Agglomeration vs. Heritage: The Molds and Plastics Industries in Portugal

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Abstract

The evolution of regional industry clusters is examined by exploring two perspectives: the mechanisms driving the performance of one clustered industry, and the mechanisms and cross-industry effects driving the collocation of related industries and enhancing their performance in the clustered region. In the first study, the analysis focuses on one clustered industry (molds manufacture for injection-molded plastics fabrication). The second study broadens the scope to examine in more detail the linkages between two closely related industries (molds manufacture and injection-molded plastics manufacture). Two theories that aim to explain these phenomena are taken into consideration: agglomeration economies and organizational heritage. The setting for this research is in Portugal, where the molds industry developed into world-class, high-technology leaders driven heavily by exports.

When looking at one specific agglomerated industry characterized by a network of small, vertically disintegrated companies, we find that both mechanisms have significant effects on performance. However, effects associated with heritage through spinoffs seem to have a stronger impact. In addition, when looking at more advanced stages of the cluster's evolution, we find evidence of durability of heritage effects in the growth and sustainment stages of the cluster life cycle. Results also point to the importance of spinoffs from related industries. When analyzing collocation of related industries, results imply that organizational reproduction through the transmission of capabilities from parent firms in the related industry to spinoffs locating in the same region is the foremost driver of collocation of the molds and plastics injection industries. The presence of the plastics industry also has a positive impact on the molds industry, but the inverse relationship is not significant.

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1 Introduction

Industry clusters are rare (Ellison and Glaeser 1997) and require explanation, particularly when there is no natural advantage underlying the clustering. Examples like Silicon Valley, where firm competiveness and employment growth in the semi-conductor industry was very high in the second half of the 20th century, motivate interest in clusters as models of successful economic development (Leslie and Kargon 1996; Chatterji, Glaeser, and Kerr 2013), potentially replicable elsewhere. Such quest requires a deeper outlook on the mechanisms driving agglomeration and the performance of firms in a successful cluster.

Studies of highly concentrated industry clusters (Saxenian 1994; 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).

A more recent line of work focused on the role played by spinoffs[1] and, more broadly, the transmission of capabilities from parent firms to independent 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 near the best parents, leading to

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

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. This research proposes a theory suggesting that each of these accounts explains different stages of the cluster's development. The argument is that the first stages of an agglomerated industry's evolution may be dominated by the spawning of multiple local spinoffs by the pioneer, better companies, as predicted by the heritage theory. However, in the more advanced stage of sustainment (after the emergence and growth stages, and before the decline stage), after 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 arguments. Under these circumstances, heritage forces would be indispensable for the creation and initial growth of a cluster, while agglomeration externalities would emerge later.

Additionally, this research proposes that collocating with a customer industry further stimulates agglomeration and improves the performance of an agglomerated industry, although it may have no effect on the customer industry. The drivers of industry collocation rely on heritage mechanisms, and there is weak evidence of a significant influence of agglomeration economies.

This study examines the case of the Portuguese industry of plastic injection molding and its linkages with an industry in its value-chain, the molded plastics industry, as well as other related industries. The molds industry agglomerates in two small regions in Portugal, and one of those has a strong presence of the molded plastics industry.

Molds are metal parts used in plastic injection to shape plastic parts that are used as inputs in many industries. Molded plastic products are pervasive in today's economy, being used in industries such as consumer packaged goods, chemicals, electronics, automobiles, communications, drug delivery devices, and packaged food products, to name but a few. Each plastic component of a product requires one mold that is unique, made to order under the specifications of the customer for the resulting plastic part. Nowadays molds apply different materials technologies, optics, and information technologies in a technologically complex product often with tolerances of only a few microns (for precision molds). The mold can then be used to inject plastic resins to yield millions of identical plastic components by the plastics industry (Sopas 2001).

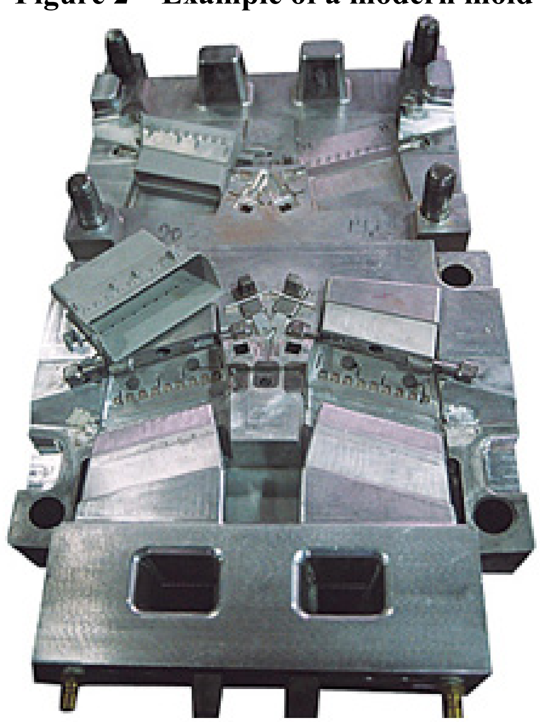
Molds are vital inputs for industries producing consumer goods. When a mold has deficiencies, these are likely to induce delays in the introduction of new products resulting in significant losses to the molds customer. Given the specificities of such intensely engineered products, they can be quite expensive and take a long time to manufacture – between 10 and 20 weeks, 12 on average (G. Silva 1996; Sopas 2001). Production requires intense communication with the customer and with possible subcontractors in order to minimize misunderstandings and consequent corrections, thus providing strong incentives for customers to establish long-term relationships with specific molds producers (Sopas 2001).

Figure 1 depicts two examples of molds produced in Portugal in the early 1950s (by A.H.A.), while Figure 2 shows a modern mold produced recently by a Portuguese molds company (Iberomoldes).

Figure 1 – Examples of molds (1950s)

Source: Molds from A.H.A. (Gomes, N. 2005)

Figure 2 – Example of a modern mold



Source: Iberomoldes (http://www.iberomoldes.pt)

The Portuguese plastic injection molding 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, where the industry was born and that still represents the largest geographical cluster, and Oliveira de Azeméis, a smaller cluster that evolved in parallel with Marinha Grande. Both regions are located outside the main metropolitan centers of Lisbon and Porto.

The first part of this study focuses on the molds industry itself and the mechanisms that drove its agglomeration. Agglomeration occurred historically since the first few firms in the molds industry chose to locate in the same region, in a process similar to that experienced by the US automotive industry in Detroit and the semiconductor industry in Silicon Valley (Klepper 2010; Kowalski 2012). The study's aim is to test what location dynamics impact agglomeration and firm performance in clusters. Therefore our level of analysis is not the cluster per se, but firms inside the cluster and the mechanisms affecting their location choice and performance. The study examines the founders' paths before they create molds companies. In particular, looking at the industry where they had previous working experience and the region where they came from. If heritage theories are able to capture the process of industry agglomeration, then entrepreneurs with previous experience in the molds or a related industry should have a higher probability of spawning new molds companies. On the other hand, if agglomeration theories describe the main drivers of the agglomeration process better, founders will move to the agglomerated region regardless of their region of origin, attracted by the potential benefits of the agglomeration process, and firms located in the agglomerated region will perform better than firms located elsewhere.

The second part of the study looks at the collocation of the molds industry with the plastics injection industry, considering why there is a significant number of plastics companies located in the region where the molds industry agglomerates. The study examines the factors influencing the location choices of industries that drive them to collocate within a region. The aim is to uncover cross-influences of the presence of one industry in the location choice of a related industry and the influence they may have over each other. Again, two theoretical streams are considered to explain the collocation of related industries: agglomeration economies and organizational heritage theories. These theories propose different dynamics to explain why related industries would locate in the same region, and this research tests the predictions of both streams.

The studies establish the main predictions of the two theoretical accounts of agglomeration, propose theoretical observations regarding the roles played by each of the accounts over the cluster's life cycle, and test the predictions of the theories, looking to discern whether the observations are in line with the evolution of the molds and plastics industries. The methodological approach is twofold and dictated by the availability of data. The first part of the analysis is an account of the pre-history, evolution, and organization of the Portuguese plastic injection molding industry until the mid-1980s, complemented by an analysis of the early history of the plastics industry in Portugal. In the second part, detailed data matching of firms, founders, and geographical regions (at the *concelho* or county level) available for the period 1986-2009 is used to examine the origin of founders, firms' locations decisions, and performance. The work focuses on investigating the mechanisms that drove the agglomeration of the molds industry and the influence the location choice of the plastics had in the process, but also the reverse: the influence of the presence of the plastics industry on the molds industry.

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

The study is organized as follows. The next section outlines the theoretical discussion. The succeeding section offers a brief account of the evolution of the Portuguese plastic injection molding and plastics industries, focusing particularly on spinoff and agglomeration phenomena, while also discussing industry organization. The fourth section describes data and some generic methodological matters. Section five describes the first study regarding the drivers of agglomeration for the molds industry. The sixth section explains the second study, which looks at the drivers of collocation of related industries. The final section offers some concluding remarks.

2 Theoretical Aspects

The mechanisms that drive the agglomeration of industries in a region have drawn the interest of scholars and policy makers throughout the world. In particular, the success of Silicon Valley motivated questions about what explains the clustering of industries in a specific region and the success of such clusters. Industry agglomeration is recognized as a prevailing characteristic associated with industrial growth, and there have been several attempts to explain it, originating from a variety of fields. The present study concentrates on two theories providing explanations for the existence of clusters, though there are alternative and complementary viewpoints that warrant discussion – see, for example, Martin and Sunley (2006); and Frenken *et al.* (2011). This research focuses on agglomeration economies theories and organizational heritage or reproduction theories, as discussed in the two following sections. The two theories provide substantially different explanations for the existence and success of clusters, though, in fact, they are not mutually exclusive.

There is, to a certain extent, a tendency for the views on agglomeration externalities and organizational heritage to share arguments, as agglomeration-based research pursues approaches associated with the changing industrial structure of regions (Martin and Sunley 2006; Menzel and Fornahl 2009; Buenstorf and Geissler 2008). While the conventional account of agglomeration externalities and heritage theory are not mutually exclusive, they each have distinctive implications regarding the motivations for agglomeration and the drivers of firm performance that can be used to assess the importance of their featured mechanisms. Buenstorf and Klepper (2009; 2010) and further studies by others (Boschma and Wenting 2007; Heebels and Boschma 2011; Kowalski 2012) find that the spinoff process was key to clustering in several industries and that agglomeration economies and proximity to markets stressed in the conventional account played a minor role in the clustering those industries. However, agglomeration economies supporters claim that although the role of spinoffs should not be neglected, the motivations for their location choice are linked to agglomeration economies (Glaeser, Rosenthal, and Strange 2010).

2.1 Agglomeration Economies Theory

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 effects, 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, may induce entrants to cluster (Marshall 1890; Porter 1990; Krugman 1991b). Supply-related factors drive companies to locate near their competitors, related industries, and suppliers: 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.

Labor pooling agglomeration economies may derive from the reduction of uncertainty for the workers, who could move to a nearby company if demand decreases for their employer (in particular if those companies are in different industries but use the same types of workers), making them more willing to accept lower wages (Marshall 1890). However, there may also be benefits associated with the higher probability of finding the best match between the employer and the talents and interests of the employee (Helsley and Strange 1990), and to coping with worker skill uncertainty (Strange, Hejazi, and Tang 2006). In addition there may be matching benefits linked to the changes of worker preferences over time (Glaeser and Gottlieb 2009). Rotemberg and Soloner (2000) also propose that workers in agglomerated industries have more incentives to invest in industry-specific training. Nevertheless, as acknowledged by Glaeser and Gottlieb (2009), there is little empirical evidence to support claims related to the agglomeration benefits of labor market pooling, although it has been shown to have an a positive effect on entry, if we refer to the presence of workers from related industries (Glaeser and Kerr 2009).

Industry agglomeration may also increase the incentives for specialized suppliers to locate in the same region as their customers, and this proximity could bring benefits to the industry in terms of transportation cost (as modeled in Fujita et al 1999), and in terms of knowledge flows (Porter 1990). Ellison *et al.* (2010) found that input-output linkages are good predictors of coagglomeration, but Glaeser and Kerr (2009) find only modest support for the effect of linkages to customers and suppliers on entry.

Technological spillovers are often referred in terms of the presence of suppliers of ideas and empirically measured through patent citations, again following Marshall (1890) and also Jacobs (1969). However Fujita (2010) acknowledges that most spatial economics models ignore knowledge externalities and information spillovers.

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). Beginning with Krugman (1991b) and Krugman and Venables (1995), a stream of literature known as the New Economic Geography has emerged to model agglomeration. In these models, pecuniary externalities arising from increasing returns at the firm level, coupled with market size effects, lead to geographical concentration. Both types of models imply that, under certain circumstances, producers and their specialized suppliers, and even related industries, agglomerate in a limited number of regions. However, it is also recognized that agglomeration economies are hard to find empirically (Glaeser and Gottlieb 2009).

