

Multinational Expansion in Time and Space*

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Abstract

This paper examines how the activities performed by multinational firms change over their life cycle, with the goal of quantifying the frictions to multinational expansion. Using a long panel of U.S. multinational firms, we document three facts: first, the ratio of affiliate-to-parent sales grows very little over the life cycle of the affiliate; second, affiliates are born specialized in their life-long main activity, which is usually serving the host market of operations, and start exporting later in life at low intensity; third, the location choice of a MNE's new affiliates does not depend on the location of pre-existing affiliates. Informed by these facts, we propose a quantitative dynamic model of multinational activity that features heterogeneous firms, persistent aggregate productivity shocks, and a rich structure of costs of multinational activity and affiliate exports. The model delivers qualitative testable implications that are consistent with the data. Quantitatively, the calibrated model sheds light on the nature of the costs of multinational activity.

JEL Codes: F1. Key Words: Multinational firms, Foreign direct investment, Firm dynamics, Sunk costs.

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1 Introduction

Multinational enterprises (henceforth, MNEs) are complex production structures engaged in different activities worldwide, and as such are the largest players in the global economy. In 2009, 75 percent of U.S. sales to foreign customers (nearly US\$5 trillion) was accounted for by the sales of foreign affiliates of U.S.-based multinationals, rather than by sales of domestically produced goods.¹ Additionally, affiliates' exports represent one third of world exports, and also one third of their total sales, according to UNCTAD (2013)'s estimates. Similar magnitudes are reported by the Bureau of Economic Analysis (BEA) for foreign affiliates of U.S. MNEs: in 2009, majority-owned foreign affiliates of U.S. MNEs accounted for US\$4.6 billion in sales, forty percent of which were exports, *i.e.* directed to customers outside the host market of operation.

A frequently overlooked aspect in the analyses of the MNE and its affiliates is their dynamic behavior, primarily because the data requirements are large. Consequently, questions about the activities of MNE affiliates and their evolution through time have been barely addressed in the literature. Yet, the answers to these questions are key to dissecting the nature of the costs of multinational activity: whether these costs are country and/or activity dependent, and whether variable, fixed, or sunk costs are relatively more important. In turn, understanding the nature of the costs of multinational activity can be crucial for the quantification of the gains from openness arising from MNEs operations.

This paper fills the gap in the literature first by documenting salient features of the life-cycle behavior of U.S.-based MNEs and of their affiliates, and second by presenting a tractable dynamic model of MNE activities amenable to quantitative analysis.

Using a panel of U.S. multinational firms over 25 years from the U.S. BEA, we classify MNE affiliates' activities as horizontal (directed to the host market) or exports (directed to other markets). We document three facts about the behavior of MNEs over time. First, the ratio of affiliate-to-parent sales is relatively flat over the affiliate life-cycle, particularly when compared with the same magnitude for new exporters. Second, affiliates of U.S. multinational firms tend to specialize in a core activity at birth, typically horizontal sales, which persists as the main activity during the life cycle. Some diversification from horizontal to export activities is observed later in life, with exports remaining secondary in terms of their share of affiliate sales. Third, the location choice of a MNE's new affiliates does not appear to depend on the location of pre-existing affiliates, or – in other words – the pattern of affiliate opening does not display extended gravity, opposite to what

¹See Antràs and Yeaple (2014) for a detailed survey of the main facts and theories about multinational firms.

we observe for firms adding new export destinations.²

Motivated by the facts, we present a dynamic model of the multinational firm that builds on elements from Fillat and Garetto (2015) and Fillat et al. (2015). We model a set of Home-based firms that must decide whether, how, and when to serve foreign markets through affiliate sales. Multinational activities are treated as a real option for the firm, which gets exercised once an affiliate opens abroad. Affiliate sales entail fixed and sunk costs of production, and the decisions of setting up an affiliate and of exporting from it are shaped by the interaction of firms’ individual productivity, persistent aggregate productivity shocks, and demand conditions in foreign markets. Guided by the observation that almost all firms in our sample have horizontal activities, we assume that firms that decide to do Foreign Direct Investment (FDI) must first set up an affiliate and sell to the local market, and only then they can consider exporting from that affiliate. The model is set up in continuous time, so that those two decisions —opening an affiliate and exporting from it— can be made virtually simultaneously. In this way, the model is able to generate affiliates that are born as exporters. Additionally, the continuous time problem delivers closed-form solutions for the value functions, which are simple additive functions of the firm’s realized profit flow plus the option value of further expansion. Consistent with the lack of extended gravity that we see in the data, we assume that the decision of opening an affiliate and eventually exporting from it is independent across markets (e.g., whether a firm decides to open an affiliate in Germany and from it export to France is independent of having an affiliate in France). In this way, we avoid having to solve the complex permutational problem present in settings that model these decisions as interdependent, such as in Tintelnot (2017), and achieve tractability in the dynamic setting.

While the dynamic component of the model is built to replicate qualitatively the motivating facts described above, the cross-sectional components of the model deliver additional testable implications which are confirmed by the data. First, affiliates that both serve the host market and export have larger horizontal sales than affiliates devoted exclusively to serving the host market. This fact mimics an analogous pattern about exporters that is documented in the literature.³ In this regard, affiliates of multinational firms are not different from standard domestic firms. Second, affiliates that are exporters at birth have larger horizontal sales than affiliates that become exporters later in their life cycle. Third, there is a pecking order in the way the MNE chooses to open foreign affiliates: MNEs open first their largest affiliates, and subsequently their smaller affiliates. Finally, there is a pecking order in the way an MNE accesses markets: first affiliates are established in the largest host markets, and in markets which are easier to access, while later in

²Morales et al. (2015) document that Chilean exporters tend to export to markets that are similar to previous export destinations, and label this feature of the data “extended gravity”.

³See Bernard and Jensen (1999), among others.

life the MNE opens affiliates in markets that are smaller and costlier to access.

These cross-sectional patterns mimic the facts for non-MNE exporters documented in the literature. The main difference between exporting affiliates and non-MNE exporters is that MNE affiliates are more engaged in exports, both on the extensive and on the intensive margin. Moreover, the evidence hints to MNEs facing an array of barriers to their expansion, in particular into export markets, that are different in nature to the barriers faced by non-MNE firms, and in particular, by non-MNE exporters.

The ability of the model to generate predictions that are qualitatively consistent with the data raises our confidence in using this framework to quantify the barriers to expansion that MNEs face. To this end, we extend the model to make it amenable to quantitative analysis, by allowing MNEs to set up affiliates in any country and from them export to any destination. Thanks to the assumption whereby an MNE's affiliate location choice is independent across locations, the quantitative model preserves most of the tractability of the simple framework. The mathematical structure of the quantitative model is the one of a compound option, where opening an affiliate in a country is an option which – when exercised – gives access to a set of additional options: exporting from the affiliate to any other location. The independence assumption allows us to solve backwards for the value of the firms in this more complex case, and to use the full model to shed light on the nature and magnitudes of the costs of multinational activity. Preliminary simulations show, for instance, that a small change in the per-period cost of multinational activities can induce large reallocations on the activities of affiliates, and the effects of these changes critically depend on which type of frictions are involved, whether variable, fixed, or sunk.

Most contributions in the literature have analyzed MNEs' complex choices in static settings. As evident in the models in Arkolakis et al. (2017) and Tintelnot (2017), allowing firms to set up affiliates in countries that might differ from the destinations of their sales results in a very complex combinatorial problem when fixed costs of production are taken into account. The sharp patterns that we document, arising from the observation of affiliates over time, help to simplify this problem by reducing the choice set of firms in a way that is consistent with the data. More precisely, given that most new affiliates in the data start out as entities partially or entirely specialized in horizontal FDI, and possibly start exporting later in life, we argue that decisions about performing complex foreign activities can be separated into simple choices that happen at different points in time. This significantly simplifies the dynamic problem of the firm.

There is a large literature on export dynamics which has been concerned primarily with quantifying fixed and sunk costs of export activities and studying their welfare implications. Earlier contributions by Baldwin and Krugman (1989), Roberts and Tybout (1997), Das et al. (2007), and

Alessandria and Choi (2007) find substantial sunk costs of exporting, by focusing on observed patterns of export entry and exit. Subsequent analyses, such as Eaton et al. (2008) and Ruhl and Willis (2017), incorporate facts related to the life-cycle dynamics of new exporters and find that those costs are much lower. Alessandria et al. (2015) take a further step and also calculate the welfare gains from trade in a dynamic setting that matches well the life-cycle facts. Arkolakis (2016) presents rich micro evidence on firm selection and export growth that supports dynamic theories of endogenous entry costs *vis-a-vis* standard export sunk costs. By analyzing MNEs' dynamics and quantifying their frictions, our work complements the literature on exporters and helps making useful comparisons between the barriers to the two modes of market penetration.

There is also a small, but growing, literature on analyzing different aspects of the dynamics of MNEs that uses rich firm-level data. Ramondo et al. (2013) study the implications of the proximity-concentration tradeoff under uncertainty using BEA data. Egger et al. (2014) and Conconi et al. (2016) use data for Germany and Belgium, respectively, and claim that their findings are consistent with substantial learning. Even though these papers have rich data on the MNE behavior, they do not focus on life cycle features. Conversely, Gumpert et al. (2016), using very rich data for several countries, focus on life-cycle patterns of both MNEs and exporters, in the context of the proximity-concentration tradeoff. Our paper complements theirs as it focuses on the life-cycle of affiliates' activities, for the first time separating them across locations and sales destinations.

Finally, our paper also makes contact with the large literature on domestic firms' life-cycle dynamics, which goes back to Davis et al. (1996), and more recently Decker et al. (2014, 2015). We show that affiliates of MNEs are starkly different from domestic firms. We interpret the difference between the behavior of new U.S. firms in the domestic and foreign markets as indicative of the fact that they face different sets of costs.

The rest of the paper is organized as follows. Section 2 documents the facts about affiliates' dynamics. Section 3 presents the simple version of the model and its testable implications. Section 4 shows empirical evidence in support of the model's qualitative predictions. In Section 5 we present the quantitative model and use it to pin down the magnitudes of the costs to MNE expansion. Section 6 concludes.

2 Establishing the Facts

We document three novel empirical regularities concerning the behavior of foreign affiliates of U.S. MNEs operating in the manufacturing sector. First, sales grow slowly over the life cycle of the

affiliate. Second, affiliates are born specialized in their life-long main activity which, for the vast majority, consists of sales to the host market; affiliates only slowly incorporate export sales as a second activity and those activities that are incorporated later in life are done at a relatively low intensity. Finally, the location choice of new affiliates does not depend on the location of preexisting affiliates.

2.1 Data

Our descriptive empirical analysis is conducted using data from the U.S. Bureau of Economic Analysis (BEA). The BEA collects firm-level data on U.S. multinational companies' operations in its annual surveys of U.S. direct investment abroad. All U.S.-located firms that have at least one foreign affiliate and that meet a minimum size threshold are required by law to respond to these surveys. The data include detailed information on the firms' operations both in the U.S. and at their foreign affiliates, for the period 1987-2011. Each foreign affiliate in the dataset is assigned an industry classification based on its primary activity according to the BEA International Surveys Industry (ISI) system, which closely follows the 3-digit Standard Industrial Classification (SIC) system.⁴ We include affiliates that list an activity in manufacturing as their primary activity and belong to a U.S. parent operating in any sector. We restrict our attention to majority-owned affiliates that do not operate in tax haven countries.⁵ We further consolidate affiliates belonging to the same parent and operating in the same country and 3-digit industry.⁶ We also remove from our sample affiliates and parents with zero total sales, assuming that there is a reporting error. Finally, since we are interested in firms' life cycle behavior, we focus on *new* affiliates that open during our sample period and that survive for at least ten consecutive years in the market. We end up with a sample that covers 23.12 percent of all new affiliates in manufacturing as well as 38.27 percent of their total sales.⁷

Crucially, the BEA data break down affiliate sales by destination. Affiliate sales can be directed

⁴The BEA data use 3-digit SIC-based ISI codes for years prior to 1999. From 1999 onward, they use 4-digit NAICS-based ISI codes. For consistency, we convert the NAICS-based codes to 3-digit SIC-based ISI codes for the relevant years.

⁵The list of tax havens is from Gravelle (2015), but we keep in our sample Hong Kong, Singapore, Ireland, and Switzerland, since these are important destinations of FDI. See Appendix A for more details.

⁶Based on the BEA definition, an affiliate is a business enterprise in a given industry operating in a particular host country; it thus could operate several plants in different locations within the host country. We discuss the rationale of this aggregation in Appendix A.

⁷The sample coverage may appear limited for a number of reasons. First, we drop tax havens. Second, we only include new affiliates that open during our sample and exist for 10 years. This implies excluding any affiliates that open in 2003 or later. We also drop observations for affiliates in their 11th year or greater, to have a balanced 10 year panel.

Table 1: Summary statistics: number of observations, by sale type.

	Horizontal sales	Export sales
No. of observations	38,088	38,088
with positive sales	36,127 (94.9%)	25,950 (68.1%)
of pure type	14,030 (36.8%)	2,423 (6.4%)
of pure type at birth	19,905 (52.3%)	3,595 (9.4%)
Sales accounted by pure-type	15.62%	7.71%

Note: Observations are at the affiliate-year level, for new majority-owned affiliates that survive for at least ten consecutive years, in manufacturing. A pure-type affiliate is an affiliate for which at least 99 percent of sales are either only horizontal or only export sales.

to the host market of operation (horizontal sales), or to other markets (exports).⁸ Table 1 shows how our sample is distributed between the two types of affiliates' activities. Almost 95 percent of our affiliate-year observations have some horizontal sales, while more than two thirds of them have some exports, indicating larger export market participation than for non-MNE firms. More than one third of the observations correspond to pure-type horizontal affiliates (*i.e.*, affiliates whose sales are all directed to the host market), while the share of pure-type exporting affiliates is only six percent. These shares go up to 52 and nine percent if one considers affiliates that are born with only horizontal and export sales, respectively.

Table 1 provides our first assessment of the fact that horizontal sales are pervasive, while pure exporting affiliates are few and account for a small share of total sales. Appendix A provides more details on the BEA data, the construction and coverage of our sample, and summary statistics.

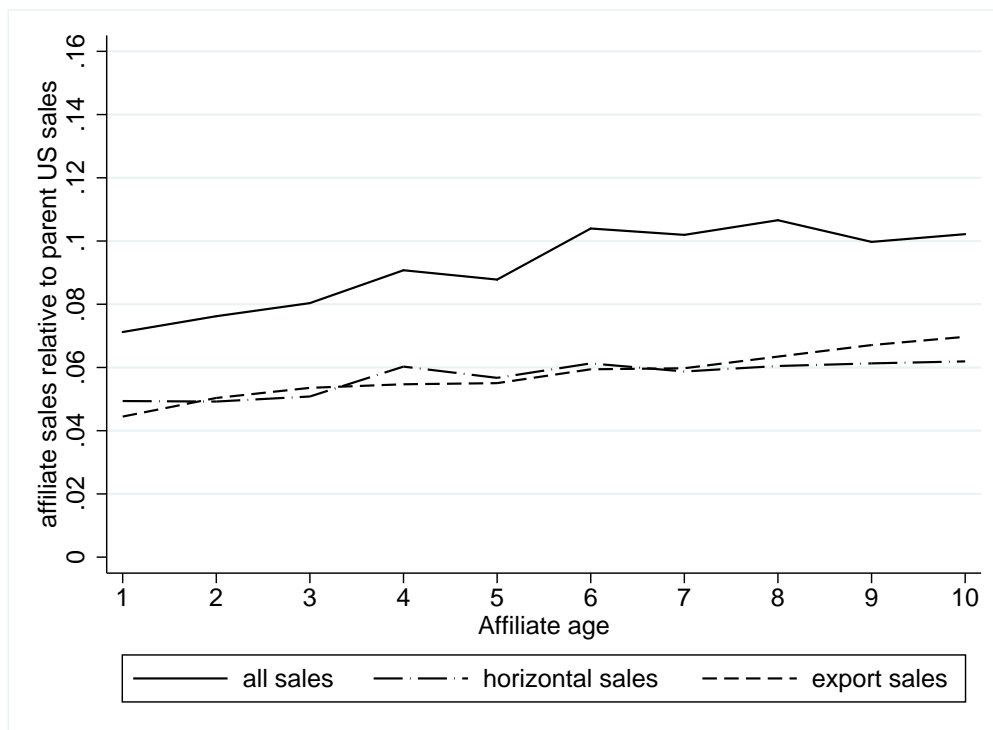
2.2 The Life-Cycle Affiliate-to-Parent Sales Ratio is Flat

Figure 1 shows the ratio of affiliate-to-parent sales, by affiliate age, for all affiliates. Sales are broken down in horizontal and export sales.

On average, new affiliates have sales volumes of about seven percent of their parent's sales. Over the first five years of life of the affiliate, this ratio goes up to about nine percent, reaching ten percent at age six and staying flat until at least the 10th year of the affiliate's life. Examining sales

⁸The data further distinguish between exports to the United States and to third markets. This distinction does not make any substantial difference for the facts presented below. We exploit the distinction among different export destination markets in the calibration.

Figure 1: Affiliate-to-parent sales ratio, by sales type.



Notes: Sample of new majority-owned affiliates that survive for at least ten consecutive years, in manufacturing. Simple averages taken over affiliates with positive sales in each category.

profiles by sale type reveals that horizontal and export sales, relative to the parent's sales, exhibit a very similar behavior in the first ten years of the affiliate's life: they grow from below five percent to more than six percent.

It is worth comparing the growth profile of horizontal sales of new affiliates with the growth profile of foreign sales for new exporters, as these two modes are the predominant ones through which firms choose to enter foreign markets. For Colombia, Ruhl and Willis (2017) report that the export-to-domestic sales share grows much faster, going from six to 14 percent in the first five years of the life of the exporter; in contrast, horizontal sales, relative to the parent's sales increase, on average, from five to six percent.⁹

The pattern observed in Figure 1 is confirmed formally by an Ordinary Least Square (OLS) regression of the affiliate-to-parent sales ratio on affiliate age, including country-year fixed effects. Results are shown in Table B.1 in Appendix B. The affiliate-to-parent sales ratio is flat not only across affiliates of different ages (i.e. including industry fixed effects), but also within affiliates (i.e. including affiliate fixed effects).

