not viable for us because the parameters govern selections are equilibrium outcomes in our model. Nevertheless, we show that the decisions of the firms at the mass point can be characterized analytically.

Lemma 3 reduces the aggregate state of the economy from the distribution over $(z, \boldsymbol{\eta}, a)$ in each country to the distribution over (z, a). Moreover, since firms' decision are linear in their net worth, we can further reduce the aggregate state into the net worth distribution over productivity in each country.[18] Formally, let $\Phi_i(z, a)$ be the joint probability density of firms' productivity and net worth in country i, and $\phi_i(z)$ be the total net worth in the hands of firms in country i with productivity z, i.e.,

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

For productivity z that takes continuous values, $\phi_i(z)$ is thus a density function that describes the measure of net worth over productivity. We will hereafter refer to $\phi_i(z)$ as the *wealth density function*. The transition from current $\phi_i(z)$ to future $\phi_i'(z)$ is implied by the exogenous productivity process and the policy functions of firms' investment and internal saving decisions, and is shown to satisfy the following equation (Appendix B.2.2):

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

where $\mathbb{E}[R_i^a(z, \boldsymbol{\eta})|z]$ is the expected (over $\boldsymbol{\eta}$) return on net worth for parents with productivity z, characterized in Lemma 3. 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 total equity invested by firms with productivity z from home i to host h is then:

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

$\psi_{ih}(z)$ takes into account the fact that active parent firms can borrow in the home country for overseas investment, as characterized in Lemma 2.

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

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

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

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

[18] Log utility function (Assumption 1) is *not* crucial for this result. We show in Appendix B.5.2 that similar reductions—hence the tractability of our model—generalize to the more general constant relative risk aversion utility, although in that case the firm-level investment decision does not admit closed-form solutions.

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

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

Finally, 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 $(\Phi_{i,t=0}(z,a))_{i\in I}$, a sequential equilibrium is a sequence of (a) wages and interest rates, (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 firms' problem; (ii) labor and bond markets clear in each country; (iii) the densities of firms are consistent with the transition implied by the firms' policy functions and the exogenous productivity processes. 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. The following proposition connect two measures of the activities by multinational firms—FDI and MP, defined in Section 3.5—with the financial market conditions of host and home countries.

Proposition 1. *For every (i,h) at any period t*

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

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

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

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

Equation (10) clarifies the relationship between bilateral FDI and the quality of host and home financial institutions. An increase in μ_h, which could happen either because country h has become financially more developed or because it has experienced a credit boom, increases the return to investment from country h (i.e., $R_{ih}(\bar{\bar{z}}_i)$), which leads to an increase in $[FDI]_{ih}$.

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

$(1+\lambda_i)$. Second, in the presence of firm heterogeneity, it also triggers reallocation of market shares towards 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 increase the wage and interest rate in country i (i.e., $R_{ii}(\bar{\bar{z}}_i)$ decreases), which pushes firms to invest abroad. Finally, with better access to finance, productive firms will be able to accumulate capital faster. If productivity is persistent, the reallocation increases the *future* aggregate wealth (W_i), resulting in a higher level of outward FDI.

Equation (11) further links FDI and other fundamentals to MP. Conditional on $[FDI]_{ih}$, 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 would not have a direct effect on Y_{ih}—it only affects Y_{ih} through the average productivity of firms $\tilde{z}_{ih}(\bar{\bar{z}}_i)$. Both predictions are consistent with the empirical facts.

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

3.8 The Static and Dynamic Gains from MP

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

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 we show in Appendix B.2.6, the effect of any policy on the real wage can be summarized (ex-post) as:

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

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 capital-weighted productivity of all firms active in host h. $\Delta \log(K_h)$ is the change in the capital utilized in production in country h. Thus, in our model, the openness of a host h to inward FDI benefits workers through two channels: by improving the productivity distribution of a country, and by increasing capital utilization.

These two channels encompasses 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 $\Delta \log(K_h)$, 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 the domestic factor prices.

Our model also connects to the technology-based models of multinational firms. In this class of models, the MP share (the share of production by foreign firms) is often the sufficient statistic for the ex-post evaluation of the wage gains (see, e.g., Ramondo, 2014). To facilitate the comparison, in the following proposition, we make an additional parametric assumption so the wage gains are a function of the MP share:

Proposition 2. *Assume that the wealth share distribution in period t for host country h (i.e., the distribution with density $\hat{\phi}_i(z)$ defined in Section 3.5) is Pareto with a tail index $\gamma > 1$ and that outward FDI from country h is restricted,*[19] *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 and $\frac{K_{hh}}{W_h}$ is the share of domestic wealth used by domestic firms.[20]

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 the host labor productivity. Conditional on the MP share, the dependence of foreign affiliates on parent versus host external finance also matters, as such dependence determines the crowd-out effect of foreign firms in the host credit market. This force is reflected in $\Delta \log\left(\frac{K_{hh}}{W_h}\right)$. Intuitively, if a big part of affiliate production is financed through FDI, or if foreign firms achieve their production through superior technologies that use little domestic factors, then more wealth of the host country will be channeled into 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.[21] Conversely, if foreign production use heavily factors from the host, the wage gains would be lower.

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

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

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 positive, equation (14) shows that focusing only on the MP share leads to an overestimation of the wage gains. Only when country h is a small open economy is the MP share a sufficient statistic for inferring the wage impacts. 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.[22]

[19] A sufficient condition for $\hat{\phi}_i(z)$ 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).

[20] 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.

[21] Because the strength of this force depends crucially on domestic firms' willingness (their productivity) and capacity (their net worth) to expand, the assumption on the joint distribution of productivity and net worth matters. Under the Pareto distribution assumption, this channel could be entirely captured by $\Delta \frac{K_{hh,t}}{W_{h,t}}$, with the corresponding elasticity dependent on the tail parameter of the Pareto distribution γ.

[22] In our model, the elasticity for MP depends on both the capital share and the Pareto parameter that governs the joint

The dynamic versus the static gains. By shifting market shares and profits among firms from different countries and with heterogeneous productivity, current openness can affect future wages. We illustrate the mechanisms in a special case of the model, with the focal country h and $N-1$ other symmetric countries, denoted by $i = 1, ...N-1$.

