The Birth of a Multinational
Innovation and Foreign Acquisitions *

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PRELIMINARY AND INCOMPLETE

Abstract

This paper studies firms' joint decision to innovate and become a multinational. Using a panel data of Spanish firms with detailed information on innovation and international activities we show that innovation is a lumpy and disruptive process: it occurs sporadically and is followed by an immediate drop in productivity. We incorporate this technological feature into a continuous-time stochastic model and derive novel empirical predictions: (1) Firms that eventually become multinationals innovate more often than those that remain domestic. (2) The headquarter unit is more likely to innovate after becoming a multinational. (3) Although in the cross-section multinational firms are more productive than domestic firms, productivity in the headquarter drops immediately after becoming a multinational. These predictions are confirmed empirically and highlight how the option of investing in foreign markets and the actual foreign investment both stimulate domestic innovation.

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1 Introduction

Researchers have consistently found differences in productivity and size across firms depending on their participation in international activities. Exporting firms are more productive and larger than those that only serve the domestic market. And multinational corporations (MNCs) are at the top of the cross-sectional distribution of productivities. This pecking order can be related to the requirements and incentives associated to international markets, the superior access to credit by larger corporations, or the selection of firms into these activities: only the best run firms manage to expand in size, export and/or invest abroad (selection is emphasized in models that follow Melitz, 2003 and Helpman et al., 2004).

The extent to which globalization, via exports or multinational production, generates improvements in innovation and productivity is at the heart of debates around welfare and prosperity. However, while the process by which firms become exporters and how this impacts productivity is well studied (Verhoogen, 2008; Bustos, 2011; De Loecker, 2011), much less is known on how firms become multinationals and how this interacts with their innovation activities.

Our current knowledge of multinationals (both in economics and international business literature) is mostly about what we will call ”mature multinationals”: Firms such as General Electric or Toyota have operated across borders for a number of years and are the most innovative, productive and best managed of all (see, among others, Antras and Yeaple, 2014 and Bloom and Van Rennen, 2010).

There is also substantial evidence on what happens when a firm becomes the subsidiary of a multinational and how that affects productivity, innovation and growth (e.g. Guadalupe et al., 2012; Arnold and Javorcik, 2009). However, when and why a purely domestic firm decides to become a multinational for the first time –that is, a ”Baby Multinational”– remains unclear. Understanding this process is important because the effect of globalization through FDI on growth and market structure changes substantially depending on whether international expansion promotes innovation or simply selects winners among existing firms. If mature multinational corporations (MNC) are more productive than purely domestic firms exclusively as a result of the self-selection of more productive firms into foreign markets, then there is no innovation or productivity gain from becoming a multinational. However, if upon becoming an MNC baby multinationals see a further increase in innovation, or if the option of becoming a multinational increases their incentives to innovate, then the policy conclusions on the goodness of globalization are very different. Despite the importance of multinational firms in total output, employment and exports, we know little of the connection between productivity, innovation and entry into multinational activities, which is subject of this paper.

Unlike most of the earlier literature, we recognize that multinational activity, productivity and innovation are jointly determined and complementary decisions. Firms are considering these strategic options simultaneously and over time, which presents a fundamental identification challenge. To analyze this joint process we adopt the following strategy. First, empirically we depart from cross-sectional analysis and exploit the panel dimension of the Encuesta Sobre Estrategias Empresariales (ESEE), a dataset of Spanish manufacturing firms that collects information on domestic investment, employment, production and exports for 1,800 firms during the period 1990-2010. The panel includes data on firms' multinational activities after 2000 and, importantly, it also collects detailed data on firms' innovation activities. Second, we use this information to guide the assumptions built into a dynamic model of innovation and productivity.

We model innovation as a disruptive event in a continuous time stochastic environment, following the literature on vintage capital and optimal investment choice in Abel (1983), Bar-Ilan and Blinder (1992), and Pavlova (2002). When firms innovate, they lose part of the expertise accumulated over the life of the old technology. Additionally, productivity is also affected by an exogenous multiplicative component, which evolves randomly according to the realization of a one-dimensional Brownian motion.

The problem of the domestic firm consists in choosing when and how much to innovate. This problem can be solved recursively and its solution is consistent with the innovation and productivity patterns found in our data. Innovation is a lumpy process. It only occurs sporadically, after the firm accumulates enough expertise associated to a given technology vintage. And, in this framework, changes in technology occur in the extensive margin. That is, the firm attains higher technological levels if it innovates more often but, conditional on innovating, the technology is always upgraded by a constant margin. Finally, innovation is a disruptive process: expected productivity growth drops immediately after innovation. This result has been extensively corroborated empirically (see, for example, Cooper et al., 1999 and Klenow, 1998, or Atkin, Chaudhry, Chaudry and Khandelwal, 2016 in an experimental setting) and it is also confirmed in our data.

We use this basic framework as a starting point to analyze a domestic firm's decision to start producing in a foreign market (FDI). We restrict the theoretical analysis to horizontal FDI because, in our sample, the purpose of the vast majority of the MNCs' first affiliates is to sell in the host country. Here, innovation is a latent option of the firm, and both the timing to exercise such option as well as the timing to enter into foreign activities are endogenous. In this sense, our life cycle model of the firm is most similar to Garetto et al. (2017), which also models entering into foreign markets as an option, although with exogenous productivity dynamics. In our model, the possibility to enter into multinational markets provides extra incentives to innovate while domestic. In this sense, innovation and entering are jointly and complementary decisions.

The decision to enter a foreign market is given, as it is usual in these models, by a cut-off rule. What is new in our framework is that the cut-off changes endogenously during the life cycle of the firm. It depends on the evolution of its productivity and the time remaining until its next round of innovation. The model delivers novel empirical predictions that are confirmed in the data: (1) Firms that eventually become multinationals innovate more often than those that remain domestic. (2) The domestic headquarter unit is more likely to innovate *after* becoming a multinational, relative to firms that remain domestic and to established multinational firms. (3) Although in the cross-section multinational firms are more productive than domestic firms, productivity growth in the headquarter drops immediately *after* becoming a multinational.

These results highlight the empirical difficulty of correctly identifying the causal effect of multinational activities on productivity. Without observing innovation decisions, a naive correlation would wrongly suggest that acquiring a foreign affiliate results in a subsequent drop in productivity growth in the source-country production unit. Instead, the possibility of opening a foreign affiliate in the future provides incentives for innovation and enhances productivity growth.

Most of the literature aimed at identifying the link between international activities and innovation focuses on export activities. A growing empirical literature is aimed at identifying the causal link of export access to innovation. Bustos (2011), for example, looks at firm-level adjustments in innovation following trade liberalization episodes. Atkin, Khandelwal and Osman (2016) conduct a randomized experiment that generates variation in firms' access to foreign markets and also find that, as a result, firms upgrade the quality of their product. Trefler (2004), Lileeva and Trefler (2010), and De Loecker (2011) estimate the effect of trade liberalization on productivity. Our goal is different from theirs. Rather than focusing on the causal link, we are interested on estimating the dynamic joint process.

Related to our approach, Atkenson and Burstein (2008) and Constantini and Melitz (2007) also model the dynamic joint decision of exporting and innovating (we focus on becoming a multinational an innovating instead) . However, in order to make the model tractable and solvable in general equilibrium, their representation of innovation is more reduced-form. Our approach is closer to Aw et al. (2007), which estimates a dynamic structural model of R&D and exports.

Note that exporting and multinational activity are different in a fundamental way, such that the conclusions in the above-mentioned literature on exports will not necessarily apply to multinational activity. For example, while exporting entails an increase in the scale of production in the source-country unit, multinational activities (especially, horizontal FDI) implies splitting production across different locations. In the presence of economies of scale, this implies in itself a differential effect on productivity. Moreover, depending on how technologies are transferred across affiliates within the multinational corporation, exporting or FDI imply different incentives to innovate for the headquarters. Our results suggest that upgrades in technology at the headquarters are transferred to the newly acquired foreign affiliate. This is a necessary condition, in our model, to obtain predictions consistent with the data, and it coincides with the findings in Bilir and Morales (2016), who analyze the transmission of technology within the MNC.

The rest of the paper proceeds as follows. Section 2 describes the data and preliminary stylized facts. In Section 3 we present a theoretical model. In Section 4, we test the predictions of the model. Finally, Section 5 concludes.

2 The Data

The dataset used for our analysis is the Encuesta Sobre Estrategias Empresariales (ESEE), a panel dataset of Spanish manufacturing firms collected by the Fundacion SEPI (a non-governmental organization) and the Spanish Ministry of Industry every year since 1990. It is designed to be representative of the population of Spanish manufacturing firms and includes around 1,800 firms per year (aiming to survey all firms with more than 200 employees and a stratified sample of smaller firms). Our sample covers the 2000-2010 period. 2000 is the first year firms were asked about their investments in foreign affiliates.[1]

We define a firm as being a multinational if it reports to hold at least 50% of the capital of a foreign firm (in a country other than Spain). This corresponds to the definition of FDI in Markusen (2002). In our sample, 94% percent of firms report to have either 0- or 100-percent stakes in the foreign firm, so our results are not sensitive to this definition.