The extent of agglomeration in any one region is limited by various forces, including transportation costs, more intense price competition among more closely located firms, decreasing returns to scale as some inputs are increased relative to those that are fixed, and congestion costs. This would imply that agglomeration economies would benefit the companies located in the region, up to the point where congestion costs[2], and even a possible decrease in relevant innovation (Pouder and St John 1996; Audretsch and Feldman 1996), begin to outweigh those benefits and the agglomerated region's performance declines.

More recently, urban economists have focused on the role played by entrepreneurship in the industry agglomeration process. The motivation for this research is that regional performance in terms of employment growth has been consistently found to be highly correlated with the presence of a multitude of small firms, and therefore with entrepreneurship (see for example Acs and Armington 2006; Glaeser *et al.* 1992; Glaeser 2007; Glaeser, Kerr, and Ponzetto 2010; Glaeser, Kerr, and Kerr 2012; Rosenthal and Strange 2010; Feldman, Francis, and Bercovitz 2005). Glaeser, Kerr, and Ponzetto (2010) proposed a model to test several possible origins for this stylized fact and found empirical support to a source proposed by Chinitz (1961), who claimed that the supply of entrepreneurs differs across space. The authors also found some

[2] Mills (1967) pointed out that agglomeration leads to diseconomies driven by congestion costs associated with land.

support to lower costs of entrepreneurship – since larger fixed costs deter entrepreneurship, while the presence of independent suppliers has the opposite effect (Glaeser and Kerr 2009).

Glaeser, Rosenthal, and Strange (2010) imply that agglomeration economies may be driving the entrepreneurship leading to clustering. In regions with a higher supply of entrepreneurs – because there are more small firms as proposed by Glaeser, Kerr, and Ponzetto (2010) – those entrepreneurs tend to locate their ventures in the same region for several reasons, but possibly also because they are attracted by agglomerative spillovers like input sharing, labor pooling, and the opportunity to learn from their neighbors.

2.2 Heritage Theory

An alternative but not mutually exclusive 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 (Buenstorf and Klepper 2009; 2010). New entrants need pre-entry organizational knowledge to compete (Phillips 2002; Helfat and Lieberman 2002; Helfat and Peteraf 2003). An important source of pre-entry capabilities is experience acquired by employees who later decide to leave and create independent spinoffs in the same or a related industry.

A stream of research in organizational ecology focuses on the transfer of routines and experience from a founder's previous employer to his or her new firm (Phillips 2002), in a process of heritage or organizational reproduction. The argument that the blueprints of a parent firm are passed on to new organizations through their founders is the cornerstone of a number of works by, among others, Carroll (1984), Hannan (1986), and Romanelli (1989). Klepper (2001;

2002) has found traction for these ideas in the context of spinoffs. A central argument of this research is that the success of new organizations is fundamentally shaped by the pre-entry experiences of their founders. This sort of relationship has been studied in the management literature. A stream of research has focused on the relationship between the experiences of top managers and corporate performance (Hambrick and Mason 1984; Murray 1989; Michel and Hambrick 1992; Hambrick, Seung Cho, and Chen 1996). 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. Founders embody that knowledge themselves and complement it with the knowledge of the founding team, which often shares the same experience (Agarwal *et al.* 2013).

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). Incumbent firms in an industry can also be an important source of entrants in the form of employees leaving to found their own firms in the same industry. Following Klepper (2007), these entrants are called spinoffs. Instead of localization economies attracting or encouraging the formation of alike firms in a region, regions with more firms in an industry will naturally spawn more spinoff entrants.

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, Guimarães, and Woodward 2002); economics of entrepreneurship (Michelacci and Silva 2007), as well as sociology and management (Dahl and Sorenson 2009; 2012) and propose explanations associated with better access to human (skilled and educated workers), social (local network ties), and physical capital (sources of financing) in the region of origin. This finding has been dubbed 'home field advantage' by Figueiredo *et al.* (2002). The location of new firms is heavily influenced by the local social ties of founders (Davidsson and Honig 2003). Beckman (2006) finds evidence for a positive effect of entrepreneurial social capital on new venture performance. Regionally bounded knowledge helps entrepreneurs assemble the assets and recruit the personnel that they need to succeed in their ventures (Delgado, Porter, and Stern 2010). For instance, new firms may wish to hire local employees since entrepreneurs have greater knowledge about local prospective hires based on their prior work experience (Carias and Klepper 2010). Stuart and Sorenson (2003), and Michelacci and Silva (2007) suggest that there are so many local entrepreneurs because locals can better exploit the financial opportunities available in the region where they were located. Dahl and Sorenson (2009, 2012) argue that social capital limits an entrepreneur's ability to found a firm in a region in which (s)he does not have connections.

Buenstorf and Klepper (2009) propose a view, called heritage theory, which features the inheritance of organizational competence as the principal force underlying industry clustering. According to this view, clustering of an industry in a region begins with one firm (for instance, Oldsmobile in the case of the automotive industry in Detroit, or Goodrich in the case of the tire industry in Akron) and its initial influence spreading to other regional producers, similar to the conventional agglomeration economics account. However, the subsequent growth of the regional cluster is attributed to an endogenous process in which incumbent firms involuntarily spawn independent spinoffs. As they try to enhance their own performance through technological innovation and improved organizational processes, successful industry incumbents inadvertently function as training grounds for their employees, allowing them to acquire the skills needed to start ventures of their own. This is part of a broader process in which firms differ in their competence. Through employee learning these competences are transferred to spinoffs. Employees become better and acquire more useful knowledge as prospective spinoff founders by working in superior incumbent firms. This increases the likelihood of spinoff formation from these firms as well as the performance of the ensuing spinoffs. Therefore, spinoffs stemming from the best founding or early firm in a region do better than those that do not. Like other new firms, spinoffs mostly locate where they originate, causing the spinoff dynamics to reinforce the existing geographical differences in birth potential for new entrants, both in number and quality.

Evidence from the regions of Detroit, Akron, and Silicon Valley shows that organizational heritage or reproduction was the main force underlying the clustering of the automotive, tire, and semiconductor industries in those regions (Klepper 2007; 2010; Buenstorf and Klepper 2009; 2010; Kowalski 2012). Employees learn through their employment experience how to organize a successful company. The ones that leave to create new companies in the same industry or a related industry will transfer that knowledge and skills, allowing them to create successful ventures. A group of superior companies will grow from this endogenous process and create a cluster of high-performance companies. Further evidence from the Dutch book publishing cluster (Heebels and Boschma 2011) and the British automotive industry (Boschma and Wenting 2007) also support the impact of prior relevant work experience. Therefore, the underlying reason for agglomeration is linked to the heritage of knowledge and skills that employees carry with them to their new ventures.

Sorenson and Audia (2000) extend a parallel argument to later stages in the cluster's existence. They propose that what drives the persistence of clusters over time, in particular in those composed of small firms (like the shoe industry in the US), is the heterogeneity in entrepreneurial opportunities. Regions with dense concentrations of firms in the same industry would increase the local pool of potential entrepreneurs, therefore increasing entry inside the cluster and thus maintaining the agglomeration. Prior experience in the industry would allow entrepreneurs to acquire specific and social capital (tacit knowledge about the industry, a relevant social network, and self-confidence) leading to the creation of spinoffs in the same region. Golman and Klepper (2013) also explain the role of entrepreneurship in cluster formation, by associating it with the market opportunities generated by innovation led by the incumbents. The authors model cluster growth by spinoff formation associated with the discovery of new submarkets through innovation. The model shows that clustering may result exclusively from the self-reinforcing dynamic generated by innovation leading to spinoffs, possibly complemented by non-Marshallian positive externalities associated with entrepreneurship (like the demonstration effect and the availability of venture capital). This process would not require the presence of agglomeration economies. Tacit knowledge would be transferred from the parent firm to the spinoff through the founders and the employees hired by the spinoff.

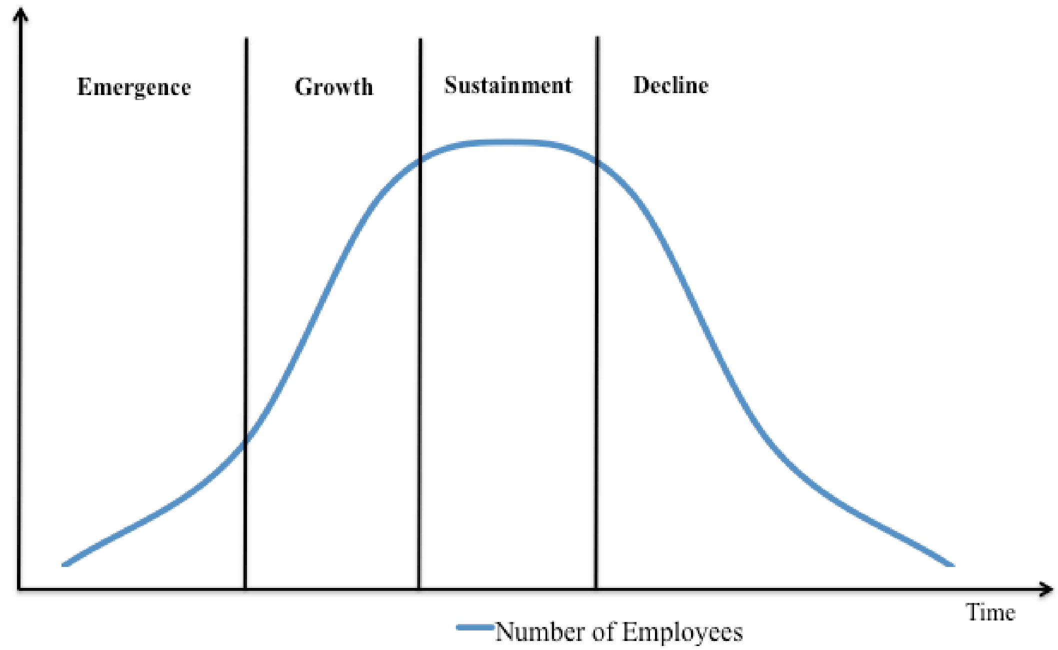
2.3 Industry Agglomeration and the Cluster Life Cycle

The propositions of agglomeration economies and heritage theories are not mutually exclusive. However, there are conflicting findings in the empirical literature (Frenken, Cefis, and Stam 2011; Henderson 2003; LaFountain 2005). This research proposes to reconcile these theories by identifying their prevalence along the cluster's life cycle and considering the type of industrial structure present in the industry.

Different agglomeration mechanisms may play different roles at different stages of the cluster's development, as the industry's structure evolves. A cluster's life cycle goes through several stages: emergence, growth, sustainment, and decline (Menzel and Fornahl 2009), as depicted in Figure 3. Although the role of entrepreneurship is often considered important in the emergence stage (Feldman, Francis, and Bercovitz 2005; Porter 1990), after the cluster is created, different theories propose that different mechanisms (agglomeration economies or organizational heritage) drive the cluster's growth and sustainment stages.

This research hypothesizes that the first stages of an agglomerated industry's evolution are dominated by the transmission of technological and organizational capabilities through startups originating in the same or related industries and, in particular, sequences of spinoffs originating in the earlier, better companies in the industry that locate near their parent companies. In these early stages entrepreneurs are not being attracted from outside by the benefits of locating close to their competitors; on the contrary, they are located in that specific region and choose to start their company in their home region. However, in the sustainment stage, 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.

Figure 3 – Cluster life cycle



Source: Adapted from Menzel and Fornahl (2009)

The cluster's decline stage is generally attributed to congestion costs that offset agglomeration economies. Therefore, agglomeration economies are not likely to play an important role at that stage. Heritage effects would make it more likely for the spinoffs to survive the decrease in the number of producers that occurs in this phase. In the case of the Portuguese molds industry, there seems to be no convincing evidence of significant congestion costs in the agglomerated region during the period of analysis (see Appendix III).

Alfred Marshall (1890) 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 wideranging empirical studies have been conducted by Holmes (1999), Li and Lu (2009), and Figueiredo *et al.* (Figueiredo, Guimarães, and Woodward 2002). These studies find a positive correlation between localization of an industry and firm vertical disintegration. Also, Maskell (2001) points out that firms in clusters can learn, and thus create knowledge, by observing their competitors (horizontal dimension), but most of all by interacting with suppliers and subcontractors specializing in parts of the production process that possess complementary capabilities (vertical dimension). Such deepening of specialization allowed by physical proximity inside the cluster would then explain the cluster's self-reinforcing higher level of knowledge creation, leading to its success.

Small, vertically disintegrated companies depend on each other to fulfill orders of complete, final products. The narrower a firm's boundaries, the more likely that it may have easy access to resources, competences, and capabilities residing in other firms (Langlois and Robertson 1995). The entrepreneur chooses to narrow the boundaries by specializing in a part of the production process where he has a comparative advantage, and locates near firms that can contribute to other parts of the production process. 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 other's 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. Mature clusters of small, integrated firms that simultaneously compete and cooperate 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.* (2012) 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.