⁹Ruhl and Willis (2017) consider exporters that survive at least four years in the export market, while we consider affiliates that survive at least ten years in their market of operations.

One could argue that the flatness in the life-cycle sales profiles of MNE affiliates may be due to the fact that the affiliate “inherits” the age of the parent so that, *de facto*, it is a much older firm and hence larger and growing more slowly. This may well be happening, as documented for multi-plant versus single-plant firms in the United States by Kueng et al. (2016).¹⁰ Unfortunately, the BEA data do not record the age of the parent firm. However, we can still look at affiliates’ position in the opening sequence of the parent—in particular, first affiliates versus subsequent affiliates. In this way, we compare affiliates belonging to younger MNEs with affiliates belonging to older MNEs (or to the same MNE when it is older). Figure B.1 in Appendix B shows that first affiliates are much larger than subsequent affiliates, but they do not appear to grow faster.

A second argument is that the flat sales profiles observed for new affiliates may be due to the fact that firms acquire experience and grow in a foreign market first through exports, and only subsequently open affiliates at their optimum long-run size. Unfortunately, the BEA data do not include information about parents’ exports that can inform our analysis in this respect. Gumpert et al. (2016), however, report that for Norway and France, the difference in growth profiles for MNEs with previous export experience into a market and those without it is not significant.

A final concern is related to the mode of FDI entry. If MNEs establish foreign affiliates mostly through mergers and acquisitions (M&A), one could argue that “new” foreign affiliates are in reality pre-existing plants that likely grew previously and were acquired by the MNEs already at their maturity stage. This would explain the observed flat sales profiles. Again, Gumpert et al. (2016) show that, for Germany, new affiliates that were previously domestic firms (i.e. were established through M&A) have flatter life-cycle sales profiles than new affiliates created through greenfield FDI. The BEA data also contain information on whether affiliates are the result of M&A or of a greenfield investment. We plan to use this information to examine separately the growth profiles of these two types of affiliates in future work.

The fact portrayed in Figure 1 suggests that MNEs’ growth happens at the extensive margin (i.e. adding new markets), not at the intensive margin within a market. For this reason, the model we propose below features growth only at the extensive margin.

2.3 Affiliates are Born Specialized in their Main Life-Long Activity

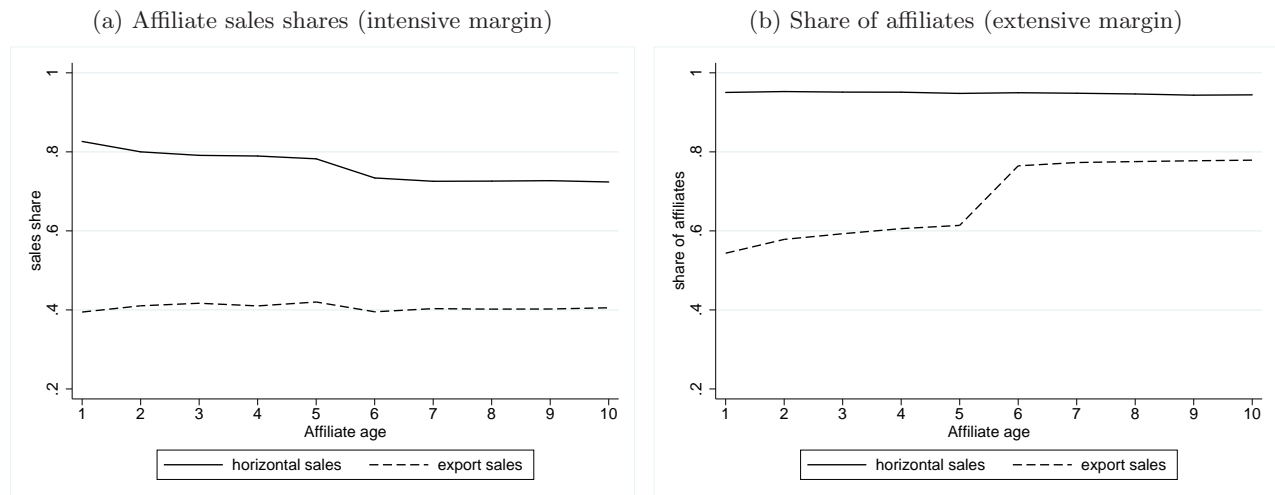
We present here evidence on the specialization pattern of affiliates in terms of horizontal versus export activities. We show that affiliates are born specialized in a core activity, typically horizontal

¹⁰Kueng et al. (2016) document a stark difference in the life-cycle employment profiles of establishments belonging to single- versus multi-unit firms in manufacturing: while establishments in single-unit firms grow steeply, the ones in multi-unit firms do not grow.

sales, that persists as the main activity later in life, even though affiliates may incorporate exports as a secondary activity.

Figure 2 shows the evolution of the intensive and extensive margins of horizontal and export sales shares. More precisely, Figure 2a shows the evolution of the mean horizontal sales share and of the mean export sales share. We include in this figure only affiliates reporting positive horizontal sales and positive export sales, respectively. On average, horizontal sales account for about 80 percent of affiliate sales and decrease by ten percentage points over the first ten years of life of the affiliate, while the export share is flat at 40 percent. To capture new affiliates that start exporting, Figure 2b plots the percentage of affiliates with non-zero horizontal or export sales, respectively. While the share of affiliates with horizontal sales is stable at more than 95 percent, the share of exporting affiliates increases from 50 to 70 percent during the affiliates' life cycle. In other words, for horizontal activities, changes in sales shares are due to the intensive margin, while for export activities, affiliates with previously zero exports are the ones contributing to the increase in export shares. Hence the data suggest that, over time, affiliates incorporate export sales into their activities, but they never stop selling in their host market.

Figure 2: Intensive and extensive margins of sale shares, by activity type.



Notes: Sample of new majority-owned affiliates that survive for at least ten consecutive years, in manufacturing. Horizontal and export sales refer, respectively, to sales to the market where the affiliate is located, and to sales to markets outside the local market. (2a): average sales, as a share of total affiliate sales, include affiliates with positive horizontal and export sales, respectively (2b): number of affiliates, as a share of the total number of affiliates, include affiliates with positive horizontal and export sales, respectively

The patterns in Figure 2 are confirmed by OLS regressions including a battery of fixed effects, as shown in Table B.2 in Appendix B. Estimates that include affiliate fixed effects suggest that, on average, horizontal (export) sales shares decrease (increase) during the life of an affiliate, and the

share of affiliates with exports is higher among older affiliates.

Appendix B reports analogous figures and regression tables for the subset of affiliates that are pure-type at birth, that is, firms that either only sell to the host market or only export on their first year of life. The results illustrate that pure type affiliates diversify their activities over the life cycle. This diversification mostly takes the form of pure-type horizontal affiliates starting exporting at some point in their life cycle. While Figure 2 illustrates a relatively low export intensity, at about 40%, Figure B.3 in Appendix B illustrates a more general relationship between the intensity at which an activity is performed and the time at which said activity is introduced: more precisely, the older an affiliate is when it starts a new activity (e.g. exporting), the lower the intensity at which that activity is performed.

The fact portrayed in Figure 2 motivates another convenient feature of the model presented below: we assume that all affiliates start foreign operations with some horizontal sales and may endogenously expand into export markets over time. Standard iceberg costs of exports imply that the activities that affiliates start later in life (i.e., exports) are performed at lower intensity.

2.4 The location of new affiliates and of affiliate exports does not depend on the location of pre-existing affiliates.

Little is known about how MNEs expand their production in space over time. This section sheds light on the sequencing of MNE’s location decisions. Table 2 illustrates that the order in which MNEs open affiliates is not necessarily related to standard “gravity” variables. More precisely, we observe that, for a given U.S. parent, the unconditional probability of opening an affiliate in a country is very similar to the probability of opening conditional on already having an affiliate in a “similar” country. We define “similarity” in a variety of ways, following Morales et al. (2015): similar countries may be ones that are located in the same continent, share a border, share a language, have similar income per capita,¹¹ or all of the above. Of course, this comparison is only possible for U.S. parents with at least two foreign affiliates. Countries are restricted to the ten most popular destinations for U.S. MNEs.

The table shows that conditional and unconditional probabilities are strikingly similar. The largest differences are observed when we include countries –such as China– that are typically part of global supply chains. Differences become even smaller if we restrict the sample to larger MNEs, with more than 5 or more than 10 affiliates (results shown in Appendix B). Compared with the

¹¹To define similarity in income per capita, we follow Morales et al. (2015) and use the World Bank classification into four groups according to their GDP per capita. Whenever two countries belong to the same income group, we refer to them as having similar income per capita.

Table 2: (Lack of) Extended Gravity in Affiliate Opening.

	Unconditional	Continent	Border	Language	Income	All =1
Canada	0.0205	0.0214		0.0231	0.0206	
UK	0.0252	0.0274	0.0296	0.0259	0.0258	0.0296
Germany	0.0232	0.0257	0.0291	0.0278	0.0238	0.0279
Ireland	0.0096	0.0103	0.0111	0.0104	0.0098	0.0111
China	0.0270	0.0368	0.0497	0.0477	0.0510	0.0573
France	0.0212	0.0238	0.0284	0.0232	0.0218	0.0286
Brazil	0.0162	0.0219	0.0269	0.0246	0.0231	0.0188
Singapore	0.0158	0.0230	0.0441	0.0168	0.0159	0.0453
Mexico	0.0239	0.0292	0.0276	0.0339	0.0310	0.0243
Japan	0.0158	0.0207			0.0160	

Note: Probabilities of opening affiliates in top-ten most popular destinations. Conditional probabilities refer to the probability of observing a MNE opening an affiliate in country i given that the parent already has an affiliate in a “similar” country. The sample is restricted to parents with at least two affiliates worldwide.

evidence for exporters in Morales et al. (2015), extended gravity is much less pronounced for MNEs opening affiliates than for domestic firms entering export destinations. Morales finds that the probability of exporting to a given country is 12.72 times higher if the firm already exports to an adjacent country, 5.26 times higher if it exports to a country in the same continent, 3 times higher if it exports to a country that speaks the same language, and 2.89 times higher if it exports to a country in the same World Bank income group. As a comparison, we find that the probability to opening an affiliate in the U.K. for example, is 17.46% higher if the firm already has an affiliate in an adjacent country, 8.73% times higher if it has an affiliate in a country in the same continent, 2.78% times higher if it has an affiliate in a country that speaks the same language, and 2.38% times higher if it has an affiliate in a country in the same World Bank income group.

The lack of extended gravity that we observe in the data motivates one of the most important assumptions of the model. Consistent with what we observe, we assume that the choice of whether to open an affiliate in a country is independent of the locations of previously opened affiliates.

Second, we report suggestive evidence that the decision to export from an affiliate in country a to country b is independent of having an affiliate in country b . Even though the BEA data contain limited information about the destination of affiliates’ exports, we are able to examine the coexistence of affiliates’ exports to three countries (Canada, the United Kingdom, and Japan) with the presence of affiliates owned by the same parents in those countries, for 2004.¹² Our calculations

¹²Benchmark year surveys contain more information about affiliate export destinations than non-benchmark year

show that of the 20,359 affiliates that export to Canada, 64 percent belong to a U.S. parent that also has affiliates located in Canada. Similarly, of the 5,017 affiliates that export to the United Kingdom, 70 percent belong to a U.S. parent that also has affiliates located in that country. Finally, of the 5,224 affiliates that export to Japan, 47 percent belong to a U.S. parent that also has affiliates located in Japan. This evidence supports an implication of the independence assumption, whereby it is possible for a firm to have an affiliate in a country and at the same time to have affiliates elsewhere that export to that same country.¹³ We discuss these assumptions in more detail below.

3 Baseline Model

We present here a simple dynamic model of MNE activities that is designed to reproduce the facts documented in Section 2. In this section we put forward several simplifying assumptions to present the intuition and the mechanism in a transparent way. In fact, this version of the model can be solved entirely in closed form. In Section 5 we extend the model in order to use it for quantitative analysis.

The static components of our model follow the treatment of firms in Melitz (2003), while the dynamic choice of whether and when to enter a country with an affiliate is modeled as in Fillat and Garetto (2015) and Fillat et al. (2015), where the dynamic FDI decision is treated as a real option that the firm has for the future, and from which it derives value. The option is exercised when the MNE enters a host market with some form of FDI activity, horizontal FDI or a mix of horizontal sales and exports.

Guided by the observations of the time series data, we assume that MNEs need to first establish an affiliate in the host country and carry out some horizontal activity before eventually engaging in export activities. Because the model is specified in continuous time, these two decisions can happen almost simultaneously, allowing for the existence of affiliates that are born as exporters. The separation in time of the two decisions is a mere artifact to gain tractability.

Also key for tractability is an independence assumption. Consistent with the evidence reported in Section 2, we assume that the choice of whether to open an affiliate in a country—and export from there—is independent for each host country. In other words, the profits of an affiliate are independent on the number of affiliates that the firm has, so that—for example—whether an MNE open an affiliate in Germany and from it exports to France is independent of having an affiliate in

ones.

¹³This is different from the models in Arkolakis et al. (2017) and Tintelnot (2017), in which each firm has only one lowest-cost location to reach final consumers in a country.

France. We can interpret this assumption as indicating that the demand for a variety that a firm produces depends both on its source and on its location of production. For example, consumers perceive differently M  t Chandon champagne produced in France and Chandon sparkling wine produced by the same firm in Napa, California. This assumption implies that there is no within-firm cannibalization associated with the production decisions of a MNE because the decision of how much to produce is independent for each host-destination country pair in which the firm operates.¹⁴ Both the independence in decisions across markets as well as the sequential choice of affiliate activities allow us to avoid the difficult computational problem faced by Tintelnot (2017) in a static setup, which would be even harder to solve in a dynamic environment.

In the baseline version of the model we assume that exit is exogenous, we do not distinguish among different affiliate export destinations, and we take aggregate prices and quantities as given. We remove all these simplifying assumptions in the extended model in Section 5.

3.1 Preferences and Technology

The economy is composed by $N + 1$ countries: the Home country (the U.S. in our data) and N possibly asymmetric foreign countries. The Home country is populated by a mass of domestic firms that decide whether to operate only in their home market or to establish foreign affiliates in other countries.

Time is continuous. In each country k , consumers have linear intertemporal preferences over an aggregate good Q ,

$$U_k = \int_0^\infty e^{-\rho t} Q_k(t) dt, \quad (1)$$

where ρ is the subjective time discount rate. $Q_k(t)$ aggregates a continuum of varieties, indexed by v , with constant elasticity of substitution (CES) $\eta > 1$:

$$Q_k(t) = \left[\sum_i \sum_j \int_{\Omega_{ijk}(t)} q_{ijk}(v, t)^{\frac{\eta-1}{\eta}} dv \right]^{\frac{\eta}{\eta-1}} \quad (2)$$

where $q_{ijk}(v, t)$ denotes consumption of variety v produced by a firm from country i via an affiliate located in j and sold to country k at time t , and $\Omega_{ijk}(t)$ denotes the set of varieties produced by firms from country i via affiliates located in j and sold to k at time t .

Labor is the only factor of production. Each country is populated by a continuum of firms.

¹⁴Notice that, as a consequence of this treatment of variety, our model does not feature the proximity-concentration tradeoff by virtue of which exports and FDI are substitutes, as in Helpman et al. (2004).

Each firm produces with a linear technology and operates under monopolistic competition. As in Melitz (2003), each firm is endowed with a productivity parameter φ that determines the labor cost of one unit of its output. Each firm sets prices to maximize profits from sales to each destination, so that prices are given by a constant mark-up over marginal cost, $p_{ijk}(\varphi) = \frac{\eta}{\eta-1} MC_{ijk}(\varphi)$, and the marginal cost depends on the location of production: $MC_{ijk}(\varphi) = w_j \tau_{jk} / \varphi$, where w_j denotes the wage of the country where affiliate production takes place, and τ_{jk} is a variable iceberg export cost.¹⁵

We assume that, when a firm establishes an affiliate in a foreign country j , it has to pay a sunk entry cost, $F_j^h > 0$. The affiliate starts by selling locally, so engaging in horizontal FDI, subject to a per-period fixed cost, $f_j^h > 0$. Once the affiliate is in place, it can expand its operations to sell in other markets, so engaging in export activities. We assume that an affiliate located in j has to pay a sunk entry cost $F_{jk}^e > 0$ to start exporting to country k , and per-period fixed export cost $f_{jk}^e > 0$. For simplicity, we assume that there are no per-period fixed costs associated with domestic production, so that all firms produce in their Home market. Finally, in the baseline model, firms and affiliates exogenously die at a constant rate δ . We will remove this assumption in Section 5, where we introduce endogenous exit to match data on exit rates.

Since in our data there is only one Home market (the U.S.) and the baseline version of the model does not distinguish among different affiliate export markets, in the remainder of this section we simplify the notation to reflect only the location of an affiliate.

Let $\pi_d(\varphi)$ denote a firm's domestic profits, $\pi_j^h(\varphi)$ denote the profits from local sales of an affiliate located in country j (horizontal sales), and $\pi_j^e(\varphi)$ denote the profits from exports of an affiliate located in country j :

$$\pi_d(\varphi) = H \left(\frac{w_d}{\varphi} \right)^{1-\eta} E_d, \quad (3)$$

$$\pi_j^h(\varphi) = H \left(\frac{w_j}{\varphi} \right)^{1-\eta} E_j - f_j^h \equiv \bar{\pi}_j^h(\varphi) - f_j^h \quad (4)$$

$$\pi_j^e(\varphi) = H \left(\frac{\tau_j w_j}{\varphi} \right)^{1-\eta} E_{\sim j} - f_j^e \equiv \bar{\pi}_j^e(\varphi) - f_j^e, \quad (5)$$

where $H \equiv \eta^{-\eta}(\eta-1)^{\eta-1}$, $E_j \equiv P_j^\eta Q_j$ is the size of market j , and $E_{\sim j} \equiv P_{\sim j}^\eta Q_{\sim j}$ is the total market size for the exports of affiliates located in j .