For firms that have some investment abroad, the data also record how many investments the firm has, the exact share of capital held in the main investments and some broad geographic characteristics of where the foreign owned firms are located. Firms are also

[1] Details on the survey characteristics and data access guidelines can be obtained at http://www.funep.es/esee/sp/sinfo_que_es.asp.

asked the motive of the foreign acquisition. The four (non-mutually exclusive) motives are: (i) adapt and assemble the firm's product, (ii) manufacture similar product as the firm, (iii) resale and distribution, and (iv) supply inputs to the firm. The dataset does not record whether the investment was in an existing company or a greenfield development, though we know from other sources that the majority of investments are acquisitions of existing companies (Barba Navaretti and Venables, 2004).

The panel nature of the data is what allows us to analyze *Baby Multinationals* (Baby MNCs): firms that declare to have no foreign holdings when they first appear in our sample (since 2000) and later acquire a foreign subsidiary. 90% percent of the firms have no foreign holding in their first year, 183 of them acquire their first foreign affiliate over the sample period.

In addition to recording information on investments abroad our dataset also reports a large number of variables that reflect firms' productivity-enhancing innovation activity. The data include variables indicating whether the firm undertook process innovation, product innovation, and the types of product and process innovation. These include investment in new machines and/or new forms of organizing for process innovations, and products with new materials or new functions for product innovations. Product innovation could mean upgrading the quality of existing products or developing new products. These are the same innovation variables used by Guadalupe et al. (2012) or Cassiman and Vanormelingen (2013). Importantly, these variables record innovations that are innovations to the firm, though not necessarily to the industry. In other words, these are not necessarily radical innovations that push the productivity frontier of the economy, but they may push the productivity frontier for the firm.

The dataset also records a set of variables that allow us to further test the mechanisms and assumptions of our model. For example, we know the volume of imports in the firm, which should capture any net changes in foreign sourcing. It also records the volume of exports, which may substitute or complement domestic sales depending on the motive for the foreign acquisition. We also know the level of employment and whether the firm hired engineers in any given year, which should relate to innovation activity.

We also use the ESEE data to define two different variables that measure firm productivity. The first is the natural log of the firm's real sales (similar to Verhoogen, 2008). The second is labor productivity defined as the natural logarithm of real value added per worker (similar to Lileeva and Trefler, 2010). The ESEE categorizes firms into 20 industries, based on the two-digit NACE classification.

Finally, all the questions asked by the ESEE refer to the domestic firm that is answering the question, not the foreign entity, so any innovations we capture related to innovations that take place in the domestic firm, not in its foreign outlets.

2.1 Stylized Facts on Baby Multinationals

We begin by presenting some stylized facts on the characteristics of the investments done by Baby MNCs. That is, firms that we observe in the data going from zero to a positive investment position abroad.

First, firms report that the main motive for the first foreign acquisition is a horizontal one: they invest in firms similar to them or in sale and distribution facilities rather than foreign source. 49% of these first foreign affiliates manufacture similar product as the firm and 45% resale and distribute firm's products; only 8% supply inputs to the firm.

Second, the first foreign investment is one that gives the firms full control of the affiliate (more than 50% stake) and in 63% of the cases firms acquire 100% of the target foreign company. The histogram with the stake in the first foreign affiliate is shown in Figure 1.a.

Third, similar to the findings in Conconi et al. (2015), in our sample of manufacturing firms, over 90% of firms were exporters the year before the first investment abroad and 80% were exporters already even 5 years before that first investment.

Finally, we analyze how persistent FDI status is and we compare that to exporting status. Figure 1.b shows that around 80% of Baby MNCs are still MNCs 5 years after that first international investment. Exporting is also highly persistent but less so. 70% of first time exporters are still exporting the year after their first year exporting and approximately 60% remain exporters 5 years after that first export year (to calculate exporting persistence we use the full ESEE sample). These figures are similar to the ones in Gumpert et al. (2017).

2.2 Stylized Facts on Innovation

Table 1 presents summary statistics, and in particular innovation and productivity characteristics, of our sample by their multinational category (variable definitions are included in the notes to the table). *Baby MNCs* (in columns 4 to 6) are firms that do not have an international investment position in year 2000 and eventually become multinationals. Columns 7 to 9 describe firms that remain domestic during the whole sample period, while Mature MNCs (columns 10 to 12) refer to those that are multinationals since we first observe them. In all cases, these figures correspond to the production units located in Spain, and not to the entire multinational corporation.

In terms of size, as expected, multinational firms are larger than domestic ones. In terms of innovation, there is also a pecking order in the average fraction of years that the corresponding group of firms report doing product and process innovations: Mature MNCs innovate more often than those that always remain domestic. The median firm that becomes a multinational during our sample period is comparable in terms of innovation and size to the domestic units of mature multinational corporations.

Product innovation can reflect changing the function or design of the product (Product - functions), or the components or materials of the product (Product - materials), although not necessarily the introduction of new products.[2] Process innovation can reflect changing the form of organizing the firm (Process - organization) or improving the machines/hard technology in the firm (Process - machines). Note that process innovation and product innovation are conceptually different from Research and Development (R&D). These innovations in technology, organization or product characteristics are not

[2] Introduction of new products is also informed. The evolution of this variable does not present distinctive patterns around the time of entering multinational activities.

necessarily extending the industry technological frontier or introducing new products or patents. In other words, they are new to the firm but not necessarily new to the economy. Table 2 shows the effect of R&D expenditure and the frequency of product and process innovations on the resulting number of patents by the firm. Accumulated expenditure on R&D is highly and significantly correlated with number of patents. Once we control for R&D, the history of innovation, both in product or process, is not.

Moreover, even when the outcome of R&D is lumpy (i.e., a new patent or a new product), the investment in R&D is a continuous effort. Firms that do R&D vary the level of investment in the intensive margin (i.e., how much they spend in R&D). Instead, process innovation is itself a lumpy phenomenon; that is, its variation in the time-series of a given firm occurs in the extensive margin (i.e., *yes/no*). This feature of the data is plotted in Figure 2. The frequency of positive R&D observations is clustered at 1: most firms report positive investment in R&D every year in our sample. Innovation, on the other hand, is typically less frequent, with a lot of dispersion in the extensive margin. [3]

Finally, innovation is a disruptive episode. Production growth is higher *prior* to the innovation episode than immediately *afterwards*. This fact is represented in Figure 3, which plots deviations of *sales growth* relative to its trend (normalized at zero), around the time of the innovation, controlling for the firm time-invariant unobservable characteristics and market-wide conditions (i.e., firm and industry-year fixed effects) and using firms with same initial observable conditions as control group (i.e., productivity, size, age): sales growth slows down after investing abroad.

These empirical regularities coincide with the findings in Cooper et al. (1999) and Klenow (1998), among others, and motivate the theoretical framework that follows.

[3] It is possible that success in the R&D process (i.e., an invention or a patent) triggers process or product innovations. In the framework proposed in the next section innovation decision is endogenous and reacts to the realization of random productivity process. This process can be understood as a metaphor for an unmodeled random success of R&D investment.

3 The Model

We model the life cycle of the firm in partial equilibrium. We propose a dynamic continuum time framework that accounts for innovation, firm growth and entry into multinational activities.

Innovation is modeled as a disruptive lumpy process: Technology is not an homogeneous good that can be freely accumulated or sold in the market. Instead, innovation replaces an old technology vintage with a new one. Correspondingly, there is loss of expertise when the old technology is replaced, which we assume to be a share of existing level of expertise. Under these conditions, innovation becomes an option, and the firm decides when to exercise it (following closely Pavlova, 2002 and Parente, 1994). This decision takes into account how it affects its future productivity path and the option to acquire a foreign affiliate.

We do not include fixed cost of production, so firms never die. Although this simplification is not crucial for the conclusions or tractability of the model, we follow it because we do not observe in our data a sufficient number of firms abandoning multinational production. We would be therefore unable to empirically estimate exit conditions. Under this assumption, the multinational option can only be exercised once and is an absorbing state.

3.1 The Firm

In each moment t, each firm i has the following production function:

$$q = \widetilde{z}\, L$$

where $\widetilde{z}$ is the *productivity* of the firm and L is the sole variable input of production, that is optimally and continuously chosen at any moment t, with price W common to all firms. Therefore, the unit cost function of the firm is $c = W/\widetilde{z}$. Firms face a CES demand function with elasticity of substitution $\eta > 1$. Then, instantaneous operating profits at time t are:

$$\pi = M\ z \tag{1}$$

where $z = \tilde{z}^{\eta-1}$ and M recovers all market wide variables and its value depends on the firm's international strategy, domestic (which may include exports) or multinational, $M \in \{M^d, M^m\}$ with $M^d < M^m$.

Innovation and the Dynamics of Firm Productivity

The *productivity* of the firm is jointly determined by its technology level, a_t, and its expertise in using it, h_t:[4]

$$z_t = a_t^{\frac{1}{2}} h_t^{\frac{1}{2}}$$

Technology, a, is not an homogeneous good that can be freely accumulated or sold in the market. Instead, innovation is a disruptive process through which an old vintage is replaced by a new one. Correspondingly, there is loss of expertise when the old technology is replaced.

Under this characterization, innovation is a lumpy process that happens only occasionally. Denote $n = 1, 2, ..., \infty$ the n-th innovation of technology, which takes place at time t_n. Then, technology at every moment t is given by:

$$a_t = a_n \qquad t \in [t_n, t_{n+1}) \tag{2}$$

To capture the uncertain profitability of a new technology, we model expertise as a random process. It evolves at a rate μ and volatility $2\sigma^2$ during the life of the corresponding

[4]This characteristics of the problems are general to any function of the form $s_t = a^\alpha h^{1-\alpha}$. We assume $\alpha = 0.5$ to simplify the computations.

technology vintage and drops in a share $\kappa \in (0,1)$ when the technology is replaced.[5]

$$\frac{dh_t}{h_t} = \mu\, dt + \sqrt{2}\sigma\, d\omega_t \qquad t \in [t_n, t_{n+1}) \tag{3}$$
$$h_{n^+} = h_{n^-}(1-\kappa) \tag{4}$$

where ω_t is a one-dimensional Brownian motion.