2.4 Industry Collocation

The collocation of related industries calls for an analysis of the drivers of agglomeration for each individual industry but also raises the issue of possible cross-industry influence, that is, the possibility that clustering in an industry might be driven by the presence of other, related industry. Empirical research claims that the concentration of related industries contributes to firm entry (Glaeser and Kerr 2009) and survival (Neffke, Henning, and Boschma 2011), as well as industry and cluster growth (Delgado, Porter, and Stern 2012); therefore one would expect to find effects of collocating with related agglomerated industries. However, research has mostly focused on single industry analysis, and the present research aims to broaden the empirical approach to look at the mechanisms affecting both collocating industries.

Location choice of one industry close to a related industry could be driven by the benefits of agglomeration economies resulting from that proximity or it could be driven by an organizational reproduction process between these related industries. Therefore, two theoretical streams to explain the collocation of related industries process are considered: agglomeration economies and organizational heritage theories.

Agglomeration economies theories explain the collocation of related industries, in particular supplier and customer industries, with the benefits firms accrue from the reduction of transportation costs of goods, people (labor market pooling), and ideas (Marshall 1890). Ellison *et al.* (2010) explain industry coagglomeration with economic benefits from supplier and customer reduction in transportation costs, labor market pooling, and intellectual spillovers. Regressing industry pairwise coagglomeration indices on measures of these three effects, they find positive and significant correlations with input-output dependencies and labor pooling benefits.

Within this line of reasoning, the collocation of related industries is fueled by the economic benefits firms are able to extract from the reduction of the transportation costs mentioned. In particular, if there is a vertical relationship between the related industries in their value chain, there would be a reduction of transportation costs of products within the supplier-customer relationship. Also, Glaeser and Kerr (2009) find that the presence of related industries, to the extent that they induce labor pooling by hiring the same type of workers, has a significant effect on entry. Delgado *et al.* (2012) also mention benefits related to access to key inputs, better interactions with customers, and facilitation of experimentation and innovation. Therefore, these authors would expect that firms that chose to locate close to related industries would improve their performance compared to firms that would locate elsewhere.

Chinitz (1961) argues that entrants are attracted to areas with many independent small suppliers, and Glaeser and Kerr (2009) find empirical support for that claim. They also find that entry in a region tends to be even more influenced by the presence of related industries that hire the same sort of workers.

Heritage theory focuses on the role played by spinoffs and, more broadly, the transmission of capabilities from parent firms to startups. Buenstorf and Klepper (2009) propose that a firm's pre-entry capabilities critically shape its performance. 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 (Michelacci and Silva 2007; Dahl and Sorenson 2009; Figueiredo, Guimarães, and Woodward 2002), this dynamic process leads 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, but simply a preference of founders to locate near their previous employer.

Often the spinoffs created in a new industry originate from parent companies that are incumbents in an older, predecessor industry, which is related to the new industry. This is the case of, for instance, glass, glass molding, and plastic injection molding in Portugal; bicycles, carriages, and automobiles in the United States (Detroit) (Klepper 2007), and radio and television receivers in the United States (Klepper and Simons 2000). This is due to the benefits that startups in the new industry accrue from inheriting important pre-entry knowledge (i.e.

capabilities and routines) from their parent firms. Such pre-entry knowledge is transmitted between firms by founders and/or employees of the new firms that previously worked in the parent firms or through diversification of the parent firm into the new industry. Such a process provides new firms with a significant competitive advantage (Helfat and Lieberman 2002; Phillips 2002).

Taking into consideration these two theoretical approaches, the aim of the second study is to understand the cross-effects that the presence of one industry may have in the location choice of a related industry.

3 The Evolution and Organization of the Molds and Plastics Industries

The molds and plastics industries emerged in parallel in Portugal in the late 1930s to the mid 1940s. Historical accounts give evidence on how these industries developed and what conditioning factors influenced their initial location choices. In addition to a thorough literature review, this section benefited from several interviews with industry organizations, researchers, and industry experts, as well as visits to the Marinha Grande region. The list of people interviewed is in Table 1 below:

Table 1 – List of People Interviewed

Name	Institution	Role	City
Rui Tocha	CENTIMFE and Pool-net	Director of the molds industry technological center	Marinha Grande
António Ruivo	Pool-net	Project manager at the tooling association	Marinha Grande
Manuel Oliveira	CEFAMOL	Director of the molds industry association	Marinha Grande
Eduardo Beira	Minho University	Professor of industrial history and innovation (molds industry)	Oporto
Nuno Gomes	CENTIMFE (former worker)	Industrial history researcher (molds industry)	Leiria
Maria Elvira Callapez	Lisbon University	Science and technology historian (plastics industry)	Lisbon
Carlos Bernardo	Minho University	Pioneer researcher in the Department of Polymer Engineering	Guimarães
António Pontes	Minho University	Researcher in the Department of Polymer Engineering	Guimarães
Isabel Ferreira da Costa	APIP	Director of the plastics industry association	Lisbon

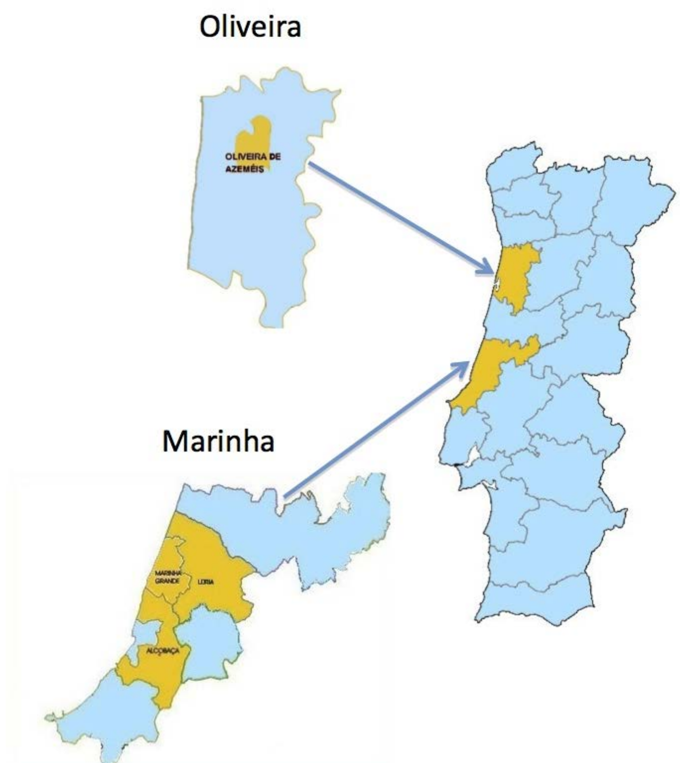
3.1 The Molds Industry

The following account of the evolution of the plastic injection molding industry aims to establish evidence on the causal mechanisms associated with clustering, by providing evidence of the importance of the phenomenon leading to entry and impacting firm performance in the molds industry. Our level of analysis is the firm inside the cluster and the mechanisms affecting the firm's location choice and performance. In the absence of quantitative data for the formative era of the molds cluster, we employ qualitative analysis to provide evidence of which agglomeration mechanisms played a relevant role at this stage of the cluster's development. Process tracing (George and Bennett 2005) and causal process observations (Collier, Seawright, and Brady 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). In addition we describe the characteristics, structure, and organization of the Portuguese molds industry to provide evidence of the specific context of the study, and thus clarify this research's contribution to theory.

The Portuguese molds industry is recognized by the US International Trade Commission as 'one of the world's principal producers of precision molds for the plastics industry.' (Fravel *et al.* 2002), traditionally exporting almost its entire production (Beira *et al.* 2004). This industry is innovative and technologically advanced (Beira *et al.* 2004). Extensive historical reports and qualitative studies have focused on this industry in an attempt to explain the success of an industry that stands out in the country's economy.

The Portuguese molds industry cluster includes two different locations in the center and north of Portugal: Marinha Grande and Oliveira de Azeméis. The Marinha Grande region includes three adjacent *concelhos*[3] (Marinha Grande, Leiria and Alcobaça), while Oliveira de Azeméis is a single *concelho* (see Figure 4). Marinha Grande region has an area totaling 1,160 km^2 while Oliveira de Azeméis is much smaller, with an area of 161 km^2. Both regions are located away from the main metropolitan centers of Lisbon and Oporto.

Figure 4 – Map of continental Portugal (molds agglomerated regions highlighted)



3.1.1 Pre-history

The origin of the plastic injection molding industry in Portugal is closely linked to the history of precursor industries in Marinha Grande: the glass and glass molds industries. The

[3] *Concelho* is the Portuguese administrative division for a region with a city council (i.e. analogous to a US county). Currently there are 278 *concelhos* in continental Portugal, with an average area of 320 km^2.

geographical roots of the Portuguese molds industry are located in two regions of Portugal that once were centers of the glass industry and later became clusters for the molds industry (Oliveira de Azeméis and, in particular, Marinha Grande).

The first record of the presence of a glass factory in Marinha Grande region dates from around 1747 when the Irishman John Beare re-located the glass factory he owned in Coina (close to Lisbon) to Marinha Grande (J. Gomes 1998; S. Gomes 1990). He aimed to locate closer to an abundant supply of the main raw materials involved in glass production: sand and firewood (to fuel the glass furnace). Marinha Grande was indeed not far from the sea, and it was located in the center of Leiria's pine forest, a dense forest several hundreds of years old, which belonged to the Portuguese crown. In addition, the region had good access to transportation by boat and by land to facilitate the shipping of final products and raw materials (S. Gomes 1990). However, the glass company faced considerable opposition and was eventually closed down by the administration of the protected pine forest, displeased by the large and careless consumption of wood.

In 1769, the Portuguese King José I, with the support of his prime minister Marquee of Pombal, commissioned an English industrialist, William (Guilherme) Stephens (Figure 5), who owned a lime furnace in Lisbon, to restart the glass factory, then named 'Real Fábrica de Vidros' (Royal Glass Factory, depicted in Figure 6) in Marinha Grande (Barosa 1993). Stephens accepted the king's generous conditions[4] and turned the plant into a successful glass factory that had a very strong impact on the region.

[4] The King granted Stephens free use of the wood from his forest, a large loan with zero interest, a waiver on the import tariffs for the raw materials, and export tariffs for the glass products sold, among other benefits (Barosa 1993).

Figure 5 - William Stephens

Source: Barosa (1993)

The factory required specialized workers knowledgeable about glassworks, and a few were recruited from Italy, England, Ireland, and Belgium. Some of these experts built families and left their names in Marinha Grande's history, e.g. Gallo, Jorge, and Plomer (N. Gomes 2005). These craftsmen would then teach the Portuguese apprentices their art, and this process eventually led to the creation of a large specialized workforce in the region (the industry involved mainly artisanal production processes).

Figure 6 – "Real Fábrica de Vidros" plan in 1860

Source: (Barros 1969)

William, and later his brother John James (João Diogo), managed the factory until 1826, when John died without descendants and generously donated the company to the Portuguese crown. In 1954 the company was named "Fábrica Escola dos Irmãos Stephens" (Stephens Brothers' School Factory) to honor the benefactors and acknowledge the role played by the factory as a school of the 'glass art' but also of the 'entrepreneurial art' (Gonçalves and Gomes 2004). By then the presence of this factory had induced the creation of many other small glass and crystal companies in the region[5] and the buildup of a mass of specialized glassworkers. Stephens took care of the workers' education by providing teachers for reading and writing, drawing, and music, and by organizing entertainment aiming to improve their cultural level (Barosa 1993). These workers became symbols of the proletariat, and unions thrived in the region like nowhere else in the country. It was said that Marinha Grande was the home of the glass industry's 'aristocratic proletariat', and there are reports of a longstanding tradition of solidarity and complicity among neighbors that was very unusual elsewhere[6] (M. Henriques, Silva, and Laranjeira 1991).

Even with many glass companies in the area, by 1920 there was only one small glass molds producer in Marinha Grande. In fact "Real Fábrica" ordered glass molds from Lisbon, Figueira da Foz, and from abroad – Germany and Austria (S. Rodrigues 2002; J. Gomes 1998). This dependence from outside regions implied long deliveries and high-priced molds. Therefore, by the mid-1920s, one young toolmaker working at "Real Fábrica" since 1923, Aires Roque, asked

[5] Examples are Nova Fábrica de Vidros, A. Central, Santos Barosa, A. Morais, Ricardo dos Santos Gallo, Guilherme Pereira Roldão, Fábrica de Vidraça à Guarda Nova, Fábrica de Vidraça no Engenho, Fábrica de Cristal de José Ferreira Custódio, Fábrica Marquês de Pombal, Nova Fábrica de Vidraças por Mariano Pereira Henriques, Fábrica de Garrafas de José de Oliveira, Fábrica de Garrafas de José Morais Matias, Fábrica de Vidro e Garrafas de Carlos dos Santos Galo, Fábrica de Vidraças e Garrafas de Guilherme Pereira Roldão, Sociedade Vidreira Marinhense, Sociedade Vidreira Lusitana, Gomes & C.a, Manuel Pereira Raposo, Joaquim Ferreira, and A. do Açúcar (Barosa, 1993).

