Firm age and the probability of product innovation
Do CEO tenure and product tenure matter?[1]

Abstract

This paper examines how firm age contributes to the probability of product innovation in Italian manufacturing firms. We distinguish the different role played by variables related to the CEO tenure and to the lifecycle of the last product introduced. Our analysis reveals that the new entrants' high innovative activity rests on the new CEO's innovation propensity, which is strictly dependent on the CEO tenure, whereas mature firms' declining innovation activity almost disappears when the role of the product lifecycle and long-tenured CEOs are considered. Consequently, the existence of a general negative relationship between innovation and firm age is questioned, as the presence of different "ages" in the company life — that is, product age and CEO tenure — makes the relationship positive. Finally, the innovative behaviour of incumbent companies appears to be dependent on the renewal ability of newly-appointed CEOs who come from outside the company, whereas the role of family CEOs appears less important for the innovation activity of the firm.

Keywords: Product innovation, firm age, CEO tenure, product tenure, product lifecycle, industry lifecycle

---

[1] Paper presented at the Conference ""The Governance of a Complex World"", track "Firm age and Performance" – 18-20 Jun 2014, Collegio Carlo Alberto, Turin (Italy).

Firm age and the probability of product innovation
Do CEO tenure and product tenure matter?

1. Introduction

The probability of introducing new products according to the firm age is a crucial topic in Industrial Economics, as it sheds light on the dynamics of industries and firm lifecycles (Huergo & Jaumandreu, 2004; Malerba, 2006; Agarwal and Gort, 2002; Sutton 1997). Following an established line of empirical research, Huergo & Jaumandreu (2004a) (henceforth HJ2004a) show that the probability of product innovation changes along the firm life. In their results, a downward-sloping line connects the probability of innovation to firm age: young firms are prone to innovate, whereas, the oldest ones propend to innovate less than the entrants. However, this result only fits firms that have entered the market within 15–20 years (entrants) and for firms older than 35–40 years (mature incumbents), whereas, for firms aged 20 to 40 years, the probability of innovation (i.e., the introduction of new products) is positively associated with firm age.

The motivation behind this evidence can be traced back to a selection effect, as good innovators do not exit the market in the first decades of their lifecycle, or surviving firms belong to markets with a special propensity to innovate (HJ2004a). However, the role of other time-varying variables that affect firm performance is partly overlooked in this approach, as also the significant nonlinearity in the probability of innovation for firms aged between 20 and 40 years. The purpose of the present study is to present empirical evidence which shows that splitting firm age in different components may contribute to explain the changes in the probability of innovation of incumbent firms over time.

The basic idea consists in modelling the changing profile of the product innovation–age relationship by taking into account three different age-related variables affecting the decision to introduce a new product: firm age, product age, and tenure of the chief executive officer (CEO). These three different — and overlapping — types of ages have different impacts on the probability of innovation. As for the firm age, the resource-based theory shows that it affects the ability of the firm to develop and accumulate resources and competences, thus providing the basis for the generation of new waves of products (Barney, 1991; Penrose, 1959). Likewise, the age of the last product introduced (product tenure) mirrors the firm's learning ability at the product level (Schoot, 2004; Bernard et al, 2010), as well as the dynamics of the product lifecycle, conditional on the structure of the existing product portfolio (Agarwal and Gort, 2002; Bernard et al, 2010). Finally, the "tenure" of the CEO, that is, the time elapsed since the last CEO change, summarises the impact of the renewal ability of the new CEO on the innovative performance of the company (Miller, 1991; Miller & Shamsie, 2001; Levinthal & March, 1993; Kuratko and Audretsch, 2009).

By integrating a unique dataset on product innovation and firm governance with company accounts, over the period 2000–2010, the article shows that the probability of product introduction does not always decrease with firm age. The negative innovation–age relationship found in other studies, and also in this dataset, turns positive when the product lifecycle and the CEO tenure are taken into account. Specifically, we find that incumbents are not worse that entrants in introducing a new product when the CEO tenure (that proxies for his willingness to innovate), and the product tenure (that proxies for the product portfolio lifecycle) are used to moderate the basic firm age-product innovation relationship.

This study makes three contributions to literature. First, it supports the hypothesis that the high probability of innovation observed by HJ2004a in firms of intermediate age, that is those ageing from 20 to 40 years, is closely related to the changes that occur in their governance structure and to the dynamic of the product portfolio. When the impacts of CEO changes and product lifecycle are taken into account, the former non-linear relationship between firm age and product innovation is significantly reduced, and its slope becomes positively oriented. Second, the innovation activity of young firms (i.e., firms younger than 20 years) is significantly moderated by the innovation propensity of new CEOs, as well as by short product lifecycles in very innovative markets or high-tech industries. Controlling for these two variables permits to not only explain a large part of the intense innovative activity of the entrants, but also the supposedly poorer innovation propensity in mature companies, when the strategic inertia of long-tenured CEOs is controlled for. Third, product innovation and succession interact during the company life, and the time interval between these two events affects the innovation activity significantly. Short-tenured CEOs come out as the most valuable drivers of the innovation activity of the company, with a more important role for external CEOs than family CEOs.

The rest of the article is organised as follows. Section 2 summarises the literature background of the study. Section 3 presents the empirical analysis, which includes the data and empirical model taken from HJ2004a. Section 4 briefly discusses the role of the innovation-CEO change time gap, to explain the probability of innovation, and Section 5 concludes.

2. Product tenure, CEO tenure, and innovation

The traditional perspective on firm growth treats each firm as producing a single product and as being run by a single entrepreneur (Kirchoff, 1994; Goldberg, 2009). This approach, which can be traced back to the dominant theories of the firm (the neoclassical economic theory, the transaction cost theory, and the behavioural theory of the firm, Stam, 2007) — has a major drawback, as it does not consider how different types of ages affect the age-innovation relationship.

Additionally, micro-level empirical studies on firm performances fail to consider the multi-product nature of the growth process, as they typically postulate a perfect overlap between the product, the firm and the entrepreneur. A notable exception to this pattern is the recent study by Bernard, Redding and Schott (2010) and Goldberg et al (2009), suggesting that product mix changes represent a potentially important channel through which firms grow by moving resources from less to more efficient uses within firms.

Despite its extensive use in the theoretical and empirical literature, the single-product approach to firm growth has two major drawbacks. On the one hand, it neglects the dynamic structure of the process of product innovation. Over time, firms create additional innovations and focus on generating a continuous stream of products, as a means of achieving growth: "the process of innovation and entrepreneurship are one and the same only when the process is carried out by a small firm early in its life" (Kirchoff, 1994; page 62). On the other hand, it fails to take into account the changing nature of the "entrepreneurial orientation" of the company over time (Miller 1991), which acts as a moderator of the probability of the firm to introduce new products. Therefore, the CEO change and the CEO tenure are crucial variables to understand if and how a new product can be developed and introduced, thus making the change in the decision-making process of the company a crucial variable to explain the probability of innovation.

In a sense, both product tenure and CEO tenure may be crucial variables affecting the decision to introduce a new product. Firms are more likely to introduce a new product when the lifecycle of the existing products approach maturity, or when a new product does not grow after the initial launch. Similarly, CEOs may have different "seasons" in their professional lifecycle, during which they may be more prone to innovate — for example, at the beginning of their activity in the company, — or more resistant to change. Also, as change may involve risk, the distinction between family and non-family (external) CEOs may also provide background motivations to study the introduction of a new product.

2.1 Product age and product innovation

It is well recognised that a firm's innovative activity can be proxied by the release of a new product by the firm.[2]

---

[2] I do not directly tackle the question of innovativeness either for the market or for the firm. However, the specification of the empirical model indirectly reflects these properties, which actually determine the adoption by consumers and the product tenure in the market (Barlet et al., 2000).

Traditional models of firm growth restrict the analysis to one firm–one product. Starting with Jovanovic (1982), firm dynamics has been explained through firm heterogeneity, as captured by the size and age of the firm. However, when we assume multi-product firms, the firm age and product age can vary greatly, and firm age is not sufficient for representing firm specificity. Also, a simple product-count approach hardly describes the true dynamic innovative activity of the company that manifests in a succession of new products, with very different market destinations, technological contents and lifecycles.

Therefore, accounting for product-specific characteristics, such as product tenure, can provide a more complete model of firm dynamics. In accordance with this perception, the extant empirical literature failed to find a robust correlation between the simple introduction of a new product and firm performance (Becheikh et al., 2006), and overlooked the call for a more fine-grained analysis of the implications of product portfolio composition on the probability to innovate.

The use of the market tenure of the latest introduced product, that is, the years that have passed since the product has been launched into the market, is more revealing. Product tenure is a crucial variable to understand the innovation propensity of a firm, as it is able to capture the position of the product in its lifecycle, or the peculiar characteristics of the new goods, such as its novelty and complexity. Recent evidence on the product lifecycle shows that different stages of the lifecycle are characterised by very different cost and price conditions, as well as different consumer sensitivities to price, and in turn, product acceptance (Golder and Tellis, 2004). Therefore, only looking at the firm age may hide the significant contribution of the product age to the understanding of the learning process behind the introduction of each product and the general innovation process (Geroski, 2002).

