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Technological opportunities, entry barriers and regional firm demographics: The case of Quebec?s manufacturing

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Abstract

This paper seeks to advance our understanding of the factors that influence the demographic profile of firms in an industrial sector. We focus on two factors which are also of interest to innovation researchers, namely technological dynamism and protective barriers. Based on a process model of the entry and evolution of firms in the competitive context of a sector, we develop a series of hypotheses about the impact of these factors on the age and size distributions of firms in a sector, in particular on the average and skewness of the respective distributions. Results show that a higher level of technological opportunities increases the size and, possibly, the age of firms in the sector and appears to reduce the positive skewness of the respective distributions. A higher level of protection increases the average age and size of firms in a sector and reduces the positive skewness of the respective distributions. Finally, technological opportunities and protective barriers have a negative interaction effect on the average age and size of firms in the sector and positive interaction effect on the positive skewness of the distribution. Results suggest that a sector-specific approach, which would combine incentive programs for R&D, and hence increase the level of

technological opportunities, with the adjustment of protective barriers, could have a significant welfare impact.

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Technological opportunities, entry barriers and regional firm demographics: The case of Quebec's manufacturing

1. Introduction

This paper seeks to advance our understanding of the factors influencing the demographic profile of the population of firms in an industrial sector. One aspect addressed in prior research was the proportion of large versus small firms, as well as young versus established firms. The goal was to understand their respective contributions to economic output and innovation (Acs and Audretsch 1988). However, firm size and age profiles were also used as evidence of unobservable firm growth mechanisms (Gibrat 1931, Simon and Bonnini 1958). In particular, researchers sought to understand whether non-linear mechanisms would disproportionately favor larger, older or more capable firms in an environmental selection process (Andriani and McKelvey 2009). Skewness was the most widely use distribution parameter for inferring such mechanisms.

Even though a large number of studies included demographic comparisons between various sectors (Cabral and Mata 2003), relatively few studies sought to isolate specific contextual factors that produce differences in distribution patterns (Henderson 1999). Even fewer studies included factors of interest to innovation researchers, such as the nature and dynamism of technology (Malerba and Orsenigo, 1997; Floricel and Dougherty 2007), and the protective barriers resulting from intellectual property rights, geographic location and cluster agglomeration (Teece 1986, Niosi, 2000). Yet, prior research shows that these factors have important demographic implications. For example, the chances that an invention will be exploited through new firm formation increase, among others, when the respective technical field is younger and the invention gets better patent protection (Shane 2001).

In this paper, we present a preliminary theoretical model and an empirical exploration of the role of technological opportunities and of barriers that preclude the entry of exporters from emerging economies on the distribution of firms in the manufacturing sectors of developed countries. Based on a process model of the entry and evolution of firms in the competitive context of a sector, we develop a series of hypotheses about the influence of sector-specific technological opportunities and entry barriers on the age and size distributions of firms in the sector. These hypotheses concern direct and interaction effects on the average and skewness of the respective distributions. Hypotheses are tested using data obtained from secondary sources for the entire population of manufacturing firms from the Canadian province of Quebec, which includes almost twelve thousands firms. We compare distributions on four subsamples obtained by classifying subsectors according to their technology and barriers characteristics (Henderson 1999).

Our empirical results suggest that technology and barriers have a significant influence on the age and size distributions of firms, and interact in affecting these distributions. These results provide clarifications in the debates concerning the nature of firm distributions and the mechanisms that produce them. In particular, they provide evidence for mechanisms that may become prevalent in the context of deindustrialization that occurs in developed economies as result of growing exports from emerging economies. In practical terms, our results can help governments fine tune their industry support programs. On the one hand, government programs that lower the threshold for pursuing technological opportunities, such as tax credits for R&D, may be fine-tuned for various sectors, by considering the joint effect of technology and barriers. On the other hand, barriers may be strengthened of weakened selectively in various sectors, by considering, among others how they moderate the impact of technological dynamism on sector demographics.

2. Process model

In order to organize the relevant literature around the issues addressed in this paper we first built a process model that spells out our assumptions about the factors and mechanisms that determine the demographics of a sector (see Figure 1). The centerpiece of the model is an industrial sector in a developed economy or region, such as the manufacturing sector in Quebec, and, at its core, the life cycle of a firm belonging to that sector. We consider two types of potential entrants in the sector: new local firms, especially entrepreneurial startups, and foreign exports, especially those coming from firms in the emerging economies such as China, Brazil and India.

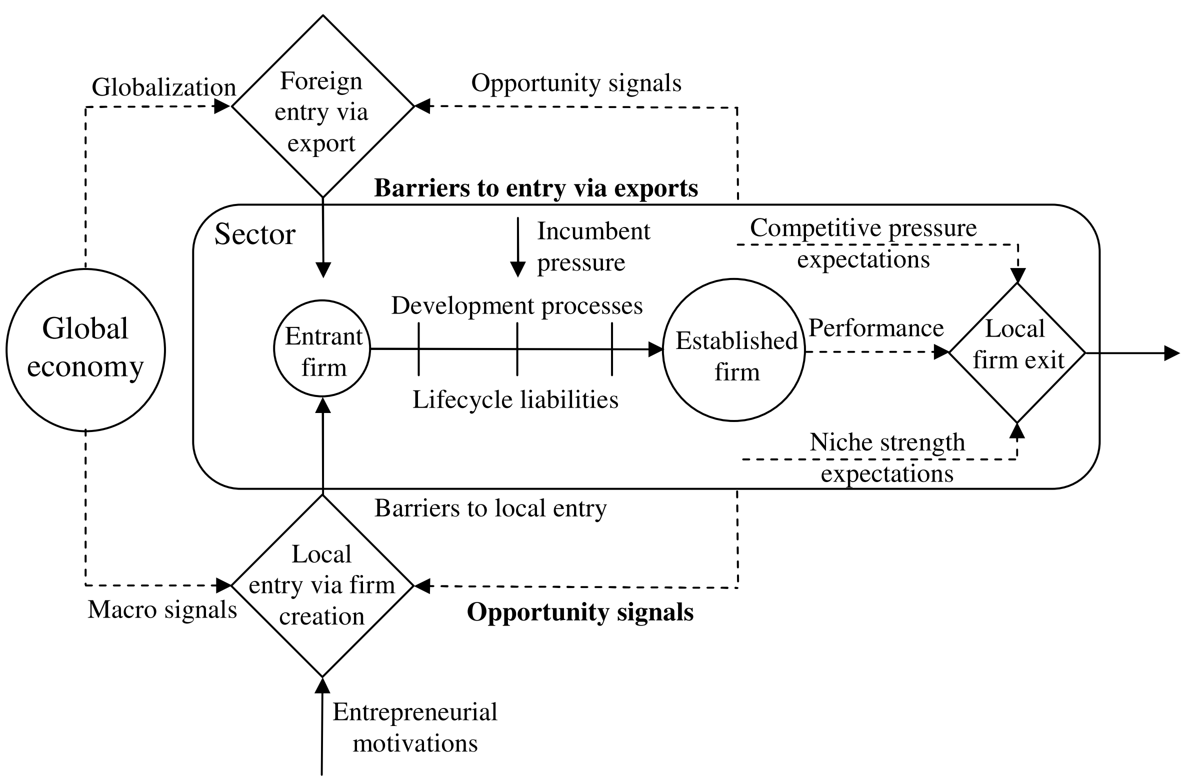

Figure 1: The process model of entry, development and exit of firms in an industrial sector