[6] An example are the events of 18th of January 1934, when the population of Marinha Grande, united by the close relationships among neighbors, overcame party divisions and stood together in a strike against the actions of Salazar, the ruling dictator (Henriques *et al*., 1991).

the manager's permission to create a molds workshop, and, together with a skilled lathe operator, António Santos, he produced the first die-cast mold for glass in Marinha Grande using chromium steel (M. Henriques, Silva, and Laranjeira 1991).

In 1926 Aires Roque headed to Lisbon, where he acquired a press-molding workshop (J. Gomes 1998). Roque moved from Marinha Grande to Oliveira de Azeméis (which had become another important glass production region further north) for nine months in 1927, in order to work in glass molds. However, in 1929 Roque returned to Marinha Grande where, together with his half-brother Aníbal H. Abrantes and António Santos, he started a small workshop (Beira *et al.* 2007).

The following year they separated: the brothers returned to Marinha Grande while António Santos stayed, and later on ran another workshop owned by Aires Roque that produced the first molds for plastic in Oliveira de Azeméis: Santos & Abrantes (J. Gomes 1998). Oliveira de Azeméis' glass industry cluster gained more relevance after 1926, when "Centro Vidreiro do Norte de Portugal" was created. This was a project that joined together several glass firms and soon became the "training center" for a new generation of molds workers. This center, due to its unusually large scale (compared with other Portuguese glass manufacturers), became the place where many future entrepreneurs took their first steps in glass molds manufacture, and where a network of personal contacts among workers was started.

In 1936 the plastics industry emerged in the region, starting with the production of Bakelite[7] lids for perfume bottles at Nobre & Silva, the first plastics company in Marinha Grande (Beltrão 1985; J. Gomes 1998). The company soon became a client of the molds manufacturers, who

[7] Bakelite was the first chemically synthetic plastic. It was invented in 1907 by Leo H. Backeland, an industrial PhD chemist who emigrated from Belgium to the US (Meikle 1995).

were starting to order a different type of very simple molds for plastic pressing, which at the time, used mechanical principles similar to those employed in the glass molds (Callapez 2000).

Soon, the workshop named after Aires Roque, but eventually managed by his half-brother Aníbal Abrantes, started experimenting with molds for Bakelite products since molds for plastic pressing used similar mechanical principles to the glass molds (Beira *et al.* 2004; Callapez 2000). Aníbal H. Abrantes' enthusiastic experiments were probably a way to escape a demand crisis in the glass molds market. Remarkably, these experiments were the origin of a disagreement between the two brothers that drove them towards separate paths (N. Gomes 2005). While Aires Roque stayed with glass molds, Aníbal H. Abrantes pursued plastic molds. This difference of opinion would eventually give rise to the first plastic injection molding company to be established in Marinha Grande, a spinoff resulting from a strategic disagreement.[8]

3.1.2 Emergence and first phase of growth: from 1946 to the early 1980s

Thermoplastics – a new class of polymer resins which turn liquid when heated and solidify to a glassy state when cooled – appeared prior to World War II but flourished in the post-war period. This product could be manufactured using plastic injection techniques (J. Gomes 1998), and therefore it brought a fundamental shift in the 'way new materials came to existence' by introducing considerable savings by eliminating the cost of separate fabricating, finishing, and assembling operations (Meikle 1995). By 1946 Aníbal H. Abrantes bought his brother's share in the workshop and founded in Marinha Grande the first Portuguese company (named after himself: A.H.A.) to produce the more resistant steel molds for plastic injection molding (J.

[8] Klepper and Thompson (2010) propose a model of spinoffs generated by strategic disagreements.

Gomes 1998). Soon the company gained more clients as more plastics companies emerged nearby, in Leiria, and also further north (J. Gomes 1998). Benefiting from the economic expansion that followed the end of WWII, the company and the industry prospered.

As it grew, A.H.A. soon became a center for worker training and networking,[9] and it also innovated significantly by introducing division of labor. While in the rest of the world plastic molds were produced with artisanal processes by trained toolmakers, this innovation permitted worker specialization along the production process (Vieira 2007). Neto (1999) explains that the inexistence of traditional toolmakers in Portugal – who would be locked into traditional ways – when the industry appeared (in the early 1940s) made it easier to innovate by organizing work in new ways. Division of labor into specialized stages became the norm in the Portuguese plastic injection molding 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 after their on-the-job learning and training periods[10] (Matos 1985; Beltrão 1987). Hence, A.H.A. paved the way for the spawning of a large number of spinoffs (Vieira 2007). Figure 7 provides a partial picture of the genealogy of the first generation of plastic injection molding companies. The connections between the companies were often intense because subcontracting and sharing the work to better respond to the customer became a common practice in Marinha Grande region (Melo 1995).

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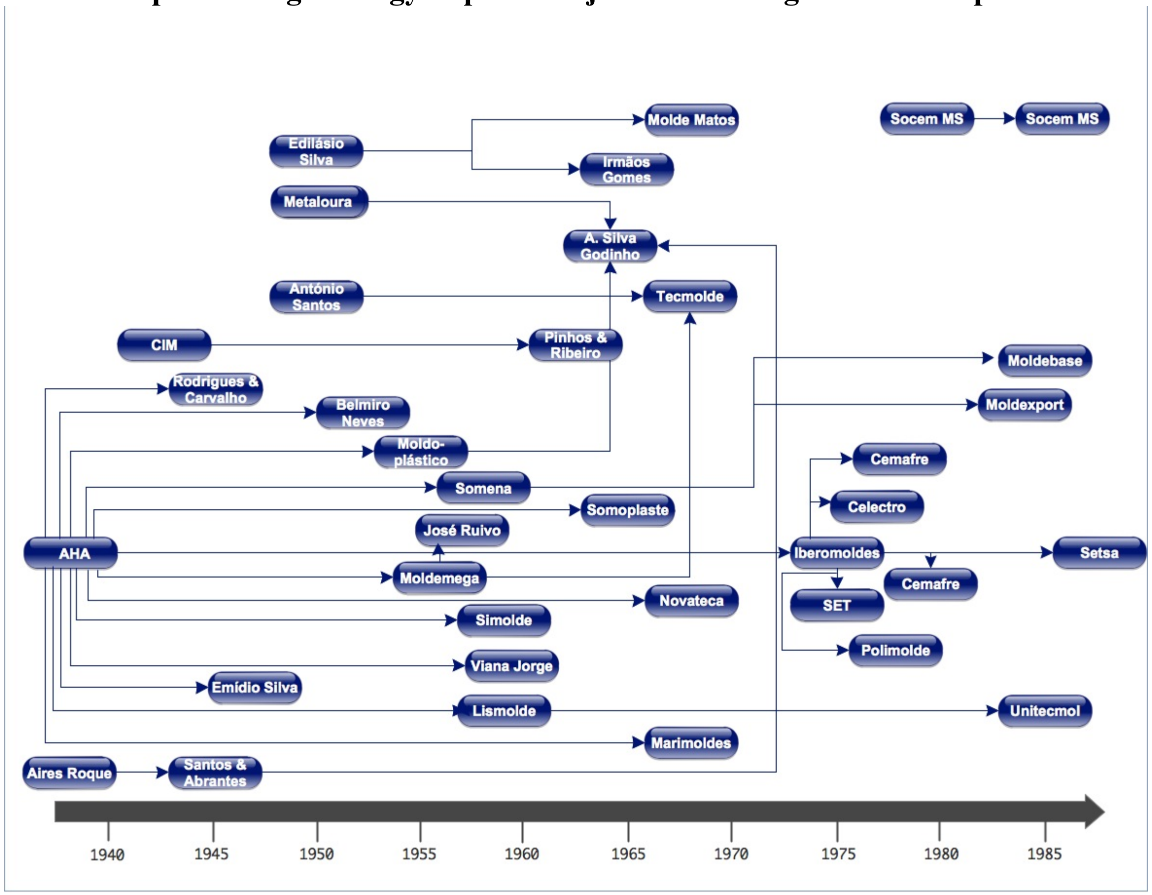
[9] The company later became known in the region as the 'university of molds' given its innovative style and the fact that many workers and future entrepreneurs learned about molds while working there (Gomes, 1998; Rodrigues, 2002).

[10] From 4 to 6 years, as mentioned by Pedro (1985).

Figure 7 – Sample of the genealogy of plastic injection molding firms in the period 1946-1989



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

Considering that one can trace the origin of a significant share of the Portuguese molds firms 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 US (Buenstorf and Klepper 2009; 2010; Klepper 2007; 2010). It is well documented that historically the industry grew in the Marinha Grande region through the substantial occurrence of intra-industry spinoffs (Melo 1995; Sopas 2001; S. Rodrigues 2002; N. Gomes 2005; Beira *et al.* 2004; 2007). A survey conducted in 1992 to 106 molds companies from Marinha Grande region found that 83% of the company owners worked previously in the industry's production area (Melo 1995).

The movement of these key pioneers is historically reported as the driver of entrepreneurship and competitiveness in the first years of the industry both in Marinha Grande and Oliveira de Azeméis regions (Beira *et al.* 2004; J. Gomes 1998; Melo 1995; S. Rodrigues 2002). People who worked together or were trained together established long-term relationships that at some point in time would lead to the creation of new molds companies. Several people became entrepreneurs in more than one company, both in this industry and in related industries[11] (H. Gomes and Soares 2002; Madelino 1996).

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, while cases of agglomeration

[11] E.g. packaging (wooden or cardboard made), electric lighting (lampstands and similar products), CAD consultancy, industrial design services, accountancy services, and training services.

benefits attracting outside entrepreneurs to move into the region, as agglomeration theory predicts, were not identified[12].

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

The second phase of growth of the molds industry's cluster 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' (M. Henriques, Silva, and Laranjeira 1991).

As molds became more complex and their production became more demanding, the design process gained more relevance, and the growing rivalry made commercial capabilities also more critical. Companies were compelled to improve their capabilities in these areas, which in the early days were mostly neglected since the focus was solely on production. Therefore, 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 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) (Oliveira 1996).

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[12] A case study of 33 molds exporters located in Marinha in 1999 (founded in 1958-1996) found that all were created by entrepreneurs with prior experience in the local companies in the industry (Sopas, 2001).

Although at its inception the industry relied on local customers, as early as 1957 the exports to the US market became regular, pioneered by A.H.A. Abrantes arranged a contract with an international agent, Tony Jongenelen, a Dutch intermediary with contacts among both European and US plastics producers (many of these were friends that fled to the US after WW II). The first mold exported was used for the production of a doll (presented in Figure 8) sold in 1954 to a company in the UK, Holloway Plastics (Beltrão 1999).

Figure 8 – Aníbal Abrantes standing next to the doll produced with the first molds exported by A.H.A.

Source: Gomes (2005)

Taking advantage of the high quality and low price of the Portuguese molds *(Beira et al.* 2004), the deal with Jongenelen allowed the company to export all of its production, mainly to the US. However, this partnership almost drove the company to bankruptcy, and therefore eventually the exclusivity deal was terminated. Hence, Jongenelen started working with other molds companies in the region, helping them gain clients abroad, and A.H.A. hired a young man, Henrique Neto, to deal with international clients. In parallel, Jongenelen's acquaintances and clients started to visit Portugal in order to buy molds directly, thus broadening the exports to newer companies (J. Gomes 1998).

The involvement of these and other foreign intermediaries contributed to a generalized boom of exports, in the beginning mainly to the US market, and transformed the Portuguese molds industry into an international player, exporting nearly its entire output (N. Gomes 2005).

The growth of the industry is traced back to what is generally called the ‘boom’ that started in the late 1970s and increased substantially in the 1980s, a time when new molds companies would emerge ‘overnight’, often in improvised facilities, working for as much as 18 hours a day, 7 days a the week (M. Henriques, Silva, and Laranjeira 1991). As an example, (N. Gomes 2005) reports that in Marinha Grande, during 1989 alone, 40 new companies were created. This growth was parallel to a strong increase in exports to the US and Europe (in 1986 Portugal became a member of the European Union).

The main factors contributing to the export boom in the Portuguese molds industry during the 1980s and early 1990s were the increase in international demand for molds and the industry’s low prices when compared to competitors’ average prices. On the one hand, demand for molds was growing due to the explosion of applications for plastic products in the industrialized world. On the other hand, prices were low because wages were lower than in other industrialized countries and because there was a policy of rolling devaluation of Portuguese Escudo against the US Dollar (aiming to correct Portugal's trade deficit).

During the 1980s some companies would get requests for quotations just because they were located in Marinha Grande (Sopas 2001). The location facilitated random contacts of customers attracted by the concentration of specialized firms. Industry concentration may also have produced a demonstration effect due to the presence of successful companies in the region that could contribute to lowering the perceived entrepreneurial risk and stimulate further entry through imitation (Porter 1998). Entrepreneurs in the molds industry mentioned that because their colleagues had already succeeded with their spinoffs provided an incentive to their decision to do the same (Sopas 2001).

