FINANCING MULTINATIONALS*

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Abstract

We develop a quantitative-oriented model that integrates the production and financing decisions of multinational corporations (MNCs). Firms can deploy their technology for production overseas and become MNCs. Due to frictions in obtaining external finance, the scale of the affiliates partially depends on the MNC's internal capital market, giving rise to foreign direct investment (FDI). The model generates empirically consistent relationships between FDI, multinational production (MP), and the financial market conditions of the host and home countries. Model-based decompositions show that the changes in financial market conditions account for a sizable fraction of the rapid growth in global FDI prior to 2008 and the slowdown afterward. Overlooking the technology content of MNCs understates the welfare gains from FDI; overlooking the capital content misses the dynamic welfare effects.

JEL Classification: F21, F23, F36, F44

*For helpful comments we thank Yan Bai, Saki Bigio, Jonathan Eaton, Stefania Garetto, Luciana Juvenal, Andrei Levchenko, Sebnem Kalemli-Ozcan, Ezra Oberfield, Fernando Parro, Ananth Ramanarayanan, Kim Ruhl, Stephen Yeaple, and workshop and conference participants at Hong Kong University, Tsinghua University, Aarhus University, SJTU, SHUFE, NYU Junior Trade Jamboree, the SAET (Taipei), the SED (Mexico City), Georgetown University, Chinese University of Hong Kong, TIGN (University of Los Andes), Rocky Mountain Empirical Trade Conference, and Hitotsubashi University.

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1 Introduction

By mobilizing technological and financial capital across borders, multinational corporations (MNCs) exert increasing influence on the world economy. Inspired by this trend, a growing literature has set up quantitative models to examine the determinants of MNC activities and their welfare consequences. With a focus on the transfer of technology within MNCs, most existing studies overlook the accompanying movement of capital. A number of important questions thus remain unanswered. First, given that capital allocation within firms is potentially influenced by the access to external credit, what is the quantitative importance of the host and home countries' credit market dynamics in determining cross-border direct investment? Second, how do the inferred welfare gains from direct investment change, once production and financing are incorporated as interconnected decisions within MNCs?

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 financial market imperfections, the affiliate's production partially relies on the MNC's internal capital market, so FDI arises as within-firm capital investment from the parent to the affiliate. We parameterize the model to match the dynamics of bilateral FDI among 36 major countries over 2001-2012, a period that witnessed a surge in global FDI (2001-2007) and its growth slowdown (2008-2012). As shown in Figure 1, this overall change coincided with the credit boom prior to the Great Recession, and the credit crunch afterward. Through counterfactual experiments, we show that the changes in financial market conditions explain a substantial part of the aggregate FDI dynamics. The dynamic wage gains from inward FDI during this period are large, dissipating over time and, depending on the host country's fundamentals, potentially negative. Viewing FDI merely as physical capital flows understates the wage gains; focusing exclusively on the technology content of FDI fails to capture the full dynamic welfare effects.

Our starting point is three facts encompassing two related measures of MNCs that have been treated largely in isolation in the literature: FDI, which captures capital invested by parent firms in their affiliates, 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 after controlling for the host and home country fixed effects and the number of affiliates at the bilateral level. Second, host countries with better financial institutions have more inward FDI and, conditional on the level of FDI, more inward MP. Third, home countries with better financial institutions have more outward FDI, but conditional on

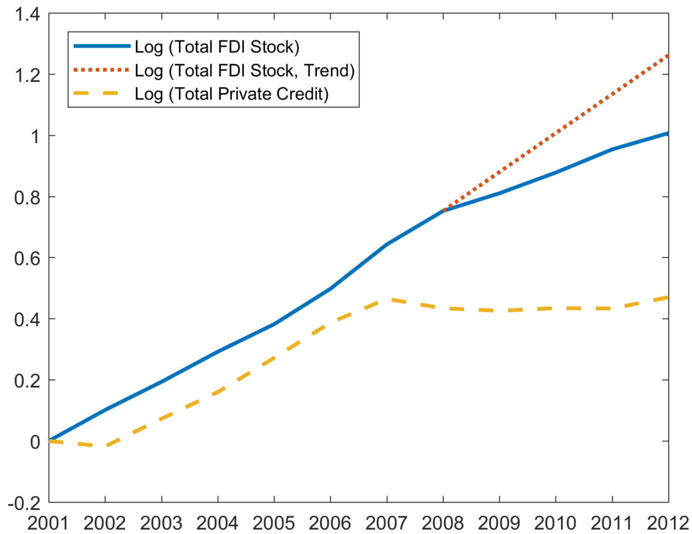


Figure 1: The Dynamics of FDI and Private Credit

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

FDI, *not* more outward MP. Together, these facts suggest that the size of affiliates partially depends on the financing from their parents, and is potentially affected asymmetrically by the access to external credit in the host and home countries.

We set up a firm dynamics model that explicitly incorporates the role of internal capital markets and external finance. Firms are heterogeneous in their pre-determined home country, productivity that follows exogenous processes, and net worth that can be accumulated over time. Firms decide whether and in which country to deploy their technology. When a firm moves production abroad, an MNC emerges. The affiliates of MNCs combine their technology with physical capital and labor to produce a homogeneous good. Besides their own net worth, firms can finance physical capital investment by raising debt in the home country and by partnering up with investors in the host country. Both types of external financing are impeded by frictions in the form of collateral constraints. The collateral for the former is the parent firm's net worth; the collateral for the latter is the capital brought into the host country by the parent firm, namely FDI.[1]

The model generates empirically consistent relationships between FDI, MP, and the financial market conditions in the host and home countries. Constrained by the access to external financing in the host country, the scale of an affiliate depends on the investment from its parent. As the financial market in the *host* country improves, foreign affiliates

[1]While financial frictions in both stages take the form of a collateral constraint, their interpretations are different. The former captures the extent to which a parent firm can borrow externally from the credit market in the home country. The latter captures the extent to which the parent firm can rely on the host country for financing, through either equity or debt, without impeding the deployment of technology (Antras, Desai and Foley, 2009).

scale up more by partnering with local investors and earn higher returns, so more FDI is drawn to the country, and conditional on FDI, the scale of the affiliates' production can be larger. As the financial market in the *home* country improves, productive firms gain higher market shares. In the short run, this drives up home wages and pushes more firms to invest abroad; in the long run, a better functioning financial market enables faster growth of productive firms, which are more likely to become MNCs. Both short- and long-run effects increase the level of outward FDI, and affect MP only indirectly through FDI.

Dynamic responses of the sort discussed above imply that the FDI time series depicted in Figure 1 could be the cumulative effects of past shocks. Moreover, with endogenous capital accumulation, the welfare implications of MNC activities depend on a country's capital abundance relative to its steady state. To answer the questions posed earlier thus requires to take the transition path of the model seriously. This is in general challenging, as the exact presence of financial market imperfections and productivity heterogeneity requires the model to track the joint distribution of firms' productivity and net worth across all countries. We characterize the affiliate- and firm-level decisions analytically and show how the model can be aggregated tractably.

We take the model to a newly assembled panel of *bilateral* FDI for a sample of 36 major countries over 2001-2012, and supplement it with country-specific time series on GDP, domestic financial market conditions (proxied by credit/GDP ratios), investment rates, and the shares of affiliate finance from foreign parents. The model is fully saturated with country-specific wedges for investment returns and bilateral wedges for FDI returns. We calibrate the structural parameters that determine financial market conditions and firms' productivity dynamics, as well as these wedges, so that the transitional dynamics of the model matches the data in *all* above dimensions.[2]

The calibration reveals improving access to credit until 2007 in the form of gradually relaxing collateral constraints for both parent firms and affiliates. This trend has reversed since the Great Recession. Our first set of exercises focuses on how changes in an individual country's fundamentals affect its own outward FDI in each of the two episodes, holding fundamentals of other countries at the calibrated values. We find that for most countries, the credit boom can explain up to 50-80% of the cumulative FDI outflows during 2002-2007 (or equivalently, the change in outward FDI stock from 2001 to 2007). On the other hand, if throughout the recession, the financial market conditions had stayed at the 2007 level, then the cumulative FDI outflows during 2008-2012 would have been 30-100% higher than the actual outcomes. With the simulated data from these counterfactual experiments, we estimate the impact of the financial conditions in the home country

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

on outward FDI using a diff-in-diff specification. We find that the resulting coefficient is close to the corresponding estimate based on the actual data. Therefore, though not targeted directly, the model does a satisfactory job in capturing the partial equilibrium effect of financial market conditions on FDI dynamics.

Both the country-specific experiment and the diff-in-diff estimate are silent on the general equilibrium responses that involve multiple countries. For example, an improvement in the financial market conditions of one home country induces more outward FDI, which may crowd out investment to the same destinations from third countries. These effects are important—if the financial market conditions of *all* countries had stayed at their 2001 levels, the cumulative global FDI flows during 2002-2007 would have fallen by one third; a naive aggregation across experiments by individual countries would overstate this fall by a factor of two. Similarly, if the financial market conditions had stayed at their peak levels in 2007, the cumulative global FDI flows during 2008-2012 would have increased by 40%, significantly smaller than what would be implied by a direct aggregation across experiments by individual countries. These exercises demonstrate the value of using a general equilibrium model that captures interactions among countries.

We further show that by overlooking the interconnectedness between financial and production decisions of MNCs, existing approaches give biased predictions on both static and dynamic welfare gains from FDI. We make this point in the context of the *ex-post* effect of changing *inward* MNC activities for a host country. In our model, the static wage gain depends on both MP and FDI. The MP share captures the relative importance of foreign affiliates in local production. Conditioning on the MP share, a higher fraction of investment by foreign parents reduces affiliates' dependence on the credit from the host country, thus alleviating the crowd out effect on domestic firms and bringing larger gains.

Compared to the neoclassical tradition that views FDI as mere movement of physical capital, in which the share of FDI in domestic capital is the sufficient statistic for the static wage gain, our model emphasizes the technology content of FDI. Focusing on 2001 alone, we show that the median wage gain from inward FDI across countries is around 8%, of which about half is due to that foreign entry brings in more productive technology or improves the efficiency of resource allocations across domestic firms. The neoclassical view thus significantly underestimates the wage gains. This finding echoes the conjecture of Gourinchas and Jeanne (2006) that large welfare gains from international financial integration, if any, are likely through the technology embedded in capital inflows.

Compared to the technology-based view of MNCs (Ramondo and Rodríguez-Clare, 2013; Cravino and Levchenko, 2017), in which the MP share is the sufficient statistic for the static wage gain, our model highlights the relevance of a crowd out effect through the domestic credit market. This static crowd out effect disappears for small economies if the world bond market is fully integrated. In that case, the static wage gain from inward FDI can be determined by a formula involving the MP share only, similar to the one in a technology-based model of multinational production up to a model-specific elasticity.[3] The technology-based model, however, still does not capture the dynamic wage effects, because it does not account for the changes in the size and productivity distribution of domestic firms after the foreign entry.

To further understand how the dynamic effects differ from the static effects, we solve counterfactual economies by shutting down inward FDI for each individual country throughout 2001-2012 and calculate the wage changes over time. On impact, the wage gains are the same as in the static experiments. Over time, however, domestic firms grow faster in the absence of foreign competitions. As a result, the wage gains gradually diminish, by as much as 50% by 2012. As we increase the productivity growth rate or improve the financial market conditions of the host country, the dynamic wage gains 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 shares of domestic firms and slows their private capital accumulation. For countries with faster growth compared to the rest of the world—either because they have a higher productivity growth rate or a more developed financial market—MNCs effectively drive market shares out of the firms that will be the most productive in the future, leading to a static-dynamic tradeoff. For this reason, the dynamic effects are heterogeneous across countries with different productivity growth rates or different levels of financial development. Ignoring this heterogeneity can overestimate the dynamic wage gain over 2001-2012 by a factor of two or underestimate it by half.

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, 2010; Ramondo and Rodríguez-Clare, 2013; Ramondo, 2014; Fillat and Garetto, 2015; Alviarez, 2016; Cravino and Levchenko, 2017; Tintelnot, 2017; Anderson, Larch and Yotov, 2017; Garetto, Oldenski and Ramondo, 2017; Arkolakis, Ramondo, Rodríguez-Clare and Yeaple, 2018, among others). Our contribution is to develop a tractable framework that combines the technology view emphasized in existing studies with the movement of capital inside MNCs. This model speaks directly to FDI,[4] a widely collected and used statistic, and how financial development af-

[3] The technology-based model of multinational production will attribute the impact of financial market conditions on FDI to bilateral wedges.

[4] Burstein and Monge-Naranjo (2009) and McGrattan and Prescott (2010) also use FDI data for theory-based measurements. Both models assume that affiliates can only be financed by the parent country and that capital markets are otherwise frictionless. The models are therefore not suitable for studying the role

fects activities of MNCs, the subject of many empirical studies.[5] This generalized model leads to significantly different estimates of the welfare effects of MNCs and establishes financial market conditions as a first order determinant of FDI dynamics.

