Financing Multinationals*

Jingting Fan[†] Wenlan Luo [‡]

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Abstract

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

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[†]The Pennsylvania State University, jxf524@psu.edu

[‡]Tsinghua University, luowl@sem.tsinghua.edu.cn

1 Introduction

By mobilizing technological and financial capital across borders, multinational enterprises (MNEs) exert important influence on the world economy. A growing literature (e.g., Burstein and Monge-Naranjo, 2009; Ramondo and Rodríguez-Clare, 2013; Ramondo, 2014; Tintelnot, 2016; Cravino and Levchenko, 2016) has built quantitative models to explain MNEs' decisions and examine their global impacts. These models share the same central view: firms are owners of proprietary technologies (or 'blueprints', 'knowhow') that can be used in multiple locations within firm boundaries, and MNEs are the firms that deploy their technology abroad.[1] As the scale of a firm reflects the efficiency of its technology, in these models, the impact of foreign MNEs on the host economy often boils down to one statistic: the production by the affiliates of foreign MNEs (or 'multinational production', hereafter MP) as a share of host production.[2] Guided by this insight, most studies viewing MNEs through the lens of technology focus on MP but overlook the financing decisions underlying MP, i.e., how investments in affiliates are financed. As such, these studies do not speak to foreign direct investment (FDI), a widely collected statistic and the subject of extensive empirical investigations.[3]

In this paper, we build a dynamic model of multinationals that integrates MP and FDI in a unified framework, in which FDI arises as a crucial, but not the only, source of financing for MP. Because it is a crucial source, to the extent that firms' allocation of internal capital depends on their use of external finance, countries' financial market conditions shape MP through FDI. Because it is not the only source—-MNEs can, and often do, seek external finance in the host—financial market conditions can insert an additional impact on MP conditional on FDI. Quantification of the model delivers two main results. First, due to the forces mentioned above, financing factors, which are omitted in the technology-based view of multinational firms, are an important determinant of MP. Moreover, the interplay between production and financing of firms play a central role in shaping the welfare effects from MP. Thus, viewing MNEs solely through the technological lens misses a crucial determinant of their activities and leads to biased welfare assessments.

Our model of MP and FDI is supported by data. As reviewed below, existing research has documented a robust positive correlation between the activities of MNEs and the financial market conditions of host and home countries. However, most of the literature either focuses only on MP (or closely related outcomes such as foreign firm employment) or focuses on FDI, regarding it as a proxy for MP. Our empirical analysis differentiates between the two. Using bilateral data, we show that host countries with better financial institutions attract more inward FDI and, conditional

[1] This view 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 the no-trade special cases of Ramondo and Rodríguez-Clare (2013), Arkolakis et al. (2018), and (up to the first order) Tintelnot (2016).

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

on the FDI stock, more inward MP. Home countries with better financial institutions send more outward FDI, but conditional on FDI, *not* more outward MP. These results are not confounded by other host and home characteristics, such as their income, sizes, and tax rates. Leveraging a firm-level panel from Orbis, we document similar patterns using the within-firm, *time changes* in financial market conditions. The correlation between financial market conditions and the activities of MNEs underscores the importance of jointly modeling their financing and production decisions. The independent effect of host financial market conditions on MP after controlling for FDI is consistent with firms' use of host external finance in production, especially in hosts with good financial institutions. To corroborate this view, using the U.S. Bureau of Economic Analysis (BEA) pubic-use host-level data, we show that the importance of host external finance relative to FDI for affiliates is higher in hosts with better financial institutions.

We set up a firm dynamics model that explicitly incorporates the role of internal capital markets and 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. Besides using their own net worth, MNEs can finance capital investment in host countries by raising debt in the home country and by partnering with investors in the host country. Both forms of external finance are impeded by contractual frictions: the debt financing of the parent hindered by a limited enforcement friction, and the financing from host investors hindered by a moral hazard problem in technology transfer, which implies that affiliate operation must be financed at least in part by the parent. These frictions lead to static and dynamic interactions between financing and production. Statically, the scale of an affiliate is constrained by the capital brought to the host by its parent firm, namely FDI. Dynamically, through their influence on firms' net worth, firms' past activities shape future FDI and MP.

In addition to being consistent with the data, the model sheds new light on the welfare implications of MP. Taking the size and productivity distributions of firms as given, we derive the *static* wage gains of a host from *inward* MP as a formula of two statistics: the MP share, and the capital use of domestic firms which depends on FDI. The MP share captures the importance of foreign affiliates in local production. Conditioning on the MP share, higher inward FDI reduces the dependence of foreign affiliates on host financing, thus alleviating the credit crowd-out effect on domestic firms and bringing larger gains. This formula encompasses two existing views of FDI. Compared to the neoclassical view that centers on capital flows (e.g., Mundell, 1957), our model highlights the importance of the technology embedded in FDI and potentially implies higher gains. Compared to the technology-based view of MNEs in which the MP share is a sufficient statistic (e.g., Ramondo, 2014), our model identifies a crowd-out effect in the capital market summarized by the capital use of host firms and implies lower gains.

By forging a link between FDI and MP, our model also uncovers a dynamic mechanism of the welfare effects. Opening up a host to inward MP raises its wage but shifts the profits from local to foreign firms. As firms differ in their future productivity and the propensities to invest in the host country, such a shift can have first-order effects on future wages. We show 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 inward MP tends to decrease the future wage; this decrease *can* outweigh the increase in future wage due to future MP, in which case openness brings net wage losses.

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

We implement the model quantitatively to examine the importance of financing factors in MNEs' decisions and the welfare implications of MP. Dynamic effects of the sort discussed above imply that past shocks matter for current MP and welfare. With countries connected by MNEs, openness in one country affects all others through third-country effects. Our model maintains tractability by combining the technical ingredients of Moll (2014) and Arkolakis et al. (2018), which allows us to derive two theoretical results: analytical characterizations for firm-level decisions, and tractable aggregation for country-level outcomes. This enables us to calibrate the *transitional dynamics* of the model to the multi-country data typical of studies on MP and international trade, capturing both the dynamic effects and the cross-country interactions.

We assemble a panel of *bilateral* FDI between 36 major countries over the period of 2001-2012, which we supplement with country-specific time series on GDP, aggregate credit volume, employment, investment rates, and the share of affiliate assets financed by foreign parents. To disentangle the role of credit market conditions from those of other macroeconomic shocks, our approach follows a wedge accounting approach (see e.g., Eaton et al., 2016). Specifically, we introduce to the model country-specific wedges for investment efficiencies and bilateral wedges for FDI returns. We calibrate these wedges, as well as the fundamentals that determine credit market conditions and other macroeconomic outcomes so that the transitional dynamics of the model agree with all the data series described above. We then use the model to conduct three counterfactual exercises.

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

In the second exercise, we quantify the role of technology and finance in the *time changes* of

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

In the last exercise, we examine the wage gains from MNE entry for a host country, underscoring the importance of the FDI-MP interplay. We move a country from the calibrated transition path to a counterfactual transition path without *inward* FDI. We define the static wage gain as the wage change in the first period, and the dynamic wage gain as the average wage changes across all sample periods. We find that, averaging across countries, inward FDI brings a static gain of 8.7%, but the gain diminishes over time, leading to a dynamic gain of 6.3%. The interplay between FDI and MP discussed earlier plays a key role in shaping the dynamic gains: when calibrated to match the same data, a technology-based model of MP without FDI, extended suitably to incorporate capital accumulation, would imply a dynamic gain of 8.5%, thus overstating the average gain by one-third. This result shows to infer the gains from MNE activities, it is crucial to account for the connection between FDI and MP.

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

The premise of our model builds on the findings of recent studies—that affiliate operation depends on financing from both the host financial market (Bilir et al., 2019; Desbordes and Wei, 2017) and the parent firm (Alfaro and Chen, 2012), and that credit crunches at home lead to sharp declines in outward FDI (e.g. Peek and Rosengren, 2000; Klein et al., 2002; Desbordes and Wei, 2017). Our specific mechanism linking host finance to inward FDI and MP is closely related to Antras et al. (2009), who show that the quality of host financial institutions can affect the financing of the affiliates, and hence the scale of their operation. Our main contribution relative to Antras et al. (2009) is to introduce the MP-FDI joint decision in a tractable dynamic general equilibrium model and quantify the aggregate implications of the mechanism.

By connecting MP with FDI, this paper engages the literature on the impacts of international capital flows (e.g. Mundell, 1957; Gourinchas and Jeanne, 2006; Bai and Zhang, 2010). We differ from the bulk of this literature by focusing on a key aspect of FDI—that it is a within-firm capital movement embedded with technology. Our model generates endogenous *two-way* FDI flows, a first-order feature of the data, and leads to new welfare implications. Of course, we are not the first to incorporate this aspect of FDI 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, the multi-country structural accounting exercise is similar in spirit to Eaton et al. (2016) in that we first use the model to fully rationalize the data, before proceeding to counterfactual experiments. Different from their work, however, our model incorporates dynamic decisions in a setting of incomplete markets. To the best of our knowledge, this is the first paper to perform a wedge accounting exercise of an incomplete 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. Sections 4 and 5 discuss quantification using the model. Section 6 concludes.

