DECLARATION FOR THE PhD THESIS

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ENTRY INNOVATION AND INDUSTRIAL DYNAMICS: THREE ESSAYS

A dissertation presented

by

Gianluca Capone

In partial fulfillment of the requirements for the Degree of Doctor in Business Administration & Management

Dissertation Committee:
Franco Malerba, Roberto Fontana, and Luigi Orsenigo

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INTRODUCTION

The entry of new competitors into markets is a very important phenomenon for the economic world, and it has been studied with different lenses and using different disciplines as background. In Economics, the interest in it goes back at least to the foundations of industrial organization (Bain, 1949). Theoretical models about entry evolved from the simple and static limit price models of the 1950s and 1960s to more dynamic models of strategic competition in the 1970s and 1980s (Geroski, 1995). Empirical studies also began in the 1970s, and culminated in the late 1980s and early 1990s (Dunne, Roberts and Samuelson, 1988, 1989; Acs and Audretsch, 1990; Audretsch, 1995); the results of this huge literature are summarized in Geroski (1995) and still represent today the bulk of our knowledge about entry.

In Sociology, a great contribution to the understanding of the entry process has come from the population ecology approach (Hannan and Freeman, 1977; Carroll and Hannan, 1989). Scholars in this area highlighted the importance of two forces in driving the evolution of populations of organizations, including the entry of new firms: social legitimization and diffuse competition. The dynamics of a population depends essentially on the density (the number of organizations in a population): at the beginning, when a new organizational form appears, the density is very low and the form lacks social legitimization, which make its life difficult; as density increases, also legitimization increases, in a self-reinforcing process. But as legitimization increases, the effect of increases in density on it is lower and lower. At the same time, a different and opposed force, diffuse competition, appears: organizations belonging to the same population compete over the same, finite set of resources. At high levels of density competition prevails on legitimization. This implies that founding (entry) rates increase with density for low levels of density, and then decrease with it for high levels of density. The opposite happens for mortality rates.

In Strategic Management, the interest in this issue has grown so much in recent years that a self-organized new field has emerged to deal with it, under the label of Entrepreneurship. A stream of literature has focused on the personality and individual traits that characterize the entrepreneur (Gartner, 1989), and the role played by factors as motivations (Shane, Locke and Collins, 2003), determinants of actions – such as overconfidence (Dosi and Lovallo, 1997) or proactivity (Baron, 2008) – and opportunity recognition (Shane and Venkataraman, 2000). More recently, a tension between the idea that motivations and opportunity recognition are cognitive processes, that, as such, can be defined only at the individual level and the idea, also appealing, that entrepreneurship is a collective and cooperative process has emerged (Shane and Venkataraman, 2000).

All these approaches share a common assumption: they consider the characteristics and the effects of entry as common across different contexts. This dissertation aims at analyzing the importance of environmental factors in determining the effects of entry at both the industry level and the firm level. In particular, it looks at the moderating role that is played by technology and demand and it exploits the concepts of technological regimes, demand regimes and submarket dynamics. Technological regimes are technology-specific patterns in the ways firms learn and include four broad dimensions: technological opportunities, appropriability of innovations, cumulativeness of technical change, properties of the relevant knowledge base. Breschi, Malerba and Orsenigo

(2000) found also a significant relationship between the dimensions of technological regimes and Schumpeterian patterns of innovation. Demand regimes refer to market-specific patterns regarding the characteristics of consumers and include both vertical and horizontal fragmentation. Submarket dynamics has been the object of growing attention as it has been recognized as an important determinant in the evolution of industries (Klepper and Thompson, 2006).

In the first study, I focus on the effects of entry on industry evolution. The starting points are history-friendly models about the computer industry (Malerba, Nelson, Orsenigo and Winter, 1999), the pharmaceutical industry (Malerba and Orsenigo, 2002) and the dynamics between upstream and downstream producers in the computer and semiconductors industries (Malerba, Nelson, Orsenigo and Winter, 2008). The interaction between environmental variables and industry outcomes is very strong. The historical evolution of the computer industry, which was characterized by a high cumulativeness of technical change and an homogenous demand (within each of the two big segments: business firms and individual consumers), saw the emergence of a strong monopoly by a first-generation firm (IBM). Although the monopoly result is unchallenged by entry alone, the probability of successfully displacing the incumbent and taking its monopolistic position in the market for a new, technologically superior firm is strongly dependent on the entry process in the past: the higher the number of entrants that compete in the early phases of the industry, and the higher the probability that the long-run leader will be the superior firm. Moreover, by introducing in this picture the role of suppliers of semiconductors components, even high concentration and monopoly tend to disappear in the downstream market. The strength of this effect is related to the concentration of the upstream market: an high concentration in this market, coupled with an high number of entrants in the downstream market, allows a more efficient use of the resources and helps in reducing the gap from the vertically integrated incumbent. Finally, in an environment with low cumulativeness of technical change and high demand fragmentation (as in the early Pharmaceutical industry) massive entry, coupled with a loose appropriability regime, may reduce the number of surviving firms, increase the concentration and reduce the propensity to innovation. Moreover, the results at the firm level show that the existence and extent of firm advantages due to entry timing depend on the characteristics of the entry process in the specific environmental context.

This observation has been the starting point of the second study. The issue of entry timing is an old one in Economics and Strategy, but it is still of the utmost importance, both on the theory side and for its practical implication. The choice of right entry time may have a strong and persistent impact on the performance of a firm, and the interacting choices of all involved actors may determine the future evolution of the sector. The study contributes to this huge literature by providing a model of industry evolution in which technological regimes and demand regimes affect the relationship between consumers switching costs and the emergence of early-mover advantages. The model is analyzed with the help of agent-based simulation techniques, and blends insights from both industrial organization and evolutionary economics in specifying firms' behavior. Results show that both demand regimes and technological regimes have a strong impact on the effectiveness of switching costs. In an environment characterized by a very fragmented demand switching costs are poorly effective because firms can exploit them on a limited group of consumers; moreover, early-mover advantages are generally quite low because the existence of several market niches offers a protecting environment for late entrants. On the other hand, in an environment with a very homogenous demand, consumers switching costs have a much stronger effect because they can influence a much bigger set of consumers. By exploiting the link between technological regimes and Schumpeterian patterns of innovations, it is possible to show that in a Schumpeter Mark I environment switching costs may reduce the importance of the availability of technological opportunities, since locked-in consumers will have lower consideration for new products. In Schumpeter Mark II environments switching costs are effective only when the accumulation of knowledge is external; the internal development of relevant knowledge constitutes a much stronger advantage for first movers that makes switching costs irrelevant. Moreover, the analysis of technological regimes also shows that switching costs may have different effects over time: they may provide a temporary protection in the short run, but increase the risk of exit in the long run. Finally, an interesting interaction between demand regimes and technological regimes also emerges. In particular, in Schumpeter Mark II environments the results can radically change in presence of a very fragmented demand: the existence of several market niches, especially those due to vertical fragmentation and quality requirements not satisfied by existing products, may be the Trojan horse through which late entrants may introduce disruptive innovations and overcome the dominant positions of early entrants.

The third study addresses the entry timing problem from the empirical side and it is based on the analysis of an original dataset about the US Comics industry. This industry presents some peculiarities that make it an interesting setting from which novel insights about the importance of entry timing emerge. First, we can identify in a clear way the entry and exit of products and firms at the month interval as comics issues always present a cover date. Second, the beginning of the industry coincides with the emergence of a common standard (the American comic book), that reduces the importance of the legitimacy forces in the early periods of the industry. Third, the presence of multiple genres allows to define different submarkets and actually the industry experienced a pattern of evolution similar to what observed in the laser industry, as predicted by Klepper and Thompson (2006). The results contributes to the first mover advantage literature, as we show that in an industry that starts with high legitimacy, entry when competition is not very intense and the market is not too crowded allows firms to build a more sustainable growth path. Moreover, submarkets (the genres) prove to be an important moderating factor: choosing a genre that is going to be very diffused across readers can give firms an important survival advantage – that more than offsets the potential threat of tougher competition. This should be also a concern for later entrants, especially when industry conditions change, either for exogenous or for endogenous reasons. Finally, we also contribute to the population ecology literature and to the recent developments of the density delay theory, by showing a way to reconcile the original predictions of the theory (Carroll and Hannan,1989) of a negative effect of density at founding on survival and the results obtained by Dobrev and Gotsopoulos (2010), that is a positive effect of density at founding on survival, when density is low, because of a legitimacy vacuum effect that persists over time.

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The Dynamics of Entry in Heterogeneous Industries

Abstract

Evolutionary theory relies on the interaction between variety generation and selection mechanisms, but theoretical models in this family have failed to consider in a proper way an important process of variety generation, that is entry of new firms. In this study we explore the dynamics of entry in history-friendly models – a specific class of evolutionary models that have been developed with the explicit aim of taking into account sectoral, institutional, and historical elements of the evolution of the industries. Our results show that the impact of entry has both similarities and differences across different industries.

1. INTRODUCTION

The idea that the entry of new firms in an industry has an important role to play in industrial dynamics is an old one, as it goes back to the origins of industrial organization (Bain, 1949). Although over the decades there has been a growing accumulation of empirical evidence related to this process (Geroski, 1995), our understanding of the mechanisms that link entry to the evolution of the industries is far from complete.

In this study we take the specific theoretical approach which goes under the label of evolutionary economics (Nelson and Winter, 1982). Two fundamental principles distinguish the evolutionary theory from the standard economic theory: the first one is that agents are heterogeneous and are characterized by routines; the second one is that the market acts as an out-of-equilibrium *ex-post* selection mechanism over firms that are constantly changing their routines. Although an overwhelming empirical evidence on firms heterogeneity in terms of size (Hall, 1987; Dosi, 2007; Dosi and Nelson, 2009), growth rates (Bottazzi and Secchi, 2006; Dosi and Nelson, 2009), profitability (Geroski, 1998; Dosi, 2007) and capabilities (Teece, Pisano and Shuen, 1997; Dosi, Nelson and Winter, 2000) has been collected over time, evolutionary models have failed to consider entry behavior that goes beyond a random process. This is an important flaw in the evolutionary theoretical agenda: one of the main criticisms towards the standard economic theory lies in the fact that selection alone cannot drive the economic system towards optimality if optimal varieties do not emerge (Dosi and Nelson, 1994).

Moreover, many of the models developed within the evolutionary family aiming at parsimony and generality have also failed to take into account sectoral characteristics (Winter, Kaniovski and Dosi, 2000, 2003; Dosi, Marsili, Orsenigo and Salvatore, 1995; Marsili, 2001; Bottazzi, Dosi and Rocchetti, 2001). Still, empirical evidence shows that "between" industry variation is quite relevant in explaining entry rates, signaling that sectoral characteristics might play an important role (Geroski, 1995; Bartelsman, Schivardi and Scarpetta, 2005).

Therefore, in this study we exploit a different class of evolutionary models – history-friendly models – that have been developed with the explicit aim of taking into account specific sectoral, institutional and historical elements of the evolution of the industries (Malerba, Nelson, Orsenigo and Winter, 1999). In particular, we can exploit the different models that have been developed to analyze specific industries (computers: Malerba et al., 1999; computers and semiconductors: Malerba, Nelson, Orsenigo and Winter, 2008; pharmaceuticals: Malerba and Orsenigo, 2002) in order to study the impact of entry on industry structure and dynamics in various technological and demand conditions. The existence of effects of entry that are context-specific should signal that more effort and attention should be devoted to the modeling of such a process.

In each of the next sections, we start by describing the evolution of the industry under analysis; then we recollect the main features of the corresponding history-friendly model; finally we describe the results of simple experiments involving the entry process.

2. ENTRY IN THE COMPUTER INDUSTRY: THE STRUGGLE BETWEEN INCUMBENT AND NEWCOMERS

The Computer industry[1]

The Computer industry started in the late 1940s boosted by government spending during World War II. Small innovative firms were followed by bigger companies coming from related fields such as the punching-card industry (IBM, Burrows, NCR, Remington Rand) and the electronic industry (Honeywell, GE, RCA). By the mid 50s IBM started gaining advantage over its competitors and in the 1960s it became the leader of the world market. The computers produced in this era were mainframes, that were attractive mostly to large firms and other large-scale organizations that could afford their high costs. One of the major drivers of the evolution of this industry was the sustained technological change in the semiconductor industry, as semiconductors were the most relevant components of a computer. The semiconductor industry experienced the introduction of several new technologies, starting from the invention of the transistor in the 1940s at the Bell Labs up to the introduction of the microprocessor in the early 1970s. The introduction of the transistor occurred when the computer industry was still in its formative stage; its development and application required huge investments in technology and manufacturing capabilities, giving the opportunity of pulling ahead to big firms and in particular to IBM. The introduction of the microprocessor had also a strong impact on the evolution of the industry; the new component technology allowed significant improvements in the performance of mainframes, but it also made possible to create smaller, low-cost computers (personal computers) that were appealing for a completely new

[1] This section draws extensively on Bresnahan and Malerba (1999).

class of customers: small firms and individuals. New firms entered the industry exploiting this technological discontinuity: quite interestingly, they managed to gain a significant share in the new personal computers market, but they were not able to affect the dominant position of IBM in the mainframes market, although the new technology allowed significant improvements also in the older segment.

History-friendly model

Malerba et al. (1999) presented an history-friendly model of the evolution of the Computer industry, aiming at addressing a peculiar challenge raised by this industry. A dominant firm (IBM) emerged very early in the history of the industry and it was able to keep the leadership of the market, although experiencing strong competence-destroying technological change (Tushman and Anderson, 1986). On the other hand, the leader was not able to contrast the entry of new, small and innovative firms in the new market segment that emerged as a result of the technical change.

The model depicts an industry where at the beginning a single component technology is available (the "transistor"); later on, a new component technology (the "microprocessor") emerges in the industry. The two technologies differ along two dimensions: performance and cheapness; in particular, the outer limits on both dimensions are higher in the case of the microprocessor, that is the latter technology has an objectively higher technology potential on both performance and cheapness. These two dimensions provide value for customers: although all users prefer faster and less expensive computers, they differ in the relative importance they give to them. Big firms give much more importance to performance in their purchasing decisions, and can sustain higher costs: therefore they prefer mainframes computers; small users has much lower performance requirements, but they are much more interested in cheapness: they prefer personal computers. The two groups of customers also differ in the minimum requirements that a computer must satisfy in both dimensions in order to consider it for purchasing. Moreover, the first technology (the "transistor") is not able to meet the cheapness minimum requirements of the small users; therefore, this market segment emerges only once the "microprocessor" technology becomes available. Within each segment, the demand is not differentiated: the segments are characterized by an homogeneous demand regime. As for technological regimes, the most relevant element in this industry is the high cumulativeness of technical change within each of the two technologies – firms improve both the performance and the cheapness of their product by investing in Research and Development laboratories, and exploiting learning from experience. Moreover, each firm has its own specific technological trajectory that determines the relative weight that is assigns to improvements in performance *vis-à-vis* cheapness; such a trajectory does not change over time and it is a basic element of firms heterogeneity.

The dynamics of the model is as follows. At the beginning, a number of firms starts R&D spending to explore technological trajectories based on the "transistor" technology; once they meet the minimum requirements by mainframes customers, they start selling products and use their profits to push technological improvements. After a certain number of periods, the "microprocessor" technology enters the stage and new firms start their R&D spending exploiting it. They can aim either at the mainframes segment or at the personal computer segment; but in the former one they have to face the competition by incumbents that are already quite advanced along their technological trajectory. Finally, incumbent firms can also choose to adopt the new technology and to enter the personal computers industry: the adoption decision is triggered by the perceived distance from the frontier of their current technology and by the success of new firms exploiting the "microprocessor" technology; the entry decision can occur only after the adoption process has been completed.

The model is able to replicate most of the relevant dynamics that was actually observed in the computer industry, under different sets of parameters. A dominant firm based on the transistor technology quickly emerges in the mainframes segment, and it is able to keep the leadership even when the new microprocessor technology emerges, exploiting the opportunity of shifting to it. In the other segment, the new firms successfully compete with the diversifying firm that enters after the adoption of the new technology. The model allows also to explore the impact of different characteristics of the industry on the specific historical dynamics: the results show that the lock-in of early customers by the dominant firm is a key driver of the evolution of the industry.

The struggle between incumbents and newcomers

In this section we focus on a different sets of history-divergent (or counterfactuals) simulations with respect to those already analyzed by Malerba et al. (1999). In the baseline model, which is quite respectful of the historical occurrences, the number of firms (*N*) that try to enter the industry by exploiting the initial "transistor" technology is fixed at a low level (6), reflecting the fact that the potential entrants in the new industry were very few, as they came from already mature industries such as punched-card machines and electronics.

The question we address is very simple: was the presence of a limited number of potential entrants at the early stage of the computer industry a key determinant of its following structure and dynamics? In principle we would expect no big change, as the effects of the cumulativeness of technical change, the existence of a homogenous demand and the presence of lock-ins for the customers should not depend on the number of competing firms.

The experiment is run as follows: we study the evolution of the industry for all the values of *N* from 6 (baseline value) up to 100. Moreover, for each value of *N* we generate a set of 100 simulations in order to reduce the impact of random elements.

Figure 1 shows the effects of these changes on the mainframes segment competitive structure: in any given period, the Herfindahl index decreases as *N* increases; the entry of the microprocessor firms has a lower and lower effect on concentration as *N* increases; the Herfindahl shows a steep increase towards the end of the simulation even when N takes its maximum value (100). These results are not really surprising: the existence of more potential entrants decreases the index concentration and the fact that even more firms try to enter with the new technology has a lower impact. On the other hand, as the three key determinants of industry structure (cumulativeness, demand homogeneity, lock-ins) are at work, a dominant firm starts emerging in all cases – potential entrants have only a short-run impact.

More surprising are the results concerning the identity of the dominant firm. The share of the first generation firms (those that enter with the "transistor" technology) in the mainframes segment decreases abruptly when the number of entrants is quite high, leaving room for the newcomers based on the "microprocessor" technology (Figure 2). This is a result obtained by averaging the outcomes of the 100 simulations; therefore, a legitimate question to ask is whether it reflects the actual situation of the industry, or it comes out from the combination of two opposite evolutions of the industry. Figure 3 shows the frequency distribution of the share of first generation firms in the mainframes market in the last period, pooling together all the simulations irrespective of *N*: in each simulation the share of first generation firms is either very high or very low; intermediate values are very rare outcomes. The insights from Figure 1 to 3 signal that there is a high probability of getting a monopolistic structure in the mainframes segment, but the number of potential entrants may strongly affect the probability of success of first generation firms.

In order to deepen our analysis we apply statistical methods to the simulation results. We consider each simulation as an observation and we build a binary variable that takes the value "1" if the share of the first generation firms in the mainframes segment in the last period is higher than 80% and the value "0" if the share is lower than 20%. We drop a small number of observations where the share is between 20% and 80% and all simulations in which either no first generation firm or no second generation firm manage to enter the market – as in this case the outcome is already determined. Therefore, the final number of observations is 90777 out of 95000 – less than 5% are dropped.

Table 1 presents the results of this analysis. In Model 1, we present the baseline model, using only a constant term as a regressor. As the previous discussion suggested an impact of the number of first generation potential entrants (*N*) on our dependent variable, we run our analysis including also *N* in Model 2. The results are quite striking: the new model provides only a limited improvement on the baseline, as it can explain only 29% of the cases that were not correctly predicted by Model 1; moreover, the marginal effect associated to *N* is very low.

In the next step, we consider four more variables that help us to explain the success of incumbents *vis-à-vis* newcomers: the level of concentration in the industry, as measured by the Herfindahl Index (HERF); the distance of the leader firm from the technological frontier (FRONTIER); the distance of the leader firm from the best technological trajectory[2] (TRAJECTORY); the distance of the leader firm from the technological trajectory of its next follower (FOLLOWER). Each of these variables can be measured in each period: we consider here two time-periods that have a particular importance, given the history of the industry and the characteristics of the model. The first measurement is performed in the period when the new “microprocessor” technology emerges and the potential entrants start their R&D activity along the new trajectories opened by this technology. We label this period as POTENTIAL (or P): notice also that it is exogenously determined by a parameter of the model. The second measurement is performed when one of the new firms starts selling its product in the mainframes segment: this period is endogenously determined within the model and therefore can change across simulations. We label it as ENTRY (or E).

Results show that the conditions of the industry when entry of the quickest second generation firm occurs (Model 4) are more important than the situation prevailing when all newcomers started their projects (Model 3) in predicting the outcomes of the industry. Moreover, the full model (Model 5), in which the relevant variables measured at both periods are taken into account, still adds something to the picture.

The results of our analysis are consistent with the following story: newcomers have more possibilities to displace the incumbents if at the

[2] The best technological trajectory is computed from 10000 independent simulations as the mean trajectory of the transistor firm that emerges as leader in the mainframes segment.

time they start their R&D operations and, more importantly, at the time they start selling their product on the mainframes segment, there is lower concentration in the industry (positive sign of HERF) and the emerging leader firm must face several threats: a close competitor within the firms that belong to the first generation (positive sign of FOLLOWER), a technological trajectory which is not perfectly tackled to demand needs (negative sign of TRAJECTORY) and a slow pace of internal technological change that keeps it far from the technological frontier (positive sign of FRONTIER). Quite interestingly, these factors refer to different domains: the competitive structure of industry (HERF), the competitive dynamics (FOLLOWER), the technological environment (FRONTIER) and the demand (TRAJECTORY). If these are the relevant variables, why then did we observe a relation between *N* (the number of first generation potential entrants) and the emergence of leader among the second generation firms? The main point is that at least three of the variables we selected are actually affected by *N*: the concentration has a negative relationship with the number of firms in an industry; there is an higher probability that a strong competitor emerges if the pool on which it can be selected is larger; finally, a tougher competition for a limited amount of resources provides a limit to the technological growth of a leader firm. Even more interestingly, once we take into account all these variables the effect of *N* switches from negative to positive: as newcomers have to face more competitors from the previous generation, there is less room for them in resources and demand space. Moreover, the chances of the first generation firms increase also because the size of this group increases.

So far, the analysis has focused on the characteristics of the first generation firms and their competitive environment. What about the newcomers? Could their characteristics affect the evolution of the industry and the winning technology in the mainframes segment?

Table 2 reports a test to evaluate whether the trajectories of leader firms differ according to their generation. Leader firms of the first generation (incumbents) present a trajectory that resembles quite perfectly mainframes consumer preferences about the minimum threshold for both performance and cheapness: such a trajectory allows them to enter very early and to exploit profits to foster continuous technological improvement. This is a clear example of first-mover advantage arising from technological leadership (Lieberman and Montgomery, 1988). If such an advantage is hampered by the conditions highlighted in our previous analysis, new entrants can catch up incumbents and become leader of the market. It is then a legitimate question to ask whether the strategy employed by the first generation firms is still a successful one for newcomers. The answer is negative: in this case, the trajectory or entry strategy that characterizes the new leaders has nothing to do with early entry, but we should rather label it as "right" entry. Successful newcomers provide a high-performance product, even if at higher price than competitors, exploiting the fact that consumers in mainframes have a high willingness to pay for improvements in performance.