Besides assessing the existence of the product lifecycle, the tenure of the last product introduced also permits to control for the possible heterogeneity of impact, pattern and duration of different new goods on the decisions inherent in the product portfolio (Burgel et al., 2002; Schott, 2004; Bernard et al. 2010; Moral and Jaumandreu 2007). The interaction between the firm and product attributes, such as product tenure, correspond to include the “quality aspects” in the measurement of the output from the innovation effort, because the tenure may reflect properties of the product (degree of newness, latest design, prestige or good reputation, product quality) that affect consumers’ preference and valuation. Thus, the tenure of the latest product can help in accounting for the heterogeneous intrinsic attributes of products in terms of technological and economic value, which would otherwise be obfuscated under the mere count of (potentially) highly differentiated new products. This requirement has been widely acknowledged (Tether, 1998; Loof and Heshmati, 2006), and product tenure is recognised as a crucial product characteristic that is strictly connected to a strategic decision on the firm’s own product portfolio (Bernard et al., 2011; Schott 2004; Moral and Jaumandreu, 2007).

Controlling for the tenure of the last product introduced in the product portfolio is useful for other reasons as well. It has been suggested that the difficulty in ascertaining the link between new products and firm performance may be due to the fact that innovations could exert different and opposite effects on a firm’s performance, according to its degree of newness and complexity, with reference to demand conditions and technological opportunities (Cefis and Marsili, 2011; Loof and Heshmati, 2006). Some new products are characterised by short product lifecycles. It is the case of innovations that are market driven, as in the case where a new product is required by the market (Barlet et al., 2000). Similarly, short product lifecycles are increasingly typical for high-tech industries, where old products frequently signal out-of-date and superseded designs (Klepper, 1996; Burgel et al., 2002; Gopalakrishnan and Bierly, 2006). In these cases, product maturity is reached far before the expected time, and the need for new product introduction is anticipated. On the contrary, for very innovative products, there is a dominating “inertia effect” (Barlet et al., 2000). In such cases, products are accepted by the market at a slow pace. This makes the product lifecycle curve to shift rightwards, as the startup phase is abnormally long and the growth phase is delayed in time. Also, in the exploitation of a particular good (Economides, 1996; Das, 1995), the network externalities on the demand side may shift the product lifecycle further rightwards, and lengthen the time taken for new products to reach maturity (Klepper and Graddy, 1990).

Finally, product tenure also allows to disentangle the learning abilities at the firm and product levels, the former being summarised by firm age and the latter by product age (Bernard et al. (2007). New products express the firm’s technical development capabilities; they are skills and knowledge that have turned into profitable goods (Deeds, 2001). The appearance of a new good can itself be regarded as a way of learning, and assuming a cumulative process for knowledge endowment, a multiplicity of goods may mirror a higher stock of knowledge (Cohen and Levinthal, 1990; Geroski et al., 1997; Geroski and Mazzucato, 2002). Geroski and Mazzucato

(2002) stress the role of new products as a learning mechanism for the company, and Geroski (2005) as the mechanism behind the dynamic of core competencies. In both cases, if products are mechanisms of learning, product tenure may summarise the manner in which product-specific competencies develop, accumulate and then become obsolete, and that may induce the firm to introduce a new product. Product tenure may summarise how firm capabilities embedded in the product portfolio may become increasingly less valuable to company performance or how they are quickly and easily imitated by competitors.

2.2 Organisational age, CEO age and innovation

Several studies have examined the manner in which age influences strategic choices and company performance over time (Jovanovic, 2001; Levesque and Minniti, 2006; Marshall et al., 2006; Sorensen and Stuart, 2000). This literature shows that firms do not perform uniformly over their lifecycle. On the one hand, experience fosters a firm's performance, as competence-enhancing activities implied by ageing favour the implementation of established routines (Acemoglu et al., 2006), or allow firms to better recognise and exploit new technological opportunities (Cohen and Levinthal, 1990). On the other hand, ageing can negatively affect a firm's performance because of inertia (Miller and Shamsie, 2001): success induces firms to codify their approach with proper organisation and processes. This behaviour seems to increasingly entangle firms in structural and process-related rigidities that are difficult to shed (Leonard-Barton, 1992) and induces them to ignore the innovation signals from the marketplace (Agarwal and Gort, 2002).

Since long, economists have considered the impact of the process of organisational ageing on the behaviour of firms and have found several reasons why inertia and age may be connected with each other (Jovanovic, 2001). Reinganum (1983) shows that an incumbent may not be interested in investing on new product development as intensely as a new entrant, because if it succeeds it would merely augment its market position. As a result, older firms are likely to show some inactivity as they age. Inertia may be also induced by deliberate actions of company insiders: as managers grow older, they become more reliant on their own sources of information for making decisions, more conservative, less likely to take risks, and less flexible in handling conflict (Marshall et al. (2006). Jovanovic (2001) argues that older owners and managers may become progressively less aligned to external conditions as these move away quite significantly from their fields of expertise. Grossman and Shapiro (1982) model a choice of specialisation that may lead the firm into a "competency trap", in which the accumulation of production experience exacerbates the decline in the organisation–environment fit. Sorensen and Stuart (2000) argue that over time firms may become better at performing routines that are increasingly less valued by the environment, thus deteriorating the organisation–environment fit and company performance.

On the other hand, ageing may benefit company performance if it allows firms to better recognise and exploit the potential of new technological opportunities in the related areas (Cohen and Levinthal, 1990; Rubenson et al, 1996), or to benefit from the previous competence building efforts (Abernathy and Utterback, 1978; Sorensen and Stuart, 2000). Furthermore, the competence-enhancing activities implied by organisational ageing may also favour a cumulative effect of established routines, thus increasing the appeal of the existing courses of action (Stinchcombe, 1965).

Age plays a crucial role when industries vary in the degree to which firm performance is determined by learning from a direct operating experience or "learning-by-doing" (Balasubramanian and Lieberman, 2010). In a model of active learning, in which firms change their pre-entry strategy choices in response to market feedback, Geroski (1995) argued that the growth and survival prospects of firms depend on their ability to learn about the environment and to link their ongoing strategy to the changing environment. Likewise, dynamic effects related to learning and experience play an important role in explaining the efficiency differences across firms (Jovanovic, 1982; Ericson and Pakes, 1995). However, despite the extensive research, the impact of organisational age on performance is still controversial.

The literature on CEO tenure — as complementary to the organisational age — is more revealing, as the performance outcome of the company may also mirror the changing performance of CEOs through their lifecycle. Therefore, both firm performance and its strategic approach may be modelled by the way in which CEOs lead the company over time.

Hambrick and Fukutomi (1991) and Miller and Shamsie (2001) show that tenure (and experience) may initially boost the firm performance, as externally hired CEOs have competences that are aligned with environmental conditions and they possess clear ideas about how to manage their role. Then eventually, they may become overly committed to the earlier formulae and find it difficult to execute new plans. This causes their performance to decline with tenure (Miller, 1991). In addition, ageing may also lead entrepreneurs to become averse to uncertainty, which makes them wary of taking the effective entrepreneurial decisions they once took (Van Praag 2003).

Besides, CEO tenure is indicated as being the most important antecedent of strategic changes, a feature that includes the decision to introduce a new product (Karaevli & Zajac, 2013; Finkelstein, Hambrick & Cannella 2009; Quigley & Hambrick, 2012; Miller, 1991; Miller & Shamsie, 2001). As long-tenured CEOs increasingly narrow their perspectives and become less open-minded, firms led by long-tenured CEOs may continue to follow the existing directions (Hambrick & Fukutomi, 1991). Therefore, strategic changes are most likely when a new CEO is appointed, and the likelihood of change gradually decreases as the CEO remains in the current position (Quigley & Hambrick, 2012; Hambrick & Fukutomi, 1991; Miller & Shamsie, 2001). Changes in the structure and composition of the product portfolio are among the most relevant strategic changes a new CEO is expected to bring on.

Therefore, the shorter a CEO’s tenure is, the less likely the CEO will be to commit to the status quo. Executives with a long tenure in the current position tend to have strong adherence to the status quo, and inhibit innovation (Finkelstein & Hambrick, 1990; McClelland, Liang, & Baker, 2010). Also, long-tenured CEOs tend to refine their existing knowledge, as opposed to learning new skills. Novel product designs, fresh marketing campaigns, and new strategic directions are more likely during this stage, which are essentially an exploration (Levinthal & March, 1993). Moreover, short-tenured CEOs are found to generate greater technological output, suggesting that CEOs with a short tenure are more likely to explore new possibilities and introduce innovation (Wu, Levitas and Preim 2005).

