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ABSTRACT

The mechanisms driving regional clustering are examined by exploring two theories: agglomeration economies and organizational reproduction. While organizational reproduction through spinoffs dominates clusters' early stages of growth, in clusters populated by small, vertically disintegrated firms accessing networks of external capabilities, agglomeration economies should emerge as a positive force. We examine just such a cluster: the molds industry in Portugal. Our empirical approach is twofold: first, we examine the early evolution (1946–1986) of the industry; second, we use detailed data on firms and founders for the period 1987–2009 to test the predictions of the two theories. We find that while organizational reproduction has played a major role in clustering, agglomeration economies recently have gained influence.

Keywords: Clusters; Spinoffs; Agglomeration Economies; Networks; External Capabilities.

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INTRODUCTION

Extreme industry clusters are rare (Ellison and Glaeser, 1997) and require explanation, particularly when there is no natural advantage underlying the clustering. Studies of extreme industry clusters (for instance, Saxenian, 1994; and Lécuyer, 2006) offer arguments stating that firms accrue benefits from agglomeration. Once firms in an industry begin to congregate in a specific region, such advantages will attract more companies into the region. The evidence compiled about clusters is broadly consistent with the existence of benefits from agglomeration associated with firm growth (Rosenthal and Strange, 2004) and innovation (Baptista and Swann, 1998).

More recent works have focused on the role played by spinoffs[1] and, more broadly, the transmission of capabilities from parent firms to startups. Klepper (2008), and Buenstorf and Klepper (2009) propose that the offspring of the better firms inherit more capabilities and therefore become superior performers. Since new entrepreneurs tend not to venture far from their geographic origins, the best spinoffs locate next to the best parents, leading to a build-up of superior firms in a region. Such a process does not strictly require the existence of any advantages associated with agglomeration.

The tension between these two approaches has not yet been resolved either theoretically or empirically. In this paper, we propose that the first stages of an agglomerated industry's evolution may be dominated by the spawning of multiple local spinoffs by the earlier, better companies, as predicted by the organizational reproduction theory. However, in more advanced stages, when the cluster has reached a critical mass, the agglomeration of firms with complementary capabilities might generate a region-specific dynamic network where interactions between firms are associated with the conventional agglomeration economies

[1] The definition of 'spinoffs' used in the present paper follows the one adopted by Garvin (1983), and Klepper (2002), i.e. *de novo* firms with one or more founders that had worked previously in the same industry.

arguments. Under these circumstances, organizational reproduction forces would be indispensible for the creation and initial growth of a cluster, while agglomeration externalities would emerge later.

Our study examines the evolution of the Portuguese industry of molds for plastic injection. Molds are metal parts used in plastic injection to shape plastic parts that are used as inputs in several industries. Molded plastic products are pervasive in today's economy, being used in industries such as consumer packaged goods, chemical, electronics, automotive, and packaged food products. The Portuguese plastic injection molds industry is recognized by the U.S. International Trade Commission as 'one of the world's principal producers of precision molds for the plastics industry.' (Fravel *et al*., 2002). Mold-making is strongly agglomerated in two regions: Marinha Grande (hereafter referred simply as 'Marinha'), where the industry was born and which still represents the largest geographical cluster, and Oliveira de Azeméis (hereafter referred to as 'Oliveira'), a smaller cluster which evolved in parallel with Marinha. Both regions are located outside the main metropolitan centers of Lisbon and Porto.

This paper establishes the main predictions of the two theoretical accounts of agglomeration, proposes theoretical observations regarding the roles played by each of the accounts over the cluster's life cycle, and tests the predictions of the theories, looking to discern whether our observations are in line with the evolution of the molds industry. Our methodological approach is twofold and, we duly acknowledge, dictated by the availability of data. In the first part of our analysis, we present an account of the pre-history, evolution, and organization of the Portuguese plastic injection molds industry until the mid-1980s. In the second part we use detailed data matching firms, founders, and geographical regions (at the county level) available for the period 1986–2009 to examine the origin of founders, firms' locations decisions, and performance.

Regarding the first part of the analysis, since there is no uniformly established work on the industry's history, we make use of varied sources from scientific studies, accounts found in industry associations' reviews, and interviews with people bearing extended historical, and technological knowledge of the industry. In the second part of the analysis we adopt an econometric approach (comparable to those used by Klepper, 2007, and Buenstorf and Klepper, 2009) using a longitudinal dataset to examine the founders' paths before they create molds companies.

The paper is organized as follows. The next section outlines the theoretical discussion. The following section offers a brief account of the evolution of the Portuguese plastic injection molds industry, focusing particularly on the spinoff and agglomeration phenomena, while also discussing the industry's organization with regard to firm size and boundaries. The fourth section describes the data and methodology used in the study, while the fifth section presents and discusses the results of the quantitative analysis. The final section offers some concluding remarks.

THEORETICAL ASPECTS

There have been several attempts from a variety of fields to explain industry agglomeration. The present paper concentrates on two theories providing explanations for the existence of clusters, though we acknowledge there are alternative and complementary viewpoints that warrant discussion – see, for example: Martin and Sunley (2006); and Frenken *et al*. (2011).

Agglomeration economies

Three fundamental factors are commonly invoked to explain clustering due to agglomeration economies, or externalities. First, some regions may have natural advantages for firms in particular industries, causing entrants to cluster there. Second, pecuniary economies related to transportation costs and scale economies as featured in new economic geography models (Krugman, 1991a; Krugman and Venables, 1995) may cause entrants to cluster near consumers and suppliers to their industry. Thirdly, and crucially, production, or supply-side externalities in which firms benefit from proximity to other firms may induce entrants to cluster (Marshall, 1920; Porter, 1990; Krugman, 1991b). Supply-related factors drive companies to locate near their competitors, suppliers, and customers: pooling of the labor market, supply of specialized inputs, and technological spillovers facilitate access to specialized workers, key inputs, and knowledge relevant for production, organization, and marketing.

There is a long tradition in regional and urban economics of modeling industry agglomerations as the result of Marshallian externalities. The micro-foundations of these externalities are reviewed in Duranton and Puga (2004) and empirically tested by Henderson (2003) and LaFountain (2005). Three main predictions emerge from this theoretical approach. If agglomeration theories better describe the main drivers of clustering, then:

1. new firm entry will be greater in the agglomerated region than in other regions;
2. founders of new firms will move to the agglomerated region regardless of their region of origin;
3. firms located in the agglomerated region will perform better than firms located elsewhere.

Reproduction of organizational competences

An alternative view to the agglomeration economies approach is that the clustering of entry is caused by the combination of entrants tending to locate close to their geographic roots and the uneven regional distribution of potential entrants (Klepper, 2008; Buenstorf and Klepper, 2009; 2010). New entrants need pre-entry organizational knowledge to compete (Philips, 2002; Helfat and Lieberman, 2002; Helfat and Peteraf, 2003). An important source of pre-entry capabilities is industry experience acquired by spinoff founders. Agarwal *et al*. (2004) and Klepper (2008) argue that the success of new organizations is fundamentally shaped by knowledge inherited from industry incumbents that was accumulated by their founders throughout their careers.