2 Relationship Between MP, FDI, and Financial Market Conditions

To guide a model of multinational firms with both production and financing decisions, we start by documenting the three-way relationship between MP, FDI, and financial market conditions of host and home countries. We describe our main data and empirical findings below; additional details about the data and robustness results can be found in Appendix A.

2.1 Data and Sample Countries

Bilateral MP and FDI. We obtain bilateral MP and FDI data from Ramondo et al. (2015). MP is defined as the total sales by the affiliates of foreign firms located in a host country, and FDI is defined as the *stock* of capital that parent firms invest in their overseas affiliates in equity or intra-company loans.[4] These measures are averaged over 1996-2001, and supplemented with additional information on countries, including their income, tax rates, an index of the restrictiveness of their policies on inward FDI, and indices on the quality of their financial institutions, all averaged over the same period. We use this dataset to examine the cross-sectional relationship between the quality of financial institutions and MP, and the role of FDI in mediating this relationship.

Firm-level MP. Our firm-level result is based on a panel dataset covering the period of 2001-2012, extracted from the Orbis database. In addition to standard accounting items such as firms' total sales and assets, the data include firms' ownership networks, which enables linking firms to their 'global ultimate owner' (i.e., their parent firm). After the cleaning procedures detailed in

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

Appendix A.2, we arrive at a firm-level panel of MNEs and their affiliates in different hosts.

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

BEA public-use data. We obtain the public-use data on the source of external finance for the overseas affiliates of U.S. MNEs. The dataset is available at the host-country-year level of aggregation and contains the information on the use of external finance from different sources (e.g. from the parent firm versus from the host country). We use it to provide supportive evidence on our interpretation of the relationship between FDI and MP.

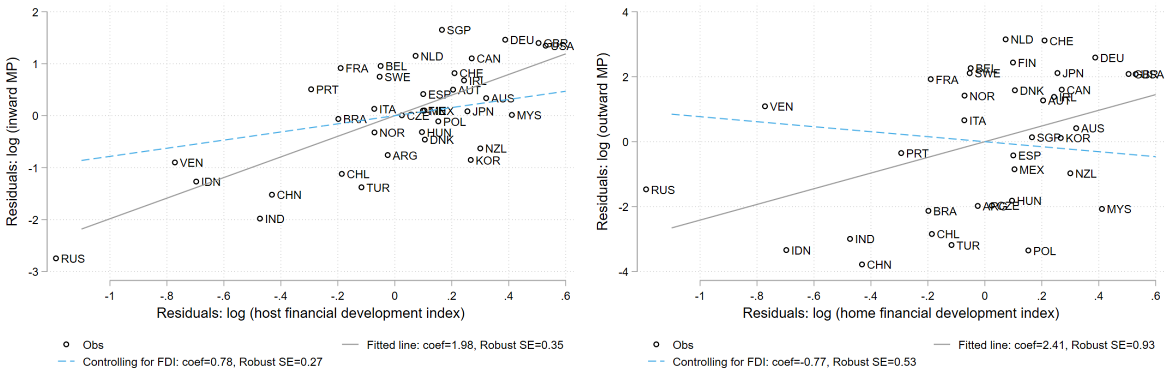
Measures of financial market conditions. Our empirical analysis exploits cross-sectional and over-time differences in financial market conditions. Across countries, differences in contractual frictions and the protection of investors lead to variation in the difficulty of accessing external finance (La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

Over time, a country's quality of financial institutions is likely to remain stable. However, short-term factors such as monetary policies or investor sentiments could still affect firms' access to external finance. Following a macroeconomic literature on the real effect of financial market conditions (e.g., Buera et al., 2015), we use the variation in total credit made to the domestic private sector, obtained from the World Bank, as a proxy for the time changes in this access.

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

2.2 Cross-Sectional Evidence

MP and financial institutions: the role of FDI. We start by examining the cross-sectional relationship between MP and quality of financial institutions. Figure 1 visualizes the data. The left panel plots the quality of *host* financial institutions against *inward* MP. The circles indicate the residuals of the two variables after the effect of host size (log GDP) is partialled out. The solid line is the fitted line, which shows a strong positive correlation between the two variables. The 1.98



(a) Host Financial Institution Quality

(b) Home Financial Institution Quality

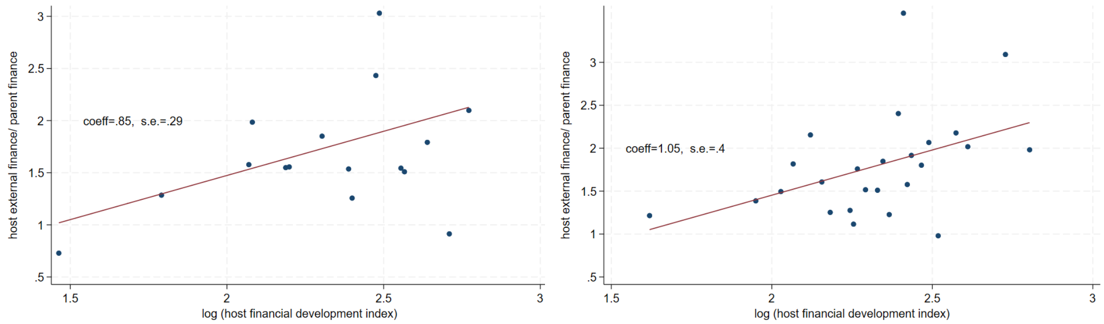
Figure 1: The Relationship Between the Quality of Financial Institutions, FDI, and MP
Notes: The left panel plots the relationship between the quality of host financial institutions and inward MP, with (the dashed line) and without (circles and the solid line) controlling for inward FDI. The right panel plots the relationship between the quality of home financial institutions and outward MP, with (the dashed line) and without (circles and the solid line) controlling for outward FDI. Both the fitted line and the circles are after netting out the effect of country size.

slope means that a one-standard-deviation increase in the index is associated with a 73-log-point increase in inward MP. The dashed line is the best fitted line when the logarithm of inward FDI stock is further controlled for. The dashed line has a smaller slope than the solid line, consistent with better financial institutions increasing MP in part by attracting more inward FDI. However, the slope is still positive, suggesting that the higher MP in hosts with good financial institutions cannot be entirely accounted for by higher FDI toward these countries.

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

In Appendix A.3, we report the results from regressions using the bilateral data. We show that the patterns in Figure 1 are robust to the inclusion of confounding factors such as a country's productivity, restrictions on inward FDI, proximity to other countries, and tax rate and status as a tax haven. We also separate our proxy for the quality of financial institutions into its two components and show that it is the protection of creditors' legal rights, rather than the depth of credit information, that drives both the correlation and its asymmetry. This finding is reassuring because, as MNEs tend to be well known, their ability to raise capital is unlikely to be severally hindered by the lack of credit information. On the other hand, the protection conferred to creditors by the legal system might help MNEs as well as local firms secure external finance.

The literature has documented a robust positive correlation between FDI/MP and the financial development of both host and home countries, treating FDI or MP as synonymous measures of MNE activities (see Di Giovanni, 2005; Desbordes and Wei, 2017 and the references therein). In



(a) Not Controlling for Host Characteristics (b) Controlling for Other Host Characteristics

Figure 2: The Relationship Between Affiliate External Finance and Host Financial Institutions
Notes: Both panels plot binned scatter plots of the ratio between host external finance and parent finance (y axis) against host financial development (x axis). The observations are at the host-year level. The left panel control for year fixed effects; the right panel controls for year fixed effects, host characteristics including log GDP, TFP, profit tax, and index on inward FDI restrictions, and controls on geographic proximity to the U.S. (distance and indicators for common border, common official language, and colonial ties). The mean of variables are added back to the axises after residualization. Standard errors are clustered by host country.

addition to affirming these findings using our sample, the afro-mentioned exercises point to an important asymmetry: while MP is correlated with both host and home financial development, the correlation of MP with the latter is only through FDI. This asymmetry highlights the distinction between FDI and MP and calls for a model that jointly incorporates MNEs' financing and production decisions.

Affiliate sources of external finance. The quantitative model described in the next section rationalizes this asymmetry by allowing affiliates to lever up on parent finance (FDI) through host external finance (see also Antras et al., 2009). Since affiliates can more easily secure external finance in hosts with better financial institutions, this mechanism implies that the ratio between host external finance and parent finance increases with the quality of host financial institutions.