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 work on the determinants and aggregate effects of FDI,[6] and the theoretical and quantitative work on the welfare implications of international capital flows (Mundell, 1957; Feldstein, 1995; Gourinchas and Jeanne, 2006; Ju and Wei, 2010; Ohanian, Restrepo-Echavarria and Wright, 2018). Our departure from this literature is to model FDI as within-firm capital flows that enable the transfer of technology to affiliates, thereby connecting the literature to the technology view of MNCs. As a result, even though FDI stock as a share of total capital in a host country tends to be small, it can have a large impact on the domestic economy.

In terms of the quantification strategy, the structural accounting procedure we use to combine the model and the data is similar to recent work such as Eaton, Kortum, Neiman and Romalis (2016), Kehoe, Ruhl and Steinberg (2018), and Caselli, Koren, Lisicky and Tenreyro (forthcoming). Different from this literature, our model allows for dynamic decisions with firm heterogeneity, incomplete markets, and multinational production, but still remains tractable. This allows us, for the first time in the literature, to perform quantitative analyses of an incomplete market model in a multi-country setting. As discussed in Sections 3.8 and 7, the model and the calibration algorithm developed here are applicable to other questions on cross-border direct and portfolio investments.

More broadly, a substantial share of the world economy is accounted for by multi-unit firms sharing an internal factor market. Recent studies show that accounting for the reallocation of resources across units is important for understanding the effects of tax policies (Giroud and Rauh, forthcoming), the transmission of business cycle across regions (Giroud and Mueller, 2019), and the gains from trade (Itoga, 2019). While focusing mostly on firms with multiple establishments within a country, the empirical patterns documented in this literature are supportive of the mechanisms in our model. We contribute to the studies of multi-unit firms in different fields of economics by developing a framework suitable for quantitative analyses.

of financial development in explaining FDI and the heterogeneous welfare effects.

[5]See, e.g., Klein, Peek and Rosengren (2002), Desai, Foley and Forbes (2008), Antras, Desai and Foley (2009), Alfaro and Chen (2012), Bilir, Chor and Manova (2014), Manova (2013).

[6]This is a very large literature. We refer the readers to Desbordes and Wei (2017) for empirical studies on how financial market conditions affect FDI, and to Alfaro, Chanda, Kalemli-Ozcan and Sayek (2004) and the reference thereto for the effects of FDI on growth.

2 Empirical Relationships between MP, FDI, and Finance

This section documents the relationships between MP, FDI, and the quality of financial institutions in the host and home countries. Our baseline measures of FDI and MP are both from Ramondo et al. (2015).[7] This data set is at the country-pair level and averaged over 1996-2001. We supplement this data set with a number of country characteristics, including country size, productivity, business tax rate, policy restrictions on FDI, and indices for the quality of financial institutions, collected from various sources. Using these data, we document three facts. This section presents the results from this baseline sample. When the U.S. is either a home or a host country, we also construct alternative and more direct measures of affiliate production and the sources of finance from the public-use data published by the Bureau of Economic Analysis. Appendix A presents detailed descriptions of the data sources and the robustness checks.

2.1 Correlation between MP and FDI

Fact 1: Controlling for extensive-margin variations, MP strongly correlates with FDI.

The first fact, reported in Table 1, speaks to the relationship between the production (log MP) and the financing of affiliates (log FDI).[8] The first column shows a high unconditional correlation between the two variables. That MP and FDI are highly correlated is unsurprising. Indeed, this correlation could be entirely mechanical, as a plant will only be defined as a foreign affiliate if the foreign share of its equity exceeds a certain threshold. To alleviate this concern, in the second column we control for the number of affiliates in a host country owned by parents from a home country. The coefficients for both independent variables are economically significant. To further control for unobserved heterogeneity, the third column includes the home and host country fixed effects; the fourth column includes various measures for bilateral distance. The coefficients remain similar.

The positive correlation between MP and FDI after controlling for the extensive margin variations is inconsistent with models featuring perfect capital markets—if affiliates can borrow in the host country under no frictions, then they can produce at the desired scale regardless of how much the parents invest. In contrast, it is consistent with a model in which affiliates have limited capabilities to raise external funds, so they rely at least partially on the parent financing for startup and production.[9] This mechanism is also

[7] In this data set, MP is defined as the total sales of foreign affiliates. FDI is defined as the stock of capital parents invest in affiliates in the form of equity and intra-company loans.

[8] To avoid potential biases, all specifications are estimated using the Poisson Pseudo Maximum Likelihood (PPML) estimator, as recommended by Silva and Tenreyro (2006).

[9] In theory, as long as the affiliates have a weak preference for investment from the parent, regardless of the underlying reasons, FDI will be correlated with MP. Facts 2 and 3 provide further evidence that this

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
Pseudo-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: the geographical distance between the home and host countries; dummies on whether they are connected via a colonial tie, a shared border, or a common official language, respectively. The specification is PPML.

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

supported by firm-level empirical studies.[10]

2.2 Host financial institutions and inward MNC activities

Fact 2: Countries with better financial institutions attract more inward FDI, and conditional on FDI, more inward MP.

The second fact relates the quality of financial institutions in the *host* country to the financing 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. Following Desbordes and Wei (2017), we use the log of the financial development index developed by the World Bank as our primary measure for the quality of financial institutions.[11]

The dependent variable in the first two columns of Table 2 is log(FDI). The first column controls for the host country's size and productivity and the home country fixed effects. The coefficient for the financial development index in the host country is eco-

preference is linked to capital market imperfections.

[10]For example, Manova (2013) finds among Chinese exporters, 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; Sun (2018), using MNC data from a large number of countries, shows that affiliates of capital-intensive parents tend to be more capital intensive.

[11]The index is the sum of two subcomponents, of which the first measures the depth of information on the credit history in an economy and the second measures the strength of legal protection for creditors' rights. Appendix A.2 investigates the individual contributions of these two subcomponents to look into the channels at work. The results are robust if the quality of financial institutions is measured by the credit over GDP ratio.

Table 2: Host Financial Institution Quality and Inward MNC Activities

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	Log (FDI)		Log (MP)		Log (# of affiliates)	
log (financial development index)	1.638***	0.927***	0.542*	0.580***	0.188	0.274
	(0.442)	(0.342)	(0.296)	(0.219)	(0.349)	(0.258)
log (FDI)			0.662***	0.575***	0.656***	0.503***
			(0.064)	(0.064)	(0.049)	(0.073)
Observations	2632	2159	1583	1276	1447	1054
Psuedo R^2	0.708	0.869	0.927	0.962	0.776	0.846
Home country FE	yes	yes	yes	yes	yes	yes
Host GDP and TFP	yes	yes	yes	yes	yes	yes
Additional host controls		yes		yes		yes
Bilateral distance measures		yes		yes		yes

Note: Bilateral distance measures include: the geographical distance between the home and host countries; dummies on whether they are connected via a colonial tie, a shared border, or a common official language, respectively. Additional host characteristics include: business tax rate, a dummy for being a low-tax country, and an index for policy restrictions on inward FDI. The estimation specification is PPML.

Standard errors (clustered by host country) in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

nomically sizable and statistically significant. In the second column we include the measures for bilateral distance and additional characteristics of the host, including its tax rate, whether it is viewed as a low-tax country, and an index measuring its restrictions on inward FDI. The coefficient of interest shrinks somewhat after including these controls, but remains significant. According to the estimate, a 10% increase in the financial development index is associated with a 9% increase in inward FDI.

Columns 3 and 4 of Table 2 establish the second part of Fact 2. Column 3 includes the basic controls and Column 4 adds additional host characteristics and the measures for bilateral distance. Focusing on Column 4, the point estimate indicates that a 10% increase in the financial development index is associated with a 6% increase in the production of affiliates, after controlling for the capital investment from the parent firms. We interpret this positive correlation as reflecting that in host countries with better financial institutions, parent firms can raise external funds from local investors more easily to scale up their affiliates.[12] Taken together, Fact 2 highlights that the host country's financial development affects MP in two ways—directly by attracting more FDI, and indirectly by allowing these affiliates to scale up more.

Given that the fact is established using cross-country variations, one might be (rightly) skeptical that the coefficient might have picked up unobserved heterogeneity correlated

[12] This positive correlation and its interpretation are in line with Antras et al. (2009), which uses firm-level data on U.S. MNCs to establish the causal effect. Our analysis complements Antras et al. (2009) by showing that the fact holds in the aggregate data across a large number of destinations.

Table 3: Home Financial Institution Quality and Outward MNC Activities

	(1)	(2)	(3)	(4)
Dependent Variable	Log(FDI)		Log(MP)	
log (financial development index)	2.089***	1.354***	0.148	0.320
	(0.544)	(0.324)	(0.371)	(0.336)
log (FDI)			0.837***	0.804***
			(0.049)	(0.045)
Observations	2730	2183	1674	1322
R^2	0.747	0.863	0.908	0.965
Host country FE	yes	yes	yes	yes
Home GDP and TFP	yes	yes	yes	yes
Additional home controls		yes		yes
Bilateral distance measures		yes		yes

Note: See Tables 2 for definition of control variables. Columns 1 and 2 show that financial development in the home country is correlated with increased outward FDI. Columns 3 and 4 show that the effect vanishes once FDI is controlled for. The estimation specification is PPML. Standard errors (clustered by home country) in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

with the financial development index. For example, countries with better financial institutions might specialize in industries in which MNCs are more active; they might be more open to inward MNCs beyond what could be captured by the policy restrictions on FDI we control for. Columns 5 and 6 perform placebo tests with the number of affiliates in a host country as the dependent variable—if the estimate is driven by the above alternative mechanisms, they would likely affect MP through the extensive margin as well. On the contrary, we find that controlling for FDI, the financial development index is not systematically correlated with the number of affiliates. This suggests that the relationship between MP and financial development operates through larger individual affiliates.

2.3 Home financial institutions and outward MNC activities

Fact 3: Countries with better financial institutions send abroad more outward FDI, but conditional on FDI, not more outward MP.

The third fact relates outward MNC activities to the quality of financial institutions in the *home* country. The first two columns in Table 3 focus on FDI and confirm the well-established relationship between the two.[13] Column 1 includes only the host country fixed effects and the home country's size and productivity as controls. Column 2 further controls for additional host country characteristics and the measures for bilateral distance. The preferred estimate in Column 2 suggests that a 10% increase in the financial

[13] Desbordes and Wei (2017) examines how home financial development affects outward FDI by exploiting the interaction between country-level financial development and sectoral variation in the dependence on external finance. Using bank-firm linked data, Klein et al. (2002) and Biermann and Huber (2018) provide causal evidence that banking crises reduce outward FDI from Japanese and German firms, respectively.

development index is associated with a 13.5% increase in outward FDI .

Columns 3 and 4 focus on the second part of Fact 3. They show that once FDI is controlled for, financial development in the home country has a positive, but statistically insignificant, effect on MP—improvements in the home country's financial institutions increase MP primarily through increasing direct investment from the parent.

Summary and robustness To summarize, using bilateral data, we document a strong positive correlation between MP and FDI through the intensive margin. Further, both the host and home countries' financial development are positively correlated with FDI, but conditional on FDI, only the host country's financial development is correlated with MP.

In Appendix A, we show that these results are robust to different measures of financial development and alternative specifications using ordinary least squares, and are not driven by the U.S. alone or a number of small countries alone. Using the public-use data from the U.S. Bureau of Economic Analysis, we show that these relationships also hold when the wage bill is used to measure the affiliate's production, which is less subject to the issue of tax avoidance (Guvenen et al., 2019). We further show that the relationship between MP and financial development operates through the size of the affiliate's balance sheet, providing further evidence on the mechanism.

3 Model

To interpret the relationships documented in the previous section and to conduct counterfactual analyses, we develop a quantitative framework. This section presents the essential ingredients of the model. The formal definition of equilibrium, proofs, extensions, and further micro foundations are delegated to the appendix.

3.1 Endowments, preferences, and technology

Time t is discrete and goes from zero to infinity. There are N countries, indexed by i. Each country is endowed with an exogenous number of workers, denoted by L_i. Workers are immobile, each supplying one unit of labor inelastically and consuming all their labor income (their only source of income).

Each country has a continuum of firms with a constant mass. Following a growing literature of firm dynamics with financial constraints (Buera et al., 2011; Midrigan and Xu, 2014; Moll, 2014), we interpret firms as owned by entrepreneurs with 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, $u(\cdot)$ is the per-period utility function, $\beta \in (0, 1)$ is the discount factor, and $\mathbb{E}$ is the expectation operator integrating over the productivity and investment return shocks that will be introduced below. Entrepreneurs make operational decisions to maximize their personal utility. Of course, most MNCs are large corporations owned not by individual entrepreneurs but rather by shareholders. In that case, we can think of the entrepreneur as the CEO of the corporation and interpret c_t as the compensation of the CEO.[14,15]

Firms differ in their productivity $z \in (0, \infty)$, which follows Markov processes with transitions characterized by the country-specific conditional density function $f_i(z'|z)$. A firm from country i can operate affiliates in different host countries (including country i). The *affiliate* with productivity z_{ih} in host country h uses l units of labor and k units of capital to produce

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

units of a homogeneous product, with $1 - \alpha \in (0, 1)$ being the labor share. Capital depreciates at rate $\delta \in (0, 1)$ every period. We assume that the productivity of an affiliate depends partially on the productivity of its parent and partially on the host country it operates in, described by the function $z_{ih} = \tilde{z}_{ih}(z)$. We assume that this function increases in z, with $\tilde{z}_{ii}(z) = z$ as a normalization.

