Financing Multinationals*

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Abstract

We develop a quantitative-oriented model that integrates production and financing decisions of multinational corporations (MNCs). Firms differ in their productivity and net worth, and expand by accumulating net worth over time and using funding from external investors. Firms can deploy their technology for production in affiliates overseas and become MNCs. However, the scale of the affiliate's operation is partially dependent on funding from the parent, giving rise to foreign direct investment (FDI). The model links FDI, affiliate production, and financial market conditions of host and home countries in ways consistent with the data, and remains tractable with heterogeneous firms and many asymmetric countries. We use the model to explore various issues such as the drivers of the global FDI growth over 2001-2007, the role of credit crunch for its growth slowdown since the Great Recession, and the welfare gains from FDI.

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1 Introduction

Multinational corporations (MNCs) tend to be more productive and have abundant financial capital at disposal. By mobilizing *both* technology *and* capital across borders, they exert a significant impact on the world economy. Recent studies have made great progress in developing quantitative models to explain the patterns of MNC activities and examine their impacts on the aggregate economy. Most existing work, however, treats MNCs merely as a vehicle for cross-border transfer of technology, overlooking the accompanying movement of capital. As a result, a number of questions on the activities of MNCs and the welfare implications of these activities remain unanswered. For example, it is natural to conjecture that factors affecting the access to capital, such as credit market tightness, should affect MNC activities, but how important are these factors quantitatively, and how do the effects differ by country? On the normative side, policymakers from many developing countries hold the view that MNCs could be a source of scarce capital for the country, yet we still know very little about the importance of this channel.

We answer these questions by developing a quantitative-oriented model of firm dynamics that integrates the movements of both technology and capital within MNCs. One key ingredient of the model is that, due to imperfections in the financial market, the operations of an affiliate partially rely on the internal capital market of the MNC. This generates an incentive for MNCs to invest in destination countries using internal funds, so foreign direct investment (FDI) arises as within-firm capital flow from the parent to the affiliate. We parameterize the model to match the transitional dynamics of FDI flows among 36 countries over 2001-2012, a period that witnessed rapid growth in the global FDI (2001-2007) and its slowdown (2008-2012). As shown in Figure 1, this overall change coincided with the credit boom among our sample countries over 2001-2007, and the credit crunch during the Great Recession. Through counterfactual experiments, we show that the changes in credit market conditions explain a substantial part of the aggregate FDI dynamics. We also show that our model generates different predictions on the welfare effects of MNCs than existing studies.

In Section 2, we start by documenting three facts on the financing and production decisions of MNCs. Our analysis encompasses two related measures of MNCs that has been treated largely in isolation in the literature: FDI, which captures the capital flow from the parent to the affiliate, and multinational production (MP), which is defined as the production by the affiliates of MNCs. Using country-pair level information on MP and FDI, we show that first, MP and FDI are highly correlated. This correlation exists even after controlling for the extensive margin of MNC activities (the number of affiliates) at the bilateral level. Second, host countries with a more developed financial market attract more FDI; conditional on the level of FDI, the affiliates in these countries also produce more. Third, home countries with a more developed financial market send out more FDI. All these results are robust to the inclusion of a number of host and home country characteristics, such as income, market size, tax rate, etc. Together, they suggest that: 1) operations of affiliates at least partially rely on the internal capital market of the MNCs; 2) access to external finance in both home and host countries matters for the allocation of FDI and the distribution of

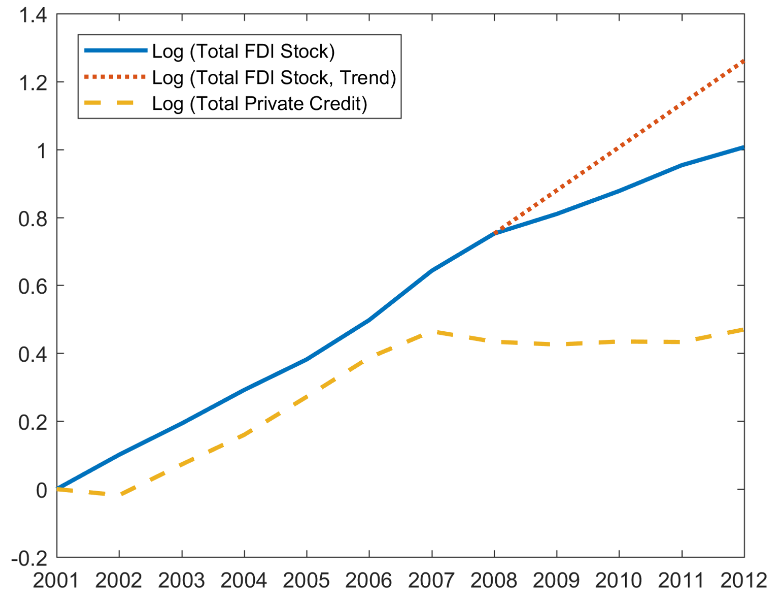


Figure 1: The Dynamics of FDI

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

MP across countries.

Motivated by the above facts, in Section 3, we develop a model of firm dynamics that explicitly incorporates the roles of internal capital markets and external finance. The goal of the model is to illustrate channels and provide quantitative answers to the questions posed earlier. In the model, firms are heterogeneous along three dimensions: their (pre-determined) home country, their productivity efficiency, which follows an exogenous Markov process, and their net worth, which is endogenous and can be accumulated over time. Firms decide whether and which country to deploy their productive technology. When a firm moves production abroad, an MNC emerges. MNCs (and domestic firms) combine their technology with physical capital and labor for the production of a homogeneous good. In addition to their net worth, firms have access to two sources of finance for physical capital: they can borrow against their net worth in the home country, and/or partner up with investors in the host country. Financial market conditions affect the availability of funding through both channels. To capture this effect in the most parsimonious setting, we assume that both types of external finance are impeded by exogenous collateral constraints, with the collateral for home financing being a firm's net worth and the collateral for host financing being the amount of capital a firm brings into the host country, namely FDI. We further allow the collateral requirement for the parent to be different from that for the affiliate, so a change in the financial market condition in a country can have differential effects on the access to external finance for parent firms and foreign affiliates operating there.[1]

[1]While in the model, financial frictions in both stages take the form of a collateral constraint, their interpretations could be different. The former captures the extent to which parent firms could borrow externally from the credit market, and therefore should be best interpreted as credit market conditions. Studies of financial frictions in macroeconomics often also interpret this as a measure of financial development (see, for example, Buera et al., 2011; Midrigan and Xu,

The model generates empirically consistent relationships between FDI, MP, and financial market conditions of a country. Because of financial frictions, the total production of an affiliate depends on how much funding the parent brings in. As a host country becomes financially more developed, foreign affiliates can more easily scale up by partnering with local investors, so the internal rate of return to investing in that affiliate increases, drawing more FDI into the country. On the other hand, as the financial market condition of a home country improves, productive firms will gain market share. In the short run, this drives up the wage and pushes more firms to invest abroad; in the long run, a better financial market enables faster accumulation of net worth, especially for the most productive firms, who are more likely to become MNCs. Both short- and long-run effects increase the level of outward FDI.

In Section 4, we take the model to the data to quantify the importance of financial market conditions for the dynamics of FDI for individual countries and for the world as a whole. We assemble a new panel of *bilateral* FDI information for a sample of 36 major developed and developing countries over 2001-2012. We supplement this data set with country-specific time series on domestic credit market conditions (captured by credit/GDP ratio), investment rate, parents' position in affiliates' balance sheet, and aggregate output. We fully saturate the model with country-specific wedges for investment returns and bilateral wedges for FDI returns, and calibrate these wedges, as well as the structural parameters of the model that characterize financial conditions and firms' productivity dynamics, so that the transitional dynamics of the model matches the data in *all* above dimensions.[2] We validate the model by showing that a few non-targeted moments are consistent with the data.

The calibration reveals gradual improvements in credit market conditions until 2007 in the form of continuously relaxing collateral constraints for both parents and affiliates. This trend was reversed since the great financial crisis. Our first set of quantitative exercises focus on how changes in individual countries' fundamentals affect their own FDI in each of the two periods, holding fundamentals of other countries at the benchmark, mimicking empirical studies that use a diff-in-diff design (see e.g. Klein et al., 2002). We find that the credit boom, through the lens of our model, can explain up to 50-80% of the cumulative FDI outflows during 2002-2007 in most of our sample countries. On the other hand, if the financial markets had stayed at the level of 2007 in the post-recession era, then the cumulative FDI outflows during 2008-2012 would have been 30-100% higher than the factual values. With the simulated data from these counterfactuals, we estimate the reduced-form impact of home market financial conditions on outward FDI using a diff-in-diff specification. We find that the resulting coefficient is close to the corresponding estimate based on the real data, so our model counterfactuals are in line with the dynamics in the data in a diff-in-diff

2014; Moll, 2014). The latter, the leverage constraint at the affiliate level captures the extent to which a parent company can rely on local partners. One interpretation for this friction is that with imperfect contract enforcement, stakes in the affiliates provide an incentive for the parents to exert effort, which makes local investors willing to invest. (See Antras et al. (2009) for a theory that links institution quality to the financing of affiliates endogenously and the empirical evidence based on American MNCs.) Despite the difference, frictions in both stages are clearly influenced by the overall quality of financial institutions and credit market conditions in a country. In the quantitative exercise, we discipline these two objects using different data and find they are indeed correlated.

[2] As in Eaton et al. (2016), once the time series of all structural parameters and wedges are fed in, the model produces the exact patterns in the data.

sense.

The above analysis overlooks domestic general equilibrium effect and the third country effect. For example, as financial market conditions in the U.S. improve, the outward investment by American MNCs increases. The increased competition created by these MNCs in their destination countries drives out investment to the same destination from third countries. Changes in domestic wage also affect inward FDI into the U.S. We find that these equilibrium responses are large — the cumulative *aggregate* FDI flow between 2002-2007, across all source and destination countries, would decrease by around a third, if the collateral constraints stay at the value of 2001; the cumulative FDI during 2008-2012 would have been 40% higher, if the credit market conditions had stayed at the peak value of 2007. While these numbers are still quantitatively significant, the difference in magnitude compared to country-specific exercises demonstrates the value of using a multi-country general-equilibrium model.

Finally, in Section 5, we study the normative implications of our model and compare them to those of existing studies. Following a tradition in international economics (see, e.g., Arkolakis et al., 2012; Ramondo and Rodríguez-Clare, 2013), the focus of our comparison will be on *ex-post effects*, defined as the percentage change in welfare as a country moves between two equilibria with different levels of MNC activities. Because of the dynamic incomplete market setting, the full welfare effects of MP cannot be characterized analytically. To clarify the channels, we first derive the static impacts of inward MNC activities on workers' real income. Our formula shows that, unlike in papers with Ricardian models of MNC (Ramondo and Rodríguez-Clare, 2013; Alviarez, 2016; Cravino and Levchenko, 2017), in which the MP shares are the sufficient statistics for the welfare effect, or the studies that model FDI as movement of physical capital only (Mundell, 1957), in which the shares of FDI in domestic capital are the sufficient statistics, in our setting, even the static income change depends on *both* MP *and* FDI. MP captures the relative importance of foreign affiliates in local production. Conditioning on the MP shares, a higher fraction of investment by foreign parents reduces affiliates' dependence on credit from the host country, thus reducing the crowd-out effect on domestic firms.

When the world credit market is fully integrated, the credit crowd-out effect is minimal. In that case, the MP shares are sufficient statistics. Yet it still encompasses two forces. First, a 'technological' channel — because foreign affiliates are on average more productive, their entry improves the productivity distribution of firms in an economy. Second, a 'capital deepening' channel — the capital brought in by foreign firms increases total amount of capital used in domestic production.[3] This latter channel corresponds to what we would obtain, if we were to use a model that treats FDI as merely capital for the welfare evaluation.

We evaluate the importance of the two static channels for the sample countries, focusing on the year 2001 for illustration. The median country has around 8% static welfare gains. On average, about 40% of the gains are through the technological channel, but this ratio differs significantly across countries— the technology channel matters more for countries with low domestic produc-

[3]Although the world credit market is integrated, the amount of capital used in domestic production might still be constrained by the net worth of domestic firms.

tivity, whereas the capital channel matters more for countries that are relatively scarce in capital. This result echoes policymakers' emphasis that for developing countries with severe financial constraints, FDI is not only a source of advanced technologies, but also a source of financial capital (UNCTAD, 2011). It also underscores the importance of jointly modeling both FDI and MP in studying the aggregate effects of MNC activities.

The static analysis takes as given the evolution of the joint distribution over productivity and net worth. The financial frictions, coupled with the incomplete market assumption, lead to additional dynamic implications because the joint distribution will change as a result of MNC activities. To make this point, we calculate the full effects of MNC activities by shutting down inward FDI for the entire period starting from 2001 and calculate the dynamic wage effects. The initial wage gains in 2001 are the same as the static experiments. Over time, however, domestic firms are able to accumulate capital. As a result, the wage gains gradually fall below those predicted by the static effects. As we increase the TFP growth rate or financial market development of a host country, the dynamic wage gains will fall further and could even turn negative — inward FDI could lead to short-run gains at the expense of long-run losses. This is because due to financial frictions, the growth of domestic firms is constrained by their size. The entry of MNCs depresses the market share of domestic firms, and slows down their capital accumulation. For countries in which the domestic sector has a higher growth rate compared to the rest of the world — either because they have a higher TFP growth rate or a more developed financial market — MNCs drive market shares out of the firms that will be the most productive in the future, resulting in lower long-run income.

Our paper is most closely related to a recent literature that studies quantitatively the patterns of MNC activities and their impacts on the aggregate economy (Burstein and Monge-Naranjo, 2009; McGrattan and Prescott, 2009; Ramondo and Rappoport, 2010; Ramondo and Rodríguez-Clare, 2013; Alviarez, 2016; Cravino and Levchenko, 2017; Tintelnot, 2017; Arkolakis et al., 2018; Anderson et al., 2017; Ghironi and Wolfe, 2018, among others). Most existing studies only consider the movement of technology (either rival or non-rival) and abstract from modeling financial capital. As a result, they are silent on FDI, a widely collected and used statistic, and do not speak to how financial market conditions affect the activities of MNCs,[4] which has been documented extensively (Antras et al., 2009; Alfaro and Chen, 2012; Desai et al., 2008; Klein et al., 2002; Bilir et al., 2014; Manova et al., 2015).[5] Our contribution is to develop a tractable heterogeneous-firm model, which combines the technology channel emphasized in existing studies with the movement of capital inside MNCs. This model gives new answers to old questions, such as how large are the welfare gains from MNC activities and moreover, allows us to answer new questions. To incorporate capital accumulation and reallocation, our model is naturally dynamic, which is related to a small but growing literature in the intersection between firm dynamics and FDI (Fillat

[4]Indeed, in their survey of MNCs studies, Antràs and Yeaple (2014) concludes by highlighting the lack of research that incorporates the allocation of capital within firms.

[5]The literature has documented a close relationship between FDI and financial development (see, for example, Desbordes and Wei, 2017; Bilir et al., 2014), and that host country financial development is important for a country to benefit from FDI (Alfaro et al., 2004).

and Garetto, 2015; Garetto et al., 2017).

As an important form of cross-border capital flow, FDI has also received considerable attention from the international finance literature. Within this literature, our paper is related to both the empirical studies on the determinants and aggregate effects of FDI,[6] as well as the theoretical and quantitative work on the welfare implications of international capital flows (Mundell, 1957; Feldstein, 1995; Gourinchas and Jeanne, 2006; Ohanian et al., 2018).[7] Relative to the empirical work, our contribution is to document the joint relationship between MP, FDI, and financial market conditions. Relative to the theoretical and quantitative work, which usually treats FDI as portfolio capital flows, our contribution is to formally model FDI as within-firm capital that enables firms to transfer their technology to affiliates, thereby connecting this literature to the studies of MNCs in international trade.

More broadly, this paper is related to recent studies on the reallocation of activities across production units within a firm in response to plant-level economic shocks, and the implications of this reallocation for the transmission of business cycle across regions (see, e.g., Giroud and Mueller, 2015; Giroud and Rauh, forthcoming). While focusing mostly in the domestic setting, the patterns documented in this literature are supportive of the mechanisms in our model. Our paper complements this literature by developing a framework suitable for quantitative analyses.

In terms of methodology, the structural accounting procedure we use in matching the data is related to Eaton et al. (2016) and Kehoe et al. (2018), but different in that our model allows for dynamic decisions with firm heterogeneity, incomplete markets, and multinational corporations, while still remains tractable.[8] This allows us, for the first time in the literature, to perform a dynamic analysis of FDI in a setting that is amenable to the multi-country data. As discussed in the conclusion section, the model and the calibration algorithm developed here can also be extended to answer other questions on FDI policies.

2 Empirical Relationship Between MP, FDI, and Financial Markets

This section documents relationships between MP, FDI and financial markets. Our measures of FDI and MP are both from Ramondo et al. (2015), which provides the average MP and FDI over 1996-2001 at the country-pair level. MP is defined as the total sales of affiliates from a given home country. FDI is defined as the stock of capital parents invest in affiliates in the form of equity and intra-company loans. We also collect a number of country characteristics, such as their income, business tax rate, policy restrictions on FDI and indices for the quality of financial institutions,

[6]The literature is too voluminous to discuss here. Most related to our focus on financial market conditions, we refer the readers to Desbordes and Wei (2017) on empirical studies of financial market conditions on FDI; and to Alfaro et al. (2004) and the reference thereto on the effects of FDI on growth.

[7]Also relatedly, Caballero et al. (2008), Ju and Wei (2010), and Wang et al. (2016) examine how financial frictions might explain the patterns of global imbalances. Our model is also suitable to for jointly analyzing the determinants and welfare implications of financial of portfolio capital and FDI flows in a multi-country setting, but we abstract from this as global imbalances are not the focus of this paper

[8]The restricted version of our model to a closed economy is also related to Buera et al. (2011); Midrigan and Xu (2014); Moll (2014). Buera et al. (2015) studies in such a framework how a credit crunch affects employment, investment, and output, but in a closed-economy setting.

from various sources. The appendix provides detailed descriptions of data sources and results for additional robustness tests. Using these data, we document three facts.

2.1 Correlation Between MP and FDI

Fact 1: MP is systematically correlated with FDI at country-pair level, controlling for extensive margin variation.

Our first fact, reported in Table 1, speaks to the relationship between the production and financing of affiliates. Specifications in the table are estimated using the Poisson Pseudo Maximum Likelihood estimator to avoid potential biases, as recommended by Silva and Tenreyro (2006). The dependent variable is log of MP. The first column reports the univariate regression of MP on FDI, which has an R-squared of over 0.7. That MP and FDI are strongly correlated should not be surprising—in fact, the literature has often used these two as interchangeable measures of MNC activities. We interpret this correlation as reflecting that affiliate production relies at least partially on financing from the parent, for either fixed investment or working capital. Of course, since a plant will only be defined as a foreign affiliate if the foreign share of its equity exceeds a certain threshold, the correlation could be entirely mechanical. In the second column, we control for the number of affiliates in a host country owned by parents from the home country. The coefficients for both independent variables are economically significant. Conditional on the number of affiliates, the more funding the affiliates receive from their parent, the more they produce. To further control for the unobserved heterogeneity, in the third column, we include home and host country fixed effects; in the fourth column, we include various measures for bilateral distance. The coefficients barely change.

The strong correlation between MP and FDI after controlling for the extensive margin variation is inconsistent with models featuring a perfect financial market — in the absence of frictions, affiliates can borrow locally, so their production should be independent of the investment they receive from the parents. Instead, it supports a model in which affiliates have limited capability to raise funding externally. This is in line with findings from firm-level empirical studies that affiliates rely on access to parents' internal capital markets.[9] Using information at the country-pair level, we show that the patterns hold for the aggregate outcomes, in a large number of countries.

2.2 Host Financial Development and MNC Activities

Fact 2: More FDI are made in countries with a more developed financial market. Conditional on the level of FDI, MP in these countries are even higher.

The second fact relates financial market conditions in the host country to financial and production activities of MNCs. A large empirical literature finds financial development to be among the most robust predictors of FDI (see, Desbordes and Wei, 2017 and the reference therein). The first part of Fact 2 confirms this result in our data set.

[9] For example, Manova (2013) looks at Chinese exporters and find that MNC affiliates are less affected by financial constraints; Alfaro and Chen (2012) shows that during the global financial crisis, multinational affiliates benefit from their access to the internal capital market.

Table 1: The Correlation between FDI and MP

	(1)	(2)	(3)	(4)
Dependent Variable		Log (MP)		
log (FDI)	0.933***	0.589***	0.422***	0.432***
	(0.040)	(0.047)	(0.061)	(0.062)
log (number of affiliates)		0.562***	0.495***	0.491***
		(0.063)	(0.061)	(0.061)
Observations	2270	2092	1353	1349
R^2	0.736	0.878	0.978	0.980
Home country FE			Yes	Yes
Host country FE			Yes	Yes
Bilateral distance measures				Yes

Note: Bilateral distance measures include: distance between host and home countries; whether there is a colonial tie between the two; whether two countries share a border; whether they speak the same language. The estimation specification is PPML.

Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Following Desbordes and Wei (2017), we use the log of financial development index developed by the World Bank as our primary measure of the quality of financial institutions.[10] The dependent variable in the first two columns of Table 2 is log(FDI). The first column includes only the financial development index and home country fixed effects. The coefficient is economically large and statistically significant, indicating a strong positive correlation between inward FDI and financial development. To rule out alternative explanations, in the second column we include host country characteristics, including size (log(GDP)), aggregate TFP, business tax rate, whether it is viewed as a low-tax country, the index for policy restrictions on inward FDI, and bilateral distance measures. Not surprisingly, the inclusion of these variables shrinks the coefficient for the financial development index, but it remains economically significant. According to the coefficient, a 10% increase in the financial development index is associated with a 6% increase in inward FDI.

Columns 3 to 6 of Table 2 establish the second part of Fact 2. The dependent variable in these regressions is MP and the primary variable of interest is financial development. In Column 3, we include home country fixed effects, bilateral distance measures, and additional host country characteristics. The coefficient for financial development indicates that a 10% increase in the index is associated with a 4% increase in the production of affiliates, controlling for the financial investment from parents. This is consistent with the mechanism that a better financial institution allows parent companies to raise capital more easily from local investors, in the form of either equity or debt, to expand the scale of their affiliates.

The above correlation has several explanations. For example, financially more developed countries might have more deep-pocketed investors, who are willing to lend with relatively less collateral. Alternatively, Antras et al. (2009) demonstrates theoretically and empirically that, better

[10] The index is the sum of two sub-components, with the first measuring the depth of credit history info in the economy and the second measuring the legal protection of creditors' rights.

Table 2: Host Financial Institution and MNC Activities

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	Log (FDI)		Log (MP)			
Log (financial development index)	3.189***	0.971***	0.580***			0.365***
	(1.221)	(0.305)	(0.219)			(0.112)
Log (FDI)		0.575***	0.601***	0.584***	0.366***	
			(0.064)	(0.063)	(0.066)	(0.037)
Log (credit info depth)				0.399		
				(0.249)		
Log (creditors' right)					0.356**	
					(0.156)	
Log (number of affiliates)						0.540***
						(0.062)
Observations	2840	2627	1276	1165	1276	1068
R^2	0.250	0.871	0.962	0.959	0.963	0.977
Home country FE	yes	yes	yes	yes	yes	yes
Additional host characteristics		yes	yes	yes	yes	yes
Bilateral distance measures		yes	yes	yes	yes	yes

Note: Bilateral distance measures include: distance between host and home countries; whether there is a colonial tie between the two; whether two countries share a border; whether they speak the same language. Additional host characteristics include: size (log gdp), average productivity, business tax rate, and an index for policy restrictions on inward FDI. The estimation specification is PPML.
Standard errors (clustered at host-country level) in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

protection of creditors' right in a country might reassure local investors that the parent company will make effort in transferring the technology, increasing local partners' willingness to invest. While we will not take a stand on the exact channel of operation, consistent with the latter explanation, when we include the two subcomponents of the financial development index separately in Columns 4 and 5, the effects are statistically stronger for protection of creditors' right than for the depth of credit history information.