Following Ghironi and Melitz (2005), we define the firm-level productivity φ to be the product of a constant firm-specific component, z , and of a stochastic Home country-specific component, Z

¹⁵ $\tau_{jk} > 1 \forall j \neq k$ and $\tau_{jj} = 1$.

$\varphi \equiv z \cdot Z$. The term z is a firm-specific draw from a distribution $G(z)$ (e.g., Pareto), as in Melitz (2003). As in Impullitti et al. (2013), we assume that $Z = e^X$, where X is a Brownian motion with drift,

$$dX = \mu dt + \sigma dW, \quad (6)$$

for $\mu \in \Re$ and $\sigma > 0$, and dW denoting a standard Wiener process. This specification is equivalent to assuming that aggregate productivity behaves like a random walk, and that productivity growth is independently and identically distributed. This is a convenient functional form assumption, which guarantees tractability to the model.

Finally, we assume that when a firm operates an affiliate in a foreign country, it transfers both the aggregate and the idiosyncratic components of the productivity shock to the host market, so that MNEs operations contribute to the transmission of productivity shocks across countries, in the spirit of Cravino and Levchenko (2017).¹⁶ In Section 4, we present evidence suggesting that the structure of shocks we impose in the model explains a significant amount of variation in the data.

3.2 The MNE Dynamic Problem

Firms take decisions about whether, when and how to enter a market j by computing their expected profits net of entry and continuation costs, which depend on their productivity z and on market specific variables (here the aggregate productivity shock X), which represent the aggregate state of the economy.

Bellman Equations. Let $\mathcal{V}(z, X)$ denote the expected net present value of a Home country firm with productivity z , when the state of the economy is described by X , and following optimal policy. The value of the firm is given by the value of its domestic operations, $V_d(z, X)$, and by the value of its operations abroad:

$$\mathcal{V}(z, X) = V_d(z, X) + \sum_{j=1}^N \max \left\{ V_j^o(z, X), V_j^h(z, X), V_j^e(z, X) \right\}. \quad (7)$$

$V_j^o(z, X)$ denotes the option value of opening an affiliate in country j , $V_j^h(z, X)$ denotes the value of a pure horizontal affiliate in country j , and $V_j^e(z, X)$ denotes the value of an affiliate in country j that also exports.

¹⁶Our shock structure shares with Cravino and Levchenko (2017) the fact that both home country- and host country-specific shocks affect affiliate sales in industry equilibrium. Exogenous home country shocks get transferred to the host country, while host country shocks affect affiliate operations through their impact on aggregate demand, as we illustrate in Section 5, where we extend the model to incorporate also foreign demand shocks.

Since all firms operate in the domestic market, the value of domestic operations is simply given by the evolution of domestic profits over time. Over a generic time interval Δt ,

$$V_d(z, X) = \frac{1}{1 + (\rho + \delta)\Delta t} [\pi_d(z, X)\Delta t + E[V_d(z, X')|X]] , \quad (8)$$

where X' denotes the next period realization of the aggregate state.

We assume that a firm must first open a horizontal affiliate and then has the choice of starting to export from it. In this simple version of the model we don't allow for endogenous exit, so the only decisions that a firm can take in a host country are whether or not to open an affiliate and whether or not to start exporting from an existing affiliate. These possibilities are reflected in the Bellman equations.

If a domestic firm does not have an affiliate in country j , all the value from operations in j is option value, *i.e.*, the value of the possibility of entering j in the future, described by:

$$V_j^o(z, X) = \max \left\{ \frac{1}{1 + (\rho + \delta)\Delta t} E[V_j^o(z, X')|X]; V_j^h(z, X) - F_j^h \right\} . \quad (9)$$

Equation (9) describes the fact that a firm may keep the option of entering market j , or may enter country j by opening a horizontal affiliate there, in which case it pays the entry cost F_j^h and gets the value of a horizontal affiliate in j , $V_j^h(z, X)$. Alternatively, a domestic firm may already have an affiliate located in country j . In this case, it gets value from horizontal sales in j . Once the affiliate is set up, it may decide to export from j to other markets. This option is reflected in the Bellman equation:

$$V_j^h(z, X) = \max \left\{ \frac{1}{1 + (\rho + \delta)\Delta t} [\pi_j^h(z, X)\Delta t + E[V_j^h(z, X')|X]]; V_j^e(z, X) - F_j^e \right\} . \quad (10)$$

The affiliate makes profits from horizontal sales and gets the continuation value of those sales in the future, or may pay the entry cost F_j^e and expand into exports.

Lastly, the value of an affiliate that both serves the host market and exports is simply given by the expected value of its profits over time:

$$V_j^e(z, X) = \frac{1}{1 + (\rho + \delta)\Delta t} [(\pi_j^h(z, X) + \pi_j^e(z, X))\Delta t + E[V_j^e(z, X')|X]] . \quad (11)$$

Value Functions. The structure that we impose on the profit functions and the shock process implies that, by evaluating the Bellman equations in their continuation regions and applying Ito's

lemma, we can solve for the value functions in closed form up to multiplicative parameters. All the derivations are contained in Appendix C.

The value of domestic sales is simply given by the present discounted value of profits from domestic sales,

$$V_d(z, X) = \frac{\pi_d(z, X)}{\rho + \delta - \hat{\mu}}, \quad (12)$$

where $\hat{\mu} = \mu(\eta - 1) - \frac{1}{2}\sigma^2(\eta - 1)^2$ is the drift of the stochastic process for the profit flow, and the discount rate $(\rho + \delta - \hat{\mu})$ takes into account the exogenous exit rate and the effect of the evolution of aggregate productivity on profits.

The option value of opening an affiliate in country j is

$$V_j^o(z, X) = B_j^o(z)e^{\beta X}, \quad (13)$$

where $B_j^o(z) > 0$ is a firm-specific parameter (yet to be determined), and $\beta > 1$ is the positive root of $\frac{1}{2}\sigma^2\beta^2 + \mu\beta - (\rho + \delta) = 0$. The option value is increasing in the realization of the aggregate productivity shock, indicating that there is a higher value to be obtained from opening an affiliate when aggregate productivity is high.

The value of an affiliate with only horizontal sales in country j is

$$V_j^h(z, X) = \frac{\bar{\pi}_j^h(z, X)}{\rho + \delta - \hat{\mu}} - \frac{f_j^h}{\rho + \delta} + B_j^h(z)e^{\beta X}, \quad (14)$$

where $B_j^h(z) > 0$ is a firm-specific parameter yet to be determined. The value of a horizontal affiliate is the sum of discounted profits from sales in the host country plus the option value of expanding to export markets. Additionally, the option value of exporting is increasing in the realization of the aggregate productivity shock, indicating that the value of exporting is higher when aggregate productivity is high.

Finally, the value of an affiliate located in country j who sells locally and exports is given by the present discounted value of its profits,

$$V_j^e(z, X) = \frac{\bar{\pi}_j^h(z, X) + \bar{\pi}_j^e(z, X)}{\rho + \delta - \hat{\mu}} - \frac{f_j^h + f_j^e}{\rho + \delta}. \quad (15)$$

Solution: Parameters and Thresholds. To completely characterize the problem of the MNE, it remains to solve for the two firm-specific parameters $B_j^o(z)$, $B_j^h(z)$ and for the aggregate productivity thresholds that induce a firm with productivity z to open an affiliate in j or to start

exporting from it, which we denote by $X_j^h(z)$ and $X_j^e(z)$, respectively. For each firm and each foreign market, these four variables are identified by the following system of value matching and smooth pasting conditions:

$$V_j^o(z, X_j^h) = V_j^h(z, X_j^h) - F_j^h \quad (16)$$

$$V_j^h(z, X_j^e) = V_j^e(z, X_j^e) - F_j^e \quad (17)$$

$$V_j^{o'}(z, X_j^h) = V_j^{h'}(z, X_j^h) \quad (18)$$

$$V_j^{h'}(z, X_j^e) = V_j^{e'}(z, X_j^e). \quad (19)$$

Thanks to the simplifying assumptions we impose in this version of the model, the entire solution can be obtained in closed form. The value function parameters $B_j^h(z)$ and $B_j^o(z)$ are given by:

$$B_j^h(z) = k_B \cdot \left(\frac{k_j^e(z)}{\beta(\rho + \delta - \hat{\mu})} \right)^{\frac{\beta}{\eta-1}} \cdot \left(\frac{f_j^e + (\rho + \delta)F_j^e}{\rho + \delta} \right)^{\frac{\eta-1-\beta}{\eta-1}} \quad (20)$$

$$B_j^o(z) = k_B \cdot \left(\frac{k_j^h(z)}{\beta(\rho + \delta - \hat{\mu})} \right)^{\frac{\beta}{\eta-1}} \cdot \left(\frac{f_j^h + (\rho + \delta)F_j^h}{\rho + \delta} \right)^{\frac{\eta-1-\beta}{\eta-1}} + B_j^h(z) \quad (21)$$

where k_B is a constant, and $k_j^h(z)$ and $k_j^e(z)$ are firm-specific revenue terms.¹⁷

Under the parameter restriction that $\beta > \eta - 1$, equation (21) shows that the option value of opening an affiliate is decreasing in both the fixed and sunk costs of opening an affiliate and of exporting from the affiliate. In other words, the less costly are an affiliate's operations in a country, the more appealing it is to open an affiliate there. Similarly, equation (20) shows that the option value of exporting from an affiliate is decreasing in both the fixed and sunk costs of exporting from the affiliate. Finally, both option value parameters are increasing in the firm productivity z , indicating that affiliate operations are more appealing for more productive firms.

The aggregate productivity thresholds $X_j^h(z)$ and $X_j^e(z)$ are given by:

$$X_j^h(z) = \frac{1}{\eta-1} \log \left[\left(\frac{\beta}{\beta - \eta + 1} \right) \cdot \left(\frac{\rho + \delta - \hat{\mu}}{k_j^h(z)} \right) \cdot \left(\frac{f_j^h + (\rho + \delta)F_j^h}{\rho + \delta} \right) \right] \quad (22)$$

$$X_j^e(z) = \frac{1}{\eta-1} \log \left[\left(\frac{\beta}{\beta - \eta + 1} \right) \cdot \left(\frac{\rho + \delta - \hat{\mu}}{k_j^e(z)} \right) \cdot \left(\frac{f_j^e + (\rho + \delta)F_j^e}{\rho + \delta} \right) \right]. \quad (23)$$

Equations (22)-(23) show that the aggregate productivity threshold to open (export from) an

¹⁷ $k_B \equiv (\eta - 1)(1 + \beta - \eta)^{\frac{\eta-1-\beta}{1-\eta}}$, $k_j^h(z) \equiv H(w_j/z)^{1-\eta} E_j$, and $k_j^e(z) \equiv H(\tau_j w_j/z)^{1-\eta} E_{\sim j}$.

affiliate in country j is increasing in the fixed and sunk costs of opening (exporting from) the affiliate. Both thresholds are decreasing in firm productivity z , indicating that more productive firms need smaller positive aggregate productivity shocks to start and expand affiliate operations compared to less productive firms.

Notice that if $\frac{f_j^h + (\rho + \delta)F_j^h}{P_j^\eta Q_j} < \frac{(f_j^e + (\rho + \delta)F_j^e)\tau^{\eta-1}}{P_{\sim j}^\eta Q_{\sim j}}$, *i.e.*, if the overall cost of a horizontal affiliate relative to its host market size is lower than the overall cost of a diversified affiliate relative to its destination market size, then $X_j^h(z) < X_j^e(z)$. We assume that this restriction holds to illustrate the predictions of the model that follow.

3.3 Testable Implications

The baseline model is designed to capture *qualitatively* the facts presented in Section 2. First, we have shown that the affiliate-to-parent life-cycle sales ratio is virtually flat (Figure 1). The presence of only aggregate Home country shocks, together with the assumption that the MNE transfers its productivity to its affiliates abroad, imply that a firm's domestic and foreign sales perfectly co-move, conditional on entry:¹⁸

$$\frac{sales_j(z)}{sales_d(z)} = \left(\frac{w_j/\varphi}{w_d/\varphi} \right)^{1-\eta} \frac{E_j}{E_d}. \quad (24)$$

Second, we documented that the vast majority of affiliates have some horizontal sales at birth and that a negligible share of affiliates are pure exporters. The assumptions we put forward are consistent with these observations: in the model, affiliates are born either with only horizontal sales or with some horizontal sales and some exports. The specification of the aggregate productivity shock as a unit root process drives persistence in the affiliate's type, as observed in the data. Moreover, if aggregate productivity grows over time (*i.e.*, $\mu > 0$), firms tend to expand internationally giving rise to the diversification pattern that we document.

Third, we have shown that the decision of where to open an affiliate is not affected much by the location of previous affiliates. We incorporated this finding in the model via the independence assumption, which postulates that both the decisions of opening an affiliate and of exporting from it are independent across countries.

Next, we illustrate the implications of the cross-sectional Melitz-style component of the model.

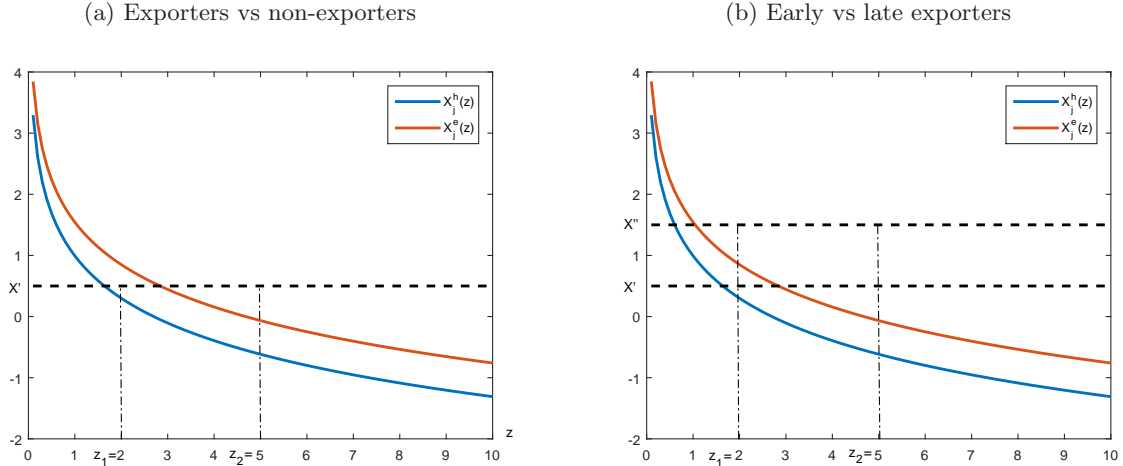
¹⁸This result is exact in partial equilibrium. In an industry equilibrium, E_j/E_d fluctuates driving fluctuations in the affiliate-to-parent sales ratio. However, the fluctuations induced by productivity shocks on aggregate variables are typically small in this class of models, so we expect that the sales ratio will be relatively stable over time.

The relationship between firm-level productivity, host market characteristics, and entry and exporting thresholds, $X_j^h(z)$, $X_j^e(z)$, has two sets of implications: within a host market, across affiliates of different MNEs; and within an MNE, across host markets.

Given a host market j , the model has two clear predictions relating affiliate size in the host market with export status and timing of exports. Since more productive firms have lower entry thresholds ($\partial X_j^h(z)/\partial z \leq 0$ and $\partial X_j^e(z)/\partial z \leq 0$): 1) affiliates that are exporters from birth have larger horizontal sales than affiliates born with exclusively horizontal sales; 2) conditional on aggregate productivity increasing over time, affiliates that start exporting later in life have smaller horizontal sales than affiliates that start exporting earlier in their life cycle.

Figure 3 illustrates these predictions. Suppose the realization of the aggregate shock is X' and we observe two firms having affiliates in the same host country j . Firm 1 (with productivity z_1) has a pure type horizontal affiliate in j , while firm 2 (with productivity z_2) has a diversified affiliate in j . Since the thresholds $X_j^h(z)$, $X_j^e(z)$ are decreasing functions of z , they are invertible. The observed selection pattern of affiliates indicates that $z_2 \geq z_j^e(X') \geq z_1$, hence (since $z_2 \geq z_1$) the horizontal sales of the diversified affiliate of firm 2 must be larger than the horizontal sales of the pure horizontal affiliate of firm 1 (panel 3a). To illustrate the prediction about the timing of exports, suppose now that as aggregate productivity grows on average, the realization of the aggregate shock becomes $X'' > X'$. Now, as illustrated in panel 3b, $z_1 \geq z_j^e(X'')$ and also firm 1 starts exporting from its foreign affiliate. Hence, keeping the host country fixed, early exporting affiliates are more productive and exhibit larger horizontal sales than late exporters.

Figure 3: Affiliate size in the host market, export status, and timing of exports.



Regarding the implications about the expansion strategies of an MNE across countries, the

model predicts that: 1) since entry thresholds are decreasing in the size of the host market ($\partial X_j^h(z)/\partial E_j \leq 0$), MNEs open first affiliates located in larger countries and subsequently affiliates located in smaller countries; and 2) MNEs open first their largest affiliates and subsequently their smaller affiliates. Moreover, since entry thresholds are increasing in entry costs ($\partial X_j^h(z)/\partial F_j^h \geq 0$), 3) MNEs open first affiliates in markets with lower entry costs.

Figure 4: Market characteristics and timing of entry.