Opportunity signals

The decision to enter a market depends on several types of conditions that present themselves as signals perceived by potential entrants. The term signal is not used here in the sense of unambiguous information available to all potential entrants but in Hayek's (1947) sense of blurry distributed opportunities that are identified or not, and interpreted by individuals and firms, based on their prior experience and current capabilities. We focus on two types of opportunity signals. One type is the emergence of new technologies, especially those that incumbent firms cannot exploit because they do not have the required capabilities, and hence open a door for entry from outside the sector (Anderson and Tushman 1986). The literature underscores two aspects with respect to way entrants perceive this signal. One is the attractiveness of the niche, which is related to the perceived superiority of the new technology but also to peripheral aspects such as the required investment (Rogers 1994). The second aspect is entrants' anticipations regarding the subsequent niche formation. Potential entrants may be deterred by perceptions that the new technology and its applications will take a long time before becoming socially legitimate (Aldrich and Fiol 1994), that niche legitimacy may depend on the entry of other firms, especially large established firms (Podolny et al. 1996), and that the niche may already become overcrowded by the time is gets legitimated. The deterrent effect may be mitigated by perceptions that a constant emergence of related niches in the sector reduces the chances that new firm will be stuck in an overcrowded niche after entry.

The second type of opportunity signal is a reduced competitive pressure or niches resulting, for example, from the exit of established firms. Even though it may signal a difficult competitive context and low potential profitability, such exits may leave open certain niches that can be exploited by smaller entrants. These could be, for example, highly specialized niches, in which small firms can develop a closer relationship with demanding clients (Miller and Floricel 2004), or low end niches, which are not interesting for the established firms (Christensen 1997).

An important assumption we make is that these signals are perceived differently by local entrants and by exporters. On the one hand, local entrants benefit from their experience in a particular industry in order to identify and assess a local technological and market opportunity as well as eventual clients and partners. This means that they have higher chances to respond to technological opportunities and high-end niches. On the other hand, export entrants may miss these opportunities altogether, or perceive a higher information asymmetry with respect to the technology, markets and local partners. As a result, they may be more attracted by the low end niches, for which they may rely on their lower cost structure.

Barriers to entry

Barriers to entry are a group of factors that give incumbents a competitive advantage or preclude entrants altogether from selling in a market. While we are focusing on barriers that can block emerging country firms from exporting products to developed country markets, we overlook tariffs and similar obstacles to international trade. Instead, we consider three types of barriers often mentioned in the literature on innovation. One is constituted by patents and other intellectual property rights may preclude new firms from entering a niche (Teece 1986). Although firms from emerging countries may circumvent such protections in their home countries, this may be more difficult to do in developed economy markets. The second type of barriers stems from agglomeration effects related to belonging to a local cluster of firms. The main advantage is the access to external sources of knowledge via multiple ties with other firms and organizations (Niosi and Bas, 2001). For example, a firm located in a cluster innovates more than the average firm (Baptista and Swann, 1998). The third type of barriers stems from a number of factors such as transportation costs for bulky or unstable products, local reputation effects, the cost of packaging and adapting the product to local requirements and regulations may also deter export and favor direct investment in local production.

Incumbent competitive pressure

Incumbent competitive pressure contributes, on top of the export activity originating in emerging countries, to the selection pressure inside a sector. Moreover, potential entrant perceptions of competition intensity inside the sector may have the same effect as a barrier to entry. It is important to note that, as a barrier, competitive pressure should perhaps be regarded at different levels (nation, region, city) when we consider the entry of local versus foreign firms (export) in the same sector. For example, national density, including firms already present through export, may be more relevant as a signal for foreign firms, say because of the expected market outcome given the distribution effort, while regional or cluster density may be more relevant for local firms, for example, because of possible shortages of qualified workforce in the respective area.

However, competitive pressure and its source, the density of firms in a niche, also impacts firm development after entry. The density dependence literature suggests that, in industries such as beer production, organizational evolution depends on the density of similar firms at the state (province) and regional level (such as a city and surrounding rural areas) (Carroll and Wade

1991). We assume that competition intensity either stimulates more aggressive strategies, such as investment in larger scale facilities and in faster learning, which means accelerated growth but also more pressure on all niches, or forces firms to seek narrower niches, in which they can benefit from higher margins by selling high-end or highly specialized products.

Local entrepreneurial entry

In addition to opportunity signals, the decision to enter the market depends, in our model, on two additional sets of factors. The first set includes “macro” signals, such as the state of the domestic and global economies, the rise of service and “creative” sectors, generalized perceptions of the effects of globalization (such all manufacturing will move to emerging countries), and even cultural propensities and societal signals concerning the desirability of entrepreneurship (Blanchflower and Oswald 1998). The second set includes personal traits and circumstances of the entrepreneur, such as age, level of technical education, attractiveness of employment opportunities, access to capital, and experience gained from previous activity in the same sector (Reynolds 1997; Evans and Jovanovic 1989; Evans and Leighton 1990; Santarelli and Vivarelli, 2007; Reuber, 1999). The latter, experience-related factor can be an important multiplier of sectoral processes, because a significant sector decline deprives entrepreneurs of such experience and can literally produce the crumbling of a sector.

Foreign entry via exports

As mentioned above, entrants via exports may receive encouraging signals from a sector, but may perceive and emphasize them differently. Among the differences we include “macro” signals regarding the degree of globalization. We assume that perceived growth in globalization increase the confidence that exporters from emerging countries have in their chances of success in developed country markets. This translated in a constant increase of the competitive pressure perceived in the industrial sectors of developed economies. We assume that this pressure affects at first the low-end niches and only later reaches the mainstream market and high-end niches. For potential local entrants, foreign exports to a local market are the equivalent of local competitive pressure and other barriers, adding to the perceived entry deterrents.

Firm development process

In Figure 1 this process is represented by the arrow that starts from the "Entrant firm" circle and ends with the "Established firm" circle. This process is essential for creating firm distributions, because it is responsible both for firm size and for its economic performance and capacity to entrench itself in a sector niche. One outcome of this process is growth in terms of employment and, especially, scale of production facilities. In many cases, larger size leads to changes in the firm production function due to economies of scale. Research shows that firms enter a sector at a smaller scale than the one needed to attain the full extent of the economies of scale (Agarwal and Audretsch, 2001). On average, incumbents are larger, and hence, benefit from substantial economies of scale. Newcomer firms strive to extend the scale of their activities in order to benefit from similar economies, but this takes some time. As a result, we can assume that scale, and associated economies, are positively related to the time elapsed since firm entry. Alternatively, to counter this "liability of smallness" (Freeman, Carroll and Hannan 1983), entrants may seek a niche that sustains their activities at a reduced scale.

The second kind of process involved in firm development is learning. One aspect of learning is the fact that firms become more efficient in performing production tasks, in particular by improving coordination and by modifying work procedures via trial and error or the adoption of quality and other standard procedures. This aspect of the process affects the production function in ways that are more clearly related to the time elapsed since entry, because economies appear to increase with the cumulative number of units produced (Argote 1999). Another aspect of learning involves the depth of knowledge about markets and user needs. Firms learn to legitimize themselves and their new products in the eyes of funds providers, regulators and other stakeholders. Firms also establish closer relations with customers, and, by interacting with them, they acquire a better understanding of user needs and become more proficient in anticipating and serving them (Pavitt 1984, Miller and Floricel 2004). This second kind of learning means that firms have an increasing ability to define and defend their niche, which is likely to translate in higher profit margins.