Finally, in Column 6, we include log number of affiliates in the regression. The coefficient associated with financial development decreases by around a third, but remains significant, so it seems that the channel operates through both extensive and intensive margins.

In summary, host country financial conditions affect MP in two ways— directly by attracting more FDI, and indirectly by allowing these affiliates to scale up. By showing that the correlations hold on aggregate data across a large number of countries, our analysis complements that of Antras et al. (2009), which focuses on U.S. MNCs and exploits exogenous variations in financial development to show a causal effect.

2.3 Home Financial Development and MNC Activities

Fact 3: Countries with a more developed financial market have a higher level of outward FDI, but conditional on FDI not necessarily a higher level of outward MP.

The third fact relates outward FDI to home country financial development.[11] Columns 1

[11] Desbordes and Wei (2017) also looks at home country financial development on outward FDI by exploiting the

Table 3: The Effects of Home Financial Development on Outward FDI

	(1)	(2)	(3)	(4)	(5)
Dependent Variable		Log (FDI)			Log (MP)
Log (financial development index)	4.102***	1.354***			0.320
	(1.586)	(0.324)			(0.336)
Log (credit info depth)			0.770		
			(0.543)		
Log (creditors' right)				0.837***	
				(0.229)	
Log (FDI)					0.804***
					(0.045)
Observations	2947	2183	2032	2183	1322
R^2	0.249	0.863	0.848	0.865	0.965
Host country FE	yes	yes	yes	yes	yes
Additional home characteristics		yes	yes	yes	yes
Bilateral distance measure		yes	yes	yes	yes

Note: See Table 2 for definition of variables. Columns 1 through 4 show that financial development in the home country is correlated with increased outward FDI. Column 5 shows that once FDI is controlled for, it no longer has an effect on MP. The estimation specification is PPML.
Standard errors (clustered at home-country level) in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

through 4 in Table 3 report the results. The dependent variable is log FDI, and the coefficient of interest is home financial development. We start with a regression in which the only control variables are host country fixed effects. The coefficient is economically large but of course, it may simply be picking up other effects, such as the size of a host country. In the second column, we control for other host country characteristics including their size, productivity, business tax information, and an index for policy restriction of FDI. The coefficient diminishes to 0.97 but remains statistically significant. As before, we further estimate the same specification separately for the two subcomponents of the financial development index, and find that legal protection of creditors' rights seems to be more important.

Finally, Column 5 can be viewed as a placebo test. It shows that home country financial institution has no effect on MP, once FDI is controlled for, so home financial institution increase MP primarily by increasing parent investment.

To summarize, using bilateral data, we document a strong relationship between MP and FDI. Our results further suggest that both home and host country financial development are correlated with FDI. But conditional on FDI, only host country financial development is correlated with MP. In the Appendix, we show these results are robust to different measures of financial development and alternative specifications using ordinary least squares, and are not driven by a number of small countries. In the next section, we develop a quantitative model that is consistent with these facts.

interaction between country-level financial development and sectoral variation in dependence on external finance. Using bank-firm linked data, Klein et al. (2002) and Biermann and Huber (2018) provides causal evidence that the collapse in the banking sector reduces outward FDI from Japanese and German firms, respectively.

3 Model

3.1 Endowments, Preferences, and Technology

Time t is discrete and goes from 0 to infinity. There are N countries, indexed by $i \in I$. Each country is endowed with an exogenous number of workers, denoted by $L_{i,t}$. Workers are immobile, each supplying one unit of labor inelastically and consuming all their labor income.

Each country also has a continuum of firms. Following a large literature in firm dynamics with financial constraints (Buera et al., 2011; Midrigan and Xu, 2014; Moll, 2014), we interpret firms as owned by entrepreneurs and further assume that they have the following preference:

$$\mathbb{E} \sum_{t=0}^{\infty} \beta^t u(c_t), \tag{1}$$

where c_t is the entrepreneurs' private consumption at period t. Entrepreneurs make operational decisions to maximize their personal utility. Of course, most MNCs are large corporations owned by not individual entrepreneurs but rather shareholders. In that case, we can think of the entrepreneur as the CEO of the company and interpret c as the compensation of the CEO.[12]

Firms differ in their productivity z which follows Markov processes with country-specific conditional density $f_i(z'|z)$. A firm from country i can operate affiliates, all of which engaging in the production of a homogeneous product, in different host countries (including country i). The *affiliate* with productivity z_{ih} at the host h uses l units of labor and k units of capital to produce

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

units of output, with $1 - \alpha \in (0, 1)$ being the labor share. We assume that the productivity of an affiliate depends partially on the productivity of the parent and partially on the host country it operates in, described by the increasing function $z_{ih} = \tilde{z}_{ih}(z)$, with $\tilde{z}_{ii}(z) = z$ as a normalization.

In the above setting, output is a homogeneous good so there is no scope for trade. As shown in the appendix, however, this setup is isomorphic to a closed-economy version of an environment with the CES preference and monopolistic competition, if capital stock is introduced as the fixed cost for the production of horizontally differentiated varieties and if this fixed cost increases with development. In that alternative model, it is possible to explore the interaction between trade and FDI policies. Since this interaction is not the focus of the present paper, we stay with the above simple neoclassical production setting throughout.

[12] In modern corporations, CEO are usually incentivized through stock options and bonus. For example, Google CEO Sundar Pichai made $100.5 million in 2015, among which only $652,500 was salary, and $99.8 million was in the form of restricted stock. Given this, how much a CEO is being paid largely depends on shareholders' wealth gains. If the CEO's compensation is proportional to total dividends to shareholders, then the incentives of CEO would be largely aligned with that of shareholders, in which case we can think of $u(c_t)$ as utility of the shareholders. In particular, when u takes the log form, CEOs being paid a fixed fraction of total dividends will act in the same way as if they were maximizing shareholders' utility.

3.2 Affiliate Finance and Production

Affiliates hire labor in perfectly competitive host country labor markets and finance their capital use with funds from the parent firm as well as funds raised from local investors. Because of the financial constraint at the corporate level, when the shadow price of internal capital is higher than the local cost of finance, parents have the incentive to use as much fund from the host country as possible, in either equity or debt. However, regardless of the instruments used, various imperfections in the financial market and the credit conditions in the host country might limit the extent to which a parent can rely on host country external finance.[13]

Given our focus on the aggregate FDI and its macro implications, we wish to capture this force in a simple environment. We assume that to raise each dollar from the host country, an exogenous minimum level of parent investment must be made. This is similar to the 'collateral constraint' setup used in many macro-finance models. Without confusion, we will refer to the funding from host country as local debt, but we interpret this broadly as capture both debt and equity held by local partners and will pin down the collateral constraint using data that include both components. Cross-sectionally, in host countries with better financial institutions, the constraint for both debt and equity finance would be less severe, so foreign affiliates can be more dependent on local partners for finance. Over time, financial institutions are unlikely to change in the short-run, but the availability of credit in a country will also affect the difficulty of accessing local funding. Our quantification strategy will allow the severity of the collateral constraint to differ both across countries and over time, but we suppress the time subscript for now.

Formally, we assume that the total amount a parent company can raise in host country h, denoted by b^F, cannot exceed $\mu_{ih} \cdot e_h$, in which e_h is the investment made by the parent company, and μ_{ih} is the maximum 'leverage' allowed in host country h for a parent firm from i and reflects financial market conditions in country h. The maximum capital that can be used in production is thus $(1 + \mu_{ih})e_h$.

The return to investment in an affiliate is output plus non-depreciated capital, minus labor cost and interest expense. Denoting the wage and net interest rate in host h by w_h and r_b^h respectively, for given e_h and affiliate productivity $z_{ih} = \tilde{z}_{ih}(z)$, the parent firm makes the affiliate financing and

[13] For example, if financed through debt, a standard enforcement problem might arise, forcing the parent to put in some collateral for borrowing; if financed through equity, an agency problem might exist— the inputs of the parent, who is the developer and original owner of a production technology, could be crucial for successful deployment of the production technology. Because the inputs, such as the transfer of know-how, are hard to specify in a contract, if the parent does not hold enough stake of the affiliate, the incentive for technological transfer will be undermined. Another way of thinking about this channel is that, because of contractual frictions on parents' input, there is no perfect market for technology. A substantial share of affiliates assets must be at parents' stake for host country investors to be willing to invest. This mechanism has been examined in a micro-founded model and tested using the data of MNCs headquartered in the U.S. in Antras et al. (2009).

production decision to maximize the return from their investment:

$$\tilde{R}_{ih}(z, e_h) = \max_{b^F,k,l,y} y + (1-\delta)k - w_h l - (1+r_h^b)b^F, \tag{2}$$

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

Cross-border investment projects are characterized by significant frictions, such as the barriers to communications and transfer of knowledge (Keller and Yeaple, 2013), the risk of extortion by corrupted foreign officials (Wei, 2000) or the expropriation of foreign governments (Thomas and Worrall, 1994), as well as idiosyncratic risks involved in individual projects. To capture these, we assume that the parent can seize 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 much like in the iceberg trade cost specification. $\eta_{ih} \equiv \bar{\eta}_{ih} \cdot \zeta_h$, in which $\bar{\eta}_{ih}$ is the deterministic component common for all firms from country i investing in host h, while ζ_h is the idiosyncratic component that is i.i.d. across parents and affiliates. The literature has documented that MNCs are more productive than domestic firms and rationalized this with a fixed cost of setting up affiliates so that the average return from opening up foreign affiliates increases in productivity (Helpman et al., 2004). In quantification, we incorporate this channel by allowing $\bar{\eta}_{ih}, i \neq h$ to be an increasing function of z and parameterize the function using firm-level data, but suppress z as an argument for now.

3.3 Parent Firm Finance and Investment

In each period, *after* seeing the realizations of the project return shocks from each potential host country, $\boldsymbol{\eta} = (\eta_{i1}, \eta_{i2}, ..., \eta_{iN})$, and the current productivity, z, firms first decide whether to produce or stay idle. An idle firm loans out its net worth a at the market interest rate. An active parent firm, on the other hand, decides whether to borrow risk-free bond domestically using its net worth as collateral to scale up, and which host country to invest in.

The rate for lending and borrowing in country i is denoted by r_i^b. For active firms, the amount they can borrow is subject to the collateral constraint

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

which says that the external funds cannot exceed λ_i fraction of the parent firm's net worth. The total fund at the parent, $a + b^H$, will then be allocated to affiliates to maximize the total return.

Formally, the Bellman equation for the value function (adding time subscript explicitly) of firm owners from country i reads

$$
\begin{aligned}
v_{i,t}(z,\boldsymbol{\eta},a) = & \max_{c,a',\{e_h\}_{h=1}^{N},b^H} \log(c) + \beta\mathbb{E}\left[v_{i,t+1}(z',\boldsymbol{\eta}',a')\middle|z\right] \\
& s.t. \quad \sum_h e_h = a + b^H \\
& \qquad -a \leq b^H \leq \lambda_{i,t} \cdot a \\
& \qquad c + a' = \sum_h \tilde{R}_{ih,t}(z,e_h)\eta_{ih} - (1+r^b_{i,t})b^H,
\end{aligned} \tag{3}
$$

where the first constraint says that funds allocated to affiliates should sum to net worth plus debt raised in the home country. The second constraint says that, (1) an idle parent firm can loan out all but not more than its net worth; and (2), funds raised by an active parent firm cannot exceed the limit imposed by the collateral constraint. $\tilde{R}_{ih,t}(z,e_h)\eta_{ih}$ in the third constraint denotes the net return from investing in host country h, which is net of wages, payment to *host* country investors, and the component melt on the way back. This constraint says that the total repatriated profits from affiliates are split among: domestic lenders, retained earnings a', and current consumption of firm owners.

3.4 Characterizing Affiliate- and Firm-Level Decisions

In the above problem, firms make a dynamic decision of capital accumulation and a static decision of investment allocation among host countries. The incomplete-market setting, while natural, means that in solving the model, we need to keep track of the joint distribution of (z,a) for each country. To bring the model to the data, we characterize all firm-level decisions analytically and provide some aggregation results with the aid of additional assumptions.

We start by solving for the return and policy functions for each affiliate, specified in Equation (2). Because both the objective function and the constraint in the problem are homogeneous of degree one in e_h, the affiliate decision and return will be linear in e_h, too, and can be characterized by the following lemma:

Lemma 1. *The affiliate return defined in (2) satisfies $\tilde{R}_{ih}(z,e_h) = R_{ih}(z)e_h$, where*

$$
\begin{aligned}
R_{ih}(z) = & \max_{\hat{b}^F,\hat{k},\hat{l},\hat{y}} \hat{y} + (1-\delta)\hat{k} - w_h\hat{l} - (1+r^b_h)\hat{b}^F, \\
& s.t. \quad \hat{y} = [\tilde{z}_{ih}(z)\hat{k}]^{\alpha}\hat{l}^{1-\alpha} \\
& \qquad 0 \leq \hat{b}^F \leq \mu_{ih} \\
& \qquad 0 \leq \hat{k} \leq 1 + \hat{b}^F.
\end{aligned} \tag{4}
$$

Correspondingly, the solutions to (2) satisfy $X_{ih}(z,e_h) = \hat{X}_{ih}(z)e_h$ for $X = (b^F,k,l,y)$, where $\hat{X}_{ih}(z)$ are solutions to (4) and can be explicitly characterized by

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

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

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

The first part of the lemma specifies that, the *affiliate*-level total return is simply the return to each unit of investment times total investment, with the unit-investment return given by the solution to Equation (4). The second part of the lemma shows that, first, affiliate decisions are linear in e_h. Second, affiliate decisions follow a cutoff rule in z: affiliates whose productivity are above the threshold z^*_{ih} will leverage the funding from local investors and produce at full capacity; on the other hand, affiliates whose productivity are below the threshold will choose not to use any funding from the host country. The cutoff is given by the equality condition between the cost of borrowing, $1 + r^b_h$, and the return from an additional unit of capital, given by $\pi_h(z_{ih})$. The selection channel as in the Melitz model operates here: as the wage goes up, the cutoff increases, so fewer active affiliates will seek funding from local investors for expansion.

Lemma 1 gives an explicit solution to the affiliates' problem and investment return $\tilde{R}_{ih,t}(z, e_h)$ in Equation (3). However, it still remains a challenge to characterize the solution to the dynamic problem at the firm-level. Following a large literature in macroeconomics, we assume the utility function of firms' owner takes the log form:

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

Under Assumption 1, the solution to Equation (3) can be characterized by Lemma 2, using the homogeneity property of the problem.

Lemma 2. *The value function of firm owners (Equation (3)) satisfies*

$$
v_{i,t}(z, \boldsymbol{\eta}, a) = \hat{v}_{i,t}(z, \boldsymbol{\eta}) + \frac{1}{1-\beta}\log(a)
$$

for some $\hat{v}_{i,t}(z, \boldsymbol{\eta})$. The Policy functions for consumption and investment satisfy

$$
\begin{aligned}
c_{i,t}(z, \boldsymbol{\eta}, a) &= \hat{c}_{i,t}(z, \boldsymbol{\eta})a, \ \hat{c}_{i,t}(z, \boldsymbol{\eta}) = (1-\beta)R^a_{i,t}(z, \boldsymbol{\eta}) \\
a'_{i,t}(z, \boldsymbol{\eta}, a) &= \hat{a}'_{i,t}(z, \boldsymbol{\eta})a, \ \hat{a}'_{i,t}(z, \boldsymbol{\eta}) = \beta R^a_{i,t}(z, \boldsymbol{\eta}),
\end{aligned}
$$

where

$$R^a_{i,t}(z,\boldsymbol{\eta}) = \begin{cases} [\max_{h'} R_{ih',t}(z)\eta_{ih'}](1+\lambda_{i,t}) - (1+r^b_{i,t})\lambda_{i,t}, & \text{if } \max_{h'} R_{ih',t}(z)\eta_{ih'} \geq 1+r^b_{i,t} \\ (1+r^b_{i,t}), & \text{if } \max_{h'} R_{ih',t}(z)\eta_{ih'} < 1+r^b_{i,t}, \end{cases} \tag{5}$$

with $R_{ih,t}$ defined in Lemma 1. The Policy function for borrowing and lending satisfies

$$b^H_{i,t}(z,\boldsymbol{\eta},a) = \hat{b}^H_{i,t}(z,\boldsymbol{\eta})a$$

where

$$\hat{b}^H_{i,t}(z,\boldsymbol{\eta}) = \begin{cases} \lambda_{i,t}, & \text{if } \max_{h'} R_{ih',t}(z)\eta_{ih'} \geq 1+r^b_{i,t} \\ -1, & \text{if } \max_{h'} R_{ih',t}(z)\eta_{ih'} < 1+r^b_{i,t}. \end{cases} \tag{6}$$

According to Lemma 2, the value function of a firm owner is the sum of two components, one depending solely on parent productivity and the idiosyncratic return draws for its potential affiliates across the world, and the other being the log net worth of a firm. Moreover, a fixed share (β) of the total end-of-period wealth will be reinvested, with the remaining used for consumption. This end-of-period wealth takes into account the net return firms will be making from either active production or staying idle loaning out the net worth. With the linear return structure at the affiliate level (Lemma 1), it follows that active firms will invest all resource into the most profitable affiliate, which might be profitable for either fundamental reasons or a lucky η_{ih} draw (recall $\eta_{ih} = \bar{\eta}_{ih}\zeta_h$ with ζ_h random). Given the financial constraint faced by the parent firm, if the highest net return is above the cost of borrowing, the firm will max out the credit allowed $(\lambda_{i,t} \cdot a)$; else, the firm owner will lend the net worth, in which case the return to wealth is the market interest rate. These decisions are summarized by Equation (5) and (6).

3.5 Aggregation

Together, Lemmas 1 and 2 express firms' decisions as functions of their states $(z,\boldsymbol{\eta},a)$ after the uncertainty about the idiosyncratic draws $(\zeta_h)_{h=1}^N$ has been resolved. Keeping track of the evolution of the net worth distribution in each country and the aggregate FDI between each country pair requires integrating across firms with all possible realizations of $(\zeta_h)_{h=1}^N$, which is in general a daunting task. To overcome this problem we make the following assumption:

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

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

This distribution is the special case (when $\rho = 0$) of the multivariate distribution introduced in Arkolakis et al. (2017).[14] One attractive property of this distribution is that $\max_h(\zeta_h)_{h=1}^N$ has

[14]Our specification differs from that in Arkolakis et al. (2017) in two regards. First, in the general distribution, pa-

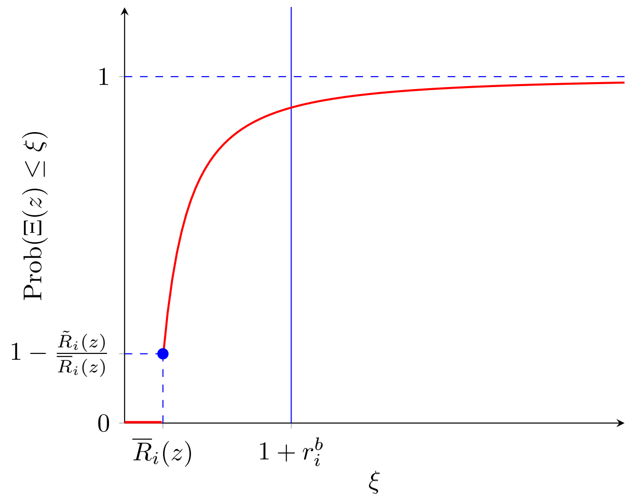


Figure 2: The CDF for $\Xi_i(z)$

a Pareto tail. As we show below, this will allow us to analytically aggregate across firms with different $(\zeta_h)_{h=1}^N$ draws in the presence of an extensive margin decision of firms.[15]

Specifically, define $\Xi_i(z) \equiv \max_{h'} \eta_{ih'} R_{ih'}(z) = \max_{h'} R_{ih'}(z) \bar{\eta}_{ih'} \zeta_{h'}$. From Equation (5), the realization of $\Xi_i(z)$ determines whether a firm with productivity z will be active and if so, which destination to invest. The CDF for $\Xi_i(z)$, denoted by $H_i(\xi|z)$, is given by the following:

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

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

Because all ζ_h draws are greater than or equal to 1, the support of $\Xi_i(z)$ is $[\overline{R}_i(z), \infty)$. Above $\overline{R}_i(z)$, the distribution of $\Xi_i(z)$ has a Pareto tail;[16] at $\overline{R}_i(z)$, there is a mass point with measure

rameter ρ governs correlation among $(\zeta_h)_{h=1}^N$, with $\rho \to 1$ corresponding to the highest correlation and $\rho \to 0$ the lowest. Because our model captures the correlation in productivity among affiliates of the same parent through $\tilde{z}_{ih}(z)$, we interpret ζ_h as capturing solely the residual idiosyncratic 'match' quality between the parent's technology and a host country, thereby setting $\rho = 0$. Second, for ease of exposition, we assume the underlying correlated Pareto distribution is standardized, so for any given parent, draws from different hosts are symmetric. In this setting, $\bar{\eta}_{ih}$ do not enter the distribution as a parameter but directly affect the return conditioning on the draws.

[15]That is, these shocks only matter if firms decide to be active; and firms only decide to be active, if the most profitable affiliate generates higher net return than risk-free bonds (see Lemma 2). This cutoff renders a widely used strategy to smooth firm decisions — adding a Frechet shock — intractable, because it is not invariant to truncations. One way to restore the tractability of the Frechet distribution is to assume that each firm operates a continuum of projects and each with a draw from the Frechet distribution. Firms make investment decisions *before* seeing the realizing of the shocks and then choose the host country for each project. This setup, however, generates the counterfactual predictions that all firms operate in all host countries. The assumption that upon seeing the realization of the draws, which could be unfavorable, firms still must carry out all projects is also at odds with reality.

[16]Note that $\text{Prob}\Big(\Xi_i(z) \leq \xi\Big) = \text{Prob}\Big(\zeta_1 \leq \frac{\xi}{\bar{\eta}_{i1} R_{i1}(z)}, \zeta_2 \leq \frac{\xi}{\bar{\eta}_{i2} R_{i2}(z)}, ..., \zeta_N \leq \frac{\xi}{\bar{\eta}_{iN} R_{iN}(z)}\Big)$. When $\zeta \geq \overline{R}_i(z) \equiv$

$1-\frac{\tilde{R}_i(z)}{\overline{R}_i(z)}$. For firms with productivity z, this measure is zero if and only if $\overline{R}_i(z)=\tilde{R}_i(z)$, that is, if all countries offers the same mean return.