We validate this prediction using the BEA data, which provide the breakdowns of external finance by their source for U.S. MNE affiliates. The vertical axis of Figure 2a is the ratio between total host external finance and total parent finance across all U.S. affiliates in a host. On average, this ratio is around 1.5, reflecting the general importance of host countries as a source of affiliate external finance. Consistent with the above mechanism, this ratio is strongly correlated with host financial development depicted in the horizontal axis, and this correlation is robust to controlling for other characteristics of the host country (the right panel).

2.3 Firm-Level Evidence

The results based on the aggregate data demonstrate both a strong connection between the quality of financial institutions and the activities of MNEs, and the central role of FDI in mediating this connection. To strength the identification, we now turn to the firm-level panel, assessing whether host and home financial market conditions have an impact on affiliate sales, and how these impacts change when parent financing is controlled for. The time dimension of the data allows us to purge unobserved time-invariant country characteristics. The granularity of the data means that we can control for shocks and firm characteristics that are common to all affiliates within a firm through firm-year fixed effects.

Specification. We estimate several variants of the following specification:

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

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

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

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

In this measure, $K_{i,t-1}$ is the total assets of affiliate i at $t-1$, and $\sum_{j \in \{o(j)=o(i),\, d(j)=d(i)\}} K_{j,t-1}$ is the total assets of *all* affiliates from home country $o(i)$ to host country $d(i)$. This formula essentially proportionally distributes the aggregate FDI from $o(i)$ to $d(i)$ to an affiliate in $d(i)$ according to its asset size.[5] In Appendix A.5, we also report results based on an alternative proxy of $\log \widehat{\text{FDI}}_{i,t}$, constructed as a nonparametric function of $\log(K_{i,t-1})$ and $\log(\text{FDI}_{o(i)d(i),t})$.

FE_i in equation (1) denotes affiliate fixed effects. By including FE_i in all specifications, we account for any invariant characteristics of the parent firm and the affiliate—and hence also those of origin and destination countries. To the extent that some time-varying characteristics might be correlated with shocks that affect both the credit market and affiliate production, we directly

[5] Results are similar if we use the contemporary size instead of the lagged size.

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

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

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

control for them in $X_{1,o(i)t}$, $X_{2,d(i)t}$, and $X_{3,f(i)t}$, which represent origin country, destination country, and firm-level controls, respectively.

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

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

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

Columns 5 through 7 of Table 1 report the relationship between *host* country credit shocks and affiliate sales. Since the variation is at the host level, in addition to affiliate fixed effects, we are able to control for firm-year fixed effects, absorbing all shocks that affect all affiliates of a firm. Column 5 shows that even with these controls, host credit shock is strongly correlated with affiliate sales.

Column 6 controls for host TFP and terms of trade. These controls do not change our finding qualitatively. Finally, Column 7 includes the proxy for direct investment to affiliate i in period t. The coefficient of host credit shocks is smaller but still sizable, echoing the findings in Figure 1a.

Robustness. In Appendix A.5, we report several robustness exercises. First, we show that the results are similar when we use flexible functions of lagged firm capital stock and bilateral FDI as a non-parametric proxy for direct investment. Second, we add interaction terms between credit market conditions and a post-crisis dummy variable, which takes a value of one for years after 2007. We find that the coefficients of these interaction terms to be small, indicating that the patterns documented above are not specifically driven by the impact of the financial crisis. Third, we show that the results are robust when wage bill is used to measure affiliate production.

Summary. Taking stock, we have shown that although both host and home credit market conditions are positively correlated with MP, once FDI is controlled for, only host country financial market condition is correlated with MP. Such a three-way relationship holds in the time changes within individual firms as well as in the cross section of countries.

The correlation between MP and both host and home credit market conditions motivates a model where affiliate production depends on finance from both countries over a model with frictionless financial markets. The asymmetric role of FDI in mediating the correlation further suggests that the home credit market condition affects MP mainly through its effect on parent investment, whereas the host credit market condition affects MP both by attracting more parent investment and by enabling additional host finance conditional on the investment. Guided by these findings, we now develop a quantitative model to investigate the importance of countries' financial market conditions in shaping the global distribution of MP and FDI, and to shed light on the welfare impacts of MNE activities.

3 Model

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

3.1 Endowments, Preferences, and Technology

Our model combines technical ingredients of firm dynamics under incomplete markets (Moll, 2014) with static models of multinational production (Arkolakis et al., 2018).

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

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

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

where c_t is the entrepreneurs' private consumption at period t. Entrepreneurs make operational decisions to maximize their personal utility. Of course, most MNEs are large corporations owned by shareholders instead of individual entrepreneurs. In this case, we can either think of the entrepreneur as the CEO of a company and interpret c_t as the compensation of the CEO,[6] or think of c_t as dividend payouts and the curvature in $u(c_t)$ as capturing the dividend smoothing motive.

Firms differ in productivity $z \subseteq (0,\infty)$, which follows Markov processes with country-specific transition probability density functions $f_i(z'|z)$. Firms can operate affiliates in different countries—including home country—to produce a homogeneous consumption good. We treat this good as the numeraire of the economy, so all prices are in units of the consumption good. At the end of each period, this consumption good can be converted to and from productive capital, the only asset in the economy, at a one-to-one ratio. Within each period, firms can borrow or lend productive capital in a rental market for capital, which we call the bond market. They deploy capital in affiliates for production and repay their lenders in the consumption good at the end of period after production has taken place.

An *affiliate* in host h of a firm from i uses l units of labor and k units of capital to produce y units of the consumption good:

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

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

3.2 Affiliate Finance and Production

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

Given our focus on aggregate FDI and MP, we wish to capture this force in a simple environ-

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

ment. We specify that to raise each unit of capital in the host country, an exogenous minimum level of parent investment (in productive capital) must be made. Letting e_h be the investment made by a parent company in its affiliate in host country h and b_h^F be the amount of external capital raised in host h, formally, the assumption states that $b_h^F \leq \mu_h \cdot e_h$, with $\mu_h > 0$ determining the maximum leverage that the affiliate can obtain in the host country.

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

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

It is worth noting that, first, the borrowed capital (b_h^F units) is repaid after production in $(1 + r_h^b) b_h^F$ units of the consumption good. Second, because capital can be converted one-to-one to the consumption good, the price for un-depreciated capital is 1. Lastly, as the loan repayment, the un-depreciated capital, and the wage are all denominated in the consumption good, the return to investment $\tilde{R}_{ih}(z, e_h)$ is also in units of the consumption good.

Micro-foundations. Although parsimonious, inequality $b_h^F \leq \mu_h \cdot e_h$ in (3) encompasses three views on why the access of an affiliate to external capital can be constrained by e_h, the investment it receives from the parent. The first view, also our preferred view, is to see the constraint as from the moral hazard problem in the transfer of production technology from the parent to the affiliate. We provide a micro-foundation to this setup in Appendix B.4.1. In the micro-foundation, as the owner of production technology, the parent firm needs to exert non-contractible efforts to ensure the success of affiliate operations. For such efforts to be incentive compatible, the parent needs to have sufficient stake in the affiliates, i.e., $\frac{e_h}{e_h + b_h^F}$ cannot be too low. Thus, the exact reason MNEs arise in the first place—contracting frictions associated with the transfer of technologies across firms—also means affiliates scale is constrained by parent investment.[7]

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

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

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

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

International frictions. Cross-border investment is characterized by significant frictions, such as the barriers to the transfer of knowledge (Keller and Yeaple, 2013), and the risk of extortion by corrupt foreign officials (Wei, 2000) and expropriation by foreign governments. To capture these frictions, we assume that the parent receives only a fraction of the return, denoted by $\eta_{ih} \cdot \tilde{R}_{ih}(z, e_h)$, with the remaining 'melt' in the repatriation process like in the iceberg trade cost specification.[8] We further assume $\eta_{ih} = \bar{\eta}_{ih} \cdot \zeta_h$, where $\bar{\eta}_{ih}$ is the deterministic component common to all firms from i operating in h, and ζ_h is the idiosyncratic component that is drawn i.i.d. across parents and affiliates, capturing the 'fit' between hosts and a firm's technology. The literature has documented an MNE productivity premium and rationalized it with a fixed cost of setting up affiliates so that the average return from opening foreign affiliates increases in 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 realization of the return shocks from all potential hosts, $\boldsymbol{\zeta} = (\zeta_1, \zeta_2, ..., \zeta_N)$, firms decide whether to be idle or active. Idle firms loan out their net worth a—the stock of productive capital they hold from the previous period—in the bond market. Active firms choose whether to scale up on their net worth through borrowing and in which host (including the country they are from) to invest.

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

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

which says that the external capital raised at home cannot exceed λ_i fraction of the parent firm's net worth. As elaborated in the micro-foundation in Appendix B.4.2, this constraint arises in an environment of endogenous bond pricing in the presence of limited enforcement in repayment,

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

and can be alleviated by improvements in both the financial contracting environment and the credit market condition. The total funds of the parent, $a + b^H$, will then be allocated to affiliates to maximize the per-period return, after which consumption and saving decisions are made.