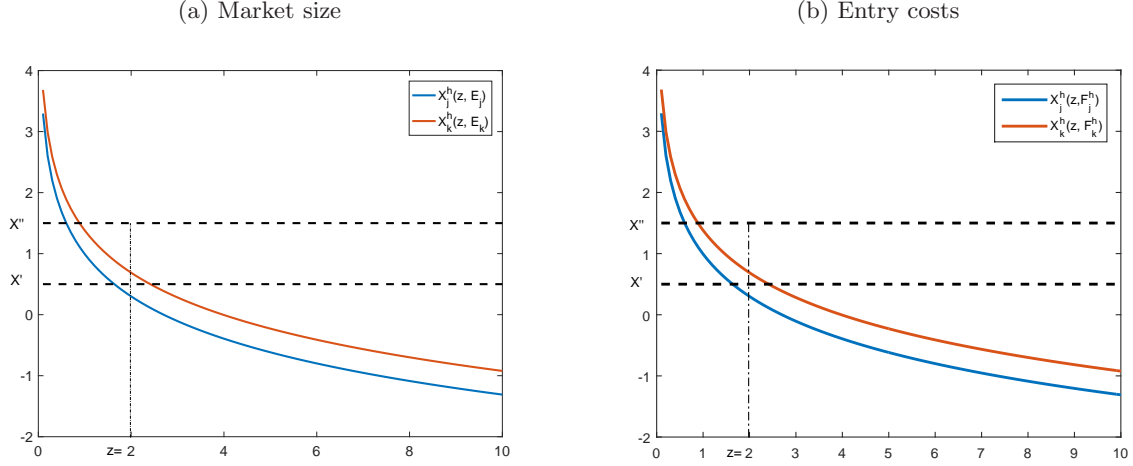


Figure 4 illustrates these predictions. Panel 4a plots affiliate entry thresholds for two host countries j, k of different size: $E_k < E_j$, so that $X_k^h(z, E_k) \geq X_j^h(z, E_j)$. As illustrated in the figure, firm z only opens an affiliate in country j when the realization of the aggregate shock is X' . When aggregate productivity grows to $X'' > X'$, the firm can afford to open an affiliate also in country k . Since affiliate sales are positively correlated with host country size, the same figure also illustrates the fact that, controlling for factor costs, an MNEs opens first its largest affiliates. Panel 4b plots affiliate entry thresholds for two host countries j, k with different entry costs: $F_k^h > F_j^h$, so that $X_k^h(z, F_k^h) \geq X_j^h(z, F_j^h)$. As illustrated in the figure, firm z only opens an affiliate in country j when the realization of the aggregate shock is X' . When aggregate productivity grows to $X'' > X'$, the firm can afford to open an affiliate also in country k . Notice that these predictions hold within a corporation across affiliates located in different countries.

4 Back to the Data: Testing the Model's Predictions

In this section we go back to the data to test the qualitative implications of the baseline model. The empirical evidence strongly supports the model's predictions about affiliate size, export status,

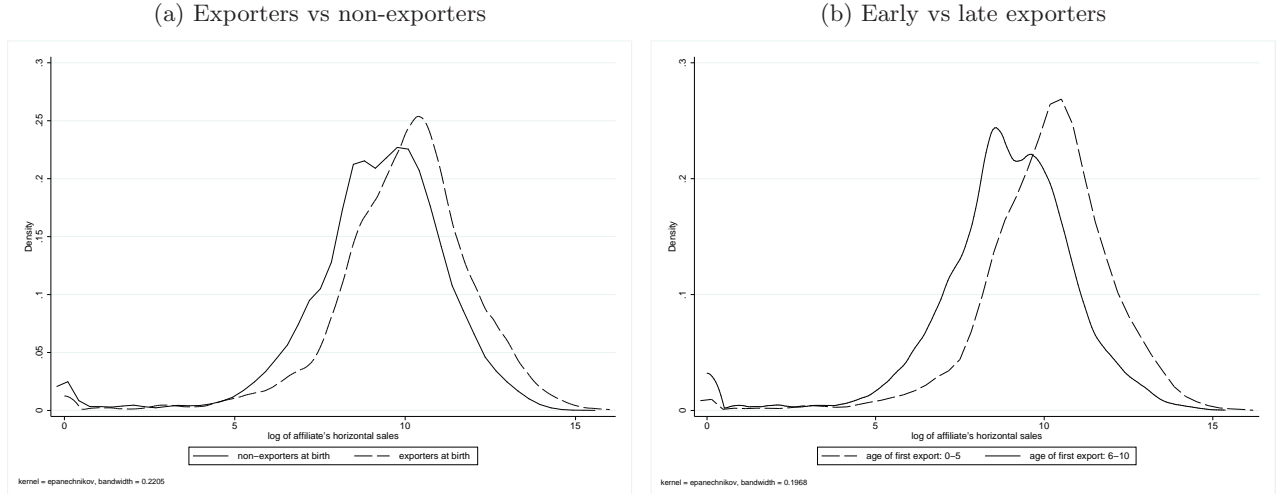
and timing of exports, as well as those about MNEs' expansion across countries.

4.1 Affiliate size, export status, and timing of export

We start by testing the model's predictions that exploit variation within a market across affiliates of different MNEs.

Prediction 1. Exporters at birth have larger horizontal sales than pure-horizontal affiliates at birth. Figure 5a plots the distribution of log horizontal sales for two subsets of affiliates in our sample: affiliates that are born with only horizontal sales, and affiliates that are born also with exports. The figure clearly shows that affiliates that export are on average larger than affiliates with only horizontal sales at birth, consistent with the model's prediction.

Figure 5: Affiliate size, export status, and the timing of export entry.



Notes: Sample of new majority-owned affiliates that survive for at least ten consecutive years, in manufacturing. Kernel density of log horizontal sales for affiliates that: are born with exclusively horizontal sales (non-exporters) and those with exports (exporters), in (5a); start exporting in their first five years of life and those that start after five years of life, in (5b).

Formally, we regress affiliate horizontal sales on a dummy variable equal one if the affiliate is pure horizontal at birth, and zero if the affiliate is also an exporter. Column 1 in Table 3 shows that the negative correlation between size in the host market and being a pure horizontal affiliate at birth survives the inclusion of an age control and of country-year and industry fixed effects.

Mimicking well-documented facts on domestic exporters, this result shows that affiliates that export are larger in their host market than affiliates whose sales are limited to their host country.¹⁹

¹⁹In a companion paper, Garetto et al. (2017) provide a thorough comparison of stylized facts about MNE exporters and non-MNE exporters.

Table 3: Affiliate size, export status, and timing of entry. OLS.

Dep var	log of horizontal sales		
	(1)	(2)	(3)
D(pure horizontal at birth)	-0.979*** (0.085)		-0.698*** (0.079)
Age at first export		-0.135*** (0.015)	-0.066*** (0.018)
Age	0.069*** (0.012)	0.072*** (0.018)	0.065*** (0.013)
Obs	33,939	30,117	30,117
R-sq	0.12	0.11	0.12

Note: Observations at the affiliate-year level, for new majority-owned affiliates that survive for at least ten consecutive years, in manufacturing. $D(\text{pure } H \text{ at birth})$ is equal to one if the affiliate is born with only horizontal sales; and zero otherwise. $D(\text{1st affiliate})$ is equal to one if the affiliate is first in the opening sequence of the MNE; and zero otherwise. Global employment refers to the aggregate employment of the MNE, both in the United States and abroad. Pure exporters are excluded from the sample. All specifications include country-year and industry fixed effects. Standard errors, clustered at the parent level, are in parenthesis. Levels of significance are denoted *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Prediction 2. Affiliates that start exporting earlier in life have larger horizontal sales than late starters. Figure 5b illustrates the relationship between the size of an affiliate in its host country, measured by the log of sales in the host country, and the time in the affiliate’s life cycle at which it decides to export. We split the sample between affiliates that start exporting in the first five years of life and affiliates that start exporting later in their life cycle. As the figure shows, affiliates that start exporting earlier in life are larger in their host country compared to affiliates that start exporting later. The pattern is robust to the choice of the age cutoff for first exports (see Figure B.4 in Appendix B). Moreover, as column 2 in Table 3 shows, the negative relationship between size in the host market and age at first export survives the inclusion of affiliate age, country-year and industry fixed effects. Column 3 in Table 3 combines Predictions 1 and 2 and shows that they jointly hold in the data.

4.2 The expansion strategies of MNEs across countries

The second set of model’s predictions refers to the expansion of individual MNEs across different host markets; that is, we exploit within-MNE variation across countries.

Prediction 3. MNEs open their largest affiliates first. Due to the monotonic relationship

Table 4: Affiliate size, host market characteristics, and affiliate position in the MNE's opening sequence. OLS.

Dep var	probability of being the first affiliate of a MNE			
	(1)	(2)	(3)	(4)
Log-horizontal sales	0.013*** (0.003)	0.012*** (0.003)	0.012*** (0.003)	0.011*** (0.003)
Host country GDP	0.011* (0.006)	0.013** (0.006)	0.008 (0.006)	0.014** (0.006)
number of business procedures		-0.006*** (0.001)		-0.008*** (0.002)
cost of starting business (% of GDP p.c.)			-0.006*** (0.0002)	-0.0004* (0.0002)
Obs	36,127	36,127	36,127	36,127
R-sq	0.291	0.295	0.293	0.297

Note: Observations at the affiliate-year level, for new majority-owned affiliates that survive for at least ten consecutive years, in manufacturing. All specifications include year fixed effects and parent fixed effects. Standard errors, clustered at the parent level, are in parenthesis. Levels of significance are denoted *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

that links entry threshold, host market size, and affiliate sales, the model predicts that MNEs open first their largest affiliates, and subsequently their smallest affiliates. Column 1 in Table 4 confirms this prediction: horizontal sales are systematically larger for the first affiliate of a MNE. Notice that this specification includes year and parent fixed effects, so that we exploit variation across affiliates of the same MNE. Table B.6 in Appendix B provides more statistics differentiating first affiliates from subsequent ones: relative to subsequent affiliates, first affiliates have employment that is about 1.35 times greater and sales that are about 3 times greater. First affiliates are also more likely to be exporters. Figure B.1 in Appendix B illustrates some of these size differences over the life cycle.

Prediction 4. MNEs open affiliates first in larger markets. The same relationship in the model implies sorting by market size in the order in which a MNE opens affiliates over time. Column 1 in Table 4 illustrates that, on average, MNEs open first affiliates located in large host markets.

Prediction 5. MNEs open affiliates first in markets with lower entry costs. The decreasing relationship between entry thresholds and sunk costs implies that MNEs open first affiliates in countries that are less costly to enter. Columns 2-4 in Table 4 provide evidence supporting this prediction. As is commonly done in the literature, we proxy for entry costs using indicators from

Table 5: MNE shock structure. OLS.

Dep var	log affiliate horizontal sales			
country-industry FE	yes	yes	yes	yes
US GDP	yes	yes	yes	yes
Host country GDP	yes	yes	yes	yes
parent FE	no	yes	yes	no
parent sales	no	no	yes	yes
affiliate FE	no	no	no	yes
Adjusted R-sq	0.243	0.268	0.290	0.794
Observations		153,773		

Notes: Sample of all affiliates born during the sample period.

the World Bank’s Doing Business Database: the number of administrative procedures required to open a business, or the cost of starting a business as a percent of host country GDP per capita. Results according to both measures are consistent with the prediction of the model. Table B.7 in Appendix B reports additional summary statistics that illustrate these facts.

We conclude this section with some additional evidence in support of the specific shock structure that we impose in the model.

4.3 The structure of MNE shocks in the data

Our model assumes that the shock structure of MNEs is composed of a MNE-wide time-invariant component and of a time-varying source-country component. The quantitative version of the model that follows also features aggregate host country-specific shocks. How much of the variation in affiliates sales is captured in the data by these shocks? Table 5 illustrates that, while country-level time-varying shocks and parent fixed effects explain almost a third of affiliate sales variation in the data, parent-level time-varying variables (i.e. parent sales) contribute little to explain affiliate sales variation in the data. We interpret this evidence as supporting our assumption that aggregate shocks are the most important drivers of MNE decisions.

To conclude, the evidence in this section suggests that while in the cross-section, affiliates of U.S. MNEs broadly behave like domestic exporters, in the time series, they display much flatter growth profiles, more persistence, and less extended gravity than domestic exporters. The evidence lends further support to modeling the cross-section of MNEs’ affiliates along the lines of a Melitz

model, and the time series with a productivity process that grows over time due to its aggregate component, and not due to the idiosyncratic component.

5 Quantitative Analysis

We extend the model to make it amenable to quantitative analysis, which will allow us to better understand the costs associated with MNE expansion. To this end, firms can endogenously decide to shut down affiliates, chose the destination of affiliate exports, and endogenously decide to exit any export market. In addition to Home market aggregate productivity shocks, dynamics are also driven by host country-specific aggregate demand shocks. We close the model in industry equilibrium with aggregation and determination of the country-level price indexes.

Incorporating endogenous exit is important for two reasons. Empirically, exit rates decline with affiliate age and size, but are independent of whether the affiliate is an exporter or not (see Table B.8 in Appendix B). Quantitatively, incorporating endogenous exit rates in the model allows us to separately identify the sunk and fixed costs of affiliate opening by matching moments on entry and exit rates, respectively. In turn, incorporating the choice of the destination of exports for affiliates will allow us to separately identify costs related to the Home market and to third markets, and possibly to separate vertical investment motives distinguishing sales back to the U.S. market.

5.1 Quantitative model

Extending the model to feature endogenous exit, from a host country and from export markets, is straightforward. The value functions include an extra term, which is the option value of exit, as well as additional value-matching and smooth pasting conditions that deliver the exit thresholds.

Modeling the choice of the destination of affiliate exports is more complex. An affiliate located in any country j can export to any subset of potential export destinations, and the value of an exporting affiliate depends on the set of countries in which the affiliate exports. To maintain tractability, we rely again on an independence assumption. Precisely, we assume that the decision of an affiliate located in country j to export to a country $k \neq j$ is independent from the decision to export to any other country. Relying on this assumption, we can write the problem of the firm as a compound option and solve it backwards, as suggested by Dixit and Pindyck (1994, chap. 10). In other words, conditional on the firm having an affiliate in country j , we solve for the value of exports and of horizontal sales, and determine the thresholds that induce the affiliate to export or stop exporting to each country $k \neq j$. Once we have determined the value of an affiliate in country

j , we solve for the thresholds that induce the firm to open or shut down that affiliate.

Finally, to match different affiliate growth patterns in different countries, we add host-country-level demand shocks to the analysis.

Shock Structure. Besides the U.S. aggregate productivity shock defined in equation (6), we assume that aggregate demand in country j evolves according to a geometric Brownian motion:

$$dQ_j = \mu_j Q_j dt + \sigma_j Q_j dW_j, \quad (25)$$

where $\mu_j \in \mathfrak{R}$, $\sigma_j > 0$, and dW_j denotes a standard Wiener process, possibly correlated with the U.S. productivity shock. We denote with γ_j the correlation between e^X and Q_j . Since affiliate profits from sales in country j are linear in the term $e^{(\eta-1)X} Q_j$, it will be convenient to define the “composite” shock $Y_j \equiv e^{(\eta-1)X} Q_j$, which captures the effect of both U.S. productivity shock and destination country demand shock on profits. Y_j is also a geometric Brownian motion, with drift $\tilde{\mu}_j$ and standard deviation $\tilde{\sigma}_j$:

$$\tilde{\mu}_j = \mu_j + \mu(\eta - 1) + \frac{\sigma^2}{2}(\eta - 1)^2 + \gamma_j \sigma_j \sigma \quad (26)$$

$$\tilde{\sigma}_j^2 = \sigma_j^2 + \sigma^2(\eta - 1)^2 + 2\gamma_j(\eta - 1)\sigma\sigma_j \quad (27)$$

As a result, we can re-specify the model in terms of the composite shocks Y_j . Together with the independence assumption, this shock structure ensures that only home country and sales destination country shocks are important for the dynamic decision of a firm to sell in a market.

Bellman Equations: the Compound Option. The state of the economy is now described by the $N + 1$ -tuple (X, \bar{Q}) , where $\bar{Q} = \{Q_j\}_{j=1, \dots, N}$. The value of a firm with productivity z when the state of the economy is (X, \bar{Q}) is:

$$\mathcal{V}(z, X, \bar{Q}) = V_d(z, X) + \sum_{j=1}^N \max \{V_j^o(z, X, \bar{Q}), V_j^a(z, X, \bar{Q})\}, \quad (28)$$

where $V_d(z, X)$ is the value of domestic sales, $V_j^o(z, X, \bar{Q})$ is the option value of opening an affiliate in country j , and $V_j^a(z, X, \bar{Q})$ is the value of an affiliate in country j , regardless of the destination of its sales. In turn, we can define $V_j^a(z, X, \bar{Q})$ as

$$V_j^a(z, X, \bar{Q}) = V_j^h(z, X, \bar{Q}) + \sum_{k \neq j} \max \{V_{jk}^o(z, X, \bar{Q}), V_{jk}^e(z, X, \bar{Q})\}, \quad (29)$$

where $V_j^h(z, X, \bar{Q})$ is the value of horizontal sales, $V_{jk}^o(z, X, \bar{Q})$ is the option value of exporting to

country k for an affiliate located in j , and $V_{jk}^e(z, X, \bar{Q})$ is the value of exports to country k for an affiliate located in j . This formulation of the problem is analogous to a compound option because opening an affiliate in a country is equivalent to exercising an option that gives access to another set of options: the options to export to any other country.

Value Functions. We start by solving for $V_{jk}^o(z, X, \bar{Q})$ and $V_{jk}^e(z, X, \bar{Q})$, conditional on the firm having an affiliate in country j . Once the location of the affiliate is determined, the only country j -specific variables in the firm problem are wages and iceberg costs, which are time-invariant. For this reason, together with the independence assumption, the value functions only depend on the U.S. productivity shock and the destination country (k) demand shock, hence on the composite shock Y_k . This is a simple case of interlinked options (see Dixit and Pindyck 1994, chap. 7), that gives as solution:

$$V_{jk}^o(z, Y_k) = B_{jk}^o(z) Y_k^{\beta_k} \quad (30)$$

$$V_{jk}^e(z, Y_k) = \frac{\bar{\pi}_{jk}^e(z, Y_k)}{\rho + \delta - \tilde{\mu}_k} - \frac{f_{jk}^e}{\rho + \delta} + A_{jk}^e(z) Y_k^{\alpha_k} \quad (31)$$

where $B_{jk}^o(z) > 0$ and $A_{jk}^e(z) > 0$ are firm-specific parameters, and $\alpha_k < 0$, $\beta_k > 1$ are the roots of $\frac{1}{2}\tilde{\sigma}_k^2\xi^2 + \left(\tilde{\mu}_k - \frac{\tilde{\sigma}_k^2}{2}\right)\xi - (\rho + \delta) = 0$. As $B_{jk}^o(z)e^{\beta X}$ represents the option value of exporting to country k , and is increasing in the realization of the aggregate productivity shock, similarly $A_{jk}^e(z)e^{\alpha X}$ is the option value of quitting the export market k , and is decreasing in the realization of the aggregate productivity shock, indicating that the option of exiting an export market has a larger value in “bad times”.