In this setting, output is a homogeneous good so there is no scope for trade. Appendix B.3 shows that this setup is isomorphic to an environment with CES preferences and firms under monopolistic competition, if the capital input is introduced as the fixed cost for producing horizontally differentiated varieties, and if the fixed cost increases with the scale of the economy. In that alternative setting, it is possible to explore the interaction between trade and FDI policies. Since this interaction is not the focus of the present paper, we stay with the homogeneous output assumption throughout.

3.2 Financing and production of the affiliates

Affiliates hire workers from the perfectly competitive labor market in the host country and finance their capital use with investment from their parents as well as funds raised from local investors. Because of the financial constraint at the corporate level, when the

[14] In modern corporations, CEOs are often incentivized through stock options and bonuses. For example, Google CEO Sundar Pichai made \$100.5 million in 2015, of which 99% was in the form of restricted stock. The remuneration of a CEO therefore depends on the shareholders' wealth gains. In such cases, CEOs maximizing their remunerations will act as if they were maximizing the shareholders' value of the firm.

[15] Alternatively, we can interpret c_t as dividend payout and the curvature in $u(c_t)$ as capturing the dividend smoothing motive.

shadow price of internal capital is higher than the cost of financing from the host country, parents have incentives to use funds from the host country as much as possible, in either equity or debt. However, regardless of the instruments used, various imperfections in the financial market in the host country might limit the extent to which a parent can rely on the host country for external financing.[16]

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 in the host country, an exogenous minimum level of parent investment must be made. Let e_h be the investment of a parent firm in its affiliate in host country h and b^F be the amount of external funds raised in country h. Formally, the assumption states that

$$b^F \leq \mu_h \cdot e_h,$$

with parameter $\mu_h > 0$ determining the maximum external financing to equity ratio for the affiliate. The total capital the affiliate can use thus satisfies $k \leq e_h + b^F$.

This setup is similar to the 'collateral constraint' setting in the macro-finance literature. Without confusion, we will refer to b^F as debt from the host country, but we interpret b^F broadly as capturing both debt and equity held by local partners and pin down the collateral constraint using data that include both components.[17] Our quantification strategy allows the tightness of the collateral constraint, captured by μ_h, to differ both across countries and over time. Cross-sectionally, in host countries with better financial institutions, frictions for both debt and equity financing would be less severe, so foreign affiliates can rely more on local partners for financing. Over time, fluctuations in the availability of credit in the host can also affect foreign affiliates' ability to raise funds externally.

Denote the wage and net bond interest rate in host country h by w_h and r_h^b respectively. For given e_h and affiliate productivity $z_{ih} = \tilde{z}_{ih}(z)$, firms make financing and production

[16]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—because the parent firm cannot commit to providing a non-contractable but vital input, a substantial share of the affiliates' assets must be at the parent's stake to make its input incentive-compatible, so that local investors come on board. Antras et al. (2009) provides a theory and firm-level evidence for the case when this vital input is the effort in monitoring local managers.

[17]Appendix B.5 shows that this constraint can be derived as a limiting case of a model in which foreign parents form a joint venture with local partners and bargain with them over the surplus. In that model b^F indeed includes equity investment from local partners.

decisions at the affiliate level to maximize the return from their investment:

$$\tilde{R}_{ih}(z, e_h) = \max_{b^F,k,l,y} y + (1-\delta)k - w_h l - (1+r_h^b)b^F, \tag{2}$$
$$s.t. \quad y = [\tilde{z}_{ih}(z)k]^\alpha l^{1-\alpha}$$
$$0 \le b^F \le \mu_h e_h$$
$$0 \le k \le e_h + b^F,$$

where the return equals production y, plus non-depreciated capital $(1-\delta)k$, net of wage cost $w_h l$ and the interest payment $(1+r_h^b)b^F$ to local investors. The first constraint is the production technology, the second the constraint for external financing in the host country, and the third the constraint for the use of capital.

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). To capture the effects of these frictions on investment returns, 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 the iceberg cost specification in the trade literature. We further assume $\eta_{ih} = \bar{\eta}_{ih} \cdot \zeta_h$, where $\bar{\eta}_{ih}$ is the deterministic component common for firms from country i investing in host h and ζ_h is the idiosyncratic component that is i.i.d. across parents, affiliates, and periods. ζ_h captures the idiosyncratic match quality between a firm and a host country. The literature has documented that MNCs are more productive than domestic firms and has rationalized this with a fixed cost for affiliate setup so that the average return from opening up foreign affiliates increases with productivity (Helpman et al., 2004). Our quantification captures this in a reduced-form way by allowing $\bar{\eta}_{ih}(z)$ to depend on firm productivity z, but we suppress z as an argument for now for ease of exposition.

3.3 Financing and investment of the parent firms

Parent firms from a given country i differ in their net worth a, productivity z, and current realizations of idiosyncratic project return shocks, $\boldsymbol{\zeta} \equiv (\zeta_1, \zeta_2, ..., \zeta_N)$. Each period, after learning z and $\boldsymbol{\zeta}$, firms first decide whether to produce or stay idle. Inactive firms loan out a at the market interest rate. Active firms decide whether to borrow risk-free bonds domestically using their net worth as collateral and which host country to invest in.

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

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

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

Formally, the decision problem of a parent firm with net worth a from country i, after seeing the realizations of z and $\boldsymbol{\zeta}$, can be described by the following Bellman equation[18]

$$\begin{aligned} v_i(z, \boldsymbol{\zeta}, a) = & \max_{c, a', \{e_h\}_{h=1}^N, b^H} u(c) + \beta \mathbb{E}\left[v_i(z', \boldsymbol{\zeta}', a') \middle| z\right] \\ s.t. \quad & \sum_h e_h = a + b^H \\ & - a \leq b^H \leq \lambda_i \cdot a \\ & c + a' = \sum_h \tilde{R}_{ih}(z, e_h) \underbrace{\eta_{ih}}_{\bar{\eta}_{ih}\zeta_h} - (1 + r_i^b) b^H. \end{aligned} \tag{3}$$

The first constraint says that the funds allocated to affiliates should sum to net worth plus debt raised in the home country. The second constraint says that, (1) an idle parent firm can loan out all but not more than its net worth; and (2) the funds raised by an active parent firm cannot exceed the limit imposed by the collateral constraint. $\tilde{R}_{ih}(z, e_h)\eta_{ih}$ in the third constraint denotes the net return from e_h invested in host country h, which is net of wages, interest payments to investors in the host country, and the component melt when repatriated. $\boldsymbol{\zeta}$ enters the value function through $\tilde{R}_{ih}(z, e_h)\eta_{ih}$. The third constraint says that the total repatriated profits from affiliates are split among domestic lenders, internal saving a', and the current consumption of the firm owners.

Problem (3) is a joint decision of internal capital accumulation and investment allocation among host countries. The incomplete-market setting, while natural, means that in solving the model, we need to track the joint distribution of (z, a) for each country. Below we first characterize the affiliate- and firm-level decisions analytically, and provide some aggregation results with the aid of two additional assumptions.

[18] Our main quantitative exercises focus on transition paths and allow for time-varying parameters (such as λ_i, μ_h, and $\bar{\eta}_{ih}$), so all value functions and decision rules in Equation (3) should have a time index, which we omit to simplify notations. The related sequential competitive equilibrium with explicit time indices is defined in Appendix B.1.

3.4 Characterizing the affiliate- and firm-level decisions

We start by solving for the return and policy functions of individual affiliates, as specified in Problem (2). Lemma 1 summarizes the results.

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

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

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

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

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

$$\pi_h(z_{ih}) = \alpha z_{ih}\left(\frac{1-\alpha}{w_h}\right)^{(1-\alpha)/\alpha} + 1 - \delta. \tag{5}$$

This lemma exploits that both the objective function and the constraints in Problem (2) are homogeneous of degree one in e_h. The first part of the lemma states that the solution to Problem (2) is linear in e_h, so the *affiliate*-level total return is simply the unit investment return times total investment, with the unit return given by the solution to Problem (4).

The second part of the lemma shows that, first, the affiliate's decisions are linear in e_h. Second, the affiliate's decisions follow a cutoff rule in productivity: affiliates above the productivity threshold z^*_{ih} leverage financing from local investors and produce at full capacity; affiliates below the threshold choose not to use any financing from the host country.[19] The cutoff is given by the equality condition between the cost of borrowing, $1 + r^b_h$, and the profit from having an extra unit of capital in production, $\pi_h(z_{ih})$. The selection

[19] We have specified a tie-breaking rule when the productivity of the affiliates is at the threshold. In the

channel as in Melitz (2003) operates here: as the wage goes up, the cutoff increases, so fewer active affiliates seek funding for expansion from local investors.

Lemma 1 gives an explicit expression of $\tilde{R}_{ih}(z, e_h)$, the investment return in Equation (3). To characterize the firms' dynamic decisions, we assume entrepreneurs have the log utility:

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

Under Assumption 1, the solution to Problem (3) is characterized by Lemma 2.

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

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

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

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

where

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

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

$R_i^a(z, \boldsymbol{\zeta})$ in the second part of the Lemma denotes the return to net worth a, which depends on whether a firm is active. The return for active firms takes into account the fact that they can lever up on a. The lemma then shows that, firms reinvest a fixed fraction β of after-return net worth $R_i^a(z, \boldsymbol{\zeta}) \cdot a$,[20] and use the remaining for consumption.

quantitative exercise, firms at the cutoff productivities are contained in a zero-measure set so the choice of the tie-breaking rule does not affect the results.

[20]This result is specific to the log utility assumption. Appendix B.4 shows that our model retains much

3.5 Aggregation

Together, Lemmas 1 and 2 express firms' decisions as functions of their states $(z, \boldsymbol{\zeta}, a)$ after the uncertainty about the idiosyncratic draws $(\zeta_h)_{h=1}^N$ has been resolved. Keeping track of the aggregate FDI between each country pair requires integrating across firms with all possible realizations of $(\zeta_h)_{h=1}^N$. To ease aggregation we make the following assumption:

Assumption 2. *The joint Cumulative Distribution Function 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 a special case (when $\rho = 0$) of the multivariate distribution introduced in Arkolakis et al. (2017).[21] Compared to a commonly used approach in international trade for analytical aggregation, which is to assume that $(\zeta_h)_{h=1}^N$ are drawn from the Frechet distribution (see Eaton and Kortum, 2002), the attractive feature of Assumption 2 is that $\max_h(\zeta_h)_{h=1}^N$ has a Pareto-shaped tail. This retains tractability even though firms in the model make an extensive-margin entry decision that is dependent on the realization of $(\zeta_h)_{h=1}^N$, as we show below.[22]

Specifically, define $\Xi_i(z)$ as the friction-adjusted maximum return across hosts for a firm with productivity z, that is,

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

The cumulative distribution function for $\Xi_i(z)$, denoted by $H_i(\xi|z)$, is given by the following:

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

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

tractability under the general constant relative risk aversion (CRRA) utility family, even though in that case the reinvestment rate is no longer a constant. Recent quantitative studies in single-country settings show that using a CRRA utility does not affect the findings based on the log utility materially (Moll, 2014).

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

[22] 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 a higher net return than the risk-free bond (see Lemma 2).

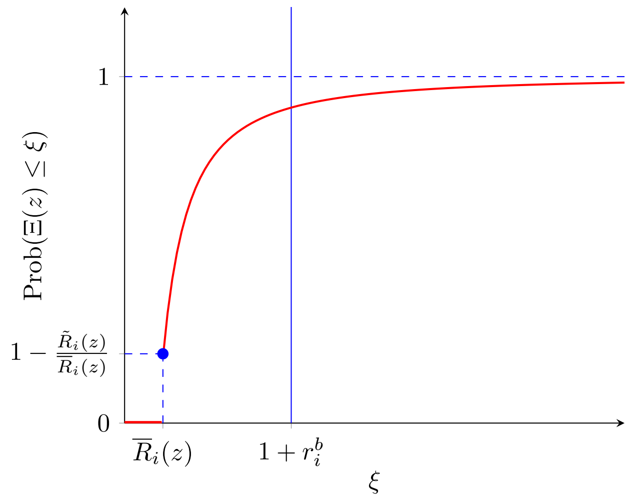


Figure 2: The CDF for $\Xi_i(z)$

Because all ζ_h draws are no smaller than 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;[23] at $\overline{R}_i(z)$ is a mass point with measure $1 - \frac{\tilde{R}_i(z)}{\overline{R}_i(z)}$, as shown in Figure 2. This measure is zero if and only if $\overline{R}_i(z) = \tilde{R}_i(z)$, which holds if the deterministic parts of the return are the same across all hosts.