Given $H_i(\xi|z)$, we characterize the aggregate investment decision and return on net worth over all firms with productivity z under two separate scenarios. 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 2. Firms will stay active if and only if the realization of $\Xi_i(z)$ falls to the right of the vertical line. The second is for when $\overline{R}_i(z)\geq r_i^b$, in which case firms will always be active. Lemma 3 summarizes the results:

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

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

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

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

$$\hat{e}_{ih}(z)=[\tilde{R}_i(z)/(1+r_i^b)]^\theta\chi_{ih}(z),\ \textit{where}\ \chi_{ih}(z)\equiv\frac{1}{N}\Big(\frac{\bar{\eta}_{ih}R_{ih}(z)}{\tilde{R}_i(z)}\Big)^\theta.$$

The expected return to the net worth of these firms is

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

(ii) *If $\overline{R}_i(z)\geq 1+r_i^b$, the share of active firms is 1. If the set $\overline{\mathbb{H}}=\arg\max_{h'}\bar{\eta}_{ih'}R_{ih'}(z)$ is a singleton, the share of active firms investing in h is*

$$\hat{e}_{ih}(z)=\begin{cases}1-[1-\chi_{ih}(z)][\tilde{R}_i(z)/\overline{R}_i(z)]^\theta,\ \textit{if}\ h\in\overline{\mathbb{H}},\\ \chi_{ih}(z)[\tilde{R}_i(z)/\overline{R}_i(z)]^\theta,\ \textit{if}\ h\notin\overline{\mathbb{H}},\end{cases},\ \textit{with}\ \chi_{ih}(z)\ \textit{defined in part}\ \textbf{(i)}.$$

The expected return to the net worth of these firms is

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

The above lemma circumvents the need to integrate across idiosyncratic return shocks in quan-

---

$\max_{h'}\bar{\eta}_{ih'}R_{ih'}(z)$, we have $\frac{\xi}{\bar{\eta}_{ih'}R_{ih'}(z)}\geq 1,\ \forall h'$, which is in the support of G, so we can apply the definition of G to obtain

$$\begin{aligned}&\text{Prob}\Big(\zeta_1\leq\frac{\xi}{\bar{\eta}_{i1}R_{i1}(z)},\zeta_2\leq\frac{\xi}{\bar{\eta}_{i2}R_{i2}(z)},...,\zeta_N\leq\frac{\xi}{\bar{\eta}_{iN}R_{iN}(z)}\Big)\\&=G\Big(\zeta_1\leq\frac{\xi}{\bar{\eta}_{i1}R_{i1}(z)},\zeta_2\leq\frac{\xi}{\bar{\eta}_{i2}R_{i2}(z)},...,\zeta_N\leq\frac{\xi}{\bar{\eta}_{iN}R_{iN}(z)}\Big)=1-\Big(\frac{\xi}{\tilde{R}_i(z)}\Big)^{-\theta}.\end{aligned}$$

tification. The first part of the lemma follows directly from the fact that $H(\xi|z)$ has a Pareto tail. To establish the second part, we need, in addition, explicitly consider the firms whose realizations of $\Xi(z)$ are right at the mass point $\overline{R}_i(z)$. The expressions for choice and returns are given for the case when $\overline{R}_i(z) \equiv \max_{h'} \bar{\eta}_{ih'} R_{ih'}(z)$ is achieved by only one host. When it is achieved in more than one country, then a positive measure of firms will be indifferent between hosts, in which case we need to impose a tie-breaking rule.[17]

In period t, the aggregate state of the economy is the joint distribution over (z, a) in each country i, characterized by joint density functions $(\Phi_{i,t}(z,a))_{i\in I}$. Since firms' saving and investment decisions are linear in their net worths, it is sufficient to track the aggregate net worth by each productivity level. Formally, define the mass of net worth held by parent firms with productivity z, denoted by $\phi_{i,t}(z)$, as

$$\phi_{i,t}(z) \equiv \int_0^\infty \Phi_{i,t}(z,a)da. \tag{7}$$

The transition of $\phi_{i,t}(z)$ is then given by the following equation:

$$\phi_{i,t+1}(z') = \int_0^\infty \phi_{i,t}(z)\beta\mathbb{E}[R^a_{i,t}(z,\boldsymbol{\eta})|z]f_i(z'|z)dz,$$

where $\mathbb{E}[R^a_{i,t}(z,\boldsymbol{\eta})|z]$ is explicitly characterized in Lemma 3. For the convenience of later analyses, we also define the aggregate net worth across all parent firms in a country, $W_i = \int_0^\infty \phi_{i,t}(z)dz$, and the marginal distribution of productivity $\hat{\phi}_{i,t}(z) = \frac{\phi_{i,t}(z)}{W_{i,t}}$.

With this, we express the aggregate objects in the model. In our model, FDI emerges as within-firm transfer of capital. With the policy functions derived in Lemma 1 and Lemma 2, the aggregate FDI stock from i to h at time t is

$$[FDI]_{ih,t} = \int_0^\infty (1+\lambda_{i,t})\hat{e}_{ih,t}(z)\phi_{i,t}(z)dz,$$

which has applied that active parent firms can borrow in the home country for overseas investment, as characterized in Lemma 2. Similarly, the aggregate multinational production conducted by parent firms from i in host h at time t is

$$Y_{ih,t} = \int_0^\infty \hat{y}_{ih,t}(z)(1+\lambda_{i,t})\hat{e}_{ih,t}(z)\phi_{i,t}(z)dz.$$

The total capital in a host h, aggregated across domestic and foreign investment, is

$$K_{h,t} = \sum_i K_{ih,t} = \sum_i \int_0^\infty \hat{k}_{ih,t}(z)(1+\lambda_{i,t})\hat{e}_{ih,t}(z)\phi_{i,t}(z)dz.$$

[17] In the quantification, however, this does not matter. Unless two hosts h and h' have the exact same primitives, equilibrium wage, and bond interest rate, $\bar{\eta}_{ih'}R_{ih'}(z)$ crosses $\bar{\eta}_{ih}R_{ih}(z), h \neq h'$ for only finitely many values of z. Because we specify z to have a continuous density, outside the special case with two identical host countries—which does not arise in the data—$\max_{h'} \bar{\eta}_{ih'}R_{ih'}(z)$ can be achieved by more than one country for only zero measure of firms.

Finally, the total output in a host h is

$$Y_{h,t} = \sum_i Y_{ih,t}.$$

3.6 Equilibrium

Given the initial distribution of parent firms $(\Phi_{i,0}(z,a))_{i \in I}$, a competitive equilibrium[18] is a sequence of (a) wages $w_{h,t}$ and interest rates $r^b_{h,t}$, (b) parent firm value and policy functions, affiliate return and policy functions, and (c) distributions of parent firms, such that at every period (i) value, return and policy functions solve the firms' problem; (ii) labor and credit (bond) markets clear in each country; (iii) the distributions of firms are consistent with the transition implied by the firms' policy functions and the exogenous productivity process.

3.7 FDI, MP, and Financial Market Conditions

We now discuss the predictions of the model on the relationship between financial market conditions and the two measures of MNC activities—FDI and MP. As country h becomes financially more developed (or as it experiences a credit boom), both μ_{ih} and λ_h increase. A higher μ_{ih} allows productive affiliates to use more external finance, which increases the return to parent investment in that affiliate. This leads to an increase in inward FDI.

A higher λ_h generates three effects. First, an increase in λ_h helps channel credits into the most productive firms, who are more likely to become MNCs. Second, this reallocation increases the wage and interest rate in the domestic economy, which pushes domestic firms to invest abroad. Finally, with better access to credit, productive firms will be able to accumulate capital faster. Because productivity is persistent, this reallocation increases the aggregate efficiency and investment of the economy in the long run, resulting in a higher level of outward FDI. All three channels imply that financial development is a push factor for FDI.

In addition to connecting FDI and financial market conditions, the model also links FDI with MP through the following proposition:

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

$$\frac{Y_{ih,t}}{Y_{h,t}} = \frac{[FDI]_{ih,t}}{K_{h,t}} \times \bar{lev}_{ih,t} \times \frac{\bar{z}_{ih,t}}{\bar{z}_{h,t}} \tag{8}$$

where $\bar{lev}_{ih,t}$ is the average leverage (total assets / investment from parent) of affiliates in host h from home i, $\bar{z}_{ih,t}$ is the average (production weighted) productivity of affiliates in host h from home i, and $\bar{z}_{h,t}$ is the average productivity of all affiliates (domestic and foreign) in host h.

$\frac{Y_{ih,t}}{Y_{h,t}}$ is a common measure of MP in the literature: share of foreign affiliates in total domestic production. $\frac{[FDI]_{ih,t}}{K_{h,t}}$ measures the share of FDI in total domestic capital stock. Because affiliates only have a finite capacity to raise external funding, MP share is tightly connected to FDI share,

[18] See the appendix for a formal definition.

consistent with Fact 1. However, these two measures are intermediated by two other components: first, how much host external finance the affiliates use, summarized by the average leverage and ultimately determined by μ_{ih}. Given the FDI share, the MP share will be higher if the host country allows affiliates to leverage more on local financing, consistent with Fact 2, as well as the empirical finding that inward FDI brings more benefits in countries with a more developed financial market (Alfaro et al., 2004). Second, the productivity of these affiliates relative to indigenous firms also matters: given the FDI share, the MP share will be higher if affiliates are more productive.

Moreover, note that conditional on the FDI share and the productivity distribution, according to Equation (8), the MP share does not depend on the financial market condition of the host ($\lambda_{i,t}$), in line with the empirical finding from the last Column of Table 3.

3.8 Model Discussion

Before moving into quantitative exercises, we discuss the motivation of some model assumptions and the implications if they are violated. One of the key assumptions is that firms face short-run financial frictions, so the shadow value of capital differs from the cost of external credits. This assumption motivates FDI as within-firm capital flow and allows the model to deliver empirically consistent relationships. Admittedly, the exact way in which we introduce the financial constraint is ad-hoc, yet as long as some forms of financial constraints exist, the qualitative channel will remain.

One might also be skeptical that whether MNCs, which are typically large conglomerates, still face financial constraints. In reality, even though large firms can borrow from banks or the bond market, as their leverage increases, the default risk and agency cost usually lead to a higher cost of borrowing (Baxter, 1967). Our model captures this idea in a parsimonious way. It is worth noting that our model only restricts the short-term debt-equity ratio. Productive firms can still expand by accumulating more equity and leveraging it to borrow more. Consistent with our assumption on the existence of financial constraints, researchers have shown empirically that large multi-establishment firms, both nationals and multinationals, use internal factor market to reallocate resources when one unit or affiliate receives a shock (Klein et al., 2002; Alfaro and Chen, 2012; Almeida et al., 2015; Giroud, 2013; Giroud and Mueller, 2015).[19]

Our current setup also abstracts from the fixed cost of setting up foreign affiliates, so the 'proximity-concentration' tradeoff emphasized in the literature (Brainard, 1997) does not play a role. Moreover, 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, 2017). On the other hand, the model incorporates the transfer of technology to affiliate and the cannibalization between affiliates in their competition for the scarce internal factor (capital). The model thus captures better the 'brown-field' investment in the form of mergers and acquisitions. Given that the latter is the dominant form of foreign investment, we view the current framework as suitable for analyzing *aggregate* FDI between countries.

[19]In particular, Giroud (2013) shows that the exogenous improvement in productivity of one plants in a multi-plant firm lead to a *decrease* in investment in *other* plants.

4 Accounting for the Dynamics of FDI

Through the lens of the model, we now explore the importance of various fundamental factors in explaining the dynamics of FDI. Throughout, we keep Assumptions 1 and 2, and further assume that the world credit market is fully integrated, so there is one interest rate that clears the global market.[20]

Constrained by the availability of bilateral FDI information over a number of years, our quantification will focus on a sample of 36 major developed and developing countries, listed in the first column of Table 14. The solid line in Figure 1 is the total FDI stock in the sample countries. As is well known, the past few decades saw increasing activities of MNCs in the world economy. This is also true for our sample countries, over 2001-2012. Looking closer, in the biggest sending countries of FDI in our sample, the U.S. and U.K., outward FDI stock increased by 170% and 90%, respectively. In smaller and less developed countries, while the level of outward FDI is not as significant, the growth rate has been more tremendous. The growth in world FDI, however, slowed down since 2008.[21] Compared to the trend extrapolated from the earlier years, the actual world FDI stock is lower by more than 20%. The yellow dashed line is the total stock of credit to the private sector, which shows a credit boom between 2001 and 2007 and a subsequent credit crunch. This naturally leads to the conjecture that the credit market conditions might have had an impact on the growth of world FDI and its slow down.

Our model provides a suitable framework to quantitatively decompose the effects of changes in various fundamental factors, including financial institution for parent companies ($\lambda_{i,t}$) and affiliates ($\mu_{ih,t}$), and aggregate technology of a country ($\bar{z}_{i,t}$, to be introduced below).

The quantification exercise follows the spirit of Eaton et al. (2016). We pick the model fundamental parameters ($\lambda_{i,t}$, $\mu_{ih,t}$ $\bar{z}_{i,t}$) and the residual wedges ($\bar{\eta}_{ih,t}$) to match the data along a number of dimensions for all countries during 2001-2012. If we feed all of these changes into the model, the model will produce the time series of GDP, domestic and bilateral foreign investment, private credit, etc., exactly as in the data. We will then switch off changes in different fundamental factors to see the contribution of each to the change in FDI.

Below we describe how we pin down the model parameters. Many of our parameters are jointly identified, but some are more crucial for matching certain empirical target than others, so we discuss the most direct target for each parameter, before describing our numerical procedures. Additional information on the sources of data and computational algorithms are provided in the appendix.

[20] Alternatively, we can treat each country as having a closed credit market. The reality likely lies between these two polar cases. Given that a large literature in international finance has explored the welfare consequences of moving from country-specific bond market to a global credit market (Gourinchas and Jeanne, 2006), to focus on FDI and its welfare implications, we assume the credit market is fully integrated. In the concluding section, we discuss how the model can be extended to study the interaction between credit market frictions and FDI, with imperfectly integrated world credit market.

[21] These two patterns are also consistent with the finding by Alviarez et al. (2017) based on sales of affiliates.

4.1 Parameterization

4.1.1 Targets and Values

Parameters calibrated independently We start with the parameters that are calibrated independently. The entrepreneurs' discount rate, β, determines the saving rate. We set $\beta = 0.9$, so the world interest rate is 3% at the initial state. We set capital share $\alpha = 0.4$ and depreciation rate $\delta = 4.5\%$ based on the average for our sample countries from the Penn World Table. The dispersion parameter of the multivariate Pareto distribution, θ, determines the sensitivity of firms' investment decision to host-country specific returns (see $\chi_{ih}(z)$ in Lemma 3). Using variations in international tax, Wei (2000) estimates this elasticity to be 4.6, which is also around the median value in a recent meta analysis (De Mooij and Ederveen, 2003). We set $\theta = 5$ as a benchmark.[22]

We next parameterize *parent* firms' idiosyncratic productivity z to follow the AR(1) process below:

$$\log(z') = \bar{z}_{i,t} + \rho_z \log(z) + \epsilon, \tag{9}$$

in which ϵ is a mean-zero innovation term with variance $\sigma^2_{\epsilon,i}$ and $\bar{z}_{i,t}$ is the fundamental productivity in country i at time t. Using firm-level data, Asker et al. (2014) estimate the productivity process for a large number of developed and developing countries. We take the median estimate from their sample of countries and set $\rho_z = 0.85$, $\sigma^2_{\epsilon,i} = 0.69$. We allow $\bar{z}_{i,t}$ to vary overtime and will use it to match the aggregate output of countries.

When an MNC opens an affiliate in a host country, the productivity of the affiliate depends on not only the productivity of the parent, but also on host-specific factors, such as infrastructures and knowledge embodied in local firms. We capture this by assuming that the productivity of an affiliate in country h is the following:

$$\tilde{z}_{ih,t}(z) = z^{\gamma}\bar{z}_{h,t}^{1-\gamma}, \text{ for } h \neq i, \tag{10}$$

in which z is the productivity of the parent and $\bar{z}_{h,t}$ is the aggregate TFP of the host country. We set $\gamma = 0.4$ based on a recent estimate by Cravino and Levchenko (2017), using a data set that covers parents and affiliates in a large number of countries.

Parameters calibrated in equilibrium. The remaining parameters are allowed to change over time, and disciplined correspondingly using time-varying targets in equilibrium. Parameter $\lambda_{i,t}$ determines to the extent to which a company can use net worth as collateral for external borrowing. In the long-run, this parameter depends on the financial institution of a country, but its short-run fluctuation is likely driven by the availability of credits in a country. We therefore use $\lambda_{i,t}$ to match the time series of credit over GDP ratio in our sample countries, interpreting its over time change as capturing the evolving credit market conditions.

Parameter $\mu_{ih,t}$ determines the extent to which a parent company can rely on local partners for finance. Its short-term fluctuations likely depend on the availability of credits in a country.

[22] Wei (2000) estimates θ using the aggregate FDI data. In our model, θ governs, on the other hand, firm-level elasticity. With the extensive margin adjustment, the aggregate elasticity is not equal to θ exactly. However, in the simulation we find the difference to be small so we directly use the this external calibration of θ.

The response of $\mu_{ih,t}$ to local credit conditions could be potentially different from that of $\lambda_{i,t}$.[23] To allow for this possibility, we discipline $\mu_{ih,t}$ independently with another time series. Recall that $\mu_{ih,t}$ directly determines the fraction of the balance sheet of an affiliate financed by its parent. We use the BEA data to construct the empirical counterpart of this object. Specifically, the BEA reports the total external finance of U.S. affiliates in each country every year, and the finance from U.S. parents in these affiliates, which allows us to construct the ratio between affiliate total finance and parent finance and pin down $\mu_{ih,t}$. Since this measure only exists for U.S.-headquartered MNCs, we specify $\mu_{ih,t} = \mu_{h,t} = \mu_{US\,h,t}$, that is, all foreign affiliates in country h face the same $\mu_{h,t}$. For the U.S. as a host country h, we pin down $\mu_{h,t}$ using the corresponding statistics of foreign affiliates in the U.S.

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

$$\bar{\eta}_{ih,t}(z) = \bar{\eta}_{ih,t} z^{\eta_z}, h \neq i. \tag{11}$$

Under this specification, the probability that a firm finds it optimal to open an affiliate overseas is an increasing function of z. We pin down η_z through indirect inference. Based on a representative survey of manufacturing firms in a number of countries (Bloom et al., 2012), we estimate a Binary Logit specification of a firm being an MNC on its productivity. We then pick η_z so that in the model, this regression specification, performed on the firms from the same set of countries as in the empirical analysis, will yield the same estimate. This determines $\eta_z = 0.04$.[24] Given η_z, we then use $\bar{\eta}_{ih,t}, h \neq i$ to match the bilateral foreign investment. This procedure ensures that the model matches exactly the evolution of capital stock in each country and the distribution of their ownership across host countries.

The labor endowment in each country, $L_{i,t}$ is set to the effective employment from the Penn World Table, which takes into account changes in population, labor force participation, and effective human capital of labor force.

With the above parameterization, our model matches the aggregate capital and labor input in each period. To match the evolution of GDP in each country, we can directly adjust the intercept of firm productivity process, specified in Equation (9). The resulting term, which we label $\bar{Z}_{i,t}$, could be thought of as the *measured* aggregate TFP, absorbing all the variation of output beyond those

[23] On the one hand, affiliates of foreign firms are backed by the reputation of their well-known parents; on the other hand, they might lack the connection to local financial institutions compared to local-grown firms.

[24] As described in Appendix B.2.1, in the special case with $\tilde{R}_{i,t}(z) = \bar{R}_{i,t}(z)$, the Binomial Logit specification can be derived as an structural equation of the model. While the premise is generally not satisfied, the relationship between a firms' productivity and whether it is an MNC still is informative about η_z. Note also that when estimating the specification using model-simulated data, we need to have calibrated the rest of the model, so our indirect inference proceeds in a recursive fashion, as described in Section 4.1.2.

Table 4: 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 (2017)	0.4
$\{L_{i,t}\}$	Effective employment	PWT	-
B: Parameters Calibrated in Equilibrium			
Parameter	Description	Target/Source	Value
$\{\lambda_{i,t}\}$	Credit market conditions for parent companies	Credit/Capital ratio	Figure 3
$\{\mu_{h,t}\}$	Credit market conditions for affiliates	Share of affiliates balance sheet financed by parents	Figure 3
$\{\bar{\eta}_{ih,t}\}$	Return wedge for domestic and foreign direct investment	$\{K_{h,t}\}$,	
η_z	Relationship between MNC status and productivity	Estimated using Bloom et al. (2012) data	0.04
$\{K_{ih,t}\}$	-		
$\{\bar{z}_{i,t}\}$	Fundamental TFP	GDP	-

of aggregate inputs. But in our heterogeneous firm model, this is different from the *fundamental* TFP, $\bar{z}_{i,t}$—in addition to the fundamental TFP, $\bar{Z}_{i,t}$ also captures the changes in allocative efficiency in response to financial market conditions. For example, in response to increases in $\lambda_{i,t}$ and $\mu_{ih,t}$, efficient firms will gain market share, resulting in an upward bias in the measured aggregate TFP. We isolate the *fundamental* TFP as the aggregate productivity needed to match the aggregate output, holding the shares of capital used by affiliates with different productivity levels the same as in 2001. Then the measured aggregate TFP change due to the allocative efficiency is $\hat{z}_{i,t} = \frac{\bar{Z}_{i,t}}{\bar{z}_{i,t}}$.[25] In some counterfactual experiments, to understand how fundamental technological progress affects the dynamics of FDI, we will change $\bar{z}_{i,t}$.

Table 4 summarizes the model parameters and how their values are determined. As indicated in the Table, parameters in Panel A are pinned down externally without solving the model. Parameters in Panel B are determined jointly. Importantly, in addition to these parameters, the dynamics of the model also depends on the joint distribution of net worth and productivity at the beginning of the period. Ideally, we would like to measure the joint distribution directly. Without access to a comprehensive firm-level data set that covers all countries for the early 2000s, we assume that the marginal distribution of productivity (i.e., $\hat{\phi}_{i,t}(z)$ defined in Section 3.5) in each country is the same as the steady-state distribution corresponding to parameters in 2001.[26]

4.1.2 Numerical Procedures

The calibration algorithm works as follows. For a guess of η_z and given the Panel-A parameters, we first solve for the steady-state marginal distribution of productivity, assuming all parameters stay constant at their 2001 values. For that given set of parameters and taking the steady-state marginal distribution of productivity as the initial distribution, we then solve for the transitional path of the model. We adjust the initial levels of aggregate net worth so that the model produces

[25] By construction, the contribution of allocative efficiency to the aggregate productivity is zero in 2001.

[26] Note that we only assume the marginal distribution (the density) of productivity is as in the steady state, but not the aggregate net worth, since our calibration matches aggregate capital stock period-by-period and does not impose that the capital-output ratios are the same as in their steady state levels.

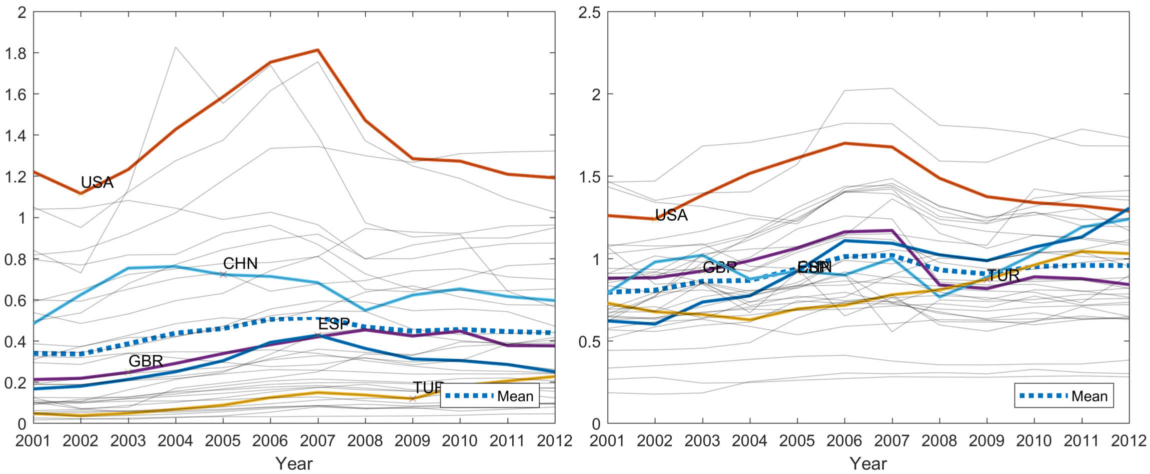


Figure 3: Measured $\lambda_{i,t}$ and $\mu_{h,t}$

Note: The left panel is the calibrated $\lambda_{i,t}$; the right panel is the calibrated $\mu_{h,t}$. The dash line represents the average across the sample countries at any given point in time.

equilibrium capital-output ratios as in the data in 2001 for each country. Simultaneously, we compare other moments of the model, such as the credit over GDP ratios, the dynamics of domestic and foreign investment, etc., along the transition, and adjust parameters until all these moments match their empirical counterparts over 2001-2012. We then check if the mode implies the same relationship between whether a firm is an MNC and its productivity as in the data and, if not, update η_z and repeat the procedure.