Companies reported advantages to locating in Marinha Grande related to the easier access to subcontracts from other producers in the region or from traders inside the region (Sopas 2001). However, it can be argued that these advantages are also linked to the fact that the entrepreneurs were previously working in the region and in the same industry. Yet other advantages associated with location reported by companies included the increased likelihood of being visited by foreign customers attracted to Marinha Grande and the support of specialized institutions like the region's training centers (Sopas 2001).

3.1.4 Organization of the molds industry

Portuguese molds companies are in general very small. A company with 100 workers is considered large (E. Henriques 2008). Companies are intensely driven by customers' needs (E. Henriques 2008). Each mold is a new, unique project, and 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 and emphasizes worker qualification and experience (J. Gomes 1998). The industry is composed of a multitude of small and micro firms specializing in specific types of molds and, often, in specific stages of the vertical integration chain. This structure is very close to the old Italian textiles and ceramic clusters in Emilia Romagna (Brusco 1982; Porter 1998).

Barriers to entry in the industry were not strong in the first three decades of the industry, and a small group of skilled workers could start a company with a small investment in used or low-quality equipment and the support of suppliers or customers (Leitão and Deodato 2005; G. Silva 1996). In the early days a rented room with some basic equipment was often enough to start a company. In fact, the critical resources were the working skills and the experience in the industry (Leitão and Deodato 2005). Entrepreneurs would use individual and family resources supplemented by personal credit secured by confirmed orders and the up-front payment by customers or special payment conditions negotiated with equipment suppliers. In some cases the former employer also became a partner of the new venture (Sopas 2001).

Due to the growing demand and competitive prices, in the early days the companies did not need to make intense commercial and marketing efforts. Traditionally they depended on intermediaries or just the local industry's reputation to get requests for quotations (J. Gomes 1998). Most companies were production-oriented (Sopas 2001) and lacked knowledge about the market and how to select and reach customers.

Subcontracting portions of the production process or even the complete mold is a pervasive behavior among Portuguese molds companies (E. Henriques 2008; Sopas 2001). Sometimes new firms would start by working on orders from the former employer of the entrepreneur(s), although some companies started by working for foreign customers that the entrepreneurs knew from working for the former employer and with whom they had established a working relationship (Sopas 2001).

The modern molds plant requires heavy reliance on advanced software and machinery increasingly based in information technologies. The industry was a pioneer in the country during the early 1980s in the adoption of technologies such as computer-aided design (CAD), manufacturing (CAM), and engineering (CAE), and nowadays numerically controlled machines are widespread. Also, product data management (PDM), database management systems (DBMS), and production planning and scheduling systems (PPS) are being introduced throughout the industry (E. Henriques 2008). Besides being an advanced technology early adopter, the Portuguese molds industry was also a pioneer in innovating business strategies and approaches to the market – e.g., introduction of division of labor, low dependency on local customers, and close relationships with key customers (Beira *et al.* 2004). The pressing need to be up-to-date with production techniques and the use of CAD/CAM and NC technologies make it crucial to have business heads with a deep technical background that helps the company to be openminded and adapt to innovative production techniques and state-of-the art machinery (E. Henriques 2008).

The economic and cultural framework of the country also had a strong influence in how the industry and the companies are organized. Traditional toolmakers emerged in the developed countries (like Germany, the UK, and the US) as a result of the industrialization process in the early 1940s, and they had the skills to perform all the steps of a molds project. However, Portugal had no industrial or technical tradition, and factory owners would simply copy products from abroad, lacking both adequate equipment and skilled technical staff to implement rigorous production methods (Callapez 2000). Indeed, the dictatorial Portuguese government did not consider industrial production as a priority and implemented, from 1931 on, laws to limit the creation of new factories and increases in production capacity – *Lei do Condicionamento Industrial* (Callapez 2000).

Therefore, without those highly skilled toolmakers, Abrantes transformed a weakness into an opportunity to innovate by dividing the work into several parts where workers would specialize, usually associated with different machines (applying Taylorist principles). Since they could focus on specific tasks, it took less time to train specialized workers than it would to train a fully skilled toolmaker. In addition, these specialized workers were less traditional and therefore more open to the introduction of new production technologies, thus giving the country's industry more growth potential (J. Gomes 1998; Neto 1999). However, this loss of generalization would later (in the 1980s) make difficult the appropriation of potential benefits of more advanced technologies like

CAD/CAM and would bring the need to change ways in managing production and human resources (M. Rodrigues 1989).

In the industry's first three decades, common equipment used by the industry included different types of lathes and milling cutters, broaching machines, pantographs, and hand metalworking tools (Gonçalves and Gomes 2004). Workshops were usually dirty, dark, and messy. However, in 1953 A.H.A. started a new era by inaugurating new and modern facilities, near the train station, that created a new standard in layout and organization. The contrast to prior factories was so big that there were accusations of excess luxury (Gonçalves and Gomes 2004). Both national and local dignitaries participated in the inauguration that was described in local newspapers (N. Gomes 2005). The new facilities separated different parts of the production process, reinforcing the innovative work division promoted by Abrantes. Inspired by factories Abrantes visited abroad, the new factory also included clean areas used for the drawing section and social areas like a cafeteria and changing rooms (Gonçalves and Gomes 2004). Figures Figure 9 and Figure 10 are pictures of the new facilities.

Modern mold production factories use milling machinery (conventional and numerically controlled), lathes (also both types), machining centers, grinding machines, boring machines, drilling machines, wire and penetration erosion machines, CAD/CAM systems, etc. (J. Gomes 1998).

Figure 9 - Drawing Department in A.H.A. in the 1960s

Source: N. Gomes (2005)

Figure 10 - Milling Department in A.H.A. in the 1960s

Source: N. Gomes (2005)

In the late 1970s, a first round of investment in new-generation technologies by the Portuguese molds industry began with the acquisition of programmable key-in machines. Such investments aimed to improve productivity but also to gain capacity to produce more demanding product specifications that were progressively less linear (Beira *et al.* 2004). Numerically controlled equipment and machining centers followed, but such expensive investment required high usage rates. Considering that production series are very small (usually one single product), this would require intense programming. Yet, programmers were hard to find in the market, very costly to train, and harder to keep due to their scarcity (Beira *et al.* 2004).

Faced with such difficulties, early on the industry became aware of the potential solution CAD/CAM technologies represented, and in 1983 this was one of the main topics discussed in the first conference of the molds industry, voicing the concerns and expectations of the businessmen (Alfaiate 1985; Neto 1985). Clients were also pushing for the use of CAD files to send the description of the product in quotation request (Beira *et al.* 2004; Neto 1987a). However, the introduction of programmable machines, and later CAD/CAM/CAE and NC systems, brought new production management challenges to the industry.

In the first few years of the industry, Abrantes solved the problem of lack of skilled toolmakers by dividing work into separate tasks and this innovative strategy helped the industry meet shorter production deadlines and decreased the learning curve. Besides promoting vertical disintegration and networks of subcontracting, this approach was also useful later on, when new production technologies were introduced because employees were less resistant to new ways of doing their work, due to their specialized and less traditional profiles. However, the introduction of CAM systems and automated production technologies implied a shift in workflow organization, and most companies were not up to the challenge. Although CAD/CAM technologies were introduced very rapidly and were considered almost mandatory in the Portuguese molds industry in the early 1990s, the way to organize work remained essentially the same. Therefore the corresponding productivity increases would often not materialize and human resources problems would arise (Alfaiate 1987). Traditionally the industry relied more on empirical, skill-based problem-solving and improvisational techniques performed by workers with low education levels (Neto 1993). To some extent, thinking was separated from implementing due to the low education level of the workers (Neto 1993) and also, in the early days, to the desire to protect production from possible worker rebellions and union fights. Therefore drawings were removed from the shop floor to the white-collar areas (Beira *et al.* 2004), as suggested in standard Taylorization of the work procedures.

The new technologies required more planning and a higher investment in verification and programing prior to manufacture. Also, in order to make equipment profitable companies had to make sure that occupation rates were high, which also required a better workflow planning effort (Neto 1987b). New technologies also required a better understanding of the entire production process by all workers. It was no longer easy to separate different tasks because machine programing required knowledge about materials, technical drawing, and machining and an understanding of the production flow (Neto 1987a; Sousa 1987). In order to do efficient programing and control, workers were now required to have a more comprehensive and multidisciplinary knowledge (Pires 1989; Sousa 1987). In the industrialized countries where toolmakers would be involved in the production process from start to finish, and not just specific tasks as in Portugal, workers might resist the introduction of new technologies that had a strong impact on their work. But, on the other hand, they were better prepared for the comprehensiveness of the tasks at hand and would find it easier to implement productivity improvements.

However, the Portuguese molds companies were very fast to adopt CAD/CAM technologies, driven by pressure from the more sophisticated and demanding customers, since companies were afraid not to get quotation requests if they would not adopt CAD/CAM (Neto 1987a). Some companies proceeded even without fully assessing the return they could obtain from such high investment and without fully researching the adequate specifications or planning how to adapt the work organization to reach the equipment's full potential (Neto 1993; Pires 1989). In fact, in the third conference of the molds industry, held in 1988, the minister for industry recommended that companies should moderate their enthusiasm to adopt advanced technologies (M. Amaral 1989).

According to worldwide industry statistics the Portuguese molds industry ranked high in investment but low in productivity per employee (Neto 1993; Pires 1989). The productivity problem became a major concern for the industry, and the prescribed solution was often based on education and training for workers and managers (Santos 1989).

The technology adoption wave was carried out within a specialized manufacture workflow, and therefore the productivity promises would often fall short of expectations. Companies would often voice their complaints about the lack of adequate training for human resources in the market (Beltrão 1987; Neto 1985; 1989; Pedro 1987; F. Silva 1985). Yet government was slow to create specific curricula for the industry's needs in public schools (Santos 1989; Pedro 1989). Nevertheless, not many companies understood the need to break from the traditional management model implemented in the industry (Alfaiate 1987; Neto 1993; M. Rodrigues 1989). The task at hand was not easy in a country where the average level of education was indeed low.

From its inception, the molds industry stood out in a poorly industrialized country with very few sophisticated industries (Neto 1989; Santos 1987). This circumstance brought a lot of attention from governmental bodies and media in the mid-1980s (in particular after the industry conferences began in 1983), but it also meant that structural problems of the country would have negative impacts in the industry's development (Pedro 1989). Work force education and training and employee turnover became prominent problems for the industry (J. Lopes 1999; Neto 1993; M. Rodrigues 1989), perhaps hampering the desired productivity increase.

Technological investments allowed the industry to upgrade into more sophisticated markets. The first customers in the 1960s were from the toy industry, which at the time was not particularly demanding in terms of quality and prices were not high. The industry's target markets evolved into the precision molds segment. Often for electronics and automotive industries, where molds have very small tolerance levels (a few microns) and therefore require high technological sophistication in the production processes (J. Gomes 1998).

Mota and Castro (2004, pages 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 vertically disintegrated firms as the molds industry in Marinha Grande, 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 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.[13] 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 about 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 [companies made frequent

[13] 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 Grande.

requests for the government to improve the supply of skilled young workers through the public school and university systems, but the response was slow and insufficient (Beltrão 1987; Neto 1985, 1989; Pedro 1987, 1989; F. Silva 1985)]. 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 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 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 (1990; 2000), might have emerged later to play a role in enhancing the performance of clustered firms.

We propose that the Portuguese molds cluster's life cycle went from emergence (late 1940s to mid 1980s), growth (mid 1980s to 1997), to sustainment (1998 to 2009). There is no evidence of congestion costs in land prices (according to the national association of the molds producers, whom we interviewed), and wages are only 7% higher than average for other manufacturing industries in the period (see Appendix III).

In summary, the Portuguese molds cluster is a case of a B2B manufacturing cluster, based on a network of small companies specializing in parts of the production process, in a vertically disintegrated environment. The industry emerged and developed in a context of economic change. From 1950 to 2010 the Portuguese economy made a remarkable transition from an agrarian society to an industry- and service-based economy, considered an advanced economy[14], but not yet a knowledge-based economy (Pereira and Laíns 2010).

3.2 The Plastics Industry

The origins of the plastics industry in Portugal can be traced to the 1930s, not long after the pioneer countries started producing the first synthetic plastic products (e.g. US, Germany, UK). However, for example, in the US the industry was far more developed and organized, mainly populated with large companies – by 1925 they started publishing the first trade journal named *Plastics*, although their first "National Plastics Exposition" was organized much later in New York in 1946 (Meikle 1995). The first company to produce plastic products in Portugal was 'SIPE,' created in 1935 to produce electrical material made out of Bakelite. An electric engineering professor at the most prominent engineering school in the country (IST) founded the company (Callapez 2000).

The company was located in the outskirts of Lisbon, not far from the university. Curiously, though, the professor had been waiting for nine years before he was allowed by authorities to start the company, who were enforcing policies limiting industrial growth. 'SIPE' imported the raw materials from England and used large electric molding press machines to mold the electric products. This company had a large impact over the

[14] Portugal is considered an advanced economy by IMF.

country's protected market because it offered high quality electric products at much lower prices than its porcelain competitors (Callapez 2000).