Denote $v_i(z, \boldsymbol{\zeta}, a)$ the expected discounted utility of firm owners from country i with characteristics $(z, \boldsymbol{\zeta}, a)$. The Bellman equation for $v_i(z, \boldsymbol{\zeta}, a)$ reads:[9]

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

The first constraint says that the capital allocated to affiliates should sum to net worth plus external capital raised in the home country. The second constraint says that, (1) an idle parent firm can loan out all but not more than its net worth; and (2) capital raised by an active parent firm cannot exceed what the constraint allows. $\tilde{R}_{ih}(z, e_h)\bar{\eta}_{ih}\zeta_h$ in the third constraint, with $\tilde{R}_{ih}(z, e_h)$ defined in (3), denotes the returns from investing in host country h, net of wages, payments to *host* country investors, and the component that is melt during repatriation. The third constraint describes the firm's capital accumulation decision. Repatriated investment return are used for covering financing costs and the payouts for current consumption; what is left is then converted one-to-one to productive capital for future use (a').

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

3.4 Characterizing Affiliate- and Firm-level Decisions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The first part of the lemma characterizes the lending/borrowing decision. If $\max_{h'} R_{ih'}(z)\bar{\eta}_{ih'}\zeta_{h'} \geq 1 + r_i^b$, i.e., the shadow return on capital is greater than the interest rate in the home bond market, the firm borrows to scale up; otherwise, it stays idle and lends out its net worth. The shadow return, which equals the return from the most productive affiliate, could be large due to either productivity (z) or luck ($\boldsymbol{\zeta}$). Because the unit shadow return is scale-independent (see Lemma 1), when a firm chooses to scale up, it will max out the available credit $\lambda_i \cdot a$. This implication might appear strong, but as we show below, our model still delivers rich implications on how bilateral FDI and MP jointly shape welfare while remaining tractable for quantification.

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

Extensive versus intensive margin FDI decisions. The choice problem in equation (7) implies that each firm invest only in one country. Our model can be modified to accommodate active operations in multiple countries. Specifically, suppose each firm operates an exogenous number of ex-ante identical projects, each of which obtain a vector of idiosyncratic return shocks $\boldsymbol{\zeta}$. A firm splits its internal capital a among these projects, discovers the realization of $\boldsymbol{\zeta}$ for each project, and then chooses the host countries. For each project, the probability that a firm chooses host h is the same as in our benchmark model (see below), but as firms operate multiple projects, some will choose to operate in more than one country.[10] Although this alternative and our baseline model

[10] In the limit case where each firm operates a continuum of projects, all firms operate in all countries and FDI is only

differs in predictions for individual firms, they agree on all other dimensions (e.g. bilateral FDI, bilateral MP, allocative efficiency of capital among firms, aggregate income). Given the focus of our paper on aggregate outcomes, we use the baseline formulation to simplify the exposition.

3.5 Aggregation

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

Assumption 2. *The cumulative distribution function (CDF) for $\boldsymbol{\zeta} = (\zeta_h)_{h=1}^N$ 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).[11] 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' decision to stay idle/be active depend on the realization of $\boldsymbol{\zeta}$.[12]

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

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

The CDF for $\Xi_i(z, \boldsymbol{\zeta})$ conditional on (i, z), denoted $H_i(x|z)$, is then given by:

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

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

Because all ζ_h draws are no smaller than 1, the support of $\Xi_i(z, \boldsymbol{\zeta})$ 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 $\Xi_i(z, \boldsymbol{\zeta})$ agrees with a Pareto distribution with a scale parameter of $\tilde{R}_i(z)$,

an intensive margin decision.

[11] 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 $\rho = 0$.

[12] A commonly used alternative in international trade for aggregation is to assume that $\boldsymbol{\zeta}$ are drawn from the Frechet distribution. The Frechet assumption loses tractability in our setting unless the idiosyncratic draws also apply to the return from being inactive, which is at odds with the interpretation of $\boldsymbol{\zeta}$ as the fit of technology between the firm and host countries and the bond return being risk-free.

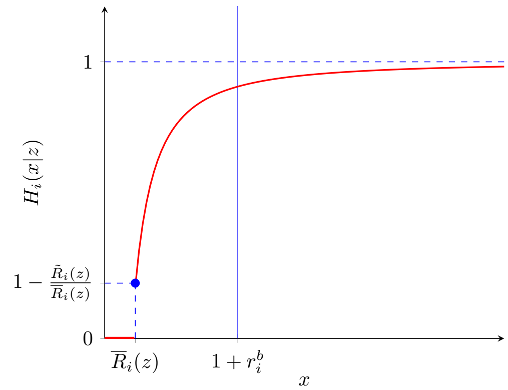


Figure 3: The conditional CDF for $\Xi_i(z, \boldsymbol{\zeta})$

the CES aggregated value of host-specific returns.[13] At $\overline{R}_i(z)$ is a mass point with measure $1 - \left(\frac{\tilde{R}_i(z)}{\overline{R}_i(z)}\right)^{-\theta}$. This measure is zero if and only if $\bar{\eta}_{ih'} R_{ih'}(z) = \bar{\eta}_{ih} R_{ih}(z), \forall (h, h')$.

With $H_i(x|z)$, we aggregate the investment decisions and the average return to net worth by firms' productivity z, under two separate case. The first is for firms whose productivity z is such that $\overline{R}_i(z) < 1 + r_i^b$. This is the case illustrated in Figure 3. Firms will be active if the realization of $\Xi_i(z, \boldsymbol{\zeta})$ falls to the right of the vertical line. The Pareto tail allows us to derive the probability of being active and of choosing each destination, and the associated expected returns. The second is for when $\overline{R}_i(z) \geq 1 + r_i^b$, in which case firms will always be active. We characterize the expected return a function of z for both cases in Lemma 3.

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

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

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

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

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

The expected return to net worth among these firms is

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

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

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

Lemma 3 refines the aggregate state of a country from a distribution over $(z, \boldsymbol{\zeta}, a)$ to a distribution over firms' beginning-of-period states (z, a). Since firms' decisions are linear in net worth, we can further reduce the aggregate state into a distribution of net worth over z, which enables us to take the dynamics of the model to multi-country data.[14] Let $\Phi_i(z, a)$ be the joint density of firms' productivity and net worth in country i, and define

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

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

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

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

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

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

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

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

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

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

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

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

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

The total capital *used* in production in a host h by firms from i, denoted by K_{ih} is

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

where K_h is the capital used in production in h. The total output in a host h is $Y_h = \sum_i Y_{ih}$.

3.6 Definition of Equilibrium

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

A stationary equilibrium is a sequential competitive equilibrium with time-invariant equilibrium objects. Note that even though production in our model features constant returns, due to financial frictions and idiosyncratic productivity shocks, in the stationary equilibrium the most productive firms will not takeover the entire market, and there is a well-defined equilibrium of active firms across the productivity spectrum as in, e.g., Moll (2014).

It is worth clarifying how the markets for goods and (rental) capital operate. Since the final consumption good is homogeneous, trade in the final consumption good between countries arise only as firms repatriate their investment returns from abroad.[15] Thus, the market clearing condition for the final good requires that the total output adjusted by the net repatriation costs equals total consumption plus investment.

International movement in productive capital can take two forms: first, firms' investment in their overseas affiliates (FDI). Second, under the assumption that there is an integrated bond (capital rental) market, part of the capital used in production in a country (K_h defined above) might be supplied by foreign idle firms as portfolio investment. In such an equilibrium, a world interest rate clears the supply and demand for rental capital, with the supply coming from inactive parent firms around the world, and the demand coming from active parent and affiliates.[16, 17]

[15] We show in Appendix B.5 how to extend our model to an environment with CES preference and monopolistic competition while maintaining tractability. In that environment, one can explore the interaction between trade and FDI policies. As this interaction is not the focus here, we stay with the homogeneous good setting in the present paper.

[16] In this case, the interest rates are the same across countries, but firms operating in different countries still face different λ_i and μ_h, which are the features of local financial institutions. For example, a firm from a developing country might be willing to borrow at the prevailing interest rate, and foreign investors willing to lend, but poor local financial institutions can impede the enforcement of the contract, limiting the access of the firm to external finance.

[17] Our model accommodates the polar case—autarky bond markets. In this case, cross-border capital movement takes the forms of FDI only and in each country there would be a local equilibrium interest rate.

3.7 FDI, MP, and the Quality of Financial Institutions

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

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

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

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

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

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

Equation (10) connect bilateral FDI to the quality of host and home financial institutions. An increase in μ_h, due to either financial development or a credit boom in h, increases the return from investing there ($R_{ih}(\bar{\bar{z}}_i)$), which leads to an increase in $[\text{FDI}]_{ih}$.