In this sense, CEO succession has often been indicated as an inertia breaker, as leader turnovers provide a periodic opportunity for organisations to break out of their inertial paths (Karaevli & Zajac, 2013; Pfeffer and Salancik, 1978) and to amplify the likelihood of change (Miller, 1991). Also, company management can improve over time as new generations of motivated CEOs join the company and adopt superior managerial tools and practices (Bloom and Van Reenen, 2008), or bring into the company new resources and competencies, thus sustaining the strategic renewal which may lead to product innovation (Quigley & Hambrick, 2012; Fernández and Nieto 2005).

3. Empirical analysis

3.1 Methodology

The paper uses the empirical approach developed by HJ2004a. It links the probability of product introduction to age, and estimates (cross-section/over time) the following probability model (HJ2004a):

$$P(y_{it} = 1 | x, \tau) = E(y_{it} = 1 | x, \tau) = x_{it}\beta + \vartheta(\tau_{it}) \quad (1)$$

where y is a 1/0 variable indicating product innovation, x is a vector of control variables, which includes product tenure and CEO tenure, τ_{it} is the age of the firm and ϑ is an unknown function linking probability to firm age. In the estimates we control for the product tenure and CEO tenure to take into account the impact of the product portfolio strategy and managerial inertia on product innovation. Following HJ2004a, β can be estimated using the non-parametric estimates (using the kernel regression Nadaraya–Watson estimator) of the conditional expectation functions of (1), which can then be used to recover the unknown ϑ.

3.2 Data

The dataset has been built by matching two complementary sources: a cross-sectional survey, collected directly from companies through a questionnaire-based interview, and a dataset with the financial data of the companies.

For the survey, we selected a large set of non-farm, non-service companies in the Italian manufacturing sector. The survey was restricted to four Italian regions that shared some common features in the organisation of the industry (presence of "Made in Italy" industries and an extensive presence of industrial districts), even if the stage of development in each region differed slightly from that in the others. The major industry specialisations included mechanical industry, fashion (clothing and footwear), wood and wooden furniture, and manufactured plastic products.

Information covered by the survey gave information on the (i) firm's age, (ii) the number of products in the portfolio, the year in which each product had been introduced and its detailed code of classification (five-digit Nomenclature of Economic Activities (NACE) Classification and Ateco 2007), (iii) the year in which the CEO had changed and the type of CEO (family or external). This information permitted the description of the temporal profile of the innovation activity as related to the firm age, product tenure and CEO tenure. As for the financial dataset, the accounting data, with reference to interviewed firms, were available from 2000 to 2010, from AIDA - Analisi Informatizzata delle Aziende - Bureau van Dijk.[3]

3.3 Summary statistics

Statistics for the complete sample, broken down by region, industry and other relevant variables, are summarised in Table 1. The largest share of firms is in the mechanical industry, which accounts for 48.2% of the sample firms, whereas the traditional sectors (food, textile and clothing, footwear, wood and furniture) account for the remaining 37.6%. Almost three firms out of four have less than 50 employees. The firm age distribution presents a large share of firms born between 1970 and 1990 (about 65%), whereas the share of firms born before 1970 is 14.7%. Figure 1 — Panel A presents the distribution of firms by age, and compares the distribution in this sample with the HJ2004a sample.

---

[3] The AIDA - Bureau van Dijk DATABASE is an authoritative and reliable source of information on Italian companies. Information is drawn from the official data recorded at the Italian Registry of Companies and from the financial statements filed at the Italian Chamber of Commerce. Companies furnish data on a compulsory basis. The information provided includes company profiles and summary of the financial statements (balance sheet, profit and loss accounts, and ratios). Each company's financial statement is updated annually. Additional information on the AIDA Bureau van Dijk database can be obtained from http://www.bvdinfo.com.

[Table 1 about here]

[Figure 1 about here]

The distribution of innovative firms, that is, firms that have introduced at least one new product, shows that older firms have a high propensity to innovate, as the share of innovative firms born before 1980 (64.7%) is higher than the share of firms of the same age in the sample (45%). Figure 1 — Panel B presents the distribution of the product tenure and the CEO tenure in the sample firms. In addition to the large share of new products of less than three years, the product tenure has an inverted u-shaped distribution, with a modal class at 22–24 years and a noticeable decrease in the frequency of older products. The CEO tenure peaks in the class 8–10 years, and then declines significantly.

3.4 Descriptive statistics on product tenure and CEO tenure

Figure 2 Panel A displays kernel estimates of the relationship between product innovation and the tenure of the last product introduced. The high probability of innovation associated with a short tenure of the last product (0 to 8-10 years) suggests either the presence of highly innovative industries, or short lifecycles in the product life on account of very competitive markets. After a decline for up to 15 years of tenure, the probability of the introduction of new products rises again from 20 to 40 years. This evidence is consistent with a last-product lifecycle whose growth phase peaks at about 20 years and, after that date, gives way to maturity and decline. Because of this, the probability of the introduction of a new product starts to rise.

Panel B of Figure 2 describes the relationship between the introduction of a new product and the CEO tenure. This relationship monotonically decreases with the CEO tenure, with a probability that tends to weaken immediately after the tenth year and then declines for very long tenures. Taken together, these pieces of evidence show that product lifecycle and CEO tenure are two variables that potentially affect the decision of product introduction, and that their role within the innovation decision process may vary with tenure.

[Figure 2 about here]

3.5 The role of industry

3.5.1 Industry lifecycle

Lifecycles of the industry affect the characteristics of demand and the rate and form of technical change (Agarwal and Gort, 2002; Malerba, 2006; Krafft & Ravix, 2008). As the market evolves to maturity, the technological opportunities decline and innovation progressively shifts to minor product refinements and cost reduction (Karlsson & Nystrom, 2003). Also competition intensifies as the competitive focus is on imitation rather than pure innovation, as in the infancy phase of the industry lifecycle (Karniouchina et al, 2013). Most importantly, the distribution of new product innovations between new and incumbent firms may change over the lifecycle, with consequences for the innovation probability of different cohorts of firms (Agarwal and Gort, 2002; Krafft, 2004). Also, the propensity of product innovation may be consistent with a highly recursive view of the industry lifecycle, where transitions are not unidirectional from earlier to later phases, but are back and forth mainly between growth and maturity, suggesting that industries are successful at adding bumps to the lifecycle prior to decline (Ekaterina et al., 2013). All these considerations stress on the importance to control for the phase of the industry lifecycle in the decision to introduce a new product. Table 2 and Figure 3 present probabilities of product introduction and kernel regression of product innovation by the industry phase. Lifecycle phases have been computed using the data on entry and exit in the Italian manufacturing industry, for the period 1995–2010. A total of 22 NACE 2-digit sectors have been considered: this is the finest disaggregation of the business demography of the Italian manufacturing industry. The phases have been identified as those time intervals for which the Agarwal and Gort (2002) definition applies, with phases being delineated on the basis of the gross entry rate per year. The phases reported in Table 2 and Figure 3 are: (1) initial low entry; (2) increasing entry rate; (3) decreasing, although still high entry; (4) low entry; and (5) erratic pattern of gross entry, which characterises the maturity of the lifecycle. From Figure 3, the probability of product innovation is significant in lifecycle phase 1 (initial low entry), it peaks in phase 2 (increasing entry rate) and then declines progressively in the maturity and decline phases. The structure of the industry lifecycle in terms of gross entry rate also impacts the innovation activity at the industry level, with product innovation clearly concentrated in the early phases of industry evolution. Also, the mean values of firm age by phase show that mature firms are also present in the early phases of the industry lifecycle, thus suggesting that these firms are active innovators even among new industries.

[Figure 3 about here]

[Table 2 about here]

3.5.2 Technological intensiveness

While the intensity of competition is captured by the lifecycle phase, industries also vary in technological intensiveness (Agarwal and Gort, 2002). To take this aspect into account, we rely on the distinction between firms that operate in Industry of Manufacture (IOM) sectors and in Sectors of Use (SOU) sectors, as illustrated by the OECD Technology Concordance Report (Johnson, 2002).[4] The IOM group includes those sectors whose patenting rate is larger than the median score of the total industry distribution, that is, patent-producing sectors, according to the definition introduced by Johnson (2002). Conversely, the SOU group includes those sectors that mainly use patents produced by some other sectors.

The distinction between the SOU an IOM sectors provides a practical approach to considering the potential impact of the technological intensity of the industry on the decision to introduce a new product. If the patents are more frequently inventions rather than innovations (Coombs et al., 1996; Flor and Oltra, 2004), belonging to the IOM indicates that the firms have proved to be efficient in the inventing activities, but

---

[4] The OECD Report (Johnson, 2002) separately maps patent categories into the economic sectors responsible for their creation (IOM index) and their subsequent use (SOU index). Although IOM represents the innovative activity within each sector, the SOU index measures the share of the total patents that are used in each sector, regardless of whether it is the sector that produced the patent. The OECD index is calculated by classifying the patents (by nationality of the applicant) for six major applicant nations — including Italy — in the EPO database in 1998.

they are not as efficient as the innovators, or that the patents have scarce business value. On the contrary, as firms in the SOU sectors decide to bear the cost of patent acquisition because of its perspective commercial exploitation, the impact of product introduction can be larger as a result of a deliberate strategy and a successful business plan. Overall, these results signal that innovation may have different features, and that patents — as a measure of technological intensity — and new products can have a very loose relationship, even if they are both assumed to be proxies for the innovation activity.