3. ENTRY IN THE COMPUTER INDUSTRY: THE ROLE OF SUPPLIERS

The coevolution of the Computer and the Semiconductor industries[3]

In the depiction of the evolution of the computer industry we drew in the previous section, we highlighted the importance of technological discontinuities arising in the semiconductor industry. Here we add some more details to that picture, by focusing on the choice faced by computer firms between internal development and external sourcing of the key electronic components. The first major discontinuity in the electronic components was related to the invention of the transistor in the late 1940s; before this date, and therefore at very early stage of the computer industry, the main electronic components were *vacuum tubes*, and computer firms bought them from existing producers. The introduction of the transistor technology generated a differentiation in the industry: some of the biggest firms (including IBM) pursued a vertical integration strategy and started producing the components by themselves; most of the smaller firms kept relying on the open market. The second discontinuity was the introduction of the integrated circuits by Fairchild at the turn of the 1960s[4]. IBM, that was already the world leading firm in the computer industry, chose again the vertical integration strategy: both because of the benefits associated with the possibility of better integrating the electronic components with the other elements of the computer; and also in order to avoid the risks associated to collaboration (information and technology leaks) and to external sourcing (shortage of components). New

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[3] This section draws extensively on Bresnahan and Malerba (1999) and Langlois and Steinmueller (1999).

[4] We did not highlight the integrated circuits discontinuity in the previous section as it had only a limited impact on the structure of the industry.

firms tried to enter the mainframes market exploiting the new technology, but they were not successful. The third major discontinuity was the introduction of the microprocessor in the early 1970s: as we mentioned before, this had no impact on the structure of the mainframes segment, but it allowed to open up the new personal computer segment. As to vertical integration, the reaction of IBM to this discontinuity marked a shift in its strategy: as a technologically advanced leader (Intel) quickly emerged in the semiconductors field, exploiting a growing demand not only from the computer industry, but also from other fields (consumers electronics, telecommunications, automobiles), IBM chose to rely on it both for the production of mainframes and for its entry on the personal computer segment.

History-friendly model

This section summarizes the main features of the history-friendly model developed by Malerba et al. (2008) to analyze the relationship of the computer industry firms with the suppliers of the key electronics components. Many elements of the model are similar to what has been presented in the previous section: we will briefly recall them and then we will focus on the novelties of this setting. There are two main segments in the computer industry: the “mainframes”, whose buyers prefer performance to cheapness, and the “personal computers”, whose buyers have opposite preferences. The production of “personal computers” is feasible only after microprocessors have been introduced. In this model, firms cannot choose different technological trajectories: each segment requires a specific and unique combination of performance and cheapness, and a firm must choose it when it starts its production. Still, there are two sources of firms heterogeneity in the model: the path-dependent process of learning and technological change; and the quality of the supplier of the component technology – or of internally developed product, in the case of a vertically integrated firm. The semiconductor industry is characterized by the emergence of different technologies over time: at the beginning, the dominant technology is the "transistor"; after a certain number of period, a superior technology – the "integrated circuit" – is introduced; finally, a third and still better technology – the "microprocessor" – emerges in the components industry. The new technology is always introduced on the market by a new cohort of supplier firms. At the beginning, computer firms are not vertically integrated and they choose a supplier among existing semiconductor firms; once the contract expires, they can either switch to a new supplier choose to vertically integrate and produce the electronic components by themselves. The higher the quality of a semiconductor product, the higher the probability it will be selected by a computer firm that is searching for a supplier. The choice of vertical integration or specialization is not symmetric: when a firm is integrated, it can compare the internally developed product with the best one available on the market. As this is not possible for a non-integrated firm, its choice depends on two observables: its size and the size of the biggest independent components producer.

The model replicates again the results of the previous one, as to the evolution of concentration in the mainframes and personal computer segment. It also generates results consistent with the historical records in terms of concentration in the components market and of integration in the computer industry. The counterfactual analysis shows the importance of customer lock-ins and demand outside the computer industry for the evolution of the semiconductor industry, but also for the dynamics of integration within the computer industry.

The entry experiment

The first experiment of this section is analogous to what we performed with respect to the previous model. The parameter of interest is again the number of firms (*N*) that try to enter the mainframes segment.

Figure 4 shows the results of a such an experiment. We observe three predictable short-run outcomes: 1) a non-linear increase in concentration over time in the mainframes segment when many firms enter – the rise is very steep with less than 10 firms, becomes smoother between 10 and 30 and then does not change anymore from 30 to 80 firms (Panel A); 2) an higher integration ratio in the mainframes segment when few firms enter, due to the increase of firms' average size (Panel C:); 3) an increase in the number of surviving firms in the components industry when many mainframes firms enter, as they generate higher demand for components (Panel D). Apparently, there is no big change in the long-period outcomes of the model: monopoly seems to be the destiny of the mainframes industry, whatever the number of initial firms (Panel B).

Still, a more careful inspection of the data shows that the Herfindahl Index does not take exactly the value 1 when the number of entrants is high: as in the previous section, this is an average across different simulations. Therefore, this outcome might be due either to the persistence of an imbalanced oligopoly or to the presence of two different regimes, monopoly and competition. An interesting variable to consider is the number of periods that elapse before a monopoly emerges in a single simulation. Figure 5 shows the frequency distribution of this variable: the most striking feature is the peak at period 250 (the last period), which signals the presence of censoring, that is of simulations that never reach the monopoly outcome. Moreover, Figure 6 shows how these censored outcomes are distributed across *N*: the probability of getting into a monopoly is 1 when the initial number of firms is lower than 20; it decreases as *N* shifts from 20 to 40; and it keeps constant for higher values of *N*.

In this model, monopoly occurs as soon as one of the firm in the mainframes segment takes the leadership in both components and systems, and gets a market share that allows a take-off due to the power of the consumers lock-ins. When there are more firms the initial market share of each of them is lower: therefore, more time is needed for the lock-ins to display all their overwhelming power. When *N* becomes greater than 40 we observe a stabilization in the time required to get a monopoly: a high number of firms just gets a very low expected market share, that determines their early exit from the market and brings the industry back to the case with a lower number of firms. Why, then, we do observe simulations that do not end in a monopoly? And why this happens only when *N* is a higher than a specific threshold? Figure 7 suggests that such an outcome is triggered by the evolution of the components market: if we run simulations in which only the integrated circuit discontinuity emerges, a monopoly emerges with probability 1 by period 350; on the contrary, if we run simulations in which only the microprocessor technology emerges, then in the 1.5% of the cases there is still strong competition at period 1000 (Figure 8).

A potential explanation of this outcome relates the sustained competition in the mainframes segment to the emergence of a monopoly in the upstream sector, that would guarantee that no difference among computers producers is due to quality differences in the semiconductors. This might be particularly relevant in the microprocessor era, when the importance and the quality of semiconductor components overwhelms that of other elements of the computer. Such an outcome resembles what happened in the late evolution of the computer industry, especially in the personal computer segment: the emergence of a strong leader in the component market (Intel) and the growing relevance of a key component (the microprocessor) as compared to other components and the assembly in determining the overall quality of a computer.

In the next sections we try to show that this story is an accurate description of the actual model dynamics; moreover, we also present some conditions under which similar results can emerge also in presence of a less radical discontinuity, such as the introduction of the integrated circuits.

The effects of timing of entry

The most natural deepening of the previous analysis consists in changing not only the number of entrants, but also the time of their entry (*T*). Given a technological regime characterized by high cumulativeness of technical change, this analysis requires a preliminary assumption regarding the technological characteristics of entrants in each time period: all new firms are assumed to be specialized producers of computers (that is, they are not vertically integrated) and are required to choose their supplier as incumbent firms do; moreover, the technological level of entrants is in line with the public knowledge in the industry[5].

We let new firms enter from period 1 to period 150, in order to cover all three technological eras (transistors, integrated circuits, microprocessors).

[5] Therefore, we rule out some alternative possibilities: entry of big firms from related markets, that could have chosen vertical integration as entry strategy; or also the possibility of spin-offs from the best firms, that should have a technological level higher than the average. Actually, these cases have been separately investigated, and they did not generate any other insight on top of what we present here.

For any value of *T*, we also let *N* change again as in the previous experiment; and for each combination (*T*,*N*) we run 100 simulations.

We focus our analysis on the outcomes of the entry process at period T+100, in order to allow a proper time to display its effects. The main results are summarized in Figure 9: it shows the number of firms that are still alive (Panel A) and the probability of survival of a newcomer (Panel B), as a function of both *N* and *T*. A striking feature is the non-linear effect of the parameters on the both variables.

We can also distinguish quite clearly the three technological eras. Let us start from the "transistor" technology era. When the number of entrants is low, newcomers can exploit the level of public knowledge in order to gain an advantage over the incumbents (bottom corner of Panel B). In any case, the structure of the industry is still a monopoly: the identity of the winner is at stake (bottom corner of Panel A). As the number of entrants increases, for each of them the probability of being the winner decreases, but the structure of industry starts changing, allowing the survival of more than one firm. Therefore, the survival probability of a firm first increases and then decreases with *N*, resembling quite closely the outcomes of population ecology models.

If we jump to the last era (the "microprocessor" technology era), we observe a similar pattern, despite a big context difference: in fact, when entry occurs late, newcomers face established oligopolies and monopolies that must be eradicated in order to get a chance to survive. A strong technological discontinuity (such as the introduction of microprocessors) gives the possibility of competing with established firms only if coupled with an high number of entrants (right-hand corner of both panels).

What if the discontinuity is weaker? An higher number of firms is required to trigger competition and the change in the industry structure is less pronounced, but the pattern is similar.

Once more, these results suggest that the dynamics in the semiconductor industry affects the structure of the downstream computer industry. In the next section we try to clarify the features of this relationship.

The role of suppliers

We focus again on the second era, characterized by the "integrated circuit" discontinuity, as here the effect of suppliers on the computer industry seems to be weaker: if we find evidence of such a relationship in this context, then it should also holds in the other cases.

We start by pooling together all the simulations, irrespective of the value of *N* and *T* (provided that entry occurs in the "integrated circuit" era). Then, we classify them according to the number of component firms that were still alive (and could be chosen as suppliers) when the entry of new computer firms occurred (that is, at period *T*). Finally, within each of these categories we compute the average number of surviving newcomers at period *T* + 100; in Figure 10 we plot the resulting values against the categories. First of all, we notice that computer firms cannot survive if no supplier is available: in fact, they would miss a key component, as they do not have the capability of vertically integrate. On the other hand, the highest number of surviving firms comes out when there is only one supplier; moreover, survival quickly declines as the number of suppliers increase. In the first experiment related to this model, we ruled out the possibility that integrated circuits could be a strong enough discontinuity to generate sustained competition; this result was obtained only in the case of microprocessors. Therefore, here we need a different explanation:

the presence of few or even one big firm in the component market allows the pooling of resources of small computer firms, that can be devoted to R&D in the semiconductors field; this cancels out the size advantage of the incumbent. When there are many suppliers, these resources are split in several, smaller research projects that cannot keep up with vertically integrated computer firms.

The determinants of the downstream industry structure

In this section we validate the explanations we proposed for the findings of the previous sections by applying statistical methods to the simulation results. The simplest distinction we can draw in terms of market structure is whether the industry ends or not in a monopoly: therefore we classify each simulation according to this type of outcome. Figure 11 shows the number of simulations that do end in a monopoly by period T + 100 as a function of both N and T. A complex pattern of interaction emerges: a small number of entrants always leads to a monopoly; the effects of a larger number of entrants depend on their time of entry. Moreover, an interesting question to ask is what are the determinants of monopoly once we keep constant both N and T.

We consider in our econometric analysis both the "integrated circuit" and the "microprocessor" eras, but we run two separate regressions in order to allow for the possibility of structural changes of the parameters. Again, the unit of analysis is the simulation; we define as our dependent variable a dummy that takes value "1" if the computer industry is a monopoly at period T + 100, and value "0" otherwise (Table 3).

As in the analysis of the previous model, we select as explanatory variables the parameters (N and T) and some variables that characterize the evolution of the industry within each simulation; they include: proxies for the industry turbulence in the “integrate circuit” and the “microprocessor” eras (TURBULENCE_IC and TURBULENCE_MP); a dummy variable that takes value “1” if there is already a monopoly in the computer industry at time T (MONOPOLY: this variable is dropped in Panel B regressions, as it takes always the value “1” if entry occurs in the “microprocessor” era); the technological level of the best performing entrant (BEST); the market share captured by all entrants at period *T* (SHARE_ENTRY) and the average market share captured by them in the following 10 periods (SHARE_AVERAGE); the level of concentration in the components market at period *T* (SUPPLIERS: we use the Herfindahl index, where a “0” indicates that no supplier exists).

The first result is consistent with the econometric outcomes about the previous model: the two parameters *N* and *T* (Model 2) perform even worse than the baseline model with the constant alone (Model 1) and do not add really much to the full model (Model 3 versus Model 4). Moreover, the full model (Model 4) has a very good explanatory power both in absolute (over 95% of the cases are correctly predicted) and in relative terms (over 85 % of cases not explained by the baseline model are correctly predicted). Together, these results (that hold for both technological eras) tell us that the explanatory variables we consider in the full model capture the main mechanisms that determine the structure of the industry and that the two entry parameters (*N* and *T*) are relevant only as far as they affect these key variables.

What about the effects of the explanatory variables? Both the variables related to the market share captured by entrants have a strong negative effect on the probability of ending in a monopoly, but entry conditions are more important than the following evolution. They signal the existence of a “global competition” effect: the market share of a firm depends also on the value of the products of all other firms, and when there are more firms and products it becomes more difficult to capture the market. This would explain why on average there is an higher probability of observing a monopoly when *N* is low.

An alternative explanation would focus on the quality of the entrants rather than on their number: it could well be that it is the presence of a very good performing firm that makes possible the displacement of monopoly, opening up the market to the emergence of competition. An higher number of entrants would just increase the probability that such a firm actually enters the market. The size of the marginal effects of BEST clarifies that this effect is by far less important than the previous one: what really matters is the sum of the quality of all entrants, not the quality of the best among them.

The presence of an established monopoly when entry occurs clearly makes more difficult the emergence of sustained competition (positive sign of MONOPOLY in Panel A); on the other hand, an higher market turbulence has the opposite effect.

So, we can go back to the variable that motivated our analysis: the concentration in the components market. As expected, in the integrated circuit era (Panel A) the variable has a negative marginal effect on the probability of getting a monopoly. Moreover, if we compute the average marginal effect of concentration in the suppliers market for each level of entrants in the computer industry, we observe that it is negligible when the number of entrants is small and it becomes stronger and stronger as entrants become more and more (Figure 12). This is coherent with the explanation we provided in the previous sections: if the competition in the computer industry is sustained by the possibility for the component firms of aggregating the resources of the newcomers in the downstream sector, than we should find (and we actually find) that when the are more entrants, more financial resources can sustain faster innovation by the semiconductor firms, and therefore we observe a more competitive environment in the computer industry.

On the contrary, the marginal effect of the concentration in the components industry has a positive sign in the microprocessor age, that is the concentration in the upstream market favors the emergence of monopoly also in the downstream market (Panel B). Moreover, this effect is stronger in presence of an intermediate number of entrants (Figure 13). Although apparently surprising, this result is consistent with the explanation we put forth after the first experiment. In the microprocessor age, the components technology jumps on a level of quality that is much higher than in the past; moreover, this increases its importance vis-à-vis the performance of all the other elements of a computer. These characteristics lead the incumbent to vertical disintegration and favor the emergence of competition in the computer industry. On the other hand, an higher concentration in the components market actually helps the incumbent to choose a good supplier (the one that will dominate the market) and deprives the entrants of a core advantage, the availability of better components.

The role of the exit rule

All the results we presented so far related to the model by Malerba et al. (2008) are based on a slight modification of the model: a change in the market share threshold that determines the exit of firms from the industry. In this model, the number of firms that can survive is strictly determined by the following exit rule:

$$Exit_{i,t} = true\ if\ LagSh_{i,t} < E_{TH}$$

where $LagSh_{i,t} = (1-\alpha) \cdot LagSh_{i,t-1} + \alpha \cdot Sh_{i,t}$, $Sh_{i,t}$ is the market share of firm i at period t and α is a parameter. The initial value of the lagged share is equal to 1/*N*. The initial value of the market share depends on the R&D process of the firm: roughly speaking, it can be described as a random variable with a mean equal to 1/*N* and a variance which is a function of the variance of R&D processes and of the number of available suppliers. Then, for any given value of the exit threshold, the probability of exiting at the very first period increases with the number of firms and there exists a sufficiently low variance that ensures the exit of all firms at the first period if 1/*N* is lower than E_{TH}. The set of parameters that is used in Malerba et al. (2008) generates the zero-firms trivial equilibrium anytime *N* has a value higher than 20. Therefore, to carry out the previous analysis we reduced the value of the exit threshold to a level that would allow the survival at entry of about 100 firms and we limited *N* to the value of 80.

The interesting element of this story is that none of the effects that we highlighted emerges if we keep the original set of parameters of the model. Somehow, the idea that tougher competition and stricter selection rules reduce the number of firms that can survive is not completely new in the industrial organization literature. On the other hand, we could also consider the change in the exit threshold as a decrease of endogenous fixed costs, which should generate an increase in the number of firms that can survive in the industry. The new element is given by the fact that the changes in entry and exit characteristics have a stronger or weaker effect according to the current evolution of the industry. There are some moments in the history of the industry in which even a weaker selection rule or a sustained entry process have a small impact on its structure; in other moments, instead, small differences in the processes of entry and exit might be of the utmost importance. Moreover, it could be very important to consider entry and exit as related processes: new firms not only need to enter markets but must also survive within them in order to trigger changes.

4. ENTRY IN THE PHARMACEUTICAL INDUSTRY

The Pharmaceutical industry[6]

The Pharmaceutical industry is by far much older than the computer and the semiconductor industry. The production and the use of drugs goes back to the ancient world; mass-production started in the early 19th century, but the origin of the modern pharmaceutical industry are strictly linked to the development of the organic chemistry and the emergence of the synthetic dye industry. Two further steps marked the evolution of the sector and contributed to the creation of the pharmaceutical industry as we know it today. First, the strong need for antibiotics during World War II pushed US government to large-scale investments in R&D that involved both universities and large companies. This effort led to the development of efficient processes for the production of penicillin; moreover, it created in the industry both the awareness of the profitability of new drug development and the organizational and technical capabilities required to successfully manage these complex processes. The second landmark has been the molecular biology revolution: the discovery of the structure of DNA, coupled with several advances in different branches of medicine and biology, offered the researchers the possibility of understanding the mechanisms through which a drug operated. Therefore, this revolution marked the shift from a “random” process of drug research and development to a “rational design”.

[6] This section draws extensively on Henderson, Orsenigo and Pisano (1999).

The Pharmaceutical industry is characterized by a very peculiar institutional environment. The industry is highly regulated: the commercialization of a new drug requires several years of development and tests, aimed to reduce and eliminate harmful side effects. Moreover, the profitability of the industry depends heavily on the patent system, that provides incentives to undertake R&D processes that are more costly and risky than in other sectors, as the institutional elements add to the inherent uncertainty that characterizes innovation.
The industry structure has been clearly affected by the specific features of the institutional and innovation environment. Entry has been a very rare occurrence between World War II and the advent of the biotechnology revolution, in spite of the high profitability of the industry: the intellectual property rights system, the lack of significant spillovers and the tacit nature of the relevant organizational capabilities contributed to protect the advantage of incumbent firms, that had entered the industry before the explosion of R&D expenditures. Still, the concentration has been relatively low in the industry as a whole; higher levels of concentration have been observed within each therapeutic area.

History-friendly model

The Pharma industry poses some interesting challenges for history-friendly modeling. Given the richness and the importance of the institutional environment, it seems an ideal setting for this type of models; on the other hand, it becomes also much more difficult to highlight the relevant elements that played the most important role in the evolution of the industry. Although Malerba and Orsenigo (2002) consider both the "random screening" and the "rational design" eras, here we focus only on the former. In terms of technological regimes, at that time the pharmaceutical industry was characterized by an high level of innovation opportunities (there were still many compounds to be found), an intermediate level of appropriability (due to the enforcement of the IPR system) and a low level of cumulativeness of technical change (finding a new drug today did not increase the probability of finding a new one tomorrow). On the demand side, the industry was characterized by an high level of (horizontal) fragmentation: consumers needs were highly differentiated and it was impossible for them to substitute a drug in a certain therapeutic area with any other drug. These elements are thoroughly replicated in the model: firms invest in R&D in order to find a new molecule in the space; if the compound is promising, it is patented and the firms starts a risky development process. If the drug gets through all the tests, it can be commercialized; the corresponding profits are invested in further research. After a certain number of periods, patents expire: although any firm can start producing the compound associated to an expired patent, there are some firms that have an higher propensity to imitation. On the demand side, any drug has value only for the customers in a given therapeutic area; therapeutic areas are heterogeneous in terms of both size and potential drugs opportunities.

The entry experiment

As in the case of the previous models, we start our analysis by changing the number of firms that can enter the industry (*N*). Here, though, it is important to underline the distinction between this number, that refers to potential entrants, and the number of actual entrants, as there are many firms that find and develop compounds that do not make all the way to the commercialization; therefore there can be an high mismatch between *N* and the number of firms actually competing in the industry.

The exit rule is based again on market share threshold, but the value of the standard set of parameters allows the survival of no more than 250 firms all together. An interesting question to ask is whether and to what extent the number of entrants increases with N: we would expect a steady increase until *N* approaches the threshold level. Figure 14 shows that there is actually an increase, but it not steady at all: when N is at value of 300, the number of entrants is still far from the threshold. Moreover, the figure also suggests that a strong selection process is under way: at the beginning an high number of firms enters the industry – and in this case the impact of *N* is much stronger. The analysis of the dynamics of entry and exit sheds more light on this selection process. Consider two extreme cases: one with a low number of potential entrants (*N* = 50) and the other one with an high number of potential entrants (*N* = 600). While gross entry rate is generally higher in the latter case, the pattern is reversed in the case of net entry: actually, net entry rates are almost always negative when there are many potential entrants (Figure 15). This signals that the industry is characterized by the existence of a revolving door: many firms try to enter, but they are pushed out of the market very quickly.

Then, a second question to ask – again as in the case of the previous models – is about the identity of the surviving firms: what are the specific features that give them an advantage? Figure 16 shows the survival rate by cohort of entry – where entry refers to the period in which the firm commercializes its first product: in low *N* case, there is a clear advantage for early entrants, that quickly decreases with entry timing; in the high *N* case, there is a wider range of cohorts enjoying a smaller advantage. If we aggregate the data, we can distinguish five groups of entrants according to the entry timing: early movers (entry in the first two periods), early followers (entry in the next three periods), followers (entry from early followers until imitation becomes feasible), imitators (entry in the next 5 periods from the expiration of the first patent), late entrants (all other entrants). Table 4 shows a clear disadvantage of imitators and late entrants in both low *N* and high *N* cases: only about 1% of these firms survives. On the other hand, when there are only few potential entrants even a small difference in the time of entry generates a huge advantage for early movers; as the number of potential entrants increases, entry timing seems to matter less – provided that entry does not occur through imitation. In fact, imitators can command a low price, which usually does not compensate the costs they must sustain to undertake all the development process – although they are lower than in the case of a proper innovation. As for late innovative entrants, they find a crowded market and a very limited amount of new opportunities. These conditions are true irrespective of the value of N. Instead, early movers enjoy an advantage due to the monopoly power granted by the IPR systems and the lack of competing products; moreover, they can also preempt the technology space by massively investing in R&D their monopolistic profits when the level of innovation opportunities is still very high, in order to gain the supremacy over the most valuable therapeutic areas. As the number of potential entrants increases, early movers face lower monopolistic opportunities and therefore their advantage towards followers decreases.

Entry and the appropriability regime

The results emerging from the previous section suggest that the appropriability regime and the possibility of imitating existing drugs once patents expire play a role in determining the survival of firms. A legitimate question that arises, then, is whether there is also an effect of imitation on the structure and dynamics of the industry.

Consider an extreme case, where the IPR system is so strict that patents never expire; here competition is still possible, but only because in a therapeutic area there could be unrelated drugs to be discovered.