Early entrants often choose to locate in regions where precursor industries were already located (Klepper, 2001; Buenstorf and Klepper, 2009; 2010). This was the case, for instance, of early firms in the automotive industry, which evolved from manufacturers of bicycles, engines, carriages, and wagons (Klepper, 2001). Several studies have shown that entrants commonly locate close to where their founders previously worked and/or were born. Such studies arise from urban economics (Figueiredo *et al.*, 2002); economics of entrepreneurship (Michelacci and Silva, 2007), as well as sociology and management (Dahl and Sorenson, 2009; 2011) and propose explanations associated to better access to human, social, and physical capital (that is, sources of financing) in the region of origin. This finding has been dubbed 'home field advantage' by Figueiredo *et al*. (2002).

Clustering of an industry would then be due to an endogenous process in which incumbent firms involuntarily spawn spinoffs. Better parent firms spawn more and better spinoffs, which prefer to locate near home base. Three main predictions emerge from this approach. If organizational reproduction better describes the main drivers of the clustering process, then:

1. incumbents in a core industry (and related industries) spawn more startups than incumbents in other industries, independently of the region where they are located;
2. incumbents in a core industry (and related industries) locating in the agglomerated region spawn more startups than incumbents in the same industries locating outside the agglomerated region;

3. spinoffs and startups originating from related industries perform better than other startups.

Firm boundaries and the cluster life cycle

Different agglomeration mechanisms and benefits may play different roles at different stages of the cluster's life cycle, as the industry's structure evolves. We propose that the first stages of an agglomerated industry's evolution are dominated by the transmission of technological and organizational capabilities through startups originating in precursor industries and, in particular, sequences of spinoffs originating in the earlier, better companies in the industry, that locate near their parent companies. In more advanced stages, when the cluster has attained a certain size, or critical mass, while reproduction through spinoffs should remain important, the agglomeration of companies with similar and/or complementary objectives and capabilities might generate a region-specific dynamic network shaped by the connections between closely located small firms. Interactions between firms may be associated with the conventional agglomeration economies arguments.

Alfred Marshall (1920) observed that a larger volume of industry output within a region (localization) would lead to specialization across firms. There is an extensive literature on industrial districts dating to the 1980s and 1990s, primarily based on case studies illustrating the presence of specialized suppliers and firm vertical disintegration in particular areas and industries (for surveys see Piore and Sabel, 1984; Markusen, 1996). More systematic and wide ranging empirical studies have been conducted by Holmes (1999), Li and Lu (2009), and Figueiredo *et al*. (2010). These studies find a positive correlation between localization of an industry and firm vertical disintegration.

Small, vertically disintegrated companies depend on each other to fulfill orders of complete, final products. The narrower the firms' boundaries, the more likely that it may have easy access to resources, competences, and capabilities residing in other firms (Langlois and Robertson, 1995). A close, well coordinated network of neighboring firms with complementary capabilities could be able to respond to a variety of customer orders of final products by pooling together their resources through sub-contracting and outsourcing (Grandori and Soda, 1995). Such transactions would be made easier by the trust built through geographical proximity (regional social capital) and by a mutual knowledge of each others' capabilities and specialties inside the network. Lorenzoni and Lipparini (1999) argue that the capability to interact with other companies accelerates a firm's knowledge access and transfer. Trade agents and marketing firms with technical capabilities and significant knowledge/links to national and international customers could build up extensive knowledge of the diverse capabilities of producers by being part of the cluster's network. These agents and firms could then contribute to fill structural holes (Burt, 1992; Walker *et al*., 1997) by connecting small firms with narrow boundaries and modest marketing capabilities with large customers interested in a final product, and not just a specific component.

Loasby (1998) regards the firm as a singular set of direct/internal and indirect/external capabilities embedded in a network of relationships that are used to access external knowledge. This view is complemented by Dyer and Singh (1998), and Barney (1999). This organization of production suggests that, while the transmission of capabilities between firms through spinoffs may play a fundamental role in cluster formation, agglomeration externalities associated with networks should eventually emerge as firms cooperate to access each others' capabilities.

Clustered firms may be able to better recognize and access specialized labor, key suppliers or critical knowledge due to the gradual acquisition of regional social capital within local networks (Dahl and Sorensen, 2009; 2011), even if founders have no link to local parent companies through spinoffs. Firms may sub-contract each other to perform different parts of the production process, therefore specializing further, avoiding costs of vertical integration, reducing capital investment, and taking advantage of the capabilities and routines that are internal to other firms, but external to them. They also may benefit from better access to customers not located in the cluster (particularly international ones) simply because these customers find it easier to visit just the clustered region, or feel more confident when purchasing from companies located in the clustered region due to its international standing. All these advantages may be accrued by non-spinoffs simply by locating in a mature cluster, without inheriting any specific capabilities from a local parent company.

The circumstances described, where local firms simultaneously compete and cooperate, apply specifically to a mature cluster populated by relatively small firms with narrow boundaries. Such a cluster would display the type of agglomeration economies implied by Brusco (1982) and Porter (1990), as well as Piore and Sabel (1984) – regarding industrial districts – and Scott (1988) – concerning flexible production agglomerations.

There are however, several cases where the spinoff process has led to a cluster dominated by large and very large firms, for instance, the automobile, semiconductor, and tire industries studied by Buenstorf and Klepper (2009); and Klepper (2007; 2010). Under such circumstances, connections between firms might not be formed so easily; any networks of firms would be more formal and agglomeration economies arising from access to external capabilities would be fewer, thus explaining the observations made by these authors with regard to the non-impact of agglomeration economies on cluster success. Inversely, work by De Vaan *et al*. (2011) for the video game industry finds that effects of clustering on firm survival become positive once a cluster exceeds a critical size. Examining the effect of clustering on firm survival, Folta *et al*. (2006) find that, while regional firm density increases the chances of bankruptcy, the quadratic effect shows that such chances decrease for larger clusters. As research on geographical agglomeration pursues approaches focusing on the changing industrial structure of regions (Hassink, 2005; Menzel and Fornahl, 2009; Buenstorf and Fornahl, 2009), individual cluster accounts are likely to provide more clarifying evidence.

THE EVOLUTION AND ORGANIZATION OF THE MOLDS INDUSTRY

In our account of the evolution of the molds industry, we try to establish evidence on the causal mechanisms associated with clustering. Process tracing (George and Bennett, 2005) and causal process observations (Collier *et al*., 2003) allow inferences about causal mechanisms within the confines of a single case by looking at how causes interact in the context of a particular case to produce an outcome (Brady, 2004; Bennett and Elman, 2006).