A third kind of process involved in firm development is the fact that organizational activities acquire a routine character. While this process accompanies the learning processes described above and contributes to their positive effect, it also has a downside, which is the increase in the rigidity of the organization. As interactions inside the organization become taken for granted, it becomes more difficult to recognize what prompted the adoption of a given procedure or pattern of interaction and whether and how the pattern should change in order to accommodate new realities (Henderson and Clark 1991). Firms lose their ability to align with environmental changes, which makes them liable to new threats such as innovative technologies and changes in competition and niche characteristics. Alternatively, firms may choose to invest a considerable effort in the development of dynamic capabilities (Teece et al. 1997), which may threaten their profitability and disrupt the efficiency of their operating processes.

These processes suggest that firm development deviates from the assumption that the chances of firm survival and growth at any given time period do not depend on the outcomes of previous periods, which is the underlying assumption for the hypotheses that the size of firms in a sector will follow a law of proportionate effects (Gibrat law). In fact, the literature on firm life cycle suggests that various stages in the firm development are fraught with liabilities that put the firm at a disadvantage in the face of other types of firms and of entrants. The first liability, called the liability of "newness," is caused by the suboptimal scale, insufficient production and niche learning, and low legitimacy characteristic for young firms. Its consequence is the fact that exit chances decrease with the age of firms (Stinchcombe, 1965; Freeman, Carroll and Hannan, 1983; Hannan, 1998; Nucci, 1999). A refinement of the "liability of newness" is the "liability of adolescence" (Bruderl and Schussler 1990; Fichman and Levinthal 1991; Henderson 1999). Namely, exit chances are not necessarily the highest in the first few years since firm entry, because companies have an initial endowment of resources that is not yet depleted. Moreover, aware of the early difficulties caused by small scale and insufficient learning, resource providers give the firm the benefit of doubt and continue to support it before the accumulation of negative information quashes their optimistic expectations. In other words, while early exit chances are high, they grow even more when firms reach "adolescence" and the initial resource endowment (and patience) dries up. Finally, for firms whose age is measured in decades, the rigidity discussed in the previous paragraph produces a "liability of obsolescence" or "senescence" which significantly increases exit chances. On average, we assume that exit chances follow the characteristic depicted in figure 2, with an increase right through year 6, followed by a decline and a relative long period of low values (note the different scale used in the figure after year 10). This characteristic can produce several nonlinear effects in the sectoral selection processes.

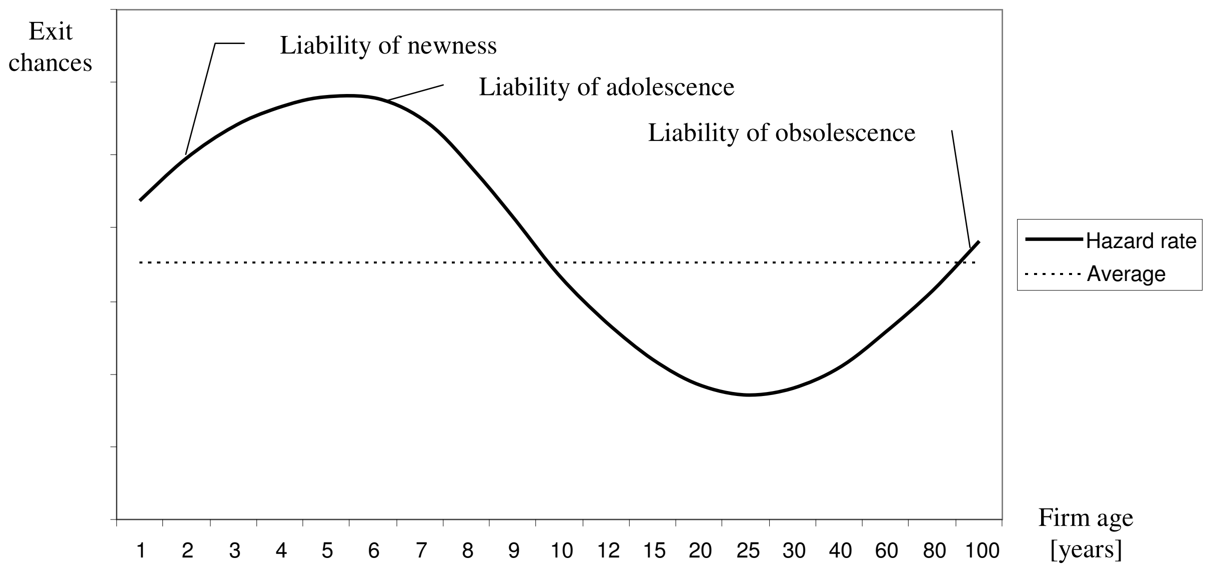

Figure 2: Evolution of firm exit chances (hazard rate) during the life cycle

(Please note that after year 10 firm age is represented with a different scale)

Exit decision

This decision can take place at any moment in the life cycle of the company, with a likelihood affected, among other factors, by the liability profile depicted in Figure 2. The decision may be in part forced, for example when the accumulation of losses and the loss of confidence from the financial backers compels a business organization to declare bankruptcy. However, many exit decisions are based on expectations regarding the future competitive pressure (from incumbents and foreign exports), and the evolution of the niche in terms of technological change and market size. It should be noted that in some cases an exit is an acquisition of the local firm by another company, local or foreign, and may be used as a vehicle of sector entry. However, in our sample the share of these situations is very small and does not significantly affect sectoral processes.

3. Hypotheses

As mentioned in the introduction, the focus of our theoretical development is not only on the average values but also on the skewness of firm age and size in the manufacturing sector of a developed country. While a shift in average can stem from conditions affecting in similar ways all the members of a population, higher positive skewness can indicate selection processes that amplify the differences in abilities between these members (Roy 1951; Tinbergen 1956). Among the factors captured by the process model we focus on the influence of technology opportunities and of sector-specific barriers on firm distributions. We will analyze the effects of these two factors separately, and in interaction. To clarify the meaning, when the hypothesis suggests a higher positive skewness, we argue that the mechanisms assumed in the model lead to an increase in the density function at lower values of age and, respectively, size, and also extend the tail of the distribution, meaning than more firms are found at extreme high values of age and size than in the case of a normal distribution.

We begin with the effect of technological opportunities. Because our hypotheses are tested on the population of Quebec manufacturing firms, we add the assumption that most technological opportunities originate locally, and hence incumbents and potential local entrants have an informational advantage with respect to export entrants from emerging economies in learning about, accessing and mastering the corresponding technologies and user requirements. Moreover, we assume that firms from emerging economies are, on average, more likely to be technological followers than firms from advanced economies, and that their strategies are more likely to emphasize low cost rather than differentiation via technological capabilities. A corollary is that entry by local entrepreneurs is more likely to carry technological advances, not necessarily in the form of innovative products and not necessarily produced by the entrepreneurs themselves, than entry via export from emerging countries. These assumptions are probably less and less valid but, they probably held for most manufacturing industries during the period when our data was gathered. A consequence of these assumptions is that firms in more developed economies, including Quebec, will perceive a stronger entry opportunity as a result of technological change.