With $H_i(\xi|z)$, we derive 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 Pareto tail allows us to derive the probability of engaging in active production and that of each destination being chosen, as well as the expected return. The second scenario is for $\overline{R}_i(z) \geq 1 + r_i^b$, in which case firms are always active and the probability of choosing particular host depends on whether the realization is on the mass point ($\overline{R}_i(z)$) or not. Lemma 3 summarizes the results:

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

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

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

[23]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 $\zeta \geq \overline{R}_i(z) \equiv \max_{h'} \bar{\eta}_{ih'} R_{ih'}(z)$, we have $\forall h'$, $\frac{\xi}{\bar{\eta}_{ih'} R_{ih'}(z)} \geq 1$, which is in the support of $G(\cdot)$, so we can apply the definition of $G(\cdot)$, given in Assumption 2, to obtain

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

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

$$\hat{e}_{ih}(z) = \underbrace{[\tilde{R}_i(z)/(1+r_i^b)]^\theta}_{\text{prob. of being active}} \cdot \underbrace{\frac{1}{N}[\bar{\eta}_{ih} R_{ih}(z)/\tilde{R}_i(z)]^\theta}_{\text{prob. of active firms choosing } h} .$$

The expected return to the net worth of these firms is

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

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

In each period, the aggregate state of the economy is the joint distribution over (z,a) in each country i, characterized by the joint density functions $(\Phi_i(z,a))_{i=1}^N$. Since firms' investment decisions are linear in their net worth, to compute aggregate quantities in the model, it is sufficient to track the total net worth by each productivity level. Formally, define the mass of total net worth held by parent firms with productivity z in country i, denoted by $\phi_i(z)$, as

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

The intertemporal transition for $\phi_i(z)$ satisfies the following (see Appendix B.2.1):

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

where $\mathbb{E}[R_i^a(z,\boldsymbol{\zeta})|z]$ is the expected return (w.r.t. $\boldsymbol{\zeta}$) on net worth for parents with productivity z, as characterized in Lemma 3. For convenience in later analyses, we also define the aggregate net worth across all parent firms in a country, $W_i \equiv \int_0^\infty \phi_i(z) dz$, the wealth share distribution over productivity z

$$\hat{\phi}_i(z) \equiv \frac{\phi_i(z)}{W_i}, \tag{9}$$

and the mass of total equity invested by firms with productivity z from home country i to host country h

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

in which $\hat{e}_{ih}(z)$ is the fraction of firms investing in h that is characterized in Lemma 3 and $(1+\lambda_i)$ accounts for that active parent firms can borrow in the home country for overseas investment, as characterized in Lemma 2.

In the 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 is

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

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

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

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

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

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

3.6 Definition of equilibrium

Given an exogenous sequence of parameters and the initial distribution of parent firms $(\Phi_{i,t=0}(z,a))_{i=1}^N$, a sequential competitive equilibrium (see Appendix B.1 for the formal definition) is a sequence of (a) country-specific wages and world bond interest rates, (b) the parent firm's value, policy and return functions, the affiliate's policy and return functions, and (c) distributions of parent firms, such that at every period (i) value, policy and return functions solve the firms' problem; (ii) the distributions of firms are consistent with the transition implied by the firms' policy and return functions, and the exogenous productivity process; (iii) labor markets clear by country and the world bond market clears.[24]

[24] This condition implies that there is one single risk-free rate in the world. We focus on this case in the rest of the paper. Alternatively, we can either assume that the credit market is closed in each country, which is clearly counterfactual, or that each country has a different credit spread, which requires taking a stand on which lenders are getting the spread. An integrated world credit market seems a more natural benchmark.

3.7 FDI, MP, and financial institutions

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 i becomes financially more developed (or as it experiences a credit boom), both μ_i and λ_i increase. A higher μ_i allows productive affiliates to use more external financing, which increases the return on the parent investment in that affiliate. This leads to an increase in inward FDI.

A higher λ_i generates three effects. First, it helps channel capital into the most productive parent firms from country i, which are more likely to become MNCs. Second, this reallocation of capital raises domestic wages and interest rates, pushing domestic firms to invest abroad. Finally, with better access to credit, productive firms will be able to accumulate wealth faster. Due to the persistence in the productivity process, this further increases aggregate efficiency and wealth in the future, leading to 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 connects FDI and MP through the following proposition:

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

$$\frac{Y_{ih}}{Y_h} = \frac{[FDI]_{ih}}{K_h} \times \bar{lev}_{ih} \times \frac{A_{ih}}{A_h}, \tag{10}$$

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

In the proposition, $\frac{Y_{ih}}{Y_h}$ is the share of foreign affiliates in total domestic production, a common measure of MP in the literature. $\frac{[FDI]_{ih}}{K_h}$ measures the share of FDI in total domestic capital stock. Because affiliates only have a limited capacity to raise funds externally, MP and FDI shares are tightly connected, as Fact 1 suggests. However, these two measures are intermediated by two other components: First, how much external capital from the host is being used by the affiliate, summarized by the average leverage and ultimately determined by μ_h. Given the FDI share, the production by foreign affiliates is larger if they can leverage more local financing. This is consistent with Fact 2. Second, the foreign production share is higher if affiliates are more productive relative to local firms. Finally, Equation (10) suggests that, conditional on FDI, the home country's financial development does not have direct effects on MP, which is in accordance with the second part of Fact 3.[25]

3.8 Discussion and extensions

Before moving into quantification, we discuss the rationale for the model assumptions and the extensions and microfoundations that address some potential concerns. One of the key assumptions of our model is that firms face short-run financial constraints, so the shadow value of capital differs from the cost of external credit. This assumption motivates FDI as within-firm capital transfer and generates empirically consistent patterns.

One might 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 rising default risk and agency cost usually leads to a higher cost of borrowing (Baxter, 1967). Our model captures this idea in a parsimonious way, as it can be viewed as a special case in which the cost of borrowing increases to infinite when the leverage is above a threshold. Further, the model only restricts the short-term leverage. Productive firms are allowed to expand by accumulating net worth and leveraging it to borrow more. The particular way of introducing financial frictions via a collateral constraint, while somewhat ad hoc, has achieved success in explaining both long-run income differences (Buera et al., 2011) and business cycles (Buera et al., 2015), and has received considerable empirical support.[26]

Our setup abstracts from fixed costs in starting up an affiliate, so the 'proximity-concentration' tradeoff emphasized in the literature (Horstmann and Markusen, 1987; Brainard, 1997) does not play a role. Relatedly, by assuming each affiliate is an independent producer of a homogeneous good, the model does not allow for the interaction between affiliates through demand cannibalization (Tintelnot, 2017). On the other hand, the model incorporates the transfer of an intangible input to the affiliate and the cannibalization between affiliates through competition for a scarce internal factor (capital). It thus captures better the 'brown-field' investment in the form of mergers and acquisitions (M&A), which creates joint ventures between foreign and domestic partners with technological and capital inputs from both. Formally, Appendix B.5 presents an extended model

[25] Because the home country's financial development improves the allocative efficiency, the average productivity of affiliates from a home country with better financial development might be higher. This is an indirect effect and could explain the positive but statistically insignificant coefficient for the financial development index in Columns 3 and 4 of Table 3.

[26] Klein et al. (2002) shows that the reduction in lending from Japaneses banks explains the collapse in Japanese overseas investment in the 1990's, while evidence from Goyal and Yamada (2004) links the reduction to a drop in firms' collateral values; Chaney et al. (2012) documents that the appreciation in the value of collaterals increases investment by U.S. listed firms. The direct implication of financial frictions in the setting of multi-unit firms—that shocks to one unit affects others through internal capital reallocation, is consistent with empirical findings (Alfaro and Chen, 2012; Almeida et al., 2015; Giroud and Mueller, 2015).

in which firms decide whether to enter a country via greenfield FDI or M&A, and if the latter, bargain with local partners to split the surplus. The host finance block of the baseline model arises as a limiting case of the latter scenario with the bargaining power of host partners approaching zero. Given that M&A is the dominant form of foreign investment, we view the current framework as suitable for analyzing *aggregate* FDI between countries.

Finally, without sunk costs, firms make location choices based on static returns only (see Lemma 3). This eliminates the option value of investing in a country with greater returns in the future and implies that there is no firm-level hysteresis. Given that our quantitative exercises all focus on medium-term aggregate dynamics over six to seven years, this simplification appears less crucial. In Appendix B.6, we present an extended model featuring hysteresis and show that the tractability of the machinery carries through.

4 Calibrating to the Transitional Dynamics: 2001-2012

Through the lens of the model, we quantitatively assess the effect of various shocks on the dynamics of FDI. Following a procedure described in Appendix C.1, we assemble a panel of bilateral FDI stock during 2001-2012 for 36 major developed and developing countries (see Table 8 for the country list). The solid line in Figure 1 is the sum of bilateral FDI stock among these countries. Aggregate FDI grew at above 10% annually during the first half of the decade. Starting in 2008, the growth decelerated to around 5%. By 2012, the actual world FDI stock fell short by 20% compared to the level linearly extrapolated from the pre-crisis period. The dashed line is the total stock of credit issued to the private sector, which shows a credit boom during 2001-2007 and a subsequent credit crunch.

We use the model to examine the effects of changes in various fundamental factors, including the financial market conditions faced by parent firms (λ_i) and affiliates (μ_h) and the fundamental productivity of a country ($\bar{z}_i$, to be introduced below). To allow for the possibility that the patterns we see are the cumulative effects of past shocks, we do not assume the model to be at the steady state in any of the years. Instead, we adopt a wedge accounting approach that matches the transitional dynamics of the model to the data. Specifically, we pick the model fundamental parameters (λ_i, μ_h, $\bar{z}_i$) and the residual wedges ($\bar{\eta}_{ih}$) over time to match the time-series data along a number of dimensions for all countries. If we feed the changes in all the parameters into the model, it will produce the time series of GDP, domestic and bilateral foreign investment, private credit, etc., exactly as in the data. By switching off the changes in different fundamental factors, we then quantify their respective contributions to the changes in the aggregate FDI.

4.1 Parameterization

This subsection explains the most relevant calibration targets for each model parameter and the numerical procedure. Additional information on the sources of data and computational algorithms are provided in Appendix C.

4.1.1 Targets and parameter values

Parameters calibrated independently The entrepreneurs' discount rate, β, determines the saving rate. We set $\beta = 0.9$, a value in the range of the recent quantitative literature on the implications of financial frictions (Buera et al., 2011, Midrigan and Xu, 2014). We set the capital share $\alpha = 0.4$ and the depreciation rate $\delta = 4.5\%$ based on the average values across the sample countries calculated from the Penn World Table. The dispersion parameter of the multivariate Pareto distribution, θ, determines the sensitivity of firms' investment decisions to host-country investment returns (see $\hat{e}_{ih}(z)$ in Lemma 3). Using cross-country variations in tax rates on foreign corporations, 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.[27]

We parameterize the idiosyncratic productivity z of *parent* firms in country i as $z = \bar{z}_i \hat{z}$, where $\bar{z}_i$ is the fundamental productivity of country i and $\log(\hat{z})$ follows an AR(1) process

$$\log(\hat{z}') = \rho_z \log(\hat{z}) + \sigma_\varepsilon \varepsilon,$$

in which ε follows the standard normal distribution, $\rho_z \in (0, 1)$ determines the persistence, and $\sigma_\varepsilon > 0$ determines the standard deviation of productivity across parent firms. Using firm-level data, Asker et al. (2014) estimates the productivity process for a large number of countries at different stages of development. We take the median estimate from their sample of countries and set $\rho_z = 0.86$ and $\sigma_\epsilon^2 = 0.90$. We will allow $\bar{z}_i$ to vary over time and use it to match the aggregate output in each country.

When an MNC opens an affiliate in a host country, the productivity of the affiliate not only depends on the productivity of the parent, but is also affected by host-specific factors, such as infrastructure and local human capital. We capture this by assuming that the productivity of an affiliate from home country i in host country h follows

$$\tilde{z}_{ih}(z) = z^{\chi_h} \bar{z}_h^{1-\chi_h}, \text{ for } h \neq i, \tag{11}$$

[27] Wei (2000) estimates θ as an aggregate FDI elasticity. In our model, θ governs the firm-level elasticity, which, in the presence of an extensive margin decision, does not equal exactly the aggregate elasticity. However, we find the difference to be rather small, so we directly use the estimate of the aggregate elasticity to pin down θ.

where z is the productivity of the parent and $\bar{z}_h$ is the fundamental productivity of host country h. χ_h could be different across hosts based on their 'absorptive capacity'. We set $\chi_h = 0.25$ for high-income host countries and $\chi_h = 0.16$ for low-income ones, based on the elasticities from Cravino and Levchenko (2017), estimated off the correlation in growth rates between affiliates and their parents.[28]

Parameters determined in equilibrium The remaining parameters are allowed to vary over time and disciplined in equilibrium using time-varying targets. Parameter λ_i determines the extent to which a firm can use its net worth as collateral for external borrowing in its home country i. In the long-run, this parameter depends on the quality of financial institutions, but its short-run fluctuation is likely driven by the availability of credit in a country. We use λ_i to match the time series of credit over GDP ratio for country i, interpreting its over-time change as capturing the evolving financial market conditions.