Pre-history

The origin of the plastic injection molds industry in Portugal is closely linked to the location of precursor industries in Marinha.[2] In 1769, the Portuguese king commissioned a large glass factory – 'Real Fábrica de Vidros' (Royal Glass Factory) in Marinha (Barosa, 1993). The presence of the Royal Glass Factory in the region induced the creation of a large number of small glass and crystal companies, and the buildup of a mass of specialized glassworkers (Barosa, 1993).

In the mid-1920s a young toolmaker, Aires Roque, left the Royal Glass Factory to create a molds workshop with his half brother, Aníbal H. Abrantes. Together, they produced the first die-casting mold for glass in Marinha using chromium and steel (Henriques *et al*., 1991). The first significant glass molds company in Marinha was, therefore, a spinoff from the first and largest glass manufacturer in the region (Rodrigues, 2002; Gomes, 1998).

[2] The major focus of our account will be on the Marinha region (about seven times larger than Oliveira), which leads the plastic injection molds industry in Portugal.

From 1936, the plastics industry emerged in the region (Beltrão, 1985; Gomes, 1998). Plastics soon became a customer of the glass molds manufacturers, since molds for plastic pressing used similar mechanical principles to the glass molds (Callapez, 2000). Before long, the workshop, managed by Abrantes, started experimenting with plastic injection molds (Beira *et al*., 2004). Abrantes' experiments were, remarkably, the origin of a disagreement that took the two brothers towards separate paths (Gomes, 2005). While Roque stayed with glass molds, Abrantes pursued plastic injection molds. This difference of opinion would eventually give rise to the first plastic injection molds company to be established in Marinha, a spinoff resulting from a strategic disagreement.[3]

Inception and first phase of growth: from 1946 to the 1970s

In 1946 Abrantes started in Marinha the first Portuguese company (named after himself: A.H.A.) to produce resistant steel molds for plastic injection (Gomes, 1998). As it grew, A.H.A. soon became a center for worker training and networking,[4] and also innovated significantly by introducing division of labor. This allowed for worker specialization along the production process (Vieira, 2007). Division of labor into specialized stages became the norm in the Portuguese plastic injection molds industry and would be influential in the proliferation of small spinoffs highly specialized in only a few parts of the production process, working mostly through sub-contracts.

A large number of young workers were trained in specialized areas of mold manufacturing, many of whom later left to start their own companies, taking some of their colleagues with them (Matos, 1985; Beltrão, 1987). Hence, A.H.A. paved the way for the

[3] Klepper and Thompson (2010) propose a model of spinoffs generated by strategic disagreements.
[4] The company later became known in the region as the 'university of molds' given its innovative style and the fact that many workers and future entrepreneurs learned about molds while working there (Gomes, 1998; Rodrigues, 2002).

spawning of a large number of spinoffs (Vieira, 2007). Figure 1 provides a partial picture of the genealogy of the first generation of plastic injection molds companies.

Figure 1 about here

Considering that we can trace the origin of a significant share of the firms created to a small group of parent companies located in the same region, the process of growth and expansion of the industry can be compared to the genesis and development of the semiconductor, automotive, and tire industries in the U.S. (Buenstorf and Klepper, 2009; 2010; Klepper, 2007; 2010). It is well documented that historically the industry grew in the Marinha region through the substantial occurrence of intra-industry spinoffs (Melo, 1995; Sopas, 2001; Rodrigues, 2002; Gomes, 2005; Beira *et al*., 2004; Beira *et al*., 2007).[5] Agglomeration externalities seem to have played at best a secondary role, as most of the entrants were spinoffs originating in the agglomerated region, benefitting from capabilities and routines acquired in their parent companies. Preference for home base location was probably due to greater access to sub-contracts and skilled labor, but these regional advantages were advanced by the spinoff process itself, so no causation may attributed to agglomeration economies.

Second phase of growth: from the mid-1980s onwards

The second phase of growth of the molds industry is traced back to a boom in demand due to the outburst of applications for plastic materials in electronics that started in the late 1970s and increased substantially in the 1980s and 1990s, a time when new molds companies would emerge 'overnight' (Henriques *et al*., 1991). While the first wave of spinoffs (until the 1970s) was headed by workers with extensive production know-how, the second wave (from the mid-1980s) was championed by workers either from commercial departments, with

[5] A survey conducted in 1992 on 106 molds companies from Marinha found that 83 percent of company owners had worked previously in the same industry and region (Melo, 1995).

knowledge about markets and customers, or design departments, working closely with customers to ensure conformity to their needs (Oliveira, 1996). This trend drove the industry further into vertical disintegration, with fewer companies involved in all the value-adding activities, and more companies specialized only in parts of the process (such as design, expert production, or marketing).

The organization of the industry

Portuguese molds companies are in general very small. A company with 100 workers is considered large (Henriques, 2008). Companies are intensely driven by customers' needs (Henriques, 2008). Each mold is a new, unique project, or rather a unique combination of standard components (for instance, heating and cooling systems, and injectors) and non-standard components (for instance, specific molding surfaces). This degree of customization and specialization limits scale economies[6] and emphasizes worker qualification and experience (Gomes, 1998).

Mota and Castro (2004, pp. 303–304) provide a detailed description of the manufacturing process, which involves several stages, constant testing and customer feedback, and frequent alterations. Fulfilling orders typically involves a multiplicity of firms. Firms have very narrow boundaries and must trust external or indirect competences through sub-contracting and outsourcing to accomplish key parts of the production process, such as designing, machining, or thermal treatments. In such a community of vertical disintegrated firms as the molds industry in Marinha, the ability to coordinate competencies and combine knowledge across corporate boundaries (but inside regional borders) has become a distinct capability itself. Managers develop a specialized supplier network and build a narrower and more

[6] In the last two and a half decades investments in physical capital required for entry have increased significantly, but are still relatively low when compared with other manufacturing industries.

competitive set of core competencies, being capable to rapidly locate and contract specific external competences from other firms located nearby.

If a marketing/engineering molds firm aims to grow in size and variety of customers, it needs to either vertically integrate or acquire a deep understanding of the capabilities of local sub-contractors, plus the ability to outsource orders with minimum risk (Mota and Castro, 2004). Very few Portuguese molds companies have chosen to extend their boundaries, vertically integrating marketing, design, and various stages of production.[7] Some of the more successful marketing/engineering firms may keep connections with as much as 70 molds producers and 10 designers simultaneously (Mota and Castro, 2004). Under these circumstances, knowledge acquired on the strengths and limitations of local firms, capabilities, for communication with different professionals, and transmission of specific knowledge, technologies, routines, and product designs, are instrumental for success. It is possible that a shortage of workers specialized in specific stages of the production process, and liquidity constraints may have prevented marketing/engineering firms from vertically integrating. More likely, access to networks of multiple producers has provided greater flexibility than vertical integration. Vertically integrated companies' internal capabilities may not be sufficient to respond to the great variety of orders received (Mota and Castro, 2004).