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

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

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

3.8 The Wage Gains from MNE Activities

We now turn to the welfare implications of MNE activities for host countries. To better connect our results to that from the technology-based models of multinational firms, we focus on the wages gains of workers—as these impacts are not affected by how we weight the welfare of firm owners, which are not present in technology-based models. We proceed in two steps.

The static wage gains from MP. In the first step, we derive the static wage gains from MP, defined as the change in wage due to inward MP taking as given of the distribution of net worth in the economy. This is a useful starting point to clarify the mechanisms since the static wage gains can be expressed as a function of MP, as in the technology-based model of multinationals, plus an extra term capturing the credit crowd-out effect. For tractability, we assume that firms' size-weighted productivity distribution is Pareto.

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

$$\Delta \log(w_h) = -\alpha \Delta \log\left(\frac{Y_{hh}}{Y_h}\right) + \alpha \frac{\gamma - 1}{\gamma} \Delta \log\left(\frac{K_{hh}}{W_h}\right), \tag{12}$$

where $\frac{Y_{hh}}{Y_h}$ is the share of production conducted by domestic firms of h and $\frac{K_{hh}}{W_h}$ is the share of domestic wealth used by domestic firms.[18]

Equation (12) 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 production. This statistic captures the *direct* effect of foreign technology on host labor productivity—as in technology-based model of multinational firms, where this statistic is the sufficient for welfare evaluation. In our model, however, conditional on the MP share, the dependence of foreign affiliates on parent versus host external finance also matters, as it determines the crowd-out effects by foreign firms in the host credit market. This force is reflected in $\Delta \log\left(\frac{K_{hh}}{W_h}\right)$. Intuitively, if a large part of affiliate production is financed through FDI, or if foreign firms achieve their production through superior technologies that use little domestic capital, then more of the host country's wealth will be available to host firms. In this case, the decrease in $\log\left(\frac{K_{hh}}{W_h}\right)$ due to openness would be smaller, implying larger wage gains. Conversely, if foreign production relies heavily on the host country for external financing, the wage gains would be lower.

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

$$\Delta \log(w_h) = -\frac{\alpha}{1-(1-\gamma)(1-\alpha)} \Delta \log\left(\frac{Y_{hh}}{Y_h}\right) - \frac{\alpha(\gamma-1)}{1-(1-\gamma)(1-\alpha)} \Delta \log(r_h^b + \delta). \tag{13}$$

[18] A sufficient condition for $\hat{\phi}_h(z)$ to be the density of a Pareto distribution is that the productivity process is i.i.d. and follows a Pareto distribution (Itskhoki and Moll, 2014). Note that the proposition holds regardless of whether the global bond market is segmented across countries or integrated.

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. If the credit market of country h is segmented from the rest of the world—that is, credit market clears with host-h supply and demand only, then the entry of foreign firms tend to raise the interest rate, in which case focusing only on the MP share leads to an overestimation of the wage gains. On the other hand, if bond can flow across borders and if h is not big enough to affect the world interest rate, then technology-based models of MP *can* measure the wage gains correctly provided the appropriate elasticity is used.[19]

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

Countries have time-varying fundamentals and the bond can flow across borders, with a world interest rate balancing global bond supply and demand. The productivity of firms in a country is drawn i.i.d. from a Pareto distribution with the location parameters (i.e., the lower bounds of support) of the focal country h and the remaining $N-1$ countries denoted $\bar{z}_{h,t}$ and $\bar{z}_{i,t}$, respectively. In this environment, we consider $\frac{d\log w_{h,2}}{d\bar{\eta}_{ih,1}}$, the impact on the second period wage in country h of h's opening up to FDI at period 1, modeled as an increase in $\bar{\eta}_{ih,1}$. $\frac{d\log w_{h,2}}{d\bar{\eta}_{ih,1}}$ thus captures the dynamic effect of the openness policy. To isolate the mechanism from the host country's perspective, we further assume that the policy change is relatively small, 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, $\frac{d\log w_{h,2}}{d\bar{\eta}_{ih,1}} > 0$.*

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

We characterize in Appendix B.2.8 the conditions that define parameters to be 'sufficiently large' or 'small.' The first part of Proposition 3 suggests that openness can either increase or decrease the future wage. Intuitively, openness in the first period shifts the market shares in host h from domestic to foreign firms, so at the end of the first period, foreign firms make more profits

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

at the expense of domestic firms.[20] Whether such a shift increases or decreases the second period wage depends on two forces: the marginal propensities of firms to invest their first-period profits in country h, and, conditional on their investment, the relative productivity of domestic versus foreign firms. If domestic firms invest a sufficiently higher proportion of their past profits in h than foreign firms, which could happen because of a higher domestic saving rate (high β_h or low β_i), better domestic financial institutions (high $\lambda_{h,2}$ or low $\lambda_{i,2}$), or geography (low $\bar{\eta}_{ih,2}$), or if domestic firms are sufficiently more productive in the second period, then such a shift tends to reduce the second period wage. Conversely, it can increase the second period wage.

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

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

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

Second, for firms making direct investment, different hosts are imperfect substitutes, with the elasticity of substitution governed by the dispersion of idiosyncratic investment efficiencies (parameter θ). This feature captures an important difference between FDI and portfolio investment: while the latter only seeks to maximize a simple return, FDI is embedded with technology and hence governed by the 'fit' between a firm's technology and a host country, embodied in the idiosyncratic draws of $(\zeta_h)_{h=1}^N$. Such a feature implies a finite elasticity of inward FDI with respect to the host investment return. To see the importance of this feature, consider an alternative setup where FDI is treated as portfolio investment. In that setup, the decline in domestic investment led by a past openness policy would be entirely compensated for by the inflow of foreign investment, so openness to foreign investment will never reduce the wage.

Proposition 3 has important implications for the ex-post evaluation of the gains from MP. To infer the gains from MP over a period of time, we can calibrate our baseline model to the observed

[20] 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.

sequence of MP shares and conduct a dynamic counterfactual experiment. Alternatively, we can view the data through the lens of a purely technology-based MP model in which FDI does not play a role, extended to incorporate capital accumulation. The above discussion suggests that, by overlooking the dynamic effect arising from the connection of FDI and MP, the estimates from the second exercise would be biased and may have the wrong sign, with both the sign and the size of the bias varying by countries' fundamentals. We will evaluate this bias in Section 5.

3.9 Discussion of Model Assumptions and Extensions

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

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

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

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

Lastly, our setup abstracts from the sunk costs of setting up foreign affiliates, so it does not feature the firm-level hysteresis emphasized in some empirical studies. Relatedly, by assuming each affiliate is an independent producer of a homogeneous good, the model does not allow for the interaction between affiliates through demand cannibalization (Tintelnot, 2016). On the other

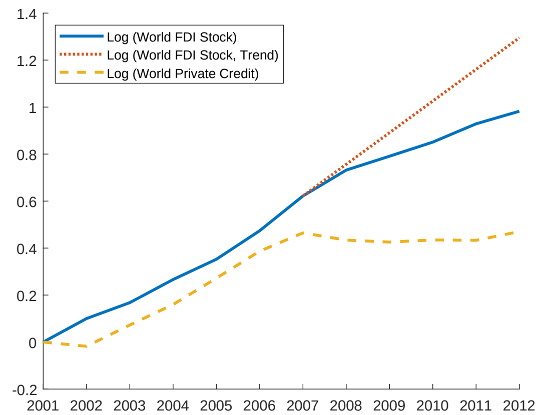


Figure 4: Private Credit and the Dynamics of World FDI

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

hand, the model incorporates the cannibalization between affiliates in competing for the scarce internal factor (capital). Given the goal of the paper in explaining aggregate FDI and MP and in examining their implications for aggregate welfare, we choose to abstract from trade and firm-level hysteresis. Nevertheless, we show that the tractability of our model extends to the inclusion of differentiated goods (Appendix B.5) and firm-level switching costs (Appendix B.6.1), so it can be the basis for answering other questions in which such features play a central role.

4 Quantitative Implementation

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

With this goal in mind, we inspect the dynamics of financial market conditions and FDI in Figure 4. The solid line depicts the logarithm of total FDI stock among the sample countries. As is well known, the past few decades saw increasing activity by MNEs. This trend shows up in our sample. The growth in total FDI stock, however, has slowed since 2008. The actual world FDI stock is 20% lower by 2012 than the linear extrapolation of the pre-crisis trend. The dashed line depicts the logarithm of total stock of credit to the private sector among the sample countries. It shows a credit boom during 2001-2007 and a subsequent credit crunch.