Parameter μ_h determines the extent to which a foreign affiliate can rely on local partners from host country h for financing. While the same fundamental forces that drive λ_h likely also affect μ_h, their impact on μ_h needs not to be the same as on λ_h,[29] so we discipline μ_h using another time series. Recall that μ_h determines the host share of the affiliate's external financing. We construct the empirical counterpart of this object using the public-use data from the Bureau of Economic Analysis, which tabulates, for each host country and year, the decompositions of the external financing of U.S. overseas affiliates into different sources. For the U.S. as a host country, we construct the corresponding numbers using the statistics of foreign affiliates in the U.S. These data allow us to pin down the sequence of μ_h for each host country.

Given other parameters, the return wedges for domestic and international investment are the residual determinants for the evolution of domestic investment and FDI. We set the capital stock in each country (K_h) to the actual values in 2001 and then use the sequence of $\bar{\eta}_{hh}$ to match the evolution of domestic investment. The return wedges of international investment have two components: a time-invariant component that depends on productivity and a time-varying component independent of productivity, specified as below

$$\bar{\eta}_{ih}(z) = z^{\eta_z} \cdot \bar{\eta}_{ih}, h \neq i. \tag{12}$$

The first component z^{η_z}, with $\eta_z > 0$, implies that the average returns from overseas operations are higher for more productive firms, so they are more likely to be MNCs. We pin

[28]The theory-consistent measure in our model is based on the productivity level. Using the Orbis data, we also find the estimate of χ_h to be between 0.15 and 0.3. Among sample countries, the following are not considered high-income countries: ARG, BRA, CHL, CHN, CZE, HUN, IDN, IND, MEX, MYS, POL, RUS, TUR, VEN.

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

Table 4: Model Parameterization

A: Parameters Calibrated Independently			
Parameter	Description	Target/Source	Value
α	Capital share	PWT	0.4
δ	Capital depreciation rate	PWT	4.5%
θ	Elasticity of FDI w.r.t. return	Wei (2000)	5.0
ρ_z	Firm productivity autocorrelation	Asker et al. (2014)	0.86
σ_ϵ^2	Firm productivity innovation variance	Asker et al. (2014)	0.90
χ	Parent weight in affiliate productivity	Cravino and Levchenko (2017)	0.25, 0.16
$\{L_i\}$	Effective employment	PWT	-
B: Parameters Calibrated in Equilibrium			
Parameter	Description	Target/Source	Value
$\{\lambda_i\}$	Financial market conditions for parent firms	Credit/Capital ratio	Figure 3
$\{\mu_h\}$	Financial market conditions for affiliates	Share of affiliates balance sheet financed by parents	Figure 3
$\{\bar{\eta}_{ih}\}$	Return wedges for domestic and foreign direct investment	Domestic investment and bilateral FDI	
η_z	Relationship between MNC status and productivity	Estimated using Bloom et al. (2012) data	0.026
$\{\bar{z}_i\}$	Fundamental TFP	GDP	-

down η_z through an indirect inference procedure. Based on a 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, the same specification, performed on simulated firms from the same set of countries as in the empirical analysis, yields the same estimate. This determines $\eta_z = 0.026$.[30] Second, given η_z, we use the sequence of $\bar{\eta}_{ih}, h \neq i$ to match the bilateral foreign investment over time.

The sequence of labor endowment in each country, L_i, is set to the effective employment from the Penn World Table, which takes into account the changes in population, labor force participation, and human capital of the labor force. We then pin down $\bar{z}_i$ as the residuals that match the aggregate GDP time series for each country.

Table 4 summarizes the model parameters and how their values are determined (see Appendix Table C.1 for the key parameters and data moments by country). 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 a comprehensive firm-level data set that covers all countries for the early 2000's, we assume that the wealth share distribution (i.e., $\hat{\phi}_i(z)$ in Equation (9)) in each country is taken from the stationary equilibrium corresponding to parameters in 2001.[31]

[30] As described in Appendix C.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 is still informative about η_z. Note also that when estimating the specification using the 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 Subsection 4.1.2.

[31] We emphasize that we only assume the wealth share distribution (the density) over productivity is as the one in the stationary equilibrium, but not the aggregate net worth. Matching the aggregate capital stock period-by-period is crucial in assessing the welfare effects of capital inflows for developing countries along the transition. We do so and thus do not impose that the capital-output ratios are at their steady state levels.

4.1.2 Numerical procedures

The calibration algorithm works as follows. For given parameters in Panel A of Table 4 and a value of η_z, we first calibrate the stationary equilibrium of the model to match the 2001 data moments, assuming all parameters stay constant. Taking the wealth share distribution from the equilibrium, we adjust the initial level of each country's aggregate net worth so that the model produces equilibrium capital-output ratios as in the data in 2001 for each country. Simultaneously, we compare other moments of the model along the transition, including aggregate outputs, credit over GDP ratios, average affiliate leverage levels, and the dynamics of domestic and foreign investment, and adjust the parameters until all these moments match their empirical counterparts over 2001-2012. In doing this, we assume the parameters remain at their 2012 values for the years after, so the economy converges to a stationary equilibrium. We then check if the model implies the same relationship between whether a firm is an MNC and its productivity in 2001 as in the data and, if not, update η_z and repeat.

The above procedure requires computing the distribution of firms and the transition of the distribution numerous times. Since policy functions are discontinuous in productivity at which the parent firm switches from inactive to active or the use of affiliate leverage switches from zero to positive, the aggregate quantities might be discontinuous in prices. To circumvent this problem, rather than approximating the firm distribution as a discrete histogram, we directly track the continuous density functions $\phi_i(z)$ that have no mass points. Appendix C.2.2 describes the algorithm.

4.1.3 The dynamics of financial market conditions

Figure 3 plots the calibrated sequences of λ_i (left panel) and μ_h (right panel). The solid curves highlight selected countries and the dashed line denotes the evolution of the mean value across all countries.

The left figure shows the significant heterogeneity in λ_i across countries. The U.S. is among the countries with the highest values with an average of 1.4. Turkey, on the other hand, has an average value of around 0.1. The different levels across countries reflect differences in the credit over GDP ratio in the data, as shown in the first two columns of Table C.1 in Appendix C.2.3. However, although different in level, the calibrated λ_i of many countries follow a common trend. They were on an upward trend in 2001-2007, corresponding to a period of easing credit in many countries. The trend was met by a sharp downturn around 2008, mirroring the credit crunch shown in Figure 1. This drop was more pronounced for some countries—the λ_i of the U.S., for example, declined from its peak value of 1.8 to 1.2 in just two years. Given the reduced-form evidence showing

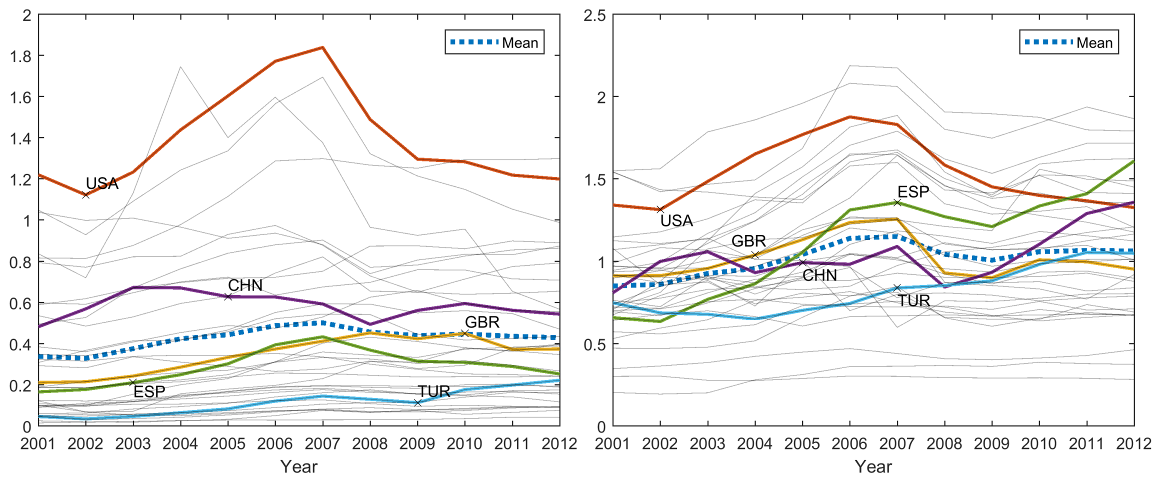


Figure 3: Measured λ_i and μ_h

Note: The left panel is the calibrated λ_i; the right panel is the calibrated μ_h. Solid lines represent values for individual countries; dashed lines denote the time series of the average value across countries.

that the domestic credit crunch caused the collapse of Japanese outward FDI in the 1990's (Klein et al., 2002), the post-2007 credit crunch episode may also impact FDI severely.

The right panel of Figure 3 plots the evolution of μ_h for each host country. As before, there is substantial heterogeneity among host countries along this dimension, which reflects differences in the average leverage ratio of foreign affiliates across host countries, as shown in Columns 3 and 4 of Table C.1. Compared to λ_i, the over-time pattern of μ_h is less clear-cut, but in many countries, we can still see a drop in μ_h in 2008.

4.2 Model validation

As a first pass of the model, we check whether the calibrated financial parameters make sense. To the extent that in countries with better financial institutions, parent firms can borrow more easily and affiliates of foreign firms can also rely more heavily on local partners, we should expect these two measures for each country to be correlated, and both related to other measures of the quality of financial institutions. In the short run, both parameters are influenced by the financial market conditions of a country, so their fluctuations are also likely correlated. We show both predictions hold in Table C.2 of Appendix C.2.4.

We further validate the model by comparing other calibrated parameters to several non-targeted external measures.

Table 5: FDI Return Wedges and Measurable Outcomes

	(1)	(2)
	$\log(\bar{\eta}_{ih})$ in year 2001	
log(distance)	-0.227***	-0.183***
	(0.013)	(0.021)
common border	0.009	0.053
	(0.042)	(0.049)
colonial tie	0.253***	0.255***
	(0.046)	(0.045)
common language	0.129***	0.185***
	(0.034)	(0.060)
low tax country		0.367***
		(0.058)
profit tax		0.002
		(0.003)
log(FDI restriction)		-0.443***
		(0.147)
log (host financial development index)		0.041
		(0.108)
log GDP		0.022
		(0.020)
TFP		0.864***
		(0.171)
Observations	1048	1007
R^2	0.772	0.672
Host country FE	yes	
Home country FE	yes	yes

Note: This table shows that the calibrated bilateral investment wedges correlate systematically with proxies for frictions and policy restrictions for FDI. Standard errors (clustered by host country) in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.2.1 Cross-border investment return wedges

In the calibration, the z-independent component of investment return wedge $\bar{\eta}_{ih}$ intends to capture all frictions and policy distortions to cross-border direct investment. We examine if they are correlated with proxies for frictions and FDI policies in expected ways.

Table 5 reports the results. The regression uses the wedge for 2001 as the dependent variable because many independent variables can only be measured in a single year. Column 1 shows that controlling for the home and host fixed effects, increasing the distance between home and parent countries decreases the net return; sharing a colonial tie or a common language increases the net return, while sharing a common border does not have a significant impact.

The second column replaces the host country fixed effects with various host characteristics. We find that while being labeled as a low-tax country has a significant positive correlation with the FDI return, conditional on that, the marginal effect of a lower profit tax rate is negligible—many low-tax countries do not necessarily have low statuary tax rates, but instead attract foreign business through special offers. Policy restrictions on inward FDI have a sizable and significant coefficient. Finally, as a placebo test, the financial institution index is unimportant, suggesting that the effect of the host country's financial development on inward FDI is entirely captured by the explicit model mechanisms and does not show up in the residual.

4.2.2 Cross-sectional relationship between MP and FDI

The model links the production of MNC affiliates (MP) to the financing of affiliates (FDI) through Proposition 1. 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 (10), holds in the data. Because both MP and FDI are well approximated by a gravity equation, directly comparing them could misleadingly show close fit. We consider the following reduced-form equation for the MP/FDI ratio instead:

$$\log\left(\frac{\sum_{i\neq h} Y_{ih}/Y_h}{\sum_{i\neq h}[FDI]_{ih}/K_h}\right) = \log(\text{average } \bar{lev}_{ih}) - \log\left(\frac{A_{hh}}{\bar{A}_{ih}}\right). \tag{13}$$

In this specification, Y_{ih}/Y_h and $[FDI]_{ih}/K_h$ are theory-consistent measures of MP and FDI shares. To minimize measurement errors in the data, we look at aggregate shares for each host country h. Correspondingly, what appears on the right hand side of Equation (13) should be a measure of aggregate affiliate leverage, and a measure of relative productivity, which we calculate as the ratio between capital-weighted average productivity of all domestic active firms, A_{hh}, to that of all foreign affiliates, $\bar{A}_{ih}$.

We estimate Equation (13) with both the actual and the simulated data. Table 6 reports the results. The first column shows that in the model, the above relationship holds strongly. The second column uses the actual data and shows that in accordance with the model's prediction, 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, the point estimate is close to that of the model.