The approaches to networks of capabilities set forth by Loasby (1998), Dyer and Singh (1998), and Lorenzoni and Lipparini (1999) seem to apply generally to the Portuguese plastic injection molds industry. This organization of production suggests that while the transmission of capabilities between parent firms and their offspring may have been at the heart of the first decades of evolution of the Portuguese plastic injection molds industry, agglomeration externalities, particularly those associated with the existence of networks facilitating access to suppliers and specialized knowledge, as conceived by Piore and Sabel (1984), and Porter

[7] One of such cases is Iberomoldes, a spinoff from A.H.A. founded in 1975 that ended up acquiring its parent company and is one of the largest molds companies in Marinha.

(1990, 2000), might have emerged later to play a role in enhancing the performance of clustered firms.

QUANTITATIVE ANALYSIS: DATA AND METHODOLOGY

In this section we describe the data and methods used to examine the predictions associated with the theories being analyzed. Our empirical approach is divided in three parts: the first part concerns the probability of firms generating spinoffs; the second part concerns the location decision of new molds firms, and the third focuses on the performance of molds companies and the way it is influenced by spinoffs and agglomeration externalities.

Data

The present study uses a dataset extracted from 'Quadros de Pessoal' (QP) micro-data, a Portuguese longitudinal matched employer-employee database including extensive information on the mobility of firms, workers and business owners for the period 1986–2009. QP data is gathered annually by the Portuguese Ministry of Employment and Social Security[8] and covers all firms (and establishments) with at least one wage-earner in the Portuguese economy. Information about firms includes size (number of employees) and location, while information on individuals covers their age, formal education, employment, and professional careers.

We use longitudinal data on founders and firms in the molds industry from all Portuguese counties in continental Portugal, differentiating between the firms located in the agglomerated regions (Marinha and Oliveira) and other firms. For each entrant in the molds

[8] Submission by firms is mandatory.

industry from 1987–2009,[9] we identify the founder(s) and look for the previous occupations of each founder in the previous five years of available data. The task of tracing the background of entrants faced several limitations. Some firms do not identify the owner, and in others there is likely to be misreporting. Some founders might have been working as sole contractors (a fairly widespread practice in the country) and are not registered previously in the data set (which includes only firms with at least one wage earner). During the period under observation, Portuguese SIC codes underwent four changes, requiring the construction of tables of correspondences between old and new industry codes and designations.

Entry in the Portuguese molds industry remained significant during the period following 1987 and the number of firms in the industry increased until 2005 (see Figure 2). Average entry size is consistently smaller in the agglomerated regions (Marinha and Oliveira). The evolution up to 2005 suggests that new firms entering the agglomerated region do not seem to enter in order to grow and vertically integrate, but to be small and specialized.[10]

Figure 2 About Here

The number of molds companies that entered the industry in the period of analysis for which we could identify the founders and their previous occupations was 653 (about 60% of all firms founded in the industry during the period). In addition to distinguishing spinoff founders from other entrants, we seek to identify and distinguish founders coming from industries that may be related to molds, either by having direct commercial relationships with the molds industry, or by sharing the same worker skills.

We capture relatedness in two ways. First, we identify industries belonging to the value chain of the molds industry (that is, industries that use significant inputs from the molds

[9] Entrants in 1986 where not included since there was no way to observe their professional backgrounds in prior years.

[10] It is perhaps too early to develop an explanation for the trends in entry and entry size after 2005. Future extensions of the QP database, as more years are included, may help clarify this issue.

industry or sell significant outputs to the molds industry). Second, we capture relatedness associated with skills by using the index of skill relatedness developed by Neffke and Henning (2009), which is based in cross-industry labor flows. If an industry has more intense labor flows with molds than would be expected given wage and other relevant differences, then the two industries likely require similar skills. Table 1 presents the list of value chain industries, while Table 2 identifies the industry/region pairs that were found to be significantly skill-related to molds, following the procedure described by Nefke and Henning (2009).

Tables 1 and 2 about here

Tables 3 and 4 show the industry of origin and location choice of new entrants in molds during the period 1987–2009. The majority of entrants (about 55.6%) are spinoffs, but a significant number (24.7%) originates in non-related industries. Location is dominated by a preference for home base, as almost 70 percent of all firms choose to locate in the same region of their parent company. However, this inclination towards home region is even stronger for spinoffs and for firms originating in the agglomerated regions.

Tables 3 an 4 about here

Methodology

In order to test the predictions derived in the theory section, we estimate three types of models regarding:

I. the probability that a firm will spawn a molds startup, given its industry of origin (molds, value chain, skill related, or other) and the home region of the founder (inside or outside the agglomerated region), while controlling for firm size (a proxy for firm quality)[11] and economic cycles;

II. the probability that a molds entrant will locate in the home region of the founder, given its industry of origin and the home region of the founder, while controlling for initial size;

III. the probability of survival of a new molds entrant, given its industry of origin and home region of the founder, while controlling for initial size, and accounting for firm heterogeneity.

The explanatory variables of interest are related to the backgrounds of the entrepreneurs, in terms of industry of origin and home region. Table 5 presents the definitions and descriptive statistics of the variables used, which are mostly binary.

Table 5 about here

Models I and II are estimated using Logit. In model I we use pooled panel data including all observed firms in all counties of continental Portugal during the period under analysis (almost five million observations), and estimate the probability that a firm will spawn at least one molds spinoff. In model II, we estimate the probability of home location, that is, the likelihood that a molds entrant will locate in a region (county) where at least one of the founders previously worked. For this, we pool all observed molds entrants for 1987–2009 together. In model III we examine the performance of plastic injection molds startups using the probability of survival as a measure of performance.[12]

[11] We acknowledge that, in an industry like molds, with mostly very small companies, firm size is unlikely to represent a good measure for firm quality. However, there are no valid alternatives in the dataset to account for sources of firm heterogeneity other than regional and industrial origin. Klepper (2007) uses firm longevity as a measure of quality. However, this choice involves significant endogeneity.

[12] While longevity may not be the most appropriate way to assess performance, data on sales or output are not available, so growth could only be measured in terms of the number of employees, which would have little significance in an industry populated by very small firms. Survival is used by Klepper (2007) to assess firm performance, and is a legitimate measure of quality used in a large variety of studies in economics and management (see Santarelli and Vivarelli, 2007, for a review).