In the above process, we need to compute the distribution of firms and the transition of the distribution numerous times. One specific challenge to our context is that when making the discrete decisions of whether to stay active and which countries to enter, firms with the same productivity will follow the same probabilistic decision rule. If a set of firms are indifferent between two decisions, aggregate quantities might be sensitive to the tie-breaking rule imposed. To avoid this possibility, rather than discretizing the firm productivity distribution, we specify it as continuous, so that firms with indifference are contained in a zero-measure set. In the Online Appendix, we describe an efficient numerical algorithm to compute the transition of $\phi_{i,t}(z)$ when the productivity follows an AR(1) process.

4.1.3 The Dynamics of Financial Market Conditions

Figure 3 plots the calibrated sequences of $\lambda_{i,t}$ (left panel) and $\mu_{h,t}$ (right panel). The colored curves highlight selected countries and the dotted line denotes the evolution of the mean value across all countries.

The left figure shows the great heterogeneity in $\lambda_{i,t}$ across countries. The U.S. is among the countries with the highest values, with an average of 1.2. Turkey, on the other hand, has an average value of around 0.1. This long-run difference across countries reflects differences in credit over GDP ratio in the data, as shown clearly in the first two columns of Table 4. However, although different in level, the calibrated $\lambda_{i,t}$ of many countries follow a common trend. They are on an upward trend in the first half of the sample period, corresponding to a period of easy credit in many countries. Subsequently, the trend is met by a sharp downtown around 2008, mirroring credit crunch since the financial crisis we have shown. This drop is more pounced for some countries—for the U.S., for example, $\lambda_{i,t}$ declines from its peak value of 1.8 to 1.2 within just two years. Given the reduced-form evidence that links available of funding to FDI, the credit crunch likely impacts FDI severally, a hypothesis we will investigate quantitatively.

The right panel of Figure 3 plots the evolution of $\mu_{h,t}$ for each host country, which captures the dependence of foreign affiliates on local partners in financing their investment. Again, there is substantial heterogeneity in host countries along this dimension. Columns 3 and 4 in Table 14 show that, the calibrated $\mu_{h,t}$ is directly linked to the average leverage of foreign affiliates in a host country. Compared to $\lambda_{i,t}$, the over-time pattern of $\mu_{h,t}$ is less clear-cut, but in many countries, we can still see a drop in $\mu_{h,t}$ in 2008.

4.2 Model Validation

We assess the validity of the model by comparing our calibration to some external measures.

4.2.1 Measurements of Financial Market Development

In the long run, the average values of $\lambda_{i,t}$ and $\mu_{h,t}$ reflect the quality of financial institutions in a country. To the extent that in countries with better financial institutions, parent firms can more easily borrow and affiliates of foreign firms can also rely more heavily on local partners, we should expect these two measures to be correlated, and both related to proxies of financial development. In the short run, both parameters are influenced by conditions of the financial market of a country, so their fluctuations are also likely correlated.

Table 5 tests if these hold empirically. The first two columns show that average $\lambda_{i,t}$ and $\mu_{h,t}$ for each country, denoted $\bar{\lambda}_{i,t}$ and $\bar{\mu}_{h,t}$, are positively correlated with the measure of the quality of financial institutions (log of the financial institution index as in Section 2). The third column shows that $\bar{\lambda}_{i,t}$ and $\bar{\mu}_{h,t}$ are correlated. Finally, Column 4 shows that the over-time variation of the two measures are correlated, as hypothesized.

4.2.2 Cross-Border Investment Return Wedges and the Correlation with Observables

Columns 4 and 5 in Table 14 report the share of foreign investment in host country h capital in 2001, and the (FDI-weighted) average wedge for investing in that country, $\bar{\zeta}_{ih,2001}$. Not surprisingly, FDI seems to be more important for smaller countries, such as Belgium and Singapore, than for large countries like the U.S. For countries with similar size, a higher FDI share translates into a higher return wedge. In our calibration, these wedges absorb anything not incorporated in the model, including both international frictions and model mis-specifications. As a test of the model, we examine if the wedges are correlated with measurable frictions and policies related to FDI.

Table 6 reports the results. The dependent variable is the bilateral wedge. Because some independent variables can only be measured in a single year, with no variation over time, we take the

Table 5: Calibrated Financial Market Conditions and External Measure

	(1) $\bar{\lambda}_{i,t}$	(2) $\bar{\mu}_{h,t}$	(3) $\bar{\mu}_{h,t}$	(4) $\Delta\mu_{h,t}$
Log (Financial Institution Index)	0.452***	0.317**		
	(0.158)	(0.142)		
$\bar{\lambda}_{i,t}$			0.299**	
			(0.140)	
$\Delta\lambda_{i,t}$				0.303***
				(0.092)
Observations	36	36	36	396
R^2	0.195	0.128	0.119	0.067

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

wedges from 2001 only. In Column 1, we examine the extent to which well-known geographic frictions, such as bilateral distance, common language, colonial tie, affect the bilateral return wedges, controlling for home and destination fixed effects. The results suggest that increasing the distance between home and parent countries decrease the net return; sharing a colonial tie or a common language increases the net return, while sharing a common border does not have a statistically significant impact.

The second column replaces the host country fixed effects with various host characteristics, including measures of tax rates and policy restrictions on inward FDI. We find that, while being labeled as a low-tax country has a significant positive effect, conditional on that, the effect from a lower profit tax rate is negligible. This is in line with that many low-tax countries do not necessarily have low statuary tax rates, but instead attract foreign business through special treaties. Policy restrictions of the host country on inward FDI also have an economically and statistically significant effect on the return wedge, consistent with our interpretation of the wedges as residual variation in frictions and policies outside the model. Finally, financial institution index is unimportant in explaining the residual wedge, suggesting that the effect of host financial development on inward FDI is entirely captured by the model mechanisms.

4.2.3 Relationship Between MP and FDI

Through Proposition 1, the model links the two related concepts of MNC activities—production of their overseas affiliates (MP) and the finance for affiliate operations (FDI). Our calibration uses only information on FDI, but not MP. We validate the model by testing if the model-implied relationship between MP and FDI, given by Equation 8, holds in the data.[27] Because both MP and FDI

[27] The last two columns of Table 14 report total foreign MP share for each country in the data and predicted by the model for 2001.

Table 6: FDI Return Wedges and Measurable Outcomes

	(1)	(2)
	$\log \zeta_{ih,2001}$	
Log(Distance)	-0.229***	-0.186***
	(0.013)	(0.021)
Common border	0.010	0.060
	(0.043)	(0.050)
Colonial tie	0.249***	0.246***
	(0.047)	(0.044)
Common language	0.127***	0.180***
	(0.035)	(0.061)
Low Tax Country		0.329***
		(0.072)
Profit tax		0.002
		(0.003)
Log(FDI restriction)		-0.391***
		(0.136)
Log (Host Financial Institution Index)		0.042
		(0.108)
Log GDP		0.011
		(0.020)
TFP		0.651***
		(0.163)
Observations	1048	1007
R^2	0.770	0.672
Host country FE	Yes	
Home country FE	Yes	yes

Notes: robust standard errors in parenthesis
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

are well approximated by a gravity equation, directly comparing them will misleadingly show close fit. We consider the following transformed equation instead:

$$\log\left(\frac{\text{MP Share}_{ih}}{\text{FDI Share}_{ih}}\right) = \log(\text{lev}_{ih}) - \log\left(\frac{\bar{z}_h}{\bar{z}_{ih}}\right). \tag{12}$$

The left-hand side of Equation 12 is the log ratio between MP and FDI. This ratio increases with the average dependence on host finance of foreign affiliates and decreases with the relative productivity between all firms operating in country h and the affiliates in h from country i. Since our measure of the host share of affiliate finance does not vary by home country, we aggregate MP and FDI shares and run the regression at host country level. In the absence of comprehensive bilateral affiliate productivity data, we use FDI-weighted source country fundamental TFP as a proxy for $\bar{z}_{ih}$.

Table 7 reports the results of the test, using both the model-implied ratio between MP and FDI (first column) and its empirical counterpart (second column) for 2001. The first column shows that in the model, the above relationship holds strongly. In addition to having consistent signs, the two measures also capture most of the variation in the model, as indicated by the high R-squared. The second column shows that in the data, the affiliate leverage ratio has a positive and statistically significant effect on the dependent variable, with a point estimate similar to that predicted by the model. Consistent with the theoretical prediction, the log relative TFP is estimated to have a negative effect on the outcome variable, although the coefficient is statistically insignificant.

Table 7: Determinants MP/FDI Ratio

	(1) Model	(2) Data
Log (lev)	1.659***	1.101*
	(0.196)	(0.584)
Log (dest TFP/source TFP)	-0.920***	-0.258
	(0.068)	(0.209)
Observations	36	36
R^2	0.869	0.101

Note: The dependent variable in the first column is the log of the ratio between foreign affiliate share of domestic production and inward FDI share of domestic capital in the model. The dependent variable in the second column is its data counterpart.
Robust standard errors in parenthesis.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Overall, the above exercises show that our model generates consistent predictions with the data in dimensions not directly targeted. Below we use the model to perform a structural accounting exercise.

4.3 Financial Markets and the Patterns of FDI

We examine the role of various 'fundamental' shocks in accounting for the dynamics of FDI. Empirical studies have found that access to credit has a significant impact on outward FDI, usually focusing on individual countries (e.g., Klein et al., 2002). Our first set of counterfactual experiment is to assess whether the calibrated financial shocks can generate significant impacts on country-specific patterns of FDI. Given the trend break in 2007 (see Figure 1), we split the counterfactual experiments into two periods: before and after 2007.

4.3.1 FDI Growth During 2001-2007

We examine first the extent to which the easing access to credit in the lead-up to the financial crisis can account for the increase in FDI during this period. The focus of our investigation is the outward FDI from each country, shown in Figure 4. Each bar in the figure is for a country; the height of the bar corresponds to the *cumulative* net outward FDI *flows* from 2002 to 2007—or equivalently, the level increase in outward FDI stock from 2001 to 2007. Consistent with the increase in aggregate FDI shown in Figure 1, most countries see increasing outward FDI stock during the sample period. The level increase tends to be higher for larger and more developed countries—for example, the U.S., the U.K., and France are the top three source countries of FDI.

We structurally decompose the cumulative outflow from each country into four components. To isolate the impact of different shocks, for experiments on country i, we change only the targeted parameter of country i, keeping all other parameters for country i and the rest of countries at the

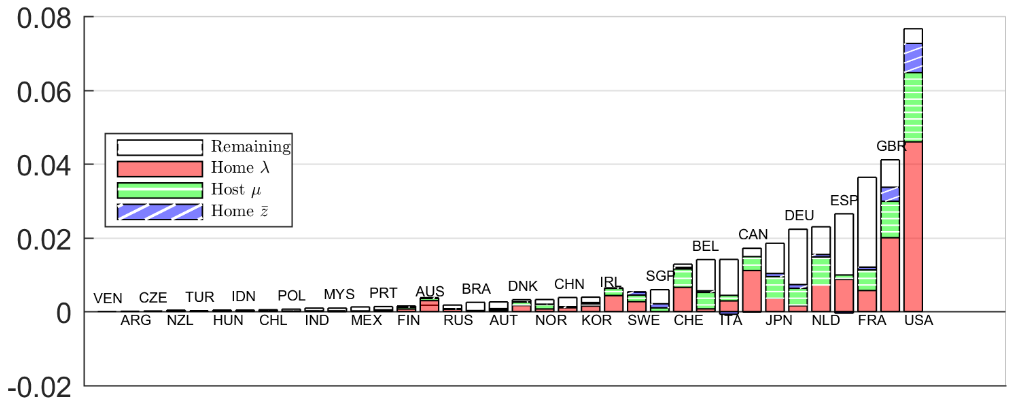


Figure 4: Cumulative Outward FDI Flows: 2002-2007

Note: Decomposition by country, 2002-2007. The height of the bar indicates the total cumulative outward FDI flow for each country. The colored bars indicate fractions accounted for by individual channels..

calibrated values.

In the first set of experiments, we set $\lambda_{i,t}$ to the 2001 value and solve for the counterfactual transitional path, one country at a time. With the calibrated $\lambda_{i,t}$ on the upward trend for most sample countries during the period, this experiment should reduce outward FDI through the static and dynamic channels discussed in Section 3.7. The pink solid bars in Figure 4 demonstrate the strength of this force for individual countries. More precisely, the height of the solid bar indicates by how much the outward FDI would have been lower, had $\lambda_{i,t}$ stayed at the value of 2001 for country i. A positive value indicates the change in $\lambda_{i,t}$ between 2001 and 2007 contributes positively to outward FDI growth. For most countries, the contribution from home country financial market change is positive, yet the importance of this channel differs. In the U.S., U.K., Israel, and Switzerland, for example, this force alone accounts for half or more of the FDI increase; in Belgium and Singapore, on the other hand, it hardly matters. Because the importance of this force in the top FDI sending countries, the sum of the pink bars across all countries account for around half of world FDI increase during the period.

To gauge the scope of the host-side financial market factors to influence FDI, in the second set of experiments, we set the $\mu_{ih,t}$ for affiliates from home country i to the 2001 value, $\mu_{ih,2001}$, for all $h \neq i$, while keeping $\mu_{i'h,t}, i' \neq i$ at the benchmark values. This exercise captures the impact on FDI through the 'pull' force of increasing credit availability in a host country. The green striped bars in Figure 4 show that, by making it easier for parent companies to rely on funding from host country partners, financial market conditions elsewhere could have a quantitatively significant impact on the investment decisions of MNCs. In fact, in some countries, such as Belgium, foreign financial shocks play a more important role than domestic financial shocks. Together, the sum across all countries of the influence of home and host country financial market conditions on outward FDI account for the majority of increase in world FDI, highlighting the importance of modeling the capital channel in understanding decisions of multinational firms.

In the last set of experiment, we explore the influence of domestic productivity growth on out-

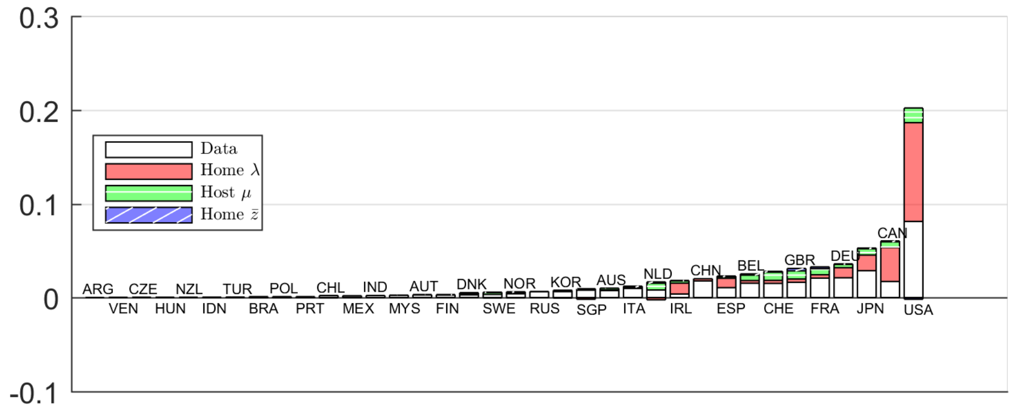


Figure 5: Cumulative Outward FDI Flows: 2008-2012

Note: Decomposition by country, 2008-2012. The white bars indicate the factual cumulative outward FDI flows for each country; the colored bars indicate predicted *additional* outward FDI from individual channels.

ward FDI.[28] The blue shaded bars in the figure indicate the importance of this channel, which differs significantly across countries. For the U.S., domestic productivity growth plays an important role; this is not the case in many European countries, such as Spain and France. This heterogeneity primarily reflects the difference in TFP growth rate across countries.

Finally, the white bars in Figure 4 are the remaining cumulative FDI outflow during this episode after deducting the above three channels. This term encompasses changes in the investment and FDI return wedges—which are not formally modeled and could be driven by policy, technology, or mis-specifications in the model—as well as the interaction among countries.

4.3.2 Slowdown in FDI: 2008-2012

Having shown that the credit boom in the leading-up of the crisis can explain an important share of outward FDI growth of individual countries, we now investigate the role of the credit crunch during and immediately after the financial crisis on the slowdown in FDI.

As before, we perform three sets of experiments. Instead of keeping $\lambda_{i,t}$, $\mu_{ih,t}$, and $\bar{z}_{i,t}$ constant at their 2001 values, we feed in the calibrated values until 2007 and fix them afterwards. Again, the experiments are performed for one country, one parameter at a time. Our exercises here are slightly different from before—instead of asking how much the FDI growth can be explained by each factor in the previous section, the question we ask here is, for example, how much *more* outward FDI we would see, had $\lambda_{i,t}$ stayed at the 2007 peak value.[29]

Figure 5 presents the results. The white bars show the factual cumulative FDI outflow during 2008-2012. The red bars show the additional outward FDI from country i, if $\lambda_{i,t}$ stays at the value of 2007 for subsequent periods. Eliminating the credit crunch can double outward FDI from

[28] Statically, more productive firms earn higher net returns on investing overseas; higher domestic wage as a result of the productive increase also pushes firms to move production abroad; dynamically, firms grower faster and accumulate more capital.

[29] An alternative exercise is to construct a counterfactual path on which FDI will keep the same speed of growth as before, and then decompose the difference between this counterfactual and the benchmark. The difficulty in implementing this decomposition is that the fundamental shocks that lead to a constant FDI growth rate are not unique.

the U.S. and Canada, and increase it by more than 30% in a number of other developed countries. In countries whose financial market was less interrupted by the crisis, such as China, this counterfactual barely makes any difference.

The green stripped bars show that, disruptions in the financial market of destination countries reduce the incentive for foreign MNCs to invest. As the biggest sending country of FDI, U.S. is the most affected, but this channel is also important for Netherlands, Switzerland, the U.K.—these countries send a large amount of investment to other EU countries, which were significantly affected by the European debt crisis. Finally, the blue shaded bars show the role of domestic productivity, which is negligible in most countries.

4.4 Comparison to the Diff-in-Diff Estimate

The above analysis shows that for individual countries, financial market conditions at home and abroad are crucial for FDI. Given that existing research frequently uses a diff-in-diff design to estimate the impact of home market financial conditions on outward FDI, we assess the model's ability to replicate findings from this design.

The first two columns of Table 8 report this estimate based on the actual data. The dependent variable is log outward FDI stock. The independent variables are the credit over GDP ratio and the calibrated $\lambda_{i,t}$. Variables are first-differenced and year fixed effects are controlled for. The estimates suggest that home country financial market conditions have a positive and statistically significant effect on outward FDI. The estimated elasticity is larger when financial market conditions are measured using credit over GDP than when they are measured using the calibrated $\lambda_{i,t}$.

The third and fourth columns perform the same regression using the model-simulated data. For each country i, we first construct the differences of its outward FDI and measures of financial market conditions between the benchmark economy and the counterfactual economy in which $\lambda_{i,t}$ is altered in ways discussed in Section 4.3. Effectively, this difference nets out the year fixed effects; we then first-difference these variables and estimate an OLS specification, to obtain a diff-in-diff estimate for the effect of the change in home country $\lambda_{i,t}$ on outward FDI generated from counterfactual experiments. We find that the elasticities for credit over GDP and (especially) $\lambda_{i,t}$ are close to those reported in Columns 1 and 2, so our model is able to replicate findings based on reduced-form studies.

Taking stock, the counterfactual exercises show that the changes in financial market conditions can have significant impacts on the dynamics of outward FDI from *individual* countries—country heterogeneity notwithstanding, financial factors can explain more than half of the cumulative FDI outflow during 2002-2007; had the access to credit remained at the peak level of 2007, the cumulative FDI outflow during 2008-2012 could almost double. While there is no way of verifying these counterfactual outcomes, we show that the diff-in-diff estimates of the impact of home market financial conditions on outward FDI based on our simulation are very similar to what one would obtain if they estimate the same specification using the actual data during this period.

The analysis so far, however, is only partial equilibrium, in the sense that it is performed for one country at a time, holding fix the evolution of other parameters of all other countries at the

Table 8: Diff-in-Diff Estimate of Home Financial Market on Outward FDI

	Data		Model	
	(1)	(2)	(3)	(4)
$\Delta\log(\text{Credit/GDP})$	0.698***		0.404***	
	(0.155)		(0.113)	
$\Delta\log(\lambda)$		0.297**		0.294***
		(0.137)		(0.054)
Year FE	yes	yes	-	-
Observations	364	364	396	396
R^2	0.205	0.194	0.358	0.531

Note: This table reports the effect of home financial market conditions on outward FDI using panel data. The dependent variable is the yearly in log outward FDI stock. The independent variables are the yearly change in credit over GDP ratio and $\lambda_{i,t}$. The first two columns are estimated based on the actual data, with year fixed effects controlled for. The last two columns are estimated based on model counterfactuals, where both dependent and independent variables are log difference between the benchmark and counterfactual variables and then first-differenced.

Standard errors (clustered by country) in parenthesis.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

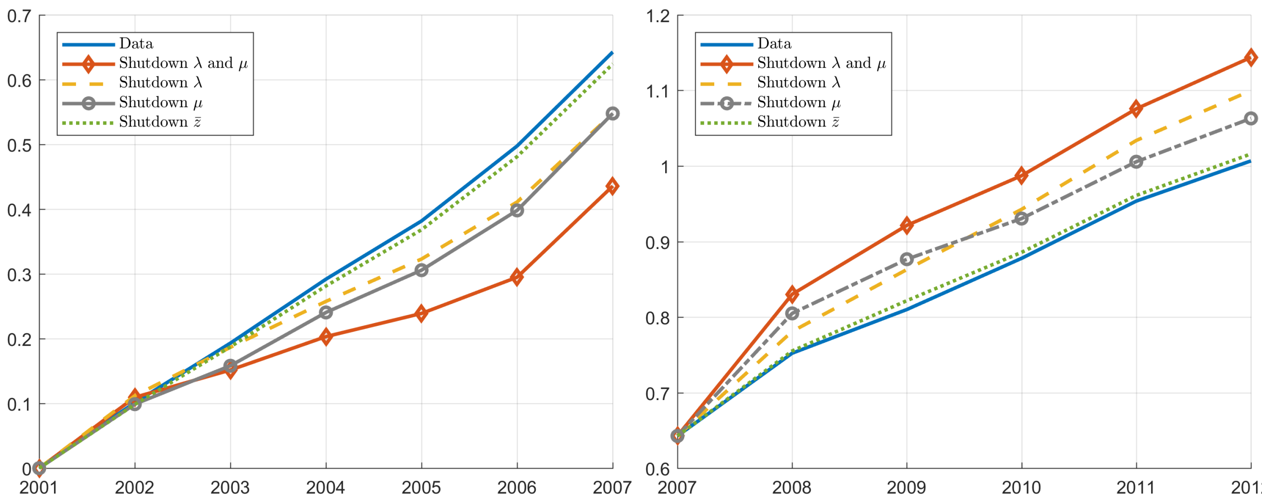
calibrated sequences. In the next subsection, we investigate the importance of the changes in *world-wide* financial market conditions on *aggregate* FDI, highlighting the importance of general-equilibrium effects.