5 Financial Market Conditions and the Dynamics of FDI

The preceding exercises show that our model delivers consistent predictions with the data in dimensions not directly targeted. We now use the model to examine the role of various fundamental shocks in accounting for the world FDI during 2001-2012. Our first set of experiments focuses on the outward FDI from *individual* countries. Given the trend break in 2007 (see Figure 1), we split the counterfactual experiments into two periods, before and after 2007.

Table 6: Determinants of MP/FDI Ratio

	(1) Model	(2) Data
Log (average lev)	1.540***	1.131*
	(0.168)	(0.579)
Log (dest TFP/source TFP)	-0.596***	-0.310
	(0.058)	(0.218)
Observations	36	36
R^2	0.827	0.117

Note: This table shows that the MP-FDI relationship holds in both the model and the data. Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5.1 FDI growth, 2001-2007

We first examine the role of the credit expansion in the lead-up to the financial crisis in explaining the surge of FDI during this period. The focus of our investigation is outward FDI from each country, as shown in Figure 4. Each bar in the figure represents a country; the total height of a bar indicates the actual cumulative outward FDI *flows* from 2002 to 2007—or equivalently, the level increase in outward FDI *stock* from 2001 to 2007. The bars show that the rise in aggregate FDI plotted in Figure 1 was across the board, but developed countries played a more important role—for example, the U.S., the U.K., and France were the top three contributors to the increase in aggregate FDI during this period.

We structurally decompose the cumulative outflows from each country into four components. To isolate the impact of different shocks, for experiments on country i, we change only the targeted parameters of country i, keeping all other parameters of country i and parameters of all other countries at the calibrated values. In the first set of experiments, we set the sequence of λ_i to its 2001 value and solve the counterfactual transition path, one country at a time. With the calibrated λ_i 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 Subsection 3.7. The solid bars in Figure 4 demonstrate the strength of this force. The height of the solid bars indicates the decrease in cumulative outward FDI by 2007, if λ_i had stayed at the 2001 value for country i. A positive value indicates that the change in λ_i between 2001 and 2007 contributed positively to outward FDI growth. For most countries, the contribution from the change in their financial market conditions was positive, yet the importance differed. For the U.S., the U.K., and Switzerland, for example, this force alone accounted for half or more of the rise in outward FDI. For Germany, on the other hand, it mattered little. Summing across all

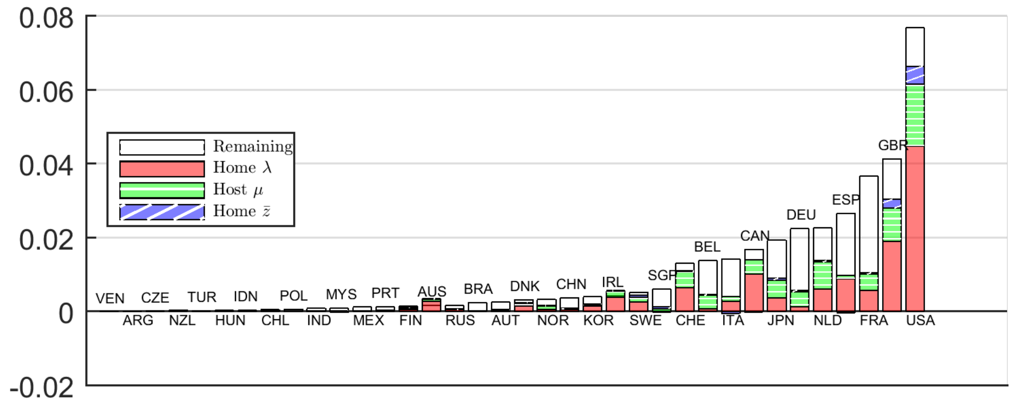


Figure 4: Cumulative Outward FDI Flows: 2002-2007

Note: The total height of a bar indicates the cumulative outward FDI flow from that country during 2002-2007. Colored bars indicate the fractions accounted for by individual channels. The U.S. 2001 GDP is normalized to one.

countries, this channel explained around half of the change in the world FDI stock during this period.

We gauge the influence of the host country's financial market conditions on FDI in the second set of experiments. For each home country i, we fix μ_h faced by its overseas affiliates to the 2001 level, and keep μ_h for affiliates from $i' \neq i$ at the calibrated series. This exercise captures the impact on FDI through the 'pull' force of easing credit access in a host country. The striped bars in Figure 4 show that, by making it easier for parent firms to rely on financing from the host country's 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 factors played a more important role than domestic ones. This reflects that their major destination countries experienced a credit boom.

In the last set of experiment, we explore the influence of the growth in domestic productivity on outward FDI. The shaded bars indicate the importance of this channel. As shown the importance differs significantly across countries. For the U.S., domestic productivity growth played a non-trivial role; this was not the case in many European countries, such as Spain. This heterogeneity primarily reflects the difference in productivity growth rates across countries.

The uncolored bars in the figure are the remaining cumulative FDI outflows during this episode after deducting the aforementioned channels from the total cumulative FDI outflows. This term encompasses the interactions among countries and the changes in the investment and FDI return wedges, which are not formally modeled and could be driven by policy, technology, or model misspecification.

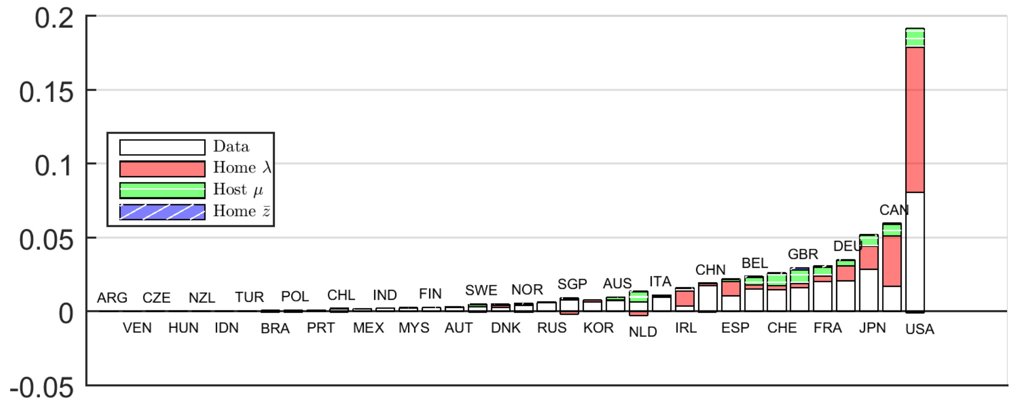


Figure 5: Cumulative Outward FDI Flows: 2008-2012

Note: The uncolored bars indicate the factual cumulative outward FDI flows for each country during 2008-2012; the colored bars indicate the predicted additional outward FDI from individual channels. The U.S. 2001 GDP is normalized to one.

5.2 FDI growth slowdown, 2008-2012

We now turn to the credit crunch episode during and after the financial crisis. As before, we perform three sets of experiments, each focusing on one of the three sets of structural parameters, λ_i, μ_h, and $\bar{z}_i$. In each experiment, we feed in the calibrated values of one target parameter for one country until 2007 and then keep it constant afterward, while letting other parameters evolve as in the baseline model. The questions posed are slightly different from before—instead of asking how much each factor can explain the actual change in FDI, we now ask, for example, how much more outward FDI flows we would have seen, if λ_i had stayed at the 2007 peak value for a country.[32]

The results are shown in Figure 5. The uncolored bars are factual cumulative FDI outflows during 2008-2012. The solid bars show the additional outward FDI from country i, if λ_i stayed at the value of 2007 in subsequent years. Eliminating the credit crunch doubles outward FDI from the U.S. and Spain and increases it by more than 30% for some other developed countries. In places where the financial market was less affected by the crisis, such as China, this counterfactual barely made any difference.

The stripped bars show that the disruptions in the financial market of destination countries reduced the incentive for foreign MNCs to invest. As the biggest sending country of FDI, the U.S. was affected the most, but this channel was also important for Netherlands, Switzerland, and the U.K.—a significant share of overseas investment from these countries went to other EU countries, which were severely hit by the crisis. Finally, the

[32]An alternative exercise is to construct a counterfactual path on which FDI keeps the same speed of growth as extrapolated from before, and then decompose the slowdown—the difference between this counterfactual and the data—into various factors. We do not conduct this exercise because there are infinitely many combinations of shocks that generate the counterfactual path.

Table 7: Diff-in-Diff Estimate of Home Financial Development on Outward FDI

	Data		Model	
	(1)	(2)	(3)	(4)
$\Delta \ln(\text{Credit/GDP})$	0.698***		0.383***	
	(0.155)		(0.103)	
$\Delta \ln(\lambda_i)$		0.291**		0.284***
		(0.129)		(0.052)
Year FE	yes	yes	-	-
Observations	364	364	396	396
R^2	0.205	0.194	0.373	0.549

Note: The dependent variable is the yearly change in log outward FDI stock. The independent variables are the yearly change in the credit over GDP ratio or λ_i. Columns 1 and 2 are estimated based on the actual data. Columns 3 and 4 are estimated based on model counterfactuals, where variables are constructed by taking log difference between their benchmark and counterfactual values and then first-differenced.
Standard errors (clustered by country) in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

shaded bars show that domestic productivity growth, which slowed down during this period in most countries, had negligible impacts on outward FDI.

5.3 Comparison with diff-in-diff estimate

We validate the overall dynamic implications by showing that the diff-in-diff estimates for the impact of the home country's financial market conditions on outward FDI, based on the variations generated from counterfactual experiments, are comparable to the estimates based on the real data.

The first two columns of Table 7 report the estimate based on the real data over 2001-2012. The dependent variable is the log of outward FDI stock. The independent variables are the credit over GDP ratio and the calibrated λ_i. Both dependent and independent variables are first-differenced and the year fixed effects are controlled for. The estimates suggest that the home country's 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 the credit over GDP ratios than when they are measured using the calibrated λ_i.

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 baseline economy and the counterfactual economy with λ_i altered as described before. Regressing the difference in outward FDI on the difference in the home country's financial market conditions is thus a diff-in-diff estimate in which each country is compared against its own counterfactual outcome. We find that the elasticities for the credit over GDP ratios and (especially) λ_i are close to those reported in Columns 1 and 2. In this sense, though not targeted directly, the model is able to account for the partial-equilibrium effects of the changes in financial market conditions on FDI dynamics.[33]

5.4 The importance of general equilibrium effects

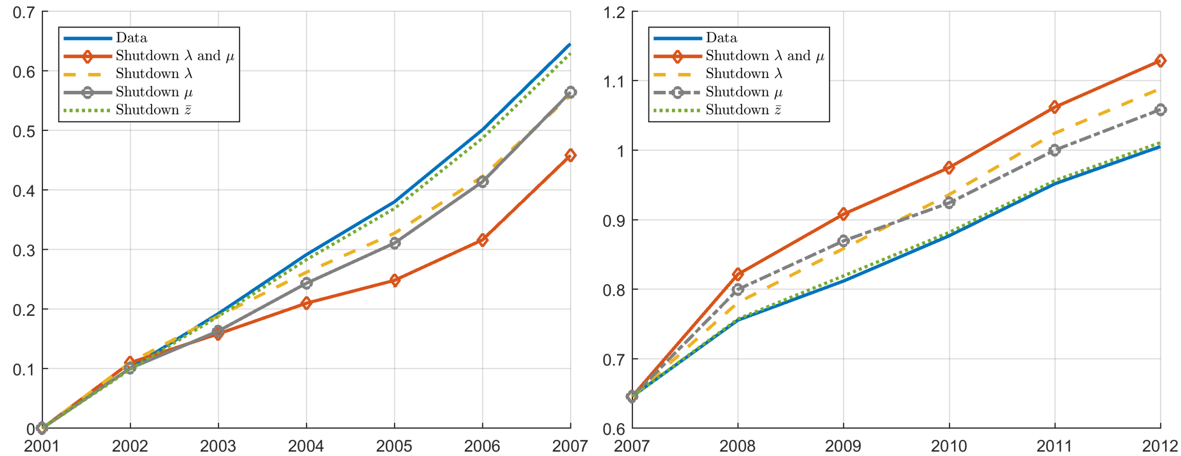
Taking stock, the counterfactual exercises show that the financial market conditions can have significant impacts on the dynamics of outward FDI from individual countries. Country heterogeneity notwithstanding, if we sum across all countries in Figures 4 and 5, financial factors can explain more than half of the cumulative FDI outflows during 2002-2007; if the access to credit had remained at the peak level of 2007, the cumulative FDI outflows during 2008-2012 would almost double. Moreover, the over-time variations generated from these counterfactuals are in line with empirical evidence. We now turn to the impact of the changes in world-wide financial market conditions on aggregate FDI .

Figure 6a plots the results for the aggregate cumulative FDI flows between 2002-2007 as a share of the 2001 FDI stock (or equivalently, the growth in FDI stock since 2001). The solid line is the data. The solid line marked by diamonds is the counterfactual aggregate FDI, if for all countries, μ_h and λ_i are kept at their respective 2001 values. In line with findings from the country-specific experiments, absent the credit boom, the aggregate FDI would have grown by less. The difference between the blue and red lines accounts for about one third of the cumulative FDI flows during this period.