In such a case the number of surviving firms declines over time at a decreasing rate, and then stabilizes. When imitation is possible, instead, the peak of entry by imitators is followed by a strong shakeout that leads to a permanent reduction in the number of surviving firms (Figure 17). What are the firms that are driven out in this process? They could be either mostly incumbents, leaving room to the newcomers; or the imitating firms, dragging out the weakest incumbents.

Panel B of Table 4 shows the survival rates of the same groups of entrants we considered before: here "imitators" are the firms that enter when patents would have expired in the case of a weaker IPR system. Panel C shows the difference between the values of Panel B and Panel A. The firms gaining from patent expiration are not the imitators but the innovative followers – especially when there are many potential entrants. In fact, most imitators enter as soon as imitation becomes feasible, that is when the patents of early movers expire. Therefore, early movers face also an early intense competition that can drive them out of the industry, especially if they do not exploit the advantage granted by the initial monopoly power.

The appropriablity regime interacts also with entry in determining an important feature of the surviving firms. Figure 18 shows the evolution of the average propensity to innovation of firms in the industry: in the low N case the negative peak in this propensity due to entry of the imitating firms has no long-lasting effects; in the high N case, instead, firms that have a very high propensity to innovation are driven out of the market by the imitators, and this determines a loss in the industry potential for innovation. In fact, when there are many potential entrants, competition is tougher and innovation does not guarantee anymore the possibility of exploiting monopoly power: the costs of innovative research projects are too high with respect to expected returns and therefore the firms undertaking them are doomed to fail.

5. DISCUSSION AND CONCLUSIONS

The exercise conducted in this study aimed at shedding light on the role played by entry in shaping industrial structure and dynamics in different sectoral environments. The differences between the sectors can be effectively classified by exploiting the concepts of technological regimes (Breschi et al., 2000) and demand regimes (Dosi and Nelson, 2009). The computer industry showed an high cumulativeness of technical change coupled with an homogeneous demand – at least within the mainframes segment, which has been the focus of our analysis. The pharmaceutical industry, instead, had quite opposite features: no cumulativeness of technical change, and a very fragmented demand. Moreover, the appropriability regimes also played a very important role.

Quite surprisingly, the two sectors share some characteristics; in both cases, in fact, early movers enjoy an advantage over later entrants – a results that is well known in the literature (Lieberman and Montgomery, 1988; Suarez and Lanzolla, 2007). The mechanisms behind such an outcome, still, are quite different. In the computer industry, entry timing advantages arise from the cumulativeness of knowledge: firms that enter the industry very soon are able to become leaders in the technology development. Moreover, a monopolistic industry structure soon emerges: the leader is able to kick out of the market all the competitors. Our experiment on entry shows that later entrants have an opportunity to challenge the incumbent monopolist by exploiting a technological discontinuity: their chances of success heavily depend on industry conditions and incumbent behavior at the moment of their entry, as well as on their ability to address in a better way consumers needs – a result that is not far from what is typically labeled as disruptive innovation (Christensen, 1997; Tushman and Anderson, 1990).

In the pharmaceutical industry, instead, the early mover advantage is based on a different mechanism: the preemption of the technology and demand space. Once they are granted a patent on a valuable drug, firms can exploit their monopolistic profits to fund R&D expenditures aimed at discovering new products and new valuable therapeutic areas: this is strong a self-reinforcement mechanism that leaves out of the market both later entrants and imitating firms – as none of them can enjoy the monopoly profits. The appropriability regime, though, can have an heavy impact on which firms, among the early movers, has the strongest advantage. When the enforcement of the IPR systems is very strict, even just one period can make the difference for survival: therefore, entry as soon as possible is of the utmost importance. On the other hand, when imitation is possible, first movers are also the first target for imitating firms: therefore their advantage is somehow neutralized. This effect is even stronger when there are many potential entrants: in fact, in such a case first movers have a lower probability to enjoy monopolistic profits, as even in the early periods they must face an high number of competitors.

Clearly, the results regarding the appropriability regime should be carefully handled, as in our experiments entry is an exogenous process:

recent evidence shows the importance of firms reaction to environment challenges in their choices about the type and the timing of entry (Ethiraj and Zhu, 2008) and in their patenting behavior (Ceccagnoli, 2009).
The model developed by Malerba et al. (2008) takes a different perspective, as it focuses on the issue of vertical relations between sectors rather than technological and demand regimes. As it might be expected, the characteristics of a sector have an impact on the evolution of a related industry: for example, the emergence of a radically new component technology can sustain competition in the downstream industry for a very long time even in presence of cumulativeness of technical change, if the new component is an important source of value for consumers. Two more results emerge from our analysis, that highlight the strong interdependence between the entry processes in the two sectors, the introduction of radical innovations and the competitive dynamics of the industries: first, if the new component technology is not radical, new firms in the downstream industry can exploit it to displace incumbents – and even a monopolist – if the upstream industry is more concentrated: the existence of a limited number of suppliers determines an involuntary coordination of R&D resources between the new small firms, and allows them to compete with bigger, vertically integrated firms; second, the concentration in the upstream industry may be harmful to new firms in the downstream industry if the new technology is so radical that even incumbent firms prefer vertical disintegration: the existence of a limited number of suppliers allows the incumbents to find with an high probability the "right" supplier. Therefore, the structure of the upstream industry may have pro-competitive or anti-competitive effects on the downstream industry according to the characteristics of the innovations that is introduced: an important difference between our findings and the existing

literature – consider for example the distinction between competence-enhancing and competence-destroying innovation (Tushman and Anderson, 1986) – lies in the fact that here a more radical innovation has anti-competitive effects and favors the incumbent against the new firms.
The last element to highlight is the role of the exit rules and the interaction between entry and exit. Our findings show that entry might not matter at all if the selection rules are very though: new entrants, in fact, might not have the possibility of challenging the incumbents by building a customer base, by accumulating knowledge or by searching the technology space. Even in the context of endogenous fixed costs – which is the case with a market share exit rule – reducing the requirements for survival may create an environment in which entrants may express fully their potential.

On the whole, our findings confirm the idea that motivated this study: entry matters, but it matters in a different way in different sectoral contexts. The different impact of entry can be ascribed to differences in the technological elements (as technological regimes or technological discontinuities), in the demand elements (as demand fragmentation or demand lock-ins), in the dynamics of related sectors or even in the strength of selection rules.
The results presented in this work have been obtained by simply changing the number of potential entrants in an industry, exploiting existing history-friendly models. Future work should clearly extend this analysis to different classes of models, starting from the evolutionary economics family. In particular, it would be necessary to build a more general model that explicitly considers the technological and demand environments, and it is able to replicate the evolution of different industries without imposing strong structural assumptions. The analysis, moreover, should not be

limited to exogenous changes in the number of entrants, but should also move to consider endogenous entry. While the latter challenge goes beyond the scope of this thesis, we develop a general evolutionary model in the next chapter and we apply it to an issue that has emerged here in different settings: entry timing advantages.

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FIGURES

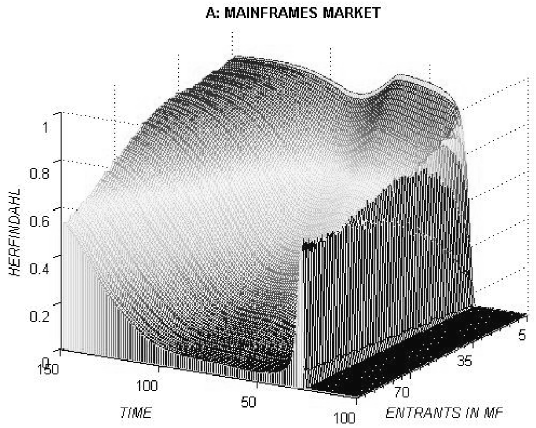


Figure 1
'ects of the changes of *N* on the Herfindahl Index over time in the mainframes segment.

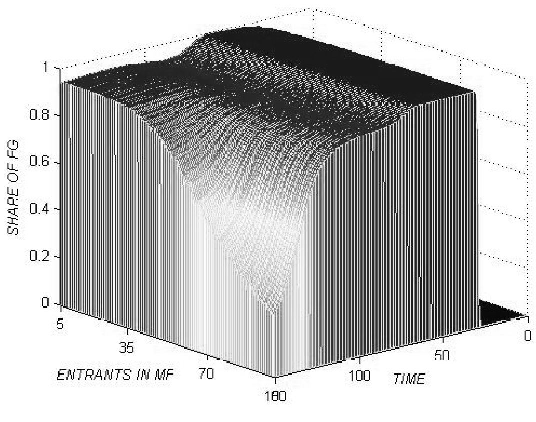


Figure 2
ıare of first generation firms in the mainframes segment over time as a function of N.

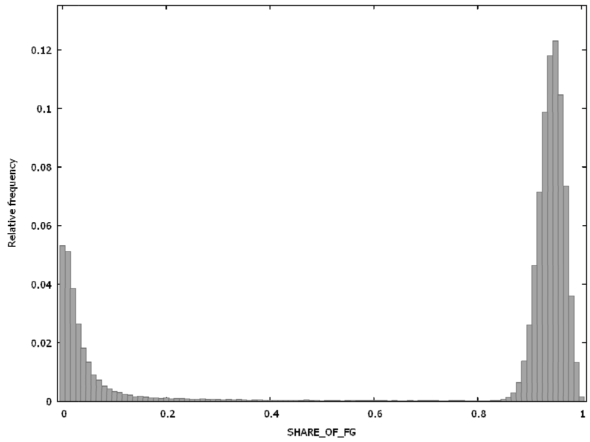
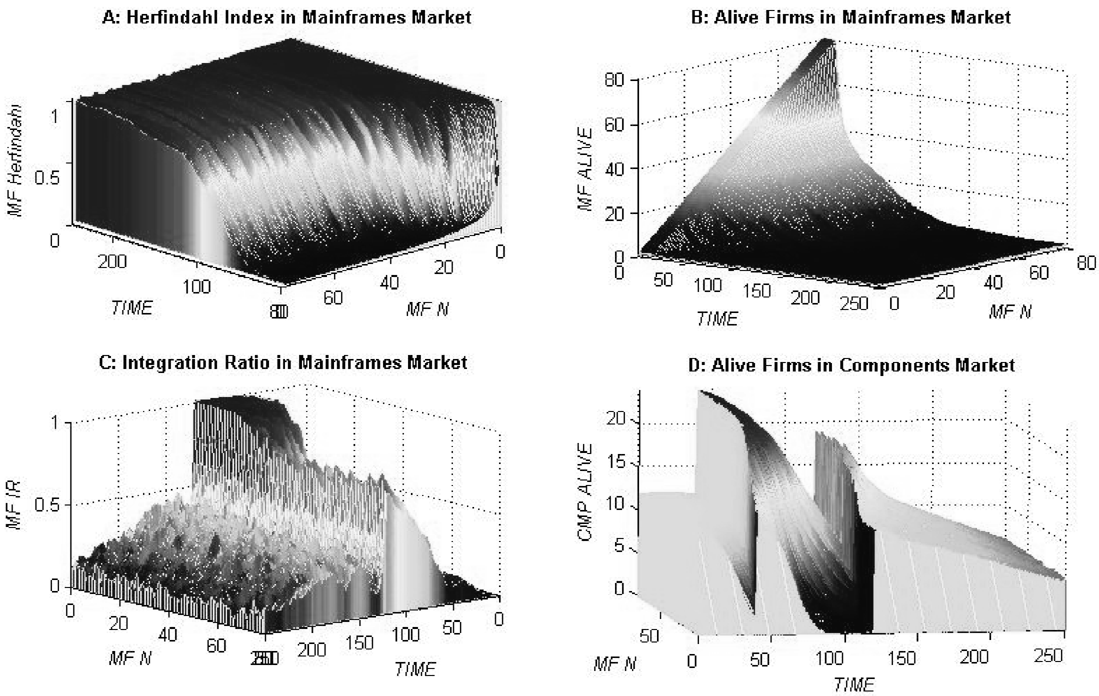
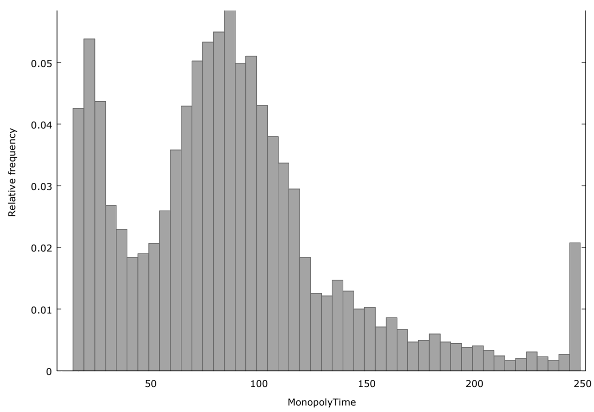


Figure 3
frequency distribution of the share of
the first generation firms at the end of simulation.


A: Herfindahl Index in Mainframes Market
MF Herfindahl
TIME
MF N
B: Alive Firms in Mainframes Market
MF ALIVE
TIME
MF N
C: Integration Ratio in Mainframes Market
MF IR
MF N
TIME
D: Alive Firms in Components Market
CMP ALIVE
MF N
TIME


Relative frequency
MonopolyTime

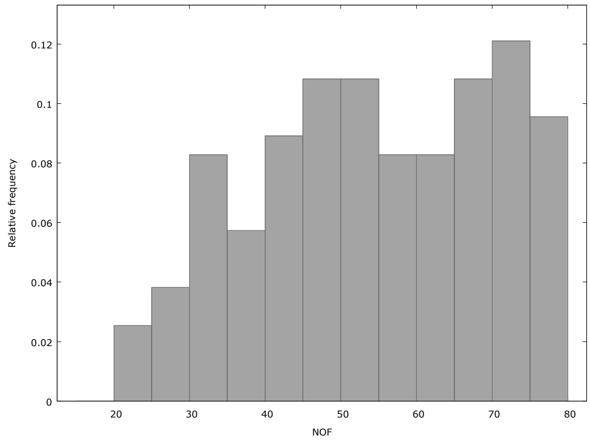


Figure 6
frequency distribution of N
when monopoly does not emerge

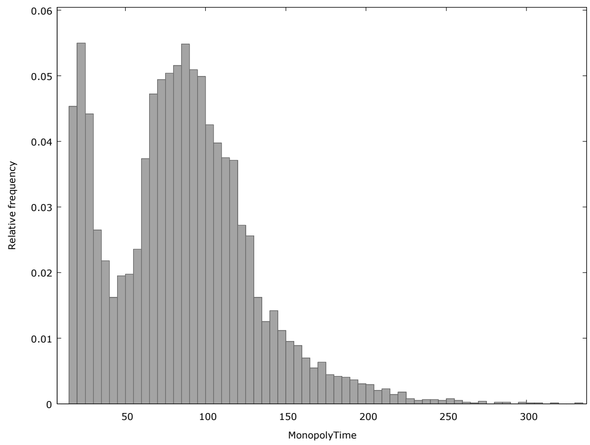
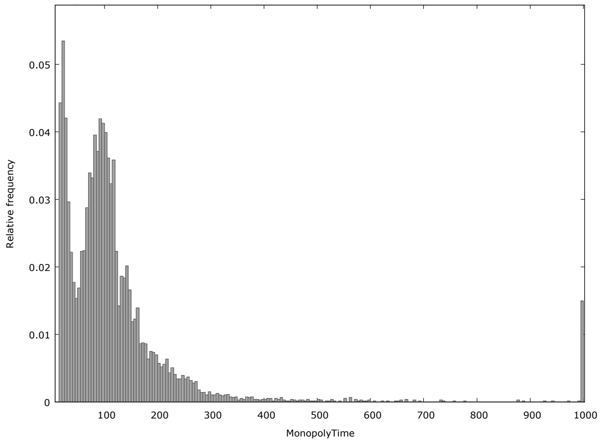
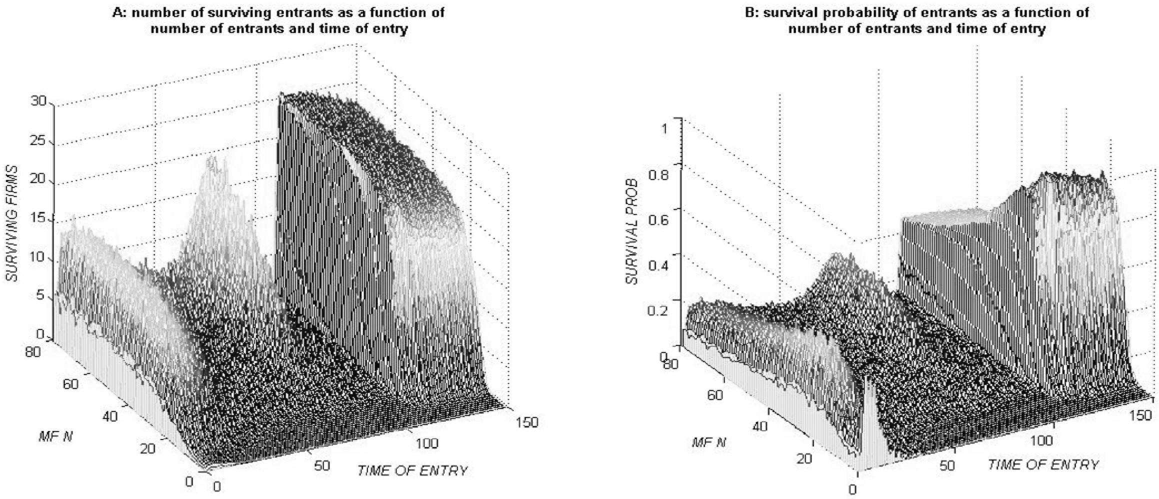
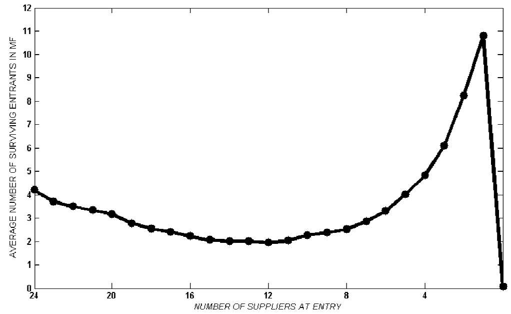
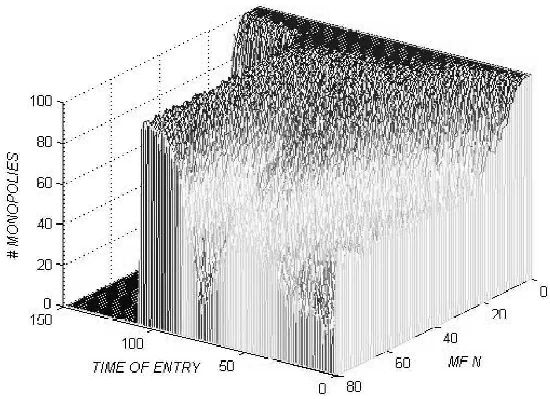


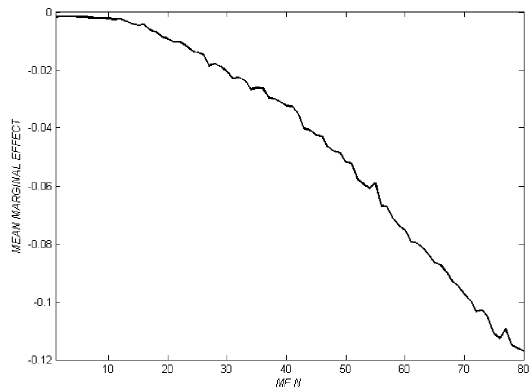
Figure 7
frequency distribution of the number of periods
by which a monopoly emerges
only integrated circuits

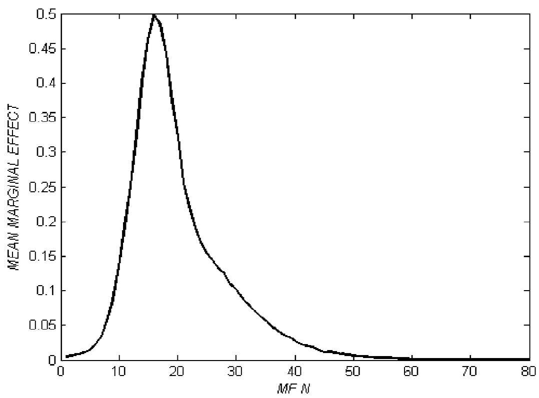

Relative frequency
MonopolyTime

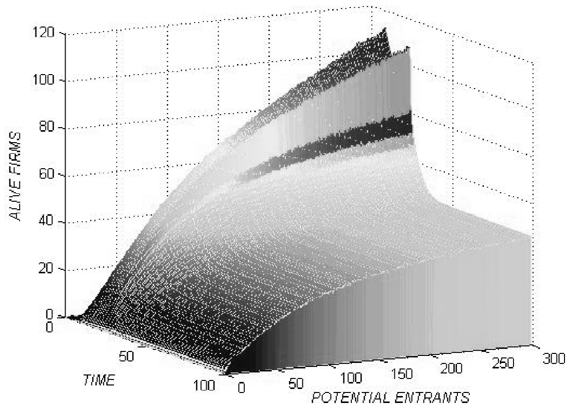

A: number of surviving entrants as a function of number of entrants and time of entry
SURVIVING FIRMS
MF N
TIME OF ENTRY
B: survival probability of entrants as a function of number of entrants and time of entry
SURVIVAL PROB
MF N
TIME OF ENTRY

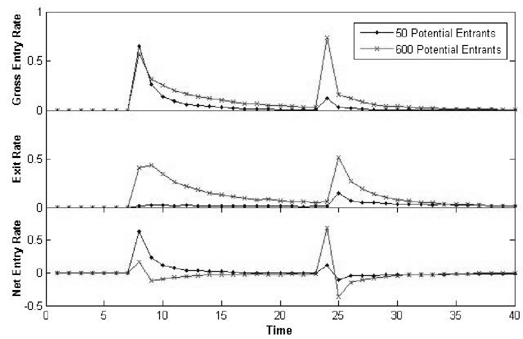

AVERAGE NUMBER OF SURVIVING ENTRANTS IN MF
NUMBER OF SUPPLIERS AT ENTRY
0
1
2
3
4
5
6
7
8
9
10
11
12
24
20
16
12
8
4

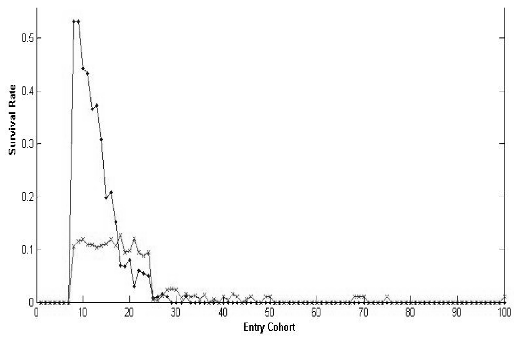

MONOPOLIES
TIME OF ENTRY
MF N
0
20
40
60
80
100
150
100
50
0
0
20
40
60
80

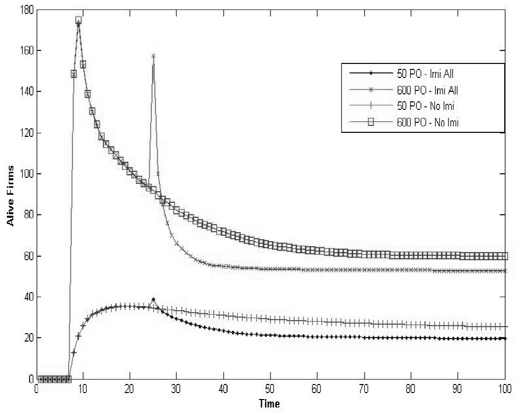

MEAN MARGINAL EFFECT
MF N
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
10
20
30
40
50
60
70
80