Then, the expected discounted value of the n-th innovation is:

$$E\int_{t_n}^{t_{n+1}} \pi_t(a_n, h_t)e^{-rt}dt$$

where r, the market interest rate, is used as a discount factor. We assume that $r > \mu > \sigma^2$.

Apart from the loss of expertise, there is a monetary cost of innovation $p_a a$. Without loss of generality, we set $p_a = 1$.

Opening a Foreign Affiliate

A domestic firm can acquire a foreign affiliate after paying an entry cost F^m that represents the acquisition cost (i.e., acquisition is the main mode of FDI in Europe). By doing so, it attains a market size M^m, which is assumed to be larger than the one supplied from its domestic firm, M^d: $\pi_d(z) = M_d\, z < M_m\, z = \pi_m(z)$.

This formulation assumes that firm's productivity is common to all production within the boundaries of the corporation, irrespectively of the location of the production unit. The analysis that follows does not require that technology transfers freely within the firm. As long as innovation at the headquarters is partially transferred to the foreign affiliates, the conclusions here are qualitatively valid. The empirical predictions depend on this assumption. So, implicitly, our empirical results suggest that the Parent's productivity is transferred within the MNC corporation. This feature has been confirmed empirically in Bilir and Morales (2016) and Bloom and Van Rennen (2010).

We do not model entry into export activities. Instead, the domestic firm's growth is

[5] Premultiplying by $\sqrt{2}$ the standard deviation simplifies the mathematical expressions.

understood to include domestic and export sales. This is because in our data, we do not observe a qualitative change around the time of entry into export activities. Firms in Spain are well integrated in EU market and they start by exporting small quantities, presumably within EU, which is not consistent in our model with an entry cost.

The objective of a domestic firm is, then, to choose an innovation plan, which consists of two sets of infinite parameters, $\mathbf{a} = \{a_1, a_2, ..., a_\infty\}$ and $\mathbf{t} = \{t_1, t_2, ..., t_\infty\}$, as well as whether and when to acquire a foreign affiliate t_M, so to maximize the value of the firm, which is given by the expected discounted flow of profits, subject to equations (2)-(4):

$$V_d(a_0, h_0) = \max_{\{\mathbf{t},\mathbf{a},\mathbf{t_M}\}} E_0 \sum_{n=0}^{\infty} \left[\int_{t_n}^{t_{n+1}} \left(\pi_d(a_n, h_t) + \Delta_\pi(a_n, h_t) \mathbf{1_{t>t_M}} \right) e^{-rt} dt - e^{-rt_n} a_n \right] - e^{-rt_M} F_M \tag{5}$$

Notice that, without fixed cost of production, becoming a multinational is an absorbing state. After paying the entry cost, F_M, no multinational firm decides to sell the foreign affiliate and return to its previous domestic status. Then, for all $t > t_M$ (i.e., $\mathbf{1_{t>t_M}}$ is an indicator function equal to one for $t > t_M$), profits increase in $\Delta_\pi(a_n, h_t)$, defined as the difference between multinational and domestic profits: $\Delta_\pi(a_n, h_t) \equiv (M_m - M_d) z_t (a_n h_t)^{1/2}$. Moreover, since this is an absorbing state, the value of a multinational firm is simply the expected discounted profits when following the optimal innovation policy:

$$V_m(a_0, h_0) = \max_{\{\mathbf{t},\mathbf{a}\}} E_0 \sum_{n=0}^{\infty} \left[\int_{t_n}^{t_{n+1}} \pi_m(a_n, h_t) e^{-rt} dt - e^{-rt_n} a_n \right] \tag{6}$$

3.2 MNCs' Optimal Innovation Policy

We begin by solving recursively the optimal innovation policy of the multinational firm described in equation 6. The solution to this problem is similar to that in Parente (1994) and Pavlova (2002). During the region of inaction, when the firm decides not to innovate, the value function evolves exogenously, given by the instantaneous profits and its change in value:

$$rV_m = \pi_m(a,h) + \frac{1}{dt}E(dV_m) \tag{7}$$

Applying Ito's Lemma:

$$rV_m = \pi_m(a,h) + \mu\, h\, \frac{dV_m}{dh} + \sigma^2\, h^2\, \frac{d^2V_m}{dh^2} \tag{8}$$

We guess the following functional form for the value function:

$$V_m(a,h) = A_m(a,h) + B_m(a)h^{\psi} \tag{9}$$

Then, from (8), we know that $A_m(a,h)$ is given by the properly discounted flow of profits

$$A_m(a,h) = \frac{\pi_m(h,a)}{r - 1/2(\mu - \sigma^2/2)}$$

and that ψ is the positive root of the following fundamental equation, which is larger than 1 for $r > \mu > \sigma^2$:[6]

$$0 = \psi^2 + \frac{\mu - \sigma^2}{\sigma^2}\psi - \frac{r}{\sigma^2} \tag{10}$$

The solution of the problem therefore consists of three unknowns: 1) two optimal policies, the optimal new technology at the time of the innovation, $a^*_m(a)$, and the timing of innovation, which is implicitly given by the level of expertise accumulated up to that point, $h^*_m(a)$; and 2) the yet to be determined $B_m(a)$ in the guessed value function 9. These unknown functions solve the following system of equations:

1. Value matching. The value of the firm at the time of abandoning the old technology coincides with the value at the time of adopting the new one.

$$V_m(h^*_m, a) = V_m(h^*_m(1-\kappa), a^*_m) - a^*_m \tag{11}$$

[6]The mathematical solution of this problem is: $V_m = A + B_1(a)h^{\psi_1} + B_2(a)h^{\psi_2}$, where ψ_1 and ψ_2 correspond to the positive and negative roots of the fundamental equations. Since the option value to innovate is null for $h \to 0$, it has to be that $B_2(a) = 0$ and only the positive root enters in the solution.

2. Smooth pasting condition on level of innovation. Provided that the firm innovates, its level of innovation is optimal.

$$\frac{dV_m(h_m^*(1-\kappa),a)}{dg}\Big|_{a=a^*}-1=0 \tag{12}$$

3. Smooth pasting condition on timing of innovation. The timing of abandoning the old technology is optimal.

$$\frac{dV_m(h,a)}{dh}\Big|_{h=h_m^*}-\frac{dV_m(h(1-\kappa),a_m^*)}{dh}\Big|_{h=h_m^*}=0 \tag{13}$$

The first condition simply states that there are no *jumps* in the value functions at the time of upgrading technology. The smooth pasting conditions are optimality conditions, i.e., the first order conditions in the maximization problem.

We show in appendix **??** that the value function of the multinational firm is given by:

$$V_m(h,a)=\frac{\pi_m(h,a)}{\widetilde{r}}+\frac{\phi^{-\psi}}{\psi-1}\left(\frac{\phi^{1/2}-2\widetilde{r}}{2\widetilde{r}}\right)a^{1-\psi}\left[M_m^2h\right]^{\psi} \tag{14}$$

where $\widetilde{r}\equiv r-1/2\mu-\sigma^2$, and ϕ is the positive root of

$$0=\phi^{1/2}\frac{(2\psi-1)}{2\widetilde{r}}\left\{\left(\frac{\phi^{1/2}-2\widetilde{r}}{\phi^{1/2}}\right)^{\frac{1}{2(\psi-1/2)}}-(1-\kappa)\right\}+\psi(1-\kappa)$$

It can be shown that $\psi>1$ and $2\widetilde{r}<\phi^{1/2}<\frac{2\widetilde{r}}{1-(1-\kappa)^{2(\psi-1/2)}}$, which guarantees that both terms of the value function in (14) are positive.

The first term in (14) corresponds to expected profits: given market size M_m, the technology in place a and its expertise h, infinitely discounted. The second term corresponds to the option of innovating. This second term is therefore higher if the current technology, a, is low, but the market size, M_m, is high. At the time of the innovation, when technology jumps from a to $a_m^*(a)$, the overall value of the firm is unchanged, but its components are: the first term (i.e., flow of profits) increases and the option value to innovate drops.

The following proposition summarizes the optimal innovation policy of the firm

Proposition 1 (Optimal Innovation by MNCs)**.** *Given a market size M_m, the optimal innovation policy of the multinational firm is determined by the firm technology level, a, and its expertise, h.*
i. If $h < h_m^*(a)$ the firm continues operating with existing technology.
ii. If $h = h_m^*(a)$ the firms adopts a new technology $a_m^* = ag_m^*$
where $h_m^*(a)$ and g_m^* are given by:

$$h_m^* = \frac{a}{M_m^2}\phi\left(\frac{\phi^{1/2}}{\phi^{1/2}-2\widetilde{r}}\right)^{\frac{1}{\psi-1/2}} > 0 \tag{15}$$

$$g_m^* = (1-\kappa)\left(\frac{\phi^{1/2}}{\phi^{1/2}-2\widetilde{r}}\right)^{\frac{1}{\psi-1/2}} > 1 \tag{16}$$

Figure 4 plots the optimal innovation policy for constant values of ω (i.e., the random component of expertise). Absent of shocks, the firm innovates at constant intervals τ. Expertise associated with a given technology vintage increases during the inaction interval and drops by a proportion $(1-\kappa)$ when expertise reaches its optimal stopping level h^* (panel a). Technology increases by a constant rate g at each innovation episode (panel b).