In Model III, since size is unlikely to capture firm heterogeneity influencing performance, we estimate the probability of survival using mixture hazard (frailty) models. Parametric specifications of survival/failure models can only go so far in explaining the variability in observed time to failure. Excess unexplained variability is known as overdispersion. Standard survival models (such as the Cox model) cannot adequately account for why firms with shorter times to failure are more 'frail' than others. A frailty model attempts to measure this overdispersion by modeling it as resulting from a latent multiplicative effect on the hazard function (Gutierrez, 2002).[13] Frailty models often use the Weibull distribution as the hazard function and the Gamma or Inverse Gaussian distributions to account for the multiplicative heterogeneity. We find that indeed the Weibull distribution with Gamma or Inverse Gaussian heterogeneity is the better fit for the data.

RESULTS

The estimations of the Logit models (in Tables 6 and 7) present the marginal effects of the explanatory variables, as recommended by Wiersema and Bowen (2009).[14] For a discrete explanatory variable, the marginal effect is the change in the dependent variable when the explanatory variable is incremented by one unit.

Probability of spawning a molds startup

In model I (Table 6), every firm identified in the database, regardless of region and industry, is a candidate to spawn a molds startup. If molds and related industries located in the agglomerated region (Marinha and Oliveira) are the ones more likely to spawn molds startups, then predictions one and two of the organizational reproduction theory are supported

[13] Goodness-of-fit tests performed on the data confirm the existence of overdispersion in firm heterogeneity.
[14] All Logit models are estimated using robust standard errors at the firm level.

by the data, that is, better parent firms (in terms of origin and location) spawn the most spinoffs. If molds and related industries are more likely to spawn molds startups regardless of location then only prediction two is confirmed.

In the first column in Table 6, we estimate a model of the probability of spawning a molds startup solely as a function of the founder's industry background. We find that firms in the molds industry are significantly more likely to spawn molds spinoffs. Since we are dealing with a dummy or binary variable 0/1, we can interpret the marginal effect of this variable as meaning that the probability of a molds firm spawning a molds startup is, all else equal, roughly 1.3 percentage points higher than that of a firm which is not in the molds industry. Firms in industries belonging to the molds value chain are also more likely to spawn molds startups, but the magnitude of the marginal effects is much smaller. The effect is insignificant for firms in skill-related industries. In the second column, we add a dummy variable equal to one when the firm is located in the agglomerated region (Marinha and Oliveira). Molds industry firms and value chain industry firms remain significantly more likely to spawn a molds startup (in fact, the marginal effect for the value chain firms increases), but firms located in the agglomerated region also are, regardless of their origin, more likely to spawn molds spinoffs. The marginal effect is, however, quite small (a probability increase of only 0.4%). Still, such result indicates that molds and related industries are not the only ones more likely to generate molds startups. Firms locating in the cluster are significantly more likely to spawn startups than firms outside the cluster, regardless of industry origin, which suggests that location in the agglomerated region also contributes directly towards the ability to spawn molds startups.

In the third column we introduce interaction terms between two dummy variables corresponding to industry of origin,[15] and the dummy variable corresponding to location in the agglomerated region. Both the individual marginal effects and the marginal effect of the interaction term are significantly positive for firms in molds as well as in industries in the molds value chain, meaning that the probability of molds firms that locate in the agglomerated region spawning more spinoffs is positive and significant. These results show that, even though the marginal effects are small, predictions one and two of the organizational reproduction theory are supported: molds firms are more likely to spawn spinoffs than firms in other industries, and are even more likely to spawn spinoffs if they are located in the agglomerated region.

The results suggest that the role played by spinoffs and the inheritance of capabilities from parent companies remains important in this more advanced stage of the industry's (and cluster's) evolution. However, results also show a positive effect of location in the agglomerated region on the probability of spawning a startup, suggesting a burgeoning effect of agglomeration externalities on the probability of a firm located in the cluster spawning a molds startup, independent of the firm's industry. A note should be made about the marginal effect of firm size (log) which is positive, as expected, but of very small magnitude. As we acknowledged above, in an industry such as molds, populated by mostly very small firms, size is unlikely to provide a good account for firm quality.

Probability of locating in the home region

In model II (Table 7) we estimate the probability of a new molds firm entering in the same region where the founder previously worked. If firms are more likely to choose home

[15] We do not estimate coefficients for interaction with skill-related industries because the relatedness index refers to pairs of industry and county.

location than any other location, then predictions one and two of the agglomeration economies account are rejected.

The first column in Table 7 estimates the probability of locating in the home region for molds startups, given their original location and industry of the parent firm. We find that both molds spinoffs and molds startups originating in value chain industry firms have a significant and sizably higher probability of locating in their home regions than other firms, regardless of the region of origin. A molds industry spinoff is, all else equal, 9.4 percentage points more likely to locate in its home region than other companies, while a startup originating in the value chain is, all else equal, 7.6 percentage points more likely to locate in its home region. The marginal effect for firms in skill-related industries is, again, insignificant. However, the marginal effect for the dummy variable representing location in the agglomerated region is also positive and significant. In fact, it has a higher magnitude, meaning that, all else equal, molds startups originating in the agglomerated region are 12.7 percentage points more likely to locate there, regardless of their industry of origin.

The second column in Table 7 includes two interaction terms between the dummy variables representing industry origin (molds or value chain industry) and the dummy variable representing geographical origin in the agglomerated region. Both interaction effects are insignificant. This result means that the startups originating in related industries that are spawned by firms in the agglomerated region are not more likely to stay in the agglomerated region, thus implying that the agglomerated region attracts all kinds of locally originated startups equally.

The main overall conclusion from model II is that every kind of startup is more likely to choose home base, so the results of this study support those obtained by Figueiredo *et al*. (2002); Michelacci and Silva (2007); and Dahl and Sorenson (2009; 2011). The results also show that, while it does not attract founders from other regions, the agglomerated region has a greater probability of holding on to its own molds startups than other regions. Whereas the predictions of the agglomeration economies theory should be rejected, this result may be judged as weakly supporting the agglomeration economies account: even though all molds startups are more likely to locate in their home region, the probability of home location for the startups in the agglomerated region is higher.

Frailty models of survival/exit

Model III looks at the probability of survival. If spinoffs or startups originating in related industries are more likely to survive, then prediction three of the organizational reproduction theory is supported. If molds companies located in the agglomerated region are more likely to survive, regardless of their industry origin, than prediction three of the agglomeration economies account is supported.

Table 8 presents the hazard ratios for exit corresponding to each explanatory variable for models mixing the Weibull distribution hazard function with Gamma and Inverse Gaussian heterogeneity distributions. The hazard ratio is the multiplicative effect of a unit change in the explanatory variable on the hazard rate (in our case, the probability of exit). Hence, a hazard ratio larger than one means a positive effect on the hazard of exit, and therefore a negative effect on the likelihood of survival; and a hazard ratio smaller than one decreases the hazard of exit, thus increasing the likelihood of survival. The mixed/frailty model specification that fits the data better is the one using the Inverse Gaussian distribution to account for multiplicative unobserved heterogeneity.