For each country pair (j, k) and for each firm with productivity z , the parameters $B_{jk}^o(z) > 0$, $A_{jk}^e(z) > 0$, and the aggregate productivity thresholds that induce the affiliate to start and stop exporting, denoted by Y_{jk}^{OE} and Y_{jk}^{EO} , respectively, can be recovered from the appropriate system of value-matching and smooth pasting conditions (see Appendix C).

The value of horizontal sales, conditional on having an affiliate, is given by the present discounted value of profits from horizontal sales plus the option value of shutting down the affiliate,

$$V_j^h(z, Y_j) = \frac{\bar{\pi}_j^h(z, Y_j)}{\rho + \delta - \tilde{\mu}_j} - \frac{f_j^h}{\rho + \delta} + A_j^h(z) Y_j^{\alpha_j}, \quad (32)$$

where $A_j^h(z) > 0$ is a firm-specific parameter. As a result, the value of an affiliate in country j can

then be written as:

$$\begin{aligned}
V_j^a(z, \bar{Y}) &= A_j^h(z)Y_j^{\alpha_j} + \frac{\bar{\pi}_j^h(z, Y_j)}{\rho + \delta - \tilde{\mu}_j} - \frac{f_j^h}{\rho + \delta} + \dots \\
&\quad \sum_{k \in \mathcal{A}_j(z)} \left[\frac{\bar{\pi}_{jk}^e(z, Y_k)}{\rho + \delta - \tilde{\mu}_k} - \frac{f_{jk}^e}{\rho + \delta} + A_{jk}^e(z)Y_k^{\alpha_k} \right] + \dots \\
&\quad \sum_{k \notin \mathcal{A}_j(z)} \left[B_{jk}^o(z)Y_k^{\beta_k} \right]
\end{aligned} \tag{33}$$

where $\mathcal{A}_j(z)$ is the subset of countries where an affiliate of firm z located in j exports. Notice that $V_j^a(z, \bar{Y})$ depends on all the destination countries' demand shocks ($\bar{Y} = \{Y_j\}_{j=1, \dots, N}$). The implications of the independence assumption are clearly shown in equation (33): the value of an affiliate does not depend on the sales or on the value of the firm's other affiliates in other countries, but it does depend on the set of potential export destinations from the affiliate's host country.

It remains to solve for the decision of a firm to set up an affiliate in country j . The option value of opening an affiliate in j is:

$$V_j^o(z, X) = B_j^o(z)Y_j^{\beta_j}. \tag{34}$$

Hence, for each host country j and for each firm with productivity z , the parameters $B_j^o(z) > 0$, $A_j^h(z) > 0$, and the aggregate productivity thresholds that induce the firm to open and shut down an affiliate, denoted by Y_j^{OH} , Y_j^{HO} , respectively, can be recovered from the appropriate system of value-matching and smooth pasting conditions.

Lastly, the value of domestic sales is simply given by the present discounted value of profits from domestic sales,

$$V_d(z, X) = \frac{\pi_d(z, X)}{\rho + \delta - \hat{\mu}}. \tag{35}$$

Industry Equilibrium. The industry equilibrium in this economy is defined by a vector of price indexes $\{P_k\}$, for $k = 1, \dots, N$, and by laws of motion ruling the evolution of affiliate operations over time across countries. The price index in country k is:

$$P_k^{1-\eta} = \sum_{i=1}^N \sum_{j=1}^N P_{ijk}^{1-\eta} \tag{36}$$

where P_{ijk} denotes the price index of varieties produced by affiliates of firms from country i located in country j and selling to country k . Unfortunately, the nature of the BEA data is such that we can only observe firms whose home country $i = U.S.$. For this reason, we compute the price index

as including only the prices of the transactions that we can observe:

$$P_k^{1-\eta} = P_{kkk}^{1-\eta} + P_{US,kk}^{1-\eta} + \sum_{j \neq k} P_{US,j,k}^{1-\eta} \quad (37)$$

where:

$$P_{kkk}^{1-\eta} = \int \left(\frac{\eta}{\eta-1} \frac{w_k}{z_k} \right)^{1-\eta} dz \equiv \bar{P}_{kkk} \quad (38)$$

$$P_{US,kk}^{1-\eta} = \int_{\Omega_k^h} \left(\frac{\eta}{\eta-1} \frac{w_k}{zZ} \right)^{1-\eta} dz \quad (39)$$

$$P_{US,jk}^{1-\eta} = \int_{\Omega_{jk}^e} \left(\frac{\eta}{\eta-1} \frac{\tau_{jk} w_j}{zZ} \right)^{1-\eta} dz \quad (40)$$

where Ω_k^h (Ω_{jk}^e) denotes the set of US MNEs with horizontal affiliates in k (with affiliates located in j and selling to k). We assume that – as each firm does not take into consideration the effect of its choices on the price index – it does not take into consideration the way in which Z , Ω_k^h , and Ω_{jk}^e affect the price index. Price indexes fluctuate every period because of US productivity shocks and because of changes in MNE activity.

Let M_i denote the (exogenous) mass of firms from country i . The endogenous mass of affiliates of firms from i located in j , M_{ij} , is given by continuing affiliates plus new affiliates,

$$M'_{ij} = M_{ij} \cdot (1 - G_i(z_{ij}^{HO})) + (M_i - M_{ij}) \cdot (1 - G_i(z_{ij}^{OH})), \quad (41)$$

while the mass of affiliates of firms from i located in j that export to k is given by continuing exporting affiliates to k plus new exporters to k ,

$$M'_{ijk} = M_{ijk} \cdot (1 - G_i(z_{ijk}^{EO})) + (M_{ij} - M_{ijk}) \cdot (1 - G_i(z_{ijk}^{OE})). \quad (42)$$

The variable z_{ij}^{OH} (z_{ij}^{HO}) is the productivity threshold that induces a firm from i to open (shut down) an affiliate in j , while z_{ijk}^{OE} (z_{ijk}^{EO}) is the productivity threshold that induces an affiliate of a firm from i in j to start (stop) exporting from j to k .²⁰ Finally, $G_i(z)$ denotes the c.d.f. of the (exogenous) firm-level productivity distribution in country i .

²⁰Theorem 1 in Fillat and Garetto (2015) assures that these firm-level productivity thresholds are well-defined.

5.2 Calibration

We calibrate the model to match the expansion of U.S. MNEs in the top ten FDI host countries during our sample period.²¹ To this end, we need to assign values to preference parameters (ρ, η) , technology parameters $(\delta, \text{the parameters of the productivity distribution, and the parameters of the shock processes})$, and to the rich set of barriers to FDI that the model considers $(F_j^h, f_j^h, F_{jk}^e, f_{jk}^e, \tau_{jk})$. We take wages and aggregate demand levels as exogenous, so we need to parameterize those from the data.

We calibrate directly preference and technology parameters, either taking them from the literature or from direct observation of related magnitudes in the data. We set an elasticity of substitution of $\eta = 5$, in line with mean estimates by Broda and Weinstein (2006). We set the exogenous death rate $\delta = 0.02$, equal to the lower bound of the observed exit rates in our data.²² The time discount rate ρ is quite high, at 0.07. We set this value not to violate the technical condition that $\rho + \delta > \mu_j, \forall j$, which ensures that the present discounted value of profits in market j does not diverge. We assume that the distribution of firm productivities is Pareto, with location parameter normalized to $b = 1$ and shape parameter $\vartheta = 3$, consistent with estimates in the literature.²³

We use data on GDP growth across countries to initialize and calibrate the parameters of the composite shock processes, $\tilde{\mu}_j, \tilde{\sigma}_j$, for $j = 1, \dots, 10$. Wages are exogenously fed into the model. Appendix D contains methodological details and data sources about this part of the calibration. The parameters and model magnitudes that we calibrate directly are reported in Tables D.1 D.2.

It remains to calibrate barriers to FDI. Recall that the BEA data do not report the destination of export platform sales except for a small number of countries in the benchmark year surveys. For this reason, we need to resort to symmetry and proportionality assumptions to recover those frictions for which we don't have good target moments. Ideally, we need to recover values for the fixed and sunk costs of affiliate opening, f_j^h and F_j^h , for $j = 1, \dots, 10$, for the fixed and sunk costs of affiliate exports, f_{jk}^e and F_{jk}^e , for $j = 1, \dots, 10$ and $k \neq j$, and for the iceberg costs of affiliate exports, τ_{jk} , for $j = 1, \dots, 10$ and $k \neq j$. These are a total of 320 parameters. To reduce the number of parameters to calibrate, we assume that the fixed and sunk costs of affiliate exports are symmetric across all third country destinations (other than the U.S.): $f_{jk}^e = f_j^e$ and $F_{jk}^e = F_j^e$, for $j = 1, \dots, 10$ and $k \neq j, U.S.$. Moreover, we assume that the iceberg costs are proportional to gravity-based estimates of trade costs for those destinations for which we don't have any bilateral

²¹Between 1987 and 2011, the top ten host countries are: Brazil, Canada, China, France, the U.K., Germany, Ireland, Japan, Mexico, and Singapore.

²²Overall exit rates in the model are given by the sum of exogenous and endogenous exits, and they are a target moment in the calibration.

²³See Simonovska and Waugh (2014).

affiliate export data (Brazil, China, France, Germany, Ireland, Mexico, and Singapore). These assumptions reduce the number of parameters to be recovered to 110.

Parameters values are then chosen to generate the best fit to the following target moments, which are computed as averages across years and industries:

1. the share of MNEs that have an affiliate in country j ;
2. the share of MNEs opening an affiliate in country j ;
3. the share of MNEs shutting down an affiliate in j ;
4. the share of affiliates in j that export to the U.S.;
5. the share of affiliates in j that export to a country other than the U.S.;
6. the share of affiliates in j that start exporting to the US;
7. the share of affiliates in j that start exporting to a country other than the US;
8. the share of affiliates in j that stop exporting to the US;
9. the share of affiliates in j that stop exporting to a country other than the US;
10. the average exports to the US/horizontal sales for affiliates in j ;
11. the average exports to third countries/horizontal sales for affiliates in j ;
12. the average exports to Canada, Japan, or Mexico/horizontal sales for affiliates in j (benchmark years only).

We calibrate the model by simulating 500 firms for 30 years. The model matches remarkably well the moments about affiliate presence, sale shares, and entry rates, while exit rates are lower than in the data. While we match moments by country, in the interest of space we report in Table 6 a summary of the model fit taking averages of each of the moments across countries. We report the full set of model-generated moments and their comparison with the data in Tables D.3- D.7 in Appendix D.

5.3 Counterfactual Analysis

TBA

STATIC MOMENTS	data	model
% of MNEs with affiliates in j	0.287	0.311
% of affiliates in j exporting to U.S.	0.566	0.558
% of affiliates in j exporting to third countries	0.650	0.658
Affiliate export share to the U.S.	0.140	0.135
Affiliate export share to third countries	0.288	0.279
Affiliate export share to Canada	0.015	0.013
Affiliate export share to the U.K.	0.069	0.040
Affiliate export share to Japan	0.033	0.015
DYNAMIC MOMENTS: ENTRY		
% of MNEs opening affiliates in j	0.035	0.018
% of affiliates in j that start exporting to the US	0.030	0.024
% of affiliates in j that start exporting to third countries	0.031	0.026
DYNAMIC MOMENTS: EXIT		
% of MNEs closing affiliates in j	0.113	0.025
% of affiliates in j that stop exporting to the US	0.025	0.020
% of affiliates in j that stop exporting to third countries	0.027	0.020

Table 6: **Moments.** Model versus data, averages across host countries and years. Moments for Japan, Canada, and the U.K. are averages over benchmark years only.

6 Conclusions

This paper is a theoretical and empirical investigation of how the activities of multinational corporations evolve over the life cycle. We establish three novel facts: first, MNEs' affiliates grow little over their life cycle; second, MNEs affiliates' are born specialized in their life-long activity then diversify a small share of their activities over their life cycle; third, the location choices of new affiliates do not depend on the locations of previously existing affiliates of the same firm.

These facts guide us in the construction of a simple dynamic model of multinational activity which, albeit stylized, delivers rich testable implications for which we find strong support in the data.

We then develop a quantitative model, which sheds light on the implications of dynamic features of the data for the magnitudes and characteristics of the costs to the MNE, an essential ingredient to study the welfare gains from multinational activity.

References

- Alessandria, G. and H. Choi (2007). Do sunk costs of exporting matter for net exports dynamics? *Quarterly Journal of Economics* 122(1), 289–336.
- Alessandria, G., H. Choi, and K. Ruhl (2015). Trade adjustment dynamics and the welfare gains from trade. Mimeo, University of Rochester.
- Antràs, P. and S. R. Yeaple (2014). Multinational firms and the structure of international trade. *Handbook of International Economics* 4, 55–130.
- Arkolakis, C. (2016). A unified theory of firm selection and growth. *Quarterly Journal of Economics* 131(1), 89–155.
- Arkolakis, C., N. Ramondo, A. Rodríguez-Clare, and S. Yeaple (2017). Innovation and production in the global economy. NBER WP 18792.
- Baldwin, R. and P. Krugman (1989). Persistent trade effects of large exchange rate shocks. *Quarterly Journal of Economics* 104(4), 635–654.
- Bernard, A. B. and J. B. Jensen (1999). Exceptional exporter performance: cause, effect, or both? *Journal of International Economics* 47, 1–25.
- Broda, C. and D. E. Weinstein (2006). Globalization and the gains from variety. *Quarterly Journal of Economics* 121(2), 541–585.
- Conconi, P., A. Sapir, and M. Zanardi (2016). The internationalization process of firms: from exports to fdi. *Journal of International Economics* 99, 16–30.
- Cravino, J. and A. Levchenko (2017). Multinational firms and international business cycle transmission. *Quarterly Journal of Economics*, Forthcoming 132(2), 921–962.
- Das, S., M. J. Roberts, and J. R. Tybout (2007). Market entry costs, producer heterogeneity, and export dynamics. *Econometrica* 75(3), 837–873.
- Davis, S. J., J. Haltiwanger, and S. Schuh (1996). Small business and job creation: Dissecting the myth and reassessing the facts. *Small Business Economics* 8(4), 297–315.
- Decker, R., J. Haltiwanger, R. Jarmin, and J. Miranda (2014). The role of entrepreneurship in us job creation and economic dynamism. *Journal of Economic Perspectives* 28(3), 3–24.
- Decker, R., J. Haltiwanger, R. Jarmin, and J. Miranda (2015). Where has all the skewness gone? the decline in high-growth (young) firms in the u.s. NBER Working Paper # 21776.

- Dixit, A. K. and R. S. Pindyck (1994). *Investment under Uncertainty*. Princeton, NJ: Princeton University Press.
- Eaton, J., M. Eslava, M. Kugler, and J. Tybout (2008). The margins of entry into export markets: Evidence from colombia. In E. Helpman, D. Marin, and T. Verdier (eds.), *The Organization of Firms in a Global Economy*. Cambridge, MA: Harvard University Press.
- Egger, P., M. Fahn, V. Merlo, and G. Wamser (2014). On the genesis of multinational foreign affiliate networks. *European Economic Review* 65, 136–163.
- Fillat, J. L. and S. Garetto (2015). Risk, returns, and multinational production. *Quarterly Journal of Economics* 130(4), 2027–2073.
- Fillat, J. L., S. Garetto, and L. Oldenski (2015). Diversification, cost structure, and the risk premium of multinational corporations. *Journal of International Economics* 96(1), 37–54.
- Garetto, S., L. Oldenski, N. Pandalai-Nayar, and N. Ramondo (2017). Exporters. Mimeo.
- Ghironi, F. and M. J. Melitz (2005). International trade and macroeconomic dynamics with heterogeneous firms. *The Quarterly Journal of Economics* 120(3), 865–915.
- Gravelle, J. (2015). Tax havens: International tax avoidance and evasion. *Congressional Research Service* 7(5700), 1–55.
- Gumpert, A., A. Moxnes, N. Ramondo, and F. Tintelnot (2016). Multinational firms and exporters dynamics. Mimeo, UCSD.
- Helpman, E., M. J. Melitz, and S. R. Yeaple (2004). Exports versus fdi with heterogeneous firms. *American Economic Review* 94(1), 300–316.
- Impullitti, G., A. A. Irarrazabal, and L. D. Opmolla (2013). A theory of entry and exit into exports markets. *Journal of International Economics* 90(1), 75–90.
- Kueng, L., M.-J. Yang, and B. Hong (2016). Sources of firm life-cycle dynamics: Size vs. age effects. Mimeo, University of Washington.
- Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica* 71(6), 1695–1725.
- Morales, E., G. Sheu, and A. Zahler (2015). Extended gravity. Mimeo, Princeton University.
- Ramondo, N., V. Rappoport, and K. J. Ruhl (2013). The proximity-concentration tradeoff under uncertainty. *Review of Economic Studies* 80(4), 1582–1621.

Table A.1: BEA minimum survey exemptions levels

survey year	Minimum exemption levels (in U\$ millions)	survey year	Minimum exemption levels (in U\$ millions)
1987-88	10	2000-03	30
1989	3	2004	25
1990 -93	15	2005-07	40
1994	3	2008	60
1995-98	20	2009	25
1999	7	2010-11	60

Note: Exemption levels are for majority-owned foreign affiliates. Benchmark survey years are highlighted.

Roberts, M. J. and J. R. Tybout (1997). The decision to export in colombia: An empirical model of entry with sunk costs. *The American Economic Review* 87(4), 545–564.