3.5.3 Industry Demand

In addition to the role played by the industry lifecycle, short-term trends in the industry demand may be crucial drivers of the decision to introduce a new product. Industry demand — as proxied by the industry turnover — is an ideal candidate to control for the role of an external condition on firm-level decisions, as it affects individual firms, but is — to a large extent — beyond the control of individual firms. As a proxy for the sectoral industry demand, we used the Eurostat Annual Turnover Index, which is a business cycle indicator provided by Eurostat, showing the evolution of the market of goods and services in the industrial sector. It records the evolution of turnover over longer periods of time and measures the market activity in the industrial sector in value. The industry breakdown is done by 101 3-digit NACE sectors, and the indicator is split into the Domestic Turnover Index (DTI) and Foreign Turnover Index (FTI). The choice to select a highly disaggregated index of industry sales originates from the risk of using the aggregate industry data: if the industry classification is too crude to account for the relevant market of the firm, the estimated sensitivity parameters may have a substantial downward bias, very similar to a measurement error.

3.6 Empirical results

The results of the estimates for the entire sample are presented in Tables 3 and 4, and the estimated age functions are shown in Figure 4. The estimates in Table 3 include a set of time dummies, industry dummies, the size of the product portfolio (number of products) and a dummy for the stock of patents. Table 4 summarises the impact of other control variables at the industry level, as well as two firm-level variables — that is, product tenure and CEO tenure — which are supposed to affect the product innovation decision.[5]

[Table 3 about here]

Time dummies reflect the effect of the absence of a relevant year effect in the decade: product innovation comes up as a decision rooted in the company structure, with a limited impact of external conditions, except for specific cases, as in the early 2000s and the period before the 2008 crisis. As for the firm size, product innovation is significant in smaller firms and medium-size firms, whereas larger firms are less innovative. Patenting is positively associated with product innovation, as firms with no patents show a low probability to introduce a new product, and a larger stock of patents correlates to a higher propensity to innovate (Le Bas & Poussing, 2012).

[5] Following the Suits (1984) method, the set of dummy coefficients adds to zero (HJ2004a).

However, despite being positive for all patent classes, the probability is significant only for the class of firms with one patent, thus indicating a very close patent–new product relationship in the sample. Also, this evidence is consistent with the assumption that patents are more effective in supporting incremental innovation rather than new products in multi-patent companies. The range of probability differences ascribed to patents is sizeable (.179) and it is almost completely due to the patenting status of the company, that is firms having one patent versus firms having none. As for the product portfolio, the probability of innovation increases with the size of the existing product portfolio, thus suggesting that scale economies in the management of product portfolio may exist, or that organisational learning in product introduction help innovation over time. Finally, industry dummies show that the most innovative sectors are rubber and plastic, industrial machines, other transportation vehicles (yachts in particular), and miscellanea (toys and furniture). The difference in the probability of product innovation between sectors ranges from -0.05 for printing to 0.17 for other vehicles. The range between extreme values reaches a 22-percentage point, which is in line with the HJ2004a results.

Table 4 presents results from estimates when other control variables are included. Later phases in the industry lifecycle, that is maturity and decline, lead to a lower product innovation activity: the decline in the probability of innovation along the industry lifecycle is statistically significant, and makes it necessary to take into account the industry attributes that affect innovation both over time and across markets. The innovation rates are significantly higher in the IOM sectors, that is, the patent-producing sectors whose patenting rate is larger than the median score of the sample distribution. Conversely, sectors in the SOU group, that is sectors that mainly use patents produced by some other sectors, show a low and non-significant relationship with the product innovation activity. Also short-term trends in industry demand — as proxied by the industry turnover — affects an individual firms' probability to introduce a new product, but only in the case of foreign demand (FTI).

[Table 4 about here]

The product tenure enters the regression model with a polynomial specification to account for the nonlinearity of the innovative behaviour by age: the coefficients are all significant and describe a u-shaped relationship between product tenure and product innovation in the relevant domain. This means that a lengthy product tenure is associated with a lower probability of innovation, but the negative trend tends to weaken when the old product is entering its maturity or decline phase. Finally, the impact of the CEO tenure is mostly linear and its coefficient is negative and moderately significant, thus suggesting a decline in the contribution of an old-tenured CEO to the innovative activity of the firm.

Firm Age, product and CEO tenure

The estimated results for the impact of firm age on product innovation are presented in Figure 4. First and foremost, the changes in the probability of product innovation over the lifecycle are sizeable and significant: a declining trend is observed until 18–20 years, then a net increase and a peak is seen at about 30 years, and then a decline is seen from 35 years onwards. Therefore, the impact of age on innovation does appear to be a significant component of the heterogeneity of innovation activity, and a driving force behind the nonlinearity in the innovative behaviour by age. Second, the range of probability values by age reaches a 12 percentage point (8 percentage point in the HJ2004a article) — a large part of the overall variation in the average probability. Third, young firms appear to have a high probability of innovation, which declines constantly in the post-entry period and increases again after about 15 years. Also, the innovation activity drops significantly in the last period of the age domain (35 to 60 years), whereas firms ageing 20 to 35 years appear to be as active as new entrants in product innovation, or even better. Thus, the trend observed by HJ2004a is confirmed, with negligible variations in the temporal profile of the relationship, due to the sample composition and the use of different control variables. Fourth, the distance between the first year estimate, that is, the probability of innovation when the firm enters the market, and the peak value is about 11%, a bit lower than the HJ2004a's estimate (15%). This lower value can be due to the potential underestimation of the innovative activity in very young firms in our sample, as we were not able to control for exiting firms.

[Figure 4 about here]

Figure 4 provides a comparison of this sample with HJ2004a. The shapes of the two curves are almost similar in the relevant domain. Also, the probability of product introduction peaks between 25 and 30 years in the two curves, after a rise in probability starting from 15 years, which then declines constantly thereafter. The most relevant difference in the two samples is observed in the post-entry period, during which the innovation activity slightly increases in the HJ2004a sample and decreases in this sample. Also, both curves start declining just above 30 years, even if the u-shaped part of the curve is more extended in this sample than in the HJ2004a analysis.

When the product tenure and CEO tenure are taken into account as crucial explanatory variables, the estimates of the probability of introducing a product innovation give further insights. Results from the estimates are summarised in Figure 5 — Panels A and B. Panel A reports the estimates of the probability of innovation when a control for CEO tenure is introduced. Panel B also includes a further control for the product tenure. A comment on these results is provided below.

[Figure 5 about here]

First, when the high innovation propensity of the early stage of the CEO career is considered, the probability of introduction of a new product shifts substantially downwards in the first period of the company life. Therefore, a significant part of the innovation activity of young firms is likely to be ascribed to the contribution by new, short-tenured CEOs, who are very well versed in the external economic environment. Besides this, the tendency of new CEOs to innovate also drives the innovation activity in firms aged 20 to 40 years, as the innovation curve flattens in this part of the age domain when we include a control for CEO tenure. In firms aged 20 to 40 years, CEO succession is positive because new CEOs are able introduce new ideas and to pursue new initiatives, which form the basis for the innovation activity of the company. This evidence is consistent with the temporal profile of the CEO tenure distribution, whose mean and the median values are 27.9 and 30 years, respectively. Finally, the low innovation activity observed in mature firms (aged 40 or more) almost disappears when the CEO tenure is controlled, thus providing new evidence to explain how inertia develops and hinders innovation in mature organisations (Miller, 1991).

Second, when we control for the product tenure, a further significant drop in the innovation activity of young firms is observed. By explicitly taking into account the existence of short-tenured products (either new products in highly technological areas or unsuccessful product launches that make product tenure shorter), the innovation probability drops significantly in the first two decades of a firm's lifecycle, after which it becomes flat. As for the case of CEO tenure, there is a close association between the observed trend in innovation propensity and the distribution of the product tenure variable, which has a median value of 22 years and the mean at 24 years. Finally, in mature firms, that is, firms aged 40 years or more, the probability of innovation jumps well above the original level and it becomes positively related to the firm's age when controls for the CEO and product tenure are included.

To sum up, the probability of product innovation appears to be increasing with the firm's age when the roles of product and CEO tenures are considered. Younger firms appear to be less innovative when their innovation activity is controlled by the positive impact of a new CEO and by the competitive conditions these firms face as entrants. On the contrary, older firms are more innovative than expected when the

CEO tenure and product lifecycles are taken into account. This evidence supports an upward-sloping curve between innovation propensity and firm age.

4. The CEO change-Innovation time gap

The empirical evidence in the previous section shows that the product lifecycle together with a new-CEOs propensity to innovation and the old-CEOs liability of senescence (Barron et al 1994), explain a significant part of the innovation propensity in mature firms. If a firm's innovative performance along its lifecycle is affected by the overlapping trend of CEO tenure and product portfolio management, it is important to understand how innovation and succession interact during the company's life, and how the time interval between these events affects the firm's innovation activity.