A positive realization of the expertise shock (ω) shortens the inaction interval and brings forward the next innovation round (panel c). Although the innovation rate g is unchanged, a history of positive realizations of the expertise shock is associated with higher technology, a, because innovation occurs more frequently. Correspondingly, negative realizations delay innovation.

3.3 Domestic Firms' Optimal Innovation and Entry Policy

The problem of the domestic firm is more complex, as it evaluates not only when and by how much to upgrade its technology, but also how the innovation path interacts with the prospects of opening a foreign affiliate.

We solve the problem in (5) recursively. Again, in the zone of inaction, when the firm is neither changing its technology nor entering into foreign production, the value function evolves according to equations 7 and 8. We guess the same functional form as the MNC's value function

$$V_d(a,h) = A_d + (B(a) + b)h^{\psi} \tag{17}$$

where $B_d(a)$ is a function of the state variable a and b is a constant. This functional form is different from the one characterizing the multinational firm in (9). As in that case, ψ is the positive root of equation 10 and the first term corresponds to the discounted flow of domestic profits:

$$A_d = \frac{\pi_d(a,h)}{r - 1/2\mu - \sigma^2}$$

Differently, the value function now includes two real options: The option to innovate, (i.e., $B(a)h^{\psi}$), which coincides with the one in equation 9, and also the option to open an affiliate in the foreign market (i.e., bh^{ψ}).

The solution consists of six unknown functions: 1) four optimal policies $a_d^*(a)$, $h_d^*(a)$, h^E and a^E, that correspond to the new technology and trigger experience levels at the time of innovation and entry into multinational activities; and 2) the yet to be determined $B_d(a)$ and b in the guessed value function. These functions satisfy the conditions 1 to 3 in the subsection 3.2, corresponding to the optimal innovation policy, and also the following three conditions corresponding to the optimal entry into multinational activities:

4. Value matching at entry. The value of the domestic firm at the time of acquiring a foreign affiliate is equal to its value as a multinational.

$$V_d(a^E, h^E) = V_m(a^E, h^E) - F_M$$

5. Smooth pasting condition on the timing of entry. The timing of abandoning the domestic market and becoming multinational is optimal.

$$\frac{dV_d(h,a^E)}{dh}\Big|_{h=h^E} = \frac{dV_m(h,a^E)}{dh}\Big|_{h=h^E}$$

6. Smooth pasting condition on innovation upon entry. The technology when abandoning the domestic market and becoming multinational is optimal.

$$\frac{dV_d(h^E,a)}{da}\Big|_{a=a^E} = \frac{dV_m(h^E,a)}{da}\Big|_{a=a^E}$$

From the first three optimal innovation conditions, we can conclude that $B_d(a)$ is parallel to $B_m(a)$ in equation 14: $B_d(a) = \frac{\phi^{-\psi}}{\psi-1}\left(\frac{\phi^{1/2}-2\widetilde{r}}{2\widetilde{r}}\right)a^{1-\psi}M_d^{2\psi}$. However, we show in the appendix that the option to become multinational provides extra incentives to innovate. When the firm is still young and small this option is negligible, for $a \to 0$, the optimal innovation policy converges to the one described in Proposition 1. However, for $a > 0$, the innovation occurs more sporadically but also with larger technological upgrades g^*. These results are summarized in the following Proposition:

Proposition 2 (Optimal Innovation by Domestic Firms)**.** *Given domestic and multinational market sizes M_d and M_m, the optimal innovation policy of the domestic firm is determined by the firm technology level, a, and its expertise, h.*
i. If $h < h_d^*(a)$ the firm continues operating with existing technology.
ii. If $h = h_d^*(a)$ the firms adopts a new technology $a_m^* = ag_d^*(a)$
where $h_d^*(a)$ and $g_d^*(a)$ are given by:

$$h_d^*(a) = \frac{a}{M_m^2}g_d^*(a) > 0 \tag{18}$$

$$g_d^*(0) = (1-\kappa)\left(\frac{\phi^{1/2}}{\phi^{1/2}-2\widetilde{r}}\right)^{\frac{1}{\psi-1/2}} = g_m^* \tag{19}$$

$$g_d'^*(a) > 0 \qquad for\ a > 0\ and\ M_m > M_d \tag{20}$$

The problem of the domestic firm also includes the decision of if/when to acquire foreign affiliate. The transition from domestic into multinational production satisfy the value matching, classic in all static selection problems, and also the smooth pasting condition for technology and expertise (conditions 4 to 6 above). Entry into multinational production is characterized by two threshold values, which summarize the level of technology and the optimal time to exercise the option:

Proposition 3 (Optimal Entry)**.** *Given domestic and multinational market sizes M_d and M_m, and a talent z, there are values of expertise and technology a^E and h^E such that*
i. If $h \geq h^E$ and $a \geq a^E$, the firms pays F_m and becomes multinational
ii. It stays domestic otherwise

3.4 Observable Predictions

This framework delivers a number of qualitative predictions that we test in Section 4.

Result 1. *Controlling for initial firm's characteristics, those that end up being multinationals innovate more often than those that remain domestic.*

As stated in Proposition 2, positive realization of the expertise shock ω implies an increase in h, which triggers a new innovation round. Therefore, a history of positive realizations of ω is associated with more innovation episodes and, therefore, higher level of technology.

Controlling for age and initial conditions, those firms that have a technology sufficiently high as to enter a foreign market are a selection of those that innovated more frequently. That is, a selection of firms with a history of positive realizations of ω. On the other extreme of *luck*, those that remain domestic are a selection of firms with worst realizations of the expertise shock.

Result 2. *Innovation happens more likely immediately after entry into a new foreign activity, both relative to firms that remain domestic and those that are established multinationals. The difference is larger when compared to those that remain domestic.*

This result follows from two reinforcing effects often mentioned in static models: *Market Size* and *Selection* effects. However, in this dynamic framework these two effects are characterized differently than in static models or in frameworks where innovation is not lumpy.

An increase in the market size (i.e., $M^m > M^d$) implies a reduction in the level of experience that triggers the next innovation round; that is, $\frac{dh^*}{dM} < 0$ in equation (18). Then, entry into a foreign market triggers the next round of innovation.

This effect is described in Figure 6. Panel (a) describes the innovation cycle of a firm with zero expertise shocks. Innovation is a lumpy decision, that occurs at periodic intervals. Panel (b) presents the effect of entry into a larger market M^m. The schedule h_t^* that characterize the new innovation cycle shifts downwards, which immediately reduces the time remaining until the next round of innovation (from 2τ to $2\tau^m$).

There is an additional reinforcing effect, *Selection*. The timing of entry is an endogenous decision of the firm. As stated in Proposition 3, firms are more likely to enter into a new international activity when they are closer to their next scheduled round of innovation; that is, the higher is h/h^*. This is because, in this framework, innovation is a disruptive event. Entering a bigger market triggers a new round of innovation, so firms prefer to wait until existing technology vintage is sufficiently old. The mirror argument explains why firms that remain domestic are less likely to innovate.

Result 3. *Established multinational firms are more productive than domestic firms, and firms entering into MP activities are more productive than those that remain domestic. But firms experience a reduction in productivity growth immediately upon entry into a new foreign activity, relative to both established multinationals and domestic firms.*

As it was established in the previous results, only those firms with high level of technology, a, enter into multinational activities. The level of technology not only directly enters into the productivity of the firm. It also signals that the firm experienced positive realizations of expertise shocks, which explains a history of frequent technology upgrades.

However, at the time of entering a foreign market, productivity growth is expected to drop. The option to enter multinational markets gives the firm extra incentives to innovate. This model makes the simplifying assumption that multinational production is an absorbing state. So this extra incentive to innovate disappears when the entry option is exercised.

4 Empirical Results

The results derived in the previous section emphasize the endogeneity of the firms' innovation and entry decisions, which implies an empirical challenge: Since firm $Size$ and $Productivity$ are variables jointly determined with Innovation and Entry decisions, we cannot control for their concurrent evolution. Instead, in our empirical analysis, we compare the innovation decision of the *Baby MNCs* with that of firms in a control group that are identical except for the timing of their entry into multinational activity. We construct two control groups for the future *Baby MNCs* by matching each of them to identical firms (on observables) that never change their multinational status during our sample: (i) always domestic firms (Domestic control), and (ii) established *mature* multinationals (MNC control).

To construct the appropriate control groups we use the *Propensity Score Procedure* in Guadalupe et al. (2012), which is based on Lechner (1999), Busso et al. (2014) and Dehejia and Wahba (1999). This procedure pools future *Baby MNCs* and control firms (Domestic firms or Mature MNCs depending on the specification) in the first year they enter the sample. We then estimate the probability that a firm is a future *Baby MNC* as a function of a number of initial characteristics (i.e. labor productivity, exporter status, average wage, capital, and labor). This estimated probability is the propensity score, $\hat{p}$; we use it to re-weight firms in equation (21) so to reflect the differences in the probability of firms being a *Baby MNC*.[7,8] The results of this first stage is shown in Table 3. When compared with other firms that were domestic when they first entered our sample, those that eventually become Baby MNCs have initial higher productivity, are more likely to be exporters, and

[7] Specifically, weighting each treated firm by $1/\hat{p}$, and weighting each control firm by $1/(1-\hat{p})$, provides an estimate of the Average Treatment Effect (ATE) of foreign investment on innovation in a specification like equation (21).