To develop our argument about the role of technological opportunities, we relied on industry life cycle theories, which suggest that some technological discontinuities are followed by a period of massive entry of new firms in a sector (Abernathy and Utterback 1976, Klepper 1996). This entry shifts the age distribution towards the left. Because, initially, these firms compete with rather crude products, built around many alternative technological principles and technical architectures, the sector gets fragmented into a large number of small niches. This implies that technological opportunities also shift the average of the firm size distribution towards the left. If a few large firms from the previous technological wave survive in the sector, this also means that they will be further away from the average for both age and size. This contributes, along with the new peak of new and small firms (left of average), to produce a higher positive skewness for the age and size distributions. The emergence and growth period of the lifecycle is followed by the shakeout period, in which most firms that entered the sector, especially laggards, exit the industry because the competitive pressure increases. This happens because sales begin to grow at a decreasing rate, and because, as a dominant design emerges, most technological niches disappear. Oligopolies of firms that have attained significant learning and scale economies dominate such industries. This self-reinforcing process implies not only a higher average size, but also an increase in the positive skewness of distribution for size, as the sector becomes composed of a low number of very large firms and a fringe of smaller firms. An increase in the average age will also happen because early entrants are more likely to survive in the sector than firms entering just before the shakeout. However, the age distribution will have a lower skewness as small firms in the surviving fringe may have different ages.

The situation depicted in the previous paragraph is characteristic for many traditional industrial sectors, in which technological discontinuities are a relatively rare occurrence, and not all of them affect the value of incumbents' competencies (Tushman and Anderson 1986). Because at any given time most sectors are in the midst of a technological stability, which are longer than the technological upheaval periods that punctuate this stability, the likely situation is observing overall firm distributions with higher average and a positive skewness of age and size distributions. However, some sectors face a higher number and frequency of technological opportunities; in fact, such opportunities emerge almost continuously in many sectors (Floricel and Dougherty 2007). These include "high velocity" sectors (Eisenhardt 1989), such as semiconductors, computers, software and digital communications, as well as "science-based" sectors (Niosi 2000), such as biopharmaceuticals, medical equipment and nanotechnology. With few exceptions, these can be assimilated with what is known as "high-tech" sectors.

In high technology sectors many emerging niches can be successfully occupied by small firms because, incumbent firms cannot master the entire spectrum of new knowledge involved in the continuously emerging technological opportunities, and because innovation success is more knowledge-dependent and less large-asset fixed-asset dependent. These small firms often do more that their share of innovative activity (Acs and Audretsch 1988). They are also more flexible in pursuing new opportunities (Bhide 1994, Baumgardner et al. 2011, Figenbaum & Karnani, 1991). Moreover, as anecdotal evidence from sectors such as pharmaceuticals and software editing suggests, large firms even sponsor small firms to develop innovations. This is likely to reduce the average size of firms in high technology sectors. However, these sectors are also likely to witness the persistence of a large number of very large firms. The moves of these firms play a key role in legitimating emerging technological niches (Podolny et al. 1996). They may also benefit from even stronger self-reinforcing standardization effects (Arthur 1989) and from network centrality effects stemming from their ties to numerous technological niches and partner firms (Powell, Koput and Smith-Doerr 1996.). The higher number of small firms and a longer tail of very large firms suggest an even higher positive skewness in terms of size distributions compared to low-tech sectors. Similar effects may happen in terms of age. Since many innovations are proposed by startups, including entrepreneurial firms originating in universities, the average firm age is also likely to be lower in high-tech sectors. Yet, being constantly prompted to change, incumbents are more likely to cultivate the dynamic capabilities enabling them to choreograph transitions from one technological niche to the next, than firms in low technology sectors which can become sluggish during the long stability periods (Brown and Eisenhardt 1997). As the examples of IBM, 3M, or Merck illustrate, the survival power of incumbents may be as good in high-technology sectors as in low-technology sectors. Considering the mitigate effect of low technology on age skewness, it is likely that high-tech sectors will have, on average, a higher skewness than low-tech sectors. These arguments suggest the following hypotheses regarding the relation between technological opportunities and the size and age distributions of firms:

Hypothesis 1: A higher extent of technological opportunities in a sector is related to (a) a lower average, and (b) a higher positive skewness of firm distribution in terms of age.

Hypothesis 2: A higher extent of technological opportunities in a sector is related to (a) lower average, and (b) a higher positive skewness of firm distribution in terms of size.

The presence of strong barriers is likely to have the opposite effect on the age distribution of firms. As mentioned above, we focus on barriers blocking the entry of exporters from emerging countries. In general, these barriers are likely to reduce the perceived competitive pressure and hence increase the perceived chances for profitable entries for local entrepreneurs. However, in a context of decline, which is currently the case for most manufacturing sectors in the advanced economies, this may not be enough to entice entry by new firms, while extending at the same time the lifespan of incumbent firms. This also means that fewer incumbent firms will leave the sector, reducing the opportunities afforded by the bequest of niches that such exits create. So, higher barriers for overseas firms do not necessarily stimulate local firm entry, which means a higher average age for incumbent firms. In addition, barriers may help local entrants survive through the periods of liability of newness and adolescence, and continue as mature firms.

Agarwal and Gort (1996) found that sectors with *low* barriers are indeed characterized by more entries, but also by more exits. However, barrier protection may not necessarily increase the survival chances for firms affected by the liability of obsolescence, because it may accentuate the routinization processes that make these firms rigid and incapable of adapting to new realities. In sum, a situation with fewer entrants and more firms surviving past initial liabilities, but not necessarily obsolescence, suggests that the age distribution of firms in high-barrier sectors is likely to have a lower positive skewness than firms in low-barrier sectors.

With respect to size, industrial organization (Bain, 1956; Caves and Porter, 1977; Porter, 1979) traditionally considered entry barriers as a factor that increases sector concentration. In time, barriers make concentration self-reinforcing, as large firms can capture even more learning, scale and other economies, and eliminate smaller firms that are unable to attain similar efficiencies. This may lead to the domination of a few large firms or even a monopolist surrounded by a fringe of smaller firms. This suggests that firms in high barrier sectors are likely to have a higher average size. However, these processes can be undercut by the low-cost strategies of exporters from emerging countries, forcing local firms to pursue differentiation strategies, in which the exporters' cost advantage has a lower impact. These strategies compel incumbents to focus on a specific segment or a niche, hence setting a narrower upper limit to the self-reinforcing effects that benefit them (Henderson 1999). Moreover, barriers to exports from emerging countries will have an even higher effect in combination with niche-specific barriers, such as those created by the relationship-specific learning between one client with complex needs and one specialized supplier, enabling smaller specialized firms to thrive. Combined with the lower number of small size entrants and a cap on large firm size, this suggests that, in a globalization context, barriers reduce the positive skewness of firm size distribution. The expected effects of high barriers are expressed in the following hypotheses:

Hypothesis 3: A higher level of barriers in a sector is related to (a) a higher average and (b) a lower positive skewness of firm distribution in terms of age.

Hypothesis 4: A higher level of barriers in a sector is related to (a) a higher average and (b) a lower positive skewness of firm distribution in terms of size.