Although the structural breaks of these two series largely coincided, our previous discussion suggests that the changes in FDI capture the impacts of past as well as current fundamentals. In addition, other macroeconomic shocks, such as those to investment return wedges, aggregate productivity, and the labor market, can exert independent impacts on FDI. To disentangle these forces, we apply a wedge accounting procedure to the transitional dynamics of the model. Specifically, we pick the series of model fundamentals (λ_i, μ_h, $\bar{z}_i$, L_i) and the bilateral investment return wedges ($\bar{\eta}_{ih}$), all of which time varying, so that the sequential equilibrium of the model matches the data for all countries. If we feed these fundamentals into the model, it will produce the *time series* of GDP, domestic and bilateral foreign investment, employment, private credit, etc., exactly as in the data. We then alter groups of fundamentals either to assess their respective contribution to the aggregate FDI or to evaluate a country's wage gains from FDI. In both the calibration and counterfactuals, we assume that there is a world interest rate that clears the global bond market.

We discuss the targets that identify each parameter below. Additional information on the data used in this section and computational algorithms are provided in Appendix C.

4.1 Targets and Numerical Procedures

Parameters calibrated independently. The model is calibrated at annual frequency. Some of these parameters have been estimated or can be matched to the data without solving the equilibrium, so we calibrate these independently.

The entrepreneurs' discount factor, β_i, determines the saving rate. We set $\beta_i = 0.9$ following Buera et al. (2011). We set the capital share $\alpha = 0.4$ and the depreciation rate $\delta = 4.5\%$ based on the average estimates for our sample countries from the Penn World Table. The dispersion parameter of the multivariate Pareto distribution, θ, determines the elasticity of firms' investment in host-specific investment return (see characterizations of $\hat{e}_{ih}(z)$ in Lemma 3). Using cross-country variation in taxes, Wei (2000) estimates this elasticity to be 4.6, which is also around the median value in a recent meta-analysis (De Mooij and Ederveen, 2003). We set $\theta = 5$.[21]

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

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

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

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

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

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

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

Parameters calibrated in equilibrium. The remaining parameters can change over time and are disciplined *jointly* using time-varying targets. We now explain the procedure and the intuition for identification.

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

$$\bar{\eta}_{ih}(z) = \bar{\eta}_{ih} z^{\eta_z}, h \neq i. \tag{14}$$

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 survey of manufacturing firms in a number of countries (Bloom et al., 2012), we estimate a Logit specification, regressing whether a firm is an MNE on its productivity. We then determine η_z so that in the model, this regression specification yields the same estimate when performed on the firms from the same set of countries as in the empirical analysis. As detailed in Appendix C.2.1, this process delivers $\eta_z = 0.03$. 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 exactly matches the evolution of each country's capital stock and distribution of direct investment across host countries.

The sequence of labor endowments in each country, L_i, is set to the effective employment from the Penn World Table, which incorporates changes in the labor market that is outside the model, e.g., changes in population, labor force participation, and the frictions in the labor market.

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

Parameter μ_h determines the extent to which affiliates can rely on local partners for financing. While μ_h likely also depends on the availability of credit in h, its level and sensitivity to credit market conditions need not be the same as λ_i.[22] To allow for this possibility, we discipline μ_h using a different time series. Recall that μ_h determines the fraction of affiliate external finance

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

Table 2: Model Parameterization

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

that is from its parent. We use the BEA data, introduced in Section 2, to construct the empirical counterpart of this object for all but the U.S. For the U.S. as a host, we calculate the same ratio for foreign affiliates operating in the U.S. using another dataset from the BEA. We then pin down the time-series of μ_h to match these ratios.

With the above parameterization, our model matches the aggregate capital and labor inputs, as well as the allocative efficiency of the economy in each period. We pick the fundamental TFP of countries, denoted by $\bar{z}_i$, to match the data on output per worker for all countries and periods.

Identification. Importantly, these time-varying parameters are jointly identified. In particular, our calibration of λ_i and μ_h takes into account the *entire history* of macroeconomic shocks, such as employment, investment efficiency (captured in η_{ih}), the aggregate productivity, and GDP. In other words, λ_i and μ_h are identified as the residual supply variation after controlling for all other macro factors that might affect the demand for credit. Therefore, in subsequent counterfactual where we vary λ_i and μ_h, we interpret the results as due to evolving financial market conditions, as in the macro studies of financial shocks (e.g., Buera et al., 2015).

Table 2 summarizes how the parameters are determined (see Table C.1 for key parameters and data statistics by country). Parameters in Panel A are pinned down externally. Parameters in Panel B are determined jointly in equilibrium. Importantly, in addition to these parameters, the dynamics of the model also depends on the joint distribution of firms' net worth and productivity in the initial period. Ideally, we would like to measure this distribution directly. Without access to a representative firm-level dataset that covers all countries for the early 2000s, we assume that the wealth share density function ($\hat{\phi}_i(z)$ defined in Section 3.5) in each country in the initial period is the same as the one in the stationary equilibrium calibrated to the data in 2001.[23]

Numerical algorithm. The calibration works as follows. In the first step, given Panel-A parameters and for a guess of η_z, we calibrate the stationary equilibrium by finding values of parameters in Panel B, such that the listed moments in Panel B match their data counterparts in 2001.

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

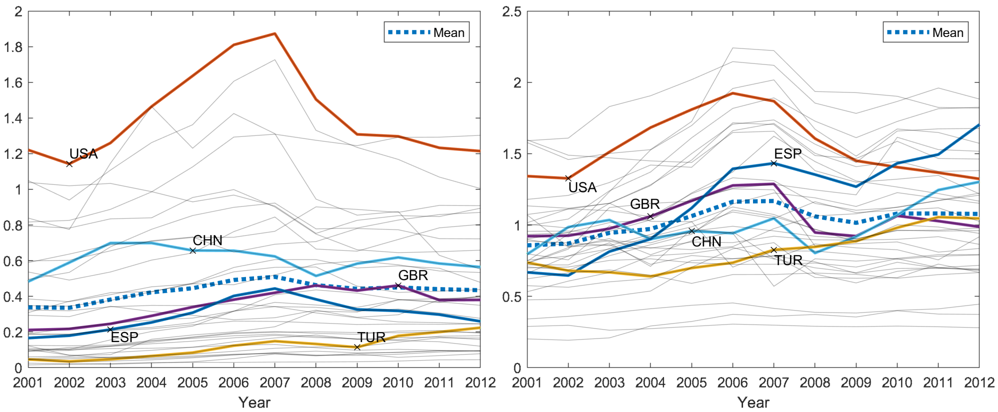


Figure 5: Inferred λ_i and μ_h

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

These moments include each country's credit/GDP ratios, shares of affiliates' assets financed by parents, GDP per efficient unit of labor, and bilateral FDI stocks as shares of receiving countries' capital stock. We then check if the model implies the same relationship between whether a firm is an MNE and its productivity as in the data and, if not, update η_z and repeat the procedure.

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

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

4.2 The Dynamics of Financial Market Conditions

Figure 5 plots the calibrated sequences of λ_i and μ_h. The solid lines highlight selected countries and the dotted line denotes the mean value across all countries.

The left panel shows the great heterogeneity in calibrated λ_i across countries. With an average of 1.4, the U.S. is among the countries with the highest level of λ_i. Turkey is among the countries with the lowest, with an average value of around 0.1. This long-run difference across countries reflects the difference in credit over GDP ratios in the data, as shown in the first two columns of Table C.1.[24] Although differing in levels, λ_i of many countries follow a similar trend. They are on an upward trend in the first half of the sample period, corresponding to a period of easy access to credit in many countries. Subsequently, the trend is met by a sharp downturn around 2008, mirroring the credit crunch shown in Figure 4. In some countries, this drop is severe—-the U.S., for example, sees its λ_i declining from the peak value of 1.8 to 1.2 within just two years. Such time

[24]The average credit GDP ratio is 1.84 in the U.S. and 0.29 in Turkey. The correlation between this ratio and λ_i is 0.74.

Table 3: Calibrated and External Measures of Financial Market Conditions

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

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

variations reflect the change in credit/GDP in the raw data. In the U.S., this ratio dropped by 30 p.p. between 2006 and 2008.

The right panel of Figure 5 plots the evolution of μ_h for each host country. Again, there is substantial heterogeneity in host countries along this dimension. Columns 3 and 4 in Table C.1 show that, the calibrated μ_h is directly linked to the average leverage of foreign affiliates in a host country. Similar to λ_i, μ_h in many countries sees a decrease around 2008.