To this aim, a variable -defined as a succession–innovation (SI) gap- has been created to measure the time lag (in years) between the new product introduction and the CEO change. Also, because of the different roles played by family CEOs and external CEOs in terms of the renewal ability of the company, a distinction between family and non-family successions has been introduced. When the total number of CEO changes is considered (n = 289), the estimated results reported in Table 5 show that the introduction of a new product is hardly observed just after the CEO change, that is, one year. The coefficient is negative and significant, thus supporting the hypothesis that CEO change and innovation are two crucial events in the company life that cannot be accommodated in a very short span of time, that is one or two years. The probability to observe product introduction becomes positive and significant only three years after succession, and then declines gradually for the remaining seven years. The partition of the sample in family and external CEO succession is more revealing. In the case of new CEOs from the founding family, the probability to observe a new product introduction is flat along the entire period, with positive values — but not statistically significant — from the second to the sixth year and negative values for the last three years. Conversely, the probability of innovation when external CEOs step into the company is significantly positive in the second- to fourth-year period, after which it turns negative. Therefore, the positive short-tenured CEOs impact on product innovation is mostly driven by external CEOs, who are able to significantly support the innovation activity in the early stage of their tenure. Figure 6 presents evidence consistent with this result, and shows that the contribution of external CEOs to innovation is significant and mostly concentrated in the early season of their tenure, whereas, the contribution of family CEOs is almost flat along the entire period.

[Table 5 about here]

[Figure 6 about here]

5. Final remarks

This article contributes to the literature on the dynamics of the probability of product innovation by age in incumbent firms. The main findings may be summarised as follows. The increase in the probability of innovation observed in firms aged 20 to 40 years is significantly explained by variables related to the CEO tenure and to the lifecycle of the last product introduced. Also, the new entrants' high innovative activity rests on the new CEO's innovation propensity, which is strictly dependent on the CEO tenure, whereas mature firms' declining innovation activity almost disappears when the role of the product lifecycle and inertia of the long-tenured CEOs are considered.

As a result, the existence of a general negative relationship between innovation and firm age is questioned, as the presence of different "ages" in the company life — that is, product age and CEO tenure — makes the relationship positive. Finally, the innovative behaviour of incumbent companies appears to be dependent on the renewal ability of newly-appointed CEOs who come from outside the company, whereas the role of family CEOs appears less important for the innovation activity of the firm.

References

Acemoglu, D., P. Aghion, C. Lelarge, J. Van Reenen, and F. Zilibotti (2006). Technology, Information and the Decentralization of the Firm, NBER Working Paper No. 12206.

Agarwal, R. and Gort M.. 2002. Firm and Product Life Cycles and Firm Survival . American Economic Review, 92(2): 184-190.

Balasubramanian N., Lieberman M.B., 2010, Industry learning environments and the heterogeneity of firm performance, Strategic Management Journal, 31: 390–412 (2010)

Barlet, C., Duguet, E. , Encaoua, D., Pradel, J., 2000. The Commercial Success of Innovations: An Econometric Analysis at the Firm Level in French Manufacturing, in: D. Encaoua et al. (eds), The Economics and Econometrics of Innovation, Boston: Kluwer Academic Publishers, pp. 435-456

Barney J. 1991. Firm Resources and Sustained Competitive Advantage, Journal of Management, March, vol. 17 no. 1 99-120

Barron, D. N., E. West, and M. T. Hannan. 1994. A Time to Grow and a Time to Die: Growth and Mortality of Credit Unions in New York, 1914-1990. Am. J. Soc.100:381-421

Becheikh, N., Landry, R., Armara, N., 2006. Lessons from innovation empirical studies in manufacturing sector: A systematic review of the literature from 1993-2003. Technovation 26, 644–664.

Bernard A.B., Redding S.J., Schott P.K., 2010. Multiple-Product Firms and Product Switching, American Economic Review, American Economic Association, vol. 100(1), pages 70-97, March

Bernard A.B., Redding S.J., Schott P.K., 2011. Multiproduct Firms and Trade Liberalization, The Quarterly Journal of Economics, Oxford University Press, vol. 126(3), pages 1271-1318.

Bloom N. Van Reenen J., 2010. Why Do Management Practices Differ across Firms and Countries?, Journal of Economic Perspectives, American Economic Association, vol. 24(1), pages 203-24, Winter

Burgel, O., Fier, A., Licht,G., Murray, G., 2002. The effects of Internationalisation on the rate of growth of High Tech start-ups: evidence for the UK and Germany. in Schätzl, L., & Revilla Diez, J. (2002). Technological change and regional development in Europe. Contributions to economics. Heidelberg: Physica-Verlag.

Cefis E., Marsili O., 2011, Born to flip. Exit decisions of entrepreneurial firms in high tech and low-tech industries, Journal of Evolutionary Economics, August 2011, Volume 21, Issue 3, pp 473-498

Coad, A., Rao, R., 2008. Innovation and Firm Growth in ‘Complex Technology’ Sectors: A Quantile Regression Approach. Research Policy 37, 633-648.

Coad A., Guenther C.,2012. Age, diversification and survival in the German machine tool industry, 1953-2002, Papers on Economics and Evolution, n.1123, Max Planck Institute of Economics, Jena, Germany

Coad A., Segarra A., Teruel M. 2013, Like milk or wine: Does firm performance improve with age?, Structural Change and Economic Dynamics, 24, pp173-189.

Cohen, W.M., Levinthal, D.A., 1990. Absorptive capacity: A new perspective on learning and innovation. Administrative Science Quarterly 35, 128-152.

Coombs, R., Narandren, P. , Richards, A., 1996. A Literature-Based Innovation Output Indicator. Research Policy 25, 403-413.

Cucculelli M., Ermini B, 2012. New product introduction and product tenure: What effects on firm growth?, Research Policy, 41, 808– 821

Das, S., 1995. Size, age and firm growth in an infant industry: the computer hardware industry in India. International Journal of Industrial Organization 13, 111–126.

Deeds, D.L., 2001. The role of R&D intensity, technical development and absorptive capacity in creating entrepreneurial wealth in high technology start-ups. Journal Of Engineering and Technological Management 18, 20-47.

Economides, N., 1996. The economics of networks. International Journal of Industrial Organization 14, 673-699.

Ericson, R., and A. Pakes (1995). "Markov-perfect industry dynamics: A framework for empirical work," The Review of Economic Studies 62 (1), 53-82.

Gerosky, P., Machin, S., Walters, C., 1997. Corporate growth and profitability. Journal of Industrial Economics XLV, 171–189.

Fernandez, Z., & Nieto, M.J. 2006. Impact of ownership on the international involvement of SMEs. Journal of International Business Studies, 37(3), 340-351.

Flor, M.L., Oltra, , M.J., 2004. Identification of innovating firms through technological innovation indicators: an application to the Spanish ceramic tile industry. Research Policy 33, 323–336.

Geroski P.A. and Mazzucato M., 2002. Learning and the sources of corporate growth, Industrial and Corporate Change, Oxford University Press, vol. 11(4), pages 623-644, August.

Geroski P.A. 2005. Understanding the implication of empirical work on corporate growth rates, Managerial and Decision Economics, 26: pp129-138

Giulioni G., 2011, The product innovation process and GDP dynamics, Journal of Evolutionary Economics, Volume 21, Issue 4, pp 595-618

Goldberg P.K., Khandelwal A., Pavcnik N., Topalova P., 2009. Multi-product firms and product turnover in the developing world: Evidence from India. NBER working paper no. 14127, National Bureau of Economic Research.

Golder P.N., and Tellis G.J., 2004, Growing, growing, gone: cascade, diffusion and turning point in the product life cycle, Marketing Science, vol23, n.2 Spring, pp 207-218.

Gopalakrishnan, S., Bierly, P.E., 2006. The Impact of Firm Size and Age on Knowledge Strategies During Product Development: A Study of the Drug Delivery Industry. IEEE Transaction on Engineering Manangement 53, 3-16

Grossman G, Shapiro C., (1982), A theory of factor mobility, Journal of Political Economy, 90, 5, 1054-1069.

Hambrick, D. C., and Fukutomi, G. (1991), The seasons of a CEO's tenure, Academy of Management Review, 16: 719-742.

Huergo E., Jaumandreu J., 2004a, How does probability of innovation change with firm age? Small Business Economics, 22, 193-207

Huergo E., Jaumandreu J., 2004b, Firms' age, process innovation and productivity growth, International Journal of Industrial Organization, 22, 541-559

Johnson, D. K., 2002. The OECD Technology Concordance (OTC): Patents by Industry of Manufacture and Sector of Use, OECD Science, Technology and Industry Working Papers, 2002/5, OECD Publishing.

Jovanovic, B. (1982). "Selection and evolution of industry," Econometrica 50(3), 649– 670.