Ruhl, K. J. and J. Willis (2017). New exporter dynamics. *International Economics Review* 58(3).

Simonovska, I. and M. Waugh (2014). The elasticity of trade: Estimates and evidence. *Journal of International Economics* 92(1), 34–50.

Tintelnot, F. (2017). Global production with export platforms. *Quarterly Journal of Economics* 132(1), 157–209.

Appendix

A Data Description and Summary Statistics

To describe the construction of our sample, it is important to notice that the BEA surveys affiliates of U.S. parents applying minimum survey exemption levels, in terms of affiliate sales, which differ over time. In general, reporting thresholds increased in recent years, reaching US\$60 millions for 2011. Additionally, benchmark survey years (i.e., years in which the survey is more comprehensive), which occur every 5 years, have lower reporting thresholds. Table A.1 shows the reporting thresholds for the years in our sample.

Since the goal of this paper is to understand the evolution of the global structure of production, and not the establishment of headquarters due to profit shifting motives, we restrict our attention

to affiliates that do not operate in tax haven countries. Affiliates in tax haven countries are likely to open for different reasons and be subject to different cost structures than those in non-tax haven countries, confounding our analysis. We compile our list of tax havens using information from Gravelle (2015). We omit countries that meet some of the criteria for tax haven status but that also have a substantial amount of real FDI production from the list. If a country is in the top ten percent of U.S. FDI destinations measured by total U.S. MNE affiliate employment, we consider it to be a location for actual production rather than a strict tax haven. Based on this definition, Ireland, Switzerland, Hong Kong, and Singapore are the only countries from the Gravelle (2015) list that we do not classify as tax havens. A full list of tax haven countries is reported below (TBA).

When a firm has more than one enterprise operating in the same country and industry, we group these enterprises' activities together and refer to them as a single affiliate. We do this for two reasons. First, the firms themselves are permitted to report combined data in this way, making it difficult to isolate individual plants. Based on the BEA definition, an affiliate is a business enterprise in a given industry operating in a particular host country; it thus could operate several plants in different locations within the host country. The BEA rules permit consolidated reporting for distinct enterprises located in the same country that operate in the same narrowly defined industry or otherwise are integral parts of the same business operation. Second, to the extent that the costs of opening a new affiliate are incurred at the country-industry level, this is the appropriate level of aggregation for our analysis. In a robustness exercise, we use reported openings of new enterprises in a country-industry in which the firm already had existing affiliates to check whether costs are incurred at the enterprise or country-industry level. This exercise, though based on noisy data, confirms that focusing on the country-industry-firm-, rather than plant-level, is appropriate.

Table A.2 shows in more detail the distribution of horizontal sales and exports as a share of total affiliate sales. On average, around 72 percent of the sales of an affiliate are destined to the host market, while the remaining 28 percent are exports. The distribution of export sales is extremely skewed: while the 25th percentile of the horizontal shares distribution is above 50 percent and reaches 100 percent at the 75th percentile, the 25th percentile of the export shares distribution is zero, and is still below 50 percent at the 75th percentile.

Table A.2: Affiliate sales distribution, by sale type.

	Horizontal sales (as a share of total affiliate sales)	Export sales
average	0.723	0.277
std dev	0.339	0.339
25 pc	0.539	0.000
50 pc	0.887	0.113
75 pc	1.000	0.461
90 pc	1.000	0.915
95 pc	1.000	1.000

Note: Observations at the affiliate-year level, for new majority-owned affiliates that survive for at least ten consecutive years, in manufacturing. Percentiles are taken with respect to the variable of interest so that the X-percentile affiliates change as the sorting variable changes. Averages of the 11 firms around the indicated percentile are reported to preserve confidentiality.

B New Facts on MNE Dynamics: Robustness

B.1 Flat Affiliate-to-Parent Sales Profiles

Table B.1 reports the results of the following regression:

$$\text{affiliate sales}_a^i / \text{parent sales} = \beta_a \text{age} + FE + \varepsilon_a^i. \quad (\text{B.1})$$

The left-hand side variable is the ratio of sales of type $i = all, H, E$, for a new affiliate of age a , to sales of the parent, age is the age of the affiliate (from 1 to 10), and ε_a^i is the error term. We include country-year and industry fixed effects, and alternatively, country-year and affiliate fixed effects.¹ The flat profiles observed in Figure 1 are confirmed by the regression analysis: the ratio of affiliate to parent sales is not significantly correlated with affiliate age, controlling for country-year and industry fixed effects. The result holds both with and without affiliate fixed effects. As a robustness check, we also include as controls the size of the affiliate and the size of the firm, measured as employment and global sales, respectively; results are unchanged.

As a further step to describe sales growth profiles of different affiliates, Figure B.1 shows that first affiliates are much larger than subsequent affiliates, but they do not appear to grow faster.

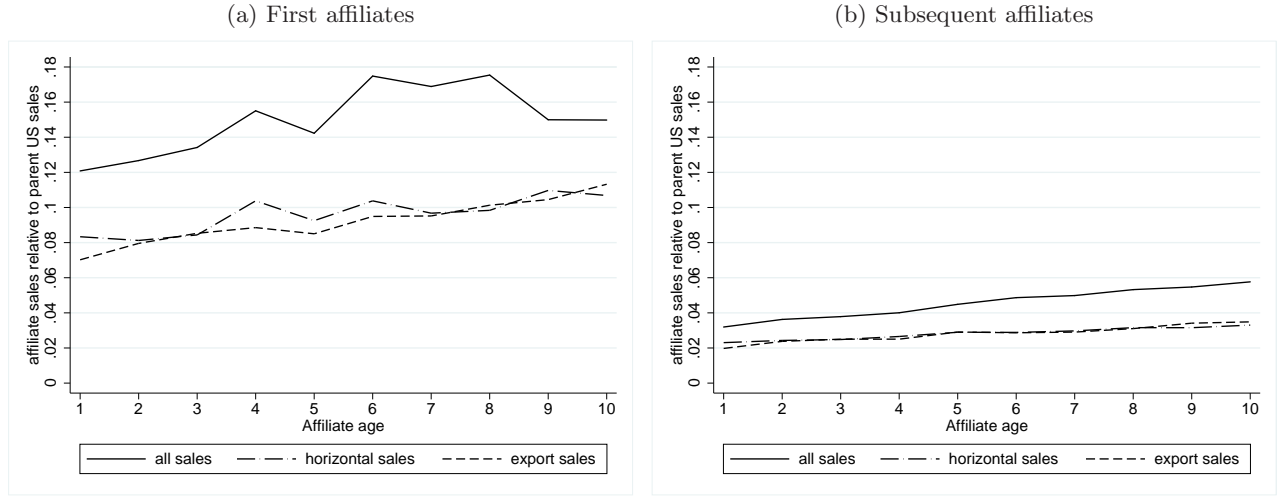
¹We drop outliers which turn out to be five percent of observations.

Table B.1: Affiliate-to-parent sales ratio, by sales type. OLS.

Dep var	affiliate-to-parent sales ratio					
	all sales		horizontal sales		export sales	
	(1)	(2)	(3)	(4)	(5)	(6)
affiliate age	0.019 (0.014)	0.005 (0.003)	0.011 (0.007)	0.002 (0.001)	0.011 (0.012)	0.004* (0.002)
industry fe	yes	no	yes	no	yes	no
country-year fe	yes	yes	yes	yes	yes	yes
affiliate fe	no	yes	no	yes	no	yes
Observations	38,088	38,088	36,127	36,127	25,950	25,950
R-square	0.01	0.0002	0.04	0.0003	0.01	0.0001

Note: Observations at the affiliate-year level, for new majority-owned affiliates that survive for at least ten consecutive years, in manufacturing. The dependent variable *affiliate to parent sales* refers to affiliate sales in each type, relative to the domestic sales of the U.S. parent. Standard errors, clustered at the parent level, are in parenthesis. Levels of significance are denoted *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Figure B.1: Affiliate size, by activity type, age, and position in the MNE opening sequence.



Notes: Sample of new majority-owned affiliates that survive for at least ten consecutive years, in manufacturing. First affiliates refer to the first affiliates opened by the MNE, while subsequent affiliates refer to the rest (2nd, 3rd, ..., nth).

Table B.2: Intensive and extensive margins of sale shares. OLS.

Dep var	Intensive margin of sale shares				Extensive margin of sale shares			
	horizontal sales		export sales		horizontal sales		export sale share	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
affiliate age	-0.002 (0.002)	-0.012*** (0.001)	-0.005** (0.002)	0.005*** (0.001)	0.00003 (0.001)	-0.001 (0.0006)	0.014*** (0.003)	0.029 (0.002)
industry fe	yes	no	yes	no	yes	no	yes	no
country-year fe	yes	yes	yes	yes	yes	yes	yes	yes
affiliate fe	no	yes	no	yes	no	yes	no	yes
Observations	36,127	36,127	25,950	25,950	38,088	38,088	38,088	38,088
R-square	0.079	0.013	0.092	0.000	0.042	0.0001	0.081	0.036

Note: Observations at the affiliate-year level, for new majority-owned affiliates that survive for at least ten consecutive years, in manufacturing. In columns (1)-(4), the dependent variable is horizontal (export) sales, as a share of total affiliate's sales, for affiliates with positive horizontal (export) sales; in columns (5)-(8), the dependent variable is the share of affiliates with positive horizontal (export) sales. Standard errors, clustered at the parent level, are in parenthesis. Levels of significance are denoted *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

B.2 Affiliate Expansion over Time

To illustrate the evolution of horizontal and export sales shares over time, Table B.2 reports the results of the following regression:

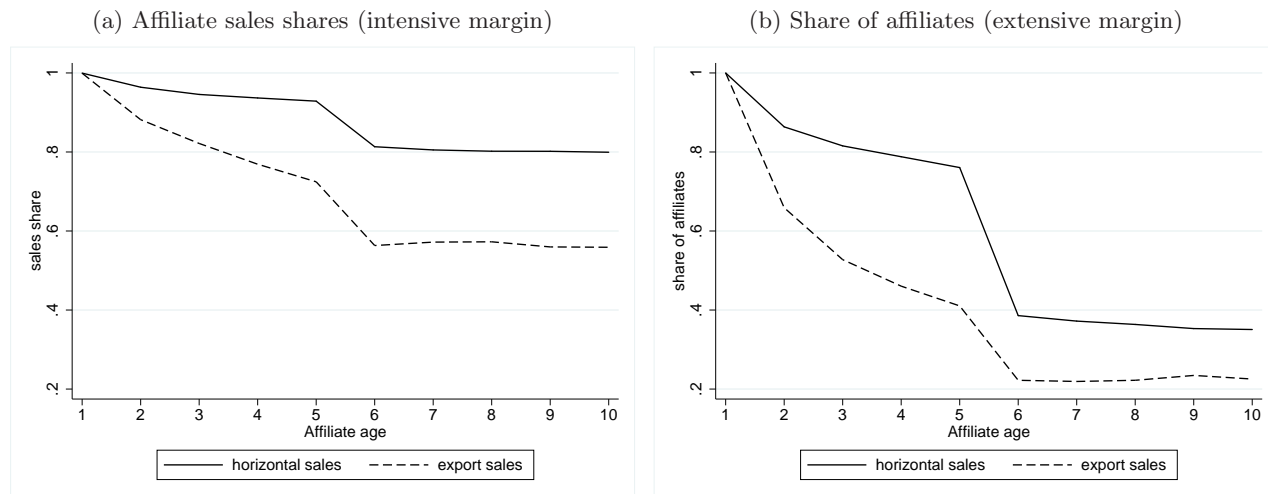
$$\text{affiliate sales}_a^i / \text{total affiliate sales}_a = \beta_a \text{age} + FE + \varepsilon_a^i \quad (\text{B.2})$$

where the left-hand side variable is the share of horizontal (export) sales of the affiliate, age is the age of the affiliate (from 1 to 10), and ε_a^i is an error term. We include country-year and industry fixed effects, and alternately, country-year and affiliate fixed effects.

Table B.2 shows the results. The regressions confirm that – within affiliates – the horizontal sales share decreases and the export sales share increase, supporting the idea of increasing diversification of affiliate sales in space over time. On the extensive margin, the share of affiliates selling to their host market does not change over the life cycle, while the share of exporters increases, confirming that affiliates add sales destinations over time.

Figure B.2 shows the evolution of the intensive and extensive margins of sales shares for affiliates that are pure-type at birth. It is worth remembering that more than 50 percent of affiliates are born with only horizontal sales, while affiliates born with only exports are less than 10 percent of

Figure B.2: Intensive and extensive margins of sale shares, by activity type. Pure-type affiliates at birth.



Notes: Sample of new majority-owned affiliates that survive for at least ten consecutive years, in manufacturing. Horizontal and export sales refer, respectively, to sales to the market where the affiliate is located, and to sales to markets outside the local market. (B.2a): average sales, as a share of total affiliate sales, include affiliates with positive horizontal and export sales, respectively, for the subset of affiliates with only horizontal and only export sales at birth, respectively). (B.2b): number of affiliates, as a share of the total number of affiliates, include affiliates with positive horizontal and export sales, respectively.

observations. Figure B.2a shows that, on average, sale shares of pure-type born affiliates decrease with age: the initial specialization is soon followed by more diversified sales patterns. One may get the misleading impression that horizontal sale shares decrease by less than export shares for affiliates born with only one type of sales. However, it is worth noting that by the tenth year of life, an affiliate born with exclusively export sales is still above the 75th percentile of the exports sale share distribution —and much above the average (0.28) and median (0.11) of the distribution, as indicated by Table A.2, while an affiliate born exclusively serving the host market, by age ten, is below the 50th percentile of the horizontal sale share distribution. As panel B.2b shows, the set of pure horizontal affiliates at birth shrinks over the life cycle of affiliates indicating, once again, that these new affiliates start by serving their host market exclusively, and then they start exporting. By their sixth year of life, more than 60 percent of previously pure horizontal affiliates have started exporting.

Table B.3 presents the econometric equivalent of Figure B.2. Both the intensive margin of horizontal and export sales shares and the extensive margin of pure affiliates decrease over the life-cycle, indicating that most affiliates that are born as fully specialized incorporate different sales destinations over the life cycle. The OLS estimates also confirm that for pure-type affiliates at birth the decrease in sales shares is a result of within-affiliate changes: on average, affiliates of different

Table B.3: Intensive and extensive margins of sale shares, pure-type affiliates at birth. OLS.

Dep var	Intensive margin of sale shares				Extensive margin of sale shares			
	horizontal sales		export sales		horizontal sales		export sale share	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
affiliate age	-0.014*** (0.001)	-0.096*** (0.001)	-0.036** (0.004)	-0.021*** (0.003)	-0.046*** (0.004)	-0.044*** (0.002)	-0.059*** (0.005)	-0.038*** (0.004)
industry fe	yes	no	yes	no	yes	no	yes	no
country-year fe	yes	yes	yes	yes	yes	yes	yes	yes
affiliate fe	no	yes	no	yes	no	yes	no	yes
Observations	19,463	19,463	3,032	3,032	19,905	19,905	3,595	3,595
R-square	0.147	0.020	0.288	0.133	0.245	0.099	0.268	0.125

Note: Observations at the affiliate-year level, for new majority-owned affiliates that survive for at least ten consecutive years, in manufacturing. In columns (1)-(4), the dependent variable is horizontal (export) sales, as a share of total affiliate's sales, for affiliates born with only horizontal (export) sales; in columns (5)-(8), the dependent variable is the share of affiliates born with only horizontal (export) sales. Standard errors, clustered at the parent level, are in parenthesis. Levels of significance are denoted *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

ages have undistinguishable export shares, but a pure exporter at birth decreases its export shares as it gets older; for pure horizontal affiliates at birth, the effect is a mix of between- and within-firm effects.

We also document here that the older an affiliate is when it starts a new activity (e.g. exporting), the lower the intensity at which that activity is performed.

Figure B.3 shows the average sales share, for horizontal and export sales, by the age at which the affiliate starts the activity. This figure makes clear that the primary activity affiliates are born doing remains their main activity for the remainder of their life. In contrast, if an activity is incorporated later in life, it never overcomes the activity performed earlier in life. Affiliates that are born doing some horizontal sales have an average horizontal sale share of around 75 percent (around the 50th percentile of this variable's distribution), while affiliates that are born doing some exports have an average export share of around 40 percent, which correspond to almost the 90th percentile of that share's distribution. If an affiliate were to start doing horizontal sales in its tenth year of life, on average, it would dedicate only 35 percent of its sales to the local market, while an affiliate that starts exporting in its tenth year would dedicate at most three percent of its sales to exports.

Finally, we report additional results about the sequencing of affiliate location decisions.

Table B.4: (Lack of) Extended Gravity in Affiliate Opening, Robustness.

	Unconditional	Continent	Border	Language	Income	All =1
Canada	0.0252	0.0258		0.0258513	0.0250	
UK	0.0300	0.0302	0.0324	0.0301367	0.0230	0.0324
Germany	0.0345	0.0353	0.0353	0.0319048	0.0346	0.0319
Ireland	0.0166	0.0169	0.0174	0.0169043	0.0167	0.0174
China	0.0451	0.0489	0.0568	0.0579747	0.0581	0.0599
France	0.0335	0.0341	0.0364	0.0322201	0.0335	0.0339
Brazil	0.0273	0.0290	0.0294	0.0253165	0.0308	0.0188
Singapore	0.0289	0.0322	0.0507	0.0293015	0.0290	0.0508
Mexico	0.0340	0.0354	0.0313	0.0367693	0.0361	0.0243
Japan	0.0269	0.0288			0.0269	

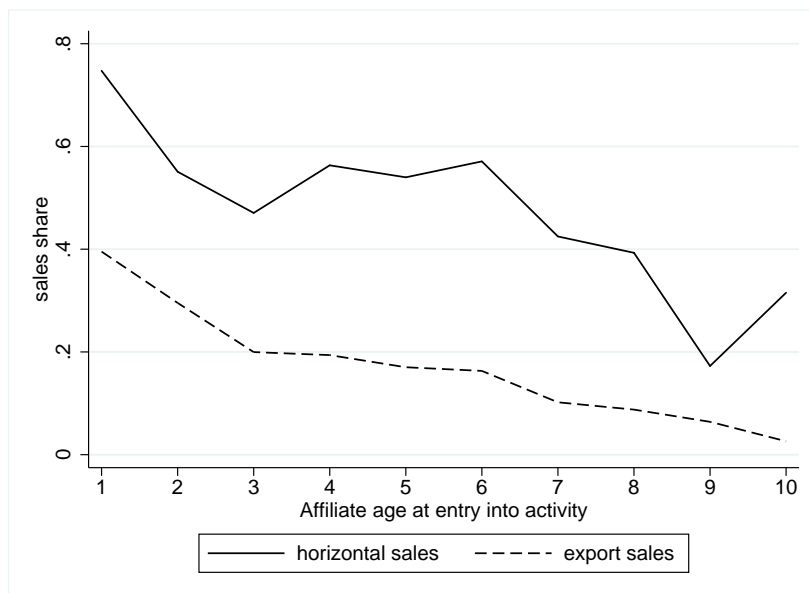
Note: Probabilities of opening affiliates in top-ten most popular destinations. Conditional probabilities refer to the probability of observing a MNE opening an affiliate in country i given that the parent already has an affiliate in a “similar” country. The sample is restricted to parents with at least five affiliates worldwide.