4.3 Model Validation

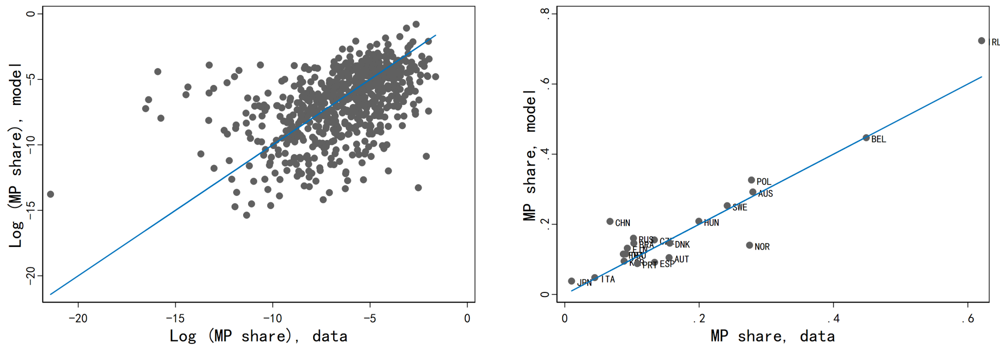
We validate the model by comparing calibrated parameters to several external measures.

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

Bilateral and aggregate inward MP. Due to the lack of comprehensive bilateral MP data over most of the sample period, we choose not to match the bilateral MP shares. Instead, we have used the newly collected bilateral FDI stock data as targets. As a validation of the model, we compare our model's implications on bilateral and aggregate inward MP shares to the data, focusing on the year 2012, when our firm-level sample has the best coverage.[25] Figure 6 shows that the model generates empirically consistent MP shares.

Cross-border investment return wedges. In our calibration, the return wedges $\bar{\eta}_{ih}$ are in-

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



(a) Bilateral MP Shares

(b) Inward MP Shares

Figure 6: MP Shares, Model v.s Data

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

Table 4: FDI Return Wedges and Measurable Frictions

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

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

tended as catch-all for frictions and policy distortions to international investment. We examine whether they are correlated with measurable frictions and policies related to FDI in expected ways.

Table 4 reports the results. The dependent variable is the bilateral wedge for the year 2012. Column 1 shows that the return wedges are strongly correlated with common proxies for geographic frictions.[26] Column 2 replaces host fixed effects with host characteristics. As expected, we

[26]To interpret the coefficients, the estimates suggest, for example, sharing a common language with the home country translates into 16% higher in the net return from investment in a host.

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

find that hosts that are viewed as tax havens (low-tax countries) have higher return wedges, although the coefficient of the profit tax itself is insignificant. Restrictive policies of the host country on inward FDI also have an economically and statistically significant effect on the return wedge, consistent with our interpretation of the wedges as the un-modeled variation in frictions. Last but not least, we find the financial development index to be unimportant in explaining the return wedge. This is reassuring as it shows that the empirical relationship between the quality of host financial institutions and inward FDI is entirely explained by the mechanism in the model.

5 Counterfactual Experiments

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

5.1 Financing Factors and the Cross Section of MP

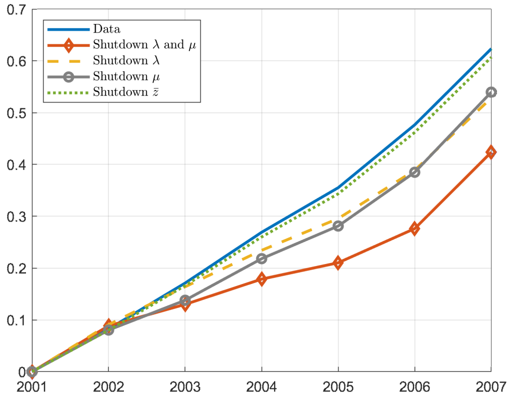
Our first exercise decomposes the determinants of cross-sectional bilateral MP. Combining equations (10) and (11) gives us:

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

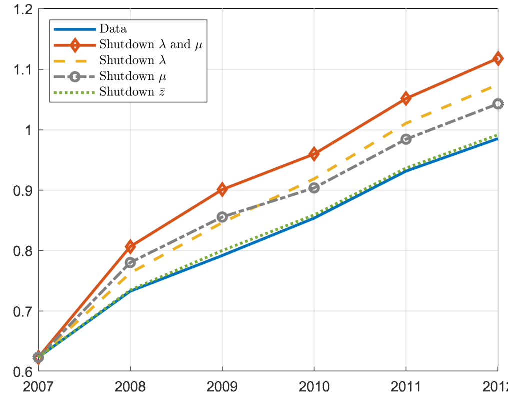
This equation relates bilateral MP to a number of factors. With the log-linear structure, we can assess the importance of these factors in accounting for bilateral MP by regressing the logarithm of each of them on the logarithm of MP as in Hottman et al. (2016). The regression coefficients sum to one and each represents the importance of one factor. Importantly, although this decomposition is theory consistent, it boils down to assessing how important are various factors in accounting for bilateral MP *in the data*. In this sense, any finding here is not 'baked-in' by our model.

Table 5 reports the result from this decomposition. Consistent with the existing literature, size and geography are the most important factors, together accounting for 75% of the variation in bilateral MP. Factors emphasized in traditional models of MP, such as firm productivity and factor prices, jointly account for 7.4% of the variation. Host and home financing factors directly account for 4.0%, and host finance further interacts with other host characteristics to account for an additional 5.4%. Thus, including the financing factor explains 9.4% of the variation. The remaining 8.7% is accounted for by firm heterogeneity. This decomposition exercise shows that financing factors are in the same order of importance as technology-related factors.[27]

[27] One might be concerned that λ_i and μ_h can capture other factors that drive the demand for credit, rather than the



(a) Log World FDI: 2002-2007



(b) Log World FDI: 2008-2012

Figure 7: Changes in World FDI Stock: Data and Counterfactuals

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

5.2 Financing Factors and the Dynamics of FDI

The previous exercise is a partial equilibrium decomposition because it takes as given the wage and total net worth of countries. However, both are shaped endogenously by countries' past fundamentals. To disentangle the effects of different fundamentals, we now move to a decomposition exercise based on counterfactuals along the dynamic transition path. Motivated by Figure 4, which shows a clear trend break in both world FDI and credit market conditions around 2007, we split the counterfactuals into two periods: before and after 2007.

The boom in FDI before 2007. In the first exercise, we examine whether the easing access to credit in the lead-up to the financial crisis can account for the increase in FDI in this period. To this end, we set the time sequence of calibrated (λ_i, μ_h) to their values at the beginning of the sample (year 2001). Per the discussion in Section 4.1 on how λ_i is identified from other fundamentals, we view this change as capturing the effect of relaxing credit market conditions.

Figure 7a plots the findings. The solid line indicates the actual evolution of world FDI stock over this period, which the model matches. The solid line with diamond markers indicates the counterfactual evolution of world FDI stock. Comparison between the two shows that, if the financial market conditions of all countries (reflected by λ_i and μ_h) had remained at the level of 2001, the increase in FDI stock during 2001-2007 would have decreased by around 30%. The dashed line and the solid line with circle markers indicate that the changes in λ_i and μ_h each account for about half of the effect. To investigate the role of changes in fundamental productivity, the dotted line plots the outcome when fundamental TFPs of all countries are kept at the level of 2001. The world FDI in this scenario decreases relative to the data, but only slightly. This reflects

conditions in the financial market. Note that in our calibration, we have controlled for the demand channel by targeting the entire sequence of GDP, employment, investment wedge, etc. This concern is further alleviated by the robustness exercises discussed in Section 2.2, which shows an independent effect of financing factors after controlling other host and home characteristics.

that over this period, the changes in fundamental TFPs among the major sending and recipient countries of FDI tend to be more modest than the changes in financial market conditions.

The slowdown in FDI growth since 2008. Our second dynamic exercise is similar in spirit but focuses on 2008-2012, a period of financial market disruptions and FDI growth slowdown. We feed in the calibrated sequence of parameters until 2007 and then 'freeze' the relevant fundamental parameters at their 2007 values for all subsequent years. Figure 7b depicts the main findings. The solid line is the data. The solid line with diamond markers shows that, had λ_i and μ_h of all countries remained at their peak values from 2007, the cumulative world FDI flow would have been around 35% higher. The dashed line and the dash-dotted line plots the individual effect of λ_i and μ_h, respectively. We find that both forces are quantitatively relevant, but the deteriorating access to credit for parent firms matters more toward the end of the period. As before, the changes in fundamental TFPs have a negligible impact on aggregate FDI.

Together, these two exercises show that the changes in financial market conditions play a first-order role in explaining the dynamics of aggregate FDI over this period.[28]

The role of general equilibrium effects and validation based on counterfactuals. In Appendix C.3, we conduct the above experiments by altering the fundamentals of one country at a time. These country-specific counterfactuals serve two goals. First, by comparing the predictions of country-specific experiments to those of experiments with simultaneous changes to all countries, we shed light on the importance of general-equilibrium forces in shaping the distribution of FDI. For example, an improvement in country A's domestic condition that leads to higher domestic factor prices and more outward FDI will suppress other countries' investment both toward country A and toward the main destinations of country A's outward FDI. We show that omitting these general equilibrium forces leads to an overestimation of the true aggregate effect, shown in Figures 7a and 7b, by two folds. This comparison highlights the value of using a multi-country general equilibrium model to evaluate the impact of shocks to fundamentals on FDI.