Evidence from Model III is positive for both theories. Spinoffs and startups originating from the molds value chain and skill-related industries have significantly greater chances of survival. This result supports the organizational reproduction account argument (prediction three) that spinoffs benefit from more pre-entry knowledge and therefore are more likely to survive.[16] However, molds firms located in the agglomerated region also have a greater probability of survival, regardless of their industry of origin, thus confirming prediction three of the agglomeration economies account. This is reinforced by the fact that the hazard ratio for firms that locate in the home region of the entrepreneur is greater than one, meaning that locating in the home region when such region is not the agglomerated one actually has a negative impact on survival. The results suggest that there are agglomeration benefits accrued by firms that locate in the agglomerated region making them more likely to survive, regardless of their origin.

CONCLUDING REMARKS

This paper has sought to examine the mechanisms that drive regional clustering of the plastic injection molds industry in Portugal by examining two alternative (though not necessarily mutually exclusive) theories: agglomeration economies and organizational reproduction. The Portuguese molds industry started taking shape in 1946, developing two clusters: Marinha (the first, and considerably larger one) and Oliveira. Its strong presence in these regions was still growing about 60 years later.

Due to constraints in the access to quantitative data on the evolution of the industry since its inception, we have based our methodology on a dual approach: first, we provide an account of the early evolution (1946–1986) and current organization of the industry, paying close attention to how access to external capabilities influences firm boundaries; second, we use detailed data on firms and founders for the period 1987–2009 (when entry remained

[16] Again, the effects experienced by spinoffs and startups coming from value chain industry firms are not confirmed for startups founded by individuals who worked in industries/regions that are skill-related to molds. This suggests that the concept may not apply with regard to the accumulation of pre-entry knowledge and capabilities relevant to the startup.

pervasive) to examine, using econometric methods, whether support for the predictions of each theory is significantly different at an advanced stage of the cluster's life cycle.

The historical account of the first decades of the industry shows that its initial location in Marinha was dictated by the presence of precursor industries, glass and glass molds, in a process of industrial heredity that marked, among others, the automobile industry in Detroit (Klepper, 2001; 2007) and the tire industry in Akron (Buenstorf and Klepper, 2009). Like Oldsmobile and Goodrich in those industries, the pioneer firm (A.H.A.) played a major role in the future evolution of the industry. This account strongly suggests that organizational reproduction was the foremost driver of agglomeration in the first decades of the industry, while agglomeration economies played, at best, a minor role. A.H.A. and its immediate followers decisively influenced both the future location of the industry – by spawning a series of successful spinoffs located around them – and the future organization of the industry, by implementing division of labor and specialization of workers. Workers would then found spinoffs whose boundaries were conditioned by their own narrow specialty, which could be refined into a high quality, price-competitive component of the final mold product.

As the industry evolved, an organic, regional networked model of production emerged, particularly in Marinha. Faced with the option between growing by vertically integrating marketing, design, and component production, or maintaining the kind of deep specialization and small size that embody the legacy of A.H.A's division of labor, most firms chose to stay small and take advantage of the local network of diverse and complementary capabilities that allow marketing/engineering firms to sub-contract and outsource design and production of multiple components of a specific final product to a variety of firms.

Our econometric analysis of data starting in 1987 reflects to some extent a mounting combination of factors encompassed by both theories under analysis. While the predictions of the organizational reproduction account remain valid at this mature stage, we also find evidence that agglomeration economies contribute to the generation of spinoffs and enhance firm performance, regardless of the firm's heritage: unrelated startups benefit from agglomeration economies as much as spinoffs and startups originating in related industries. It is then possible to conclude that while the transmission of specific knowledge from parent firms continues to represent a significant mechanism for clustering and enhanced performance, agglomeration benefits now also play an important role enhancing firm performance and generating offspring startups.

These findings provide support to our observations about the role played by organizational reproduction and agglomeration economies theories over the cluster life cycle. Pre-entry knowledge about customers, suppliers and technologies usually associated with spinoffs and startups coming from related industries was determinant for clustering in the early stages of the industry, and is still very influential. However, the dynamics of the local network of capabilities allow companies to access external knowledge and perform highly specialized services while maintaining their very narrow boundaries, thus also increasing their probability of survival.

While Klepper's (2008) account of the geography of organizational knowledge strongly contributes to explain the emergence and evolution of a cluster such as Portuguese molds, the accounts by Piore and Sabel (1984) and Porter (1990, 2000) of simultaneous cooperation and rivalry in small firm clusters seem to gain substance as the industry matures. This is likely due to the specific organizational form of the cluster, where access to external capabilities is the strongest determinant of firm boundaries (Loasby, 1998; Dyer and Singh, 1998). In the clusters observed by Klepper (2007; 2010), and Buenstorf and Klepper 2009, composed mainly of large, vertically integrated firms, the generation of a dynamic network sharing capabilities would be less likely, hence the lack of support for the role of agglomeration externalities found by these authors.

The present study has several limitations that were already pointed out, but should be restated now. Firstly, detailed data are not available for the formative era of the industry, which does not allow us to use econometric techniques to test the predictions of the two theories under consideration for the period 1946–1986. Our alternative approach – a historical account of the industry's history and organization – was put together from a variety of sources, most of them were not scientific papers, but industry associations' publications and oral accounts, so some of the observations made are necessarily subjective. We do, however, believe we provide sufficient information for a process of causation to be established between the birth and growth of the molds industry and the local presence of precursor industries, as well as the importance of capabilities acquired while ‘on-the-job’ and the spawning of multiple spinoffs.

Regarding the econometric study, tracing backgrounds of entrepreneurs is not always possible when dealing with the data, although we believe we have assembled a sizable and representative sample of molds startups entering over 23 years. Also, the unavailability of firm-specific data other than size imposed serious limits to our ability to control for firm heterogeneity in the Logit models, as size is not a critical variable accounting for quality in the Portuguese plastic injection molds industry. A final difficulty lied in the identification of industries related to molds. Identification of industries in the molds value-chain would benefit from additional analyses of input-output data which was not accessible, compelling us to resort to published lists of industries.

Our findings have impacts for both practitioners and policy makers. For practitioners, our findings seem to confirm that access to external capabilities can substitute for vertical integration in localized networks of firms. For policy makers, our results suggest that industrial districts remain a valid model for regional growth, at least in industries where knowledge and variety play a greater role than scale.