The dashed line and the solid line marked by circles focus on the two subcomponents of the credit boom that matter for the parents and affiliates, respectively. These two subcomponents contributed about equally to the growth in overall FDI—without either subcomponent, the cumulative FDI flows during 2002-2007 would have been one-sixth lower. In contrast, the growth in fundamental productivity had a negligible effect, as shown by the dotted line.

Figure 6b plots the corresponding results for 2008-2012. In each counterfactual scenario, we feed in the calibrated sequences of parameters until 2007 and keep the relevant set of parameters constant in subsequent years. The solid line is the data. The solid line marked with diamonds shows that, if λ_i and μ_h had all remained at their peak values in 2007, the cumulative world FDI flows would have been higher by almost 40%. The

[33] Although the model matches the data perfectly on bilateral FDI flows and credit over GDP ratios, it is *not* by design that the coefficients from model-based regressions are close to those from the data. In the model-based regressions, the comparison is *within* country, between the calibrated value (the data) and the counterfactual outcome.



(a) 2001-2007

(b) 2008-2012

Figure 6: Log Aggregate FDI Stock: Data and Counterfactuals

Note: The figures plot log aggregate FDI stock in the sample countries under different scenarios. The left panel is for 2001-2007; the right panel is for 2008-2012. The stock in 2001 is normalized to one.

dashed line and the line marked by circles decompose this effect into those of λ_i and μ_h, respectively. We find that both forces were quantitatively relevant, but toward the end of the period, the deteriorating access to credit for parents (captured by changes in λ_i) mattered slightly more. Finally, changes in fundamental productivity had a very minor impact on the aggregate FDI.

Together, the exercises demonstrate that the financial market conditions are a first order determinant of the world FDI—credit expansion explained up to a third of the increase in the world FDI before 2007; absent the credit crunch, the cumulative FDI flows between 2008 and 2012 would have been 40% higher. While still important, the magnitude of the aggregate effect is much smaller than the sum of impacts across country-specific experiments. In Appendix C.3, we decompose the difference and show that the domestic general equilibrium effect—for example, an increase in the U.S. direct investment in Germany crowds out German domestic investment—and the third country effect—the same investment also crowds out Japanese investment in Germany—each explains about half of the difference. Such interaction among countries through the general equilibrium effects highlights the need to analyze MNC activities in a multi-country framework capable of accounting for the rich heterogeneity in the data.

6 Welfare Analysis

We have shown that recognizing financing as an integral part of MNC decisions is important in explaining the dynamics of FDI. This section argues that viewing MNCs as a combination of technology and capital in a world with financial frictions also gives substantially different answers to the old question of how large are the gains from FDI. Following a growing literature on the gains from trade and MP (e.g., Arkolakis et al., 2012), we demonstrate this through the ex-post effect of a policy change.

6.1 Static effect

Our analysis proceeds in two steps. In the first step, we consider the static effect of international integration and compare it to existing studies. Characterizing analytically the broad impact of a general policy is difficult. Instead, the following proposition focuses on the wage effect of a specific policy change, which liberalizes inward FDI while keeping outward FDI restricted.

Proposition 2. *Assume the wealth share distribution in host country h follows a Pareto distribution with scale parameter $z_m > 0$ and tail index $\gamma > 1$, that is,*

$$\hat{\phi}_h(z) = \gamma z_m^{\gamma} z^{-(1+\gamma)} \quad \forall z \geq z_m,$$

and that outward FDI from country h is prohibited.[34] *Then the contemporaneous change in workers' wages in country h in response to a change in inward FDI policy is:*

$$\Delta \log(w_h) = -\alpha \Delta \log\left(\frac{Y_{hh}}{Y_h}\right) + \alpha \frac{\gamma - 1}{\gamma} \Delta \log\left(\frac{K_{hh}}{W_h}\right), \tag{14}$$

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

The thought experiment considered in Proposition 2 is between two equilibria with different degrees of *inward* FDI, which could be implemented by, for example, an increase of $\bar{\eta}_{ih}, i \neq h$ for host country h. Besides the restriction on outward FDI, the thought experiment needs not to impose whether the credit market in country h is integrated with the rest of the world, or whether the status of integration is modified by the policy.

Equation (14) shows that the wage effect is summarized by sufficient statistics with two components. The first, $\frac{Y_{hh}}{Y_h}$, depends only on the MP share. This ratio captures the *direct* effect of openness on wages without taking into account general equilibrium

[34] These assumptions are maintained only for Equations (14) and (15). None of the other results depend on these assumptions. The former is an equilibrium outcome if the productivity process is i.i.d. and follows Pareto distribution, as in, e.g. Itskhoki and Moll (2019); the latter holds if a policy restriction makes the return from operating overseas too low, e.g., if $\bar{\eta}_{hh'} = 0, \forall h' \neq h$. The restriction on outward FDI is a strong one, but it allows us to focus on inward FDI as a benchmark. We derive the proposition assuming not all firms choose to be active in both equilibria.

responses—assuming domestic firms do not respond to entry of foreign firms, the total output (hence the labor demand) would be scaled up by a factor of $\frac{Y_h}{Y_{hh}}$. Given the labor demand elasticity α, the resulting increase in log wage is therefore $-\alpha\Delta\log(\frac{Y_{hh}}{Y_h})$. In addition to the direct effect, by pushing up domestic factor prices, the entry of foreign firms drives out domestic producers, so the increase in log wage is less than $-\alpha\Delta\log(\frac{Y_{hh}}{Y_h})$. The second component, $\frac{K_{hh}}{W_h}$, the ratio between the total capital used in local firms and the total domestic wealth, captures exactly this offsetting force. A decrease in this value means that domestic firms as a whole use less capital, and thus a stronger crowd out effect and a smaller wage gain.[35]

Proposition 2 readily shows that the productivity of foreign affiliates and their sources of financing matter. Given the MP share, if foreign affiliates have a smaller presence in the domestic credit market, either because they are very productive so they use very little capital to begin with, or because they are mostly financed by foreign parents via FDI, the wage gain would be higher.

The crowd out effect operates through both higher wages and interest rates, and $\frac{K_{hh}}{W_h}$ captures both channels. In the special case that country h is a small open economy such that the policy change does not affect the interest rate, Equation (14) reduces to:

$$\Delta\log(w_h) = -\frac{\alpha}{1-(1-\gamma)(1-\alpha)}\Delta\log\left(\frac{Y_{hh}}{Y_h}\right). \tag{15}$$

In this case (see Appendix B.2.5 for the proof), $\frac{Y_{hh}}{Y_h}$ is sufficient for inferring the static wage impact. Because this term includes both the direct effect and the crowd out effect led by the wage increase, the elasticity now depends on both the capital share α and the productivity distribution parameter γ.

Comparison to the technology-based view of MP In the technology-based models of multinational production, MP shares are sufficient for the ex-post welfare evaluation. For example, in Ramondo (2014), and Ramondo and Rodríguez-Clare (2013), the gains from MP are akin to Equation (15), in which the elasticity depends on the degree of heterogeneity in firm productivity. Our model departs in two ways. First, outside the small open economy case, conditional on MP shares, how foreign affiliates achieve their shares of production—whether by being more productive or by being larger—matters, as this determines the crowd out effect on domestic firms. Second, in the case of the small open economy, the elasticity of wage gains with respect to the MP share depends on the joint

[35]Because the strength of this force depends on domestic firms' willingness (their productivity) and capacity (their net worth) to expand, the joint distribution of productivity and net worth matters. This channel could be entirely captured by $\Delta\log(\frac{K_{hh}}{W_h})$ under the Pareto distribution assumption, with the corresponding elasticity dependent on the tail parameter γ of the Pareto distribution.

distribution of productivity and net worth and the capital share in production, not the elasticity of FDI with respect to investment returns (i.e., parameter θ).[36]

Comparison to the neoclassical view of FDI Consider instead following a neoclassical tradition that views FDI purely as the movement of physical capital (Mundell, 1957; Feldstein, 1995). For concreteness, we focus on a simple setting in which there is a representative aggregate firm with the same Cobb-Douglas production function. The equilibrium wage in host country h is determined by

$$w_h = (1-\alpha)\left(\frac{A_h K_h}{L_h}\right)^{\alpha}, \tag{16}$$

where A_h is the aggregate productivity and K_h is the aggregate capital in use. Given constant L_h, the wage change in this model between any two equilibria is:

$$\Delta \log(w_h) = \alpha \Delta \log(A_h) + \alpha \Delta \log(K_h). \tag{17}$$

Through the lens of the neoclassical model, in response to FDI inflows, $\Delta \log(A_h) = 0$, so the net wage change is proportional to the change in capital used in the economy as a result of the policy change: $\alpha \Delta \log(K_h)$.

To see how far off this estimate is, Appendix B.2.6 shows that the wage change in our baseline model also follows Equation (17), with K_h defined as the total capital used across all domestic and foreign firms in country h, and A_h defined below as the capital-weighted productivity of these firms:

$$A_h = \sum_i \int_0^{\infty} \frac{\hat{k}_{ih}(z)\psi_{ih}(z)}{K_h} \tilde{z}_{ih}(z) dz. \tag{18}$$

Because the entry of foreign firms may improve A_h both directly by bringing in more productive technology and indirectly through improving domestic allocative efficiency, the neoclassical view may underestimate the wage gain.

We quantify this bias through a perhaps extreme experiment in which country h bans foreign affiliates from operations in 2001 by setting the inward investment wedge $\eta_{ih} = 0, \forall i \neq h$. The experiments are conducted for one country at a time. We then measure the static gain from inward FDI as the change in log wage from the counterfactual equilibrium to the benchmark and decompose it according to Equation (17). The first three columns in Table 8 present the results. The first column is the share of production by foreign affiliates. The second column is the wage gains from inward FDI. Unsurprisingly, the

[36] This is related to a recent discussion in the international trade literature that different models might deliver the same formula for the ex-post welfare gains, but imply different theory-consistent estimate of the trade elasticity. See, e.g., Arkolakis et al. (2012).

inferred wage gains are tightly connected to the MP shares in the first column. The third column reports the fraction of the wage change contributed by $\alpha\Delta\log(A_h)$ in the decomposition equation, which we label as the technology channel. On average, this channel accounts for more than half of the wage gain, so treating FDI as simply another form of capital flow significantly underestimates the inferred static gain.

The importance of the technology channel is heterogeneous across countries, ranging from 15% for Switzerland to about 93% for India. Such heterogeneity arises because host countries differ in own their productivity and in where they receive investment from. In general, countries already with productive firms benefit less from the technological channel, while the opposite is true for developing countries.

6.2 Dynamic implications

The static analysis centers on the contemporaneous impact of inward FDI on wages in the host country, holding the size and productivity distribution of domestic firms constant. Both objects, however, evolve endogenously over time, leading to a dynamic impact. In the second step of the welfare analysis, we show that the full dynamic wage impact differs substantially from the static effect and the predictions of exiting models.

We consider two sets of counterfactual experiments for each country. The first set corresponds to a straightforward thought experiment in which inward FDI is shut down for all periods. In particular, we choose a host country h and solve a counterfactual transition path setting $\bar{\eta}_{ih} = 0, \forall i \neq h$ for all model periods. We then calculate the sequence of dynamic wage gains as the percentage change in wages from the counterfactual transition path to the baseline. The second set of experiments aims to recover the wage gains that would be inferred from a static model period by period. In particular, we solve the counterfactual equilibrium setting $\bar{\eta}_{ih'} = 0, \forall i \neq h$ for a single period t, assuming that prior to t, the economy evolves exactly as in the benchmark. We then calculate the static wage gain as the percentage change in wages moving from the counterfactual economy to the benchmark in period t. We collect the static gains calculated this way for each $t \in \{2001, 2002, ..., 2012\}$ to construct the sequence of static gains.