Countries have time-varying fundamentals (e.g., $\lambda_{h,t}, \mu_{h,t}, \bar{\eta}_{ih,t}$) and share an integrated credit market. The productivity of firms in a country is drawn i.i.d. from a Pareto distribution with the location parameters for the focal country h and the remaining $N-1$ countries denoted by $\bar{z}_{h,t}$ and $\bar{z}_{i,t}$, respectively. We consider in this environment $\frac{d \log w_{h,2}}{d\bar{\eta}_{ih,1}}$, 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 openness. To isolate the mechanism, we further assume that $d\bar{\eta}_{ih,1}$ is relatively small and that the labor supply in foreign countries are all 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, 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, $\frac{d \log w_{h,2}}{d\bar{\eta}_{ih,1}} > 0$.*[23]

2. *Hold fixed all other fundamentals and consider a permanent openness policy in country h, modeled as an increase of $\bar{\eta}_{ih,1}$ and $\bar{\eta}_{ih,2}$ from 0 to a common value $\bar{\bar{\eta}} > 0$. 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 profit at the expense of domestic firms.[24] Whether this shift leads to a higher or lower wage in the second period depends on two forces: the marginal propensities of firms to invest their first-period profit in country h; conditional on their investment, the relative productive of domestic versus foreign firms. If domestic firms invest a sufficiently higher proportion of their profit in h than foreign firms, which could happen either because of their high saving rate (high β_h or low β_i), their good financial institutions (high λ_h or low λ_i), or geography (low $\bar{\eta}_{ih,2}$), or if domestic and foreign firms have a similar propensity to invest in h, but are sufficiently more productive in the second period, then the shift reduces the second period wage. Conversely, it increases 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. As we can see from equation (14), the policy unambiguously increases the wage of host h at period 1. Its impact on the second period wage is more subtle. To unpack the channels, we can view the policy as a combination of two changes: an increase of $\bar{\eta}_{ih,2}$ from 0 to $\bar{\bar{\eta}}$,

distribution of productivity and net worth. This is different from purely technology based model of MP, in which the elasticity is the parameter governing the heterogeneity in technology. This observation is related to the recent finding in international trade that different models might yield the same ex-post gains, but imply different theory-consistent ways of estimating trade elasticity. See, e.g., Arkolakis et al. (2012) and Melitz and Redding (2015).

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

[24] 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.

and a subsequent increase of $\bar{\eta}_{ih,1}$ from 0 to $\bar{\bar{\eta}}$. The first change unambiguously increases the wage at period 2. The subsequent change might increase or decrease the wage at period 2, as described by the first part of Proposition 3. 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 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 the imperfections in the capital market, MP cannot take place without FDI. Since FDI is at least in part financed by firms' retained earnings, changes in the market share in one period can affect future MP. This feature gives room to closeness as the second-best policy to address capital market imperfections.

Second, for firms making direct investment, different hosts are imperfect substitutes, with the elasticity of substitution governed by θ. This feature captures an important difference between FDI and portfolio investment: while the latter only seeks to maximizes the return, FDI is embedded with technology and hence governed by the 'fit' between a firm's technology and host h, captured in the idisocynratic draw η_h. With this feature, even though there would be more FDI in h in response to a decrease in its period 2 domestic investment (due to openness in the first period), the increase in FDI may not be enough to bid the wage to the level of the autarky economy. To see the importance of this feature, consider an alternative setup where FDI is treated as portfolio investment. In that setup, a decrease in the domestic investment of a small open economy will be entirely compensated 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 during a period of time from the real world data, we can calibrate our dynamic 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 static, purely technology-based MP model and perform a period-by-period calibration to infer the gains for each point in time. The above discussion suggests that, by overlooking the dynamic effect of openness on the size and productivity distribution of firms, the estimates based on second exercise are biased and can have the wrong sign, with both the sign and the size of the bias varying across countries according to their fundamentals. We will examine the importance of such biases in Section 5.

3.9 Discussion of Model Assumptions and Extensions

Before proceeding to quantification, we discuss the rationale of some model assumptions and the implications if they are relaxed. One of the key assumptions is that firms face short-run financial frictions, so the shadow value of capital differs from the cost of external credits. This allows the model to speak to the 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 that whether MNEs, which are typically listed conglomerates, still face financial constraints at their headquarters. In reality, even though these firms can borrow from banks or the bond market, as their leverage increases, the default risk and agency cost usually lead to a higher cost of borrowing (see Corbae and D'Erasmo, 2021 and the reference therein for quantitative models with this mechanism). Our parent financing model block captures this idea parsimoniously, as it arises as the equilibrium outcome of a model with firm default and endogenous bond pricing (Appendix B.3.2). We also wish to note that the model only restricts the short-term debt-equity ratio. Productive firms can still expand by accumulating more equity and leveraging it to borrow more. Ultimately, our channel will be active, as long as firms make some investment out of their retained earnings.

The way in which we introduce the financial frictions, while somewhat ad hoc, has received considerable 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 the Japanese overseas investment via reduced bank lending; Chaney et al. (2012) document a decrease in activities among U.S. listed companies whose value of collaterals were hit during the Great Recession. Moreover, this set up has been widely used in quantitative models to examine the role of financial shocks in business cycles (Buera et al., 2015).

An additional implication of the model, arising from the two-stage financing decision, is that the financial frictions faced by the parent and the affiliate affect affiliate sales in a log-separable manner (see Proposition 1), which implies that when estimating the specification for affiliate sales in logarithm, we should not see an interaction between host and home financial market conditions. We show in the Appendix that it is indeed true, further supporting the model assumptions.

Lastly, our setup abstracts from the sunk costs of setting up foreign affiliates, so it does not feature 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 transfer of technology to affiliate and the cannibalization between affiliates in their competition for the scarce internal factor (capital). Given the goal of the paper is to explain the aggregate FDI and MP and to understand their implications for aggregate welfare, we view the abstraction from trade and the hysteresis as preferable and choose to focus on this case in our analysis. Nevertheless, we show that the tractability of our model extends to the inclusion of differentiated goods (Appendix B.4) and firm-level switching costs (Appendix B.5.1), so our model can be easily extended for questions in which such features play a central role.