With respect to the interaction between technological opportunities and barriers we begin by discussing the situation in all four combinations of high and low technology, with, respectively, high and low protection. In high technology sectors, protection from emerging country exports reduces the perceived competitive pressure for all firms and potential local entrants. This may reduce the intensity of opportunity signals for local firms that seek to profit from the exit of large incumbents and may also stimulate the growth strategies of incumbent firms (investment in learning, network centrality). However, technological change continually creates new niches that can be pursued with equal success by local entrants as well as by small and large incumbents that have developed dynamic capabilities, because such change reduces the advantage that large firms have from previous learning and scale of operations. Barriers may protect the niches occupied by young entrepreneurial firms against foreign exporters and enable them to overcome the liabilities of newness and adolescence. On the other hand, for incumbents which have not developed dynamic capabilities barriers may accentuate organizational routinization processes, and increase their rigidity in the face of emerging technologies. This means that local entrants are likely to occupy some of these niches at the expense of large and average size incumbents. This suggests a negative interaction between technology and protection in influencing the average for both size and age of firm distribution. At the same time with a higher proportion of small firms, an important number of large firms will persist in proportion to the average size firms, because these firms are more likely to benefit from network centrality effects and have a better ability to invest and successfully develop in dynamic capabilities. This suggests a positive interaction between technology and protection with respect to the skewness of the size and age distributions of firms in a sector.

In high technology sectors with low protection against exports, chances are higher that exporters from emerging countries will attack local niches at the low-cost end of the respective markets. While local entrants have a time advantage in profiting from the emerging technological niches, exporters will attempt to occupy these niches after a certain lag. This lag may not be sufficient to allow local entrants to overcome the liabilities of newness and adolescence. Moreover, efforts made by local entrants to legitimate new niches may benefit export entrants without them having to make a similar technology legitimating efforts (Garud and Van de Ven 1993). This kind of phenomena may send deterring signals to new local entrants, as well as increase the rate of early exit among new local firms. On the other hand, established firms will improve their survival chances because they do not suffer from the liabilities of newness and adolescence. Being less protected they will also be less prone to rigidities and the associated liability. Large firms will be more able to benefit from innovative activities, compared to the one-project startups or small firms, due to network centrality effects as well as synergies with other activities, via knowledge and legitimacy spillovers. This will lead to a higher average for age and size distribution in high tech, low protection sectors, which confirms that technological change and protection level interact *negatively* in this respect. Because these effects are more or less proportionate with the age and size of firms, they are also likely to produce a reduction in the positive skewness of sector age and size distributions, which also confirms the argument advanced in the previous paragraph with respect to the positive interaction between technology opportunities and protection level in increasing positive skewness of the age and size distributions.

In low tech sectors, barriers to entries via exports tend to reinforce the processes that increase the average age and size, as well as reduce the left-leaning skewness of the respective distributions. Yet, barriers that keep overseas exporter at bay not only favor processes that produce learning, scale and scope economies in incumbents, but also reduce the chances of large firm exit and hence send negative opportunity signals to eventual entrepreneurs, whose firms would enter the sector at smaller sizes in order to take advantage of the niches left unoccupied by the exit of established firms. Moreover, if exports from emerging countries are possible at all, they are likely to be confined to the low-end niches, in which the cost advantage of firms from emerging countries may be a deciding factor, but which are also likely the niches in which a fringe of smaller firms could have survived in the sector if large firms chose to ignore these niches. Hence, the effect of barriers in low technology sectors is an increase in the average size and age of local firms and, assuming that a large number of mid-size firms also survive, also a move of the median towards the left, which often means a reduction of the positive skewness. This confirms that there is a negative interaction between technological change and protection level in determining the average age and size of firms in a sector as well as a positive interaction in determining the positive skewness of the respective distributions.

The absence of barriers changes the situation in important ways, most of all with respect to the later point. It enables foreign exporters to occupy a more significant part of the low-end and even move into higher-priced markets, undercutting the self reinforcing processes that enable large firms to persist in the sector. This forces most firms in the sector to lay off some of their workforce, reducing the average size of firms. However, it also forces the exit of some incumbent firms, leaving behind niches that are, in part, occupied by local entrepreneurial entrants. If this happens, a lower average age of firms is likely to be observed. However, firms most likely to exit are perhaps closer to the average size, while the largest firms that still benefit from important economies are more likely to survive. In addition, some exits may take the form of purchase by these larger firms, further increasing the number of firms at the largest size and older age ends of the respective distributions. In all, while the net effect of an absence of barriers is a reduced average size and age of the firms, the entry of small firms, the exit of average-size firms and the consolidation of a few large firms is likely to increase the positive skewness of age and size distributions. This also implies a negative interaction between technological opportunities and protection level with respect to the average age and size of firms in a sector and a positive interaction with respect to the positive skewness of the corresponding distributions. This enables us to propose the following hypotheses:

Hypothesis 5: The interaction between technological opportunities and the level of barriers in a sector will have (a) a negative effect on the average age, and (b) a positive effect on the positive skewness of firm distribution in terms of age.

Hypothesis 6: The interaction between technological opportunities and the level of barriers in a sector will have (a) a negative effect on the average size, and (b) a positive effect on the positive skewness of firm distribution in terms of size.

4. Data and methods

We built a large database of the manufacturing firms (NAICS codes 31-33) having at least one establishment in Quebec. We used multiple secondary sources, the most important one coming from a public R&D laboratory: the Quebec Industrial Research Centre (CRIQ). Other sources included the Quebec Statistical Institute compilation of R&D-active companies, the Industry Canada database and USPTO for patent data. After cross validating firm data and checking that firms still existed in 2010, we were left with 12,008 active manufacturing firms in Quebec, out of which 11,698 firms have had complete data for our purposes. The data collected for each firm and used in this paper include the year of foundation, size (employment), number of employees with R&D tasks, location (region), country origin of the owner, number of US patents obtained and NAICS code (6-digit).

For sector-specific protection, we built a complex sectoral protection index. This index combines several measures of protection, at the level of 3-digit industry:

1. Density of patenting firms, DP(j), as the proportion of firms having at least one patent in the industry's total. The density of patenting firms (or propensity to patent) varies largely between sectors (Arundel & Klabe, 1998; Arundel, 2001), while the patents are a classical entry barrier in industrial organization (Siegfried & Evans, 1994), especially in the high tech sectors (Pitofski,

2001; Langinier, 2004). An industry with a higher density of patenting firms means that new entrants must be more creative and spend more in R&D to have chances to survive.

2. Index of geographical clustering of the industry: $ICS_j = \frac{\sum_{r=1}^{N_r} \operatorname{mod}\left(ICG_{r,j} - \frac{\sum_{r=1}^{N_r} ICG_{r,j}}{N_r}\right)}{N_r}$

where: $ICG_{r,j} = \frac{NF_{r,j}}{NF_j} \div \frac{\sum_r NF_{r,j}}{\sum_j NF_j}$ = index of clustering for region r and industry j

NF = number of firms respecting criteria

N_r = number of regions (Quebec has 17 regions)

r = region

j = 3-digit NAICS code industry

There are 374 clustering indexes. If the firms would be uniformly distributed, all indexes must be 1. The real values are strictly positives, between 0 and 4.60 (for the most concentrated industry in a region). The clustering index reflects the tendency of firms, especially in the high tech sectors, to choose their location in the same area with incumbent firms in the same sector. This suggests an underlying benefit, in terms of knowledge or others, which can also deter entry via exports. The departure from the theoretical values in a uniform distribution reflects the degree of concentration of the industry. We used a mean of these real values in order to compute the overall index of concentration for an industry. As an example, if the firms in an industry are uniformly distributed between regions, the value of the industry's index of concentration is 0. More the firms of a specific industry are agglomerated in some (few) regions, higher the index.