In the following year the firm 'Nobre & Silva' also started to produce Bakelite products. The company was created in 1927 in Leiria (Marinha Grande region), but initially produced espadrilles with rubber soles (Callapez 2000). The founders of the company were two bank employees who took advantage of county regulation – commanding the population to refrain from walking barefoot – in order to produce and sell low cost espadrilles (Callapez 2000).

In 1936 the company acquired an hydraulic press machine and started producing Bakelite lids for perfume bottles (Beltrão 1985; Callapez 2000; J. Gomes 1998). The mold for this lid was made by a local blacksmith workshop owned by José Marques, known as 'Wooden Eye' (Beltrão 1985; Callapez 2000). Other products followed, such as Bakelite corks and ashtrays and later products made with other plastics, including extruded and injected thermoplastics (Callapez 2000). 'Nobre & Silva' soon became a client of the Marinha Grande region's molds manufacturers and started to order a different type of very simple molds for plastic pressing.

Possibly driven by the demand of the first few plastics companies in the country but also by the potential this new industry represented, other glass and glass molds companies started to experiment with very simple molds for plastic pressing, which at the time used similar mechanical principles to the glass molds (Callapez 2000). These experiments were a breakthrough in the inception of the plastic injection molding industry in the country, which soon outgrew the plastics industry itself.

Soon other small, family-owned plastics companies joined the market to produce toys, plastic flowers, corks, slippers and lids. The use of such plastic products became widespread, and in the 1940s a new set of plants for plastic products emerged to produce products like belts, personal hygiene products, and vanity goods (Callapez 2000).

By then, the first fully automatic injection molding machine named ISOMA was developed in Germany and manufactured by the firm "Franz Braun AG" starting from 1933 and exported to other 28 countries in the following 10 years (the first machine imported in the US was bought in 1935 by the Index Machinery Corporation of Cincinnati)[15]. This equipment automatically molded and ejected a finished plastic product at 'every stroke of the machine' (Meikle 1995), thus allowing for a much less expensive production process.

In Portugal, examples of other early plastics entrants in Marinha Grande region are prolific. In 1946 "Baquelite Liz" was created in Leiria to produce Bakelite wine glasses, toys, combs, kitchenware, and office supplies. In the same year 'Matérias Plásticas' was created in Leiria, and in 1955 'Plásticos Santo António' started up in Leiria. Together with 'Nobre & Silva', these companies were considered to be the largest in the country within this industry (Callapez 2000).

After WWII plastics products proliferated with the post-war expansion both in Europe and the US (Meikle 1995), while in Portugal the industry also developed at a faster pace (Callapez 2000). Companies started using plastic injection equipment, and demand was boosted by the lower classes, driven by examples of imported plastic products that were

[15] For more information on the ISOMA machines see for example Maschinenhandel Borowski (http://www.mhborowski.de/Glossar/Spritzgiessmaschinenbau-der-DDR_-7.html).

substitutes for more expensive products. By 1947 the industry had 34 registered companies operating in the country, in a policy framework that did not favor industrial development (Callapez 2000).

From 1958 to 1970 the number of plastics companies in the Portuguese plastics industry grew at a 23% annual rate, reaching 383 companies registered with the mandatory national industry association by that time. During the 1970s and 1980s the industry's growth continued, once the industrial development limitations were no longer enforced (after 1974). In parallel, by 1979 in the US the annual volume of plastic production exceeded that of steel for the first time (Meikle 1995).

3.3 The Portuguese Economy

The Portuguese economy experienced intense change from the time when the molds and plastics industries were created to the later stages of our analysis. Coming from a background as a rural, illiterate, and poor country by 1900, Portugal raised its standard of living by about 10 times in a century[16], bridging the gap with the average of the European Union countries to become a middle-income, industrialized country (J. S. Lopes 2001; Murteira 2011; Pereira and Laíns 2010).

Suffering the negative impacts of the world economic crises that emerged after World War I and again after 1929, the country's development in between the World Wars was moderate but higher than the European average – 2.2% GDP growth rate between 1919 and 1939, while the average for the majority of European countries was 1.8% (J. S. Lopes

[16] Lopes's (2001) calculations show that average *per capita* GDP in Portugal grew tenfold during the twentieth century, while the average for the planet was a fivefold growth.

2001). There were improvements in agriculture and manufacturing, but the country faced high inflation levels up to 1924.

The military coup of 1926 established a dictatorship led by António de Oliveira Salazar that prevailed until 1974, even after his death in 1968. Salazar introduced financial reform policies as well as a state corporatism economic system. From 1928 on, a law of industrial conditioning was enforced, aiming to limit market competition, particularly in manufacturing industries. New companies and production investments required official authorization from the state to ensure market protection for the existing companies. Large private corporations protected by the state controlled most economic activity in the country. However, new industries that, by definition, would not have large incumbents, would face fewer restrictions to entry because they would not be seen as threats by the large corporations. This was the case in the molds industry that did not attract the attention of the large economic groups and, therefore, was allowed to grow without major restrictions.

During World War II Portugal remained neutral and managed to avoid the destructive impact of the conflict (Pereira and Laíns 2010). The country had a trade balance surplus from 1941 to 1945, due to exports of wolfram and other raw materials. However, due to the difficulties associated with importing fuel, raw materials, machinery, and other equipment, internal production could not increase significantly (J. S. Lopes 2001).

The post-war period, however, brought an unprecedented level of sustained economic growth propelled by the industrialization process – with a 3.5% GDP average yearly growth between 1945 and 1960. A massive imports program that secured energy, equipment, and machinery fueled this growth (J. S. Lopes 2001). In particular, the import of capital goods was crucial to industrialization, as inputs for production, but mainly as vehicles of technology transfer (Afonso and Aguiar 2004). At the same time there was an imports substitution policy in the 1950s and an exports promotion policy related to the increasing trade openness after 1960 (Pessoa 2013). It was in the midst of this industrialization effort that the molds and plastics industries were created in Portugal. By then there was a decline in the weight agriculture had in the economy, being slowly replaced by manufacture while the country moved from low-productivity agricultural employment to higher productivity industrial employment.[17] Qualified human capital was still a scarce resource as average education levels were low and illiteracy, although decreasing, was still high[18] (J. S. Lopes 2001).

This period of economic growth was further intensified from 1960 to 1973, the "golden years" of economic development for the country. GDP growth rate averaged 6.4%, while occidental Europe was averaging only 4.8% (J. S. Lopes 2001). This growth was propelled both by physical capital investment and the beginning of a technological catching-up effect, and by an education improvement (Pessoa 1998).

This accelerated growth occurred in parallel with a strong population decrease due to massive emigration flows, motivated by the war with the African colonies and the political and social repression of Salazar's dictatorship – 1.4 million individuals according to Lopes (2001). In an economy that was begging to open its trade borders to

[17] In 1950 agriculture employed 50% of the country's manpower, while in 2000 it was only responsible for 12%. Moreover, manufacturing employed 24% of the population in 1950, reached 38% in 1980 and leveled in 35% by 2000. The service sector occupied 24% of the active population in 1950 and increased up to 55% in 2000 (J. S. Lopes 2001).

[18] The percentage of illiteracy represented 40% of the population over 7 years of age in 1950, decreasing to about 30% by 1960, and about 25% in 1970. By 1990 this percentage was only 5%, however it remained the highest in Europe (J. S. Lopes 2001).

foreign countries (as founding member of OECD in 1948 and EFTA in 1960), there was a generalized strategy to encourage exports, while importing new technologies. The manufacturing industry grew 9% on average in this period, while services grew 5.8% per year (J. S. Lopes 2001).

Both large and small companies prospered in this "golden years", molds and plastics companies included. In particular, molds companies were predominant in exploiting the export market, mainly to the USA. The country's pattern of exports changed during the 1960s, when the main share of exports switched from food to manufactured products, with investment products gaining importance towards the end of the century (Afonso and Aguiar 2004). This was also a fast growth period for the molds and plastics industries.

After the revolution in 1974 that institutionalized a democratic regime, and up until 2000, the economy slowed down and went through fluctuations, in parallel to what was happening in the rest of Europe. However, the GDP *per capita* average growth rate from 1973 to 2000 was 2.7%, while the EU-15 average for the same period was 1.9% (J. S. Lopes 2001). Portugal suffered from the crises brought about by the 1973 and 1979 OPEC oil price shocks, as did most of the industrialized world. Internal issues added to that problem, through the turbulence generated by the political revolutionary process and increasing unemployment (J. S. Lopes 2001).

The new political leaders of the country engaged in the nationalization of the major companies and in policies that increased wage levels dramatically, resulting in improvements in the standards of living but also in the loss of competitiveness, especially for exporting companies (L. Amaral 2010). There was a strong investment in education, which had a high impact in the economy: human capital accounted for 41% of the growth between 1973 and 1990, as capital decreased its importance (Pereira and Laíns 2010). However, Pereira and Laíns (2010) claim that "the Portuguese economy was employing more people and using more capital but using them in a less efficient way, in contrast to what happened before 1973."

High unemployment resulted from the return of about 800,000 people from Portugal's ex-colonies in Africa, once these countries were offered independence, the return of soldiers after the end of the colonial overseas war, as well as the end of the emigration flows (J. S. Lopes 2001; Murteira 2011). Inflation rose, external debt grew, and exchange rate crises triggered two IMF interventions, in 1978-1979 and later in 1983-1984.

The competitiveness of exports was largely sustained by crawling peg exchange rate devaluations. From 1976 to 1980 exports were also fueled by the economic recovery of the remaining European countries as they rose from the depression. However, from 1980 to 1985, as the consequences of the second oil crisis that emerged in 1979 started to have an impact, the level of exports decreased because Portuguese exchange rates were also not as competitive.

Conversely, from 1985 to 1990 the economy expanded rapidly. After the decrease in the oil prices and the country's accession to the European Community in 1986, exports to the EC member countries, Spain in particular, rose immensely, as did foreign investment. However, the composition of the Portuguese exports was still based on unqualified labor-intense products (Courakis and Roque 1992). There was also a substantial influx of

Structural Funds [19] attributed by the European Union and policies leading to the liberalization of the economy.

During this period the European export markets started to increase in importance for the molds industry as well. The US market continued to be a large customer, but countries like Germany, France, and Spain gradually gained permanent and significant preference in the market's ranking.

In 1990 Portuguese economic growth started to decline, and by 1993 and 1994 the country was again in a depression, in parallel with the crisis in Europe, which represented about 80% of international trade (J. S. Lopes 2001; Afonso and Aguiar 2004). The policies aiming to stabilize the Escudo exchange rate, which was no longer devaluated after 1990, contributed to this depression.[20] Prevailing since 1977, this devaluation had been a strong policy strategy to ensure the competitiveness of the country's exports. However, by 1990 the main policy objective became the participation in the Economic and Monetary Union project, which demanded control over inflation rates to ensure the fulfillment of the criteria for participation in the first wave of countries officially adopting the Euro in 1999. Inflation remained higher than the average for all Euro countries; therefore nominal wages (despite their restraint) continued to increase at a higher rate for the Portuguese companies, and that was not compensated by productivity increases or by the exchange rate devaluation. As a consequence, exports decreased from 1990 to 1994, while imports driven by internal demand were increasing.

[19] Structural Funds and the Cohesion Fund are financial tools implemented by the European Union aiming aim to reduce regional disparities among the member states in terms of income, wealth and opportunities.

[20] The Portuguese Escudo increased value by 30% between 1989 and 1992 (Amaral 2010).

After 1994 there was a slow recovery phase, with an average GDP growth rate of 3.3% until 2000, driven mainly by the construction and services industries since the competitiveness of Portuguese exports remained low. Therefore, by 2000 the trade balance deficit amounted to 10% of the GDP and was being financed by the now accessible foreign loans (since they were exchange rate risk free after adoption of the Euro).

From 2000 to 2009 the Portuguese economy had a negative performance, a reflection of how ill-prepared it was for this change, in terms of productivity, wage levels, and inflation levels (L. Amaral 2010). The low interest rates increased consumption but not investment, possibly due to the decreasing opportunities in the tradable industries, given strong Euro rates (L. Amaral 2010). In addition, wage levels were difficult to change due to labor legislation and to inertia of the institutionalized yearly wage increase practices. These trends had negative effects on the competitiveness of Portuguese exports, resulting in the decline of world market shares (to new EU members and China) and lower average export prices (L. Amaral 2010).

Amaral (2010) argues that the Portuguese labor market is considerably flexible, due to precarious employment laws introduced in 1976, although it is also segmented: contrasting a group of workers who are very protected against unemployment with a group of others who are very exposed. In the author's view, the main problem hindering the economic development of the Portuguese economy is its low productivity. He believes that this is a result of low capital intensity and low productivity of the existing capital. The country's main policy objectives were the accession to the European Union, and to the Economic and Monetary Union, as well as building a Welfare State model.