4 Quantitative Implementation

To shed light on the size of the mechanisms, we implement the model quantitatively. We focus on the same 36 countries as in the empirical section (see the first column of Table C.1) over the period 2001-2012. We discipline the model by matching the series of country TFP, labor employment, and

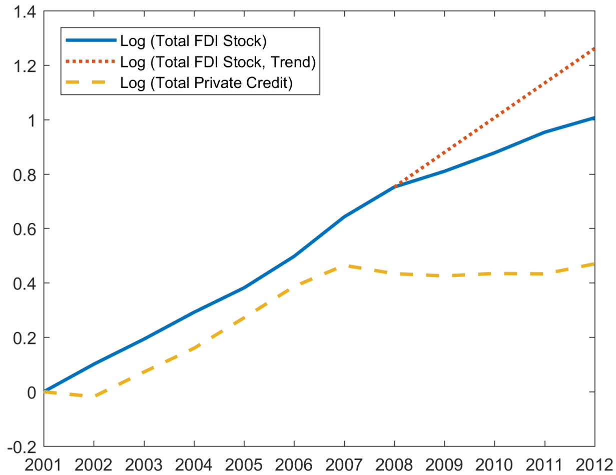


Figure 3: Private Credit and the Dynamics of World FDI

Note: The solid line is the aggregate FDI stock in a sample of 36 countries (see Table 6 for the country list). 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.

most important, bilateral FDI, and financial market conditions.

Given that one of our goals is to assess how the changing financial market conditions affect world FDI, we first take a look at the time series of these two variables. The solid line in Figure 3 is the aggregate FDI stock in our sample countries. As is well known, the past few decades saw increasing activities of MNEs. This shows up in our sample. The aggregate FDI growth, however, slowed down since 2008. Compared to the extrapolation from the previous years, the actual world FDI stock is 20% lower by 2012. The dashed line plots the total stock of credit to the private sector. It shows a credit boom during 2001-2007 and a subsequent credit crunch.

We will use our model to assess the role of various fundamental factors, including financial market conditions, in the world FDI. The previous discussion on the dynamic effects suggests that the changes in FDI capture the impacts of the past as well as the current fundamentals. To account for these impacts, instead of calibrating the steady state of the model to some average values of the data, we apply a wedge accounting procedure to the transitional dynamics of the model. Specifically, we pick the model fundamental parameters (λ_i, μ_h, $\bar{z}_i$) and the residual wedges ($\bar{\eta}_{ih}$), all of which time varying, so that the sequential equilibrium of the model matches the data along a number of dimensions for all countries. If we feed all 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 will then alter different groups of fundamentals to assess their respective contribution to the aggregate FDI or to evaluate a country's gains from FDI.

In quantification, we assume that the world credit market is fully integrated, so every period, there is a single interest rate that clears the global bond market.[25] Below we first discuss the targets

[25] 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.

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. We start with the parameters that are calibrated independently. The entrepreneurs' discount rate, 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 for our sample countries from the Penn World Table. The dispersion parameter of the multivariate Pareto distribution, θ, determines the sensitivity of firms' investment decision to host-country specific returns (see $\hat{e}_{ih}(z)$ in Lemma 3). Using variations in international 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 $\theta = 5$ as a benchmark.[26]

We next parameterize firms' productivity process. We assume that the productivity of firm z in 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 productivity 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. standard normal shock. According to this specification, firms' productivity fluctuate around the fundamental productivity of a country, with the deviations following an AR(1) process. $\rho_z \in (0, 1)$ determines the persistence, and $\sigma_\varepsilon > 0$ determines the dispersion of the deviations. We set $\rho_z = 0.85$, $\sigma^2_\epsilon = 0.69$, 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 z_i, our specification also accommodates for changes in the fundamental productivity. We will pin down z_i to match the aggregate output of countries, as described below.

We specify the productivity of an affiliate of firm z from i in country h 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 component of the affiliate productivity. Both components fluctuate around the country fundamental productivity following the same AR(1) process (i.e., $\log(\tilde{z}_k(z)) - \log(\bar{z}'_k) = \rho_z\big[\tilde{z}_k(z) - \log(\bar{z}_k)\big] + \sigma_\epsilon \varepsilon(z)$, which also implies $\tilde{z}_{ii}(z) = z$.) 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 correspondingly using time-varying targets in equilibrium. Parameter λ_i

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

determines the extent to which a company can use net worth as collateral for external finance. In the long run, this parameter depends on quality of financial institutions, but in the short run, it is also shaped by the availability of credits in a country. We therefore use λ_i to match the time series of private credits in our sample countries, 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 finance. While μ_h likely also depends on the availability of credits in h, its level and its sensitivity to credit market conditions need not be exactly the same as λ_i.[27] To allow for this possibility, we discipline μ_h using another time series. Recall that μ_h determines the fraction of the balance sheet of an affiliate financed by its parent. We use the BEA data to construct the empirical counterpart of this object. Specifically, the BEA reports the total external finance of U.S. affiliates in each country and every year and the affiliates' finance from the U.S. parents, which allows us to construct the ratio between affiliate total external finance and parent finance. For the U.S. as a host, we construct the same ratio for the foreign affiliates operating in the U.S. We then pin down the time-series of μ_h by matching the model-implied ratios to 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 investments, the literature has documented that more productive firms are more likely to become MNEs. We capture this in a reduced-form way by assuming that the international investment wedge has a time-invariant 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 of a firm being an MNE on its productivity. We then pick η_z so that in the model, this regression specification, when performed on the firms from the same set of countries as in the empirical analysis, yields the same estimate. This determines $\eta_z = 0.03$.[28] Given η_z, we then use the sequence of $\bar{\eta}_{ih}, h \neq i$ to match bilateral FDI over time. This procedure ensures that the model matches exactly the evolution of capital stock in each country and the distribution of their ownership across host countries.