Second, using the outcomes from these country-specific experiments, we estimate a diff-in-diff specification for the impact of financial market conditions on outward FDI, which we compare to the empirical estimates based on the bilateral FDI panel. We find that the model can account for the empirical estimates both qualitatively and quantitatively. This lends strong support to the model as it shows that the model's *counterfactual* predictions also fit the empirical relationship.[29]

[28] Although our model builds in an effect of financial market conditions on FDI by design, whether the change in financial market conditions is *quantitatively important* in accounting for *aggregate* FDI dynamics is an empirical question, with the answer hinging on whether the elasticity of FDI with respect to financial market conditions implied by the model is close to the data counterpart, which we validate below, and whether the changes in financial market conditions took place in countries that were major FDI senders or recipients, which are the features of the data.

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

5.3 The Wage Gains from FDI

Our third exercise investigates countries' wage gains from opening up to foreign direct investment (FDI) and the associated short- and long-term tradeoffs in these gains. We examine how these tradeoffs differ across countries, as characterized by Propositions 2 and 3, by setting a host country's inward FDI wedges to zero (i.e., for a country h setting $\bar{\eta}_{ih} = 0$, $\forall i \neq h$) in all periods and calculating the change in the country's wage from the calibrated equilibrium. We conduct this analysis for each host country individually and summarize our findings in Table 6.

The first two columns of the table reports the share of MP in host production in 2001, and countries' static wage gains from this production. On average, MP increases host country wage by 8.7%. The static wages gains tend to be higher in hosts with higher MP share, which is consistent with equation (13).

In Column 3 of Table 6 , we report the average change in the logarithm of wages over the sample period resulting from the calibrated level of MP path, which we call the dynamic wage gain for a country. These gains tend to be smaller than the on-impact wage gains.

To explore the role of the FDI-MP nexus emphasized in Proposition 3 in driving dynamic wage gains, we compare our model to a technology-based model of MP, extended to incorporate capital accumulation. This alternative departs from the benchmark model in two main aspects: 1) λ_i and μ_h are set to infinite; 2) each firm chooses at most one host country,[30] and their production function, altered as below, features a return to scale of $1-\varphi$ in k and l, with φ being the share of firms' knowhow as a fixed input:

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

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

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

We report in the last column of Table 6 the inferred wage gains from the alternative model. Two observations are note worthy. First, the dynamic gains inferred by this alternative model are on average similar to the static gains, so it is not the dynamics per se that leads to the lower

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

Table 6: Static and Dynamic Wage Effects

	Static gains (%)		Dynamic gains (%)	
	(1)	(2)	(3)	(4)
	MP Share$_{2001}$	$\Delta \log(w_{h,2001})$	Benchmark	No-FDI
ARG	13.7	5.5	5.2	7.1
AUS	19.9	7.8	6.4	9.0
AUT	8.3	3.1	2.8	3.7
BEL	49.1	17.8	14.3	16.8
BRA	15.1	6.0	3.8	5.7
CAN	29.8	12.3	10.1	13.8
CHE	22.6	7.9	8.9	9.5
CHL	28.9	12.6	8.1	12.4
CHN	13.2	5.4	4.6	8.3
CZE	11.9	4.2	3.6	4.7
DEU	9.1	3.3	2.9	4.3
DNK	9.3	3.4	3.2	4.3
ESP	8.4	3.2	2.0	2.7
FIN	7.3	2.6	3.7	4.9
FRA	15.7	5.9	3.3	5.0
GBR	27.9	11.0	8.1	10.9
HUN	21.3	8.9	7.0	10.5
IDN	28.0	12.2	4.4	7.5
IND	10.2	4.1	3.0	4.7
IRL	88.6	56.1	21.4	34.8
ITA	3.7	1.3	1.1	1.8
JPN	1.7	0.6	0.6	0.9
KOR	5.5	2.1	1.7	2.4
MEX	18.0	7.5	5.3	8.3
MYS	21.0	8.5	6.1	9.0
NLD	70.6	34.4	33.7	33.9
NOR	16.0	6.1	3.2	5.0
NZL	37.1	16.6	9.2	15.7
POL	20.4	8.7	8.2	12.3
PRT	6.9	2.5	2.4	4.0
RUS	2.7	1.0	2.7	3.5
SGP	37.9	17.1	13.0	11.6
SWE	13.0	4.7	6.7	8.2
TUR	7.4	3.0	2.2	3.8
USA	8.5	3.1	2.1	3.3
VEN	8.3	3.0	2.2	3.1
Mean	19.9	8.7	6.3	8.5

Note: Column 1 reports the share of host production at foreign firms. Column 2 reports the static wages gains from inward MP in 2001. Column 3 reports the dynamic wage gains constructed by averaging the changes in log wages during the sample period (2001-2012). Column 4 reports the dynamic wage gains in the alternative model with the MP-FDI linkage shutdown (see text for details).

dynamic gains in the benchmark model.

Second, in most countries, the alternative model infers higher dynamic gains than the benchmark model, on average overstating the gains by one-third (8.5/6.3). Such tendency to overestimate the gains stems mainly from the home bias in direct investment, as characterized in Proposition 3. In the presence of such home bias, a reshuffling of profits to foreign firms due to past openness can reduce current investment if internal capital is crucial for investment—as is the case

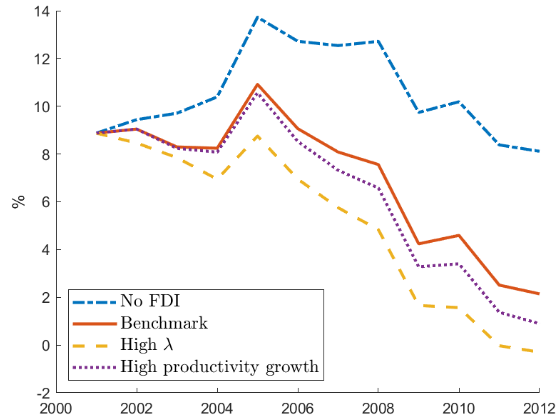


Figure 8: Wage Gains in Benchmark and Other Models: Openness to FDI for Hungary

Note: The figure depicts Hungary's wage gains from raising inward FDI wedges from zero to the calibrated values. 'Benchmark' refers to the benchmark model. 'No FDI' refers to the alternative model without FDI. 'High λ' refers to a different calibration of the benchmark that raises λ_{HUN} in every period by 2 s.d. of λ_i across countries (0.76); 'High productivity growth' refers to a different calibration of the benchmark that raises the annual productivity growth rate of Hungary in every period by 2 s.d. of the productivity growth rates across countries (5%). The inward wedges in alternative calibrations are chosen so that alternative models imply the same wage gains in 2001 as the benchmark.

of the benchmark model—but it would not have a dynamic effect in the alternative model. This effect is stronger in countries with rapidly growing domestic productivity or better financial market conditions, as these countries lose more from foregone investment by domestic productive firms. Therefore, the magnitude of the home bias effect is heterogeneous across countries.

To more closely compare the models with and without FDI, Figure 8 depicts their implications on wage gain dynamics, focusing on Hungary as an example. The solid line is the wage gains inferred by the benchmark model. Hungary's wage increased by 8.9% on impact due to the entry of foreign firms. This increase climbed to 11% in 2005, before it slowly gave way to the dynamic mechanisms discussed earlier. The dash-dotted line depicts the wage gains in the alternative model. On impact, the two models make the same prediction by design. Over time, the alternative model predicts higher gains. By the end of the sample period, the alternative model overestimates the wage gains by more than 100%. This difference highlights the importance of accounting for the FDI-MP nexus in welfare evaluations.

To further gauge the importance of a country's fundamentals in determining the welfare trade-off that arises from the home bias effect, the dashed line of Figure 8 depicts the inferred gains in a re-calibrated model where λ_i of Hungary is increased by 0.76 (2 s.d. of the measure among sample countries).[31] Under the new parameterization, the model infers substantially lower dynamic gains than the benchmark model, with the gap increasing over time and turning negative by 2012—echoing the trade off between static gains and dynamic losses raised in Proposition 3. The dotted line depicts the counterfactual wage gains in a re-calibrated model where the annual growth rate of Hungary's fundamental productivity, $\bar{z}_i$, is increased by 5% (2 s.d. of the measure

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

across sample countries). As shown, the inferred dynamic wage gains are also lower than the benchmark, although the difference is more modest. In Appendix C.4, we summarize similar exercises for each country, which demonstrates that the biases in assessing dynamic wage gains are both large and heterogeneous by country fundamentals.

6 Concluding Remarks

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

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

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

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