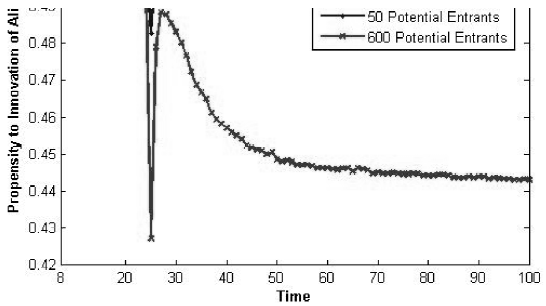

MEAN MARGINAL EFFECT
MF N
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
10
20
30
40
50
60
70
80


ALIVE FIRMS
TIME
POTENTIAL ENTRANTS


Gross Entry Rate
Exit Rate
Net Entry Rate
50 Potential Entrants
600 Potential Entrants
Time


Survival Rate
Entry Cohort


50 PO - Imi All
600 PO - Imi All
50 PO - No Imi
600 PO - No Imi
Alive Firms
Time


50 Potential Entrants
600 Potential Entrants
Propensity to Innovation of All
Time

TABLES

TABLE 1

	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	0.2129***	0.7008***	-1.7231***	-1.33***	-1.3699***
N		-0.0089***	-0.0039***	0.0021***	0.0013***
HERF(P)			1.4781***		0.3454***
FRONTIER(P)			3.4417***		0.6235***
TRAJECTORY(P)			-0.7423***		-0.2165***
FOLLOWER(P)			0.1363***		0.037**
HERF(A)				1.6013***	1.2589***
FRONTIER(A)				1.3093***	0.9972***
TRAJECTORY(A)				-0.6963***	-0.4419***
FOLLOWER(A)				0.26***	0.1032***
% Correctly Predicted Cases	74.7	82.1	93.5	96.2	96.5
Errors	22924	16285	5898	3467	3183
% Correctly Predicted – Adj	-	29.0	74.3	84.9	86.1
McFadden R^2	-	0.365347	0.717132	0.829435	0.844550
BIC	102607.3	65135.65	29089.56	17567.80	16062.69
Observations	90777	90777	90777	90777	90777

TABLE 2

Difference between the means of the technological trajectories

First Generation	
Mean	0.822071
S.D.	0.0133
Second Generation	
Mean	0.8754
S.D.	0.0474
H_0: FG = SG	Rejected
p-value	0.0000
t-statistics	-168.0062
Difference (C.I.)	(-0.0540, -0.0527)

TABLE 3

PANEL A: Integrated Circuits

	Model 1	Model 2	Model 3	Model 4
Constant	0.2418***	0.2968***	0.2187***	0.1889***
N		-0.0062***	0.0003***	
T		0.0027***	-0.0007***	
SHARE_ENTRY			-0.3543***	-0.3050***
SHARE_AVERAGE			-0.1313***	-0.1247***
MONOPOLY			0.0025***	0.0054***
SUPPLIERS			-0.0441***	-0.0527***
BEST			0.0052***	0.0089***
TURBULENCE_IC			0.0004***	0.0002
TURBULENCE_MP			-0.0161***	-0.0183***
% Correctly Predicted Cases	84.8	84.7	98.6	98.6
Errors	85214	85952	7843	8086
% Correctly Predicted – Adj	-	Negative	90.8	90.5
McFadden R^2	-	0.229775	0.902052	0.895756
BIC	477638.5	367918.6	46914.72	49895.38
Observations	560000	560000	560000	560000

PANEL B: Microprocessors

	Model 1	Model 2	Model 3	Model 4
Constant	-0.2327***	0.6388***	0.1937***	0.1874***
N		-0.0125***	-0.0019***	
T		-0.0032***	-0.0004***	
SHARE_ENTRY			-0.7095***	-1.1095***
SHARE_AVERAGE			-0.1955***	-0.2057***
SUPPLIERS			0.0588***	0.0807***
BEST			0.0054***	0.0096***
TURBULENCE_IC			-0.0009*	-0.0011*
TURBULENCE_MP			-0.0080***	-0.0084***
% Correctly Predicted Cases	79.1	95.5	97.1	97.1
Errors	66981	14349	9330	9380
% Correctly Predicted – Adj	-	78.6%	86.1	86
McFadden R^2	-	0.762923	0.861228	0.858687
BIC	328362.8	77882.19	45679.84	46488.86
Observations	319998	319998	319998	319998

TABLE 4

PANEL A: Survival Rates in the Standard Model

Cohort / *N*	**50**	**100**	**200**	**300**	**400**	**500**	**600**
First Movers	0.530	0.411	0.273	0.206	0.160	0.127	0.110
Early Followers	0.430	0.338	0.220	0.166	0.146	0.132	0.112
Followers	0.264	0.230	0.187	0.155	0.133	0.129	0.112
Imitators	0.011	0.009	0.012	0.012	0.010	0.009	0.008
Late Entrants	0.011	0.015	0.028	0.022	0.018	0.017	0.018

PANEL B: Survival Rates in the Strong Appropriability Regime

Cohort / *N*	**50**	**100**	**200**	**300**	**400**	**500**	**600**
First Movers	0.671	0.478	0.292	0.224	0.188	0.160	0.143
Early Followers	0.561	0.383	0.219	0.166	0.134	0.120	0.111
Followers	0.402	0.245	0.145	0.105	0.086	0.092	0.091
Imitators	0.145	0.144	0.069	0.052	0.061	0.073	0.077
Late Entrants	0.114	0.061	0.064	0.051	0.049	0.071	0.081

PANEL C: Difference in Survival Rates

Cohort / *N*	**50**	**100**	**200**	**300**	**400**	**500**	**600**
First Movers	0.141	0.068	0.018	0.018	0.028	0.032	0.033
Early Followers	0.131	0.045	-0.001	0.000	-0.012	-0.011	-0.002
Followers	0.138	0.015	-0.042	-0.050	-0.047	-0.037	-0.021
Imitators	0.134	0.134	0.056	0.040	0.051	0.063	0.069
Late Entrants	0.103	0.046	0.036	0.029	0.031	0.054	0.063

Are Switching Costs Always Effective?
The Moderating Role of
Technological and Demand Regimes

Abstract

This paper presents a model of industry evolution in which technological regimes and market regimes shape the relationship between consumers switching costs and first mover advantage. By using simulation techniques, we show that in some environments (homogenous demand, Schumpeter Mark I) switching costs are very effective in generating entry timing advantages, while in others (fragmented demand, Schumpeter Mark II) they are much less important. Moreover, the interaction between technological and demand regimes does also affect the results.

1. INTRODUCTION

Back in 1988, Lieberman and Montgomery presented a critical assessment of the literature regarding the commonly used but quite ambiguous concept of first mover advantage. They put forward a unified conceptual framework to serve as a guide for future research and concluded by underlining that "future empirical research needs to be more precise in elucidating specific first mover mechanisms [whilst…] theoretical work in the area has often suffered from the opposite problem" (Lieberman and Montgomery, 1988). Ten years later, in their retrospective reflection, the same authors claimed that "many of the fundamental conceptual problems that we discussed remain unresolved" (Lieberman and Montgomery, 1998). More recently, Suarez and Lanzolla (2007) in their critical review of the literature make analogous claims: the academic literature has been able to provide neither conclusive empirical evidence in favor or against first mover advantage, nor a theory that could help to sort out the emerging contradictions.

In order to overcome these problems and help the progress in the field, we present a formal model of industry evolution that builds on the framework developed by Suarez and Lanzolla (2007). Through the lenses of technological and demand regimes, we show the separate and combined effects of environmental influences on the role that consumers switching costs – an important mechanism long recognized in the literature – play in the emergence of first mover advantages.

The model is rooted in the evolutionary economics tradition (Nelson and Winter, 1982) and exploits the experience of the "history friendly models" (Malerba, Nelson, Orsenigo, and Winter) in reducing the gap between the richness and complexity of the empirical evidence, and the abstractness of formal models. We present the model as an example of how reciprocally fruitful a closer collaboration between evolutionary economics and strategic management can be (Gavetti and Levinthal, 2004): the concepts and the tools of the former can be used to advance our knowledge in the strategy field, while the latter provides a challenging ground in which evolutionary theory may prove able to generate sound and precise implications, both positive and normative.

2. BACKGROUND LITERATURE

The literature on first mover advantage is very broad and multidisciplinary, since it includes contributions from the industrial economics, marketing, and strategy fields. On the empirical side, several advances have been achieved over time. The early contributions were plagued by many problems, such as endogeneity of first mover opportunities, sample selection bias, and operationalization issues regarding the time horizon and the measurement of the dependent variables. In their meta analysis study, VanderWerf and Mahon (1997) showed that these methodological issues had a strong impact on the findings about the existence of first mover advantage. Over time, many of these problems have been solved through the help of methodological advances or more suitable datasets: for example, Bijwaard, Janssen, and Maasland (2008) and, more recently, Eggers, Grajek, and Kretschmer (2011) focused on the mobile telecommunications industry to deal with the endogeneity of entry timing by exploiting the regulated nature of the entry process. Still, methodology alone cannot be considered the panacea for all contradictory findings in the field. As an example, consider the issue of sample selection bias: Mitchell (1991) showed that a strong first mover advantage for newcomers could still be identified after removing the bias, while Golder and Tellis (1993) found that early market leaders, entering on average 13 years after pioneers, obtain the strongest position.

Another insight that comes from the empirical literature is the contingent nature of first mover advantage: in many cases, differences in the results are due to the specific characteristics of the industries selected for the analysis. Even in this case, the results are far from being clear: while Makadok (1998) found evidence of first mover advantage in a context where the probability of observing it was very low, Lieberman (2007) showed that in the growing Internet industry, where the expectations about first mover advantage were high and widespread, only early entrants with important patented innovations or in submarkets with network effects enjoyed an advantage.

On the theory side, it is more difficult to recognize advances in a precise way. As highlighted by Mueller (1997), first mover advantage emerges as a common regularity in the industry life cycle literature. Theoretical models in the industry life cycle stream (Klepper, 1996, 2002) focus on the dynamics over time of specific sectors, highlighting the relationships between industry variables and innovation patterns: they are able to generate early mover advantage through a combination of increasing returns to process R&D, decreasing industry cost price margins and transitory idiosyncratic cost shocks. In order to explain the evolution of sectors that do not conform to the industry life cycle story (such as the laser industry), Klepper and Thompson (2007) developed a different model, where the driving force is the creation and destruction of submarkets: first mover advantage here emerges because of the positive relationship between the age of a firm and the average number of submarkets in which it operates, and the negative relationship between such a number and the probability of exit. The industrial organization literature has clarified the specific mechanisms that drive the emergence of first mover advantage, by means of more and more technically sophisticated models, but still limited to a static duopoly context (Dutta, Lach, and Rustichini, 1995; Fudenberg and Tirole, 1985; Hoppe and Lehmann-Grube, 2001). Several classifications have been proposed, but the most widely accepted is the distinction of first mover advantage mechanisms into three categories: technological leadership, preemption of scarce assets, and consumers switching costs (Lieberman and Montgomery, 1988).

3. ARE CONSUMERS SWITCHING COSTS ALWAYS EFFECTIVE?

Although incomplete, the previous review makes clear that the first mover advantage field is highly fragmented and lacks a unifying framework that could make sense of the contradictory or at least highly contingent empirical evidence. Lieberman and Montgomery (1998) proposed resource based view for this heavy task; unfortunately, this theory has been much more helpful in dealing with the issue of the determinants of entry timing (Helfat and Lieberman, 2002; King and Tucci, 2002; Klepper and Simons, 2000; Lee, 2008) rather than its effects on competitive advantage (Bayus and Agarwal, 2007). Suarez and Lanzolla (2007) present a theoretical framework where the mechanisms that generate and protect first mover advantage are complemented by what happens at both the “micro” (firm level resources and capabilities that allow organizations to exploit first mover advantage) and the “macro” level (the market and technological environment). Recent empirical contributions (Dobrev and Gotsopoulos, 2010; Echambadi, Bayus, and Agarwal, 2008; Franco, Sarkar, Agarwal, and Echambadi, 2009; Eggers et al., 2011) have built upon this framework and have actually showed that it is a promising path for future research.

Our purpose it to contribute to this stream of literature by focusing on the role played by a specific mechanism identified by the early literature on first mover advantage: consumers switching costs (Klemperer, 1995; Wernerfelt, 1985). Consumers switching costs may arise because of different reasons: initial investment in supplier specific assets; supplier specific learning; contractual switching costs (Lieberman and Montgomery, 1988). Buyer inertia may also have similar effects, especially in the case of experience goods or credence goods. In all these cases, the institutional context plays an important role, but firms may also purposefully adopt behaviors that aim at increasing switching costs. There are also some theoretical reasons to believe that switching costs could be not an effective mechanism: consumers may anticipate or recognize the institutional contexts or the actions of the firms that increase the extent of switching costs, and therefore reduce their consumption (Mata, Fuerst, and Barney, 1995). Recent evidence has showed that switching costs can provide an effective advantage for early movers in the mobile telecommunications industry (Gòmez and Maìcas, 2011), but it has not clarified whether this relationship is limited to the very specific technological and demand environment that has been investigated, where it might be quite common to find early mover advantages (Bijwaard et al., 2008; Eggers et al., 2011). In order to answer to this question, we extend the framework provided by Suarez and Lanzolla (2007) by presenting a formal model of industry evolution. Adner, Pòlos, Ryall, and Sorenson (2009) advocated for a greater diffusion of formal models in management, highlighting their benefits relative to merely verbal theories: formal models require precision and non ambiguity in the definition of key concepts; they ensure the logical consistency of the arguments; and they also favor the generation of novel and unanticipated implications. The lack of a formal model might be traced to the difficulty of reconciling the complex framework that emerged in the first mover advantage field with the modeling style that has been dominant since its beginning (game theoretic industrial organization). The evolutionary tradition of models of industrial dynamics (Nelson and Winter, 1982; Winter, Kaniovski, and Dosi, 2003) may prove useful as an alternative tool that allows a formal representation of the rich framework that should explain first mover advantage: a recent stream of this literature (history friendly models: Malerba et al., 1999) has gone as far as modeling the historical evolution of specific industries, with high richness of details, that allowed also to study counterfactual histories (Durand and Vaara, 2009). Moreover, the evolutionary theory can also contribute to a more general specification of the technology and demand environments, through the concepts of technological regimes – technology specific patterns in the ways firms learn – and demand regimes – market specific patterns regarding the characteristics of consumers. Technological regimes (Malerba and Orsenigo, 1997; Winter, 1984) are fundamental characteristics of the technological environment: they have been recognized as important determinants of firms innovative activities (Breschi, Malerba, and Orsenigo, 2000; Peneder, 2010), firms productivity growth (Castellacci and Zheng, 2010), technological entry (Malerba and Orsenigo, 1999), and new firm formation (Shane, 2001). Very recently, they have also been successfully applied to the issue of early mover advantage (Kim and Lee, 2011). On the other hand, demand regimes, although once confined in the role of selection rules, have been the subject of a growing attention in the past decade, with a specific focus on the role of demand in the growth process (Metacalfe, 2001), the importance of demand fragmentation in the evolution of industries (Malerba and Klepper, 2010) and economies (Langlois, 2001), the interaction between consumers preferences and innovation (Consoli and Nelson, 2010), the role of users in the innovation process (Malerba, Nelson, Orsenigo, and Winter, 2007) and the interaction between different sectors (Malerba, Nelson, Orsenigo, and Winter, 2008). This stream of literature has also benefited from several contributions in the fields of management of innovation (von Hippel, 1988) and strategy (Adner and Levinthal, 2001; Christensen, 1997).

Summarizing, we present a formal model of industry evolution in which technological regimes and market regimes shape the relationship between consumers switching costs and the emergence of first mover advantage. The objective of the study is to provide a theoretically sound taxonomy of the environmental conditions under which switching costs may or may not be an effective mechanism in generating entry timing advantages. The model is analyzed with the help of simulation techniques: firms and consumers behaviors are specified by a number of equations, that are computed in each discrete time step. The next section provides the main insights of the model; a fully detailed description can be found in the appendix.

4. MODEL

The Topography

The basic environment of the model is an industry with two main components: the market space and the technology space. The former is a characterization of consumers preferences for the products and their characteristics. Consumers preferences usually differ along two dimensions: preferences for variety (or horizontal fragmentation) refer to differences in "locations" and "ideal distances" from products (Hotelling, 1929); preferences for quality (or vertical fragmentation) refer to differences in the evaluation of the "minimum quality" that can satisfy consumers needs (Shaked and Sutton, 1982). Consumers are grouped in submarkets according to their preferences for variety. Within each submarket, consumers have heterogeneous minimum quality thresholds: the product is not taken into consideration for purchase until it meets this requirement. In this market space, we can define two different demand regimes: a fragmented demand regime, where consumers preferences are both horizontally and vertically differentiated, and several market niches exist; and a homogeneous demand regime, where all consumers have the same preferences.

The technology space is a characterization of potential products and their technological trajectories. Following the literature about technological regimes, four broad dimensions define the technology space: technological opportunities, appropriability of innovations, cumulativeness of technical change, properties of the relevant knowledge base (Breschi et al., 2000). Technological opportunities define the availability of innovative solutions to firms in search for them. Appropriability conditions express the possibility of protecting firms innovations from imitation. The cumulativeness of knowledge defines the degree to which today innovations depend on the level of knowledge that has been already reached. Finally, there are several properties of the knowledge base that may be relevant in this context: tacitness, complexity, specificity, applicability (Marsili, 2001). The property that better fits with the level of analysis adopted in the model is the *locus* of knowledge accumulation (whether it occurs within the firm or in the external environment). We will consider the two main technological regimes that have been identified on both the theory (Winter, 1984) and the empirical side (Breschi et al., 2000): the Schumpeter Mark I (or entrepreneurial) regime, characterized by high level of innovative opportunities, low degree of appropriability, and low cumulativeness of knowledge; and the Schumpeter Mark II (or routinized) regime, characterized by low level of opportunities, high degree of appropriability, and high cumulativeness of knowledge. Moreover, as the *locus* of knowledge accumulation becomes relevant when cumulativeness is high, we distinguish two cases within the Schumpeter Mark II regime: a situation in which knowledge is generated and accumulated mostly within the firm (Schumpeter Mark II with Internal Knowledge) and a situation in which knowledge is generated and accumulated mostly in the external environment (Schumpeter Mark II with External Knowledge).

The link between the market space and the technology space is established through firms activities. Firms search the technology space in order to find promising potential products from which they create products that generate utility for the consumers in the market space. A potential product is defined by a specific combination of characteristics and a technological trajectory that determines the evolution of its quality. A product is a firm specific realization of the potential product, which is sold on the market space. Firms may differ either because they discover different potential products or because they do not have the same capabilities of exploring the technological trajectories.

The Market Space and the Behavior of Consumers

In the market space there are *S* submarkets, heterogeneous in size. The preferences of consumers in a submarket about the combinations of product characteristics are represented by a vector $\boldsymbol{v_s}$ of real values in the set [0,1] of dimension equal to the number of potential products (*J*). The highest value (1) means that the product perfectly satisfies the preferences for the combination of characteristics; the lowest value (0) means that the product has no utility for that group of consumers. A full description of the preferences of consumers would require a matrix $\boldsymbol{R}$ of dimension $S \times J$. In order to reduce the computational and memory burden of the model, we assume that for each product there is at least one submarket where it provides the maximum utility: we call it the main submarket of product *j* and we denote it by s_j. Products sharing the main submarket are considered as equivalent by consumers of other submarkets. By this simplifying assumption, the dimension of $\boldsymbol{R}$ reduces to $S \times S$, but $\boldsymbol{R}$ needs not to be symmetric: the fact that consumers in submarket s_j consider product *k* a good substitute for product *j* does not imply that consumers in submarket s_k consider product *j* a good substitute for product *k*. All the elements on the main diagonal of $\boldsymbol{R}$ are equal to one. The off diagonal elements are independently extracted from a beta probability distribution: the mean of this distribution (μ_R) represents the extent to which consumers preferences are homogeneous. Starting from it, we can define the degree of horizontal fragmentation in the market space as $\mu_H = 1 - \mu_R$: when μ_H takes its maximum value (1) the fragmentation is so high that consumers consider purchasing only products belonging to their submarket; when μ_H takes its minimum value (0) consumers consider all the products as perfect substitutes for each other.

The preferences described by ***R*** interact with the quality of the products and determine their evaluation by consumers. Quality is a product specific variable that may change over time: we denote as $q_{j,t}$ the quality that product j has in period t. Then, the quality of product j as perceived at time t by consumers in the submarket s is $q_{j,s,t} = q_{j,t} \cdot R_{s,s_j}$.

Within each submarket, the consumers refer to the perceived quality to evaluate whether the product satisfies their minimum quality requirements. The thresholds are distributed according to a beta cumulative function $F(\cdot)$, which is the same for all submarkets. One of the shape parameters represents the degree of vertical fragmentation (μ_V) in the market space: when this parameter takes its minimum value (0) all consumers have the same minimum quality requirements; when μ_V takes its maximum value (1) consumers minimum thresholds are uniformly distributed along the quality dimension.

Consumers consider also price in their purchasing decisions: the higher the price of a product, the lower the probability of buying it, keeping constant the perceived quality. Firms choose the price of their products with a profit maximization rule, that takes into account both the price elasticity of demand and the degree of competition in the previous period.

Finally, consumers that already bought the product in the past can be affected by switching costs, whose strength is expressed by the parameter ρ: when it takes its minimum value (0) consumers do not consider their past behavior in the purchasing choice; when ρ takes its maximum value (1) consumers keep buying the same product they bought in the past, irrespective of any change in quality or price that may occur over time.

The Technology Space and the Behavior of Firms

In the technology space there are *J* potential products. Each of them has its own main submarket (s_j) and its own technological trajectory. A technological trajectory is a potential product specific map from the dimension of knowledge (k) to the dimension of quality (q). This relationship is represented by a generalized logistic function, which imposes that quality is non decreasing in knowledge and that the shape of relationship is like an S, as it is well established in the technology literature (Foster, 1986).

Firms innovation activities are twofold: they can either search the technology space to find new products or explore the knowledge dimension of existing products in order to improve their quality. In both cases, firms choices are based on routines and are a function of observable variables, which include profits, sales or quality, but do not include knowledge. For the sake of simplicity, we assume that a firm uses all its profits to finance innovation activities. The allocation of financial resources to innovation activities follows a multi step procedure. First, we assume that all the operations regarding a product in a firm are conducted by a specific team: firms producing multiple products allocate the resources among multiple teams. A team has more resources if its product earns a higher share of firm's profits or if its innovation activities are successful, both in relative and in absolute terms. Then, each team chooses whether to use its financial resources to improve its existing product or to search for new products: this choice depends on the past achievements of the team in the two activities.

When a team searches for new products, the amount of invested financial resources determines the probability of finding a promising product, given the level of innovative opportunities in the technology space, which is the fraction ξ of potential products that have a quality higher than 0. When the parameter ξ takes a low value, teams have a limited amount of innovative opportunities; when it takes its maximum value (1) it becomes much easier for them to discover new potential products. A team may also run into products already discovered by other firms; in this case, it can use the product only if it is not protected by a patent. Let *L* and *T* be the granted length of a patent and the time horizon of the industry, respectively; then, the ratio $\chi = \sqrt{L/T}$ represents the degree of appropriability of innovations. When χ takes its minimum value (0) there is no patent protection; when it takes its maximum value (1) patents, once granted, last until the end of the simulation.