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Table 1 – Value chain industries*

Suppliers and subcontractors:	Customers:
Basic industries of iron and steel, not specified Aluminum production Manufacture of basic iron and steel and of ferro-alloys Casting of iron Casting of other non-ferrous metals Casting of light metals Casting of non-ferrous metals General mechanical engineering Manufacture of other fabricated miscellaneous metal products Treatment and coating of metals Manufacture of other miscellaneous special purpose machinery Manufacture of tools Manufacture of machinery for plastics and rubber industries Wholesale of metals and metal ores Engineering activities and related technical consultancy	Manufacture of footwear Manufacture of parts of footwear Manufacture of lighting equipment and electric lamps Manufacture of plastic packing goods Manufacture of builders' ware of plastic Manufacture of other plastic products Manufacture of cutlery Manufacture of electric domestic appliances Manufacture of equipment for low-voltage electrical installations Manufacture of other electrical equipment Manufacture of electrical and electronic equipment for motor vehicles Manufacture of motor vehicles Manufacture of other parts and accessories for motor vehicles Manufacture of bicycles and invalid carriages Manufacture of motorcycles Manufacture of games and toys Wholesale of machine tools

* Sources: Based on data from Beira *et al.*, 2004; Henriques, 2008; Mota and Castro, 2005.

Table 2 – Skill-related pairs of industries and regions

Region	Industry
Marinha	Manufacture of corrugated paper and paperboard (includes containers)
Marinha	Printing n. s.
Marinha	Manufacture of plastics in primary forms
Marinha	Manufacture of plastic plates
Marinha	Manufacture of plastic packing goods
Marinha	Manufacture of other plastic products
Marinha	Casting of iron
Marinha	General mechanical engineering
Marinha	Manufacture of other fabricated miscellaneous metal products
V. F. Xira	Manufacture of general purpose machinery
Marinha	Manufacture of equipment for low-voltage electrical installations
Marinha	Manufacture of other electrical equipment not specified
Marinha	Agents specializing in the sale of particular products (or ranges) n. s.
Marinha	Wholesale of other household goods
Marinha	Wholesale of machine tools
Marinha	Other wholesale
Marinha	Retail sale of office machinery and other equipment
Marinha	Retail sale of hardware and flat glass
Marinha	Freight transport by road
Marinha	Other computer related activities
Marinha	Business and management consultancy activities
Marinha	Architectural activities
Marinha	Engineering activities and related technical consultancy

Table 3 – Background of the molds entrants

Origin	N.	%
Molds industry	363	55.6%
Value chain industry	161	24.7%
Skill-related industry	70	10.7%
Other	177	27.1%

Table 4 – Attraction to the home region

Background	Locate Home	%
All backgrounds	456	69.8%
Molds	217	77.0%
Marinha	215	74.1%
Oliveira	62	87.3%

Table 5 – Variable definitions and descriptive statistics

Variable	Definition	Mean	SD
spin	Dummy for creation of molds spinoffs by company *i* in year *t* (DV)	0.025	0.155
pemp	Size of company *i*, measured by the number of employees in year *t*	10.988	103.76
Molds	Dummy for company in the molds industry	0.002	0.047
Vc	Dummy for company in an industry from the value chain of molds	0.035	0.184
Rel	Dummy for company in a skill-related industry and region	0.001	0.028
Moldsreg	Dummy for company located in the molds agglomerated region (Marinha and Oliveira)	0.035	0.185
home	Dummy for entry in a *county* where at least one founder had a previous job (DV and IV)	0.698	0.459
pemp_f	Size of the entrant measured by the number of employees in the first year	6.590	11.836
molds	Dummy for company with at least one founder with a previous job in the molds industry	0.556	0.497
vc	Dummy for company with at least one founder with a previous job in an industry from the value chain of molds	0.247	0.431
rel	Dummy for company with at least one founder with a previous job in a skill-related industry and region	0.107	0.310
moldsreg	Dummy for company with at least one founder with a previous job in the molds agglomerated region (Marinha and Oliveira)	0.564	0.496
agg	Dummy for company located in the molds agglomerated region (Marinha and Oliveira)	0.553	0.498

Table 6 – Model I: Estimates of the molds spinoff Logit model – marginal effects†

VARIABLES	(1)	(2)	(3)
Size (log(*pemp*))	0.0002*** (0.0000)	0.0002*** (0.0000)	0.0002*** (0.0000)
Molds industry (*Molds*)	0.013*** (0.0001)	0.010*** (0.0000)	0.012*** (0.0001)
Value chain industry (*Vc*)	0.0005*** (0.0000)	0.0004*** (0.0000)	0.0004*** (0.0000)
Skill-related Industry (*Rel*)	0.0002 (0.0000)	0.0001 (0.0000)	0.0001** (0.0000)
Molds agglomerated region (*Moldsreg*)		0.0004*** (0.0000)	0.0006*** (0.0000)
Agglomeration in molds (*Molds*Moldsreg*)			0.0004*** (0.0001)
Agglomeration in value chain (*Vc*Moldsreg*)			0.0002*** (0.0001)
Observations	4,946,611	4,946,611	4,946,611
Log-pseudo likelihood	-7,031.71	-6,835.77	-6,788.78
Pseudo R^2	0.3697	0.3872	0.3914
Wald test	0.0000	0.0000	0.0000

† *significant at the 0.10 level; ** significant at the 0.05 level; ***significant at the 0.01 level (cluster standard errors in parentheses); Year dummies omitted.

Table 7 – Model 2: Estimates of the Logit model of the likelihood of locating in the home region – marginal effects†