Karaevli A., Zajac E.J., 2013. When do outsides CEOs generate strategic change? The enabling role of corporate stability, Journal of Management Studies, 50:7, pp 12671294

Karlsson C., Nystrom K., 2003. Exit and entry over the product life cycle: Evidence from the Swedish manufacturing industry, Small Business Economics, volume 21; pp 135-144

Karniouchina E., Carson S., Short J., Ketchen D.J., 2013. Extending the firm vs industry debate: Does industry life cycle stage matter?, Strategic Management Journal, volume 34; pp 1010-1018

Kirchoff B.A., 1994. Entrepreneurship and Dynamic Capitalism: The Economics of Business Firm Formation and Growth, Praeger Publishers, Westport CT, USA.

Klepper, S., Graddy, E. 1990. The evolution of new industries and the determinants of market structure. Rand Journal of Economics 21, 27-44.
Klepper, S., 1996. Entry, exit, growth and innovation over the product life cycle. American Economic Review 86, 562–583.
Krafft J., Ravix J.L., 2008 The firm and its governance along the industry life cycle. In B. Laperche and D. Uzunidis. “Powerful Finance and Innovation Trends in High-Risk Economy”, Palgrave MacMillan, pp.131-148.
Krafft J. 2004. Shakeout in industrial dynamics: new developments, new puzzles. In J. Foster and W. Hoelzl. Applied Evolutionary Economics, Edward Elgar, pp.181-196.
Kuratko, D. F. and Audretsch, D. B. 2009, Strategic Entrepreneurship: Exploring Different Perspectives of an Emerging Concept. Entrepreneurship Theory and Practice, 33: 1–17.
Le Bas, C. and Poussing, N., 2012, Are Complex Innovators More Persistent than Single Innovators? An Empirical Analysis of Innovation Persistence Drivers. GATE Working Paper No. 1201
Leonard-Barton D. (1992). “Core capabilities and core rigidities: a paradox in managing new product development,” Strategic Management Journal 13(S1), 111–125.
Levesque M., and M. Minniti (2006). “The effect of aging on entrepreneurial behaviour,” Journal of Business Venturing 21, 177-194.
Levinthal, D., March J.G. 1993. The Myopia of Learning, Strategic Management Journal Vol 14 95-112
Lööf, H., Heshmati, A., 2006. On the Relation between Innovation and Performance: a Sensitivity Analysis. Economics of Innovation and New Technology 15, 317-344.
Malerba F., 2006, Innovation and the evolution of industries, Journal of Evolutionary Economics, April, Volume 16, Issue 1-2, pp 3-23
Marshall, P.J., R. Sorenson, K. Brigham, E. Wieling, A. Reifman, and R. S. Wampler, (2006). “The paradox for the family firm CEO: Owner age relationship to succession-related processes and plans”, Journal of Business Venturing 21, 348– 368.
McClelland, Patrick L., Xin Liang, and Vincent L. Barker, III. "CEO Commitment to the Status Quo: Replication and Extension Using Content Analysis." Journal of Management 36, no. 5 (September, 2010): 1251-1277.
Miller D. 1991. Stale in the Saddle: CEO Tenure and the Match Between Organization and Environment, Management Science, 37, 34-52.
Miller, D., and J. Shamsie J. (2001). “Learning across the Life Cycle: Experimentation and Performance among the Hollywood Studio Heads,” Strategic Management Journal 22(8), 725-745.
Moral, M.J., Jaumandreu, J., 2007. Automobile demand, model cycle and age effects. Spanish Economic Review 9, 193–218.
Penrose, E. T. 1959. The Theory of the Growth of the Firm. New York, John Wiley and Sons
Pfeffer Jand Salancik G., 1978, The External Control of Organizations, Harper & Row, pp 39-61
Quigley T.J., Hambrick D.C. 2012, When the former CEO stays on as board chair: effects on successor discretion, strategic change and performance, Strategic Management Journal, 33, pp834-859
Reinganum J., (1983), Uncertain innovation and the persistence of monopoly, American Economic Review, 73: 4, 741-748
Rubenson, G.C. and A.K. Gupta, (1996), A Contingency Model of Founder Tenure, Entrepreneurship. Theory and Practice, V. 21, Winter, 21-35
Schott P.K., 2004. Across-product Versus Within-product Specialization in International Trade, The Quarterly Journal of Economics, MIT Press, vol. 119(2), pages 646-677, May.
Shane, S.A., (2003), A General Theory of Entrepreneurship, Edward Elgar, Cheltenham, UK, and Northampton, MA (USA).

Segarra A., Callejon M., (2002), New firms' survival and market turbulence: New evidence from Spain, Review of Industrial Organisation, 20: 1-14

Sorensen, J. and T. Stuart (2000). "Aging, obsolescence and organisational innovation," Administrative Science Quarterly 45, 81-112

Stam E. 2007. Why butterflies don't leave: location behaviour of entrepreneurial firms. Economic Geography, 83 (1), 27-50.

Stinchcombe, A. L. (1965) , Social structure and organizations, in J. G. March (ed.), Handbook of Organizations: 142-193. Chicago: Rand McNally

Suits, D., 1984. Dummy variables: mechanics vs. interpretation. Review of Economics and Statistics 66, 177– 180.

Van Praag C.M., (2003), Business Survival and Success of Young Small Business Owners, Small Business Economics, Vol. 21, pp. 1–17.

Woerter M., 2009, Industry diversity and its impact on the innovation performance of firms, Journal of Evolutionary Economics, Volume 19, Issue 4, pp 675-700

Wu S., Levitas E. and Priem R. L., 2005. CEO Tenure and Company Invention under Differing Levels of Technological Dynamism, The Academy of Management Journal, Vol. 48, No. 5 (Oct.), pp. 859-873

Table 1 – Description of the sample. Number of firms and percent composition

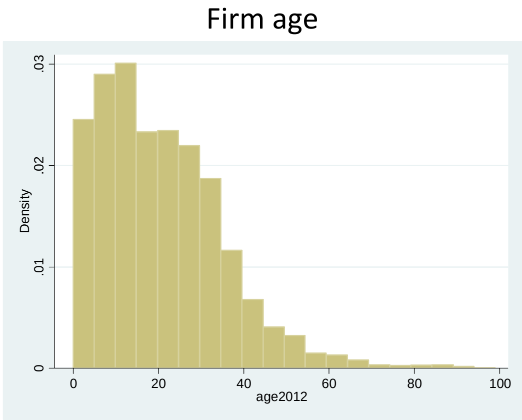
Variables	Sample			Variables	Sample	
	N°	%			N°	%
Sectors				**Size**		
Foods	78	3.6		>=10 employees < 50	1702	78.7
Textile and clothing	63	7.5		>=50 employees <= 200	436	20.2
Footwear	74	8.0		>200 employees	25	1.1
Wood, paper	70	7.9				
Chemicals, rubber plastic	68	7.8		**Firm starting year**		
Minerals (no metals)	38	6.4		Before 1970	318	14.7
Metalworking	40	20.3		1970–1979	656	30.3
Mechanical industry	66	16.9		1980–1989	734	33.9
Machinery, appliances, vehicles	37	11.0		1990–	455	21.0
Furniture, toys, jewels	29	10.6				
				Innovative firms by age		
Regions				Before 1970	297	35.6
Veneto	835	38.6		1970–1979	243	29.1
Emilia-Romagna	661	30.6		1980–1989	183	21.9
Marche	580	26.8		1990–	110	13.2
Abruzzo	87	4.0		**Innovative firms ***	833	100.0
				Total Sample	2,163	100.0

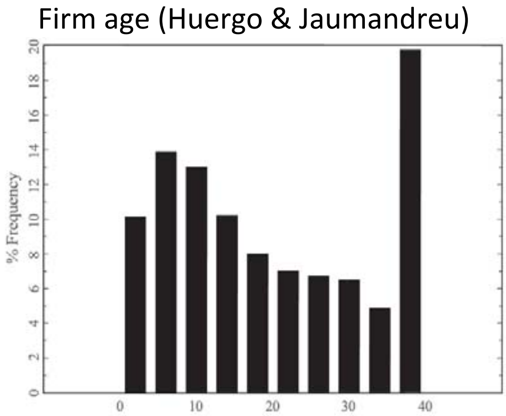
Source: Università Politecnica delle Marche

* Firms that have introduced at least one new product in the period 2000–2010

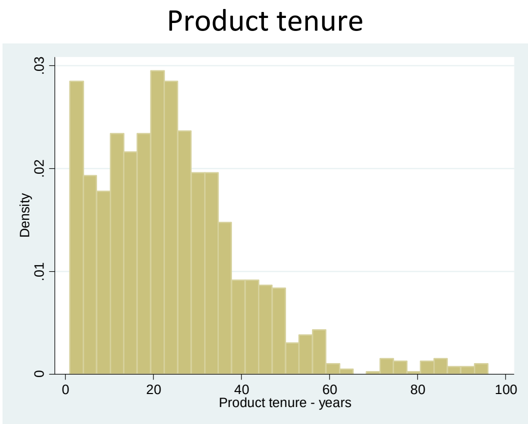
Figure 1 – Descriptive statistics — Firm age, product tenure and CEO tenure