Such policies set in motion incentives favoring the expansion of non-tradable industries and the substitution of savings and investment by consumption. This resulted in lower competitiveness of the manufacturing industry in general, and it also affected the performance of the molds and plastics industries. However, as stressed by Pessoa (2013), this poor performance should be analyzed in its international context, considering also that the earlier growth was due to a technological catching-up effect.

Pereira and Laíns (2010) believe that the disappointing levels of productivity from 1990 to 2009 may be caused by the rise of a service sector that has lower labor productivity levels than the manufacturing industry it diverts employment from. The authors consider that the lingering human capital gap to most developed countries hinders productivity improvements and the transition to a high-growth knowledge economy. While it can be argued that the Portuguese plastics industry fell into this low-wage country competition trap, the molds industry has made some headway towards a knowledge economy.

Pessoa (2013) argues that the decrease in economic growth that affects Portugal is both a result from its inability to translate the evolution of its technological setting (R&D and innovation investments) into economic convergence. The general economic growth slowdown in the developed world in the first decade of the twenty-first century has also hamstrung the Portuguese economy. Braguinsky *et al.* (2011) add to the discussion by arguing that the pronounced decrease in average firm size that occurred between 1986 and 2009 in Portugal, driven by labor laws favoring small firms, also drove down the economy's overall productivity and slowed its growth.

The evolution of both the molds and the plastics industries should be analyzed in light of the country's economic history described in this section. The Portuguese molds industry emerged in the context of an increasingly open economy and at a time when economic policy favored exporting industries. The industry was able to seize this opportunity to build a profitable cluster that nowadays continues to be a success case in the Portuguese economy. Persistently investing in new technologies and adapting to new markets, the molds industry has been able to maintain a remarkable export rate even when the country's exports in general are losing competitiveness. The plastics industry, albeit much more vulnerable to foreign competition, is much larger in number of companies and employees.

The following sections focus on the econometric analysis aiming to understand the process of agglomeration of the molds industry and the collocation with the plastics industry.

4 Data

This section describes the data on the molds, plastics, and related industries and the methods that are used to analyze agglomeration dynamics. The empirical approach focuses on firm performance. However descriptive results on entry and location decision are also presented.

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 are gathered annually by the Portuguese Ministry of Employment and Social Security and cover all firms (and establishments) with at least one wage-earner in the Portuguese economy (submission by firms is mandatory). Information about firms includes size (number of employees) and location, while information on individuals covers their age, formal education, employment, and professional careers. The data include extensive information on the mobility of firms, business owners, and employees.

Observations in our sample refer only to continental Portugal. Data for firms located in the Portuguese islands were excluded to remove possible insularity bias, due to the specificities of firm and entrepreneur behavior in isolated regions. Changes in the definition of Portuguese *concelhos* over the period of analysis were corrected to maintain data comparability for 275 *concelhos* in continental Portugal (new *concelhos* Vizela, Trofa, and Odivelas, created in 1998, were recoded into the original ones). In addition, companies that changed identification number in the data but maintained location and the majority of workers were identified, in order to distinguish them from new entrants in the plastics and molds industries. These companies may have been acquired by other companies or changed their legal status, however they should not be considered new entrants in the scope of this research. During the period of analysis there were four different versions of the CAE codes (official economic activity codes) in force, which identify industries in the data, requiring the construction of tables of correspondences between old and new industry codes and designations. Appendix I details the correspondences created for the relevant industries.

Longitudinal data on founders and firms in the molds industry from all Portuguese *concelhos* in continental Portugal are used, differentiating between the firms located in the agglomerated regions (Marinha Grande and Oliveira de Azeméis) and other firms. For each entrant in the molds industry from 1987–2009,[21] the founder(s) were identified as well as the previous occupations of each founder in the previous five years of available data (see Appendix II). The task of tracing the backgrounds of entrants faced several limitations. Some firms do not identify the owner, and in others there may be misreporting issues. 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).

In order to understand the agglomeration process and the relationship with related industries, the origin of founders of new entrants in the molds and plastics industries was investigated, geographically and industry wise (see Appendix II).

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

5 Performance Drivers for the Molds Industry in Portugal

This section addresses the first research question: what mechanisms drive performance of an agglomerated industry along the cluster's life cycle? Agglomeration economies theory introduced in Section 2 would lead to one main prediction about firm performance. If agglomeration theories better describe the phenomena, then:

- firms in the agglomerated industry located in the agglomerated region perform better than firms located elsewhere.

In addition, we obtain one main predictions that emerge from the heritage theory approach. If heritage better describes the phenomena, then:

- spinoffs and startups originating in the same agglomerated or related industries perform better than other startups.

The methodological approach is based on an econometric analysis for the growth and sustainment stages, using detailed data on firms, founders, and workers in the Portuguese molds industry covering the period 1986-2009. The quantitative empirical study focuses on the performance of molds companies and the way it is influenced by spinoffs and agglomeration externalities. Additional descriptive results are also presented, analyzing the probability of firms generating spinoffs and the location decision of new molds firms.

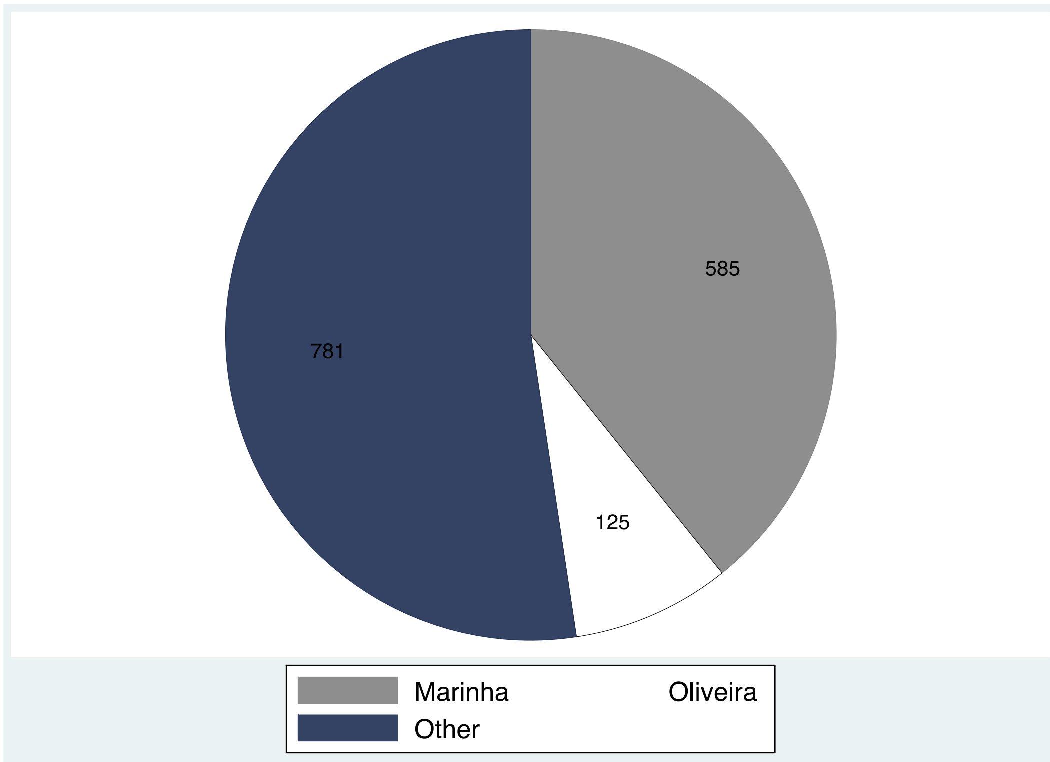
This study captures industry relatedness in two ways. First, it identifies industries belonging to the value chain of the molds industry (that is, industries that use significant inputs from the molds industry or sell significant outputs to the molds industry). Second, it captures relatedness associated with proximity of worker skills by using the index of skill relatedness developed by Neffke and Henning (2013), which is based in cross-industry labor flows. Regarding location, this study focuses mainly on two categories of interest, which may overlap: home region and agglomerated region. Home region is defined as the *concelho* where at least one of the entrepreneurs was working prior to creating the company.

5.1 Molds Industry Data

It should be noted that the data available do not cover the formative era of the molds industry, which emerged in the 1940s. Data for that period would be interesting for this research's purposes, but QP data are only available since 1986. In this research it is argued that one can learn from the dynamics observed in the period from 1986 to 2009, but it is important to acknowledge this time frame. Using the available data it was possible to provide descriptive statistics concerning the industry's evolution during the period of analysis. The industry is still growing in this period, if one measures its size by the number of companies in the market. The average size of the companies is rather small (less than 25 employees).

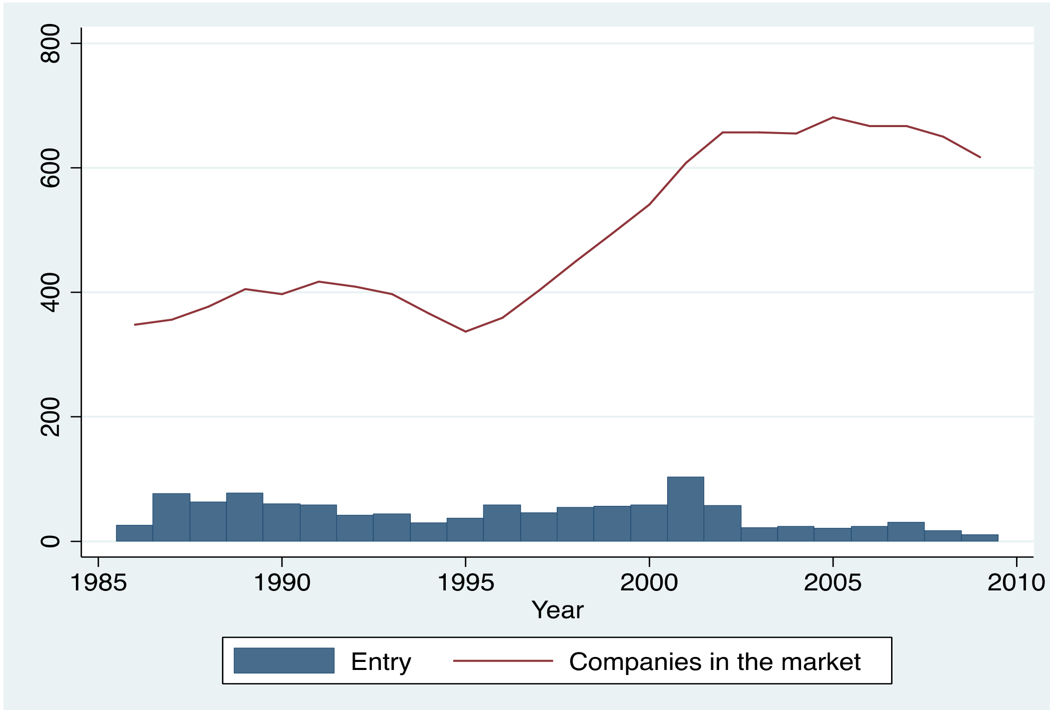
Nearly half the companies in the industry are still located in the agglomerated regions: Marinha Grande and Oliveira de Azeméis (see Figure 11). These regions concentrate 48% of the molds companies existing between 1986 and 2009 (39% in Marinha Grande and 8% in Oliveira de Azeméis). The agglomeration tendency seems to be increasing in Marinha Grande, since 43% of the entrants in the period chose to locate in Marinha Grande (and 9% in Oliveira de Azeméis), while the remaining entrants scattered over 99 other *concelhos*. Oliveira de Azeméis has fewer companies, but these companies tend to be larger (with an average of 21 employees compared to 6 in Marinha Grande), and they focus on the market segment of large-sized molds.

Figure 11 - Location of molds companies



Entry in the Portuguese molds industry remained significant during the period following 1987 and the number of firms in the industry increased through 2005 (see Figure 12). Between 2005 and 2009 entry is still positive but much lower. Average entry size is consistently smaller in the agglomerated regions (Marinha Grande and Oliveira de Azeméis).

Figure 12 – Entry and number of firms in the molds industry by year: 1986–2009



The number of molds companies that entered the industry in the period of analysis was 1,066. However we could only identify previous occupations of founders[22] for 611 companies (about 57% of all firms founded in the industry during the period) – see Appendix II. In addition to distinguishing spinoff founders from other entrants, the research identifies and distinguishes 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.

[22] Entrepreneurs were empirically defined as the person(s) listed as "employer" in the company's first of ten years of activity when an "employer" is listed, or, if none were listed, the top managers in the first year of the company. This empirical definition aims to include the companies that did not report "employers" correctly in the first year but eventually corrected the data in the next ten years. We assume it is not highly likely that entrepreneurs change in the first 10 years of activity.

All firms in the data are considered potential spawners (even the molds entrants because they can spawn later on), except for the ones located outside continental Portugal. In all the models, information about the entrepreneur's background regarding his/her prior location (of employment) and industry was used.