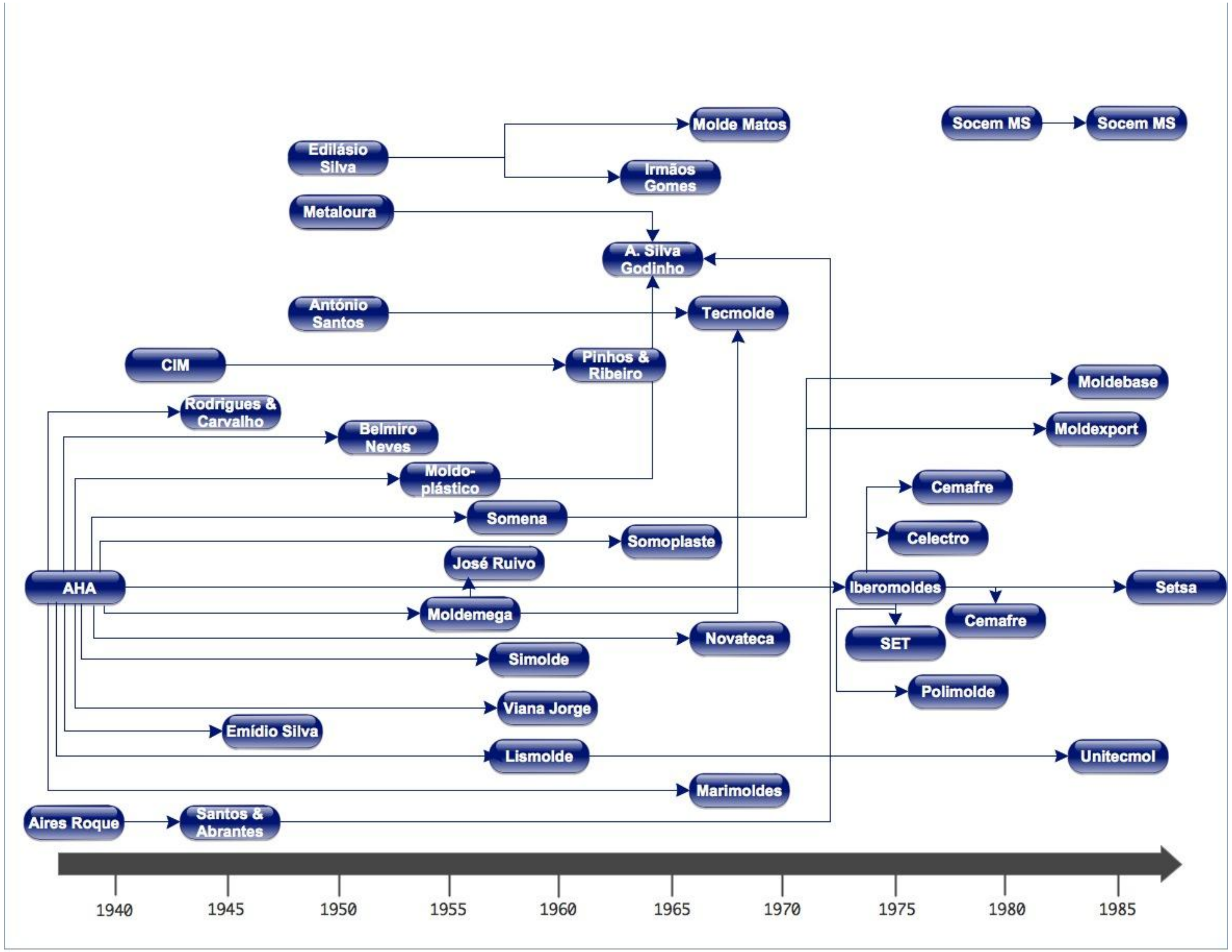
VARIABLES	(1)	(2)
Entrant's initial size (log(*pemp_f*))	0.0324 (0.0214)	0.0323 (0.0215)
Founder from molds (*molds*)	0.0941** (0.0423)	0.1100** (0.0482)
Founder from value chain (*vc*)	0.0759** (0.0353)	0.0669 (0.0579)
Founder from skill-related (*rel*)	-0.0063 (0.0717)	-0.0135 (0.0734)
Molds agglomerated region (*moldsreg*)	0.1268*** (0.0423)	0.1398* (0.0726)
Molds industry and molds region (*molds*moldsreg*)		-0.0328 (0.0877)
Value-chain and molds region (*vc*moldsreg*)		0.0227 (0.0933)
Observations	610	610
Log-pseudo likelihood	-345.09	-344.94
Pseudo R2	0.0414	0.0418
Wald test	0.0001	0.0002

† *significant at the 0.10 level; ** significant at the 0.05 level; ***significant at the 0.01 level (robust standard errors in parentheses)

Table 8 – Model III: Estimates of the frailty models for startup survival†

	Weibull distribution with GAMMA heterogeneity ***(1)***	***Weibull distribution with INVERSE GAUSSIAN heterogeneity*** ***(2)***
VARIABLES	**Hazard Ratio**	
Entrant's initial size (log(*pemp_f*))	1.0475 (0.1133)	0.9581 (0.1275)
Locating in the agglom. region (*agg*)	0.6132** (0.1342)	0.5855** (0.1454)
Locating in the home region (*home*)	1.6011** (0.3490)	1.5479* (0.3830)
Founder from molds (*molds*)	0.4872*** (0.1065)	0.4737*** (0.1154)
Founder from value chain (*vc*)	0.3473*** (0.0869)	0.3042*** (0.0870)
Founder from skill-related(*rel*)	1.9516** (0.6030)	2.4661** (0.8854)
Observations	610	610
Log-likelihood	-655.27	-653.06
Likelihood-ratio test of θ = 0	0.001	0.000

† *significant at the 0.10 level; ** significant at the 0.05 level; ***significant at the 0.01 level (standard errors in parentheses)



(Figure based on information from: Beira *et al*., 2004; J. Gomes, 1998; N. Gomes, 2005; Lopes, 2004; Rodrigues, 2002; G. Silva, 1996)

Figure 1 – Sample of the genealogy of plastic injection molds firms in the period 1946–1989

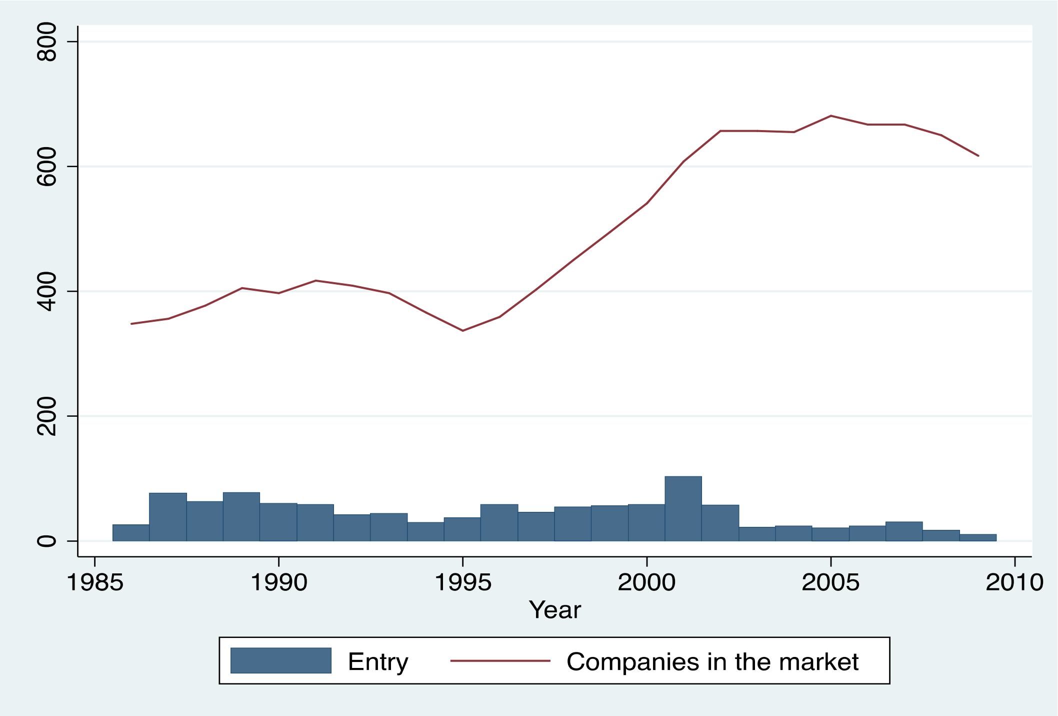


Figure 2 – Entry and number of firms in the molds industry by year: 1986–2009