4.5 Aggregate FDI Dynamics and the Importance of General-Equilibrium Effects

We analyze the two periods separately. Figure 6a plots the results for the cumulative FDI between 2002-2007. The solid blue line is the data. The red line (with diamond markers) is the counterfactual aggregate world FDI, if for *all countries*, $\mu_{h,t}$ and $\lambda_{i,t}$ are kept at their respective 2001 values. In line with findings from the country-specific experiments, if the world economy had not experienced the credit boom, the aggregate FDI would have grown by less. The difference between the blue and red lines accounts for about a third of the cumulative FDI flows during this period.

The yellow dashed and gray (with circle markers) lines focus on the two sub-components of the credit boom that matter for the parents and affiliates, respectively. These two components contribute about equally to the growth in overall FDI—without either component, the cumulative FDI flows during 2002-2007 would have been one-sixth lower. In contrast, the growth in fundamental productivity has a negligible effect, as shown by the dotted green line.

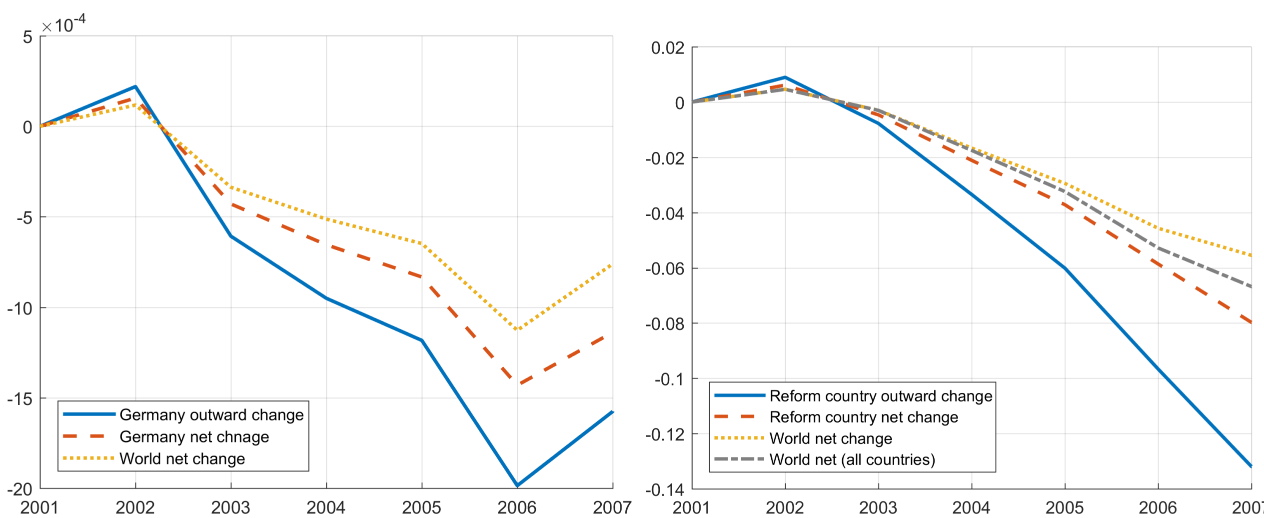
Figure 6b plots similar exercises focusing on 2008-2012, an episode featuring financial market disruptions and the slowdown of global FDI growth. In counterfactual experiments, we feed in the calibrated sequences of parameters until 2007 and keep the relevant set of parameters constant for subsequent years. The blue solid line is the data. The red solid line shows that, had $\lambda_{i,t}$ and $\mu_{h,t}$ all remained at their peak values in 2007, the cumulative world FDI flow would have been



(a) Log World FDI: 2002-2007 (b) Log World FDI: 2008-2012

Figure 6: Log Cumulative World FDI Flow: Data and Model-based Counterfactuals
Note: The figures report the effects of changes in $\lambda_{i,t}$, $\mu_{h,t}$, and $\bar{z}_{i,t}$ on aggregate FDI

around 40% higher. The yellow dash line and gray dash-dotted line decompose this effect into for parents and affiliates, respectively. We find that both forces are quantitatively relevant, but the deteriorating access to credit for parents mattered more towards the end of the period. As before, shutting down the dynamics of mean productivity has a very minor impact on the aggregate FDI.



(a) Germany (b) The World

Figure 7: The Importance of General Equilibrium Effects: 2002-2007

Together, the above exercises show that the change in financial market conditions plays an important role in explaining the world FDI. However, compared to the sum of country-specific results, the impacts on aggregate dynamics are substantially smaller. To understand the sources of the difference, Figure 7a plots a few outcome variables corresponding to an experiment in Germany that fixes its $\lambda_{i,t}$ at 2001 throughout the sample period. The blue solid line indicates that, without the improvement in the financial market, the cumulative FDI outflows from Germany would decrease. Because the credit boom in Germany is only moderate, by the end of 2007, the decrease accounts for around 8% of the cumulative FDI outflow during the period.

This change, however, still overstates the influence on the *world* FDI for two reasons. The first is a general equilibrium effect within the German economy: efficient firms are more constrained in the absence of the credit boom, which reduces aggregate productivity and wage in Germany. This attracts more inward FDI, alleviating the decrease in the aggregate FDI. The second force is a third-country effect. As German firms decrease investment overseas, the labor market in the destination countries become less competitive, drawing more foreign investment from third countries. To gauge the strength of these two forces, the red dashed line in Figure 7a plots the net change in the sum of inward and outward FDI in Germany, whereas the yellow dotted line plots the net change in FDI across all countries. The difference between the solid and dotted lines is the strength of the first force; the difference between the dotted and dashed lines is due to the second channel. In the case of German $\lambda_{i,t}$ shock, both forces play a similar role; together, they reduce the decline in the aggregate FDI by half.

The above analysis focuses on $\lambda_{i,t}$ changes in Germany only. Figure 7b shows that the domestic general equilibrium and third country interactions are important in other countries as well. Specifically, the blue solid line in the figure is the sum of the impacts across the country-specific $\lambda_{i,t}$ experiments described before — each of the experiments focuses on one country by setting its $\lambda_{i,t}$ to the 2001 value, while keeping all other parameters of the country and parameters for all other countries as in the benchmark. The absolute value of the sum at 2007 is thus equivalent to the sum of all the pink bars in Figure 4. The red dashed line is the sum across all these experiments of both inward and outward FDI for the country of focus. In 2007, this value is only 60% of the blue line, indicating a significant domestic general-equilibrium effect. The yellow dotted line is the sum of the net change in world FDI across all experiments. The difference between this curve and the red dashed line suggests that the third country effect is also quantitatively significant. Finally, the gray line corresponds to the change in world FDI, when $\lambda_{i,t}$ in all countries are set to their 2001 values at the same time. The gray line shows a bigger decline than the dotted yellow line — because the changes in financial markets were largely a global phenomenon, when we fix $\lambda_{i,t}$ for all countries, third-country effects resulting from changes in $\lambda_{i,t}$ of individual countries offset each other. This interaction dampens the third-country effect by around half and brings the net change back toward the sum across individual experiments.

In summary, consistent with our analysis on country-specific FDI, we find that the booming credit market can explain up to a third of the world FDI increase before 2007; in the absence of the credit crunch in the crisis, the cumulative FDI flow between 2008 and 2012 would be 40% higher. While still significant, the aggregate effect is much smaller than the sum of impacts on individual countries across country-specific experiments. These results demonstrate the value of a quantitative general-equilibrium framework in evaluating the effects of various shocks on FDI.

5 Welfare Analysis

We now discuss the implications of the model for the welfare gains from MNC activities. Following a growing literature on the gains from trade and MP (see, e.g., Arkolakis et al., 2012), we focus on the ex-post effect. To demonstrate the channels at play, we proceed in two steps.

5.1 The Static Effect

In the first step, we consider the static effects of international integration and compare them to existing studies on multinational firms. Characterizing analytically the broad impact of a general policy change is difficult. Instead, the following proposition focuses on the wage impact of a specific type of policy change, which liberalizes inward FDI while keeping outward FDI restricted.

Proposition 2. *Assume the marginal distribution of productivity in period t for host country h (i.e., $\hat{\phi}_{i,t}(z)$ defined in Section 3.5) is Pareto with tail index $\gamma > 1$ and that outward FDI from country h is restricted,*[30] *then the contemporaneous change in workers' wage in country h in response to a change in inward FDI policy is:*

$$\Delta \log(w_{h,t}) = -\alpha \Delta \log \left(\frac{Y_{hh,t}}{Y_{h,t}} \right) + \alpha \frac{\gamma - 1}{\gamma} \Delta \log \left(\frac{K_{hh,t}}{W_{h,t}} \right), \tag{13}$$

where $\frac{Y_{hh,t}}{Y_{h,t}}$ is the share of production conducted by domestic firms and $\frac{K_{hh,t}}{W_{h,t}}$ is the share of domestic wealth used by domestic firms, which can be expressed as:

$$\Delta \log \left(\frac{K_{hh,t}}{W_{h,t}} \right) = -\gamma \Delta \log(r^b_{h,t} + \delta) - \frac{\gamma(1-\alpha)}{\alpha} \Delta \log(w_{h,t}). \tag{14}$$

The thought experiment considered in Proposition 2 is between two equilibria with different degrees of *inward* FDI, which could be the result of, for example, an increase of $\bar{\eta}_{ih,t}, i \neq h$ for country h. The restriction on outward FDI is strong and violated in most countries, but it allows us to focus on inward FDI as a benchmark. Besides this restriction, the thought experiment needs not to take a stand on whether the credit market in country h is integrated with the rest of the world, or whether this has changed between the equilibria.

Equation (13) relates the wage impact to two sufficient statistics. The first, $\frac{Y_{hh,t}}{Y_{h,t}}$, depends only on the MP shares and captures the importance of foreign firms. A policy change that makes country h more attractive to foreign firms will reduce $\frac{Y_{hh,t}}{Y_{h,t}}$, which would lead to an increase in wage. This effect can happen for two reasons, both subsumed in the MP share. First, foreign affiliates might be much more efficient than the average domestic producer, so their entry might increase aggregate productivity. Second, given the credit constraint faced by domestic producers, the entry of foreign firms increases the capital used in domestic production.

Comparison to Ricardian models of multinational production. In Ricardian models of multinational production, knowing the MP shares is sufficient to conduct ex-post welfare evaluation.

[30]The former holds exactly if productivity process is i.i.d. and follows Pareto distribution, as in, e.g. Itskhoki and Moll (2014); the latter holds if a policy restriction makes the return from operating overseas too low, e.g., if $\zeta_{hh',t} = 0, \forall h' \neq h$.

However, in our model, conditioning on the MP shares, the composition of the 'technology' and 'capital' content of foreign firms also affect the wage gains. This composition effect is captured by the second term in Equation (13), in which $K_{hh,t}$ is the capital used in production by domestic firms and $W_{h,t}$ is their net worth. Their ratio is closely connected to inward FDI. Intuitively, if affiliates rely more heavily on internal funds from their parents (in the form of FDI), then they will use finance from partners in country h less intensively, resulting in a higher $\frac{K_{hh,t}}{W_{h,t}}$.

The term $\Delta \frac{K_{hh,t}}{W_{h,t}}$ enters Equation (13) because it captures the crowding out effect of foreign affiliates in the domestic credit market. An increase in the ratio means that a higher fraction of entrepreneur net worth is used by indigenous producers and a lower fraction by foreign affiliates or flow out in the form of bond, so the crowding out effect is weaker.[31] Given the MP shares, the wage gains are higher, if the MP share is driven by either high productivity of foreign affiliates or parent investment in these affiliates; the wage gains are lower if the affiliates use a lot of credit from the host country.

This effect can be best understood by inspecting Equation (14), which shows that $\Delta \frac{K_{hh,t}}{W_{h,t}}$ depends on the equilibrium change in wage and interest rate. If the policy change decreases the interest rate, then the wage gains for workers will be higher because domestic firms will have a higher demand for workers; this, however, generates an offsetting equilibrium effect — as wage increases, fewer domestic firms will be active, resulting in a lower labor demand, thereby reducing the wage gains. This second effect is captured by the wage term in Equation (14). Combining Equations (13) and (14), we can write the equilibrium wage change as a function of the MP shares and the change in interest rate only:

$$\Delta \log(w_{h,t}) = -\frac{\alpha}{1-(1-\gamma)(1-\alpha)} \Delta \log\left(\frac{Y_{hh,t}}{Y_{h,t}}\right) - \frac{\alpha(\gamma-1)}{1-(1-\gamma)(1-\alpha)} \Delta \log(r^b_{h,t}+\delta) \tag{15}$$

In the special case that country h is a small open economy, the equilibrium interest rate does not change, so the second term in Equation (15) vanishes. In this case, the MP shares are sufficient for inferring the wage impacts, as in existing studies. The elasticity for the MP shares depends on both the capital share, and the Pareto parameter governing the joint distribution of productivity and net worth, which is different from in, for example, Ramondo and Rodríguez-Clare (2013).[32]

Comparison to neoclassical models of FDI. In the above special case, the MP shares still compose of the 'technology' and 'capital' channel, the latter directly corresponding to the inferred wage gains from FDI, if one were to follow a different tradition of studies on FDI that treats it as just another form of international capital flow (Mundell, 1957; Feldstein, 1995). To see this, note

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

[32] This is related to recent findings in international trade that different models might yield the same ex-post gains, but imply different theory-consistent ways of estimating trade elasticity. See, e.g., Arkolakis et al. (2012) and Melitz and Redding (2015).

that the equilibrium wage in a host country h is:

$$w_{h,t} = (1-\alpha)\left(\frac{A_{h,t}K_{h,t}}{L_{h,t}}\right)^{\alpha},$$

where

$$A_{h,t} = \sum_{i}\int_{0}^{\infty}\frac{\hat{k}_{ih,t}(z)(1+\lambda_{i,t})\hat{e}_{ih,t}(z)\phi_{i,t}(z)}{K_{h,t}}\tilde{z}_{ih}(z)dz$$

is the size-weighted productivity across all foreign affiliates operating in and firms native to country h. Thus, fixing $L_{h,t}$, the change in wage between any two equilibria can be decomposed into two terms:

$$\Delta\log(w_{h,t}) = \alpha\Delta\log(A_{h,t}) + \alpha\Delta\log(K_{h,t}). \tag{16}$$

The first component above captures the improvement in productivity distribution because of technology embedded in affiliates; the second component corresponds to the wage gains in response to the increased capital stock. This channel exits despite the world credit market being fully integrated because domestic firms might lack the collateral to borrow. If measured through the lens of a neoclassical Model that treats FDI inflow as an increase in capital stock, the static wage increase as a result of FDI is exactly $\alpha\Delta\log(K_{h,t})$, so it is clear that this will underestimate the true wage effect.

We examine the significance of the underestimation and its heterogeneity across countries. As a baseline, we perform a perhaps extreme experiment in which countries ban foreign affiliates from operations. Given the static focus, we perform this only for the year 2001. Specifically, for each country h, we shut down the inward FDI by setting the bilateral investment return wedge $\eta_{ih,2001} = 0, \forall i \neq h$. We then measure the static gains from inward FDI by the change in equilibrium wage from the counter-factual equilibrium to the benchmark and apply the decomposition described in Equation (16). We run this experiment for each country independently.

The first three columns in Table 9 present the results. Column 1 is the share of production by foreign affiliates. The second column is the wage gains from inward FDI. Given that our calibration assumes an integrated world credit market, as predicted by Equation (15), the inferred wage gains are tightly connected to the values in the first column. Workers in countries with significant inward FDI, such as Canada and Indonesia, benefit more. The third column reports the contribution of the technological channel to the wage gains. On average, the technology channel accounts for more than half of the welfare gains, so treating FDI as simply another form of capital flow would significantly underestimate the inferred static gains.

The extent of the bias differs significantly across countries, ranging from 2% for Ireland to about 100% for India. This heterogeneity arises because host countries receive investment from different origins, some more productive than others. In general, countries already with productive firms benefit less from the technological channel, while the opposite is true for developing countries. To systematically account for what type of countries have a higher static gain, and

Table 9: Static and Dynamic Wage Effects

	Decomposition of the Static Effect			Comparison Between Static and Dynamic	
	(1)	(2)	(3)	(4)	(5)
ISO	MP Share$_{2001}$	$\Delta \log(w_{h,2001})$	$\Delta \log(A_{h,2001})$ fraction (%)	Static: Average	Dynamic: Average
ARG	0.19	0.08	67.55	0.09	0.06
AUS	0.24	0.10	59.80	0.11	0.07
AUT	0.10	0.04	43.13	0.05	0.04
BEL	0.59	0.19	31.37	0.20	0.17
BRA	0.23	0.10	88.04	0.09	0.06
CAN	0.36	0.16	62.95	0.19	0.13
CHE	0.32	0.10	42.53	0.15	0.13
CHL	0.37	0.18	76.01	0.16	0.10
CHN	0.17	0.08	99.36	0.10	0.06
CZE	0.17	0.07	77.28	0.07	0.05
DEU	0.13	0.05	69.01	0.06	0.04
DNK	0.13	0.05	51.74	0.07	0.05
ESP	0.10	0.04	43.67	0.04	0.03
FIN	0.10	0.04	50.58	0.07	0.05
FRA	0.19	0.07	52.02	0.06	0.04
GBR	0.36	0.14	57.08	0.17	0.13
HUN	0.24	0.11	62.10	0.12	0.08
IDN	0.35	0.17	97.39	0.09	0.06
IND	0.14	0.06	101.60	0.06	0.04
IRL	0.92	0.50	1.94	0.37	0.22
ITA	0.04	0.02	38.20	0.02	0.02
JPN	0.03	0.01	73.11	0.02	0.01
KOR	0.07	0.03	66.12	0.03	0.02
MEX	0.24	0.11	77.82	0.11	0.07
MYS	0.24	0.11	74.52	0.11	0.06
NLD	0.77	0.35	24.12	0.45	0.38
NOR	0.16	0.06	30.77	0.05	0.03
NZL	0.43	0.20	58.95	0.19	0.11
POL	0.23	0.10	75.41	0.13	0.08
PRT	0.10	0.04	53.79	0.05	0.04
RUS	0.04	0.01	93.66	0.03	0.02
SGP	0.42	0.20	36.43	0.20	0.16
SWE	0.18	0.06	46.65	0.12	0.09
TUR	0.06	0.03	58.46	0.03	0.02
USA	0.10	0.04	51.91	0.04	0.03
VEN	0.15	0.06	83.03	0.05	0.04
Mean	0.24	0.10	60.50	0.11	0.08
Std	0.19	0.10	21.77	0.09	0.07

from which channels, Table 10 regresses the total wage gains and the channels on two country characteristics: their capital scarcity, as measured by the ratio between capital stock (excluding inward FDI stock) and GDP, and their aggregate TFP. The first column shows that countries relative scarce in capital tend to enjoy a greater benefit. The second and third column relate the gains from the capital and technology channels to the same set of country characteristics. According to the estimates, countries scarce in capital (holding constant total productivity) tend to benefit more from the capital channel, whereas countries with lower productivity tend to benefit more from the technological channel. This systematic patterns suggests that while focusing only on the capital channel will lead to underestimation of the wage gains for all, such bias would be larger for less developed countries.

Table 10: Static Wage Gains and Country Characteristics

	$\Delta \log(wage)$	Change in K	Change in A
$\log(K/Y)$	-0.241***	-0.321**	0.0799
	(0.0808)	(0.128)	(0.0523)
$\log(\text{Host TFP})$	0.00287	0.0420*	-0.0391***
	(0.0247)	(0.0244)	(0.0143)
Observations	36	36	36
R-squared	0.445	0.548	0.411

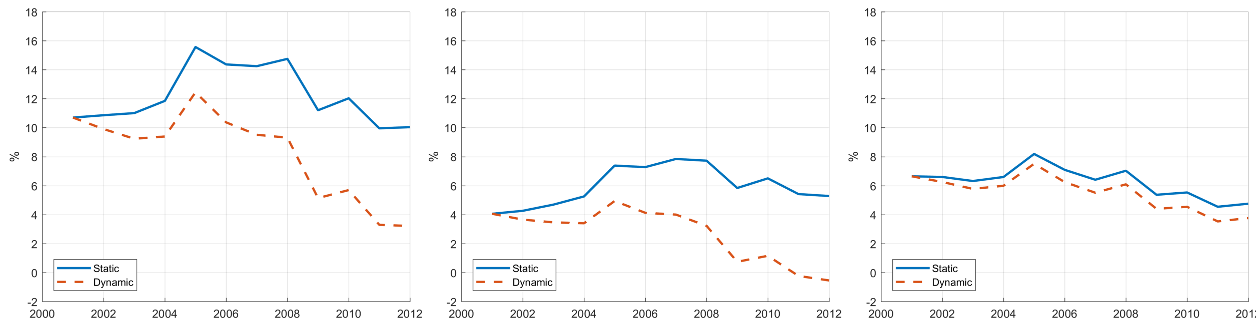
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

5.2 Dynamic Effects

The previous discussion centers on the contemporaneous impact of inward FDI on wage in the host country, holding the size and productivity distribution of domestic firms constant. Both objects, however, also evolve endogenously in response to the exit of foreign firms, leading to a dynamic impact. In the second step of the welfare analysis, we show that once this is factored in, the full dynamic wage impact will differ substantially from the static effect.

To illustrate this point, we consider two sets of counterfactual experiments for each country. In the first experiment, we calculate the full dynamic gains from inward FDI, by solving a counterfactual equilibrium with $\eta_{ih,t} = 0, \forall i \neq h, t \geq 2001$ and comparing the path of wage in this counterfactual equilibrium to that in the benchmark economy. In the second set of experiments, we calculate the *static* wage gains from inward FDI, by shutting down inward FDI to country h at each point in time, assuming up to that point, the world economy (including country h) has evolved exactly as in the benchmark economy. For example, the static wage gains for 2006 could be calculated by letting the economy evolve as before in 2001-2005, and then hitting it with a sudden shock change by setting $\eta_{ih,2006} = 0, \forall i \neq h$.

Figure 8 shows the finding from these experiments for Hungry as an example. Panel (a) plots the wage gains. The solid line is the inferred static wage gains. At the beginning of the sample period, the static wage gain from FDI is around 11%. Driven by the influx of foreign investment after the EU accession in 2004, the wage gain increases to around 15%, before it decreases again to



(a) Change in wage (b) Capital Stock Contribution (c) Aggregate Productivity Contribution

Figure 8: Static v.s Dynamic Gains from the Entry of FDI, Hungry

Note: Static gains are calculated by shutting down the inward FDI to Hungary for each single period. Dynamic gains are calculated by shutting down the inward FDI to Hungary from year 2001 onward.

around 10% since the financial crisis. The dashed line plots the dynamic wage effect obtained by solving the transitional path after inward FDI is shut down. Clearly, the dynamic effect lies below the static effect except for in the first period. The difference first increases and then stabilizes at around 5 p.p. Table 9 shows that this is not specific to Hungry—the last two columns report the average static and dynamic effects over 2001-2012 for each country.[33] The average dynamic effect is on average 30% smaller than the average static effect.