3. Density of foreign ownership firms, DF(j), as the proportion of firms (establishments) with headquarters outside the province of Quebec. The density of foreign ownership firms could be considered as a proxy for both the existence of some more subtle barriers to entry in a specific market and for the existence of valuable local resources. In the first case, a foreign firm may consider either less costly to produce locally than to export in the local market, or to use the local facility to benefit from some market regulations (NAFTA effect). In the second case, the foreign entry, either by acquisition or by facility building seeks to exploit the market imperfections, disequilibrium of resources volume or quality, like highly qualified workforce (Buckley and Casson, 1976; Caves, 1998). Locally implanted branches of foreign companies have higher survival chances in difficult contexts (Kronborg and Thomsen, 2009), and their influence on local environment may be twofold: first, this premium is a synonym for an advantage of foreign branches over existing local firms, and second, by deterring the entry of new, local firms.

The aggregate level of protection of an industry was determined by considering the values of each index for each industry. We first normalized the three indexes and next we fixed a cut point at 0 (mean value for a normalized distribution), for each of these indexes. For each index, a normalized value over 0 means that the sector benefits of a higher protection, based on the corresponding criterion. If a sector is highly protected on all three criteria, it is finally considered as being a HP sector, but, if for at least one criterion it has lower then 0 values, it is considered a LP sector. This is not a 50-50% split, but being the result of the intersection of three different sets, the number of firms in HP sectors could be between 12.5% and 50%.

5. Results

In order to test our hypotheses we divided the subsectors Quebec manufacturing sector into subgroups according to their technological dynamism and protection level. For technological dynamism we used as an indicator whether the sector was classified as high tech (HT) or low tech (LT), based on the current classification methodology employed by the National Science Foundation. This methodology uses NAICS codes with 4 to 6 digits to identify the technological level of an industry. For barriers, we used the synthetic indicator discussed in the previous section in order to distinguish two groups: low protection (LP) and high protection (HP). By combining these distinctions we obtained four groups: LT-LP, LT-HP, HT-LP and HP-HT, which are described in Table 1 in terms of number and proportion of firms.

Group	Number of firms	% in Total
LT-LP	7615	65.1
LT-HP	1926	16.5
HT-LP	1792	15.3
HT-HP	365	3.1
Total	11698	100.0

Table 1. Number and proportion of firms in the four groups of sectors

Age distribution

Figure 3 indicates, on the left side, the overall age pyramid of firms in Quebec's manufacturing sector. For comparison purposes, and because age was mentioned above a factor that influence entrepreneurial entry, with a maximum propensity for persons in the 25-34 age group, we included on the right side the age pyramid of Quebec's population. We can observe that the difference between the peaks of the two curves is around 30 years. When the largest population cohort was around 30 years, Quebec recorded its peak in manufacturing firm entries.

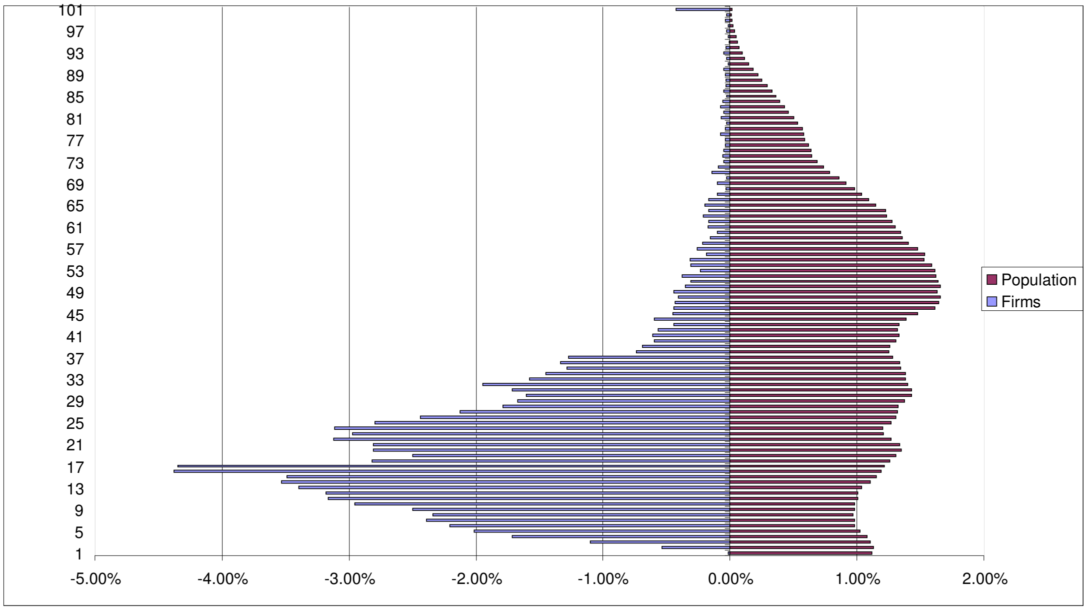

Figure 3 Age distribution of Quebec manufacturing firms (left) and population (right), in 2010

Table 2 shows the average age and the skewness coefficient for each of the four groups of sectors, which can be used to detect interaction effects. It also shows the average and skewness for all high protection and, respectively, low protection firms (in the column under the "Line total" cell), as well as the average and skewness for all low tech and high tech firms (in the line to the left of the "Column total" cell).

Protection level		Technology opportunities LT	Technology opportunities HT	Line total
Protection level	HP	24.67 **1.746**	19.36 **2.106**	23.82* **1.832**
	LP	21.42 **2.535**	23.24 **1.962**	21.76* **2.410**
Column total		22.07 **2.334**	22.58 **2.015**	

* Difference between HP and LP is significant at $p < 0.01$

Table 2 Average (first line of each cell) and skewness coefficient (second line, bold) for age distributions of each of the four subgroups and of the LT, HT, LP and HP totals.

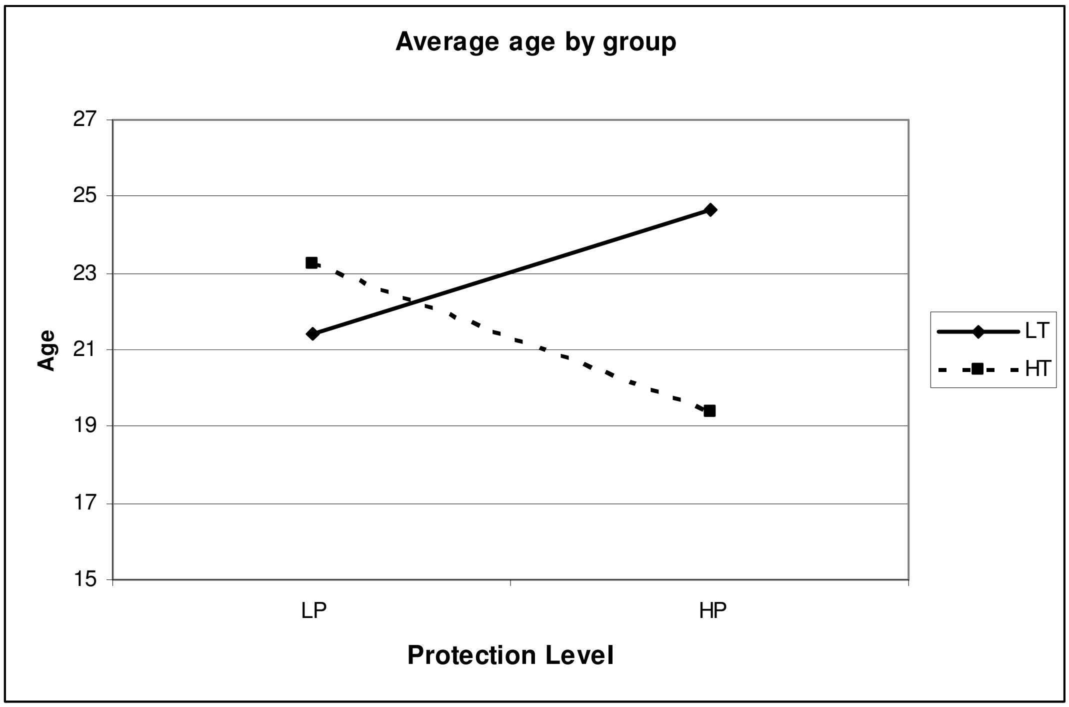

Figure 4 Illustration of the interaction effect between technology and protection on average age