Panel A – Firm age distribution in the sample and in the HJ 2004 sample





Panel B – Product tenure and CEO tenure



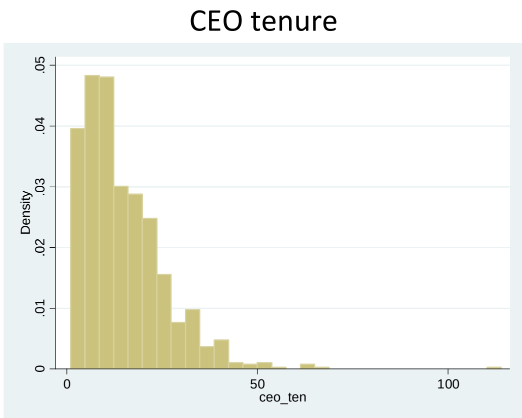
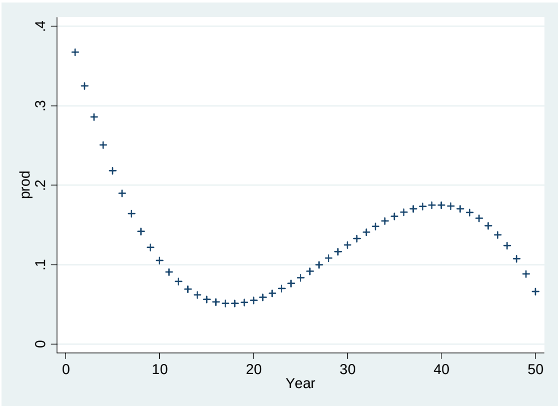


Figure 2 - Descriptive statistics — Innovation propensity by product tenure and CEO tenure

Panel A – Propensity of product introduction (y-axis) and Product tenure (x-axis)



Panel B – Propensity of product introduction (y-axis) and CEO tenure (x-axis)

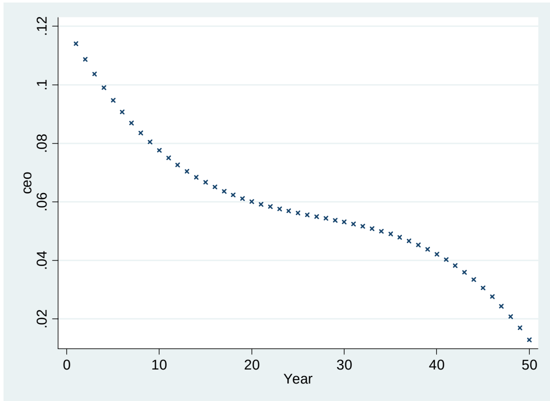


Figure 3 – Product innovation propensity in the industry lifecycle

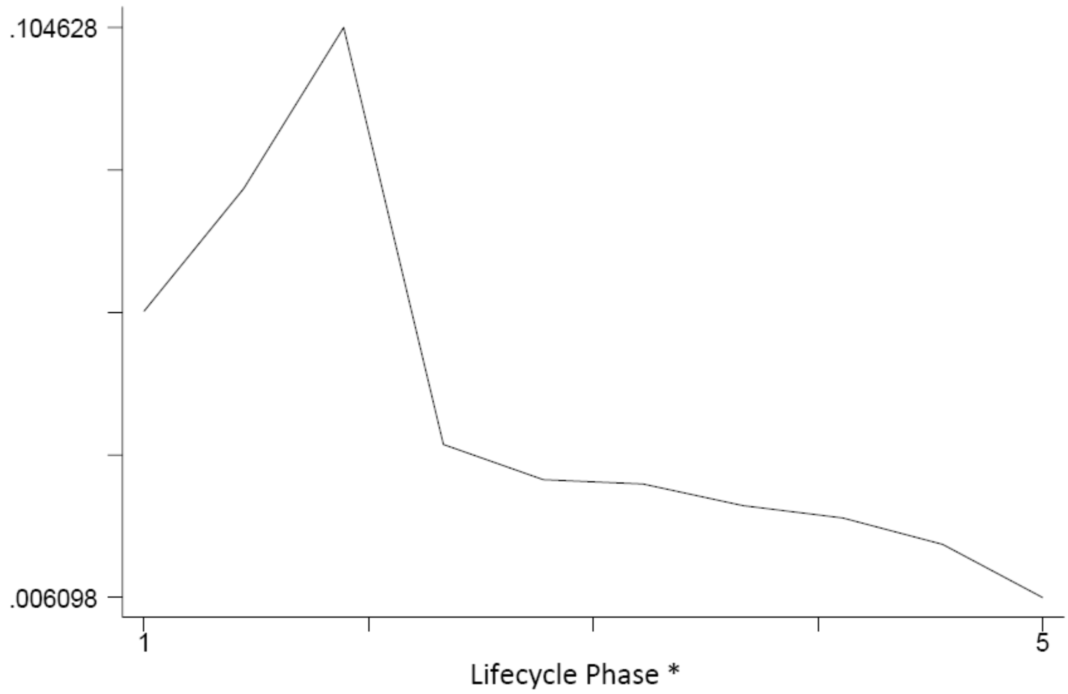


Table 2 – Descriptive statistics of new product introduction by the industry lifecycle phase

Phase *	New products		Firm age	
	Mean	sd	Mean	sd
1 – Initial low entry	0.056	0.236	59	32
2 – Increasing entry rate	0.105	0.315	43	9
3 – Decreasing rate although still entry	0.026	0.160	34	18
4 – Low entry	0.020	0.140	38	20
5 – Erratic pattern of gross entry	0.006	0.078	39	18
Total	0.023	0.150	37	19

* Phases have been obtained following the procedure in Agarwal & Gort, 2002.

Table 3 – Results from the estimation of model (1) — Control variables* – 2000–2010

Industry dummies	coeff	se		Time dummies	coeff	se
Food and beverage	0.012	(0.019)		a2000	0.008	(0.010)
Textile	0.001	(0.032)		a2001	-0.018*	(0.010)
Clothing	-0.018	(0.021)		a2002	0.012*	(0.010)
Leather and Footwear	-0.010	(0.012)		a2003	-0.011	(0.010)
Timber and wood products	0.007	(0.025)		a2004	-0.001	(0.010)
Paper products	-0.031	(0.028)		a2005	-0.001	(0.010)
Printing	-0.057	(0.039)		a2006	0.004	(0.010)
Chemical products	0.013	(0.032)		a2007	0.013*	(0.010)
Rubber and plastic	0.028*	(0.015)		a2008	0.015	(0.010)
Non-metallic minerals	-0.033	(0.028)		a2009	-0.024	(0.010)
Metals and other metallic minerals	-0.045	(0.032)		a2010	0.005	(0.010)
Metal products	0.001	(0.012)				
Industrial and agricultural machines	0.033***	(0.012)		**Size dummies**		
Office and data processing machines	0.031	(0.054)				
Electrical equipments and electronics	-0.001	(0.018)		Employees: 1_19	0.028*	(0.016)
Radio, TV, communication machines	-0.024	(0.029)		Employees: 20_49	-0.002	(0.008)
Medical, optical machines	-0.040	(0.032)		Employees: 50_99	0.024***	(0.006)
Vehicles, cars and motors	-0.057	(0.038)		Employes: 100_249	0.004	(0.008)
Other trasportation vehicles	0.170***	(0.052)		Employees: 250_1000	-0.055***	(0.015)
Furniture and miscellanea	0.023**	(0.010)				
				Patents dummy		
Product dummies						
				Patents : 0	-0.123**	(0.049)
Products: 1	-0.033***	(0.011)		Patents : 1	0.056***	(0.020)
Products: 2	-0.032**	(0.014)		Patents : 3-5	0.021	(0.015)
Products: 3	0.027**	(0.013)		Patents : 6-9	0.019	(0.016)
Products: 4	0.038*	(0.021)		Patents : 10+	0.027	(0.017)

* Dummy coefficients constrained to add up to zero (Suits, 1984)

Table 2 – Results from the estimation of model (1) – Main variables – 2000–2010

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Phase	-0.012**			-0.005	-0.005	-0.005	-0.001
	(0.005)			(0.006)	(0.006)	(0.006)	(0.003)
SOU: sector of use		0.014					
		(0.010)					
IOM: industry of manufacture			0.021**	0.018*	0.016*	0.016*	0.016*
			(0.009)	(0.008)	(0.010)	(0.010)	(0.010)
Domestic Turnover Index				0.000	0.000	0.000	0.000
				(0.035)	(0.025)	(0.002)	(0.010)
Foreign Turnover Index				0.002**	0.001**	0.001**	0.001**
				(0.000)	(0.000)	(0.000)	(0.000)
ltenprod					-1.065***		-1.067***
					(0.019)		(0.019)
ltenprod2					0.401***		0.402***
					(0.009)		(0.009)
ltenprod3					-0.047***		-0.047***
					(0.001)		(0.001)
lceotenure						-0.013*	-0.006*
						(0.007)	(0.003)
_cons	0.066***	0.020***	0.011***	0.187***	0.376***	0.138***	0.526***
	(0.019)	(0.005)	(0.004)	(0.037)	(0.021)	(0.021)	(0.023)
Number of observations	1,804	1,804	1,804	1,790	1,790	1,790	1,790
Adjusted R2	0.003	0.001	0.004	0.128	0.378	0.146	0.584
note: *** *p*<0.01, ** *p*<0.05, * *p*<0.1							