Figure 7 plots the sequences of dynamic and static gains for Hungary, a country with median wage gains in our sample. As shown, at the beginning of the sample period, the static wage gain from FDI was around 8%. Driven by the influx of foreign investment after the EU accession in 2004, the wage gain rose to around 12%, before decreasing again to around 10% after the financial crisis. The dynamic wage gains in general were below the sequence of the static gains except for 2001. The difference increased initially and then stabilized at around 5 p.p. Table 8 shows that the lower dynamic gains are not specific to

Table 8: Static and Dynamic Wage Gains

	Decomposition of the Static Gains in Year 2001			Comparison Between Static and Dynamic	
	(1)	(2)	(3)	(4)	(5)
ISO	MP Share	$\Delta \log(w_h)$	$\Delta \log(A_h)$ fraction (%)	Static: Average	Dynamic: Average
ARG	0.13	0.05	49.25	0.07	0.05
AUS	0.21	0.08	57.85	0.09	0.06
AUT	0.09	0.03	33.66	0.04	0.03
BEL	0.48	0.17	22.39	0.18	0.14
BRA	0.13	0.05	71.09	0.05	0.03
CAN	0.29	0.12	54.79	0.16	0.10
CHE	0.22	0.08	14.82	0.12	0.09
CHL	0.26	0.11	57.78	0.12	0.07
CHN	0.09	0.04	88.67	0.06	0.03
CZE	0.11	0.04	56.80	0.04	0.03
DEU	0.09	0.04	54.40	0.04	0.03
DNK	0.09	0.03	28.28	0.05	0.03
ESP	0.09	0.03	41.50	0.03	0.02
FIN	0.08	0.03	38.02	0.05	0.04
FRA	0.15	0.06	42.80	0.05	0.03
GBR	0.27	0.11	40.66	0.12	0.08
HUN	0.19	0.08	50.43	0.09	0.06
IDN	0.21	0.09	86.27	0.05	0.03
IND	0.07	0.03	93.43	0.03	0.02
IRL	0.86	0.51	3.06	0.40	0.21
ITA	0.04	0.01	37.85	0.02	0.01
JPN	0.02	0.01	49.00	0.01	0.01
KOR	0.05	0.02	54.79	0.02	0.01
MEX	0.16	0.07	63.14	0.08	0.05
MYS	0.17	0.07	61.17	0.08	0.05
NLD	0.69	0.33	18.63	0.45	0.35
NOR	0.15	0.06	27.46	0.05	0.03
NZL	0.37	0.17	51.69	0.16	0.09
POL	0.17	0.07	65.06	0.11	0.07
PRT	0.08	0.03	43.64	0.04	0.03
RUS	0.02	0.01	78.94	0.03	0.02
SGP	0.39	0.18	34.99	0.19	0.13
SWE	0.13	0.05	29.76	0.09	0.07
TUR	0.06	0.03	62.41	0.03	0.02
USA	0.08	0.03	43.09	0.03	0.02
VEN	0.08	0.03	52.61	0.03	0.02
Mean	0.13	0.08	48.89	0.09	0.06
Std	0.18	0.10	20.37	0.09	0.07

Note: Column 1 is the foreign share of domestic production. Columns 2 and 3 report the static wage gain from inward FDI in our model and the fraction accounted for by the increase in aggregate productivity. Column 4 reports the average of static gains between 2001 and 2012. Column 5 reports the average of dynamic gains between 2001 and 2012.

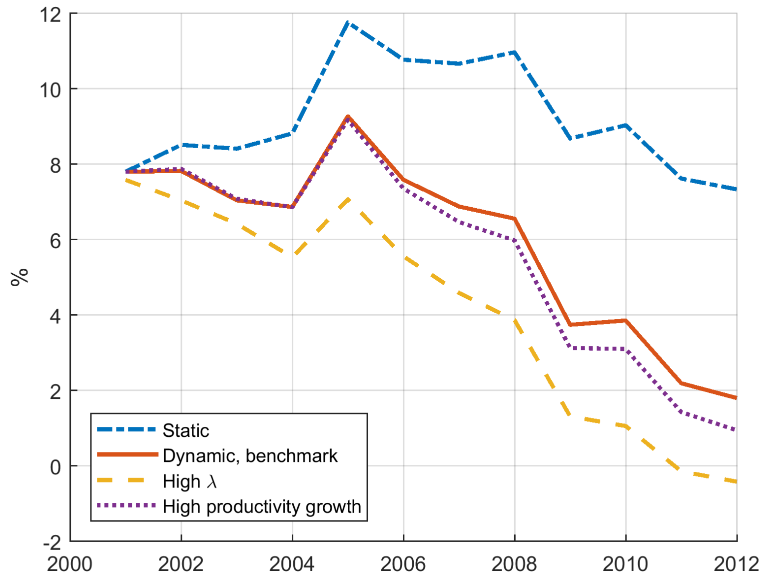


Figure 7: Wage Gains Under Counter-factual Primitives, Hungary

Note: High λ: dynamic gains when λ_{HUN} is set two standard deviation higher. High productivity growth: dynamic gains when the growth rate of $\bar{z}_{\text{HUN}}$ is set two standard deviation higher.

Hungary—the last two columns report the average static and dynamic wage gains over 2001-2012 for each country.[37] The average dynamic gain is around 30% smaller than the average static gain.

Two channels drive the decrease in wage gains over time. The first is a domestic capital accumulation channel—by pushing up the wages, foreign affiliates drive the marginal domestic firms out of the market and reduce the profits of continuing firms. This slows the accumulation of net worth by domestic firms, which, with the presence of financial constraints, reduces capital that can be used in production. Second, in a model with heterogeneous productivity and financial frictions, the entry of foreign firms also affects the capital allocation across domestic firms and thus the aggregate productivity. When foreign firms enter, on impact, unproductive domestic firms exit, releasing factors to more productive firms, so the aggregate productivity increases. This selection effect, however, dissipates gradually—with higher wages, the return difference between productive and unproductive firms narrows. As a result, among active firms, the share of net worth owned by the most productive gradually declines, so the gain from allocative efficiency deteriorates.

Through the two channels, the wage increase induced by the entry of foreign firms has a negative dynamic effect on the size and productivity of domestic firms. The magnitude

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

of this dynamic crowd out effect depends on the fundamentals of the domestic economy. To further understand this, we conduct a series of experiments by changing the primitives of one host country at a time, and calculating the dynamic gains as before.[38] We focus on the financial development parameter λ_i and the growth of fundamental productivity $\bar{z}_i$, as they have direct data counterparts and are what differentiate countries in the model.

The last two lines in Figure 7 plot the results for Hungary. The dotted line is the counterfactual dynamic wage gains when we increase the annual growth rate of the domestic fundamental productivity, $\bar{z}_{\text{HUN}}$, by 5% throughout the period, which is equivalent to two standard deviations of the variable in our sample countries. The dashed line denotes the counterfactual path when λ_{HUN} is increased by 0.76 (two standard deviations of λ_i). In both scenarios, the dynamic gains are smaller compared to the baseline experiment. In the model, better financial development leads to faster accumulation of net worth by domestic firms and more efficient capital allocation over time; a higher growth rate in productivity directly leads to faster growth of all domestic firms. Both imply that absent competitions from foreign firms, the domestic sector could have grown more rapidly. Precisely because of this higher growth potential in autarky, by reducing the market share of the domestic sector, the entry of foreign firms will lead to a larger crowd out effect.

The dynamic crowd out effect is potentially significant. As Figure 7 shows, for Hungary, the wage change will eventually drop below zero, implying losses to domestic workers. In that case, restricting foreign entry could be welfare improving, since it helps domestic firms, which are financially constrained and will be productive in the future, accumulate wealth in their early stages.[39]

A natural question is, then, after the initial period, as the size and productivity of the domestic sector gradually fall, why are there not enough additional foreign entrants to bid up wages. There are two reasons. First, in the model, the elasticity of foreign entry in response to a decrease in domestic wages is finite (determined by parameter θ of the multivariate Pareto distribution). This elasticity reflects a key difference between FDI and portfolio investment—because FDI is tied to technology and the same technology might have different 'match qualities' across host countries, the number of firms responding to a small change in the host production cost is limited. Second, conditional on entering

[38]That is, in each experiment, we calculate a benchmark equilibrium after changing the fundamental parameter of a host country. Starting from this alternative benchmark, we shutdown inward FDI and calculate the dynamic wage gains.

[39]We focus on the effects on wages instead of 'aggregate welfare' because measuring the latter requires taking a stand on the Pareto weights put on domestic entrepreneurs. Because the diminishing dynamic wage gains are due to the wealth accumulation by domestic entrepreneurs being slowed down, if we assign any positive Pareto weights to the entrepreneurs, or if we use GDP or GNP to measure welfare, the aggregate welfare is also likely to fall over time. An analysis of optimal policy is beyond the scope of this paper. See Itskhoki and Moll (2019) for a study of optimal policy in a closed-economy setting with firms facing financial constraints that features similar dynamic crowd out mechanisms.

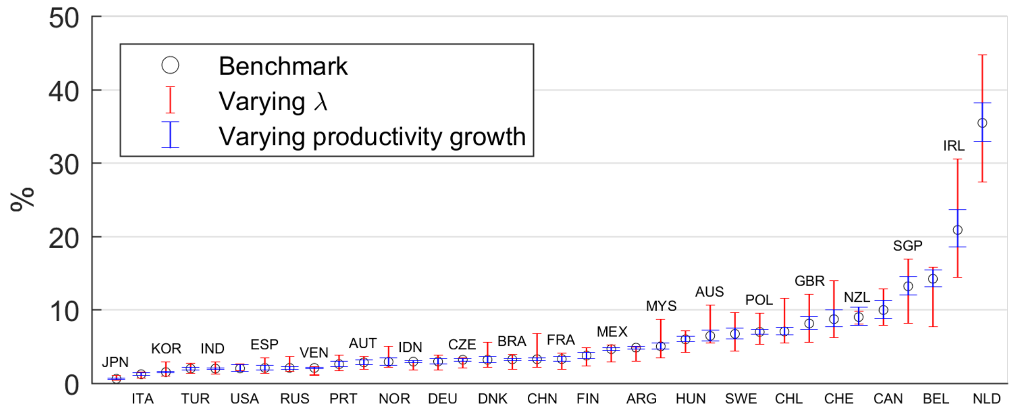


Figure 8: Average Dynamic Wage Gains under Counterfactual Primitives

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

into the host market, the labor demand from foreign affiliates is constrained by capital brought by their parents. This reflects our modeling of FDI as within-firm capital movement which arises due to capital market imperfections. It turns out that these two channels, disciplined by the data and the general equilibrium structure of our model, imply that long-run wage losses are possible.[40]

The case study on Hungary shows that ignoring differences in the host country's fundamentals biases the estimate of the dynamic gain. To gauge the biases across countries, Figure 8 summarizes the dynamic gains from experiments in which fundamentals for each host country are altered. The circles denote the average dynamic wage gains in the baseline that corresponds to Column (5) of Table 8. The intervals denote the range of dynamic wage gains as we vary host country h's financial development parameter λ_h from $\lambda_h - 0.76$ to $\lambda_h + 0.76$, and the growth rate of its fundamental productivity ($\bar{z}_h$) from the baseline to plus and minus 5%. What stands out is the wide range of possible outcomes, especially as we vary λ_h. For Malaysia and Austria, for example, the upper end of the range is about twice as much as the baseline values; for Mexico, on the other hand, the baseline value is close to the upper end, but much higher than the bottom of the range. Overlooking heterogeneity in fundamentals could severely bias welfare assessments. The broad message that the dynamic effects are both time-dependent and highly heterogeneous, raises important caveats in interpreting reduced-form estimates of FDI on growth.

[40]Indeed, if we assume θ is infinite (so FDI acts like homogeneous capital flows), or that foreign affiliates can scale up in the host country infinitely, then dynamic wage losses would never arise.

The mechanism for dynamic welfare gains discussed here should be distinguished from a seemingly similar mechanism related to international capital market integration. For example, Gourinchas and Jeanne (2006) argues that the gains from capital inflows are small for developing countries, because without capital inflows, domestic households can catch up fast with capital accumulation. The dynamic mechanism discussed here differs in two aspects. First, throughout the quantitative exercises, we assume the world credit market is fully integrated and focus on frictions that affect direct investment only. Because developed countries also receive direct investment, the mechanisms for both static and dynamic welfare gains apply to all countries in our model, as opposed to only capital-scarce countries in the neoclassical model. Second, the strength of the dynamic adjustment in our model is heterogeneous and depends on country characteristics, which is not captured by a conventional neoclassical model.

Combining the static and dynamic effects, our model paints a subtle picture on how financial development in a host country determines welfare gains. Countries with better financial market benefit more in the short run because they attract more FDI and allow foreign affiliates to operate at a larger scale, but less in the long run, precisely because with a well-functioning financial market, domestic firms are already set up for rapid growth.

7 Final Remarks

Systematic relationships exist among MP, FDI, and the financial market conditions of the host and home countries. A parsimonious model that respects these relationships generates new predictions on the determinants and welfare consequences of MNC activities. First, the financial market conditions during 2001-2012 were a first order factor in determining aggregate direct investment (hence MP) during this period. Second, the wage gains from MNC activities are large but declining over time and potentially negative, with the dynamic responses depending crucially on the host country's fundamentals. Two common views of MNCs, either only as a vehicle for technology or only as a movement of capital, are silent on the role of financial market conditions as determinants of FDI, and do not capture the full welfare effects.

This paper abstracts from a number of elements that can be incorporated to answer related questions. On the positive side, recent studies have shown that MNCs play a heterogeneous role for international transmission of productivity shocks (Cravino and Levchenko, 2017). Our model can be readily used to examine their importance in the transmission of financial shocks. On the normative side, an important next step is to incorporate technological spillovers from foreign plants and quantify their roles. In light of our findings on the dynamic gains, this seems a particularly important channel for countries that already have a well-functioning capital market to reap the long-run benefits.

More broadly, we view this paper as a step toward analyzing direct and portfolio investments in a unified setting. For simplicity, we have treated the bond market as perfectly integrated. Relaxing this assumption might yield additional insights on the interaction between MP and bond market integration, during both normal times and cycles. We have also deliberately kept the household sector simple. Extending the model to incorporate household savings would allow it to match the dynamics and compositions (FDI versus portfolio) of capital flows. Such an extension can then be used to study the differences and interactions between the two types of capital flows and the effects of capital control policies that treat them differently.

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