When a team chooses to improve its existing product, the amount of invested financial resources ($b_{j,t}$) determines the probability of getting a positive increase in quality, given the firm's capabilities (θ_f), the existing level of product specific knowledge ($k_{j,t-1}$) and the existing level of external knowledge ($k_{e,t-1}$). The importance of past knowledge in generating new knowledge, that is the cumulativeness of knowledge, is expressed by the parameter γ: when it takes its minimum value (0), the increase of knowledge depends only on the financial resources and the capabilities of a firms; when γ takes it maximum value (1), the starting point for the generation of new knowledge is the existing level of knowledge. The relative strength of internal, product specific knowledge *vis-à-vis* external, publicly available knowledge is represented by the parameter δ: when it takes its minimum value (0), internal, product specific knowledge plays no role in the generation of new knowledge; when δ takes its maximum value (1), only internal knowledge matters and there is no role for external knowledge.

Model Dynamics

A simulation run represents the evolution of an industry over time and it goes on until the last period (*T*) is reached. At the beginning of each period, a new potential firm searches the technological space: if it finds a promising potential product which is not under patent protection, the firm enters and starts producing and selling the product in the market space; otherwise, in that period no entry occurs. Since no more than one firm can enter the market in each period, it is possible to define a univocal order of entry.

Then all the existing firms perform their activities in the following order: first, they allocate among their teams the existing financial resources; then, each team chooses and executes its specific innovative activity. Once new products have been discovered and existing products have been improved, firms set the prices and try to sell their products in the market space: market shares and profits are determined according to the utility that products provide to consumers.

Finally, exit of products and firms occurs. A product that does not reach a minimum market share (*E*) in at least one submarket is withdrawn from the market space. A firm that does not have any product to sell in the market space fails and exits from the industry.

5. ANALYSIS

Before specifying the strategy we used to obtain and analyze results, we need to clarify our terminology. A simulation model of industrial dynamics describes the rules that govern the evolution of an industry over time; the actual realization of the model is a run and it is a function of a set of initial conditions, which include both the values of the parameters and the initial values of variables. The parameters are the elements of the model whose value does not change within a single run; the variables are the elements of the model whose value is updated according to the rules of the model. We distinguish three groups of parameters. Individual parameters refer to the invariant properties of specific objects (firms, products, submarkets) that guarantee within category heterogeneity (for instance: capabilities of firms; relatedness of submarkets): they are randomly extracted from the range of all meaningful values. General parameters are the elements that do not change across different runs: their value is determined through a process of calibration that ensures some basic requirements (for example: the viability of the industry). Several methods have been proposed for calibration (Fagiolo, Moneta, and Windrum, 2007; Werker and Brenner, 2004): here we refer to the history friendly literature and use as reference points the models about the computer industry (Malerba et al., 1999) and the pharmaceutical industry (Malerba and Orsenigo, 2002).

Focal parameters are the elements we choose in a systematic way in order to answer the research questions of this paper: they include switching costs, the four dimensions of technological regimes, and the two dimensions of demand regimes. Depending on the combination of regimes under analysis, we set their values as indicated in Table 1; if no value is specified, the parameter takes a random value (in its range) changing across different runs.

We focus our analysis on twelve cases. First, we study the existence of a generic relationship between switching costs and first mover advantage, which should hold irrespectively of the value taken by the focal parameters: therefore they randomly take any value in their range. Then, we study this relationship in the five specific technological and demand regimes contexts: Homogenous Demand, Fragmented Demand, Schumpeter Mark I, Schumpeter Mark II with External Knowledge, Schumpeter Mark II with Internal Knowledge. Finally, we study the six combinations between technological and demand regimes. For each of these twelve cases, we systematically change the value of switching costs from 0 to 1 at intervals of 0.01; moreover, in order to reduce the impact of random elements on results, we perform 100 runs for each case/switching costs combination.

The next step requires the choice of a indicator for first mover advantage. The empirical literature has employed several measures both for the "first mover" and for the "advantage", according to the characteristics of the setting; moreover, VanderWerf and Mahon (1997) show that this choice can have an impact on the findings. Since our purpose is inherently comparative and involves quite different settings, we choose the measures that are less affected by these differences. Our measure of advantage is in terms of survival odds; since the time dimension of the model is intrinsically discrete, we use a logit specification, which also allows us to include time varying covariates (Jenkins, 2005). In order to capture order-of-entry effects, we include as explanatory variables a dummy for first movers (firms that enter the industry earlier than any other firm) and a dummy for followers (firms that enter as second, third or fourth in the industry). The baseline is given by all other firms that enter the industry: we will refer to them as late entrants. Given the characteristics of the simulation model, we can exclude most of the causes of duration dependence: we only include a dummy for the first period of life of each firm, as in that interval there is an higher hazard rate for all firms. We also include other controls in the regression: the capabilities of the firm, the level of concentration (as expressed by the Herfindahl index), density, squared density, and all the focal parameters that are not fixed in the

specific case. In each regression we include all firms that entered the industry in the 100 runs for a given case/switching costs combination.
Finally, in order to capture the relationship between switching costs and order of entry we separately regress the odds ratio of first movers and followers we obtained through this analysis against the value of switching costs, by using both a linear and a quadratic specification. We also provide graphical representations of the relationship.

6. RESULTS

First of all, we study the existence and the relevance of a relationship between switching costs and order of entry advantages, i.e. whether there is any difference in survival rates due to order of entry and whether this difference changes as a function of switching costs. Results summarized in Table 2 and Figure 1 show that the odds of survival are 4 times higher for first movers than for late entrants even when switching costs are very low. Moreover, switching costs have only a limited impact on such an advantage, especially if we compare their effects on first movers and followers: the latter category enjoys a much stronger advantage as switching costs increase, until any difference with the first movers disappears. Although this result may appear surprising, it is perfectly consistent with the idea that switching costs may have different effects in different contexts. Moreover, it also suggests that other early entrants, and not only first movers, may benefit from it.
If we move to the analysis of demand regimes, we can see in details the mechanisms that drive the contingency. A very fragmented demand ensures the existence of profitable niches also for late entrants; early movers (both the first and the followers) cannot exploit switching costs,

because they do not provide any advantage in the expansion towards new niches, in which early and late entrants compete on a parity base (see Figure 2 and Table 3). On the other hand, switching costs are very effective in the opposite case: when the demand is completely homogenous, the other forces driving first mover advantage are already quite strong, but a small increase in the level of switching costs destroys any risk of non survival for first movers. Since the survival analysis was technically unfeasible for this situation, in Table 4 we provide different indicators: in the first line (Any Technological Regime) we see that the odds of survival are 7 times higher for first movers when switching costs do not exist and they quickly rise to about 100 when switching costs are still quite low (0.14). For higher level of switching costs, the odds cannot be estimated because the first mover always survive. On the other hand, followers are heavily harmed by an increase of switching costs: while their odds are between 6 and 7 (not very far from first movers) when there are no switching costs, they become undistinguishable from those of late entrants as soon as switching costs reach the very low value of 0.08.

The mechanisms in different technological regimes are also very interesting, although less clear cut. In a Schumpeter Mark I regime, switching costs have a clear positive effect (see Table 5) on the survival of both first movers and followers, and the differences between the two categories are very small. Plenty of technological opportunities are available in such an environment, but high switching costs make them unprofitable, since consumers will not consider new products. From Figure 3 it is also possible to notice an initial disadvantage due to the increase of switching costs, for both first movers and followers: it is a selection effect due to the fact that low values of switching costs initially protect weak early entrants, but are not strong enough to protect them in the long run.

While the early exit of early entrants is captured by the duration variable, when exit occurs later it appears as a disadvantage linked to the timing of entry.

In a Schumpeter Mark II environment early movers generally enjoy an advantage, but switching costs are effective only when the relevant knowledge base is generated in the external environment (Table 6 and Figure 4). In such a situation late entry occurs more rarely, but it could be very disruptive: switching costs reduce the probability of success of late entrants because they destroy the demand base that could sustain them. When the relevant knowledge base is generated within the firm, switching costs have no impact: the advantage of first mover is already strong, and there is no mechanism they can interact with to enhance it, or to reduce the advantage of late entrants (Table 7 and Figure 5).

The interaction between technological and demand regimes is dominated by the second element. A homogenous demand is always synonymous of strong first mover advantage; moreover, in a Schumpeter Mark II environment switching costs become almost irrelevant because the first mover has almost no exit risk even when they are not present (see again Table 4). The introduction of a fragmented demand in a Schumpeter Mark I environment has also a dominant effect: the opportunities for late entrants cannot be counterbalanced by switching costs anymore, because the market niches over which they can have an effect are too small (Table 8 and Figure 6). As a consequence, an early time of entry does not provide any advantage.

The most interesting results, though, emerge from the analysis of Schumpeter Mark II environments with a fragmented demand. Quite surprisingly, in both cases we observe strong early mover disadvantages. When relevant knowledge is external (Table 9 and Figure 7), we observe a dynamics similar to what we already saw in the case with no interaction with the demand regime: in this case, the existence of many niches, and particularly of consumers that have quality preferences still not satisfied by early products, guarantees a strong demand base for late entrants that can exploit the knowledge accumulated also by their competitors. Moreover, the low level of innovative opportunities, rather than being a disadvantage, contributes to increase the protection of late entrants from the reaction of early movers. Only very high level of switching costs may reduce the liability of early entrants and remove the difference in survival odds with late entrants.

When knowledge is internal, what we observe in Figure 8 and Table 10 is a strong selection over late entrants: since the opportunities are very rare in a Schumpeter Mark II environment, and this is exacerbated by the dynamics of internal accumulation of knowledge, only very competitive late entrants are able to survive to the first period, either because of their capabilities or because they found a "heavenly" niche. In both cases, it is almost impossible that they exit once they are able to enter, which is reflected as a disadvantage of early movers.

7. CONCLUSIONS

The exercise conducted in this study aimed at clarifying the role played by the environmental context in shaping the relationship between consumers switching costs and first mover advantages. Integrating insights from previous empirical and theoretical literature with the formal and conceptual elements developed by evolutionary theories of industrial dynamics, we have provided a detailed taxonomy of the conditions under which consumers switching costs may be more or less effective in generating an advantage related to entry timing.

Both demand regimes and technological regimes have a strong impact on the effectiveness of switching costs. For example, in an environment characterized by a very fragmented demand switching costs are poorly effective because firms can exploit them on a limited group of consumers; moreover, early mover advantages are generally quite low because the existence of several market niches offers a protecting environment for late entrants. On the other hand, in an environment with a very homogenous demand, consumers switching costs have a much stronger effect because they can influence a much bigger set of consumers.

Technological regimes are also very important. In a Schumpeter Mark I environment switching costs may reduce the importance of the availability of technological opportunities, since locked-in consumers will have lower consideration for new products. In Schumpeter Mark II environments switching costs are effective only when the accumulation of knowledge is external; the internal development of relevant knowledge constitutes a much stronger advantage for first movers that makes switching costs irrelevant. Moreover, the analysis of technological regimes also shows that switching costs may have different effects over time: they may provide a temporary protection in the short run, but increase the risk of exit in the long run. This result is coherent with the findings by Kim and Lee (2011) that show how first mover advantages might be less sustainable over time in Schumpeter Mark I environments and more sustainable in Schumpeter Mark II environments.

Finally, the interaction between demand regimes and technological regimes is also very relevant. In Schumpeter Mark II environments the results can radically change in presence of a very fragmented demand.

The existence of several market niches, especially those due to vertical fragmentation and quality requirements not satisfied by existing products, may be the Trojan horse through which late entrants may introduce disruptive innovations and overcome the dominant positions of early entrants (Tushman and Anderson, 1990; Christensen, 1997).

Although the focus of the paper is mostly theoretical, the results may also have practical importance. Since switching costs depend on both the institutional context and the actions of firms, it is possible to understand the conditions in which it might be more useful to have strong or weak investments in specific behaviors. For example, in environments with a fragmented demand the impact of switching costs is very weak, therefore even massive investments could be unrewarding. For very different reasons, this could be the case also in environments with a very homogenous demand: here the effects are so strong that a even a quite limited investment might suffice to obtain the desired advantage. On the other hand, such an investment might provide important advantages in Schumpeter Mark I environments; moreover, it might generally be more beneficial to followers, in order to overcome the difference with first movers.

Some limitations may be highlighted in this study. First, we focus the analysis on extreme cases in order to get results that might be more easily interpreted; still, in the literature it is possible to identify other possible technological and demand regimes, in which the relationship between switching costs and first mover advantage might still be different. Second, although firms heterogeneity is included in the model as a control variable, the potential interactions between micro level and macro level variables are not explicitly considered: it would be interesting to conduct an analysis on the specific capabilities that allow a firm to capture stronger entry timing advantages in the different technological and demand environments.

Finally, the model is characterized by exogenous entry. While exogeneity is useful in that it helps to isolate causal mechanisms, it may prove tricky at providing clear implications. For example, with respect to one of the dimensions of technological regimes – the appropriability of innovations – recent evidence shows the importance of firms reaction to environment challenges in their choices about the type and the timing of entry (Ethiraj and Zhu, 2008), and patenting behavior (Ceccagnoli, 2009). Therefore, a necessary step for the future lays in providing endogenous mechanisms to model entry behavior in an evolutionary framework.

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APPENDIX

Market Activities

Consumers purchasing decisions depend on their preferences, the characteristics of products (including quality and price) and their past purchasing behavior (as summarized in the past market share of the product). Let the consumers in a submarket be uniformly distributed along the real unit segment: we define the propensity for the product *j* ($j \in \{1, \ldots, J\}$) to be sold to a consumer *i* ($i \in [0,1]$) in the submarket *s* ($s \in \{1, \ldots, S\}$) at time *t* ($t \in \{1, \ldots, T\}$) as:

$$U(i)_{j,s,t} = \begin{cases} 0 & , \quad q_{j,s,t} < F(i) \\ \dfrac{q_{j,t} \cdot R_{s,s_j}}{p_{j,t}} & , \quad q_{j,s,t} \geq F(i) \ \wedge \ \nexists h \colon U(i)_{h,s,t-1} > 0 \\ (1-\rho) \cdot \left(\dfrac{q_{j,t} \cdot R_{s,s_j}}{p_{j,t}} \right) + \rho \cdot \left(m_{j,s,t-1} \right), & \quad q_{j,s,t} \geq F(i) \ \wedge \ \exists h \colon U(i)_{h,s,t-1} > 0 \end{cases} \tag{1}$$

where $q_{j,t}$ is the quality of product *j* at time *t*, R_{s,s_j} is the preference of consumers belonging to submarket *s* for the product *j*, $q_{j,s,t}$ is the quality of product *j* as perceived at time *t* by consumers in the submarket *s* ($q_{j,s,t} = q_{j,t} \cdot R_{s,s_j}$), $p_{j,t}$ is the price of product *j* at time *t*, $m_{j,s,t-1}$ is the market share of product *j* in the submarket *s* at time *t-1*, *h* refers to any product that was produced by firms at time *t-1*, ρ is the degree of switching costs and F(.) is a function that assigns a minimum quality threshold to each consumer. Condition (1) says that consumers never consider a product for purchase if it does not meet their minimum quality requirements; they consider objective (quality and price) and subjective (preferences for variety) elements in their decision, if they never bought anything in the past; they also consider past purchasing behavior, if they were already active in the past. In the following sections we provide details on all the elements included in the equation.

Consumers preferences and horizontal and vertical fragmentation. The preferences of consumers for variety are summarized in the matrix ***R*** of dimension $S \times S$. The value at the intersection of the row s_{row} and the column s_{col} expresses the extent to which a product that has s_{col} as its main submarket is a good match for consumers belonging to submarket s_{row}. The maximum value (1) represents perfect matching; the minimum value (0) means that consumers of s_{row} will never buy a product in s_{col}. By assumption, all the elements on the main diagonal of ***R*** are equal to one: a product is always a perfect matching for consumers of submarket *s* if *s* is its main submarket. The off-diagonal elements are independently extracted from a beta probability distribution: the mean of this distribution (μ_R) represents the extent to which consumers preferences are homogeneous; then the degree of horizontal fragmentation in the market space is $\mu_H = 1 - \mu_R$.

The beta probability distribution has two shape parameters, usually denoted as α and β. An intermediate level of fragmentation is obtained by setting both the shape parameters to the value 1, which yields a uniform distribution between 0 and 1. In order to get higher values of fragmentation, we decrease the value of β keeping constant α at 1; symmetrically, to get lower values of fragmentation we decrease the value of α keeping constant β at 1. Since the beta distribution is defined only for strictly positive shape parameters, we separately define the matrix ***R*** in the extreme cases of maximum and minimum fragmentation: in the former case, ***R*** is the identity matrix; in the latter case, ***R*** is a matrix of ones.

All consumers prefer a higher quality product, keeping constant the price and the preferences for variety. Still, consumers have different minimum quality requirements: if (perceived) quality is lower than their threshold, they do not take the product into consideration for purchasing whatever the price. By no loss of generality, we can assume that consumers are distributed along the unit segment so that their thresholds are in non-decreasing order; moreover, we also assume that quality is bounded between 0 and 1. Then, the function $F(\cdot)$ that assigns to each consumer i its minimum quality requirement $F(i)$ can be represented through a cumulative distribution function: we use the beta cumulative distribution function. The highest level of vertical fragmentation (1) is obtained when both the shape parameters are equal to 1 and $F(\cdot)$ is analogous to the standard uniform distribution. In order to get lower values of vertical fragmentation, we increase the value of β keeping constant α = 1; the value of vertical fragmentation is the reciprocal of β. The lowest level of vertical fragmentation (0) implies that all consumers will consider a product with a strictly positive quality.

Market shares. The computation of market shares is non-trivial because horizontal and vertical fragmentation affect the boundaries of the space that should be considered as the "relevant market". Consider a generic submarket s and assume there are J_s products with a strictly positive perceived quality in this submarket, arranged in ascending order by quality, so that $q_{1,s} \leq q_{j,s} \leq q_{J_s,s}$. Moreover, let $F^{-1}(\cdot)$ be the inverse of $F(\cdot)$. Since a product j with quality $q_{j,s}$ has a strictly positive propensity to be sold only to the fraction of consumers whose quality threshold is no higher than $q_{j,s}$, that is $F^{-1}(q_{j,s})$, we can also define J_s groups of consumers such that $\mathfrak{G}_1 = F^{-1}(q_{1,s})$ and $\mathfrak{G}_g = F^{-1}(q_{j=g,s}) - F^{-1}(q_{j=g-1,s})$. The market share of product j in group g is:

$$m_{j,g} = \begin{cases} \frac{U_{j,g}}{\sum_{j=g}^{G} U_{j,g}}, & if\ j \geq g \\ 0 \quad , & if\ j < g \end{cases} \qquad (2)$$

The market share of product *j* in the whole submarket is simply the sum of its shares in the groups weighted by group size (possibly rescaled if some consumers are not satisfied by any competing product), that is:

$$m_{j,s} = \sum_{g=1}^{J_s} m_{j,g} \cdot \frac{\mathfrak{G}_g}{F^{-1}\left(q_{J_s,s}\right)} \qquad (3)$$

Finally, if there is at least one product with a market share lower than the exit threshold (*E*), we exclude from the market the product with the lowest market share and repeat the procedure with J_s-1 groups; the process is iterated until all the remaining products have a market share higher than the threshold.

Price. Firms set the price of each product according to a mark-up rule, as follows:

$$p_{j,t} = C \cdot \left(1 + w_{j,t}\right) \qquad (4)$$

where *C* is the marginal cost, that we assume equal across all products and constant over time. At time *t*, a firm chooses the mark-up $w_{j,t}$ for product *j* in order to maximize profits, given the price elasticity of demand η and the global competitive pressure at time *t-1* as expressed by market share:

$$w_{j,t} = \frac{m^*_{j,t-1}}{\eta - m^*_{j,t-1}} \qquad (5)$$

It is important to highlight that $m^*_{j,t}$ is product-specific variable, while $m_{j,s,t}$ differs across submarkets. Moreover, $m^*_{j,t}$ takes into account only consumers whose quality threshold is lower than the quality of the product, as consumers with an higher threshold would not be affected by changes in price; and it ignores other products of the same firm. In order to compute it, we start by defining the number of consumers in the group *g* of a submarket *s* that buy product *j* as:

$$\mathfrak{C}_{j,g,s} = m_{j,g} \cdot \mathfrak{G}_g \cdot \mathfrak{C}_s \qquad (6)$$

where $\mathfrak{C}_s$ is the number of consumers in submarket s. Then, the number of consumers in submarket *s* that buy product *j* is simply:

$$\mathfrak{C}_{j,s} = \sum_{g=1}^{J_s} \mathfrak{C}_{j,g,s} \qquad (7)$$

The number of potential consumers of product *j* in submarket *s* ($\widehat{\mathfrak{C}}_{j,s}$) is given by all customers whose quality threshold is lower than the perceived quality of the product; to this number, we have to subtract the consumers in the submarket that chose another product of the same firm, even if they were satisfied also by the focal one:

$$\widehat{\mathfrak{C}}_{j,s} = F^{-1}(q_{j,s}) \cdot \mathfrak{C}_s - \sum_{j=1}^{J_f} \mathfrak{C}_{j,s} \qquad (8)$$

where J_f is the number of products of firm *f*.
Then, the number of consumers that buy product *j* and the number of potential consumers to use as a benchmark are:

$$\mathfrak{C}_j = \sum_{s=1}^{S} \mathfrak{C}_{j,s} \qquad (9)$$

and

$$\widehat{\mathfrak{C}}_j = \sum_{s=1}^{S} \widehat{\mathfrak{C}}_{j,s} \qquad (10)$$

respectively.

Finally, the market share a firm uses to set the markup in the next period is given by:

$$m_j^* = \frac{\mathfrak{C}_j}{\widehat{\mathfrak{C}}_j} \qquad (11)$$

All earned profits are used to finance innovation expenditures in the following period.

Innovation Activities

All firms finance their innovation activities by investing all the profits earned in the previous period. The profits of firm *f* at time *t* are the sum of the profits obtained from all its products:

$$\Pi_{f,t} = \sum_{j=1}^{J_f} \Pi_{\mathrm{j,t}} = \sum_{j=1}^{J_f} \left(p_{j,t} - C\right) \cdot \mathfrak{C}_j \qquad (12)$$

Innovation activities require several procedures. First of all, available financial resources must be allocated between different teams. Let $q'_{j,t}$ be the increase in the quality of product *j* that has occurred from the previous period, that is:

$$q'_{j,t} = q_{j,t} - q_{j,t-1} \qquad (13)$$

then the budget of team *j* for its innovative activities in period *t* ($b_{j,t}$) is determined according to the following rule:

$$b_{j,t} = \left[\lambda_{f,t} \cdot \frac{q'_{j,t-1}}{\sum_{j=1}^{J_f} q'_{j,t-1}} + \left(1 - \lambda_{f,t}\right) \cdot \frac{\Pi_{j,t-1}}{\sum_{j=1}^{J_f} \Pi_{\mathrm{j,t-1}}}\right] \cdot \Pi_{f,t-1} \qquad (14)$$

which means that the share of resources that can be used by group *j* depends on both the percentage of profits actually earned by the product and the team innovative performance in the last period *vis-à-vis* the other teams of the firm. Moreover, the weight that is assigned to earned profits and innovation performance varies over time, according to the overall innovative performance obtained by the firm:

$$\lambda_{f,t} = \frac{1}{2}\left(1 - \frac{1}{1 + \sum_{j=1}^{J_f} q'_{j,t-1}}\right) \qquad (15)$$

A team *j* is completely autonomous in its decision about the use of the financial resources it obtains: it can use them either to improve the quality of its product or to search for new products. A team *j* will use its resources at time *t* to improve its product with probability $z_{j,t}$:

$$z_{j,t} = \frac{1}{2}\left(z_{j,t-1}\right) + \frac{1}{2}\left(\hat{z}_{j,t}\right) \qquad (16)$$

The new element $\hat{z}_{j,t}$ depends on the type of activity the team chose in the previous period and on whether it was successful or not: if the team chose to improve its product in the previous period, then:

$$\hat{z}_{j,t} = \begin{cases} 1, & q'_{j,t-1} > 0 \text{ or } t_j = 1 \\ 0, & otherwise \end{cases} \qquad (17)$$

If the team chose to look for new products, then:

$$\hat{z}_{j,t} = \begin{cases} 0, & found\ new\ product \\ 1, & otherwise \end{cases} \qquad (18)$$

Search for new products. If the team chooses to search for new products, the probability of success will be a non-linear function of the level of innovative opportunities (ξ) and the appropriability of innovations (χ). The team will try to extract a promising potential product from the technology space until it is successful or it exhausts its financial resources for the current period. The number of tries that are available for a team *j* with financial resources $b_{j,t}$ is equal to $floor\left(\frac{b_{j,t}}{C_1}\right)$, where C_1 is the unit cost of search for new products.