[8] We restrict the analysis to firms that fall within the common support, and perform the standard tests to check that the balancing hypothesis holds. We find that all covariates are balanced between treated and control observations for all blocks.

have higher initial labor intensity (i.e., higher total employment and lower capital stock). Instead, when pooled with firms that are MNCs when they first appear in our sample, the probability of being a future *Baby MNC* is mostly associated with smaller initial size (although not always statistically significant) and not being exporter (column 2). Mature MNCs and Future Baby MNCs had similar initial productivity. All the regressions in the remainder of the paper will used this propensity score reweighting methodology so that we can compare *like with like* (on a set of covariates) and the difference between treated and control firms is just the timing of entry into the foreign market.

Result 1. *Controlling for initial firm's characteristics, those that end up being multinationals innovate more often than those that remain domestic.*

Table 4 shows the average probability of innovation by group of firms. The probability of innovation of firms that become multinationals during our sample period is significantly larger than of those firms that remain domestic during the whole sample. For product innovation, the probability of future Baby MNC is 0.11 larger than for the domestic group, which has a mean frequency of 0.17. The probability of process innovation of future Baby MNCs is larger than for domestic firms in 0.172 (46% increase relative to the mean frequency across domestic firms). There is no significant difference in the probability of innovation between Mature MNCs and future Baby MNCs.

Result 2. *Innovation happens more likely immediately after entry into a new foreign activity, both relative to firms that remain domestic and those that are established multinationals. The difference is larger when compared to those that remain domestic.*

We are interested in the dynamic relationship between innovation and FDI. As emphasized in the theoretical framework, these are two interlinked choices: Firms that innovate are sufficiently productive for their investment abroad to be worthwhile. And becoming a multinational triggers innovation. In order to test these dynamics we estimate a distributed lag model. This is our main equation, estimating it in first differences allows us to see how the stock of innovations (which we do not observe since we only have access to the flow variable) changes as a function of whether the firm changes its multinational status. Estimating in first differences also eliminates the firm-level fixed effect. This equation captures how much innovation activity the firm does the years before (leads), the year of and the years after (lags) its first investment abroad.

$$\Delta NInnovation_{it} = \sum_{\tau=t-2}^{t+1} \Delta FDI_{i\tau} + \Delta\epsilon_{it} \tag{21}$$

where $NInnovation_{it}$ is the number of innovation episodes up to year t. In first differences, $\Delta NInnovation_{it}$ is a dummy that takes value 1 if the firm i innovates in year t. $FDI_{it} \in \{0, 1\}$ is equal to 1 if the firm has majority stake in a foreign affiliate in year t and 0 if it does not; so, ΔFDI_{it} signals a change in the multinational status.

We estimate equation (21) for process and product innovations in a systems of two equations using a bivariate probit model. The reason is twofold. First, product and process innovations are dummy variables, which calls for a limited dependent variable model. And second, because a bivariate probit allows for these two firm-level innovation decisions to be correlated (i.e., standard errors can be correlated across the system of equations).

The results of estimating (21) are in Table 5. We find that, relative to these two control groups, *Baby MNCs* innovate, both in product or process, upon first investing abroad. The results are statistically stronger for Product Innovation (columns 1 and 2): the probability is larger in the year of entry and picks in the following year, when the marginal probability increases in 0.275 and 0.121 relative to domestic and multinational firms, respectively. In the case of Process Innovation, the probability of innovating also picks the year after entering into multinational production activities. In both cases, and consistent with the predictions of the model, the probability of innovating is larger when compared with the group of those firms that remain domestic than relative to mature MNCs.

Result 3. *Established multinational firms are more productive than domestic firms, and baby multinationals (firms entering into multinational production) are more productive than those that* *remain domestic. But firms experience a drop in productivity immediately upon entry into a new foreign activity, relative to both established multinationals and domestic firms.*

We take an empirical approach similar to the one in equation (21) and compare domestic production of a *Baby Multinational* with domestic and established MNC during a period of four years around the time of acquiring the first foreign affiliate. As before, we estimate the equation in first differences to be identical to the previous regression.

$$\Delta \ln(Sales_{it}) = \sum_{\tau=t-2}^{t+1} \Delta FDI_{i\tau} + \Delta \epsilon_{it} \tag{22}$$

Just as before, we use *Propensity Score Matching* procedure to define two control groups of firms that never change their multinational status during our sample. Column 1 in Table 6 compares sales growth of baby multinationals with domestic firms, and column 2 with established multinationals. Although the levels of statistical significance vary across specifications, we can observe a pattern: sales of future *Baby MNCs* were growing faster than in the control groups prior to acquiring the first affiliate, and decreases after entry by 0.08% and 0.04% relative to controls of domestic and multinational firms, respectively.

Columns 3 to 6, show the decomposition of total sales growth into domestic sales ($\ln(DomSales_{it})$ in columns 3 and 4) and exports ($\ln(X_{it})$ in columns 5 and 6). Both domestic sales and exports follow a similar trend. They grow faster than for domestic and multinational firms prior to entering into multinational activities, indicating that the fastest growing firms self-select into multinational activity, and drop in the aftermath. The effect is more pronounced for export growth. This is to be expected. As explained in Subsection 2, most of the first foreign affiliates are *horizontal* investments. They produce or distribute goods similar to those produced in the source country. Therefore, it is to be expected that these multinational expansions partly substitute for exports. The horizontal nature of these *Baby MNCs* is also consistent with the results in columns 7 and 8: Import growth is not significantly affected by the acquisition of this first foreign affiliate.

5 Conclusion

In this paper we analyze at the firms' joint process of innovation and multinational activities. Using panel data on Spanish manufacturing firms, with detailed information on innovation and international activities, we start by documenting some stylized facts that guide our theoretical framework. First, we show that innovation is a lumpy and disruptive process. Changes in technology, organization, or inputs of production occur sporadically and imply an immediate drop in sales. And second, the motive for the first foreign acquisition is *horizontal*. That is, the objective of the foreign affiliate is to sell or distribute products similar to the ones sold in the home country, as opposed to producing inputs for the headquarters.

Based on these stylized facts, we model innovation and market expansion as two complementary discrete options. Productivity of the firm is a combination of expertise (learning-by-doing) and technology. Innovation implies the replacement of existing technology for a better vintage, but also loss of the expertise accumulated over the life of the old technology. This model delivers a number of observable predictions that we confirm in the data.

First, even if innovation is associated with an immediate negative effect on sales, firm's sales growth is associated with higher frequency of innovation. Correspondingly, domestic firms that grow enough to become multinationals are those that innovated more often.

And second, the cyclicality of the innovation policy interacts with the decision to enter into foreign markets. Firms prefer to delay entry until the technology in place is sufficiently old and replace it immediately after entering. Given that upgrades in technology are disruptive, firms are likely to experience negative sales growth immediately after entering into multinational markets.

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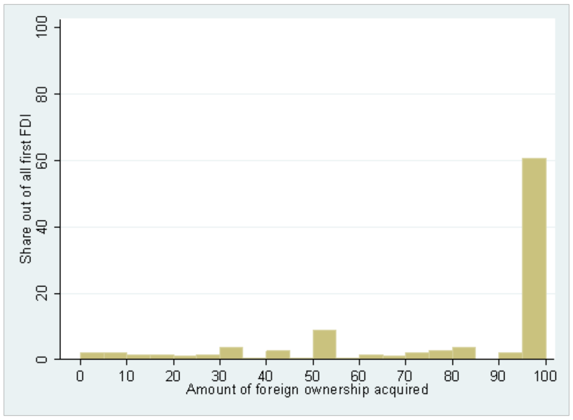
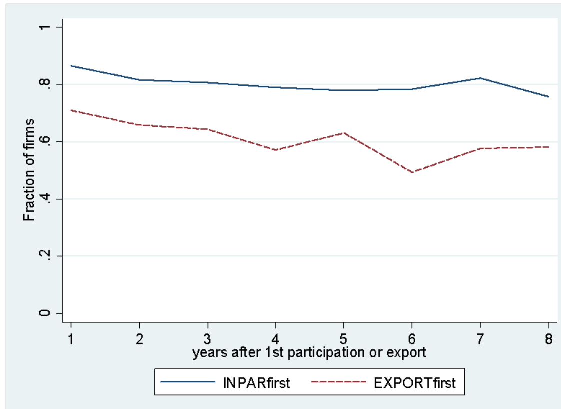
Tables and Figures

Figure 1: Baby MNCs: Descriptive Statistics



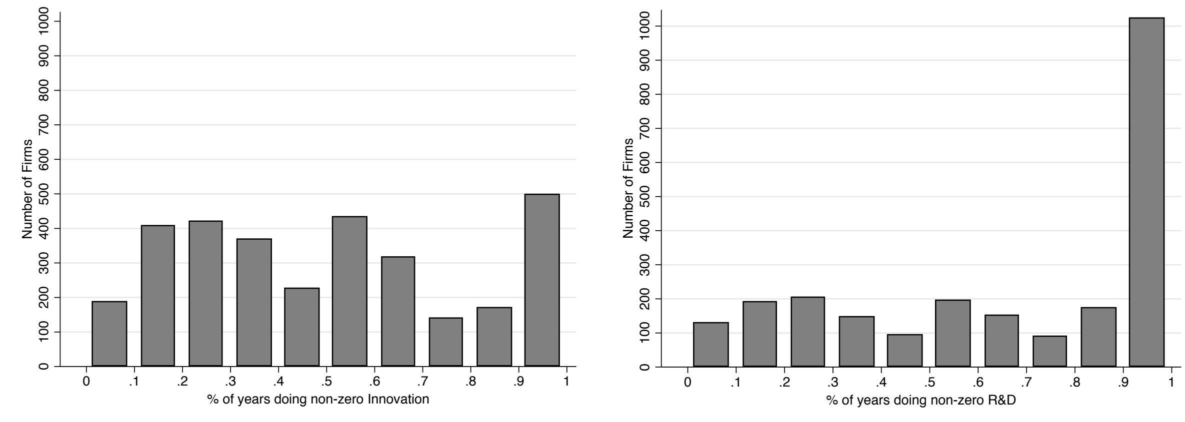
(a) Stake Control



(b) Exit from International Activities

Note: Panel (a) plots the share of firms according to their percentage stake in the first foreign investment. Panel (b) plots the fraction of firms that remain Exporters or MNC in the n-year after first entering the corresponding international activity.