The sequence of labor endowments in each country, L_i, is set to the effective employment from

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

[28] As described in Appendix C.2.1, in the special case with $\tilde{R}_{i,t}(z) = \bar{R}_{i,t}(z)$, the Logit specification can be derived as an structural equation of the model. While the premise is generally not satisfied, the relationship between a firms' productivity and whether it is an MNE still is 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 recursive fashion, as described in Section 4.1.

Table 2: Model Parameterization

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	Credit/GDP ratios	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 efficient labor unit	-
η_z	Relationship between MNE status and productivity	Estimated using Bloom et al. (2012) data	0.03

the Penn World Table, which incorporates the 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. To match the evolution of GDP in each country, we can directly adjust the mean level of productivity. The resulting term, which we label $\overline{Z}_i$, could be thought of as the *measured* aggregate TFP, absorbing all the variation of output beyond those of aggregate inputs. However, in the current model that features heterogeneous firms, $\overline{Z}_i$ is different from the *fundamental* TFP, z_i, as it also captures the changes in allocative efficiency due to the changes in the financial market conditions and firm distribution. We isolate the *fundamental* TFP as the aggregate productivity needed to match the aggregate output, holding the shares of capital used by affiliates with different productivity the same as in 2001. Then the measured aggregate TFP change due to allocative efficiency is $\bar{Z}_i/\bar{z}_i$, which is by definition equal to one in 2001. We will change $\bar{z}_i$, in stead of $\bar{Z}_i$, to understand the role of productivity growth in explaining the dynamics of FDI.

Table 2 summarizes how the model parameters are determined (Table C.1 reports key parameters and data by country). Parameters in Panel A are pinned down externally without solving the model. Parameters in Panel B are determined jointly. Importantly, in addition to these parameters, the dynamics of the model also depends on the joint distribution of net worth and productivity in the initial period. Ideally, we would like to measure the joint distribution directly. Without access to a representative firm-level data set that covers all countries for the early 2000s, we assume that the wealth share density function (i.e., $\hat{\phi}_i(z)$ defined in Section 3.5) in each country in the initial period is the same as the one from the steady state that is calibrated to data in 2001.[29]

Numerical algorithm. The calibration works as follows. Given Panel-A parameters and for a guess of η_z, we first calibrate the steady state by finding values of parameters in Panel B, such that the listed moments in the "Target/Source" column of Panel B match their data counterparts in 2001. These moments include credit/GDP ratios, shares of affiliates' assets financed by parents,

[29]Note that we only assume the marginal distributions (the densities) of productivity in each country start from those of the steady state, but not the aggregate net worth. Our calibration matches aggregate capital stock and aggregate output period by period.

capital/GDP ratios, GDP per efficient unit of labor of each country, and bilateral FDI stocks as shares of receiving countries' capital stock. Since the number of moments equals the number of parameters, the parameters are exactly identified. We then check if the model implies the same relationship between whether a firm is an MNE and its productivity as in the data and, if not, update η_z and repeat the procedure.

Starting from the wealth share density functions of the steady state, we then calibrate the time sequence of parameters along the transition path of the model. We adjust the initial levels of *aggregate* net worth so that the model produces equilibrium capital-output ratios as in the data in 2001 for each country. Simultaneously, we impose other moments of the model along the transition path to be equal to their data counterparts that are listed in the "Target/Source" column of Panel B. The number of parameters equals the number of moments so the parameters are also exactly 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, which we describe in Appendix C.2.2.

4.2 The Dynamics of Financial Market Conditions

Figure 4 plots the recovered sequences of λ_i (left) and μ_h (right). The colored curves highlight selected countries and the dotted line denotes the mean value across all countries.

The left figure shows the great country heterogeneity in λ_i. With an average of 1.4, the U.S. is among the countries with the highest values. Turkey is among the countries with the lowest, with an average value of around 0.1. This long-run difference across countries reflects differences in credit over GDP ratio in the data, as shown in the first two columns of Table C.1. Although λ_i of countries differ in level, many of them 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 downtown 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 declines from its 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, which captures the dependence of foreign affiliates on host finance. 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, but μ_h in many countries see a decrease in 2008.

4.3 Model Validation

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

Financial market conditions. We first relate the calibrated values of $\lambda_{i,t}$ and $\mu_{i,t}$ to the external measure of financial development. Insofar as in countries with better financial institutions, parent firms can more easily borrow and affiliates of foreign firms can also rely more on local partners,