Two channels in our model drive the difference. The first is a domestic capital accumulation channel — by pushing up the domestic wage, foreign firms drive marginal domestic firms out of the market and reduce shares of the firms continuing to operate. The lower return from production depresses capital accumulation of active domestic firms, leading to lower net worth in the long run. This in term reduces the capital that can be used in production, given the collateral constraint, thereby reducing the demand for labor.

Second, conditioning on the level of capital, the entry of foreign firms also affects allocative efficiency of capital among domestic firms and hence the aggregate productivity. Specifically, on impact, the entry of foreign firms will drive out some unproductive domestic firms, increasing the productivity of the economy. This 'selection' effect, however, dissipates over time—with the wage higher, the return differentials between productive and unproductive firms narrows. Among the active firms, the fraction of net worth in the hands of the most productive also shrinks, so the gains from allocative efficiency deteriorate over time.

Panels (b) and (c) evaluate the quantitative importance of these two channels. With the exact decomposition in Equation (16), if we add up the corresponding curves from Panels (b) and (c) we would obtain the curves in Panel (a). In both figures, the dynamic effects are below their static counterparts, with the difference gradually increasing, so both channels are at play. However, although the technology channel seems to be more important for the *level* of the wage increase in the dynamic experiment, it is the capital channel that explains most of the *difference* between the

[33] We compare simple averages, as opposed to discounted effects, because the latter is not well defined for the static experiments—the static effects are results of a sequence of experiments and do not correspond to any specific policy.

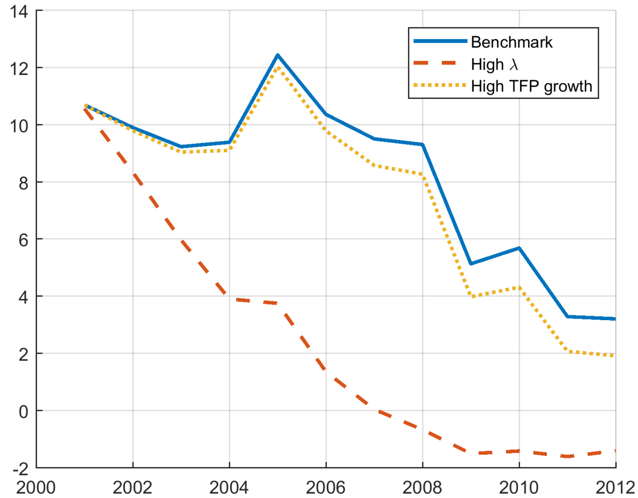


Figure 9: Welfare gains under counter-factual primitives, Hungry
Note: High lambda: multiply $\lambda_{HUN,t}$ by a fixed factor so that it has the same average value as the U.S. High TFP growth: increase the annual growth rate in $\bar{z}_{\text{HUN},t}$ by 1 p.p.

static and dynamic effects — by the end of the sample period, the capital channel explains about 5 out of 6 p.p. difference between the static and dynamic wage gains, so in the context of Hungry, the capital crowding out effect is more important.

Figure 9 explores how the dynamics of wage effect depends on various primitives of a country. The solid line replicates the benchmark dynamic effect. The dotted line is the counterfactual wage gains when the annual growth rate of domestic TFP, $\bar{z}_{\text{HUN},t}$, is increased by 1 p.p. Because this change only affects future evolution of TFP, the wage effect in the first year remains the same. Subsequently, however, the two curves start to diverge — in the economy with a higher domestic productivity growth rate, the wage gains of inward FDI are smaller. The dashed line is for the counterfactual when $\lambda_{\text{HUN},t}$ is higher.[34] It also lies below the benchmark effect, with the difference increasing over time. More interestingly, after 2008, the wage effect is negative — inward FDI creates short-term wage gains, at expenses of long-term wage losses.

The mechanism for the lower wage effect in these two alternative counterfactuals is as follows. From the perspective of workers in a country, wage growth is tied to the growth rate of labor demand, which in turn depends on the size and productivity growth of firms. Given that for most countries, domestic firms account for the bulk of employment, the dynamic wage gains would be smaller, when the crowd-out effect from FDI leads to a bigger decline in domestic labor demand than that could be made up for by foreign affiliates. This is more likely to occur, when the productivity growth rate of domestic firms a whole exceeds that of foreign firms.

In the model, the domestic producers as a whole can exhibit faster productivity growth for two reasons. First, the fundamental productivity might be growing faster; second, the reallocation process might be more efficient—that is, the domestic financial market is more efficient. When these two channels are strong enough, because the size of domestic firms and foreign affiliates

[34] Because $\lambda_{i,t}$ affects contemporary inward MP, we recalibrate the wedge so that the level of inward MP shares are the same as in the benchmark economy. This ensures that the static wage effect in 2001 is the same as in the benchmark model.

in the future depends on their current market shares (as the result of the financial friction), to maximize the long-run wage, it makes sense to give higher market shares to domestic firms.[35]

One natural question is, then, why more foreign firms do not enter to arbitrage out the wage decline. The answer is that, for firms, different destinations are not perfect substitutes. As can be seen from Lemma 3, the elasticity with respect to the return from country h of the probability that a firm opens up an affiliate in country h is θ. That θ is finite captures the difference between FDI and general capital flow — because FDI is tied to technology and the same technology might have different 'match qualities' across host countries, firms will not respond infinitely strongly to a small decrease in production cost in any host. Therefore, even though the credit market is perfectly integrated, the long-run wage decline will not be arbitraged out by inward FDI.

The exercises in this section demonstrate that the dynamic impacts of FDI differ markedly from the static impacts. Moreover, the two deviations we introduced to the neoclassical framework (see, e.g., Gourinchas and Jeanne, 2006), financial constraints and technology-embed in capital, imply that inward FDI can have opposite effects on the long-run and short-run wages.

6 Concluding Remarks

This paper integrates two distinct approaches in studies of FDI through a unified model, which enables the quantitative analysis of FDI in a setting where FDI embodies both technology and capital. We show that financial market conditions play an important role in explaining the dynamics of FDI between 2001-2012. We further show that in our setting the welfare implications of FDI differ substantially from those predicted by existing models.

Our model abstracts from a number of interesting channels. From the micro side, we overlook potential technological spillovers from foreign to domestic firms, which many empirical studies find important. Aside from financial constraints, we also abstract away from firm-level distortions, which are salient in many developing countries. These elements could be conveniently incorporated in our model and, combined with increasingly available microdata, for a more comprehensive understanding of FDI. From the macro side, we deliberately keep the household sector simple. Extending the model to incorporate household saving would allow it to simultaneously match the dynamics of the current account, which consists of mainly portfolio investment, and FDI flows.[36] Such extension can then be used to study the interaction between these two types of capital flows and the effects of various capital control policies that differentiate the two.

[35] One implication of our model is that, in this situation, subsidizing domestic firms might be welfare-improving. See Itskhoki and Moll (2014) for a study of optimal policy in a closed-economy setting with firms facing financial constraints.

[36] International portfolio investment flows, similar to trade and FDI flows, have been shown to follow a gravity equation (Portes and Rey, 2005). It is relatively straightforward to introduce the multivariate shock into the households' portfolio choice problem to allow for a partially integrated international bond market.

Appendix A Data and Facts

A.1 Data Sources and Summary Statistics

This appendix describes the data used in Section 2 and results from additional robustness tests.

Our primary source of data is from Ramondo et al. (2015), which compiles data on bilateral FDI stock and MNC affiliates sales for a sample of 58 countries, including most developed and large developing countries. The same dataset also provides information on various measures of bilateral distance, size of a country. All variables are averaged over the period of 1996 and 2001.

We supplement the above dataset with additional information. To be consistent in timing, to the extent possible, we average the data over 1996 and 2001. If a data series is missing value during none of these years, we impute the average using the last year with non-missing values before 1996, or (if none exists) the first year with non-missing values after 2001. Table 11 present the summary statistics of these variables. Below we explain their sources.

Table 11: Summary Statistics for the Empirical Sample

	N	Mean	Std. Dev.	min	Max
Credit/GDP (%)	58	64.69	46.73	1.48	213.13
Log (GDP)	56	12.57	1.48	9.28	16.31
Log (TFP)	52	0.74	0.22	0.27	1.21
Tax Rate (% of profit)	56	15.71	7.89	1.20	28.80
Inward FDI Restriction Index	43	0.83	0.16	0.37	0.99
Financial Development Index	56	9.98	3.30	3.00	16.00

The World Development Indicator: We obtain country tax rates, financial development index, and private credit GDP ratio from the World Bank Database. Country tax rates are defined as the total tax payable by domestic business as percent of commercial profits, averaged across all firms surveyed in a given country under the World Bank Doing Business Project. The financial development index consists of two sub-indices. The first is the depth of credit information index, which takes values between 0 (low) to 8 (high). It measures rules affecting the accessibility and quality of credit information to facilitate lending decisions. The second is the strength of legal rights index, which takes values between 0 (weak) and 12 (strong). This index measures the protection of borrowers and lenders through collateral and bankruptcy laws. In the empirical analysis, we use the log of the sum of these two indices as the benchmark measure. The private credit includes resources provided to the private sector by financial corporations including, but is not limited to, banks.

The Penn World Table: the aggregate TFP (ctfp) and real GDP (cgdp) are obtained from PWT 9.0. For reduced-form analysis, we take average values over 1996-2001. For countries with missing ctfp, we impute its value using the relative gdp per labor input between these countries and that of the U.S.

OECD: the FDI Regulatory Restriction Index is obtained from the OECD. It takes values between 0 (open) and 1 (closed), and measures statutory restrictions on FDI across sectors in a few aspects.[37] Our empirical analysis uses the aggregate restriction index, which is the average measure across sectors.

Additional sources: we define low-tax countries based on information from Wikipedia page for tax heavens.[38] According to our reading of the materials, the following countries in our sample are defined to have low tax rate—BRB, PAN, LUX, CHE, SGP, IRL, BHS, and NLD.

A.2 Additional Robustness Analysis

Table 12 reports robustness analysis for Fact 2. In Table 2, we use the index developed by the World Bank to measure the quality of financial institutions of a country. A strand of empirical and quantitative research (Manova, 2013; Buera et al., 2011) uses credit over GDP ratio as the measure for the quality of financial institutions. The advantage of this measure is that it is available for a large number of countries and covers a long time period. The drawback is that, since this measure is an outcome, it captures not only the quality of financial institutions, but also other aspects of the economy. As a robustness test, in the first column of Table 12 we use this alternative measure. The coefficient associated with log credit/GDP is 0.24, which is economically and statistically significant.

Second, to rule out the possibility that our finding is driven by a few small outlier country pairs, in the second column of Table 12, we report the result from a regression weighted by log GDP of host countries. The coefficient barely changes. Finally, Column 3 of the table shows that our results are robust to using the ordinary least square estimation, as opposed to PPML.

Table 13 reports the robustness tests for Fact 3. As above, the first column uses credit over GDP ratio as the measure for financial development. Column 2 uses the same benchmark specification as in Table 3, but weights each observation by the size of the home country. Column 3 reports the ordinary least square estimations. The results are robust to these alternative choices.

Appendix B Quantification

B.1 Sample and Construction of Additional Variables

We restrict the quantification analysis to larger economies and countries in which foreign affiliates play an important role. To this end, we start with the 58 countries from the empirical analysis, and drop countries that are outside the top 35 in *all* of the following: GDP, total outward FDI, total inward FDI. This restriction leaves us with 39 countries. We further exclude Uruguay, El Salvador, Croatia, and Bulgaria because the BEA does not provide the balance sheet information of American MNC affiliates in these countries, which is needed for our calibration of $\mu_{h,t}$. Table 14 lists the 36 countries in the quantification. The additional variables used in the quantification are constructed as follows:

[37] These include, 1) limitations on equity holding; 2) discriminatory policies on screen and approval process; 3) restrictions on employment of foreigners as key personnel; and 4) other operational restrictions.

[38] The link is https://en.wikipedia.org/wiki/Tax_haven.

Table 12: Additional Robustness Exercise for Fact 2

	(1)	(2)	(3)
Dependent Variable		Log (MP)	
Log (Financial development index)		0.589***	0.184*
		(0.214)	(0.092)
Log (credit/GDP)	0.322***		
	(0.099)		
Log (FDI)	0.609***	0.565***	0.938***
	(0.059)	(0.064)	(0.030)
Observations	1276	1276	1551
R^2	0.964	0.963	0.963
Home country FE	yes	yes	yes
Additional host characteristics	yes	yes	yes
Bilateral distance measures	yes	yes	yes

Note: See Table 2 for definition of variables. The first column is the same as Column 3 in Table 2, but use Log (credit/GDP) as the measure for financial development. The second column is PPML weighted by host GDP. The third column is estimated using OLS. Standard errors (clustered at host-country level) in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 13: Additional Robustness Exercise for Fact 3

	(1)	(2)	(3)
Dependent Varaible		Log (FDI)	
Log (credit/GDP)	0.895***		
	(0.225)		
Log (Financial development index)		1.005***	1.026**
		(0.273)	(0.436)
Observations	1717	1717	1792
R^2	0.882	0.885	0.707
Host country FE			
Additional home characteristics	yes	yes	yes
Bilateral distance measures	yes	yes	yes

Note: See Table 2 for definition of variables. The first column is the same as Column 3 in Table 2, but use Log (credit/GDP) as the measure for financial development. The second column is PPML weighted by home GDP. The third column is estimated using OLS. Standard errors (clustered at host-country level) in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

GDP, capital, and effective employment: The time series of GDP, total capital stock, and effective employment are all obtained from Penn World Table 9.0. The data series for GDP and capital stock are *cgdpo* and *ck*, respectively. The series for effective employment is constructed as the product of employment (*emp*) and human capital (*hc*).

Bilateral FDI: The quantification requires bilateral FDI stocks during 2001-2012. We construct this dataset by combining the bilateral FDI *stocks* from Ramondo et al. (2015) and a newly assembled panel of bilateral FDI *flows* from the UNCTAD.[39] Specifically, total FDI stock from country i to country h at the end of year t is constructed as:

$$\text{FDI Stock}_{ih,t} = (1-\delta)\text{FDI Stock}_{ih,t-1} + \text{FDI Flow}_{ih,t},$$

under the assumption that the depreciation δ is the same for both foreign and domestic capital.

A few economies outside our sample might carry disproportionate weights in world FDI (some of these could be the top 35 in FDI destination countries, but are not in the sample of Ramondo et al. (2015)), which leads to the concern that the FDI in the sample might not align well with the aggregate FDI in the world. Figure 10 shows that, although there is a difference between the aggregate FDI in the world and in our sample countries, the overall trend of the world FDI is captured by the sample. Moreover, a simple adjustment can reduce the difference between the two lines by half. Specifically, countries outside the sample, but nonetheless attract/send a large amount of FDI, are usually offshore financial centers that act as intermediaries for investment in third countries. For example, Hong Kong has been an important intermediary for mainland Chinese enterprises to invest in other countries and for the RoW to invest in China; similarly, as the most important sending countries of FDI, the U.S. also invest heavily in Bahamas and Panama, presumably to direct investment elsewhere while avoiding taxes. Given that China (mainland) and the U.S. are among the largest countries, we add back the FDI from/to U.S. and China through offshore financial centers, including Hong Kong, Cayman Islands, Bahamas, Dominica, British Virgin Island, Panama, and Luxumberg, to the sample countries. We make a proportionate assumption in this adjustment. Specifically, we redistribute the FDI flows from China and the U.S. to the offshore financial centers to other countries in our sample based on their relative shares in outward FDI from China and U.S., respectively. We make similar adjustments for inward FDI to China and U.S. The red line in Figure 10 shows that adjusting for these two countries alone reduces the gap by a half.

Both the initial FDI stocks and subsequent flows have missing values (the above figures exclude observations with missing observations). Ramondo et al. (2015) provides imputation procedures based on the reported number of affiliates, which reduces the number of missing values significantly. For quantification, we use this imputation (note that we do not use the imputed values for empirical analysis). We assume the remaining missing values in the initial bilateral FDI stock are zero.

The bilateral FDI flows are constructed as follows. For each directed pair of countries, we

[39]UNCTAD also provide bilateral FDI stocks over the same period, but missing values are more prevalent and from the documentation it is not clear how the series is constructed.

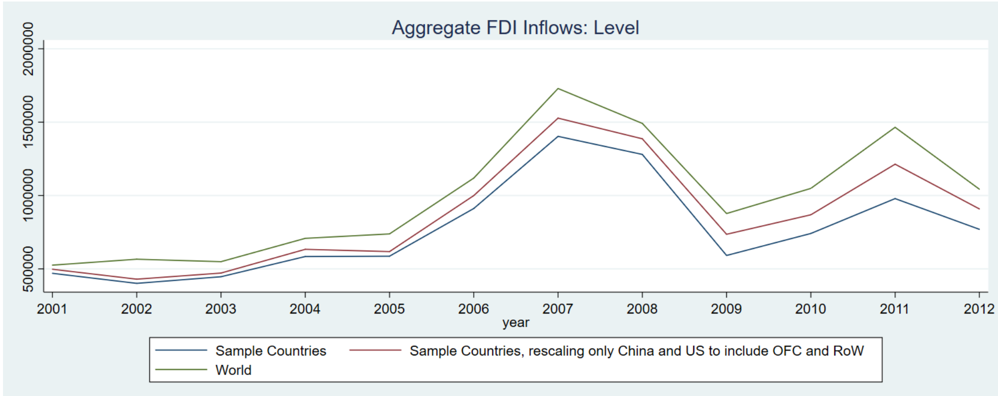


Figure 10: Sample and World Aggregate FDI Inflow

Note:

observe potentially two reporting, one from the host country, the other from the home country. When both values are non-missing, we use the number reported by the source country, as this measure captures better indirect FDI (i.e., a Chinese firm invests in Japan through an affiliate in Hong Kong). When both values are missing, we consider the following scenarios. First, if a country pair has a recorded 0 in all years aside from the year with missing values, we replace the missing value with 0, too. Second, if a country pair has one or more gaps in non-missing and non-zero values, we calculate the shares of the destination country in the host country total outward FDI flows in years with available data, and then linearly impute this share, and calculate the corresponding level in the years with missing data. After these two procedures, the remaining missing values are from country pairs with mostly only missing values over the sample period, or are after all years with available values. To avoid extrapolation, we simply assume these values are 0.

Given that the FDI statistics from the UNCTAD is in current USD, whereas the capital stock and GDP from the PWT are in constant prices, we first construct ratios between FDI statistics and current-price USD GDP of destination countries in each year, and then use this ratio, and the constant-price GDP from PWT to construct constant-price FDI statistics.

Affiliate financing: We use the BEA data to construct series for affiliate financing conditions. Conceptually an affiliate could be financed by three different groups of investors: from the home country (including but is not limited to the parent company), the host country, and third countries. Each of these three groups can then be further classified into creditors or equity investors. Given that our model is not designed to study capital structure choices, we will not differentiate between equity and debt, but instead bundle them together. In our model, affiliate finance comes from only two sources: home and host countries. Presumably, a lot of third-country investors only come on board because the backing of the parent firm. Through the lens of our model, therefore, it is most appropriate to treat this as funding from the parent country, raised with the parent net worth as collateral.

There are two separate measures that allow us to measure the share of finance from the host country. **The first measure** is based on the statistics on the composition of external finance, avail-

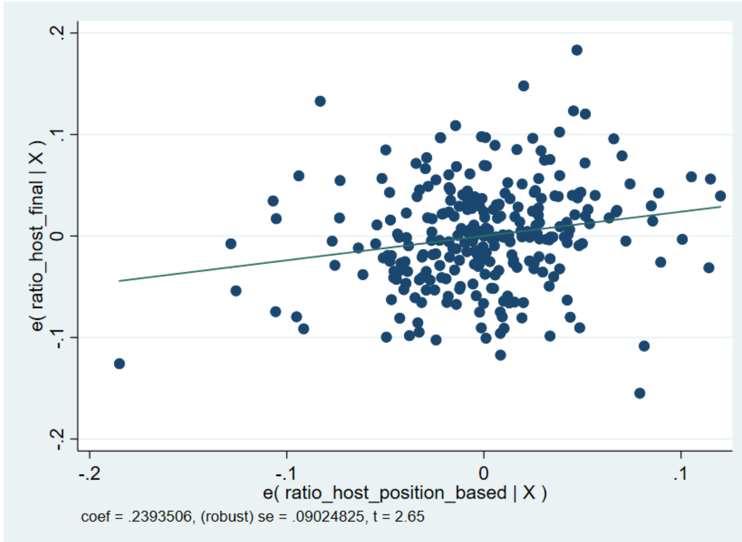


Figure 11: Correlation Between Two Measures of Host Finance Share

Note:

able between 1983-2008. During these years, the overseas affiliates of U.S. MNCs report their source of finance from the three groups of countries (host, home, and others), decomposed into debt and equity. Using this data series, we can directly construct the host finance share, but it is discontinued after 2009.

The second measure can be constructed as the ratio of two variables: first, the total position of U.S. investment in affiliates in a host country and, second, the total assets of U.S. affiliates in a host country. These two series are available over a longer horizon, covering our entire sample period, but it classifies all third-country finance as host finance, inflating the influence of host country financial markets.

We combine these two series to construct our measure of host country finance share. Between 1983 and 2008, we use the first measure. Between 2009 and 2012, we use the level from the first measure in 2008, together with the yearly change from the second measure, to impute the host country finance share in the balance sheet. The underlying assumption behind this imputation is that the yearly changes in these two measures after 2008 are correlated. This assumption cannot be tested directly, but we can test if it holds before 2008. Figure 11 shows the residual plots when we regress one measure on the other, controlling for year and country fixed effects. It shows that indeed these two measures are correlated.

To construct the analogous measure for the U.S. as a host country, we apply a similar approach to the data on affiliates of foreign MNCs operating in the U.S., which are also available from the BEA.

There are two remaining challenges in constructing the series. First, between 1999 and 2003, the total value of host finance is missing from the first measure, but the host *debt* finance is reported. In this case, we first try to impute the total host country finance by assuming that the share of host debt in all debt finance is the same as that in 1998, and then use this share and the total debt finance during 1999-2003, which is reported, to impute the total host finance. In a couple of cases, there are still missing values for host debt finance or total debt finance in one of the years, in which case we linearly interpolate the ratio of host finance share.

Second, there is a change of definition in the second measure, so that in some years, it includes non-bank affiliates, while in other years, it does not. In years in which both non-bank affiliates and bank affiliates are reported, we construct the ratio for all affiliates and non-bank affiliates only, and find that they are very similar.

Credit over GDP ratio: We use the same data series from the World Bank Database for the ratio between total credits to the private sector and GDP. We inspect each time series and notice that for Canada, the ratio jumps from 93% to 172% in 2001 and from 188% to 123% in 2007, and series stops in 2008. Such dramatic shifts do not show up in alternative sources of data such as the Bank of International Settlement database, so it is likely due to undocumented changes of definitions. To avoid using data series from two different sources (with different definitions), we assume the credit over GDP in Canada are the same as that of the U.S. (Between 2001 and 2007, the two countries show similar level and trend for the credit over GDP ratio.)