Controls: year, industry, patents and product dummies. The coefficient sets are constrained to add up to zero (Suits, 1984)

Figure 4 – Innovation propensity by firm age

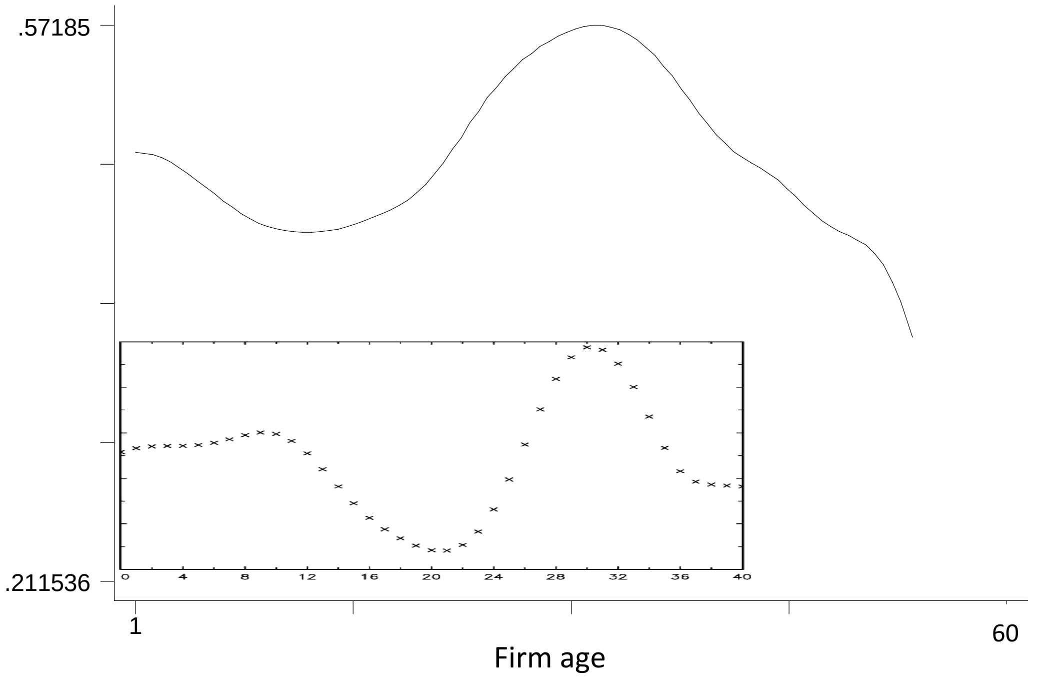
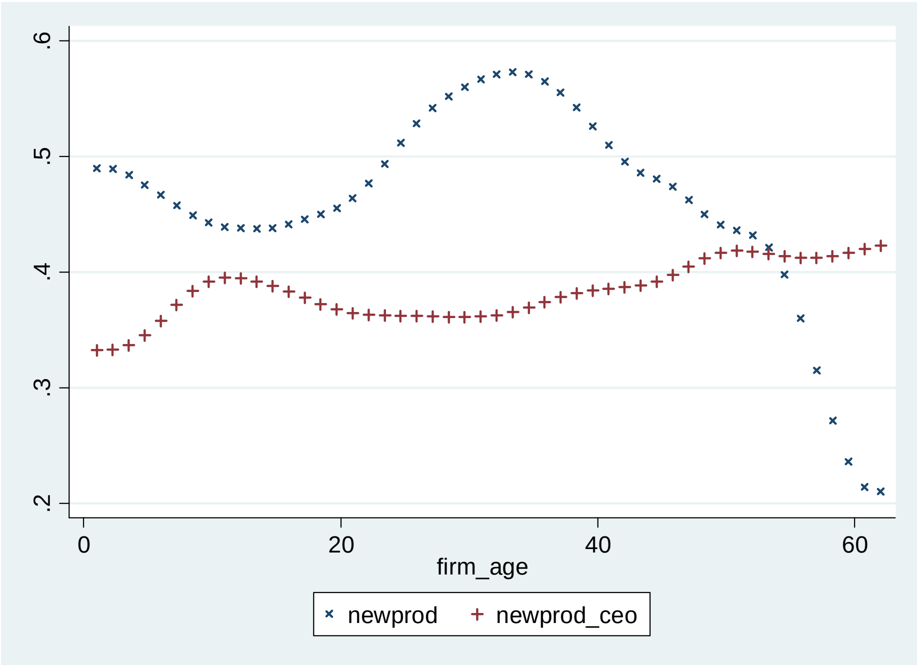


Figure 5 – Innovation probability as a function of firm age. Estimates controlled for CEO tenure (Panel A), and CEO tenure and product tenure (Panel B)



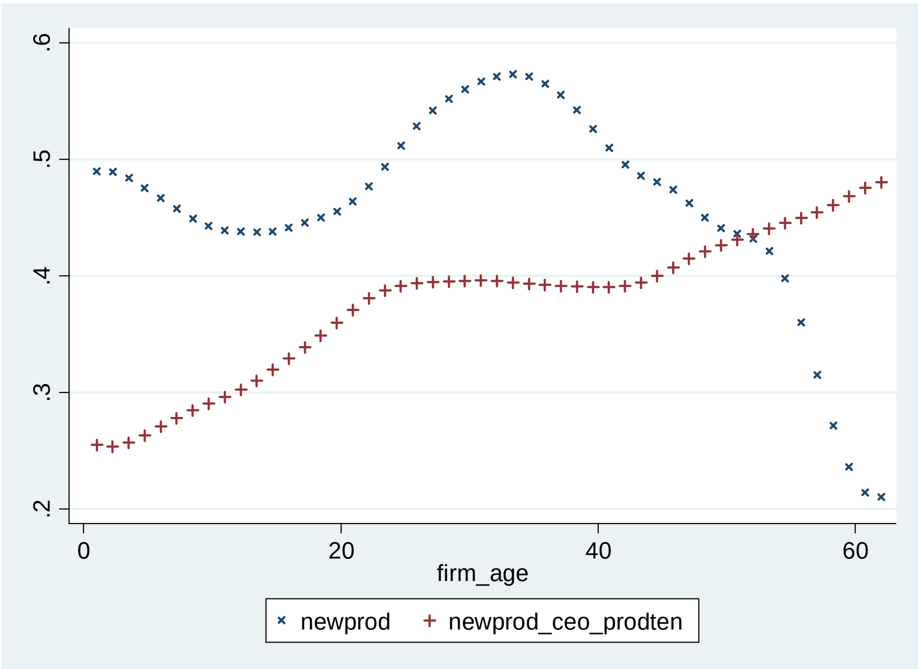


Table 5 — Results from the estimation of the model linking product innovation to the time (years) elapsed since the last CEO change, by type of change (family vs external)

Inno = New product introduction	Total CEO changes		Family	new-CEO	External	new-CEO
Inno 1 year after succession	-0.287**	(0.143)	-0.361*	(0.192)	-0.539	(0.423)
Inno 2 years after succession	0.106	(0.068)	0.088	(0.087)	0.362**	(0.153)
Inno 3 years after succession	0.138*	(0.075)	0.132	(0.091)	0.359**	(0.152)
Inno 4 years after succession	0.044	(0.077)	0.014	(0.101)	0.384**	(0.178)
Inno 5 years after succession	0.022	(0.081)	0.040	(0.114)	0.176	(0.168)
Inno 6 years after succession	0.064	(0.065)	0.137*	(0.073)	-0.014	(0.167)
Inno 7 years after succession	-0.073	(0.070)	0.015	(0.083)	-0.114	(0.159)
Inno 8 years after succession	0.035	(0.095)	-0.041	(0.117)	-0.492	(0.258)
Inno 9 years after succession	-0.049	(0.079)	-0.021	(0.095)	-0.097	(0.210)
Inno 10 years after succession	-0.035	(0.089)	-0.002	(0.098)	-0.025	(0.160)
Firm age	0.008***	(0.001)	0.007***	(0.001)	0.009***	(0.002)
Firm size (employees)	-0.000	(0.000)	-0.000	(0.000)	-0.001	(0.001)
Constant	-		-		-	
Number of observations	829		458		371	
note: *** *p*<0.01, ** *p*<0.05, * *p*<0.1						
Includes: year , industry, patents and product dummies. The coefficient sets are constrained to add to zero (Suits, 1984)						

Figure 6 – Probability of product innovation and the succession-Innovation gap – External new-CEOs (Panel A) and family new-CEOs (Panel B)