Figure 2: Frequency of Innovation and R&D

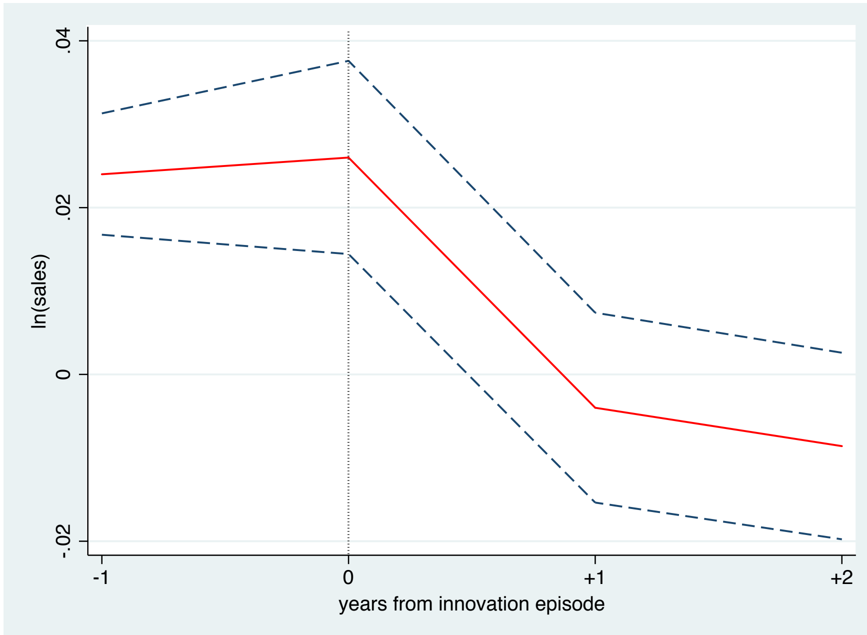


(a) Frequency of Process Innovations

(b) Frequency of R&D

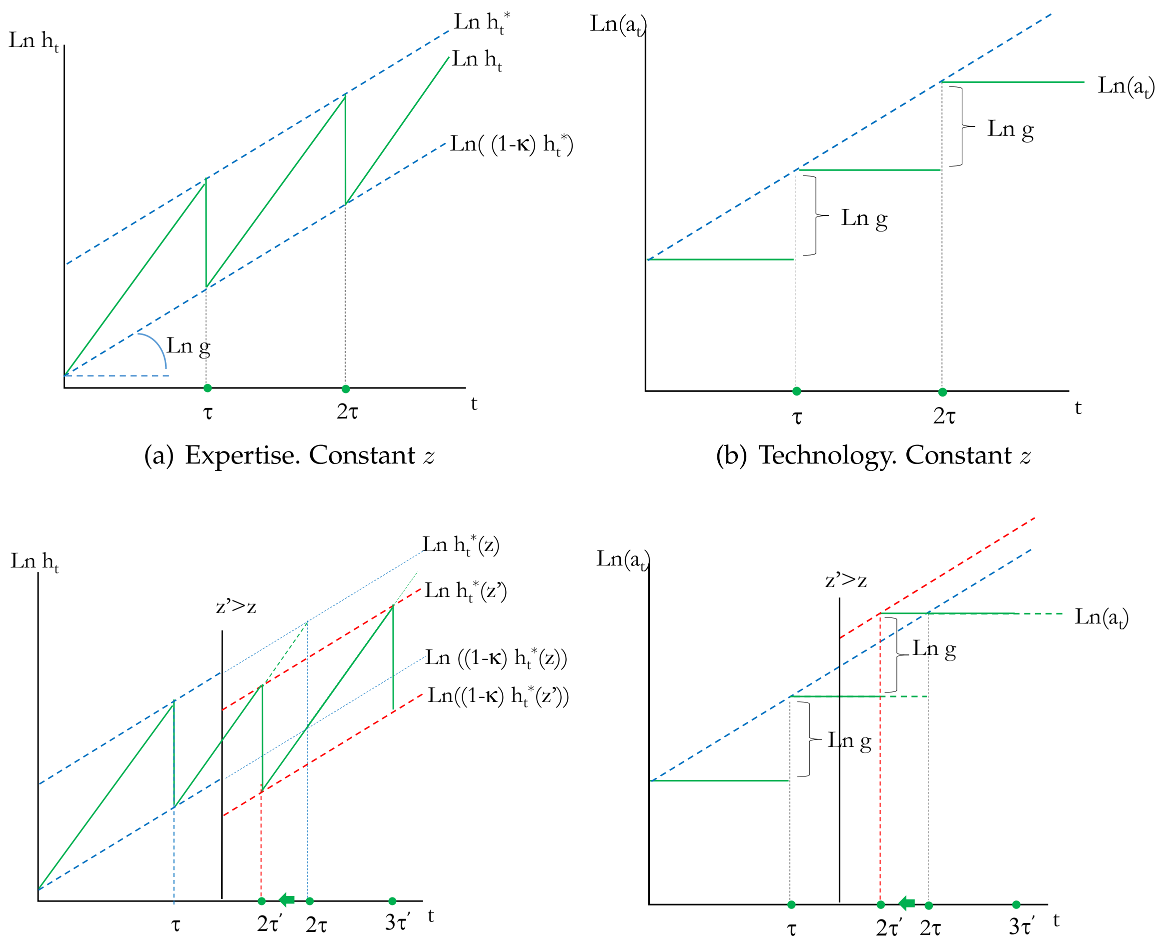
Note: Figures based on the entire ESEE database from 1990 to 2010.

Figure 3: Sales Growth and Innovation



Note: Figure based on the entire ESEE database from 1990 to 2010 (25,626 observations). Coefficient based on the OLS regression $\Delta \ln(Sales_{it}) = \sum_{\tau=t-2}^{t+1} Inn_{i\tau} + \epsilon_{it}$, with industry fixed effect and errors clustered at the industry level. Inn_{it} is a dummy variable equal to 1 if the firm i reports innovation in product or process at time t.

Figure 4: Optimal Innovation Policy



(a) Expertise. Constant z

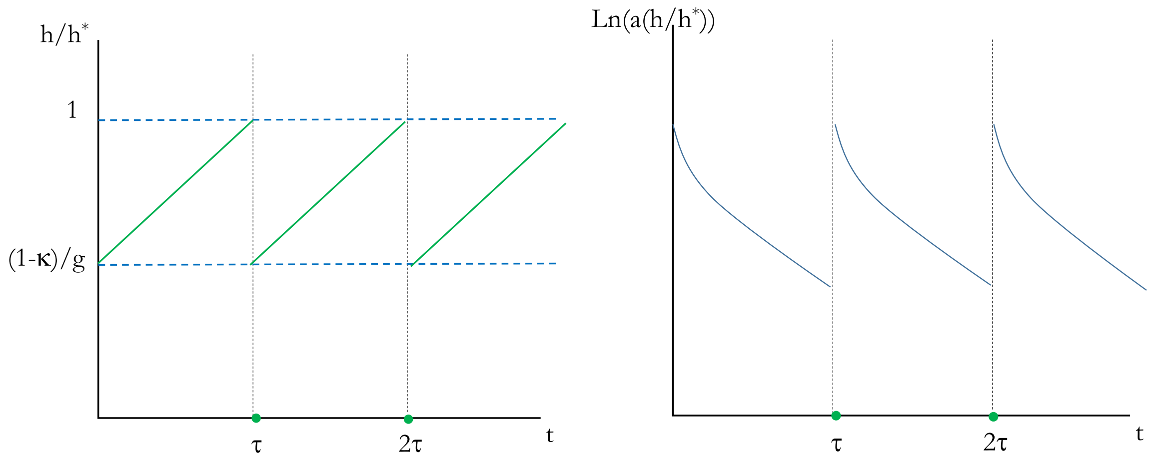
(b) Technology. Constant z

(c) Expertise. Positive change of z

(d) Technology. Positive change of z

Note: The variable h_t describes expertise of the firm at time t. $h_t^*(z, M)$ is the expertise level that triggers a new round of innovation, defined in Proposition 1. $(1 - \kappa)$ is the expertise loss upon technology change. In panels (a) and (b), firm's talent and market size (z, M) are constant over time. Panels (c) and (d) plot the effect of a positive realization of z.