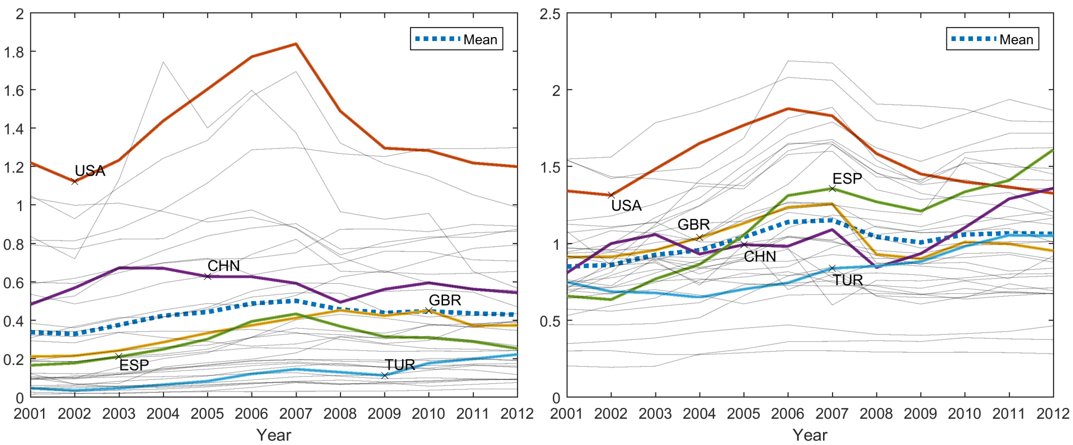


Figure 4: Measured λ_i and μ_h

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

Table 3: Calibrated and External Measures of Financial Market Conditions

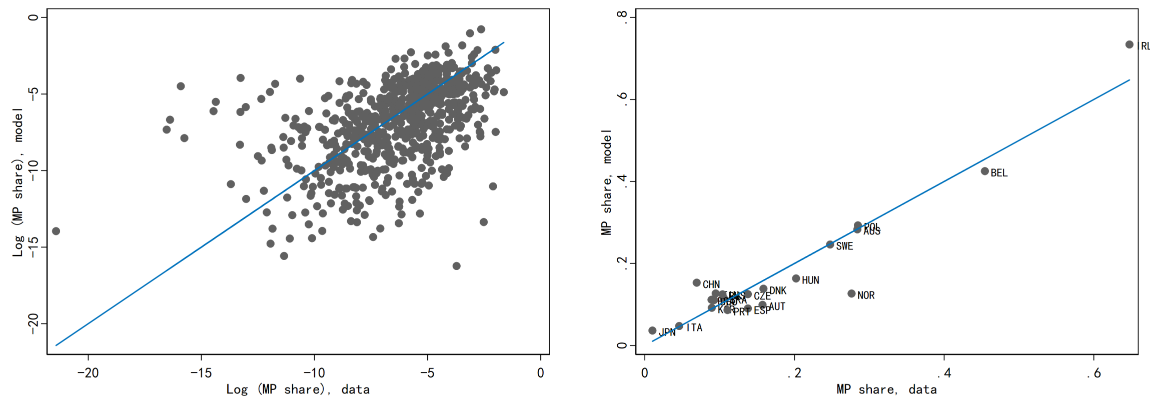
	(1) $\bar{\lambda}_i$	(2) $\bar{\mu}_h$	(3) $\bar{\mu}_h$	(4) $\Delta\mu_h$
log (financial development index)	0.453***	0.318**		
	(0.153)	(0.155)		
$\bar{\lambda}_i$			0.275*	
			(0.157)	
$\Delta\lambda_i$				0.365***
				(0.105)
Observations	36	36	36	396
R^2	0.204	0.110	0.083	0.074

Note: The dependent variable in the first three columns are the average λ_i and μ_h over the sample period. The dependent variable in the fourth column is the year-to-year change of μ_h. The independent variable in the first column is the financial institution index of a country; $\Delta\lambda_i$ is the year-to-year change of λ_i. Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

these two parameters should be correlated with each other and both correlated 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 value of $\lambda_{i,t}$ and $\mu_{h,t}$ for each country are correlated with each other and with the log of the financial development index. The fourth column shows that the over-time variation of the two measures are also correlated.

Bilateral and total 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 collected new bilateral FDI stock data to use as targets. As a validation of the model, we compare our model's implication on bilateral and total inward MP shares to the data, focusing on the last year of the sample (2012), when our firm-level sample from the Orbis data have better coverage of the sample countries.[30] Figure 5 shows that the model generates empirically consistent MP shares.

[30]Despite the generally good coverage, the firm-level sample is tilted toward manufacturing, in which activities of MNEs are more active. On the other hand, our bilateral FDI stocks are originally reported by the central bank and presumably cover the entire economy. To adjust for difference due to sectoral compositions, we scale our model implied



(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 are calculated as the ratio between total turnovers of foreign affiliates from the home country and total turnovers of all firms in the host country. Inward MP share of a host country is calculated as the ratio between total turnovers of foreign affiliates from the sample countries and total turnovers of all firms in the host country.

Table 4: FDI Return Wedges and Measurable Frictions

	(1)	(2)
	log $\bar{\eta}_{ih}$	
Log(Distance)	-0.240***	-0.173***
	(0.014)	(0.018)
Common border	-0.056	-0.008
	(0.045)	(0.049)
Colonial tie	0.214***	0.222***
	(0.051)	(0.047)
Common language	0.159***	0.244***
	(0.035)	(0.054)
Low Tax Country		0.309***
		(0.071)
Profit tax		0.003
		(0.003)
Log(FDI restriction)		-0.054**
		(0.026)
Log(host financial development)		0.171
		(0.147)
Observations	1136	1078
R^2	0.676	0.596
Home country FE	Yes	Yes
Host country FE	Yes	
Host country chars.	-	Yes

Note: The host country characteristics controlled in the second column include log GDP and TFP. Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Cross-border investment return wedges. In the calibration, the $\bar{\eta}_{ih}$ wedges are intended to catch all frictions and policy distortions to international investment. We examine if they are corre-

MP shares so that the model-implied share of capital stocks owned by foreign firms matches the share of assets owned by foreign firms from the Orbis data.

lated 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 proxy for geographic frictions. Column 2 replaces host fixed effects with host characteristics. We find that, while being labeled as a low-tax country has a significant positive effect, conditional on that, the effect from a lower profit tax rate is negligible. This is in line with that many low-tax countries do not necessarily have low statuary tax rates, but instead attract foreign business through special treaties. Policy restrictions 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 but not least, we find the quality of financial institutions unimportant in explaining the return wedge. This is reassuring as it shows the empirical relationship between host financial development and inward FDI is captured by our model mechanism.