Table B.5: (Lack of) Extended Gravity in Affiliate Opening, Robustness.

	Unconditional	Continent	Border	Language	Income	All =1
Canada	0.0252	0.0258		0.0258513	0.0250	
UK	0.0300	0.0302	0.0324	0.0301367	0.0230	0.0324
Germany	0.0345	0.0353	0.0353	0.0319048	0.0346	0.0319
Ireland	0.0166	0.0169	0.0174	0.0169043	0.0167	0.0174
China	0.0451	0.0489	0.0568	0.0579747	0.0581	0.0599
France	0.0335	0.0341	0.0364	0.0322201	0.0335	0.0339
Brazil	0.0273	0.0290	0.0294	0.0253165	0.0308	0.0188
Singapore	0.0289	0.0322	0.0507	0.0293015	0.0290	0.0508
Mexico	0.0340	0.0354	0.0313	0.0367693	0.0361	0.0243
Japan	0.0269	0.0288			0.0269	

Note: Probabilities of opening affiliates in top-ten most popular destinations. Conditional probabilities refer to the probability of observing a MNE opening an affiliate in country i given that the parent already has an affiliate in a “similar” country. The sample is restricted to parents with at least ten affiliates worldwide.

Figure B.3: Sales shares and entry age, by activity type.



Notes: Sample of new majority-owned affiliates that survive for at least ten consecutive years, in manufacturing. Average horizontal (export) sales shares, by affiliate first age with positive horizontal (export) sales.

Tables B.4 and B.5 report the conditional and unconditional probabilities of affiliate opening in one of the top 10 host countries for subsets of the largest MNEs in the sample: Table B.4 (Table B.5) restricts the sample to MNEs with more than 5 (10) affiliates.

B.3 Testing the Predictions of the Model

Figure B.4 illustrates the relationship between affiliate size and timing of export for different time cutoffs.

Table B.6 illustrates systematic differences between the first affiliate and subsequent affiliates of a MNE in terms of size (defined as sales to the host market) and likelihood of being an exporter.

Table B.7 provides additional support for the predictions of the model regarding the order in which MNEs open affiliates over time. First, MNEs tend to open first affiliates in larger markets. Second, MNEs choose, on average, to open affiliates first in markets that are less costly to enter, under various measures of entry costs. Countries in which MNEs open their first affiliate have around a 20 percent lower number of business procedures, take 20, rather than 25, days to open a business, and have a cost of starting a business that is two thirds of the cost faced in subsequent markets. Additionally, on average, affiliates are first opened in markets for which the minimum capital needed to start a business is 20 percent lower.

Table B.6: Affiliate size, by affiliate position in the MNE opening sequence.

Avg.	first affiliates	subsequent affiliates
affiliate employment	709	526
affiliate sales, as % of parent's	20	6.5
affiliate H-sales, as % of parent's	10	3.8
diversified affiliates (%)	65.7	59.3

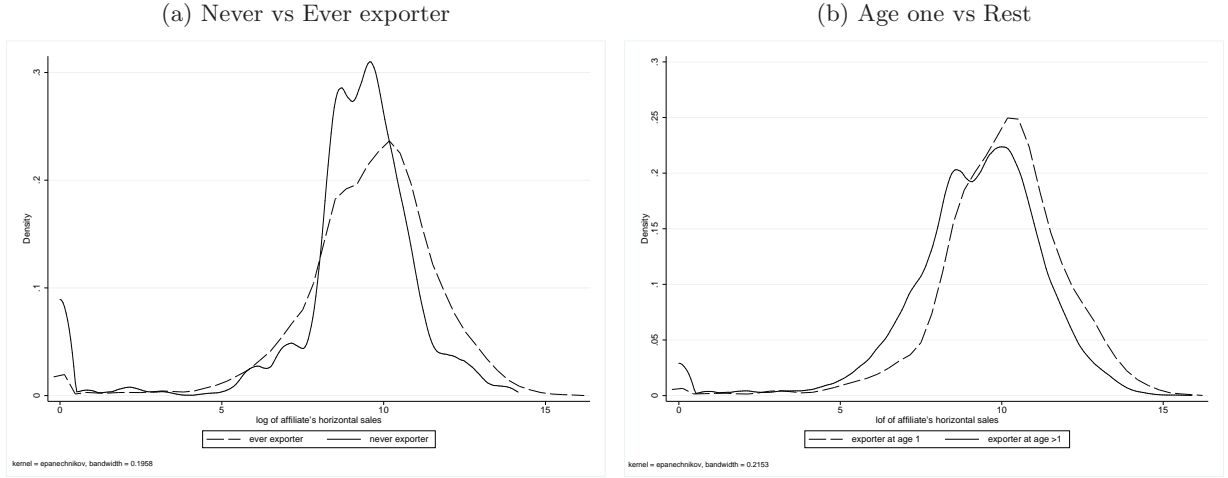
Note: Observations at the affiliate level, for new majority-owned affiliates that survive for at least 10 consecutive years, in manufacturing.

Table B.7: Host market characteristics, by affiliate position in the MNE opening sequence.

Avg.	first affiliates	subsequent affiliates
GDP (billions of US\$)	970	868
number of business procedures	6.4	7.6
number of days to start business	20.2	24.6
cost of start business (% of GDPpc)	7.0	11.8
Min K needed to start business (U\$)	4,634	6,017

Note: Observations at the affiliate level, for new majority-owned affiliates that survive for at least ten consecutive years, in manufacturing. Variables related to entry costs are from the World Bank, Doing Business. GDP is from the Penn World Tables (8.0).

Figure B.4: Affiliate size, export status, and timing of export entry.



Notes: Sample of new majority-owned affiliates that survive for at least ten consecutive years, in manufacturing. Pure exporters are not included. Kernel density of (log) horizontal sales for affiliates that: never export versus the ones that export at some point in their life, in (B.4a); first export at age one versus the ones that export at any age older than one, (B.4b).

B.4 Affiliate Exit

Table B.8 provides evidence that affiliate exit is not random and motivates our decision to incorporate endogenous exit into the quantitative model. As shown in Table B.8, exit rates are slightly higher for younger affiliates than for older affiliates. Exiting affiliates are also smaller than those that continue to operate.

Table B.8: Affiliate exit, by affiliate type. OLS.

Dep var	D(affiliate exit)		
	all affiliates	pure horizontal affiliates	exporting affiliates
age	-0.001* (0.0003)	-0.001 (0.001)	-0.001** (0.0003)
log affiliate employment	-0.016*** (0.0007)	-0.014*** (0.001)	-0.015*** (0.001)
log global employment	0.001 (0.001)	0.001 (0.002)	0.001 (0.001)
Observations	156,446	47,772	102,518
R-square	0.031	0.033	0.031

Note: Observations at the affiliate-year level, for new majority-owned affiliates that survive for at least ten consecutive years, in manufacturing. Pure exporters are not included. The variable D(affiliate exit) equals one if the affiliate exits the following year. The variable "global employment" refers to the aggregate MNE employment, both in the United States and abroad. All specifications with country-year and industry fixed effects. Standard errors, clustered at the parent level, are in parenthesis. Levels of significance are denoted *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

C Derivation of the Solution of the Model

In this Appendix we provide details about the solution procedure of the model presented in Section 3 and of its quantitative extension in Section 5.

C.1 Solution of the value functions in the baseline model

In Section 3 we specified the problem of the firm by defining the Bellman equations. We derive here the solution of the value functions. We start by writing equation (8) in the continuation region:

$$[1 + (\rho + \delta)\Delta t]V_d(z, X) = \pi_d(z, X)\Delta t + E[V_d(z, X')|X].$$

Taking the limit for $\Delta t \rightarrow 0$:

$$\begin{aligned} (\rho + \delta)V_d(z, X)dt &= \pi_d(z, X)dt + E[V_d(z, X')|X] - V_d(z, X) \\ (\rho + \delta)V_d(z, X) &= \pi_d(z, X) + E\left[\frac{dV_d(z, X)}{dt}\right]. \end{aligned} \tag{C.1}$$

From Ito's Lemma:

$$E[dV_d(z, X)] = \mu V_d'(z, X) + \frac{\sigma^2}{2} V_d''(z, X), \tag{C.2}$$

where $V'_d(z, X)$ and $V''_d(z, X)$ denote the first and second derivative of the value function with respect to X . By substituting (C.2) into (C.1), we obtain the non-arbitrage condition:

$$(\rho + \delta)V_d(z, X) = \pi_d(z, X) + \mu V'_d(z, X) + \frac{\sigma^2}{2}V''_d(z, X) \quad (\text{C.3})$$

which states that the expected value of the asset (profit flow plus expected change) must be equal to its normal return. We guess the following form for the value function:

$$V_d(z, X) = W_d(z, X) + e^{\xi X}$$

and substitute it into (C.3):

$$(\rho + \delta)[W_d(z, X) + e^{\xi X}] = \pi_d(z, X) + \mu[W'_d(z, X) + \xi e^{\xi X}] + \frac{\sigma^2}{2}[W''_d(z, X) + \xi^2 e^{\xi X}].$$

We solve using the method of undetermined coefficients. Collecting the homogeneous terms we obtain:

$$\begin{aligned} (\rho + \delta)e^{\xi X} &= \mu\xi e^{\xi X} + \frac{\sigma^2}{2}\xi^2 e^{\xi X} \\ (\rho + \delta) &= \mu\xi + \frac{\sigma^2}{2}\xi^2. \end{aligned}$$

Hence ξ is given by the solution of the quadratic equation:

$$\xi = \frac{-\mu \pm \sqrt{\mu^2 + 2\sigma^2(\rho + \delta)}}{\sigma^2}. \quad (\text{C.4})$$

Collecting the non-homogeneous term we obtain:

$$(\rho + \delta)W_d(z, X) = \pi_d(z, X) + \mu W'_d(z, X) + \frac{\sigma^2}{2}W''_d(z, X). \quad (\text{C.5})$$

We guess the following form for the nonhomogeneous term:

$$W_d(z, X) = \frac{\pi_d(z, X)}{\kappa} = \frac{H \left(\frac{w_d}{z} \right)^{1-\eta} e^{(\eta-1)X} P_d^\eta Q_d}{\kappa}.$$

Substituting it into C.5:

$$\begin{aligned}
(\rho + \delta) \frac{H\left(\frac{w_d}{z}\right)^{1-\eta} e^{(\eta-1)X} P_d^\eta Q_d}{\kappa} &= H\left(\frac{w_d}{z}\right)^{1-\eta} e^{(\eta-1)X} P_d^\eta Q_d + \mu \frac{H\left(\frac{w_d}{z}\right)^{1-\eta} (\eta-1) e^{(\eta-1)X} P_d^\eta Q_d}{\kappa} + \dots \\
&\quad \dots \frac{\sigma^2 H\left(\frac{w_d}{z}\right)^{1-\eta} (\eta-1)^2 e^{(\eta-1)X} P_d^\eta Q_d}{2\kappa} \\
(\rho + \delta) \frac{1}{\kappa} &= 1 + \frac{\mu(\eta-1)}{\kappa} + \frac{\sigma^2 (\eta-1)^2}{2\kappa} \\
\kappa &= (\rho + \delta) - \mu(\eta-1) - \frac{\sigma^2}{2}(\eta-1)^2
\end{aligned}$$

so that:

$$W_d(z, X) = \frac{\pi_d(z, X)}{(\rho + \delta) - \mu(\eta-1) - \frac{\sigma^2}{2}(\eta-1)^2}.$$

Hence the general solution for the value of domestic sales is given by:

$$V_d(z, X) = \frac{\pi_d(z, X)}{(\rho + \delta) - \mu(\eta-1) - \frac{\sigma^2}{2}(\eta-1)^2} + A_d(z)e^{\alpha X} + B_d(z)e^{\beta X},$$

where $\alpha < 0$ and $\beta > 1$ are the two values of ξ . Since all firms always have domestic sales, there is no option value of domestic sales, so $A_d(z) = B_d(z) = 0$, and the value of domestic sales is simply given by the present discounted value of domestic profits.

We proceed in an analogous way to solve for the other value functions. By following the same steps as above, we obtain a no-arbitrage condition for the option value of an affiliate $V_j^o(z, X)$:

$$(\rho + \delta)V_j^o(z, X) = \mu V_j'^o(z, X) + \frac{\sigma^2}{2} V_j''^o(z, X). \quad (\text{C.6})$$

We guess a functional form for the value function:

$$V_j^o(z, X) = e^{\xi X}$$

and following the procedure outlined above, we obtain the general solution:

$$V_j^o(z, X) = A_j^o(z)e^{\alpha X} + B_j^o(z)e^{\beta X}$$

where $\alpha < 0$ and $\beta > 1$ are the two values of ξ . Notice that there are no profit flows associated with an option value function. Finally, as $X \rightarrow 0$, the option of opening an affiliate becomes worthless, so it must be that $A_j^o(z) = 0$. Conversely, the option of opening an affiliate becomes more attractive as X increases, so it must be that $B_j^o(z) > 0$.

The no-arbitrage condition for the value of a pure-type horizontal affiliate $V_j^h(z, X)$ is:

$$(\rho + \delta)V_j^h(z, X) = \pi_j^h(z, X) + \mu V_j'^h(z, X) + \frac{\sigma^2}{2}V_j''^h(z, X). \quad (\text{C.7})$$

We guess the following form for the value function:

$$V_j^h(z, X) = W_j^h(z, X) + e^{\xi X}.$$

The homogeneous term has the same functional form as in the previous cases. We then guess the following form for the non-homogeneous term:

$$W_j^h(z, X) = \frac{\bar{\pi}_j^h(z, X)}{\kappa_1} + \frac{f_j^h}{\kappa_2}$$

and applying again the method of undetermined coefficients we find:

$$\begin{aligned} \kappa_1 &= (\rho + \delta) - \mu(\eta - 1) - \frac{\sigma^2}{2}(\eta - 1)^2 \\ \kappa_2 &= (\rho + \delta) \end{aligned}$$

so that the general solution for the value of a pure-type horizontal affiliate is:

$$V_j^h(z, X) = A_j^h(z)e^{\alpha X} + B_j^h(z)e^{\beta X} + \frac{\bar{\pi}_j^h(z, X)}{(\rho + \delta) - \mu(\eta - 1) - \frac{\sigma^2}{2}(\eta - 1)^2} - \frac{f_j^h}{(\rho + \delta)}.$$

Notice that, as $X \rightarrow 0$, the value of horizontal sales also goes to zero (exit is only exogenous and random in this version of the model), so it must be that $A_j^h(z) = 0$. Conversely, as X increases, the value of the affiliate also increases because of the option of starting to export, so it must be that $B_j^h(z) > 0$.

Finally, the no-arbitrage condition for the value of an exporting affiliate $V_j^e(z, X)$ is:

$$(\rho + \delta)V_j^e(z, X) = \pi_j^e(z, X) + \mu V_j'^e(z, X) + \frac{\sigma^2}{2}V_j''^e(z, X). \quad (\text{C.8})$$

We guess a functional form for the value function:

$$V_j^e(z, X) = W_j^e(z, X) + e^{\xi X}.$$

The homogeneous term has the same functional form as in the previous cases. We guess the

following form for the non-homogeneous term:

$$W_j^e(z, X) = \frac{\bar{\pi}_j^h(z, X) + \bar{\pi}_j^e(z, X)}{\kappa_1} - \frac{f_j^h + f_j^e}{\kappa_2}$$

and applying again the method of undetermined coefficients we find:

$$\begin{aligned}\kappa_1 &= (\rho + \delta) - \mu(\eta - 1) - \frac{\sigma^2}{2}(\eta - 1)^2 \\ \kappa_2 &= (\rho + \delta)\end{aligned}$$

so that the general solution for the value of a diversified affiliate is:

$$V_j^e(z, X) = A_j^e(z)e^{\alpha X} + B_j^e(z)e^{\beta X} + \frac{\bar{\pi}_j^h(z, X) + \bar{\pi}_j^e(z, X)}{(\rho + \delta) - \mu(\eta - 1) - \frac{\sigma^2}{2}(\eta - 1)^2} - \frac{f_j^h + f_j^e}{(\rho + \delta)}.$$

Notice that, as $X \rightarrow 0$, the value of the affiliate also goes to zero (exit is only exogenous and random in this version of the model), so it must be that $A_j^e(z) = 0$. Also, as X increases, the value of the affiliate converges to the discounted profit flow (there is no further expansion option), so it must be that $B_j^e(z) = 0$.

C.2 Solution of the value functions in the quantitative model

In Section 5 we outlined the solution of the model with endogenous affiliate exit, choice of affiliate export destinations, endogenous exit from each export market, and destination country-specific demand shocks. We provide here some details about the derivation of the solution of the value functions in this more general case.

Since the model has the structure of a compound option, we solve it backwards, starting from the problem of a firm that already has an affiliate in country j and has to decide whether to export to any country $k \neq j$.