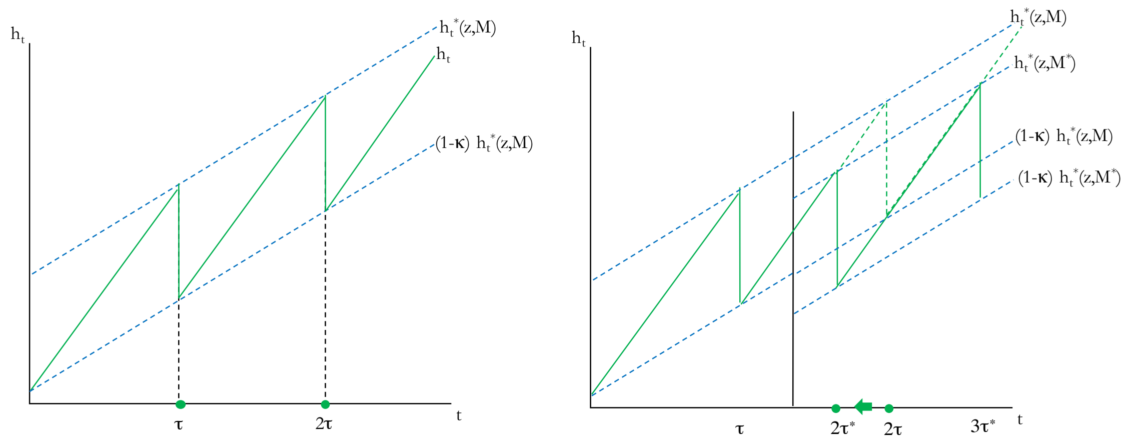
Figure 5: Cyclical Entry Policy



(a) Cycle of the ratio h_t/h_t^* (b) Cycle of entry cutoff $\ln(\bar{a}_t)$

Note: The variable h_t describes expertise of the firm at time t. h_t^* is the expertise level that triggers a new round of innovation, defined in Proposition 1. $(1-\kappa)$ is the expertise loss upon technology change. The technology cutoff $\bar{a}(h_t/h_t^*)$ is defined in Proposition **??**. In both panels, firm's talent and market size (z, M) are constant over time.

Figure 6: Innovation and Entry into Multinational Activities



(a) Constant M and z (b) Entry with $M^m > M^d$

Note: The variable h_t describes expertise of the firm at time t. $h_t^*(z, M)$ is the expertise level that triggers a new round of innovation, defined in Proposition 1. $(1 - \kappa)$ is the expertise loss upon technology change. In Panel (a) firm's talent and market size (z, M) are constant over time. In panel (b) the vertical line signals entry into a foreign market with $M^m > M^d$.

Table 1: Descriptive Statistics

	Total Sample N firms= 3,514			Baby MNC N firms= 183			Always Domestic N firms= 2,973			Mature MNC N firms= 315		
	Mean (1)	Median (2)	SD (3)	Mean (4)	Median (5)	SD (6)	Mean (7)	Median (8)	SD (9)	Mean (10)	Median (11)	SD (12)
FDI participation (%)	10.74	0.00	29.46	42.62	6.00	46.14	0.00	0.00	0.00	75.46	100.00	36.01
N of participations	0.55	0.00	3.66	1.44	1.00	4.35	0.00	0.00	0.00	4.29	2.00	10.03
Process innovation	0.32	0.00	0.47	0.46	0.00	0.50	0.28	0.00	0.45	0.51	1.00	0.50
Process - organization	0.17	0.00	0.37	0.29	0.00	0.46	0.14	0.00	0.34	0.30	0.00	0.46
Process - machines	0.3	0.00	0.46	0.42	0.00	0.49	0.26	0.00	0.44	0.47	0.00	0.50
Product innovation	0.21	0.00	0.41	0.37	0.00	0.48	0.17	0.00	0.38	0.44	0.00	0.50
Product - functions	0.18	0.00	0.38	0.32	0.00	0.47	0.14	0.00	0.35	0.38	0.00	0.48
Product - materials	0.16	0.00	0.37	0.28	0.00	0.45	0.13	0.00	0.33	0.34	0.00	0.47
Sales (€Mill)	69.45	6.76	325.42	246.40	62.85	790.28	36.27	3.83	163.55	190.37	66.87	484.05
Average wage (€Th)	29.91	27.52	21.24	36.75	34.69	12.56	28.13	25.36	22.46	38.64	37.61	12.05
Exporter dummy	0.64	1.00	0.48	0.92	1.00	0.26	0.57	1.00	0.50	0.98	1.00	0.13
Foreign ownership dummy	16.2	0.00	35.84	38.32	0.00	46.66	12.32	0.00	32.16	29.59	0.00	43.33
$\ln(Capital)$	45.25	44.73	22.01	50.83	54.12	20.72	44.30	42.77	21.98	49.02	53.19	22.31
$\ln(Labor)$	4.23	3.93	1.49	5.70	5.78	1.28	3.88	3.58	1.33	5.83	5.76	1.07

Note: Statistics pooled across all years (2000 to 2010). Baby MNC are firms that do not report any foreign investments at the time they enter the sample, but will make one in the future. Always Domestic correspond to firms that do not change their MP status. Mature MNC are firms that are multinational since we first observe them in the sample. (%) of Product and Process Innovations respectively indicate whether the proportion of years in the sample that the firms reported the corresponding innovation. Product innovation can be changing the function or design of the product (Product innov. - functions), or the components or materials of the product (Product innov. - Materials). Process innovation can be changing the form of organizing the firm (Process innov. - organization) or improve the machineries (Process innov. - machines).

Table 2: Innovation vs R&D: Effect on Patents

Dep Var.	N Patents$_{it}$		
	(1)	(2)	(3)
Product Innovation Frequency$_{it-1}$	0.242		0.290
	(0.312)		(0.356)
Process Innovation Frequency$_{it-1}$		0.020	-0.106
		(0.294)	(0.335)
$\ln(1 + R\&DStock_{it-1})$	0.806***	0.828***	0.808***
	(0.151)	(0.165)	(0.154)
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
N	8494	8494	8494

Note: Poisson Regression based on total ESEE data from 1990 to 2010. The dependent variable is the number of patents by firm i up to year t. Innovation frequency (process or product) is the fraction of years the firm innovating since entering in the sample until year $t-1$. R&D stock is its accumulated expenditure since entering the sample until year $t-1$.

Table 3: Propensity Score

	Future Baby MNC_i	
	Dom	MNC
	(1)	(2)
Initial Productivity_i	0.393***	0.045
	(0.086)	(0.114)
Initial Exporter Status_i	0.477***	-0.809**
	(0.104)	(0.320)
Initial Average Wage_i	-0.006*	-0.005
	(0.003)	(0.005)
Initial $\ln(K_i)$	-0.008**	-0.009*
	(0.003)	(0.005)
Initial $\ln(L_i)$	0.389***	-0.056
	(0.052)	(0.049)
N	3043	437
Pseudo R^2	0.244	0.066

Note: Probability (Probit regression) that a firm is part of the group *Future Baby MNC* based on observable characteristics at the year they first enter the database. Sample in column (1) pools future *Baby MNC* with domestic firms. Sample in column (2) pools future *Baby MNC* with mature MNCs.

Table 4: Frequency of Innovation

	Do-Not Enter		Mature MNCs	
	Product Innovation (1)	Process Innovation (2)	Product Innovation (3)	Process Innovation (4)
Baby MNC	0.131***	0.110***	-0.018	-0.008
	(0.039)	(0.040)	(0.050)	(0.038)
Year FE	Yes	Yes	Yes	Yes
Pscore	Domestic	Domestic	Mature MNC	Mature MNC
N	12419	12419	1868	1868

Note: Logit regression (marginal effects) comparing probability of innovation of Future MNCs with those that never enter (columns 1 and 2) and with those that are always MNCs (columns 3 and 4). For Future Baby MNCs the time period is restricted to the years up to their entry into multinational activities.

Table 5: Innovation around the Time of Entry

	Product Innovation$_{it}$		Process Innovation$_{it}$	
	(1)	(2)	(3)	(4)
ΔFDI_{it+1}	-0.003	-0.046	0.085	0.007
	(0.053)	(0.065)	(0.069)	(0.068)
ΔFDI_{it}	0.210***	0.051	-0.020	-0.100
	(0.062)	(0.056)	(0.089)	(0.075)
ΔFDI_{it-1}	0.275***	0.121***	0.156***	0.090
	(0.058)	(0.046)	(0.049)	(0.057)
ΔFDI_{it-2}	0.090*	0.017	0.123	0.044
	(0.047)	(0.044)	(0.085)	(0.064)
Year FE	5699	1032	5699	1032
Pscore	Dom.	MNC	Dom.	MNC
Obs.	5699	1032	5699	1032

Note: Bi-Probit regressions, estimating the probability of doing product and/or process innovation. Results correspond to the unconditional marginal effects on probability of innovating. In columns (1) and (3), Baby MNCs are matched to domestic firms in the first year firms are in the sample. In columns (2) and (4), Baby MNCs are matched to mature MNC in the first year firms are in the sample. The matching is performed using the propensity scores estimated in Table 3.