5 Counterfactual Experiments

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

5.1 Financing Factors and the Cross Section of MP

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

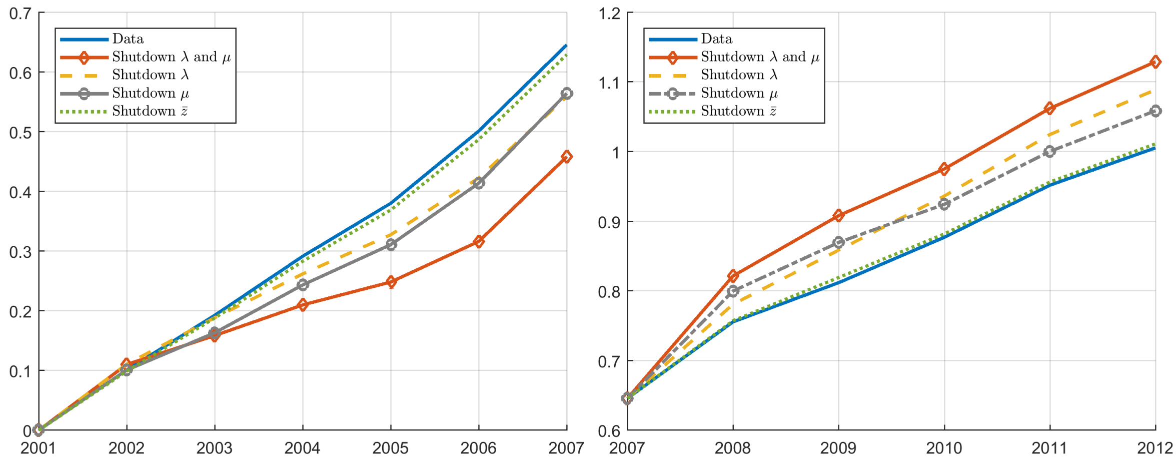
$$Y_{ih} \propto \underbrace{W_i}_{\text{size}} \times \underbrace{\bar{\eta}_{ih}^{\theta}}_{\text{geography}} \times \underbrace{\tilde{z}_{ih}(\bar{z}_i)}_{\text{productivity}} \times \underbrace{w_h^{-\frac{1-\alpha}{\alpha}}}_{\text{factor price}} \times \underbrace{(1+\lambda_i)}_{\text{home finance}}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

The above equation relates bilateral MP to a number of factors. With the log-linear structure, we can assess the importance of each factor on the right hand side in accounting for the variation of bilateral MP by regressing the logarithm of each of them on 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. Not surprisingly, the most important factors of bilateral MP are size and geography, which together account for about 75% of the variation. Within the remaining variations, factors emphasized in traditional models of MP, such as firm productivity and factor prices, account for 7.4% of the variations. Host and home financing factors independently account for 4.0% of the variation, and host finance further interacts with other host characteristics to account for 5.4%. Thus, the inclusion of the financing factor explains extra 9.4% of the variation. Last but not least, forces related to firm heterogeneity account for the remaining 8.7%. This decomposition exercise shows that although financing factors are less important than size and geography, they are in the same order of importance of technology-related factors emphasized in existing studies of MP.

Table 5: Cross-Sectional Decomposition

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



(a) Log World FDI: 2002-2007

(b) Log World FDI: 2008-2012

Figure 6: Log Cumulative World FDI Flow: 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; alternatively, this is the logarithm of the cumulative world FDI flow between 2001 and year t.

5.2 Financing Factors and the Dynamics of FDI

The previous exercise is a partial equilibrium decomposition because it take as given the total wealth and wage of countries. However, both are endogenous and shaped by countries' past fundamentals, as discussed in Sections 3.7 and 3.8. To understand the full impacts of various fundamentals, we now move to a decomposition based on dynamic counterfactuals. Motivated by the evolution of the world FDI and the credit market conditions in Figure 3, which shows a clear trend break in 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 sequence of calibrated $\lambda_{i,t}$, and $\mu_{i,t}$ for all i and t to $\lambda_{i,2000}$, and $\mu_{i,2000}$, i.e., their values in the beginning of the sample. Figure 6a plot the findings. The solid line indicates the actual evolution of world FDI over this period. The solid line with diamond markers indicate the counterfactual evolution of world FDI. Comparison between the two shows that, if the financial market of all countries, for both parents and affiliates, 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 $\lambda_{i,t}$ and $\mu_{i,t}$ each accounts for about half of the effect. To investigate the role of fundamental productivity changes, the dotted line plots the outcome when the fundamental TFP is kept at the level of 2001. The world FDI in this scenario decreases from the data, but only slightly. This reflects that over this period, the changes in the fundamental TFP among the major sending and recipient countries of FDI tend to be more modest compared to the financial market conditions.

The slowdown in FDI growth since 2008. Our second dynamic exercise is similar in spirit but focuses on 2008-2012, an episode of financial market disruptions and the slowdown of global FDI growth. We feed in the calibrated sequences of parameters until 2007 and unexpectedly 'freeze' the relevant fundamental parameters at the 2007 value for all subsequent years. Figure 6b plots the main findings. Th solid line is the data. The solid line with diamond markers shows that, had λ_i and μ_h of all remained at their peak values in 2007, the cumulative world FDI flow would have been around 35% higher. The dash line and the dash-dotted line plots the effect of λ_i and μ_h, respectively. We find that both forces are quantitatively relevant, but the deteriorating access to credit for parents mattered more towards the end of the period. As before, shutting down the dynamics of the fundamental TFP has a very minor impact on aggregate FDI.

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

Validation based on counterfactuals and the role of the GE. In Appendix C.3, we conduct the same experiments separately for each country, which serves two goals. First, using the simulated data from the experiments by country, we can calculate the average effect of financial market conditions on outward FDI during these two episodes. We then compare the average effect to their empirical analog, estimated through a 'diff-in-diff' specification of outward FDI on home financial market conditions using our bilateral FDI panel. This is a strong test of the model, as it checks whether the model's *counterfactual* predictions fit the estimated relationship in the data.[31] We find that the model can account for the empirical estimates both qualitatively and quantitatively.

Second, by comparing the prediction from the country-specific experiments and the aggregate experiments, we are able to shed light on the general equilibrium interactions in FDI between countries. We show that such interaction is important and that their omission leads to an overestimation of the true aggregate effect, shown in Figures 6a and 6b, by two folds. This comparison highlights that the value of using a multi-country general equilibrium model to evaluate the impact on FDI of the shocks to fundamentals.

5.3 The Static and Dynamic Wage Gains from FDI

Our last set of excises assess the importance of the mechanisms discussed in Section 3.8 for workers' static and dynamic wage gains from MP. Following the literature on the gains from trade and MP (e.g., Arkolakis et al., 2012), we focus on the ex-post effect by moving countries from the observed equilibrium to one without *inward* MP.

Static wage gains and the role of technology and capital. We first examine the static wage

[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 backed in by the calibration process.