The Bellman equation describing the value of the option to export to country k for a firm with an affiliate in country j is:

$$V_{jk}^o(z, X, \bar{Q}) = \max \left\{ \frac{1}{1 + (\rho + \delta)\Delta t} E[V_{jk}^o(z, X', \bar{Q}') | (X, \bar{Q})]; V_{jk}^e(z, X, \bar{Q}) - F_{jk}^e \right\}, \quad (\text{C.9})$$

which describes the fact that the affiliate may keep the option of exporting to country k (and get the continuation value of that option), or may start exporting to country k , in which case it pays the entry cost F_{jk}^e and gets the value of exporting to k from j , $V_{jk}^e(z, X, \bar{Q})$. After acknowledging

the the option value of exporting to k only depends on the composite shock Y_k , we write equation (C.9) in the continuation region, take the limit for $\Delta t \rightarrow 0$, and apply Ito's Lemma, to obtain the non-arbitrage condition:

$$(\rho + \delta)V_{jk}^o(z, Y_k) = \tilde{\mu}_k Y_k V_{jk}^{'o}(z, Y_k) + \frac{\tilde{\sigma}_k^2}{2} Y_k^2 V_{jk}^{''o}(z, Y_k). \quad (\text{C.10})$$

Following the same procedure outlined in the previous section, we conclude that the value of the option of exporting to country k for an affiliate in country j has the following general solution:

$$V_{jk}^o(z, Y_k) = A_{jk}^o(z) Y_k^{\alpha_k} + B_{jk}^o(z) Y_k^{\beta_k}$$

where $\alpha_k < 0$ and $\beta_k > 1$ are the roots of $\frac{1}{2}\tilde{\sigma}_k^2 \xi^2 + \left(\tilde{\mu}_k - \frac{\tilde{\sigma}_k^2}{2}\right) \xi - (\rho + \delta) = 0$. As $Y_k \rightarrow 0$, the option of exporting becomes worthless, so it must be that $A_{jk}^o(z) = 0$. Conversely, the option of exporting becomes more attractive as Y_k increases, so it must be that $B_{jk}^o(z) > 0$.

Similarly, the Bellman equation describing the value of exporting to country k from an affiliate in country j is:

$$V_{jk}^e(z, X, \bar{Q}) = \max \left\{ \frac{1}{1 + (\rho + \delta)\Delta t} [\pi_{jk}^e(z, X, \bar{Q})\Delta t + E[V_{jk}^e(z, X', \bar{Q}')|(X, \bar{Q})]] ; V_{jk}^o(z, X, \bar{Q}) \right\}, \quad (\text{C.11})$$

which describes the fact that the affiliate may keep exporting to country k (and get the continuation value of that option), or may stop exporting to country k , in which case it gets the value of the option of exporting to k from j , $V_{jk}^o(z, X, \bar{Q})$. Writing equation (C.11) in the continuation region, taking the limit for $\Delta t \rightarrow 0$, and applying Ito's Lemma, we obtain the non-arbitrage condition:

$$(\rho + \delta)V_{jk}^e(z, Y_k) = \pi_{jk}^e(z, Y_k) + \tilde{\mu}_k V_{jk}^{'e}(z, Y_k) + \frac{\tilde{\sigma}_k^2}{2} Y_k^2 V_{jk}^{''e}(z, Y_k). \quad (\text{C.12})$$

Following the same procedure outlined in the previous section, we can conclude that the value of the option of exporting to country k for an affiliate in country j has the following general solution:

$$V_{jk}^e(z, Y_k) = A_{jk}^e(z) Y_k^{\alpha_k} + B_{jk}^e(z) Y_k^{\beta_k} + \frac{\bar{\pi}_j^e(z, Y_k)}{\rho + \delta - \tilde{\mu}_k} - \frac{f_j^e}{\rho + \delta}.$$

Notice that, as $Y_k \rightarrow 0$, there is value from the possibility of endogenously stopping to export, so it must be that $A_{jk}^e(z) > 0$. Also, as Y_k increases, the value of exports converges to the discounted profit flow (there is no further expansion option), so it must be that $B_{jk}^e(z) = 0$.

For each country pair (j, k) and for each firm with productivity z , the parameters $B_{jk}^o(z) > 0$, $A_{jk}^e(z) > 0$, and the aggregate productivity thresholds that induce the affiliate to start and stop

exporting, denoted by Y_{jk}^{OE} and Y_{jk}^{EO} , respectively, can be recovered from the following system of value-matching and smooth pasting conditions:

$$\begin{aligned} V_{jk}^o(z, Y_{jk}^{OE}) &= V_{jk}^e(z, Y_{jk}^{OE}) - F_{jk}^e \\ V_{jk}^o(z, Y_{jk}^{EO}) &= V_{jk}^e(z, Y_{jk}^{EO}) \\ V_{jk}'^o(z, Y_{jk}^{OE}) &= V_{jk}'^e(z, Y_{jk}^{OE}) \\ V_{jk}'^o(z, Y_{jk}^{EO}) &= V_{jk}'^e(z, Y_{jk}^{EO}). \end{aligned}$$

The Bellman equation describing the value of horizontal sales for an affiliate in country j is:

$$V_j^h(z, Y_j) = \max \left\{ \frac{1}{1 + (\rho + \delta)\Delta t} \left[\pi_j^h(z, Y_j)\Delta t + E[V_j^h(z, Y_j')|Y_j] \right]; V_j^o(z, Y_j) \right\}, \quad (\text{C.13})$$

which describes the fact that the affiliate may keep surviving and have horizontal sales in j , or may shut down, in which case the firm gets the value of the option of opening an affiliate in j , $V_j^o(z, Y_j)$. Writing equation (C.13) in the continuation region, taking the limit for $\Delta t \rightarrow 0$, and applying Ito's Lemma, we obtain the non-arbitrage condition:

$$(\rho + \delta)V_j^h(z, Y_j) = \pi_j^h(z, Y_j) + \tilde{\mu}_j Y_j V_j'^h(z, Y_j) + \frac{\tilde{\sigma}_k^2}{2} Y_j^2 V_j''^h(z, Y_j). \quad (\text{C.14})$$

Following the same procedure outlined in the previous section, we can conclude that the value of horizontal sales for an affiliate in country j has the following general solution:

$$V_j^h(z, Y_j) = A_j^h(z)Y_j^{\alpha_j} + B_j^h(z)Y_j^{\beta_j} + \frac{\bar{\pi}_j^h(z, Y_j)}{\rho + \delta - \tilde{\mu}_j} - \frac{f_j^h}{\rho + \delta}.$$

Notice that, as $Y_j \rightarrow 0$, there is value from the possibility of shutting down the affiliate, so it must be that $A_j^h(z) > 0$. Also, as Y_j increases, the value of horizontal sales converges to the discounted profit flow (the option value of exports has been determined already above), so it must be that $B_j^h(z) = 0$.

At this point, the value of an affiliate in country j , $V_j^a(z, X)$ is completely characterized up to the option value parameter $A_j^h(z)$:

$$V_j^a(z, \bar{Y}) = A_j^h(z)Y_j^{\alpha_j} + \frac{\bar{\pi}_j^h(z, Y_j)}{\rho + \delta - \tilde{\mu}_j} - \frac{f_j^h}{\rho + \delta} + \sum_{k \in \mathcal{A}_j(z)} \left[\frac{\bar{\pi}_{jk}^e(z, Y_k)}{\rho + \delta - \tilde{\mu}_k} - \frac{f_{jk}^e}{\rho + \delta} + A_{jk}^e(z)Y_k^{\alpha_k} \right] + \sum_{k \notin \mathcal{A}_j(z)} \left[B_{jk}^o(z)Y_k^{\beta_k} \right] \quad (\text{C.15})$$

where $\mathcal{A}_j(z)$ denotes the set of export markets in which an affiliate of a firm with productivity z

located in country j exports.

Lastly, the Bellman equation describing the value of the option to open an affiliate in country j is:

$$V_j^o(z, X, \bar{Q}) = \max \left\{ \frac{1}{1 + (\rho + \delta)\Delta t} E[V_j^o(z, X, \bar{Q}') | (X, \bar{Q})]; V_j^a(z, X, \bar{Q}) - F_j^h \right\}, \quad (\text{C.16})$$

which describes the fact that the affiliate may keep the option of opening an affiliate in country j (and get the continuation value of that option), or may open an affiliate in country k , in which case it pays the entry cost F_j^h and gets the value of an affiliate in country j , $V_j^a(z, X, \bar{Q})$. Writing equation (C.16) in the continuation region, taking the limit for $\Delta t \rightarrow 0$, and applying Ito's Lemma, we obtain the non-arbitrage condition:

$$(\rho + \delta)V_j^o(z, Y_j) = \tilde{\mu}_j Y_j V_j'^o(z, Y_j) + \frac{\tilde{\sigma}_j^2}{2} Y_j^2 V_j''^o(z, Y_j). \quad (\text{C.17})$$

Following the same procedure outlined in the previous section, we can conclude that the value of the option of exporting to country k for an affiliate in country k has the following general solution:

$$V_j^o(z, Y_j) = A_j^o(z) Y_j^{\alpha_j} + B_j^o(z) Y_j^{\beta_j}.$$

As $Y_j \rightarrow 0$, the option of opening an affiliate becomes worthless, so it must be that $A_j^o(z) = 0$. Conversely, the option of opening an affiliate becomes more attractive as Y_j increases, so it must be that $B_j^o(z) > 0$.

Finally, the determination of the option value parameters in the more general case needs attention: when the firm decides to open an affiliate in a country, it considers not only the value of its horizontal sales, but also the option value of potential export to any destination country. For this reason, the value-matching and smooth-pasting conditions that deliver the parameters $A_j^h(z)$, $B_j^o(z)$ together with the aggregate productivity thresholds that induce the firm to open or shut down the affiliate (Y_j^{OH} and Y_j^{HO}) are computed using the option value function $V_j^o(z, Y_j)$ and the total value of the affiliate $V_j^a(z, \bar{Y})$:

$$\begin{aligned} V_j^o(z, Y_j^{OH}) &= V_j^a(z, Y_j^{OH}) - F_j^h \\ V_j^o(z, Y_j^{HO}) &= V_j^a(z, Y_j^{HO}) \\ V_j'^o(z, Y_j^{OH}) &= V_j'^a(z, Y_j^{OH}) \\ V_j'^o(z, Y_j^{HO}) &= V_j'^a(z, Y_j^{HO}). \end{aligned}$$

Parameter	Definition	Value	Source
η	elasticity of substitution	5	Broda and Weinstein (2006)
ρ	time discount rate	0.07	s.t. $\rho + \delta > \mu_j, \forall j$
δ	exogenous death rate	0.02	minimum exit rates in BEA data
b, θ	productivity distribution parameters	1,3	Simonovska and Waugh (2014)

Table D.1: **Direct Calibration.** Parameters common across countries.

D Details of the Calibration Procedure

Table D.1 reports the common parameters that we calibrate directly, either from the literature or from direct observation of the data.

Table D.2 reports the calibrated parameters of the country-specific composite shock processes and the wages that we exogenously feed into the model. The composite shock Y_j captures the effect of both U.S. productivity and destination country demand on profits. We set the drift of the process, $\tilde{m}u_j$, to match the growth rate of GDP in country j . Matching $\tilde{\sigma}_j$ to the standard deviation of GDP growth, however, would generate too little volatility to induce reasonable firm dynamics. For this reason, we set σ to match the standard deviation of labor productivity among U.S. firms, σ_j and γ_j to match country j 's standard deviation of GDP growth and correlation with U.S. GDP growth, respectively, and use equation (27) to recover values for $\tilde{\sigma}_j$. The GDP growth data ("Real GDP expenditure based") are taken from the Penn World Table, version 9.0. The shocks are initialized by setting initial values of Y_j to match average real GDP per capita relative to the U.S. Finally, wages are calculated as real GDP per unit of equipped efficient labor from Klenow and Rodriguez-Clare (2005) (average 1995-2000).

Tables D.3 - D.7 report the match between model-generated moments and data by host country.

Country	$\tilde{\mu}_j$	$\tilde{\sigma}_j$	w_j
Brazil	0.0505	0.1094	0.7110
Canada	0.0302	0.1135	0.8306
China	0.0636	0.0999	0.3069
France	0.0253	0.1041	0.9807
U.K.	0.0255	0.1136	0.9302
Germany	0.0262	0.1049	0.8246
Ireland	0.0478	0.1217	1.1881
Japan	0.0274	0.1109	0.7189
Mexico	0.0359	0.1055	0.6985
Singapore	0.0796	0.1156	0.9498
U.S.	0.0277	0.0927	1.0000

Table D.2: **Direct Calibration.** Parameters of the shock processes, wages.

% of MNEs with affiliates in j			% of affiliates in j exporting to US			% of affiliates in j exporting to third countries		
country	data	model	country	data	model	country	data	model
BRA	0.198	0.203	BRA	0.515	0.506	BRA	0.674	0.691
CAN	0.544	0.554	CAN	0.725	0.716	CAN	0.478	0.533
CHN	0.184	0.18	CHN	0.382	0.373	CHN	0.548	0.554
FRA	0.312	0.322	FRA	0.539	0.53	FRA	0.747	0.740
GBR	0.554	0.563	GBR	0.605	0.596	GBR	0.739	0.732
GER	0.367	0.377	GER	0.608	0.602	GER	0.760	0.750
IRE	0.122	0.132	IRE	0.575	0.567	IRE	0.760	0.754
JPN	0.155	0.231	JPN	0.468	0.458	JPN	0.578	0.575
MEX	0.302	0.312	MEX	0.647	0.639	MEX	0.494	0.508
SGP	0.129	0.234	SGP	0.597	0.589	SGP	0.724	0.739
average	0.287	0.311	average	0.566	0.558	average	0.650	0.658

Table D.3: **Static moments: FDI participation.** Model versus data, averages across years.

Affiliate export share to the US			Affiliate's export share to third countries		
country	data	model	country	data	model
BRA	0.072	0.077	BRA	0.142	0.155
CAN	0.261	0.260	CAN	0.113	0.119
CHN	0.099	0.134	CHN	0.219	0.279
FRA	0.075	0.074	FRA	0.364	0.356
GBR	0.111	0.108	GBR	0.371	0.363
GER	0.092	0.090	GER	0.413	0.406
IRE	0.242	0.233	IRE	0.515	0.501
JPN	0.047	0.047	JPN	0.130	0.131
MEX	0.173	0.175	MEX	0.128	0.131
SGP	0.222	0.150	SGP	0.488	0.344
average	0.140	0.135	average	0.288	0.279

Table D.4: **Static moments: export shares.** Model versus data, averages across years.

Affiliate export share to Canada			Affiliate export share to the U.K.			Affiliates export share to Japan		
country	data	model	country	data	model	country	data	model
BRA	0.0077	0.0058	BRA	0.0080	0.0003	BRA	0.0040	0.0002
CAN			CAN	0.0058	0.0005	CAN	0.0033	0.0005
CHN	0.0077	0.0362	CHN	0.0016	0.0035	CHN	0.0370	0.1269
FRA	0.0102	0.0208	FRA	0.0913	0.2879	FRA	0.0055	0.0015
GBR	0.0116	0.0084	GBR			GBR	0.0094	0.0006
GER	0.0089	0.0100	GER	0.0788	0.0629	GER	0.0104	0.0007
IRE	0.0532	0.0012	IRE	0.3858	0.0066	IRE	0.0818	0.0001
JPN	0.0059	0.0183	JPN	0.0011	0.0011	JPN		
MEX	0.0074	0.0180	MEX	0.0011	0.0002	MEX	0.0017	0.0003
SGP	0.0240	0.0005	SGP	0.0467	0.0001	SGP	0.1466	0.0005
average	0.0152	0.0132	average	0.0689	0.0403	average	0.0333	0.0146

Table D.5: **Static moments: Export shares to selected destination markets.** Model versus data, averages across benchmark years only.

% of MNEs opening affiliates in j			% of affiliates in j that start exporting to the US			% of affiliates in j that start exporting to the EU	
country	data	model	country	data	model	country	data
BRA	0.021	0.013	BRA	0.032	0.024	BRA	0.037
CAN	0.060	0.024	CAN	0.024	0.033	CAN	0.036
CHN	0.029	0.028	CHN	0.027	0.019	CHN	0.040
FRA	0.038	0.013	FRA	0.033	0.024	FRA	0.025
GBR	0.069	0.026	GBR	0.029	0.028	GBR	0.027
GER	0.046	0.014	GER	0.030	0.027	GER	0.025
IRE	0.015	0.007	IRE	0.037	0.024	IRE	0.030
JPN	0.020	0.013	JPN	0.032	0.014	JPN	0.030
MEX	0.036	0.011	MEX	0.029	0.028	MEX	0.033
SGP	0.019	0.034	SGP	0.026	0.016	SGP	0.028
average	0.035	0.018	average	0.030	0.024	average	0.031

Table D.6: **Dynamic moments: Entry.** Model versus data, averages across years.

% of MNEs closing affiliates in j			% of affiliates in j that stop exporting to the U.S.			% of affiliates in j that stop exporting to the EU	
country	data	model	country	data	model	country	data
BRA	0.102	0.020	BRA	0.027	0.020	BRA	0.032
CAN	0.125	0.020	CAN	0.021	0.020	CAN	0.028
CHN	0.082	0.028	CHN	0.020	0.020	CHN	0.031
FRA	0.117	0.020	FRA	0.029	0.020	FRA	0.021
GBR	0.128	0.020	GBR	0.026	0.020	GBR	0.023
GER	0.122	0.020	GER	0.029	0.020	GER	0.024
IRE	0.119	0.020	IRE	0.030	0.020	IRE	0.030
JPN	0.111	0.043	JPN	0.029	0.020	JPN	0.029
MEX	0.114	0.020	MEX	0.021	0.020	MEX	0.026
SGP	0.115	0.037	SGP	0.023	0.020	SGP	0.026
average	0.113	0.025	average	0.025	0.020	average	0.027

Table D.7: **Dynamic moments: Exit.** Model versus data, averages across years.