B.2 Calibration

B.2.1 Estimating η_z

We explain below how we estimate η_z in Equation (11). In the model, when $\tilde{R}_{i,t}(z) = \bar{R}_{i,t}(z)$, or alternatively, when we focus solely on the firms that are not at the mass point of the distribution, the odds ratio of a firm becoming an MNC is

$$\frac{Pr(MN|z)}{1 - Pr(MN|z)} = \frac{\sum_{h' \neq i} \chi_{ih'}(z)}{\chi_{ii}(z)}.$$

The log odds ratio is therefore

$$\log(\frac{Pr(MN|z)}{1 - Pr(MN|z)}) = \log(\frac{\sum_{h' \neq i} [\bar{\eta}_{ih'} R_{ih'}(z)]^{\theta}}{[\bar{\eta}_{ii} R_{ii}(z)]^{\theta}}) + \theta \cdot \eta \log(z).$$

Generally, $\log(\frac{\sum_{h' \neq i} [\bar{\eta}_{ih'} R_{ih}(z)]^{\theta}}{[\bar{\eta}_{ii} R_{ii}(z)]^{\theta}})$ depends on z. However, for productive enough firms, the following holds:

$$\lim_{z \to \infty} \frac{\sum_{h' \neq i} [\bar{\eta}_{ih'} R_{ih'}(z)]^{\theta}}{[\bar{\eta}_{ii} R_{ii}(z)]^{\theta}} = \frac{z^{\gamma\theta} \sum_{\tilde{h'}} [\bar{\eta}_{ih'} \bar{z}_{h'}^{1-\gamma} w_{h'}^{\frac{\alpha-1}{\alpha}}]^{\theta}}{z^{\gamma\theta} [\bar{\eta}_{ii} \bar{z}_{i}^{1-\gamma} w_{i}^{\frac{\alpha-1}{\alpha}}]^{\theta}}$$

which is i specific and does not depend on z. Therefore, for productive enough firms, we have the following structural equation:

$$\log(\frac{Pr(MN|z)}{1 - Pr(MN|z)}) \approx \beta_{0i} + \theta \cdot \eta_z \log(z),$$

in which β_{0i} is country fixed effects.

Note that in the model, it is $\tilde{z} \equiv z^{\alpha}$, rather than z, that represents the firm-level TFP. To write the above structural equation as a function of firm-level TFP that can be mapped to the data, we substitute in $\tilde{z} \equiv z^{\alpha}$ and obtain:

$$\log\left(\frac{Pr(MN|\tilde{z})}{1 - Pr(MN|\tilde{z})}\right) \approx \beta_{0i} + \frac{\theta\eta_z}{\alpha}\log(\tilde{z})$$

This specification corresponds exactly to a Logit regression model, with the probability of a country-i firm being an MNC being

$$Pr(MN|z) = F(\beta_{0i} + \beta_1 \log(\tilde{z})) = \frac{\exp(\beta_{0i} + \beta_1 \log(\tilde{z}))}{1 + \exp(\beta_{0i} + \beta_1 \log(\tilde{z}))}. \tag{17}$$

Because this is only an exact structural equation when $\tilde{R}_{i,t}(z) = \bar{R}_{i,t}(z)$, and only for firms with the highest productivity, we cannot directly estimate the structural parameter. Instead, we adopt an indirect-inference procedure.

Specifically, we estimate Equation (17) using the data set described in Bloom et al. (2012), which covers basic information of manufacturing firms surveyed in a dozen countries. Given that the structural equation is a good approximation only for firms that are productive enough, we keep only firms in top 25% of the productivity distribution in each country, and regress a dummy of whether a firm is an MNC on its productivity, controlling for country fixed effects. We find a point estimate of 0.46 for $\hat{\beta}_1$. We then pick η_z so that when estimated using the simulated-data from the model and focusing on the common set of countries as Bloom et al. (2012), Equation (17) produces same elasticity. This determines $\eta_z = 0.04$.[40]

B.3 Additional Information on the Calibration

Table 14 reports some country characteristics and the corresponding parameters.

[40]Note also that this is not far off from using Equation (17) as the structural equation directly, in which case we would obtain, $\hat{\eta}_z = 0.46 * \alpha/\theta = 0.0368$.

Table 14: Country Characteristics and Calibrated Parameters

ISO	(1) Credit/GDP	(2) $\bar{\lambda}_{i,t}$	(3) Host Finance	(4) $\bar{\mu}_{h,t}$	(5) FDI Share	(6) $\bar{\zeta}_{ih,t}$	(7) MP Share: Data	(8) MP Share: Model
ARG	0.06	0.08	1.58	0.69	0.06	0.53	0.10	0.19
AUS	0.37	0.77	2.03	1.29	0.06	0.57	0.23	0.24
AUT	0.15	0.22	1.67	0.94	0.04	0.51	0.29	0.10
BEL	0.08	0.11	1.53	0.75	0.26	0.75	0.46	0.59
BRA	0.07	0.10	1.77	0.86	0.04	0.51	0.14	0.23
CAN	0.46	1.23	2.42	1.65	0.09	0.61	0.35	0.36
CHE	0.38	0.58	1.43	0.55	0.15	0.59	0.37	0.32
CHL	0.35	0.77	1.71	0.80	0.10	0.42	0.15	0.37
CHN	0.31	0.59	1.95	0.99	0.01	0.36	0.04	0.17
CZE	0.05	0.07	1.56	0.78	0.05	0.56	0.34	0.17
DEU	0.21	0.30	1.99	1.21	0.03	0.73	0.29	0.13
DNK	0.29	0.46	1.62	0.82	0.05	0.53	0.13	0.13
ESP	0.18	0.28	1.67	0.95	0.04	0.60	0.17	0.10
FIN	0.12	0.16	1.86	1.12	0.04	0.62	0.20	0.10
FRA	0.12	0.15	1.94	1.22	0.06	0.77	0.20	0.19
GBR	0.21	0.33	1.73	0.90	0.12	0.72	0.32	0.36
HUN	0.07	0.12	1.22	0.28	0.11	0.53	0.44	0.24
IDN	0.02	0.03	1.35	0.39	0.06	0.43	0.12	0.35
IND	0.12	0.17	1.74	0.76	0.01	0.21	0.04	0.14
IRL	0.22	1.00	1.48	0.62	0.55	0.65	0.35	0.92
ITA	0.11	0.14	1.87	1.22	0.02	0.63	0.11	0.04
JPN	0.41	0.73	2.36	1.53	0.01	0.43	0.04	0.03
KOR	0.27	0.43	1.89	1.09	0.02	0.51	0.06	0.07
MEX	0.05	0.07	1.78	0.86	0.05	0.45	0.18	0.24
MYS	0.42	0.93	1.55	0.64	0.07	0.46	0.41	0.24
NLD	0.16	0.47	1.47	0.64	0.44	0.86	0.41	0.77
NOR	0.40	0.67	1.76	0.95	0.07	0.52	0.14	0.16
NZL	0.42	1.12	1.72	0.84	0.13	0.49	0.18	0.43
POL	0.15	0.23	1.71	0.78	0.06	0.46	0.22	0.23
PRT	0.16	0.27	1.69	1.08	0.04	0.49	0.38	0.10
RUS	0.21	0.30	1.25	0.29	0.01	0.40	0.03	0.04
SGP	0.15	0.28	1.62	0.85	0.22	0.56	1.33	0.42
SWE	0.20	0.29	1.82	1.05	0.07	0.61	0.30	0.18
TUR	0.09	0.12	1.73	0.85	0.02	0.36	0.06	0.06
USA	0.56	1.34	2.07	1.36	0.03	0.96	0.15	0.10
VEN	0.04	0.05	1.72	0.84	0.04	0.40	0.13	0.15
Mean	0.21	0.42	1.73	0.90	0.09	0.55	0.25	0.24
Std	0.14	0.36	0.25	0.30	0.11	0.15	0.22	0.19

Appendix C Theory

C.1 Formal definition of equilibrium

The aggregate state of the economy is the joint distribution of parent firms' net worth and productivity in each country. Throughout the paper, we work with equilibria with distributions that can be characterized by the joint density functions $\Phi_{i,t}(z,a)$. Utilizing the property that the policy functions for parent firms' financing, investing and fund allocation are linear in the net worth (Lemma 2 and 3), and that the policy functions for affiliates' financing, production and factor usage are linear in the funds from the parents (Lemma 1), we can track the mass of net worth held by parent firms with productivity z (i.e., $\phi_{i,t}(z)$ defined in section 3.5), and express market clear conditions combining $\phi_{i,t}(z)$ and the linear parts of the parents' and affiliates' policy functions. Formally, given initial distributions characterized by density functions $\Phi_{i,0}(z,a)$, a competitive equilibrium is marginal distribution $\{\phi_{i,t}(z)\}_{t=0}^{\infty}$, wage and interest rate $\{w_{i,t}, r_{i,t}^b\}_{t=0}^{\infty}$, affiliates' return and policy functions $\{R_{ih,t}(z), \hat{b}_{ih,t}^F(z), \hat{k}_{ih,t}(z), \hat{l}_{ih,t}(z), \hat{y}_{ih,t}(z)\}_{t=0}^{\infty}$, parents' value and policy functions $\{v_{i,t}(z,\boldsymbol{\eta},a), \hat{c}_{i,t}(z,\boldsymbol{\eta}), \hat{a}_{i,t}'(z,\boldsymbol{\eta}), \hat{b}_{i,t}^H(z,\boldsymbol{\eta}), R_{i,t}^a(z,\boldsymbol{\eta}), \hat{e}_{ih,t}(z)\}$, such that

1. Affiliates' return and policy functions solve affiliates' financing and production problems, characterized by Lemma 1. Parents' value and policy functions solve parents' financing, investing and fund allocation problems, characterized by Lemma 2 and 3.

2. The labor market clears in each country h:

$$\sum_{i=1}^{N} \int_0^{\infty} \hat{l}_{ih,t}(z)(1+\lambda_{i,t})\hat{e}_{ih,t}(z)\phi_{i,t}(z)dz = L_{h,t}.$$

   The global bond market clears[41]:

$$\underbrace{\sum_{i=1}^{N} \int_0^{\infty} \left[1 - \sum_{h=1}^{N} \hat{e}_{ih,t}(z)\right]\phi_{i,t}(z)dz}_{\text{Bond supplied by idle parent firms}} = \underbrace{\sum_{i=1}^{N} \int_0^{\infty} \lambda_{i,t} \sum_{h=1}^{N} \hat{e}_{ih,t}(z)\phi_{i,t}(z)dz}_{\text{Bond demanded by active parent firms}}$$
$$+ \underbrace{\sum_{i=1}^{N}\sum_{h=1}^{N} \int_0^{\infty} \hat{b}_{ih,t}^F(z)(1+\lambda_{i,t})\hat{e}_{ih,t}(z)\phi_{i,t}(z)dz,}_{\text{Bond demanded by affiliates}}$$

   and $r_{i,t}^b = r_{i',t}^b, \forall i, i'$.

3. The initial mass function $\phi_{i,0}(z)$, following its definition in section 3.5, satisfies

$$\phi_{i,0}(z) \equiv \int_0^{\infty} \Phi_{i,0}(z,a)da$$

[41] If we assume that the bond market is segregated, then the bond market clears by country with country-specific interest rates.

The transition of $\phi_{i,t}(z)$ is implied by the policy and return functions of the parent firms and the exogenous Markov process $f_i(z'|z)$, and satisfies

$$\phi_{i,t+1}(z') = \int_0^\infty \phi_{i,t}(z)\beta\mathbb{E}[R^a_{i,t}(z,\boldsymbol{\eta})|z]f_i(z'|z)dz.$$

C.2 Proofs

Proof of Lemma 2.

Proof. We proceed by a guess-and-verify strategy. Suppose the value function is in the following form:

$$v_{i,t}(z,\boldsymbol{\eta},a) = \hat{v}_{i,t}(z,\boldsymbol{\eta}) + B\log(a).$$

where $\hat{v}_{i,t}(z,\boldsymbol{\eta})$ and B are functions and coefficients to be determined. Plug the guess into the right hand side of the parent firm's Bellman equation (3) we have

$$\begin{aligned} v_{i,t}(z,\boldsymbol{\eta},a) = &\max_{c,a',\{e_h\}_{h=1}^N,b^H} \log(c) + \beta\mathbb{E}\left[(\hat{v}_{i,t+1}(z',\boldsymbol{\eta}') + \ B\log(a'))\middle|z\right] \\ s.t. \quad & \sum_h e_h = a + b^H \\ & -a \leq b^H \leq \lambda_{i,t}\cdot a \\ & c + a' = \sum_h R_{ih,t}(z)\eta_h e_h - (1+r^b_{i,t})b^H. \end{aligned} \tag{18}$$

The problem can be solved in two steps. In the first step, firms solve the investment allocation problem by choosing $\{e_h\}_{h=1}^N, b^H$ to maximize total net return on net worth a

$$\begin{aligned} \tilde{R}^a_{i,t}(z,\boldsymbol{\eta},a) = &\max_{\{e_h\}_{h=1}^N,b^H} \sum_h R_{ih,t}(z)\eta_h e_h - (1+r^b_{i,t})b^H \\ s.t. \quad & \sum_h e_h = a + b^H \\ & -a \leq b^H \leq \lambda_{i,t}\cdot a. \end{aligned}$$

Since the objective is linear in b^H and e_h, if $1+r^b_{i,t} > \max_{h'} R_{ih',t}(z)\eta_{h'}$, the firm chooses to be idle and loan out all the net worth by setting $b^H = -a$. If $1+r^b_{i,t} < \max_{h'} R_{ih',t}(z)\eta_{h'}$, the firm chooses to be active, borrows to the maximum and allocates e_h to hosts that attains $\max_{h'} R_{ih',t}(z)\eta_{h'}$. If $1+r^b_{i,t} = \max_{h'} R_{ih',t}(z)\eta_{h'}$, the firm is indifferent between being idle and active, since both generate the same returns. Therefore, we have $\tilde{R}^a_{i,t}(z,\boldsymbol{\eta},a) = R^a_{i,t}(z,\boldsymbol{\eta})a$ with

$$R^a_{i,t}(z,\boldsymbol{\eta}) = \begin{cases} [\max_h R_{ih,t}(z)\eta_h](1+\lambda_{i,t}) - (1+r^b_{i,t})\lambda_{i,t}, & \text{if } \max_h R_{ih,t}(z)\eta_h \geq 1+r^b_{i,t}, \\ (1+r^b_{i,t}), & \text{if } \max_h R_{ih,t}(z)\eta_h < 1+r^b_{i,t}. \end{cases}$$

Therefore the right hand side of equation (18) reduces to

$$\max_{a'} \log(R^a_{i,t}(z,\boldsymbol{\eta})a - a') + \beta\mathbb{E}[(\hat{v}_{i,t+1}(z',\boldsymbol{\eta}') + \ B\log(a'))|z].$$

First order condition w.r.t. a'

$$\frac{1}{R^a_{i,t}(z,\boldsymbol{\eta})a - a'} = \frac{\beta B}{a'}$$
$$\Rightarrow a' = \frac{\beta B}{1+\beta B} R^a_{i,t}(z,\boldsymbol{\eta})a. \tag{19}$$

Plug (19) into (18) we have

$$v_{i,t}(z,\boldsymbol{\eta},a) = \log(\frac{R^a_{i,t}(z,\boldsymbol{\eta})}{1+\beta B}) + \log(a) + \beta\mathbb{E}[(\hat{v}_{i,t+1}(z',\boldsymbol{\eta}')|z] + \beta B \log\left(\frac{\beta B}{1+\beta B} R^a_{i,t}(z,\boldsymbol{\eta})a\right).$$

Comparing with guessed functions and coefficients to be determined we have verified B and $\hat{v}_{i,t}(z)$ that satisfy the following

$$1+\beta B = B$$
$$\hat{v}_{i,t}(z,\boldsymbol{\eta}) = \log(\frac{R^a_{i,t}(z,\boldsymbol{\eta})}{1+\beta B}) + \beta\mathbb{E}[(\hat{v}_{i,t+1}(z',\boldsymbol{\eta}')|z] + \beta B \log\left(\frac{\beta B}{1+\beta B} R^a_{i,t}(z,\boldsymbol{\eta})\right)$$

solve the Bellman equation. Thus we have

$$B = \frac{1}{1-\beta}$$

and

$$a' = \beta R^a_{i,t}(z,\boldsymbol{\eta})a$$
$$c = R^a_{i,t}(z,\boldsymbol{\eta})a - a' = (1-\beta)R^a_{i,t}(z,\boldsymbol{\eta})a.$$

□

Before proving Lemma 3, we first characterize several properties of the correlated Pareto distribution. Some of these properties are also covered in Arkolakis et al. (2017).

Lemma 4. *Suppose $\boldsymbol{\zeta} = (\zeta)_{h=1}^N$ follows the standardized correlated Pareto distribution with cumulative distribution function (cdf)*

$$Pr(\zeta_1 \leq \tilde{\zeta}_1, ..., \zeta_h \leq \tilde{\zeta}_h) = \begin{cases} 1 - \left(\sum_h \frac{1}{N}[\tilde{\zeta}_h^{-\theta}]^{\frac{1}{1-\rho}}\right)^{1-\rho}, if\ \tilde{\zeta}_h \geq 1, \forall h, \\ 0, if\ \exists h\ s.t.\ \tilde{\zeta}_h < 1. \end{cases}$$

Given any constants $\{A_h\}_{h\in\mathbb{H}}$ s.t. $A_h > 0\ \forall h$, define $\Xi = \max_{h'} A_{h'}\zeta_{h'}$.

1. *The cdf for Ξ is*

$$Pr(\Xi \leq B) = \begin{cases} 1 - \tilde{A}^{\theta} B^{-\theta}, \ \text{if } B \geq \max_{h'} A_{h'} \\ 0, \ \text{if } B < \max_{h'} A_{h'}. \end{cases}$$

where $\tilde{A} = \left(\frac{1}{N}\sum_{h'} A_{h'}^{\frac{\theta}{1-\rho}}\right)^{\frac{1-\rho}{\theta}}$. *This immediately implies*

$$Pr(\Xi = \max_{h'} A_{h'}) = 1 - \tilde{A}^{\theta}[\max_{h'} A_{h'}]^{-\theta}.$$

2. *The bottom truncated mean of Ξ is*

$$\mathbb{E}[\Xi | \Xi \geq B] = \begin{cases} \frac{\theta}{\theta - 1} B, \ \text{if } B > \max_{h'} A_{h'} \\ (1 - \tilde{A}^{\theta}[\max_{h'} A_{h'}]^{-\theta}) \max_{h'} A_{h'} + \tilde{A}^{\theta}[\max_{h'} A_{h'}]^{-\theta} \frac{\theta}{\theta - 1} \max_{h'} A_{h'}, \ \text{if } B \leq \max_{h'} A_{h'} \end{cases}$$

3. *The conditional probability of each choice attaining maximum*

$$Pr(\arg\max_{h'} A_{h'}\zeta_{h'} = h \Big| \Xi \geq B) = \frac{A_h^{\theta/(1-\rho)}}{\sum_{h'} A_{h'}^{\theta/(1-\rho)}}, \ \text{if } B > \max_{h'} A_{h'}.$$

and if $\overline{\mathbb{H}} = \arg\max_{h'} A_{h'}$ *is a singleton, then for* $\bar{h} \in \overline{\mathbb{H}}$*,*

$$Pr(\arg\max_{h'} A_{h'}\zeta_{h'} = \bar{h} \Big| \Xi = \max_{h'} A_{h'}) = 1.$$

Proof. 1. Consider

$$\begin{aligned} Pr(\Xi \leq B) &= Pr(A_1\zeta_1 \leq B, ..., A_h\zeta_h \leq B) \\ &= Pr(\zeta_1 \leq \frac{B}{A_1}, ..., \zeta_h \leq \frac{B}{A_h}) \\ &= 1 - \Big(\sum_{h'} \frac{1}{N}\big[(\frac{B}{A_{h'}})^{-\theta}\big]^{\frac{1}{1-\rho}}\Big)^{1-\rho}, \quad \text{for } \frac{B}{A_{h'}} \geq 1, \forall h' \\ &= 1 - \Big(\frac{1}{N}\sum_{h'} A_{h'}^{\frac{\theta}{1-\rho}}\Big)^{1-\rho} B^{-\theta}, \quad \text{for } B \geq \max_{h'} A_{h'} \end{aligned}$$

If $B < \max_{h'} A_{h'}$, then $\exists h$ s.t. $\frac{B}{A_h} < 1$. Therefore,

$$Pr(\Xi \leq B) = Pr(\zeta_1 \leq \frac{B}{A_1}, ..., \zeta_h \leq \frac{B}{A_h}) = 0.$$

Therefore,

$$Pr(\Xi = \max_{h'} A_{h'}) = Pr(\Xi \leq \max_{h'} A_{h'}) - \lim_{B \uparrow \max_{h'} A_{h'}} Pr(\Xi \leq B) = 1 - \Big(\frac{1}{N}\sum_{h'} A_{h'}^{\frac{\theta}{1-\rho}}\Big)^{1-\rho} [\max_{h'} A_{h'}]^{-\theta}.$$

2. For $B > \max_{h'} A_{h'}$, from part 1, $\forall C \geq B$

$$Pr(\Xi > C | \Xi > B) = \Big(\frac{C}{B}\Big)^{-\theta}.$$

Therefore, $\Xi | \Xi > B$ follows a Pareto distribution with tail parameter θ and scale parameter B, and thus we have

$$\mathbb{E}[\Xi | \Xi > B] = \frac{\theta}{\theta - 1} B.$$

Since for $B > \max_{h'} A_{h'}$, $Pr(\Xi \leq B)$ is continuous in B, we have $Pr(\Xi = B) = 0$ and therefore

$$\mathbb{E}[\Xi | \Xi \geq B] = \mathbb{E}[\Xi | \Xi > B] = \frac{\theta}{\theta - 1} B.$$

For $B \leq \max_{h'} A_{h'}$, since $Pr(\Xi \geq B) = 1$, we have

$$\begin{aligned}
\mathbb{E}[\Xi | \Xi \geq B] &= \mathbb{E}(\Xi) \\
&= Pr(\Xi = \max_{h'} A_{h'}) \mathbb{E}(\Xi | \Xi = \max_{h'} A_{h'}) + Pr(\Xi > \max_{h'} A_{h'}) \mathbb{E}(\Xi | \Xi > \max_{h'} A_{h'}) \\
&= (1 - \tilde{A}^{\theta} [\max_{h'} A_{h'}]^{-\theta}) \max_{h'} A_{h'} + \tilde{A}^{\theta} [\max_{h'} A_{h'}]^{-\theta} \frac{\theta}{\theta - 1} \max_{h'} A_{h'}.
\end{aligned}$$

3. For $B > \max_{h'} A_{h'}$,

$$Pr(\arg\max_{h'} A_{h'}\zeta_{h'} = h \wedge \Xi \geq B) = \int_B^{\infty} Pr(A_{h'}\zeta_{h'} \leq u, \forall h' \neq h \big| A_h \zeta_h = u) g_h(u) du$$

where $g_h(u)$ is the marginal distribution of $A_h\zeta_h$. For $u > \max_{h'} A_{h'}$,

$$\begin{aligned}
Pr(A_{h'}\zeta_{h'} \leq u, \forall h' \neq h \big| A_h\zeta_h = u) g_h(u) &= \frac{\partial Pr(A_1\zeta_1 \leq u, A_h\zeta_h \leq C, A_{h'}\zeta_{h'} \leq u)}{\partial C}\Big|_{C=u} \\
&= \frac{A_h^{\frac{\theta}{1-\rho}}}{N} \Big(\frac{1}{N}\sum_{h'} A_{h'}^{\frac{\theta}{1-\rho}}\Big)^{-\rho} \theta u^{-\theta-1}.
\end{aligned}$$

Therefore,

$$Pr(\arg\max_{h'} A_{h'}\zeta_{h'} = h \wedge \Xi \geq B) = \frac{A_h^{\frac{\theta}{1-\rho}}}{N} \Big(\frac{1}{N}\sum_{h'} A_{h'}^{\frac{\theta}{1-\rho}}\Big)^{-\rho} B^{-\theta}.$$

And

$$Pr(\arg\max_{h'} A_{h'}\zeta_{h'} = h \Big| \Xi \geq B) = \frac{Pr(\arg\max_{h'} A_{h'}\zeta_{h'} = h \wedge \Xi \geq B)}{Pr(\Xi \geq B)}$$
$$= \frac{\frac{A_h^{\frac{\theta}{1-\rho}}}{N}\left(\frac{1}{N}\sum_{h'} A_{h'}^{\frac{\theta}{1-\rho}}\right)^{-\rho} B^{-\theta}}{\left(\frac{1}{N}\sum_{h'} A_{h'}^{\frac{\theta}{1-\rho}}\right)^{1-\rho} B^{-\theta}}$$
$$= \frac{A_h^{\frac{\theta}{1-\rho}}}{\sum_{h'} A_{h'}^{\frac{\theta}{1-\rho}}},$$

where the second equality applies $Pr(\Xi \geq B) = \left(\frac{1}{N}\sum_{h'} A_{h'}^{\frac{\theta}{1-\rho}}\right)^{1-\rho} B^{-\theta}$ from part 1 of the lemma.