Table 6: The Static and Dynamic Wage Gains from MP

	(1)	(2)	(3)	(4)
Panel A: high-income countries				
	average MP share	average static	$A_{h,t}$ contribution (%)	average dynamic
Canada	0.36	0.15	57.07	0.10
Switzerland	0.32	0.12	14.48	0.09
Germany	0.12	0.04	47.84	0.03
Japan	0.03	0.01	51.41	0.01
Singapore	0.42	0.18	21.85	0.13
United States	0.10	0.03	44.90	0.02
Mean (all high-income)	0.24	0.10	34.59	0.07
Panel B: other countries				
	average MP share	average static	$A_{h,t}$ contribution (%)	average dynamic
Hungary	0.25	0.11	50.21	0.07
Czech	0.14	0.05	62.51	0.04
Malaysia	0.24	0.10	70.95	0.06
China	0.20	0.08	97.21	0.05
Brazil	0.15	0.06	77.10	0.04
Russia	0.09	0.04	85.61	0.03
Mean (all others)	0.18	0.07	71.92	0.05

This table summarizes the results on the static and dynamic wage gains from inward MP for a subset of countries, grouped by whether they are high-income (Panel A) or not (Panel B). Column (1) reports countries' average share of production by foreign firms over 2001-2012. Columns (2) and (3) report the average of a country's static wage gains from the period-by-period exercise and the contribution of the technological component to the static gains. Column (3) reports the average value of a country's dynamic wage gains over this period. Mean values reported are for all countries within the 'high-income' or the 'other' group, instead of for the selected countries. High-income is classified based on 2001 GDP per capita (>10k USD).

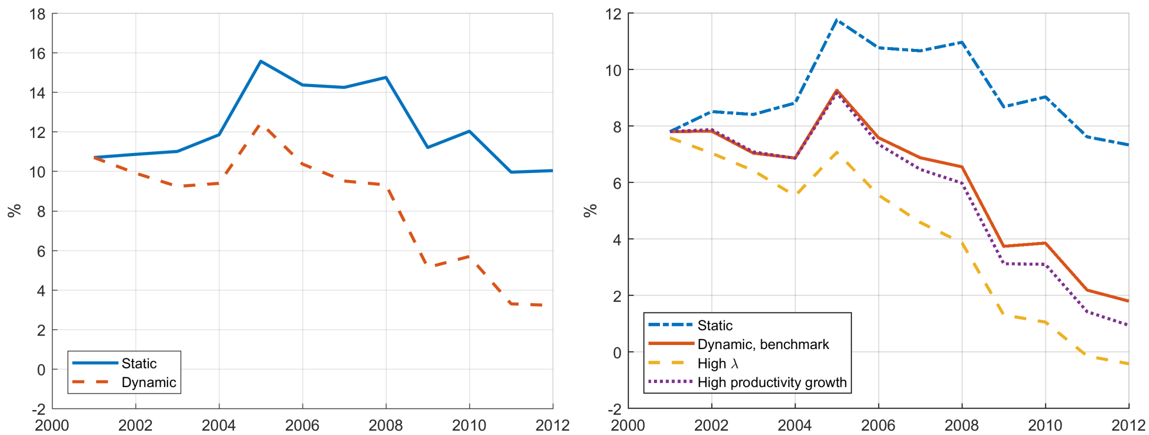
gains. As in the static exercise we take as given the distribution of firms, we can perform the exercise separately for each period, assuming that the economy has evolved exactly as in the baseline economy until that period and is then hit by a shock that shuts down the inward MP for country h (by setting the bilateral investment return wedge $\eta_{ih} = 0, \forall i \neq h$). This mimics the exercise of measuring the wage gains from MP period-by-period with the static version of our model.[32]

The first two columns of Table 6 report, for a subset of the sample countries, the average MP shares and the average value of the period-by-period static wage gains from MP over 2001-2012. On average, the inferred static wage gains are 10% for the high-income country group, and 7% for other (mostly middle income) countries. This difference mostly reflects the higher MP shares among high-income countries.

It is instructive to compare our findings to the estimates based on alternative models of multinational firms. As we have assumed the world credit market to be fully integrated, for countries whose changes do not have a first-order impact on the world interest rate, our model's prediction on their static wage gains map one-to-one to their MP shares, as indicated by equation (14). Thus, as long as appropriate elasticities are used, researchers analyzing the same data using the technology-based models of MP will infer similar static wage gains.

On the other hand, researchers viewing the data through the lens of the neoclassical frame-

[32]Because our model benchmark model does not have sunk costs in investment, firms choose where to invest to maximize the static return. This means our focus in this exercise—the on-impact change on the wage of workers—is invariant to how the shock affect the future of the economy.



(a) Comparison between static and dynamic

(b) The role of country fundamentals

Figure 7: Static versus Dynamic Wage Gains: Hungary

Note: In the left panel, static gains are calculated by shutting down the inward FDI to Hungary through a period-by-period exercise; dynamic gains are calculated by shutting down the inward FDI to Hungary from year 2001 onwards. In the right panel, 'high λ' means we multiply $\lambda_{HUN,t}$ by a fixed factor so that it has the same average value as the U.S.; 'high productivity growth' means we increase the annual growth rate in $\bar{z}_{\text{HUN},t}$ by 1 p.p.

work of international capital movement may give biased answers because of the omission of the technology embedded in FDI. We decompose the static wage gains into due to the improvement in technology and the increase in capital utilization in production using equation (12). On average, the technological component account for about half of the static gains, while the capital component accounts for the remaining half. This finding echoes the finding of Gourinchas and Jeanne (2006) that the gains from international capital market integration itself is relatively low, and their conjecture that an important part of the benefit from capital market integration is through the technology embedded in capital. We also find that the technology component plays a more important role for emerging countries than for high-income countries, so the omission of it leads to systematically higher biases for emerging countries.

Dynamic wage gains and the role of country fundamentals. We now examine how the dynamic mechanisms discussed in Proposition 3 shape the wage gains. For each country, we calculate the paths of its dynamic wage gains from inward MP by solving a counterfactual sequential equilibrium with $\eta_{ih} = 0, \forall i \neq h$ at all periods, and comparing the path of wage in this counterfactual equilibrium to that in the benchmark economy. The difference between the dynamic wage gains for a period calculated this way and the static wage gains for the same period captures the dynamic effect of past openness.