We assume that the financial resources of a new firm that wants to enter the industry guarantee that is has at least (and no more than) one try.

Improvement of existing products. If the firm chooses to improve its existing product, it tries to explore its technological trajectory, which expresses the relationship between knowledge and quality. A simple formalization of this relationship is provided by the generalized logistic function:

$$q_j(k_j) = \frac{1}{\left[1 + X_j e^{-Y_j \cdot k_j}\right]^{\frac{1}{Z_j}}} \qquad (19)$$

The numerator sets to 1 the maximum quality that can be reached by any product. Three parameters, which differ across potential products, determine the exact shape of the technological trajectory. The parameter X_j determines the level of quality when there is no knowledge, that is $q_j(0)$: the only constraint we impose to its value guarantees that quality has a strictly positive value even for $k = 0$. The parameter Z_j determines the symmetry of the function and in particular the distance of the maximum growth rate from the asymptotes. If Z_j is higher than 1, the maximum growth rate occurs towards the upper asymptote, vice versa if it is lower than 1. Z_j takes any value in the range of real numbers (to the extent this is possible in a simulation model) with the same probability. The parameter Y_j represents the average growth rate of quality with respect to knowledge. Its value is partially constrained by the previous parameters; we also restrict the range of possible values so that the growth of quality is neither too fast nor too slow.

A team undertaking innovative activities aimed at improving an existing product explores its knowledge dimension. The probability of generating a new piece of knowledge ($n_{j,t}$) depends on the amount of resources that is invested in this activity; if a new piece of knowledge is generated, then its importance is a positive function of the technological capabilities of the firm (θ_f); this is formally expressed by the following condition:

$$n_{j,t} = \begin{cases} 0, & if\ U(0,1) < \dfrac{1}{1+\sqrt{b_{j,t}/C_2}} \\ \mathrm{Exp}\left(\dfrac{1}{\theta_f}\right), & \text{otherwise} \end{cases}; \qquad (20)$$

where C_2 is the unit cost of improvements of existing products.

The extent to which the new piece of knowledge can be added to the existing knowledge depends on the degree of cumulativeness (γ); moreover, the parameter δ determines the mix of internal and external knowledge in the composition of the relevant existing knowledge. The new knowledge ($k_{n,t}$) is given by the combination of the new piece of knowledge and the relevant existing knowledge, and can be expressed formally as:

$$k_{n,t} = \gamma \cdot \left[\delta \cdot k_{j,t-1} + (1-\delta) \cdot k_{e,t-1}\right] + n_{j,t} \qquad (23)$$

The external knowledge ($k_{e,t}$) is a function of the increase in knowledge generated by all the teams working on the improvements of existing products in the current period:

$$k_{e,t} = k_{e,t-1} + \frac{\sum_{f=1}^{\mathfrak{F}} \sum_{j=1}^{J_f} q'_{j,t}}{\sum_{f=1}^{\mathfrak{F}} \sum_{j=1}^{J_f} j} \qquad (24)$$

where $\mathfrak{F}$ is the number of firms currently operating in the industry.

Finally, the firm uses the new knowledge only if it allows to increase the quality of the product, that is if the new knowledge is higher than the previous internal knowledge:

$$k_{j,t} = \max\left(k_{j,t-1}, k_{n,t}\right) \tag{25}$$

FIGURES

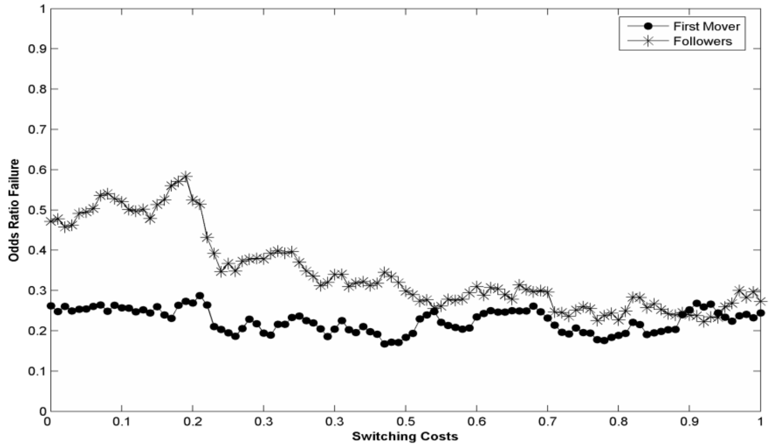

Figure 1. Failure-to-survival odds ratio for the first mover and the followers in a general case.

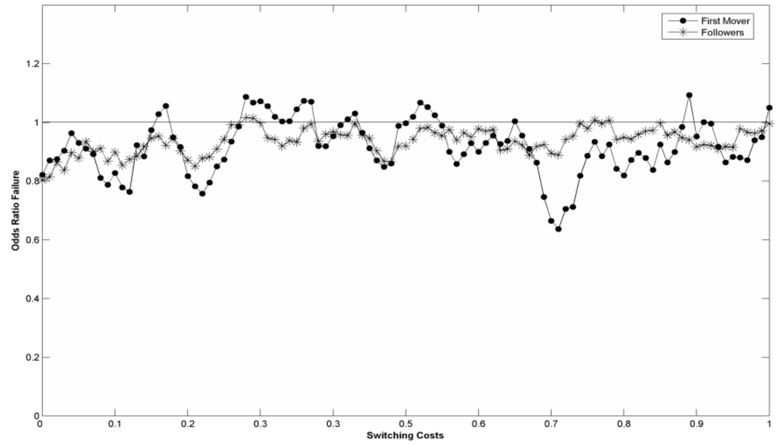

Figure 2. Failure-to-survival odds ratio for the first mover and the followers in a Fragmented Demand regime.

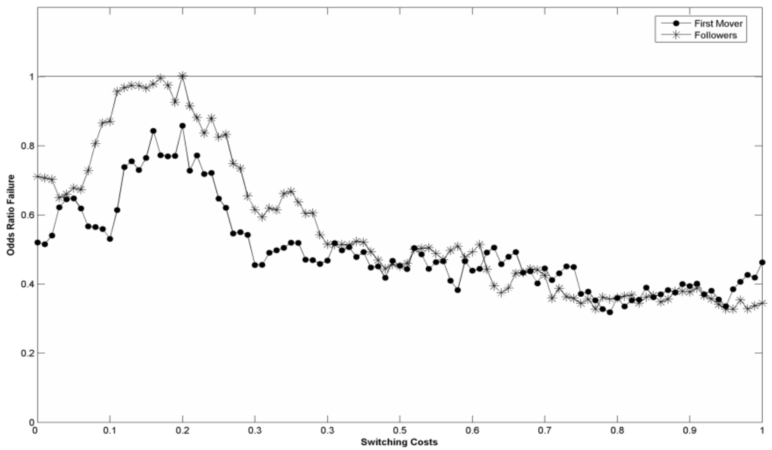

Figure 3. Failure-to-survival odds ratio for the first mover and the followers in a Schumpeter Mark I regime.

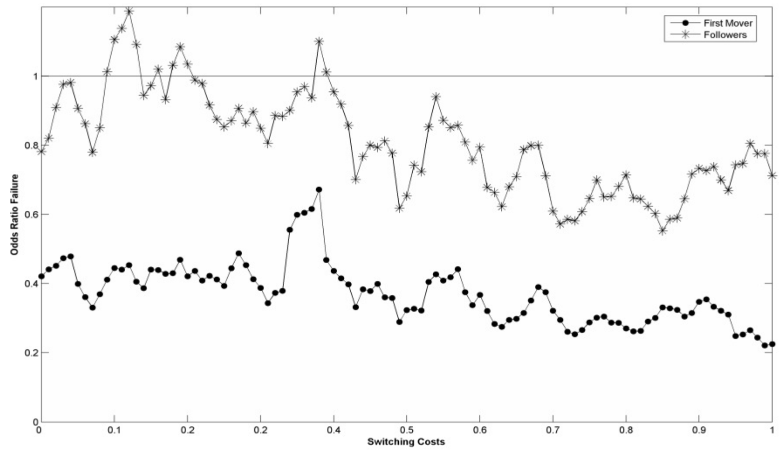

Figure 4. Failure-to-survival odds ratio for the first mover and the followers in a Schumpeter Mark II regime with External Knowledge.

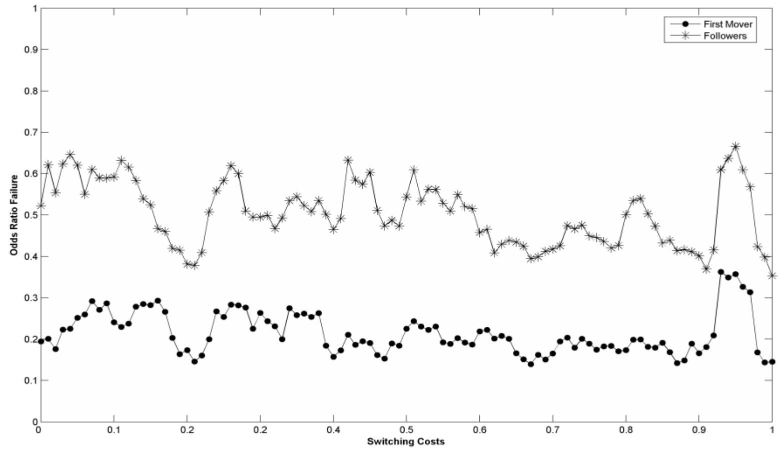

Figure 5. Failure-to-survival odds ratio for the first mover and the followers in a Schumpeter Mark II regime with Internal Knowledge.

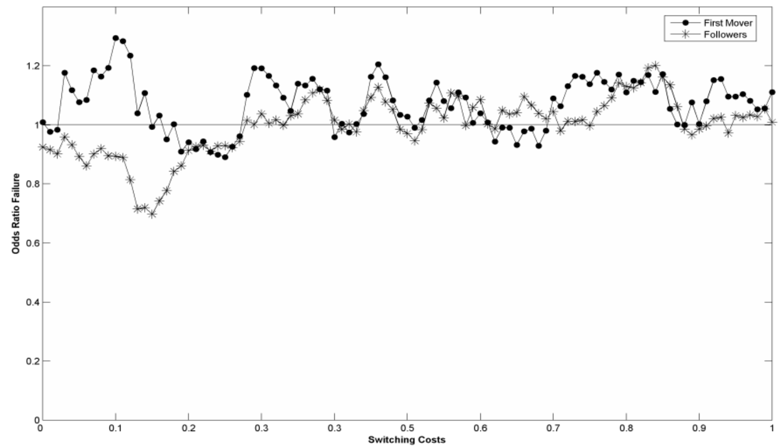

Figure 6. Failure-to-survival odds ratio for the first mover and the followers in a Schumpeter Mark I regime with Fragmented Demand.

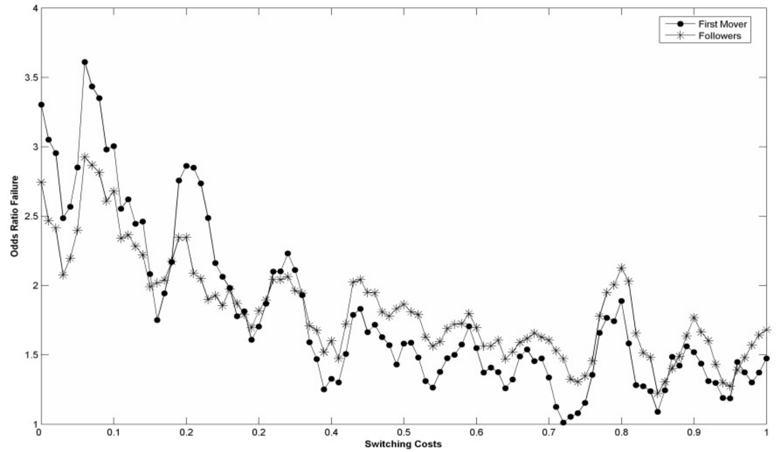

Figure 7. Failure-to-survival odds ratio for the first mover and the followers in a Schumpeter Mark II regime with External Knowledge and Fragmented Demand.

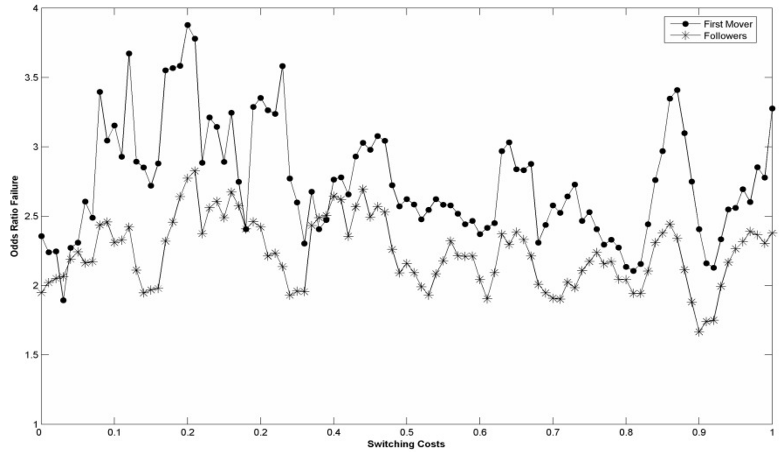

Figure 8. Failure-to-survival odds ratio for the first mover and the followers in a Schumpeter Mark II regime with Internal Knowledge and Fragmented Demand.

TABLES

Table 1
Focal Parameters

Regime	Demand Regimes		Technological Regimes			
	μ_H	μ_V	ξ	χ	γ	δ
Fragmented Demand	1	1				
Homogenous Demand	0	0				
Schumpeter Mark I			1	0	0	-
Schumpeter Mark II External Knowledge			0.1	1	1	0
Schumpeter Mark II Internal Knowledge			0.1	1	1	1

Table 2
General Relationship

	First Mover odds ratio	First Mover odds ratio	Followers odds ratio	Followers odds ratio
Switching Costs	-0.000271	-0.00211**	-0.00301***	-0.00672***
$(\text{Switching Costs})^2$		1.84e-05**		3.71e-05***
Constant	0.239***	0.270***	0.495***	0.556***
R-squared	0.016	0.067	0.590	0.651

Ordinary Least Squares
*** p<0.01, ** p<0.05, * p<0.1

Table 3
Fragmented Demand

	First Mover odds ratio	First Mover odds ratio	Followers odds ratio	Followers odds ratio
Switching Costs	-5.46e-05	0.00185	0.000640*	0.00264*
$(\text{Switching Costs})^2$		-1.91e-05		-2.00e-05
Constant	0.921***	0.890***	0.904***	0.871***
R-squared	0.000	0.005	0.031	0.052

Ordinary Least Squares
*** p<0.01, ** p<0.05, * p<0.1

Table 4
Homogeneous Demand

Technological Regime	First Movers: Threshold_PS	First Movers: Odds Ratio (SC = 0)	First Movers: Odds Ratio (SC = Threshold_PS)	Followers: Threshold_LE	Followers: Odds Ratio (SC = 0)
Any	0.14	0.1305	0.0173	0.08	0.1541
Schumpeter Mark I	0.13	0.1450	0.5214	0.09	0.1293
Schumpeter Mark II External Knowledge	0.16	0.0563	0.0001	0.09	0.5983
Schumpeter Mark II Internal Knowledge	0.06	0.0068	0.0074	0.06	0.0931

SC: Switching Costs; **PS:** Perfect Success of First Movers; **LE:** No Difference between followers and Late Entrants

Table 5
Schumpeter Mark I

	First Mover odds ratio	First Mover odds ratio	Followers odds ratio	Followers odds ratio
Switching Costs	-0.00336***	-0.00488**	-0.00625***	-0.00921***
$(\text{Switching Costs})^2$		1.52e-05		2.97e-05
Constant	0.667***	0.692***	0.873***	0.922***
R-squared	0.282	0.286	0.633	0.643

Ordinary Least Squares
*** p<0.01, ** p<0.05, * p<0.1

Table 6
Schumpeter Mark II – External Knowledge

	First Mover odds ratio	First Mover odds ratio	Followers odds ratio	Followers odds ratio
Switching Costs	-0.00196***	0.000373	-0.00368***	-0.00452
$(\text{Switching Costs})^2$		-2.33e-05		8.41e-06
Constant	0.469***	0.431***	0.994***	1.008***
R-squared	0.116	0.127	0.198	0.198

Ordinary Least Squares
*** p<0.01, ** p<0.05, * p<0.1

Table 7
Schumpeter Mark II – Internal Knowledge

	First Mover odds ratio	First Mover odds ratio	Followers odds ratio	Followers odds ratio
Switching Costs	-0.000409	-0.00180	-0.00103*	-0.00244
$(\text{Switching Costs})^2$		1.39e-05		1.41e-05
Constant	0.234***	0.257***	0.554***	0.578***
R-squared	0.012	0.021	0.032	0.036

Ordinary Least Squares
*** p<0.01, ** p<0.05, * p<0.1

Table 8
Schumpeter Mark I and Fragmented Demand

	First Mover odds ratio	First Mover odds ratio	Followers odds ratio	Followers odds ratio
Switching Costs	0.000286	-0.00123	0.00219***	0.00678***
$(\text{Switching Costs})^2$		1.51e-05		-4.59e-05**
Constant	1.056***	1.081***	0.888***	0.812***
R-squared	0.002	0.005	0.171	0.223

Ordinary Least Squares
*** p<0.01, ** p<0.05, * p<0.1

Table 9
Schumpeter Mark II – External Knowledge and Fragmented Demand

	First Mover odds ratio	First Mover odds ratio	Followers odds ratio	Followers odds ratio
Switching Costs	-0.0173***	-0.0512***	-0.0103***	-0.0268***
(Switching Costs)^2		0.000338***		0.000165**
Constant	2.676***	3.234***	2.361***	2.632***
R-squared	0.315	0.396	0.267	0.313

Ordinary Least Squares
*** p<0.01, ** p<0.05, * p<0.1

Table 10
Schumpeter Mark II – Internal Knowledge and Fragmented Demand

	First Mover odds ratio	First Mover odds ratio	Followers odds ratio	Followers odds ratio
Switching Costs	-0.00380	-0.00177	-0.00223	0.00294
(Switching Costs)^2		-2.03e-05		-5.17e-05
Constant	2.943***	2.910***	2.344***	2.259***
R-squared	0.011	0.011	0.016	0.022

Ordinary Least Squares
*** p<0.01, ** p<0.05, * p<0.1

Table A1
Index of Symbols

Symbol	Meaning	Type	Level (Indicator)	Value / Range
b	Financial resources for innovation	Variable	Team (j)	$\mathbb{R}_+$
C	Marginal cost of production	Parameter	General	1
C_1	Unit cost of search for new products	Parameter	General	50
C_2	Unit cost of improvement of existing products	Parameter	General	10
E	Market share threshold for exit	Parameter	General	0.05
$F(\cdot)$	Minimum quality requirements	Function	Consumers (i)	[0,1]
g	Indicator	Indicator	Group of consumers	$\{1,\dots,J_s\}$
h	Indicator	Indicator	Products, Teams	$\mathbb{N}_{++}$
i	Indicator	Indicator	Consumers	[0,1]
J	Number of potential products	Parameter	General	1000
J_f	Number of products of a firm	Variable	Firm	$\mathbb{N}_+$
J_s	Number of products in a submarket	Variable	Submarket	$\mathbb{N}_+$
j	Indicator	Indicator	Products, Teams	$\mathbb{N}_{++}$
k	Knowledge	Variable	Product (j), Industry (e)	$\mathbb{R}_+$
m	Market share	Variable	Product / Submarket (j/s), Firm /Submarket (f/s)	[0,1]
m^*	Market share for markup	Variable	Product (j)	[0,1]
n	New piece of knowledge	Variable	Product (j)	$\mathbb{R}_+$
p	Price of a product	Variable	Product (j)	$\mathbb{R}_{++}$
q	Quality of a product	Variable	Product (j)	[0,1]
q'	Increase in quality	Variable	Product (j)	[0,1]
R	Relatedness matrix	Parameter	Submarkets	[0,1]
S	Number of submarkets	Parameter	General	50
s	Indicator	Indicator	Submarkets	{1,…,S}
s_j	Main submarket of a product	Parameter	Product	{1,…,S}
T	Time-horizon of the industry	Parameter	General	100
t	Indicator	Indicator	Time	{1,…,T}
$U(\cdot)$	Propensity to purchase	Function	Consumers (i)	[0,1]
w	Markup	Variable	Product (j)	$\mathbb{R}_+$
X	Intercept of technological trajectory	Parameter	Product (j)	$\mathbb{R}$

Y	Growth of technological trajectory	Parameter	Product (j)	$\mathbb{R}_{++}$
Z	Symmetry of technological trajectory	Parameter	Product (j)	$\mathbb{R}$
z	Probability of improving existing product	Variable	Team (j)	[0,1]
$\hat{z}$	Updating element of z	Variable	Team (j)	{0,1}
$\mathfrak{C}$	Consumers	Variable	Product / Submarket (j/s), Product (j)	$\mathbb{R}_{+}$
$\hat{\mathfrak{C}}$	Potential consumers	Variable	Product / Submarket (j/s), Product (j)	$\mathbb{R}_{+}$
$\mathfrak{F}$	Number of firms in the industry	Variable	Industry	$\mathbb{N}_{+}$
$\mathfrak{G}$	Group of consumers	Variable	Submarket (g)	$\mathbb{N}_{+}$
α	Shape parameter of beta distribution	-	-	$\mathbb{R}_{+}$
β	Shape parameter of beta distribution	-	-	$\mathbb{R}_{+}$
γ	Cumulativeness of knowledge	Parameter	Focal	[0,1]
δ	Weight of internal knowledge	Parameter	Focal	[0,1]
η	Price elasticity of demand	Parameter	General	1.5
θ	Firms improvement capabilities	Parameter	Firm (f)	$\mathbb{R}_{+}$
λ	Weight of innovation in resources allocation	Variable	Firm (f)	[0,1]
μ_H	Horizontal fragmentation	Parameter	Focal	[0,1]
μ_V	Vertical fragmentation	Parameter	Focal	[0,1]
ξ	Level of opportunities	Parameter	Focal	(0,1]
Π	Profits	Variable	Product (j), Firm (f)	$\mathbb{R}_{+}$
ρ	Switching costs	Parameter	Focal	[0,1]
χ	Appropriability of innovations	Parameter	Focal	[0,1]

In the Right Place at the Right Time: Submarkets and Entry Timing Advantages in the US Comic Books Industry

Abstract

In this work, we investigate the role that submarkets play in the emergence of early movers and later entrants survival advantages in the US Comic Book industry from its inception in 1935 through 2005. Consistent with the past literature, we find evidence of survival advantages for early movers that is driven by density delay effects. Moreover, within each cohort of entrants, a fundamental determinant of survival is the focus on submarkets that dominate the industry in the same period. The same effect does not hold for incumbents competing in the same period and also for all the submarkets irrespectively of the industry era.