Table 6: Sales around the Time of Entry

Dep Var	$\Delta \ln(Sales_{it})$		$\Delta \ln(DomSales_{it})$		$\Delta \ln(X_{it})$		$\ln(IM_{it})$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔFDI_{it+1}	0.009	-0.004	-0.033	-0.041	0.226	0.090	0.038	-0.091
	(0.028)	(0.024)	(0.045)	(0.036)	(0.162)	(0.081)	(1.140)	(0.305)
ΔFDI_{it}	0.235*	0.120**	0.036	0.029	0.223	0.116	0.394	-0.308
	(0.127)	(0.059)	(0.174)	(0.103)	(0.210)	(0.101)	(0.990)	(0.465)
ΔFDI_{it-1}	-0.026	-0.032	0.089	-0.003	-0.225***	-0.111	0.090	0.079
	(0.025)	(0.022)	(0.068)	(0.047)	(0.072)	(0.074)	(0.110)	(0.116)
ΔFDI_{it-2}	-0.080***	-0.041**	-0.083**	-0.048	-0.172**	-0.115*	0.134	0.017
	(0.030)	(0.020)	(0.038)	(0.035)	(0.077)	(0.063)	(0.178)	(0.148)
Obs	5,699	1,055	5,668	1,047	5,686	1,052	5,678	1,046
R^2	0.18	0.24	0.08	0.09	0.03	0.08	0.01	0.01
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PScore	Dom	MNC	Dom	MNC	Dom	MNC	Dom	MNC

Note: In columns (1)-(3)-(5)-(7), Baby MNCs are matched to domestic firms in the first year firms are in the sample. In columns (2)-(4)-(6)-(8), Baby MNCs are matched to mature MNC in the first year firms are in the sample. The matching is performed using the propensity scores estimated in Table 3.

Appendix: Proofs and Derivations

A.1 The MNC's Value Function

This solution follows Pavlova (2002). We guess the following form for the value function: $V_m(ah) = aJ_m(x)$, where $J_m(x) = A_m x^{1/2} + B_m x^{\psi_m}$ and $x = \frac{M_m^2 h}{a}$ for some unknown parameters ψ_m, A_m and B_m.

Then, we can re-write (8) as follows:

$$rJ(x) = x^{\frac{1}{2}} + \mu x J'(x) + \sigma^2 x^2 J''(x)$$

Replacing the guessed value function into the above arbitrage condition, we obtain ψ_m and A_m:

$$A_m = \frac{1}{r - 0.5(r - 0.5\sigma^2)} = \frac{1}{\tilde{r}}$$

and ψ_m is the positive root of the following quadratic expression:

$$F(\psi) = \psi^2 + \frac{\mu - \sigma^2}{\sigma^2}\psi - \frac{r}{\sigma^2} = 0$$

For $r > \mu > \sigma$: $F'(\psi) > 0$ for all $\psi > 0$ and $F(1) < 0$. Therefore, the positive root of $F(\psi)$ satisfies that $\psi > 1$.

We can rewrite the conditions (11), (12), and (13) as functions of x right before and after the innovation $x_- = M_m^2 h/a$ and $x_+ = M_m^2 h(1-\kappa)/(ag)$, where $g = a^*/a$ is the technology growth rate:

$$J(x_-) = \frac{x_-}{x_+}(1-\kappa)\left(J(x_+) - 1\right) \tag{A.1}$$

$$x_+ J'(x_+) = J(x_+) - 1 \tag{A.2}$$

$$J'(x_-)x_+ = (1-\kappa)\left(J(x_+) - 1\right) \tag{A.3}$$

Notice that the system of equations is invariant to the state variables. That is, x_+, x_-, and B_m are independent on the productivity at the time of innovation (i.e., h and a). They are functions of the parameters only. We then name $x_+ \equiv \phi_m$, which is given by the following implicit function, based on model parameters only:

$$F(\phi) = \frac{\phi^{1/2}}{2\tilde{r}}(2\psi - 1)\left\{\left[1 - \frac{2\tilde{r}}{\phi^{1/2}}\right]^{\frac{1}{2(\psi - 1/2)}} - (1-\kappa)\right\} + \psi(1-\kappa) = 0$$

The solution to the above equation exists. To see this, let $\phi^a \equiv (2\tilde{r})^2$ and $\phi^b \equiv (2\tilde{r})^2[1 - (1-\kappa)^{2(\psi-1/2)}]^{-2}$. Notice that $\phi^a < \phi^b$, $F(\phi^a) < 0$ and $F(\phi^b) > 0$, and $F'(\phi) > 0$ for all $\phi \in (\phi^a, \phi^b)$. It follows that there is a solution to $F(\phi_m) = 0$ with $\phi_m \in (\phi^a, \phi^b)$.

Replacing, we obtain B_m:

$$B_m = \frac{\phi_m^{-\psi}}{\psi - 1}\left[\frac{1}{2\tilde{r}}\phi_m^{\frac{1}{2}} - 1\right]$$

And the optimal technology upgrade for MNCs, which is given by a constant growth rate g_m:

$$g_m = (1-\kappa)\left[\frac{\phi_m^{1/2}}{\phi_m^{1/2} - 2\tilde{r}}\right]^{\frac{1}{\psi - 1/2}}$$

A.2 The Value Function of the Domestic Firm

The problem of the domestic firm is more complex, as its innovation policy also affects the option of eventually acquiring a foreign affiliate. Parallel to the value function of the MNC, we guess the following form $V_d = aJ_d(x) + ab(a)x^{\psi}$. As in the case of MNC's value function, $J_d(x) = A_d x^{1/2} + B_d x^{\psi_d}$ and $x = \frac{M_d^2 h}{z}$. Differently, the guessed value function includes the term $ab(a)x^{\psi}$, which corresponds to the option of becoming a MNC.

$V_d(a,h)$ also satisfies the arbitrage condition 8, which results in $A_d = A_m = 1/\tilde{r}$ and $\psi_m = \psi_d$.

Parameter $b(a)$ and entry policy x_E solve the Value Matching and Smooth Pasting conditions that characterize the optimal entry into MP activities:

$$J_d(x_E) + b(a)x_E^{\psi} = J_m\left(x_E(M_m/M_d)^2\right) - \frac{F}{a} \quad \text{(A.4)}$$

$$J_d'(x_E) + \psi\, b(a)x_E^{\psi-1} = J_m'(x_E(M_m/M_d)^2) \quad \text{(A.5)}$$

The coefficient dictating the option value to enter increases with the firm technology, a, the difference in market size $M_m - M_d$ and decreases in the entry cost, F:

$$b(a) = (2\psi-1)^{2\psi-1}(2\psi)^{-2\psi}\left[\frac{M_m}{M_d} - 1\right]^{2\psi}\left(\frac{a}{F}\right)^{2\psi-1} + \left[B_m\left(\frac{M_m}{M_d}\right)^{2\psi} - B_d\right]$$

Entry is conditional to the level of technology. x_E, the ratio of expertise to technology, that triggers entry is a decreasing function of a:

$$x_E^{1/2} = \frac{F}{a}\left[\frac{M_d}{M_m - M_d}\right]\left(\frac{2\psi}{2\psi - 1}\right)$$

Replacing into the guessed value function:

$$V_d(a,h) = a\left[\frac{x^{1/2}}{\tilde{r}} + Bx^{\psi} + \beta a^{2\psi-1}x^{\psi}\right]$$

where $B = B_m(M_m/M_d)^{2\psi}$ and $\beta \equiv (2\psi-1)^{2\psi-1}(2\psi)^{-2\psi}\left[\frac{M_m}{M_d}-1\right]^{2\psi}\left(\frac{1}{F}\right)^{2\psi-1}$. The problem consists now on two policy functions $h^*(a), g^*(a)$ and a confirmation of the functional form that satisfy the value matching and the smooth pasting conditions for a and h that characterize the optimal innovation decision.

$$\begin{aligned}
J(x_-) + \beta a^{2\psi-1}x_-^{\psi} &= \frac{x_-}{x_+}(1-\kappa)[J(x_+) + \beta\ (ag)^{2\psi-1}x_+^{\psi} - 1] && \text{(A.6)}\\
x_+J'(x_+) - (\psi-1)\beta(ag)^{2\psi-1}x_+^{\psi} &= J(x_+) + \beta(ag)^{2\psi-1}x_+^{\psi} - 1 && \text{(A.7)}\\
J'(x_-)x_- + \psi\beta a^{2\psi-1}x_-^{\psi} &= \frac{x_-}{x_+}(1-\kappa)\left[J'(x_+)x_+ + \psi\beta(ga)^{2\psi-1}x_+^{\psi}\right] && \text{(A.8)}
\end{aligned}$$

Replacing:

$$\begin{aligned}
J'(x_-)x_- - J(x_-) &= \beta a^{2\psi-1}x_-^{\psi}\left[(2\psi-1)g^{\psi}(1-\kappa)^{\psi} - (\psi-1)\right]\\
-J'(x_+)x_+ + J(x_+) &= 1 - \psi\beta(ag)^{2\psi-1}x_+^{\psi}
\end{aligned}$$

These equations converge to the ones characterizing the MNC when $M_d = M_m$ and therefore $B = B_m$ and $\beta = 0$. Taking that limiting case as benchmark for comparison:

$$\begin{aligned}
-\frac{1}{2\tilde{r}}x_-^{-(\psi-1/2)} + (\psi-1)B &= \beta a^{2\psi-1}\left[(2\psi-1)g^{\psi}(1-\kappa)^{\psi} - (\psi-1)\right]\\
\frac{1}{2\tilde{r}}x_+^{-(\psi-1/2)} - (\psi-1)B &= x_+^{-\psi} - \psi\beta(ag)^{2\psi-1}
\end{aligned}$$