As an illustration, Figure 7a plots the static and dynamic wage gains for Hungary. The solid line is the static wage gains inferred from the period-by-period exercise. At the beginning of the sample period, the static wage gain from FDI is around 11%. Driven by the influx of foreign investment after the EU accession in 2004, the wage gains increase to around 15%, before decreasing again to around 10% after the financial crisis. The dashed line plots the dynamic wage gains. The

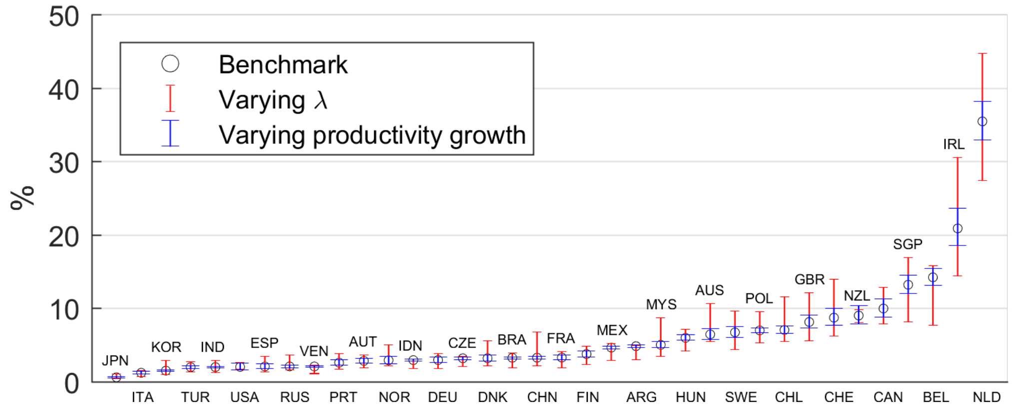


Figure 8: Average Dynamic Wage Gains under Counterfactual Primitives

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

dashed line lies below the solid line, with their gap first increasing and then stabling at around 5 p.p., or around half of the static wage gains.

Column (4) of Table 6 reports the average value of the dynamic wage gains over the period, which shows that the dynamic wage gains are smaller than the static wage gains for all countries. This happens because, given the international frictions, most firms make most of their investment domestically. By shifting investment from the host to foreign firms, past openness reduce the current investment. In our calibration, this negative effect dominates the differences in the productivity and financial institutions of countries, which imply ambiguous dynamic effect of openness depending on country fundamentals.[33]

We explore how country fundamentals affect the dynamic effects in Figures 7b and 8. Figure 7b focuses on Hungary. The solid line replicates the benchmark dynamic effect. The dotted line is the counterfactual wage gains in a re-calibrated model where the annual growth rate of the Hungary fundamental productivity, $\bar{z}_{\text{HUN},t}$, is set 1 p.p. higher. Because this change only affects future evolution of TFP, the wage effect in the first year remains the same. Subsequently, however, the two curves start to diverge—in the economy with a higher domestic productivity growth rate, the wage gains of inward FDI are smaller. The dashed line is for the counterfactual with a higher $\lambda_{\text{HUN},t}$. It also lies below the benchmark effect, with the difference increasing over time. After 2008, the wage effect is negative, a possibility predicted in Proposition 3.

Figure 8 plots the variation in the average dynamic wage gains of a country as we vary its fundamental productivity and the quality of financial institutions. The circles denote the average

[33]Our result is related to, but distinct from, an intuition one might have from neoclassical model, according to which the access to the international capital market leads to larger static than dynamic wage gains because over time domestic capital accumulation can substitute the access to foreign capital. In all our counterfactuals, the international credit market are fully integrated, so our finding is not due to a change in access to the capital market per se. Moreover, while openness to international capital in the neoclassical model never leads to dynamic wage losses, dynamic losses due to inward FDI can arise in our model.

dynamic wage gains in the baseline, corresponding to Column 4 of Table 6. The intervals denote the range of dynamic wage gains as we vary host country h's financial development parameter λ_h from $\lambda_h - 0.76$ to $\lambda_h + 0.76$, and the growth rate of its fundamental productivity ($\bar{z}_h$) from the baseline to plus and minus 5%. What stands out is the wide range of possible outcomes, especially as we vary λ_h. For Malaysia and Austria, for example, the upper end of the range is about twice as much as the baseline values; for Mexico, the baseline value is close to the upper end, but much higher than the bottom of the range. Such heterogeneity highlight the crucial role of country fundamentals in shaping the dynamic effect. Interestingly, for some countries (Australia and the Netherlands), the higher end of the interval is above the average static wage gains. Thus, even though the dynamic effect due to past openness is negative in our calibration, it could have been be positive if country fundamentals were different.

The exercises in this section demonstrate the importance of the mechanisms discussed in Section 3.8. A broad message from these exercises is that modeling FDI as within-firm capital transfer embedded with technology leads to quantitatively important new 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 the static gains correctly, but it would still miss the dynamic wage gains and their systematic relationship with country fundamentals.

6 Concluding Remarks

In this paper, we have documented novel three-way relationships between MP, FDI, and the financial conditions of host and home countries. Motivated by these patterns, we integrate two distinct approaches in the studies of MNEs in a unified framework, which enables a quantitative analysis of FDI and MP. Through a structural accounting exercise, we show that financing factors are as important as the technological factors emphasized in existing studies in explaining the *cross-sectional* MP and a first-order determinant of the *dynamics* of FDI over 2001-2012. We further show that our model, capturing the distinction and connection between FDI and MP, leads to novel and quantitatively important channels for the gains from MP.

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 number of interesting channels. In particular, we have omitted technological spillovers from foreign to domestic firms. Aside from financial constraints, we also abstract away from firm-level distortions, which are salient in many developing countries. These elements could be conveniently incorporated in our model and, combined with increasingly available microdata, for a more comprehensive understanding of FDI. In terms of optimal policy. Our model points to potentially interesting second-best interactions between financial market conditions and the optimal path for the FDI policy, 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 the current account, which consists of mainly portfolio investment, and FDI flows. Such extension can then be used to study the interaction between these two types of capital flows and the effects of various capital control policies that differentiate the two.

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