1. INTRODUCTION

Although a wide academic literature has flourished on this issue of first mover advantage in the last twenty years, there is still no conclusive empirical evidence either in favor or against it (Suarez and Lanzolla, 2007). A natural, obvious candidate to put on trial for this unpleasant situation is the empirical literature: Lieberman and Montgomery (1988) recognized its lack of precision as a problem, and VanderWerf and Mahon (1997) showed that many issues that plagued the field (including the endogeneity of first-mover opportunities, the sample selection bias, and measurement problems) had a strong impact on the findings. On the other hand, the existence of advantages accruing to firms entering very early in the history of an industry is an implications of many theories of industrial evolution: early entrants might benefit from R&D increasing returns to size (Klepper, 1996) or from a low competitive pressure in their formative years (Carroll and Hannan, 1989).

Recent works have focused attention on the role of moderating factors in the relationship between entry timing and different type of advantages. Several firms characteristics – including size, capabilities, experience and product strategies – have been investigated, while lower attention has been devoted to industry elements. Moreover, most of these variables are not within the choice set of the firms in the short run – and therefore they might not be useful in guiding managerial decisions.

The recent literature on industry evolution, instead, has focused on the dynamics of submarkets, that is groups of users that may differ in preferences, knowledge or needs (Sutton, 1998; Klepper and Thompson, 2006; de Figueiredo and Silverman, 2007).

In this work, we investigate the role that submarkets play in the emergence of early movers survival advantages in the US Comic Book industry. Moreover, we extend our analysis also to later entrants and we show that the choice to focus on specific submarkets in specific periods of time can affect in a fundamental way the survival chances of entrants.
In the next section we develop our working hypotheses; then we describe the empirical setting in which we are going to test them; the following sections include methods and results. Conclusions and limitations are provided at the end of the study.

2. BACKGROUND AND THEORY DEVELOPMENT

Survival advantage of early movers

Empirical studies on entry timing advantages can be divided in two main groups. The first group of studies has applied historical analysis to specific industries. Many of these studies showed the existence of first mover advantages in terms of market shares: Hurwitz and Caves (1988) found this result in the US pharmaceutical industry, even after patent expiration – when competition from generics should have washed out any advantage of patent holders; Bijwaard, Janssen, and Maasland (2008) found similar results in the European telecommunications industry by employing both static and dynamics models of market share; Gòmez and Maìcas (2011) confirm these results in the same industry by using both market shares and profitability. Some works have also considered international comparisons within the same industry: Mascarenhas (1992) explored the offshore drilling industry – an highly internationalized industry – in the era of semi-submersible rigs and showed the existence of market share advantages for early movers; Eggers, Grajek, and Kretschmer (2011) looked at the telecommunications industry in 30 countries and found evidence of first-mover advantages related to the technological or marketing capabilities of the firms. A well-known critique to this type of studies refers to the possibility that analyzed industries have been selected not randomly, but exactly because advantages for early movers could be expected (Kerin, Varadarajan, and Peterson, 1992; VanderWerf and Mahon, 1997). Still, there are works that suggest that this is not the case: Makadok (1992) tested entry-timing advantages in the money market mutual fund industry, a young, fragmented sector with low entry and imitation barriers – and it still found market-share advantages for first and early movers; Tufano (1989) showed that also in other segments of the financial industry early movers enjoy such an advantage, although coupled with an aggressive entry strategy. On the other hand, Lieberman (2007) found little evidence of entry-timing advantages in the Internet sector, where expectation were very high before the explosion of the dotcom bubble. Within the first group there are also studies that focus on survival effects rather than market shares: VanderWerf and Mahon (1997) found that using a dependent variable other than market share decreases the probability of finding entry-timing advantages – as it happens in the study by Mitchell (1991) about the diagnostic imaging industry: he found early movers advantages in terms of market share and disadvantages in terms of survival. Still, there are also many studies that find positive effects of early entry on survival, although coupled with experience or capabilities: these include the works by King and Tucci (2002) and Franco et al. (2009) on the disk drive industry, and by Bayus and Agarwal (2007) on the US personal computer industry.

The second group of empirical studies has focused on cross-sectional comparisons across different sectors. Early works in this group has found

evidence of market share advantages for first-movers in both consumers goods (Robinson and Fornell, 1985; Urban, Carter, Gaskin and Mucha, 1986) and industrial goods (Robinson, 1988) industries, by exploiting PIMS and ASSESSOR survey data. Golder and Tellis (1993, 1996) attributed these findings to an important methodological flaw: the survivor bias. By using historical analysis, they were able to identify the actual pioneers in over 50 product categories and they found that early market leaders, rather than pioneers, enjoyed an advantage. Recent studies using the PIMS data again have also found that by taking into account the costs disadvantages of a first-mover strategy the long-term effect of pioneering on profits is negative (Boulding and Christen, 2003, 2008). In general, we should expect to find less evidence of entry timing advantages in these comparative studies (VanderWerf and Mahon, 1997), but this mixed evidence might also depend on the definition of advantages related to the time of entry: while it is not clear whether being exactly the first to enter a market provides an advantage, there is wider consensus about the benefits of being early movers (Echambadi et al., 2008).
As a whole, the existing literature provides more support for the existence of entry timing advantages, especially when we refer to specific industries and to the whole group of early movers. Therefore, we put forth the following baseline hypothesis:

Hypothesis 1: Early movers have a survival advantage over later entrants.

The mechanisms of entry timing advantages

The theoretical literature on entry timing advantages has identified some “isolating” mechanisms that generate and protect early movers from the threats of later entrants (Lieberman and Montgomery, 1988; Suarez and

Lanzolla, 2007). First, pioneers can gain an advantage by achieving technological leadership: they can either exploit proprietary learning (Spence, 1981) or win patent races (Gilbert and Newbery, 1982). Second, they can preempt later entrants in the acquisition of scarce resources, that could include input factors (McMillan, 1983), geographical space (Hotelling, 1929), product space (Schmalensee, 1978) or capacity (Dixit, 1980). Third, early-movers may also exploit some characteristics of the consumers, such as searching and switching costs (Wernerfelt, 1985; Klemperer, 1995) or path-dependent preference formation (Carpenter and Nakamoto, 1989). More recently, network effects have also received some attention (Lieberman and Montgomery, 1998; Lieberman, 2007).

Population ecology literature provides an alternative framework in which early mover advantages can be conceptualized (Lambkin, 1988). The original theory developed by Hannan and Freeman (1977) considers population density – that is the number of alive firms – as a key driver of the evolution the industry. At low levels of density, an increase in the number of firms enhances the legitimization of the organizational form – and therefore it has a positive impact on survival; at high levels of density, legitimacy is already high and any further increase in density determines a tougher competition for scarce resources – which has a negative impact on survival. As a whole, the theory predicts a curvilinear effect of density on survival. Further refinements has broadened this theory to include also effects of density at founding: the density delay theory (Carroll and Hannan, 1989) claims that the conditions of an industry (and especially the density) when a firm is founded have a persistent effect on its survival chances. A young firm facing intense competition might devote too much time, attention and resources to immediate survival, neglecting the creation of organizational structures, routines and capabilities that are relevant for long-term success. Moreover, it could also develop a strong dependence on marginal or very specialized resources, and therefore experience higher risks of failure in case of unexpected shocks. Both mechanisms would lead to a negative effect of density at founding on survival. In a recent extension of the density delay theory, Dobrev and Gotsopoulos (2010) propose and test the hypothesis that low density at founding has a negative effective on survival, because of a legitimacy vacuum: new firms will develop routines that are aimed at gaining legitimacy, but that could prove harmful once the market is developed; moreover, they bear also higher risks of misaligned investments. Such a theory has a clear implication in terms of entry timing advantages: firms entering in the early, formative years of an industry will be more prone to experience legitimacy vacuum effects and therefore will have a survival disadvantage. On the other hand, there could also be industries in which legitimacy is already high in the very early stage, as it could benefits from strong perceptual similarity with already existing and may be related industries. In such a case, we would expect the existence of early mover advantages, as early entrants would not suffer from the legitimacy vacuum and could also avoid the "liability of scarce resources" and the "tight niche packing" generated by high density at founding. Moreover, it would also be possible to reconcile the findings by Carroll and Hannan (1989) – a negative effect of density at founding on survival – and those by Dobrev and Gotsopoulos (2010) – a positive effect of density at founding.

In our empirical setting – the US Comic Book Industry – none of the traditional mechanisms seems to be really at work. Learning curves or patents are not really relevant, as this is not an high-tech industry. Preemption of the product space is also very difficult: the characteristics of the product and its low average price allow consumers to buy several titles at the same time. Moreover, although character loyalty is very high, novelty is also very appreciated by comic book readers – and this reduces the impact that switching costs or network effects can have in this industry. On the other hand, for some historical reasons we will present later, the industry enjoyed since its formation an high level of legitimacy, which favored early entrants. As this appears to be the only mechanism driving entry timing advantages in this setting, we present the following:

Hypothesis 2. Once accounted for density at founding, early movers do not enjoy any survival advantage over later entrants.

Entry and the role of submarkets

Up to this point, we have focused on the different survival patterns that we could expect when firms are grouped according to their entry timing. Still, what are the firms that enjoy an advantage within the category of early movers is an open question. In the recent years there has been a growing attention towards the role that moderating factors could play in determining the entry timing advantages. Klepper and Simons (2000a) showed that among entrants in the TV receiver industry, firms with prior experience in the production of radios would enter earlier, and would also have lower hazard rates when compared with other early entrants. Bayus and Agarwal (2007) considered the importance of coupling entry timing and pre-entry experience with product technology strategies in the US personal computer industry: they found that choosing in the early stage a technology that will not become the standard in the industry will be much more harmful to inexperienced start-ups rather than to diversifying entrants – as they will have lower ability to migrate to the selected standard. Echambadi, Bayus and Agarwal (2008) found interesting moderating effects pertaining to both the firm level (size and experience) and the industry level (innovativeness): early entry provides an advantage to big experienced firms and a disadvantage to small start-ups, but these effects decrease in more innovative industries. Franco, Sarkar, Agarwal and Echambadi (2009) focused on the moderating effect of technological capabilities in the Rigid Disk Drive industry: they found that early entry is beneficial for firms that have high technological capabilities, but it can be harmful for less advanced companies.

All these factors have been considered as moderators for the relationship between entry timing and survival because they also play a more general role in the evolution of industries: size, experience and dominant design are key mechanisms behind the industry life cycle (Abernathy and Utterback, 1978; Klepper, 1996), and innovativeness and technology can be important determinants of the structure of industries (Klepper and Simons, 2000b). An element that has gained increasing attention in the studies about industry evolution is the dynamics of submarkets. Klepper and Thompson (2006) showed that the creation and the destruction of submarkets has been a fundamental driver in the evolution of the Laser industry, that for many years has followed a pattern not conforming to the traditional industry life cycle model. Bhaskarabhatla and Klepper (2009) developed a model that explains the recent shakeout in the Laser industry, showing that the most important determinant has been the dynamics of an old submarket increasing its importance and size with respect to the other submarkets of the industry. Buenstorf and Klepper (2010) found a similar pattern in the Tire industry, although in this setting the main role has been played by new submarket rather than by an old one. Fontana and Nesta (2006) showed that submarkets are also an important element that firms take into account in their entry decision in the LAN switch industry.

The growing literature on the role of submarkets in industry evolution may rise the question of whether they could be also important in determining entry timing effects. Existing studies showed that submarkets within an industry are not homogeneous: they can differ in size, growth potential, visibility, technological change, consumers tastes. Some of these characteristics may have positive effects on the survival chances of firms, others may have negative effects. Selecting the submarket with the right characteristics might be particularly important for young firms – as they are more prone to failure. The size of the submarket in terms of potential consumers should have a positive impact on the survival of new firms, as it would reduce the probability that a submarket could disappear and cause the exit of a firm. On the other hand, more consumers could attract more firms and generate tougher competition, reducing the probability of survival. In our empirical setting it is possible to consider the comic genres as submarkets and it also possible to identify the genres that were more successful among the readers over the decades – the "dominant" genres. Therefore, we put forth the following competing hypotheses:

Hypothesis 3a: Among early movers, the firms focusing on the dominant submarkets have survival advantages.
Hypothesis 3b: Among early movers, the firms focusing on the dominant submarkets have survival disadvantages.

The motivations behind Hypothesis 3 are actually not limited to early entry. If dominant genres change over time, then also entrants in the following periods could enjoy a similar advantage or suffer an analogous disadvantage. Moreover, they could also benefit from the emergence of completely new submarkets – because of the lack of competition by incumbent firms. Therefore, we will also test the following competing hypotheses:

Hypothesis 4a: Among each cohort of entrants, the firms focusing on the dominant submarkets have survival advantages.
Hypothesis 4b: Among each cohort of entrants, the firms focusing on the dominant submarkets have survival disadvantages.

3. THE US COMIC BOOK INDUSTRY

The US comic book industry provides an ideal setting for testing our hypotheses about entry timing advantages and submarkets. First of all, it is possible to define submarkets in a precise way by exploiting the existence of genres. A genre is a well defined space within the industry: the creators and the readers of a comic book share the categories defining its genre, such as the style, the language, the key elements of the plot. Genres may also be combined – but this could be a very risky undertaking, as readers have precise expectations and could easily reject a product that does not meet them. Second, it is possible to obtain detailed data about the entry and the exit of firms and products by exploiting the cover dates of comic issues. Third, the peculiar history of the industry allows us to identify different cohorts of entrants without turning to arbitrary selection of thresholds.
The main issue about our data concerns the beginning of the industry. Taylor and Greve (2006) report the 1897 as the starting point of the industry, referring to the publication *The Yellow Kid* as the first American

book. Actually, Coville (2003) reports the existence of a much older comic book, dating back to 1842: *The Adventures of Obadiah Oldbuck*, the reprint of an English translation of the strips created by a Swiss author. On the other hand, all the comic book published until the early 1930s – including *The Yellow Kid* – were just reprints of non-original materials from newspapers strips. The first all-original comic publication was *The Funnies,* a "short-lived newspaper tabloid insert" published by Dell Publishing Company in 1929 (U.S. Library of Congress, 2010). It took still some more years to get the publication of a comic book containing no reprints and completely independent from newspapers: it was *New Fun*, published by National Allied Publications in 1935.

Choosing a moment for setting the birth of the industry between 1842 and 1935 is not an easy task, as the what is currently considered as a comic book evolved over this long time. In our opinion, the separation from newspapers and the publication of all-original content are two basic requirements to define the birth of the comic book industry: the first requirement is necessary to distinguish the demand for comics from the demand for newspaper – as it was probably the latter to drive the choice to buy the bundled product; the second element is important to keep a coherent selection rule over time – as we dropped from the sample all special editions, anthologies and reprints. On the other hand, we admit that this definition leaves out the formative stage of the industry: this is why we think this could be a good setting to test our second hypothesis. In 1935, readers were already aware of the existence of comic books; moreover, distribution channels were developed, and even formats were quite well standardized – essentially, many of the problems related to the lack of legitimacy were not an issue anymore for the young firms that started publishing the comic books.

The four ages of the comics industry

The period that goes from the mid 1930s to 1954 goes under the name of Golden Age of the Comic Books. It was characterized by the wide popularity of funny animal comics (such as Walt Disney's characters) classified within the Anthropomorphic genre, teen and more generally Comedy humor, and Science Fiction comics. The end of the Golden Age was marked by the formation of the Comics Magazine Association of America in September 1954, and the establishment of Comics Code Authority some months later. The Authority, a self-regulatory body, banned several topics and scenes - including violence, blood, drugs, horror and sex – from comic books, fulfilling the social and political requests and giving rise to the Silver Age. The enforcement, although not complete, was quite strict, as many distributors refused to sell comics that were not approved by the Authority. This institutional change had a strong impact on the structure of the industry: some of the genres (Horror, Crime, Adult) were almost completely driven out of the market, while others emerged as dominant ones, especially the Super-Heroes and the Fantasy. On the other hand, the limitations imposed by the censorship contributed to the creation of a new genre, Underground comics, that flourished through unconventional channels and where all the themes thrown out of the official market could find fertile ground.

The end of the Silver Age and the advent of the Bronze Age were triggered by another institutional change – the breaking of the Code by one of the biggest firms in the industry (Marvel) supported by the Department of Health and Education in a story about drug abuse. The story was well received in the market – and determined both a change of the Code and a reduction of the power of the Authority. The Bronze Age

saw the emergence of different genres, in particular the entry of Japanese Manga comics and a growing importance of the Non-Fiction genre.
Finally, the last age in the Comics industry is known as the Modern Age or also the Dark Age. The shift between the Bronze and the Dark age is less clear-cut than the previous ones, but it can be placed in the late 1980s. As the name suggests, this era is dominated by darker tones and scenarios (as in the Mystery genre); moreover, a tendency to mix different genres gained acceptance among the consumers. A notable feature of this age has also been the boom in collectible comics that ended in a massive market glut and a strong shakeout in the late 1990s. The entry process, still, started again in the first decade of the 21^{st} century (see Figure 1).

4. METHODS

Our data include the population of US Comic Books publishers from 1935 to 2005. We extracted the data from Comicbase, a comic book collection software including a detailed database with information about specific issues, titles, publishers and authors of comic books. Although not all the issues ever published in the US are included in the database, we have information on virtually all the titles – that correspond to products. For each title, we coded as entry date the cover date corresponding to the first issue and as exit date the cover date corresponding to the last issue. We excluded from the analysis all types of special editions, reprints, and all the books within the Anthology genre, because potentially misleading for the analysis of survival. We then aggregated data at the firm-month level. We tried to account as possible for changes in the name of titles and in the name of firms. The resulting data include 2010 firms and 59826 firm-month observations.

Dependent Variable

Our dependent variable is the timing of firm exit from the industry. We consider firm exit to occur in period t if the firm has no titles in the following 5 years. We consider such a long period to take into account a specificity of the US comics industry, that is the existence of many independent publishing companies owned by or strictly related to an artist/author: these companies may stay silent for a long time because of lack of resources, while the artist works for bigger companies, and then come out again as soon as it is possible to bear the costs of the new endeavor (Koesoema, 2012). Acquired companies are not dropped from the data if they keep publishing using their brand name.

Independent Variables

Entry Time is defined by referring to the cover date of the first issue of the first title published by the firm. We use this variable to define four dummy variables, mutually exclusive, for each of the Ages of the industry: a dummy variable takes value "1" the Entry Time is within the range of the corresponding age, and "0" otherwise. A firm is defined as an incumbent in a certain era if it was an entrant in one of the previous eras.

Density at Founding (N_0) is measured as the number of firms in the industry in the period in which entry occurs.

Dominant Genres are coded for each of the four ages: in the Golden Age the key genres are Anthropomorphic, Comedy and Science Fiction; in the Silver Age: Super-Heroes, Fantasy and Underground; in the Bronze Age: Manga and Non-Fiction; in the Modern Age: Mystery and Mixed Genres. A firm that has the majority of its titles in one of the dominant genres of the age takes a value “1” in the corresponding dummy variable (GenresGA, GenresSA, GenresBA, GenresMA) and “0” otherwise.

Control Variables

Control variables include dummies for the *current age* (they take value “1” if the observation is in a period within the age span), *contemporaneous organizational density* (measured as the number of firms currently in the industry) both as a linear term and as a squared term, *number of titles* (which is a proxy for size), *number of genres* in which the firm has at least one title (a proxy for scope), *genres specialization* (measured through an Herfindahl index over genres shares in the firm’s portfolio of titles) both as a linear term and as a quadratic term, and two more variables that control for the extent of licensed titles in the firm’s portfolio (*licensed*) and for the average number of genres covered by each title (*multiple genres*).

Genres are already coded in the Comicbase database: they include Action, Adult, Anthropomorphic, Comedy, Crime, Drama, Fantasy, Horror, Manga, Mystery, Non-Fiction, Art Book, Religious, Romance, Science Fiction, Sports, Super-Heroes, Underground, War, Western. We dropped the Anthology and the Licensed genres. This variable gets value “1” if the firm has at least one title in that genre in the current period, and “0” otherwise.

Estimation

In order to test our hypotheses we use discrete-time survival models (Jenkins, 2005). Although the size and the monthly frequency of our database would allow us to use also continuous time techniques, we chose the discrete time specification because of the underlying structure of our entry and exit data: since we coded entry and exit by referring to comic books issues – that are in the countable domain – there is an high probability of observing grouping of failures, especially in the first month. This is also the reason why we chose a very flexible specification for modeling the baseline duration dependence: during the first year we have a non-parametric specification (a dummy for each month), then we include a dummy for each year from 2 to 5, a dummy for next five years period and finally a dummy for all the following periods. Unfortunately the data do not allow a fully non-parametric specification. Some other specifications of duration dependence have been tried, but results are not affected – but in the case of a quadratic function, where convergence was not reached (as it clearly does not fit the data).

We assume that the hazard rate satisfies the proportional odds specification, which yields the logistic hazard model:

$$\log\left[\frac{h(j,X)}{1-h(j.X)}\right] = \alpha_j + \beta' X \qquad (1)$$

where α_j has the following specification:

$$\alpha_j = \sum_{m=1}^{12} \gamma_m + \sum_{y=2}^{5} \delta_y + \theta_1 + \theta_2 \qquad (2)$$

where γ_m is a dummy that takes value "1" when j = m , δ_y is a dummy that takes value "1" when j is between 13 and 60, θ_1 is a dummy that takes value "1" when j is between 61 and 120, and θ_2 is a dummy that takes value "1" whenever j is higher than 120.

The vector X include all independent and control variables according to the model that has to be estimated.

5. RESULTS

We start by presenting non parametric estimates of the survivor function obtained using the Kaplan-Maier estimator. Figure 2 presents the estimates for the whole population: the strong steepness of the function in the earliest periods signals an high mortality rate for very young firms – that somehow justifies the choice of specifying in a fully flexible way the duration dependence along the first year. Figure 3 presents different survivor functions for each cohort of entrants: while entrants in the Bronze and Modern age have lower survival rates at any time period, entrants in the Silver age in some periods perform even better than firms entering the Golden age – implying no advantage for early movers. The historical account of the industry, still, suggests a different interpretation of this patterns, as entrants in the Golden Age may have experienced problems from the introduction of the Comics Code Authority in 1954 and entrants in the Silver Age could have benefited from the loosening of the code in the early 1970s. A regression analysis, where such conditions can be taken into account, is therefore needed.

Table 1 shows the baseline models. In Model 1 we present just the pattern of duration dependence: as expected, the first month has by far the worst impact on survival justifying our non-parametric specification. In Model 2 we include also the control variables: the positive and significant coefficient for the Silver Age signals that the reduction of resources and freedom generated by the censorship had a strong negative impact on survival. It is also worth to notice the strong and positive impact of size (*Number of Titles*) on survival and the contemporaneous density effects: as the legitimization of the industry is already high along the whole period under analysis, the density is dominated by the competition effect, which has a negative impact on survival, although at a slightly decreasing rate.

In Table 2 we test the first two hypothesis: in Model 3 we observe that the coefficient for all the cohorts are negative and significant, signaling a survival advantage of the first three cohorts over entrants in the Modern Age (the reference category); moreover, all the coefficient are in the right order, which means a stronger advantage for Golden age entrants (-1.69), then for entrants in the Silver age (-1.41) and finally for Bronze age entrants (-0.54). All together, these results support Hypothesis 1. In Model 4 we test Hypothesis 2 by including also density at founding variables (both a linear and a quadratic term): as predicted, the coefficients of all the entry cohorts variables become non-significant. The new variables have the expected signs: positive for the linear term and negative for the quadratic term. The early mover advantage is strictly linked to the low density and low competition in the early periods of the industry, and firms do not suffer from any legitimacy vacuum.

In order to test Hypotheses 3 and 4, we introduce interactions between the cohorts dummies and the dominant genres in each age. All the interacting variables have negative and significant coefficients: entrants in each cohort have lower hazard rates if they focus on the dominant genres of their age (Table 3).