We used Anova Onew-Way to test the main effects of technology and protection on the average age. Results appear to confirm hypothesis 3a, which stated that firms in low tech sectors will have a lower average age than firms in high tech sectors. The difference is statistically significant and has the expected direction. However, hypothesis 1a is not supported, because the expected difference is not statistically significant. Moreover, contrary to our expectations, the average age of firms in high technology sectors seems higher than that of firms in low technology sectors. To test the hypotheses with regard to interaction effects on average age, we used Anova One-Way and Post-Hoc tests to check for the significance of mean differences between the four groups of sectors. Because we cannot assume the equal variances, we used the Tamhane's T2 test. Between the 6 possible pairs to be compared, 5 of them were significant at 5%, while the mean difference between LT-HP and LP-HT was significant at 10%. We can conclude that overall, the differences are statistically significant. From Table 2 and Figure 4, we can see that indeed the interaction between technological opportunities and barriers has a significant negative effect on the average age, which seems to also confirm hypothesis 5a.

Results presented in Table 2 suggest that the distribution of firm ages in the high technology sectors has a lower positive skewness than that for firm ages in low technology sectors, which seems to contradict hypothesis 1b. However, the difference is not very large. The same table show that, as expected, the distribution of firm ages in high protection sectors has a lower positive skewness than the age distribution of firms in the low protection sectors. The difference is quite large and appears to confirm Hypothesis 3b. Results presented in table 2, and figure 5 show a higher positive skewness (i.e. towards the left side, or lower ages) for the LT-LP and HT-HP subgroups compared to the other subgroups (LT-HP and HT-LP). The LT-HP subgroup has the lowest skewness, while its diagonal opposite, the HT-LP group, also shows a relatively high average and low skewness. Values are comparable to the LT-HP group, and higher than two LT-LP and HT-HP groups that make up the other diagonal. This suggests that the interaction between technology and barriers has a positive effect on the positive skewness of the age distribution of firms. This result appears to confirm hypothesis 5b.

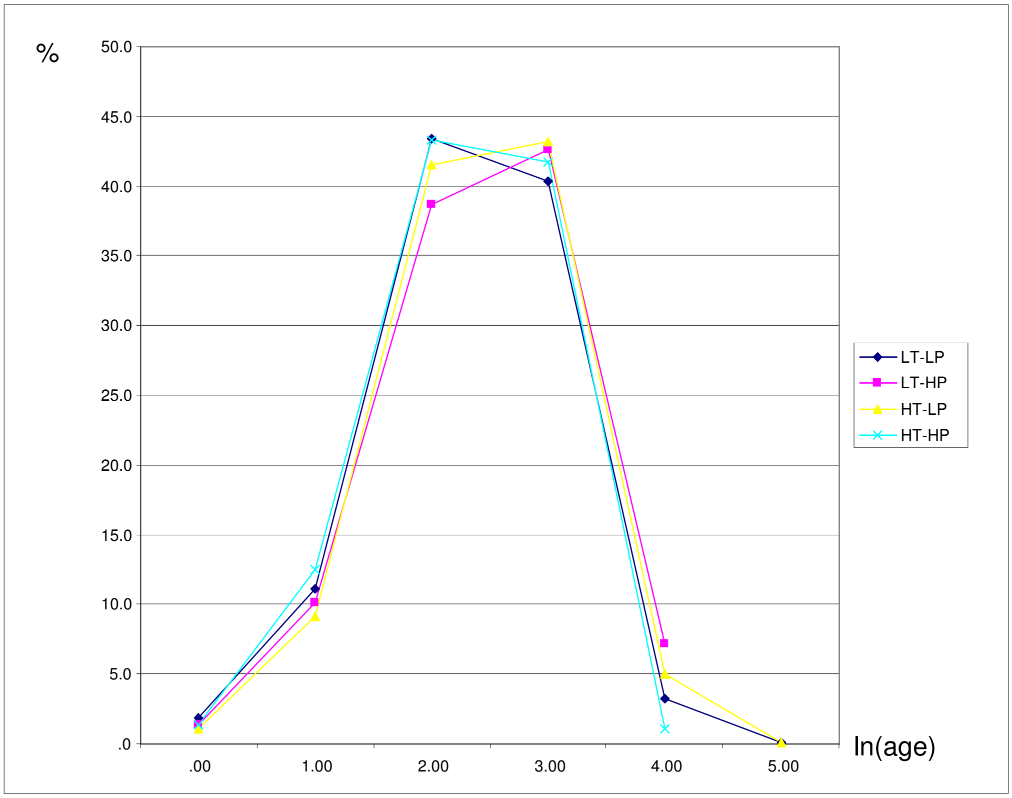

Figure 5. Age distribution of firms by technological opportunity and barrier groups of sectors

Size distribution

Table 3 shows the average and the skewness coefficient for the size distribution in each of the four groups of sectors, which can be used to detect interaction effects. It also shows the average and skewness of the size distributions for all high protection and, respectively, low protection firms (in the column under the "Line total" cell), as well as the average and skewness for all low tech and high tech firms (in the line to the left of the "Column total" cell). Figure 6 presents the size distributions for the four groups. The scale for size is logarithmic because it makes easier the visualisation of differences. The percentages on the Y-axis represent the density with respect to the total number of firm in each subgroup.

We used One-Way Anova to verify the statistical significance of the differences between low technology and high technology firms, and, respectively, between low protection and high protection firms, and hence test the direct effects hypotheses with respect to size. Results with respect to technology opportunity effects do not confirm hypothesis 2a. Contrary to our expectations, the average size of high technology firms is higher than that of low technology firms and the difference is statistically significant at $p < 0.01$ level. Because most firms in the sample are small, this pattern may be explained by a higher variance in the minimum efficient scale in low tech sectors. Results in table 3 also show that firms in high protection sectors have a higher average size than firms in low protection sectors. The difference is statistically significant and supports hypothesis 4a.

		Technology opportunities		Line total
		LT	HT	
Protection level	HP	57.6 **0.356**	60.3 **0.384**	58.01* **0.360**
	LP	35.0 **0.574**	51.3 **0.508**	38.09* **0.564**
Column total		39.55* **0.534**	52.79* **0.487**	

* Differences between HP and LP, and between HT and LT are significant at p < 0.01

Table 3 Average (first line of each cell) and skewness coefficient (second line, bold) for size distributions of each of the four subgroups and of the LT, HT, LP and HP totals

We used the same procedure, One-Way Anova, to verify the statistical significance of mean differences between the four groups. The Tamhane's T2 test show that the only significant (at 5%) difference exists between the LT-LP group and all the other groups. Differences between these three remaining groups are not significant using this procedure. Because the average of the

LT-LP is significantly lower than that for the other three groups, which are statistically indistinguishable, we can infer, with some caution, that the sum of the LT-LP, HT-HP diagonal is lower than the sum of the LT-HP, HT-LP diagonal. This would suggest a negative effect of the interaction between technology and protection on the average size of firms and appears to support Hypothesis 6a.