If $\overline{\mathbb{H}} = \arg\max_{h'} A_{h'}$ is a singleton, then consider for $h \notin \overline{\mathbb{H}}$, we have $A_h < \max_{h'} A_{h'}$, and

$$Pr\Big(A_h\zeta_h = \max_{h'} A_{h'} \ \wedge \ \Xi \leq \max_{h'} A_{h'}\Big)$$
$$\leq Pr\Big(\zeta_h = \frac{\max_{h'} A_{h'}}{A_h}\Big) = 0,$$

since $\frac{\max_{h'} A_{h'}}{A_h} > 1$. Therefore,

$$Pr\Big(\Xi \leq \max_{h'} A_{h'}\Big) \leq \sum_{\tilde{h}} Pr\Big(A_{\tilde{h}}\zeta_{\tilde{h}} = \max_{h'} A_{h'} \wedge \ \Xi \leq \max_{h'} A_{h'}\Big)$$
$$= \sum_{\tilde{h}\in\overline{\mathbb{H}}} Pr\Big(A_{\tilde{h}}\zeta_{\tilde{h}} = \max_{h'} A_{h'} \wedge \ \Xi \leq \max_{h'} A_{h'}\Big).$$

Since $\overline{\mathbb{H}}$ is a singleton, for the only element $\bar{h} \in \overline{\mathbb{H}}$, we thus have

$$Pr\Big(A_{\bar{h}}\zeta_{\bar{h}} = \max_{h'} A_{h'} \wedge \ \Xi \leq \max_{h'} A_{h'}\Big) = Pr\Big(\Xi \leq \max_{h'} A_{h'}\Big).$$

And since $Pr(\Xi < \max_{h'} A_{h'}) = 0$ and $Pr(\Xi = \max_{h'} A_{h'}) > 0$ (from part 1) , we have

$$Pr(\arg\max_{h'} A_{h'}\zeta_{h'} = \bar{h} \Big| \Xi = \max_{h'} A_{h'}) = 1.$$

□

Proof of Lemma 3.

Proof. Omit time subscript for short notations. Define $\Xi = \max_{h'} \bar{\eta}_{ih'} R_{ih'}(z)\zeta_{h'}$. Notice we have defined $\overline{R}_i(z) \equiv \max_{h'} \bar{\eta}_{ih'} R_{ih'}(z)$ and $\tilde{R}_i(z) \equiv \left(\frac{1}{N}\sum_{h'} \left[\bar{\eta}_{ih'} R_{ih'}(z)\right]^{\theta}\right)^{\frac{1}{\theta}}$. If $1 + r_i^b > \overline{R}_i(z)$, apply part 1 of Lemma 4 we have

$$Pr(\Xi \geq 1 + r_i^b | z) = [\tilde{R}_i(z)]^{\theta}(1 + r_i^b)^{-\theta}.$$

Apply part 3 of Lemma 4 we have the probability of investing in h conditional on being active

$$\chi_{ih}(z) = \frac{1}{N}\Big(\frac{\bar{\eta}_{ih} R_{ih}(z)}{\tilde{R}_i(z)}\Big)^{\theta}.$$

Apply part 2 of Lemma 4 we have the return conditional on z

$$\mathbb{E}[R_i^a(z, \boldsymbol{\eta})|z] = \underbrace{\Big(1 - [\tilde{R}_i(z)/(1+r_i^b)]^{\theta}\Big)}_{Pr(\Xi < 1+r_i^b|z)}(1+r_i^b) + \underbrace{[\tilde{R}_i(z)/(1+r_i^b)]^{\theta}}_{Pr(\Xi \geq 1+r_i^b|z)}\Big(\underbrace{\frac{\theta}{\theta-1}(1+r_i^b)}_{\mathbb{E}[\Xi|\Xi>1+r_i^b, z]}(1+\lambda_i) - (1+r_i^b)\lambda_i\Big).$$

This proves part **(i)**.

For part **(ii)**, if $1 + r_i^b < \overline{R}_i(z)$, from part 1 of Lemma 4

$$Pr(\Xi \geq 1 + r_i^b|z) = 1,$$

i.e., all firms with productivity z are active.

If set $\overline{\mathbb{H}} = \arg\max_{h'} \bar{\eta}_{ih'} R_{ih'}(z)$ is a singleton, apply part 3 of Lemma 4 we have

$$Pr(\arg\max_{h'} \bar{\eta}_{ih'} R_{ih'}(z)\zeta_{h'} = \bar{h}\Big|\Xi = \overline{R}_i(z), z) = 1,$$

which says that conditional on $\max_{h'} \bar{\eta}_{ih'} R_{ih'}(z)\zeta_{h'} = \overline{R}_i(z)$, with probability one the investment goes to the host that attains the maximum. And we thus have for $h \in \overline{\mathbb{H}}$, the share of active firms investing in h

$$\begin{aligned}\hat{e}_{ih}(z) &= \underbrace{\Big(1 - [\tilde{R}_i(z)/\overline{R}_i(z)]^{\theta}\Big)}_{Pr(\Xi = \overline{R}_i(z)|z)} + \underbrace{[\tilde{R}_i(z)/\overline{R}_i(z)]^{\theta}}_{Pr(\Xi > \overline{R}_i(z)|z)}\chi_{ih}(z) \\ &= 1 - [1 - \chi_{ih}(z)][\tilde{R}_i(z)/\overline{R}_i(z)]^{\theta},\end{aligned}$$

and for $h \notin \overline{\mathbb{H}}$,

$$\hat{e}_{ih}(z) = \chi_{ih}(z)[\tilde{R}_i(z)/\overline{R}_i(z)]^{\theta}.$$

Apply part 2 of Lemma 4, the return conditional on z

$$\mathbb{E}[R_i^a(z, \boldsymbol{\eta})|z] = \underbrace{\Big(1 - [\tilde{R}_i(z)/\overline{R}_i(z)]^{\theta}\Big)}_{Pr(\Xi = \overline{R}_i(z)|z)}\overline{R}_i(z)(1+\lambda_i) + \underbrace{[\tilde{R}_i(z)/\overline{R}_i(z)]^{\theta}}_{Pr(\Xi > \overline{R}_i(z)|z)}\underbrace{\frac{\theta}{\theta-1}\overline{R}_i(z)}_{\mathbb{E}[\Xi|\Xi>\overline{R}_i(z), z]}(1+\lambda_i) - (1+r_i^b)\lambda_i.$$

□

Proof of Proposition 1

Proof. The proof utilizes constant return to scale production functions and applies a series of definitions. To shorten notations, we suppress the time subscript throughout the proof.

Define

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

the mass of investment in host country h by parent firms with productivity z from home country i. Define

$$y(w_h) = \left(\frac{1-\alpha}{w_h}\right)^{(1-\alpha)/\alpha}$$

as output per unit of efficient capital given wage w_h. Then we have

$$\begin{aligned} Y_{ih} &= \int_0^\infty \hat{y}_{ih}(z)(1+\lambda_i)\hat{e}_{ih}(z)\phi_i(z)dz \\ &= \int_0^\infty \psi_{ih}(z)\hat{k}_{ih}(z)\tilde{z}_{ih}(z)y(w_h)dz. \end{aligned}$$

Therefore,

$$\frac{Y_{ih}}{\sum_j Y_{jh}} = \frac{\int_0^\infty \psi_{ih}(z)\hat{k}_{ih}(z)\tilde{z}_{ih}(z)dz}{\sum_j \int_0^\infty \psi_{jh}(z)\hat{k}_{jh}(z)\tilde{z}_{jh}(z)dz}.$$

Rewrite

$$\begin{aligned} Y_{ih} &= \int_0^\infty \psi_{ih}(z)\hat{k}_{ih}(z)\tilde{z}_{ih}(z)dz \\ = \int_0^\infty \frac{\psi_{ih}(z'')}{\int_0^\infty \psi_{ih}(z')dz'}\hat{k}_{ih}(z'')dz'' \times &\int_0^\infty \frac{\frac{\psi_{ih}(z)}{\int_0^\infty \psi_{ih}(z')dz'}\hat{k}_{ih}(z)}{\int_0^\infty \frac{\psi_{ih}(z'')}{\int_0^\infty \psi_{ih}(z')dz'}\hat{k}_{ih}(z'')dz''}\tilde{z}_{ih}(z)dz \\ &\times \int_0^\infty \psi_{ih}(z')dz'. \end{aligned}$$

And

$$\begin{aligned} \sum_j Y_{jh} &= \sum_j \int_0^\infty \psi_{jh}(z)\hat{k}_{jh}(z)\tilde{z}_{jh}(z)dz \\ = \int_0^\infty \sum_j \psi_{jh}(z')\hat{k}_{jh}(z')dz' \times &\int_0^\infty \frac{\sum_j \psi_{jh}(z)\hat{k}_{jh}(z)}{\int_0^\infty \sum_j \psi_{jh}(z')\hat{k}_{jh}(z')dz'}\tilde{z}_{jh}(z)dz. \end{aligned}$$

Therefore

$$\begin{aligned} \frac{Y_{ih}}{\sum_j Y_{jh}} &= \frac{\int_0^\infty \psi_{ih}(z')dz'}{\int_0^\infty \sum_j \psi_{jh}(z')\hat{k}_{jh}(z')dz'} \times \int_0^\infty \frac{\psi_{ih}(z'')}{\int_0^\infty \psi_{ih}(z')dz'}\hat{k}_{ih}(z'')dz'' \\ \times \Big[\int_0^\infty &\frac{\frac{\psi_{ih}(z)}{\int_0^\infty \psi_{ih}(z')dz'}\hat{k}_{ih}(z)}{\int_0^\infty \frac{\psi_{ih}(z'')}{\int_0^\infty \psi_{ih}(z')dz'}\hat{k}_{ih}(z'')dz''}\tilde{z}_{ih}(z)dz \Big/ \int_0^\infty \frac{\sum_j \psi_{jh}(z)\hat{k}_{jh}(z)}{\int_0^\infty \sum_j \psi_{jh}(z')\hat{k}_{jh}(z')dz'}\tilde{z}_{jh}(z)dz \Big] \end{aligned} \tag{20}$$

Notice that from definitions in Section 3.7,

$$\int_0^\infty \psi_{ih}(z')dz' = [FDI]_{ih}$$
$$\int_0^\infty \sum_j \psi_{jh}(z')\hat{k}_{jh}(z')dz' = K_h.$$

And $\int_0^\infty \frac{\psi_{ih}(z'')}{\int_0^\infty \psi_{ih}(z')dz'}\hat{k}_{ih}(z'')dz''$ is the average leverage of affiliates in host h from home i, denoted by $\bar{lev}_{ih}$, since $\hat{k}_{ih}(z'')$ is the leverage (affiliate total asset over parent financing) of affiliates from parent with productivity z'', and $\frac{\psi_{ih}(z'')}{\int_0^\infty \psi_{ih}(z')dz'}$ is the density of affiliates from parent firms with productivity z'' conditional on entering host h. Similarly, $\int_0^\infty \frac{\frac{\psi_{ih}(z)}{\int_0^\infty \psi_{ih}(z')dz'}\hat{k}_{ih}(z)}{\int_0^\infty \frac{\psi_{ih}(z'')}{\int_0^\infty \psi_{ih}(z')dz'}\hat{k}_{ih}(z'')dz''}\tilde{z}_{ih}(z)dz$ is the average productivity of affiliates in host h from home i weighted by capital uses, denoted by $\bar{z}_{ih}$. And $\int_0^\infty \frac{\sum_j \psi_{jh}(z)\hat{k}_{jh}(z)}{\int_0^\infty \sum_j \psi_{jh}(z')\hat{k}_{jh}(z')dz'}\tilde{z}_{jh}(z)dz$ is the average productivity of all affiliates in host h weighted by capital uses, denoted by $\bar{z}_h$. With the above (re)definitions of variables, Equation (20) can be rewritten as

$$\frac{Y_{ih}}{Y_h} = \frac{[FDI]_{ih}}{K_h} \times \bar{lev}_{ih} \times \frac{\bar{z}_{ih}}{\bar{z}_h}.$$

□

Proof of Proposition 2

Proof. Following the definitions in our the proof to Proposition 1, we define

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

as the mass of investment in host country h by parent firms with productivity z from home country i. Define

$$y(w_h) = \left(\frac{1-\alpha}{w_h}\right)^{(1-\alpha)/\alpha}$$

as output per unit of efficient capital given wage w_h and

$$l(w_h) = \left(\frac{1-\alpha}{w_h}\right)^{1/\alpha}$$

as labor demand per unit of efficient capital given wage w_h.

Because firms from country h are restricted from investing overseas, from Lemma 3, their investment decision reduces to a threshold rule: a firm leverages up, operates and invests domestically if $z > z_h^*$, and stays idle if $z < z_h^*$, where z_h^* is determined by

$$\alpha z_h^* y(w_h) = r_h^b + \delta. \tag{21}$$

Using the policy function and aggregate wealth and wealth share distribution defined in Section 3.6, the total capital used by domestic firms is

$$W_h \int_{z_h^*}^{\infty} \hat{\phi}_h(z)(1+\lambda_h)dz = K_{hh},$$

Plug in the the Pareto pdf $\hat{\phi}_h(z) = \gamma \bar{z}_h^{\gamma} z^{-1-\gamma}$ we have

$$\bar{z}_h^{\gamma}[z_h^*]^{-\gamma}(1+\lambda_h) = \frac{K_{hh}}{W_h}. \tag{22}$$

From labor market clear we have

$$[\sum_{i \neq h} \int_0^{\infty} \psi_{ih}(z)[1+\hat{b}_{ih}^F(z)]\tilde{z}_{ih}(z)dz + W_h \int_{z_h^*}^{\infty} \hat{\phi}_h(z)(1+\lambda_h)\tilde{z}_{hh}(z)dz]l(w_h) = L_h,$$

Apply the normalization $\tilde{z}_{hh}(z) = z$, and notice that the production conducted by the affiliates of country-i parents in country h is

$$Y_{ih} = y(w_h) \int_0^{\infty} \psi_{ih}(z)[1+\hat{b}_{ih}^F(z)]\tilde{z}_{ih}(z)dz,$$

and hence we have

$$[\sum_{i \neq h} Y_{ih} + y(w_h) W_h \int_{z_h^*}^{\infty} \hat{\phi}_h(z)(1+\lambda_h)zdz]\frac{l(w_h)}{y(w_h)} = L_h. \tag{23}$$

Apply the Pareto pdf $\hat{\phi}_h(z) = \gamma \bar{z}_h^{\gamma} z^{-1-\gamma}$ we have

$$\int_{z_h^*}^{\infty} \hat{\phi}_h(z)zdz = \frac{\gamma}{\gamma-1}\bar{z}_h^{\gamma}[z_h^*]^{1-\gamma}. \tag{24}$$

Combine (22), (23) and (24) we have

$$\frac{W_h(1+\lambda_h)\frac{\gamma}{\gamma-1}\left(\frac{\frac{K_{hh}}{W_h}}{1+\lambda_h}\right)^{\frac{\gamma-1}{\gamma}}\bar{z}_h}{\frac{Y_{hh}}{Y_h}} l(w_h) = L_h.$$

Apply the definition of $l(w_h)$ and take log both sides, we have

$$Cons - \frac{1}{\alpha}\log(w_h) + \frac{\gamma-1}{\gamma}\log\left(\frac{K_{hh}}{W_h}\right) - \log\left(\frac{Y_{hh}}{Y_h}\right) = 0,$$

where $Cons$ is a constant (notice that W_h does not change at the impact of the reform). The change in wage between two equilibria with different levels of inward MNC activities is given by:

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

Combining Equations (21) and (22), and taking log difference between two equilibria, we obtain:

$$\Delta \log \left(\frac{K_{hh,t}}{W_{h,t}} \right) = -\gamma \Delta \log(r_{h,t}^b + \delta) - \frac{\gamma(1-\alpha)}{\alpha} \Delta \log(w_{h,t}).$$

□

C.3 Trade framework

The benchmark model adopts a homogeneous good assumption. In this subsection, we show that if we interpret capital stock as the fixed cost needed for the production of differentiated varieties, then an environment with CES aggregation and monopolistic competition is isomorphic to the benchmark setup.

Consider there is a single final good across countries, assembled using intermediate-goods varieties according to

$$Y_h = \left(\int_0^{M_h} q_h(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}, \sigma > 1.$$

where M_h is the number of varieties in country h.

Denote X_h the aggregate expenditure in country h, the demand function for each variety ω is thus

$$q_h(\omega) = \frac{X_h p_h(\omega)^{-\sigma}}{P_h^{1-\sigma}},$$

where P_h is the aggregate price index

$$P_h = \left[\int_0^{M_h} p_h^{1-\sigma}(\omega) d\omega \right]^{\frac{1}{1-\sigma}}.$$

Assume the fixed cost for opening a product line is $\frac{X_h}{P_h}$, the total final goods produced in country h. The fixed cost captures the congestion from other affiliates' production and removes a potential 'scale effect' in the model with CES aggregation. After paying up the fixed cost, each product line produces a differentiated variety according to

$$y = z_{ih}^{\frac{1}{\sigma-1}} l,$$

which uses labor l from the host country labor market at a competitive nominal wage rate $\tilde{w}_h$. $z_{ih}^{\frac{1}{\sigma-1}}$ is the productivity of the affiliate. After the production, the affiliate can recover $1-\delta$ of final goods from the product line, analogous to the non-depreciated capital in the neoclassical setup. Facing the downward sloping demand function derived from the CES preference, the affiliate solves

$$\Pi(z_{ih}) = \max_{p,q,l} pq - \tilde{w}_h l$$
$$s.t. \quad q = \frac{X_h p^{-\sigma}}{P_h^{1-\sigma}}$$
$$q = z_{ih}^{\frac{1}{\sigma-1}} l.$$

The optimality condition gives

$$p = \frac{\sigma}{\sigma-1}\frac{\tilde{w}_h}{z_{ih}^{\frac{1}{\sigma-1}}},$$
$$q = \frac{X_h\left(\frac{\sigma}{\sigma-1}\frac{\tilde{w}_h}{z_{ih}^{\frac{1}{\sigma-1}}}\right)^{-\sigma}}{P_h^{1-\sigma}},$$
$$l = \frac{X_h\left(\frac{\sigma}{\sigma-1}\tilde{w}_h\right)^{-\sigma}}{P_h^{1-\sigma}} z_{ih},$$
$$\Pi(z_{ih}) = \frac{1}{\sigma}\frac{X_h\left(\frac{\sigma}{\sigma-1}\tilde{w}_h\right)^{1-\sigma} z_{ih}}{P_h^{1-\sigma}}.$$

The real profits per unit of investment is thus

$$\pi_h(z_{ih}) = \frac{\Pi(z_{ih})/P_h}{X_h/P_h} + 1 - \delta = \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\left(\frac{\tilde{w}_h}{P_h}\right)^{1-\sigma} z_{ih} + 1 - \delta \tag{25}$$

Assume each seed money of the parent firm can be paired with local funds in the host country to open multiple product lines and the maximum local funds financed per unit of seed money is μ_h. The unit return of investment in country h is

$$R_{ih}(z) = \max_{\hat{b}^F} \pi(\tilde{z}_{ih}(z))(1+\hat{b}^F) - (1+r_h^b)\hat{b}^F$$
$$s.t. \quad 0 \leq \hat{b}^F \leq \mu_h.$$

We can similarly derive $\hat{e}_{ih}(z)$ the fraction of firms with productivity z from home country i investing in host country h, and the return on net worth $R_h^a(z)$ with accounting for the return shocks as in the model with neoclassical production.

Denote $\psi_{ih}(z)$ the mass of funds from country i to country h with parent firm productivity z (at the optimal choice of the parent firm, $\psi_{ih}(z) = (1+\lambda_i)\hat{e}_{ih}(z)\phi_i(z)$ as in the benchmark model) and $\hat{k}_{ih}(z) = 1 + \hat{b}_{ih}^F(z)$ the number of product lines operated per unit of fund. The labor market clear condition in host country h is

$$L_h = \sum_i \int_0^\infty \left(\frac{\sigma}{\sigma-1}\frac{\tilde{w}_h}{P_h}\right)^{-\sigma} \tilde{z}_{ih}(z)\hat{k}_{ih}(z)\psi_{ih}(z)dz. \tag{26}$$

The goods market clear condition states that

$$\sum_i \int_0^\infty \left(\frac{\sigma}{\sigma-1}\frac{\tilde{w}_h}{P_h}\right)^{1-\sigma} \tilde{z}_{ih}(z)\hat{k}_{ih}(z)\psi_{ih}(z)dz = \frac{X_h}{P_h}. \tag{27}$$

A competitive equilibrium is a time sequence (omitted time subscript) of $\left(\frac{\tilde{w}_h}{P_h}, \frac{X_h}{P_h}, r_h^b, \phi_i(z)\right)$ s.t. the labor market, goods market and global bond market clear, and the transition of $\phi_i(z)$ is consistent with the policy functions and shocks.

Recall in the model with neoclassical production, the unit return of investment is

$$\pi_h(z_{ih}) = \alpha z_{ih}\left(\frac{1-\alpha}{w_h}\right)^{(1-\alpha)/\alpha} + 1 - \delta, \tag{28}$$

the labor market clear condition is

$$L_h = \sum_i \int_0^\infty l(w_h)\tilde{z}_{ih}(z)\hat{k}_{ih}(z)\psi_{ih}(z)dz, \tag{29}$$

where $l(w_h) = \left(\frac{1-\alpha}{w_h}\right)^{1/\alpha}$, and the goods market clear condition is

$$Y_h = \sum_i \int_0^\infty y(w_h)\tilde{z}_{ih}(z)\hat{k}_{ih}(z)\psi_{ih}(z)dz, \tag{30}$$

where

$$y(w_h) = \left(\frac{1-\alpha}{w_h}\right)^{(1-\alpha)/\alpha}.$$

Comparing Equations (25), (26) and (27) with (28), (29) and (30), we see that by setting $\frac{1}{\sigma} = \alpha$, $\frac{\tilde{w}_h}{P_h} = w_h$ and $\frac{X_h}{P_h} = Y_h$, the model with CES aggregation is equivalent to the model under neoclassical production for all static conditions. Given the decision rule for capital accumulation, it follows that the dynamic behaviors of the two models coincide, too.

The assumption that the fixed cost of a setting up a product line is proportional to the real income of a country is crucial for the isomorphism because it offsets exactly the scale effect. More generally, when this is not true, the two models are not isomorphic, but the trade framework still retains all the tractability.

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