Robustness checks

The first objection that could be raised to our findings is that dominant genres in each era could be important not only for entrants in that era, but for all firms in the industry. In order to verify whether this is the case, we include also interactions for incumbent firms with the dominant genres: if dominant genres matter for all firms, we should observe significant coefficients for all the variables. Model 7 in Table 4 shows that this is not the case: the interaction terms including entrants are all still significant, and the only significant term including incumbents refers to the Silver age. This outcome signals again the importance of the censorship during that period: in fact, as some genres were actually prohibited also incumbents could benefit from a shift towards safer areas.

On the other hand, this result is not robust to the next check. In fact, a second objection that could be raised concerns the importance of specific submarkets over the whole evolution of the industry: if that is the case, we should observe different results by including in the analysis a dummy that signals the dominant submarket of the firm in each period. Model 8 shows that a sustained focus on some genre (Sports, Minor genres, and even Underground) is actually deleterious for survival; on the other hand, the interaction coefficients between entry cohort and dominant genres are all still negative and significant.

More technical robustness checks have also been performed. We run all the analysis by using a complementary log-logistic hazard model, and results do not change (Table 5 compares the relevant variables in Model 8 with this specification).

6. DISCUSSION AND CONCLUSIONS

In this paper we tried to combine different theoretical perspectives to explain the dynamics of entry and exit in the US Comic Books industry, but also to contribute to the more general debate on the evolution of industries.

First of all, our work contributes to the first mover advantage literature. We show that even when the isolating mechanisms identified in the past are not at work, firms can obtain an advantage from early entry because of density delay effects: entry when competition is not very intense and the market is not too crowded is important not only because of the preemption of resources, but also because it allows firms to build a more sustainable growth path. An important choice in this industry is about the submarkets (the genres) that a firm will focus on: choosing a genre that is going to be very diffused across readers can give firms an important survival advantage – that more than offsets the potential threat of tougher competition. This leads us to our second contribution to this literature, that concerns the role of moderating factors. Recent works have emphasized that entry timing advantages may accrue only to firms that are able to grasp the opportunity, maybe because of pre-entry experience (Klepper and Simons, 2000), technological capabilities (Franco et al., 2009), or size (Echambadi et al., 2008). All these elements are somehow outside the set of choices available to the firms in the short run. On the other hand, entry timing advantages may also depend on factors that the firm can choose together with the time of entry, such as product technology strategy (Bayus and Agarwal, 2007). We believe that the focus on specific submarkets might be another important variable that early entrants should take into account: being in the right place at the right time could prove of the utmost importance for their survival. Moreover, our results show that this should be also a concern for later entrants, especially when industry conditions change, either for exogenous or for endogenous reasons.

Our third contribution is to the population ecology literature and to the recent developments of the density delay theory. Our findings reconcile the original predictions of the theory (Carroll and Hannan,1989) of a negative effect of density at founding on survival and the results obtained by Dobrev and Gotsopoulos (2010) in their analysis of the US Automobile industry, that show a positive effect of density at founding on survival, when density is low, because of a legitimacy vacuum effect that persists over time. The US Comic Books industry provides an empirical setting in which legitimacy is already high at the dawn of the industry: as a consequence, we expected and found only a negative effect of density at founding on survival. It is an interesting feature, though, that the tests originally provided by Carroll and Hannan (1989) include several newspapers industries, that share some characteristics with our setting.

Clearly, this work has some limitations. Data merging has been as accurate as possible, given the their characteristics; still, further refinement is needed. In particular mergers and acquisitions should be taken explicitly into account in our analysis, possibly by complementing our data with different sources of information about the industry.

Second, a more precise definition of dominant submarkets is necessary. Although historical records support our ideas, it should be possible to exploit our database to investigate the dynamics at the submarket level, in order to understand whether density effects are driving the results also here.

The recent development of the industry evolution literature shows a growing attention towards the role of submarkets and their internal dynamics in shaping the competitive and innovative patterns of wider sectors. Future work should extend these insights to different empirical settings.

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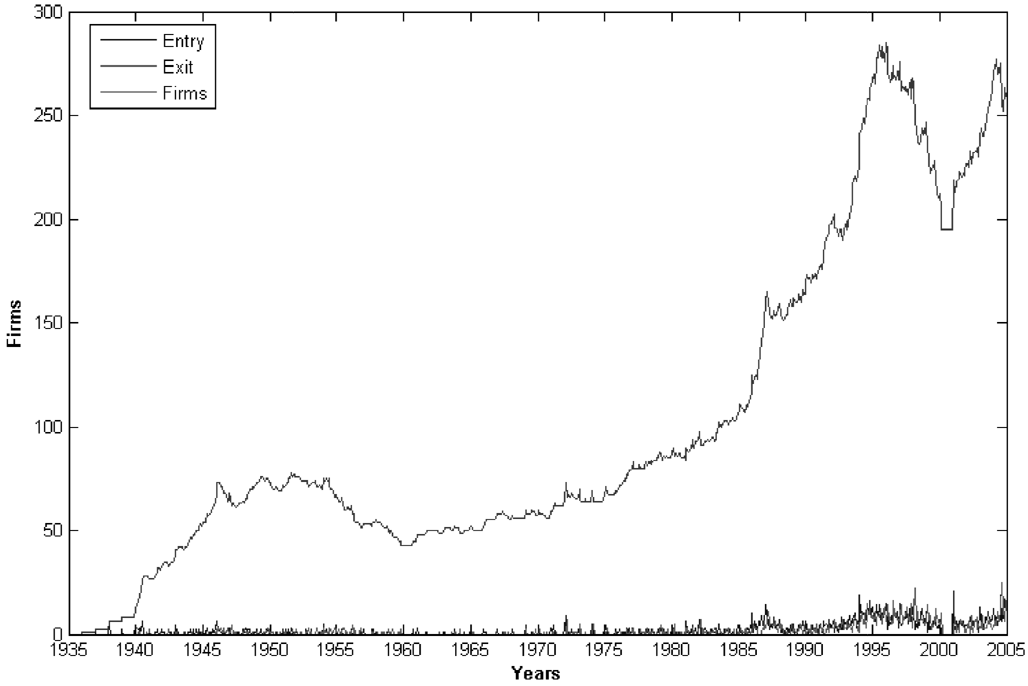
FIGURES


Entry
Exit
Firms
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Years
300
250
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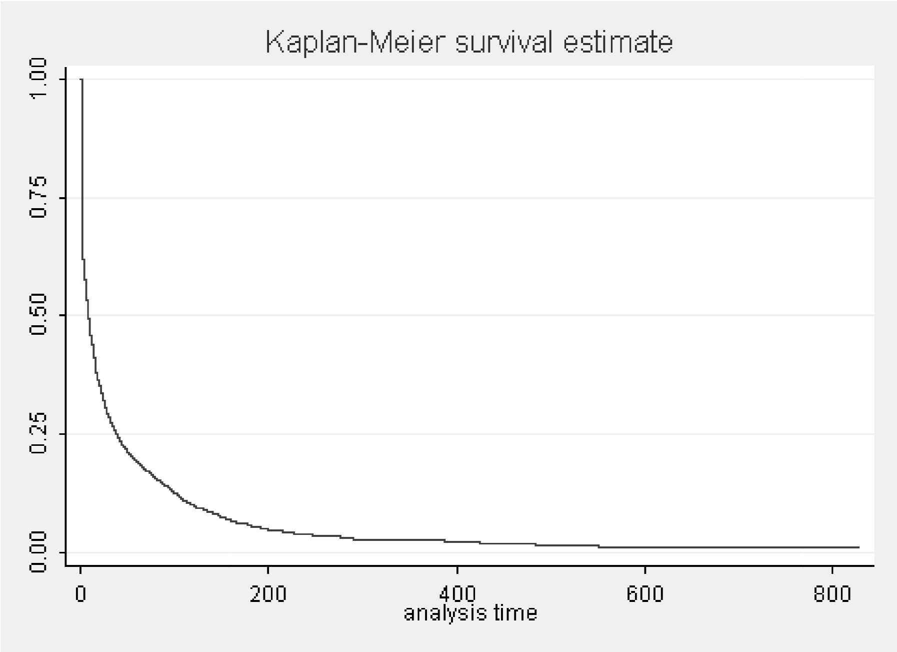
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0.75
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200
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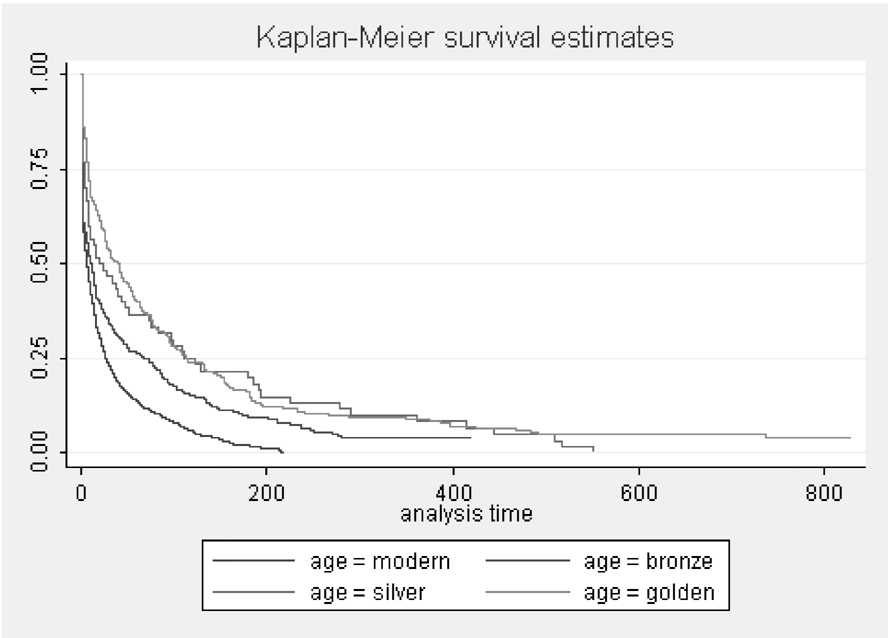
analysis time


Kaplan-Meier survival estimates
1.00
0.75
0.50
0.25
0.00
0
200
400
600
800
analysis time
age = modern
age = bronze
age = silver
age = golden

TABLES

Table 1. Duration dependence and baseline models: Logistic Hazard Model.

VARIABLES	Model 1		Model 2	
Month 1	-0.587**	(0.0465)	-0.0457	(2.338)
Month 2	-3.005**	(0.145)	-2.429	(2.343)
Month 3	-3.139**	(0.158)	-2.538	(2.344)
Month 4	-3.046**	(0.154)	-2.415	(2.343)
Month 5	-2.925**	(0.150)	-2.286	(2.342)
Month 6	-3.125**	(0.168)	-2.467	(2.343)
Month 7	-2.780**	(0.147)	-2.112	(2.342)
Month 8	-3.156**	(0.181)	-2.480	(2.345)
Month 9	-3.184**	(0.186)	-2.491	(2.345)
Month 10	-3.016**	(0.176)	-2.317	(2.344)
Month 11	-3.375**	(0.212)	-2.656	(2.348)
Month 12	-3.386**	(0.217)	-2.657	(2.348)
Year 2	-3.322**	(0.0677)	-2.512	(2.338)
Year 3	-3.623**	(0.0921)	-2.696	(2.339)
Year 4	-3.926**	(0.117)	-2.940	(2.339)
Year 5	-4.170**	(0.140)	-3.164	(2.341)
Years 6-10	-4.291**	(0.0798)	-3.231	(2.340)
Year 11-more	-5.046**	(0.0927)	-3.783	(2.339)
Golden Age (GA)			0.396	(0.227)
Silver Age (SA)			0.734**	(0.253)
Bronze Age (BA)			0.316*	(0.138)
Specialization (S)			-5.114	(4.858)
S^2			3.570	(2.920)
Number of Titles			-0.679**	(0.0956)
Number of Genres			-0.425	(0.350)
Licensed			-0.255*	(0.116)
Multiple Genres			0.179	(0.254)
Density (N)			0.0200**	(0.0035)
N^2			-4.02e-05**	(8.3e-06)
Observations	59,826		59,826	
Log-Likelihood	-6717.53		-6362.58	

Standard errors in parentheses
** p<0.01, * p<0.05

Table 2. Impact of Entry Cohort and Density at Founding: Logistic Hazard Model.

VARIABLES	Model 3		Model 4	
Month 1	1.144	(2.438)	0.935	(2.449)
Month 2	-1.235	(2.442)	-1.445	(2.454)
Month 3	-1.344	(2.443)	-1.554	(2.455)
Month 4	-1.220	(2.442)	-1.429	(2.454)
Month 5	-1.090	(2.442)	-1.300	(2.453)
Month 6	-1.272	(2.443)	-1.480	(2.454)
Month 7	-0.915	(2.441)	-1.122	(2.453)
Month 8	-1.281	(2.444)	-1.487	(2.456)
Month 9	-1.291	(2.444)	-1.497	(2.456)
Month 10	-1.115	(2.444)	-1.320	(2.455)
Month 11	-1.452	(2.447)	-1.655	(2.458)
Month 12	-1.452	(2.447)	-1.655	(2.459)
Year 2	-1.300	(2.438)	-1.497	(2.449)
Year 3	-1.468	(2.438)	-1.648	(2.450)
Year 4	-1.703	(2.439)	-1.869	(2.450)
Year 5	-1.913	(2.440)	-2.051	(2.452)
Years 6-10	-1.940	(2.440)	-2.039	(2.451)
Year 11-more	-2.200	(2.446)	-2.090	(2.457)
Golden Age (GA)	1.779**	(0.514)	1.238*	(0.535)
Silver Age (SA)	1.535**	(0.511)	0.901	(0.537)
Bronze Age (BA)	0.665**	(0.169)	0.595**	(0.170)
Specialization (S)	-6.805	(5.049)	-7.032	(5.074)
S^2	4.561	(3.026)	4.671	(3.040)
Number of Titles	-0.669**	(0.0952)	-0.653**	(0.0950)
Number of Genres	-0.543	(0.364)	-0.567	(0.366)
Licensed	-0.221	(0.117)	-0.248*	(0.117)
Multiple Genres	0.181	(0.254)	0.179	(0.255)
Density (N)	0.0180**	(0.00360)	0.00700	(0.00494)
N^2	-3.84e-05**	(8.52e-06)	-1.78e-05	(1.1e-05)
Incumbent SA	0.735	(0.472)	0.567	(0.472)
Incumbent BA	0.405	(0.466)	-0.139	(0.488)
Founded GA	-1.693**	(0.467)	-0.849	(0.514)
Founded SA	-1.405**	(0.434)	-0.537	(0.486)
Founded BA	-0.539**	(0.132)	-0.253	(0.149)
N at Founding (N0)			0.0126**	(0.00405)
N0^2			-2.17e-05*	(9.4e-06)
Observations	59,826		59,826	
Log-Likelihood	-6341.55		-6332.88	

Standard errors in parentheses
** p<0.01, * p<0.05

Table 3. Impact of Dominant Genres: Logistic Hazard Model.

VARIABLES	Model 5		Model 6	
Month 1	0.870	(2.441)	0.831	(2.445)
Month 2	-1.510	(2.445)	-1.548	(2.450)
Month 3	-1.619	(2.446)	-1.657	(2.451)
Month 4	-1.495	(2.446)	-1.531	(2.450)
Month 5	-1.365	(2.445)	-1.401	(2.449)
Month 6	-1.546	(2.446)	-1.580	(2.450)
Month 7	-1.188	(2.445)	-1.221	(2.449)
Month 8	-1.552	(2.448)	-1.584	(2.452)
Month 9	-1.562	(2.448)	-1.597	(2.452)
Month 10	-1.386	(2.447)	-1.420	(2.451)
Month 11	-1.721	(2.450)	-1.756	(2.454)
Month 12	-1.721	(2.451)	-1.757	(2.455)
Year 2	-1.565	(2.441)	-1.594	(2.445)
Year 3	-1.716	(2.442)	-1.740	(2.446)
Year 4	-1.939	(2.442)	-1.954	(2.446)
Year 5	-2.121	(2.443)	-2.128	(2.448)
Years 6-10	-2.112	(2.443)	-2.114	(2.447)
Year 11-more	-2.160	(2.449)	-2.107	(2.453)
Golden Age (GA)	0.956	(0.552)	0.857	(0.547)
Silver Age (SA)	0.880	(0.534)	0.709	(0.544)
Bronze Age (BA)	0.590**	(0.171)	0.438*	(0.171)
Specialization (S)	-6.785	(5.059)	-6.194	(5.071)
S^2	4.532	(3.033)	4.063	(3.041)
Number of Titles	-0.663**	(0.0958)	-0.684**	(0.0968)
Number of Genres	-0.536	(0.365)	-0.525	(0.368)
Licensed	-0.226	(0.117)	-0.257*	(0.118)
Multiple Genres	0.192	(0.255)	0.466	(0.268)
Density (N)	0.00754	(0.00496)	0.00621	(0.00500)
N^2	-1.90e-05	(1.14e-05)	-1.62e-05	(1.15e-05)
Incumbent SA	0.376	(0.476)	0.380	(0.479)
Incumbent BA	-0.177	(0.487)	-0.232	(0.494)
Founded GA	-0.500	(0.536)	-0.462	(0.533)
Founded SA	-0.552	(0.482)	-0.242	(0.512)
Founded BA	-0.265	(0.150)	-0.172	(0.160)
N at Founding (N0)	0.0113**	(0.00410)	0.0121**	(0.00416)
N0^2	-1.87e-05*	(9.51e-06)	-2.00e-05*	(9.65e-06)
Founded GA * Genres GA	-0.525**	(0.205)	-0.726**	(0.213)
Founded SA * Genres SA			-0.747*	(0.303)
Founded BA* Genres BA			-1.500**	(0.301)
Founded MA * Genres MA			-0.448**	(0.123)
Observations	59,826		59,826	
Log-Likelihood	-6329.34		-6300.93	

Standard errors in parentheses
** p<0.01, * p<0.05

Table 4. Robustness cheks – Incumbency and Genres: Logistic Hazard Model

VARIABLES	Model 7		Model 8	
Month 1	0.872	(2.466)	-0.717	(2.848)
Month 2	-1.505	(2.471)	-3.083	(2.852)
Month 3	-1.615	(2.472)	-3.191	(2.852)
Month 4	-1.488	(2.471)	-3.065	(2.852)
Month 5	-1.359	(2.470)	-2.931	(2.851)
Month 6	-1.538	(2.471)	-3.107	(2.852)
Month 7	-1.178	(2.470)	-2.751	(2.851)
Month 8	-1.542	(2.473)	-3.110	(2.854)
Month 9	-1.553	(2.473)	-3.115	(2.854)
Month 10	-1.376	(2.472)	-2.932	(2.853)
Month 11	-1.712	(2.475)	-3.269	(2.856)
Month 12	-1.712	(2.476)	-3.271	(2.856)
Year 2	-1.551	(2.466)	-3.091	(2.848)
Year 3	-1.696	(2.467)	-3.210	(2.848)
Year 4	-1.911	(2.467)	-3.412	(2.850)
Year 5	-2.088	(2.469)	-3.570	(2.851)
Years 6-10	-2.074	(2.468)	-3.564	(2.851)
Year 11-more	-2.077	(2.475)	-3.561	(2.858)
Golden Age (GA)	0.911	(0.555)	1.079	(0.561)
Silver Age (SA)	0.733	(0.553)	0.926	(0.563)
Bronze Age (BA)	0.504**	(0.191)	0.577**	(0.191)
Specialization (S)	-6.246	(5.114)	-4.211	(5.712)
S^2	4.090	(3.065)	2.986	(3.361)
Number of Titles	-0.693**	(0.0972)	-0.688**	(0.109)
Number of Genres	-0.525	(0.371)	-0.503	(0.373)
Licensed	-0.265*	(0.118)	-0.178	(0.121)
Multiple Genres	0.410	(0.274)	0.526	(0.282)
Density (N)	0.00606	(0.00505)	0.00811	(0.00511)
N^2	-1.60e-05	(1.16e-05)	-2.11e-05	(1.18e-05)
Incumbent SA	0.615	(0.483)	0.586	(0.489)
Incumbent BA	-0.133	(0.500)	-0.0550	(0.508)
Founded GA	-0.508	(0.539)	-0.514	(0.548)
Founded SA	-0.254	(0.520)	-0.198	(0.530)
Founded BA	-0.225	(0.173)	-0.209	(0.173)
N at Founding (N0)	0.0122**	(0.00425)	0.0139**	(0.00433)
N0^2	-2.01e-05*	(9.84e-06)	-2.31e-05*	(1.00e-05)
Founded GA * Genres GA	-0.762**	(0.218)	-0.535*	(0.236)
Founded SA * Genres SA	-0.782**	(0.305)	-0.896**	(0.312)
Founded BA * Genres BA	-1.486**	(0.301)	-1.342**	(0.323)
Founded MA * Genres MA	-0.398**	(0.134)	-0.325*	(0.142)
Incumbent SA * Genres SA	-1.111*	(0.535)	-0.872	(0.543)
Incumbent BA * Genres BA	-0.645	(0.633)	-0.458	(0.646)
Incumbent MA * Genres MA	0.214	(0.251)	0.303	(0.256)
Action / Adventure			0.126	(0.173)
Adult			0.156	(0.199)

Anthropomorphic		0.250	(0.193)
Comedy		-0.169	(0.176)
Crime		0.268	(0.211)
Drama		0.0128	(0.209)
Fantasy		-0.234	(0.176)
Horror		0.282	(0.181)
Manga / Anime		0.324	(0.241)
Mystery		-0.0318	(0.245)
Non-Fiction		-0.180	(0.211)
Pin-Ups / Art Book		0.306	(0.250)
Religious		0.465	(0.326)
Romance		0.214	(0.247)
Science Fiction		0.00968	(0.173)
Sports		1.066*	(0.438)
Super-Heroes		0.239	(0.169)
Underground		0.738**	(0.196)
War		0.0558	(0.258)
Western		0.181	(0.257)
Others		0.411*	(0.169)
Observations	59,826	59,826	
Log-Likelihood	-6297.14	-6246.13	

Standard errors in parentheses
** p<0.01, * p<0.05

Table 5. Robustness checks: Proportional Hazard Model (Cloglog)

VARIABLES	Model 9 Cloglog	Model 8 Logistic
N at Founding (N0)	0.0139**	0.0139**
N0^2	-2.36e-05*	-2.31e-05*
Entrant Genres GA	-0.547*	-0.535*
Entrant Genres SA	-0.861**	-0.896**
Entrant Genres BA	-1.351**	-1.342**
Entrant Genres MA	-0.279*	-0.325*
Incumbent Genres SA	-0.878	-0.872
Incumbent Genres BA	-0.507	-0.458
Incumbent Genres MA	0.306	0.303
Action	0.126	0.126
Adult	0.168	0.156
Anthro	0.238	0.250
Comedy	-0.150	-0.169
Crime	0.260	0.268
Drama	0.00527	0.0128
Fantasy	-0.214	-0.234
Horror	0.263	0.282
Manga	0.300	0.324
Mystery	-0.0438	-0.0318
Non-Fiction	-0.115	-0.180
Art-Book	0.283	0.306
Religious	0.475	0.465
Romance	0.191	0.214
Science Fiction	0.0191	0.00968
Sports	0.937*	1.066*
SuperHeroes	0.216	0.239
Underground	0.672**	0.738**
War	0.0741	0.0558
Western	0.152	0.181
Others	0.380*	0.411*
Observations	59,826	59,826
Log-Likelihood	-6250.13	-6246.13

Control variables are not reported
but were included in the regression
Standard errors in parentheses
** $p<0.01$, * $p<0.05$