Results in Table 3 also suggest that hypothesis 2b is not supported. The distribution of firm sizes in high technology sectors has a lower positive skewness than the similar distributions for low technology sectors, albeit the difference is quite small. However, hypothesis 4b is supported, because, as expected, the distribution of firm size in high protection sectors has a lower positive skewness than the similar distribution in low protection sectors. The difference is quite important. Results in Table 3 and Figure 7 also suggests that hypothesis 6b is supported. Namely the values on the LT-LP, HT-HP diagonal appear higher than the values on the other diagonal, which would suggest that, as expected, the interaction between technology and protection increases the positive skewness of the size distribution.

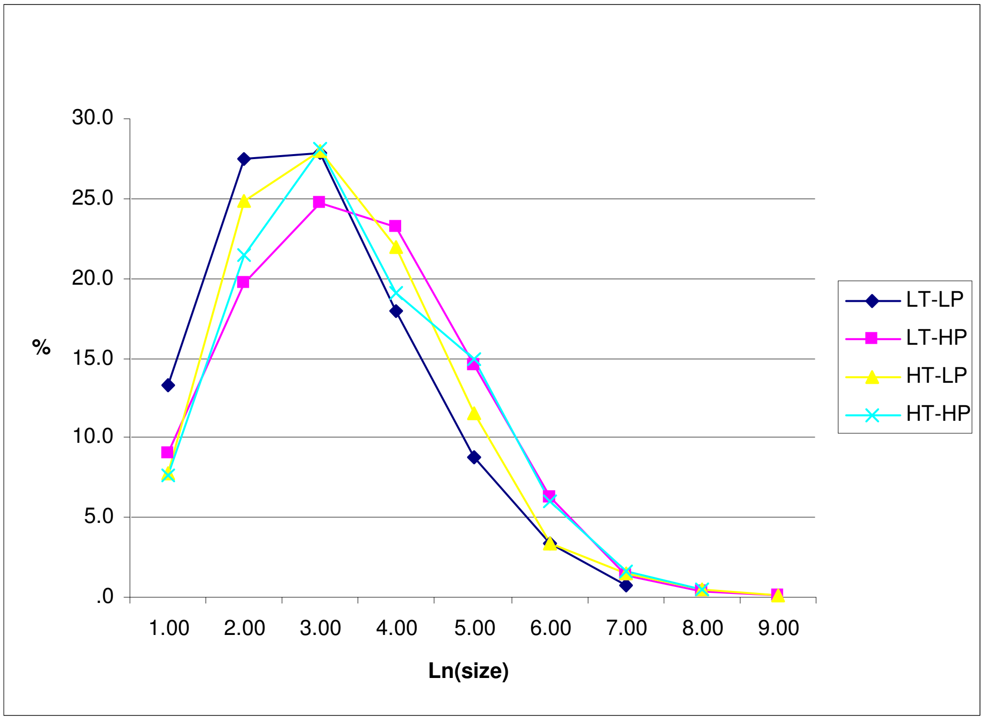

Figure 6. Distribution of firm size in terms of employment for technological opportunity and barrier groups of sectors

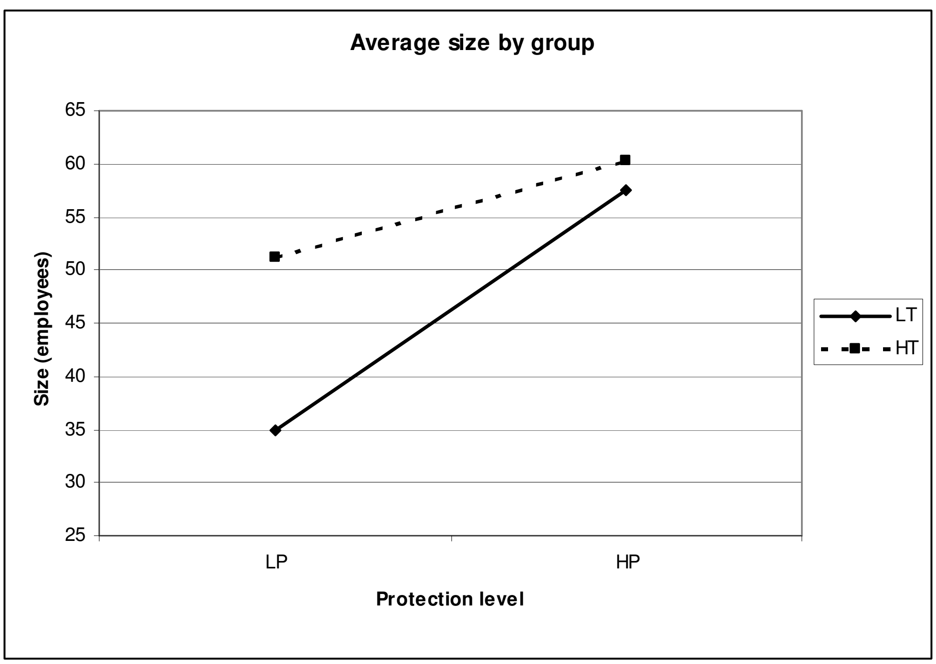

Figure 7 Illustration of the interaction effect between technology and protection on average size

6. Discussion and conclusion

Empirical results confirm most of our hypotheses. The exceptions concern the direct effect of technological opportunities on the average age and size of firms, and on the skewness of the respective distributions. But even in this case, only the impact of technology on the average size appears to produce a large enough and statistically significant difference in the opposite sense than we expected. Overall, results appear to support the main point advanced in this paper that technological opportunities and protective barriers have an important influence on firm demographics, both separately and in interaction. Age and size distribution are an indicator of the health of an economic sector, such as manufacturing, and have broader welfare implications.

Age distribution: A higher average age means more economic stability both for individuals employed in firms and for the regions in which they are established. Yet, a higher positive skewness signals both a vibrant formation or entry of new firms, and a persistence of a relatively large proportion of these firms. More young firms means that enough of them are available to be selected, which increases the likelihood that at least some of them persist through the early life liabilities (Le Mens, Hannan and Pólos 2011). In turn, a denser tail indicates that a higher proportion of firms have acquired the capabilities that enable them to weather economic downturns in their niche.

Size distribution: A higher average size may mean better employment conditions and the possibility of creating local development anchors. Yet, a lower positive skewness is better. Small firms produce more than their share of innovations, but large firms ensure that all scale, scope and perhaps even learning effects are captured. They also have higher chances of obtaining better legitimacy and reputation effects, as some of these effects operate at a national or global scale rather than at a regional or city level (Bigelow, Carroll, Seidel and Tsai 1997). Also, for a fixed number of firms, total employment is usually higher in a normal than in a skewed distribution.

Our results can inspire practical approaches with dealing with a particular process that occurs in all advanced economies: the decline of the home manufacturing sector due to globalization and the invasion of home markets by exports coming from firms in emerging economies.

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