The industry background categories were defined using the similar criterion of having at least one entrepreneur with a previous job in the same industry (molds) or related industries. The aim is to identify the backgrounds where the entrepreneur could have gained specific knowledge that could be applied in creating and developing a successful molds company. Relevant knowledge for this purpose is likely to be of a specific nature and very closely related to the molds industry. This would naturally include the molds industry itself but also key supply industries, with knowledge about inputs and technologies, and major client industries, with knowledge about the products and the market. Specific knowledge from such industries of the molds value-chain could have a strong impact on the future performance of the molds entrant. For example, in the Portuguese molds industry (after division of labor was introduced) production often involved subcontracting specific tasks to other types of companies that perform tasks like design, metal polishing, milling, etc. Workers from companies in these and other supply areas that work with molds companies can acquire technical knowledge that would be advantageous for an entrant. In addition, workers from customer industries may gain knowledge about applications and requirements for the molds as well as valuable contacts in the molds market that would also be advantageous.

Another way to identify related industries is by looking at their human capital closeness. If two particular industries draw from a similar pool of human resources it is likely that they are related and that they require similar skills in order to succeed. If that is the case, then knowledge acquired in one industry is likely to have a high impact in the performance of a company in the other skill-related industry. Neffke and Henning (2013) argue that, if two industries have a high flow of workers between them, it is likely that they are using similar skills in their production process and are therefore closely related industries. We use an adaptation of their skill-relatedness index to identify relevant backgrounds for molds entrepreneurs.

Summarizing, this study captures relatedness in two ways. First, identifying industries belonging to the value chain of the molds industry (that is, industries that use significant inputs from the molds industry or sell significant outputs to the molds industry). Second, capturing relatedness associated with skills by using the index of skill relatedness developed by Neffke and Henning (2013), 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 2 presents the list of value chain industries and is based on information gathered about the main customers and suppliers of the Portuguese molds industry. The molds industry has produced a large diversity of products for different customer industries. Among the main plastic products that were made using Portuguese molds are toys, construction ware, electrical material, domestic appliances, kitchenware, electronics, packaging, and automotive products (Beira *et al.* 2004). The main suppliers/subcontractors from within the country are technically similar industries that are hired to perform specific services or tasks involved in the manufacturing process.

Table 2 – Industries in the molds value chain *

Suppliers and subcontractors:	Customers:
Basic industries of iron and steel, not specified	Manufacture of footwear
Aluminum production	Manufacture of parts of footwear
Manufacture of basic iron and steel and of ferro-alloys	Manufacture of lighting equipment and electric lamps
Casting of iron	Manufacture of plastic packing goods
Casting of other non-ferrous metals	Manufacture of builders' ware of plastic
Casting of light metals	Manufacture of other plastic products
Casting of non-ferrous metals	Manufacture of cutlery
General mechanical engineering	Manufacture of electric domestic appliances
Manufacture of other fabricated miscellaneous metal products	Manufacture of equipment for low-voltage electrical installations
Treatment and coating of metals	Manufacture of other electrical equipment
Manufacture of other miscellaneous special purpose machinery	Manufacture of electrical and electronic equipment for motor vehicles
Manufacture of tools	Manufacture of motor vehicles
Manufacture of machinery for plastics and rubber industries	Manufacture of other parts and accessories for motor vehicles
Wholesale of metals and metal ores	Manufacture of bicycles and invalid carriages
Engineering activities and related technical consultancy	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 2004.

Related industries were identified using an adaptation of the skill-relatedness index proposed by Neffke and Henning (2013), based on cross-industry labor flows. The skill-relatedness index aims to capture industry relatedness, as defined by Teece *et al.* (1994), through the use of human resources. It is a measure of inter-industry similarity, based on the human capital industries employ. The underlying assumption is that industries that require similar human capital use similar skills and therefore work in strategically related areas.

The relatedness index was computed for the molds industry from 1995 to 2002 (using a 5-digit CAE level). Over this period the CAE industry classifications remained unchanged, therefore there is no need to establish correspondences for all the codes. Contrary to Neffke and Henning (2013), this index did not exclude the managers. The reason for this was that, on average, these are medium and small companies where most managers are performing industry-specific tasks and have a high proportion of industry-specific knowledge and skills (E. Henriques 2008). The estimated index of skill-relatedness compares the actual flow of workers between each pair of industries and regions with the estimated flow expected to occur given the characteristics of the industry in each region. The skill-related index is given by:

$$SR_{ixjy} = \frac{F_{ixjy}^{obs}}{Fx_{ixjy}}$$

Where:

SR_{ixjy} – skill-relatedness index for industry i in region x and industry j in region y

F_{ixjy}^{obs} – observed flow of workers between industry i in region x and industry j in region y

F_{ixjy} – predicted flow of workers between industry i in region x and industry j in region y, based on industry and region-specific variables

The index focused on the molds industry; therefore either i or j must be the molds industry, since we care about the flow of workers to and from the molds industry. When this ratio is over 1 and the estimates are significant, it can be concluded that the industry-region is skill-related to the molds industry. A dummy variable that identifies the pairs of industry and regions that were considered skill-related was created. An additional variable was introduced in the estimation of the predicted labor flows that accounts for the density of industry workers in the region. This additional variable aims to account for regional differences in terms of worker density that we expect to influence the predicted flows of workers across industries and regions. The estimation requires a count model of flow of workers between industries and regions. We use a zero-inflated negative binomial model that accounts for the many zeros in the sample.

The model estimated is:

$$E(F_{ixjy} \mid v_{ix}, w_{jy}, \varepsilon_{ixjy}) = [1 - \pi_o(\gamma + \delta_i emp_i + \delta_j emp_j)].$$
$$f(\alpha + \beta_{1i}\log(emp_i) + \beta_{2i}\log(wage_i) + \beta_{3ix} workerden_{ix} + \beta_{4j}\log(emp_j) + \beta_{5j}\log(wage_j) + \beta_{6jy} workerden_{jy}))$$

where:

F_{ixjy}	Flow of workers from industry *i* in region *x* to industry *j* in region *y*
v_{ix} , w_{jy}	Industry-level variables for industry *i* in region *x* and industry *j* in region *y*
π_o	Probability that a flow can in principle take place as a function of the vectors v_{ix} and w_{jy}
emp_i	Sum of employment in industry of origin *i* from 1995 to 2002
emp_j	Sum of employment in industry of origin *j* from 1995 to 2002
$wage_i$	Average wage in industry of origin *i* from 1995 to 2002
$wage_j$	Average wage in industry of origin *j* from 1995 to 2002
$workden_{ix}$	Density of workers in industry of origin *i* from 1995 to 2002 in region *x*
$workden_{jy}$	Density of workers in industry of origin *j* from 1995 to 2002 in region *y*

Results from estimation, shown in Table 3, seem plausible and conform to the expectations with the exception of the coefficient estimate of the wage of the origination industry, which was expected to be negative. The flows of workers across industries are influenced by the size of their employment and their wages, which is reflected in the positive and significant coefficient estimates. Opposite to Neffke and Henning (2013), a higher coefficient for the wage of the destination industry is found. This is consonant with the higher effect of the size of employment effect, which is also higher in the destination industry.

Table 3 - Zero Inflated Negative Binomial estimates†

VARIABLES	*(1)*
Count data equation:	
Log of number of workers in origin industry and region *(log(empi_o))*	0.071 (0.044)
Log of number of workers in destination industry and region *(log(empi_d))*	0.256*** (0.049)
Log of average wage in origin industry and region *(log(wage_o))*	0.777*** (0.138)
Log of average wage in destination industry and region *(log(wage_d))*	1.079*** (0.144)
Worker density in origin industry and region *(workden_o)*	0.103*** (0.008)
Worker density in destination industry and region *(workden_d)*	0.120*** (0.010)
Constant	-10.271*** (0.866)
Regime selection equation:	
Number of workers in origin industry and region *(empi_o)*	-2.48e-05*** (0.000)
Number of workers in destination industry and region *(empi_d)*	-2.35e-05*** (0.000)
Constant	3.562*** (0.192)
Overdispersion parameter:	
(log(alpha))	2.318*** (0.116)
Observations	184,280
Zero observations	183,244

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

Table 4 identifies the industry/region pairs that were found to be significantly skill-related to molds, following the procedure adapted from Neffke and Henning (2013).

Table 4 – Skill-related pairs of industries and regions

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

Table 5 and Table 6 show the industry of origin and location choice of new entrants in molds during the period 1987–2009. The majority of entrants for whom we can trace backgrounds (about 57.3%) are spinoffs, but a significant number (23.2%) originates in non-related industries. Location is dominated by a preference for home base, as more almost three quarters 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.

Table 5 – Background of the molds entrants

Origin	N.	% Entrants	% Known
Molds industry	350	32.8%	57.3%
Value chain industry	154	14.4%	25.2%
Skill-related industry	58	5.4%	9.5%
Other	142	13.3%	23.2%
Unknown	455	42.7%	-

Table 6 – Attraction to home region

Background	Locate Home	% Known
All backgrounds	447	73.2%
Molds	276	78.9%
Marinha Grande	215	77.9%
Oliveira de Azeméis	59	85.5%

5.2 Methodology

The empirical specifications aim to evaluate the main mechanisms of agglomeration that drive entry and increase the success of entrants. Both cross-section data and pooled panel data were used in the empirical approaches. In order to test the predictions derived from both the agglomeration theory and the organizational heritage theory, two main types of models are estimated regarding:

I. the probability of survival of a new molds entrant, given its industry of origin (molds, value chain, skill related, or other) and the location of the founder (inside or outside the agglomerated region), while controlling for firm quality (with proxies by firm size)[23], location in the same county as the parent company (home), and accounting for firm heterogeneity;

II. the probability a new entrant will become a top one-third seller in its third year in the market, given its industry of origin and the location of the founder, while controlling for firm quality (with proxies by firm size), location in the same county as the parent company (home), and economic cycles;

In addition we present results from additional descriptive models regarding:

III. the probability that a firm will spawn a molds startup, given its industry (molds, value chain, skill related, or other) and region where it is located (inside or outside the agglomerated region), while controlling for firm quality (with proxies by firm size) and economic cycles;

IV. 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 (inside or outside the agglomerated region), while controlling for initial size;

V. the effects on sales in the third year of activity, of industry of origin (molds, value chain, skill related, or other) and the location of the founder (inside or outside the agglomerated region), while controlling for firm quality (with proxies by firm size) and economic cycles.

Model I examines the performance of plastic injection molding industry entrants using the probability of survival as a measure of performance.[24] The analysis of survival over

[23] It should be acknowledged 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.

the period of 24 years is used as a measure of performance for the molds entrants. The performances analysis aims to identify which factors influence the quality of the spinoffs. Cox proportional hazards model and frailty models are used. Data is right-censored in 2009 and the models account for that.

The first empirical model, Model I, estimates the probability of survival using both a Cox Proportional Hazards model and mixture hazard (frailty) models (considering that size is unlikely to capture firm heterogeneity influencing performance). 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).[25] Frailty models often use the Weibull distribution as the hazard function and the Gamma or Inverse Gaussian distributions to account for the multiplicative heterogeneity. Indeed the Weibull distribution with Gamma or Inverse Gaussian heterogeneity is the better fit for the data.

Model II examines the likelihood an entrant will become a top one-third seller in its third year of activity. This model provides an additional assessment of the entrants' performance. The model uses Logit estimation of the likelihood to rank in the top one-

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[24] 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).

[25] Goodness-of-fit tests performed on the data confirm the existence of overdispersion in firm heterogeneity.

third molds sellers among entrants by the time the company reaches its third year in the market. Both performance assessment models (survival and sales ranking) use cross-section data.

The remaining models contribute to better describe the cluster but do not aim to distinguish the mechanisms driving cluster performance.

Model III, using pooled panel data, looks at which companies are more likely to spawn new entrants in the molds industry. The sample for the spawning models has one observation per year for each company in the period of analysis. Each company has as many observations as years of data reported in QP, depending on how many years it survived during the period of analysis and how many years it reported data (some companies have periods with missing reports). Nevertheless, when a company spawns more than one molds entrant in one year, one observation per each entrant in that year is kept. The total number of companies included in the sample as potential spawners is 833,803. On average there are 6.42 observations per company.[26] In cases where firms had more than one entrepreneur that came from different firms all of them were considered as spawners. For the hazard models the sample included one observation for each entrant for which there was information on background (again, 611 molds companies).

The explanatory variables of interest are related to the backgrounds of the entrepreneurs, in terms of industry of origin and home region. Table 7 presents the definitions and descriptive statistics of the variables used, which are mostly binary.

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[26] Standard deviation of 5.84.

The dependent variable in the Logit spawning models is a dummy for whether that company was a prior job of an entrepreneur before establishing the entrant in the molds industry (*spin*). Companies are classified as entering their home region when they locate in the same *concelho* where at least one of their entrepreneurs had a previous job.

Models II, III, and IV are estimated using Logit. Model I uses both Cox Proportional Hazards models and Frailty survival models, while model V uses an OLS. In Model I, pooled panel data are used, including all observed firms in all *concelhos* of continental Portugal during the period under analysis (almost five million observations).

Table 7 – Variable definitions and descriptive statistics

Variable	Definition	Mean	SD
spin	Dummy for creation of molds spinoffs by company *i* in year *t* (DV)	2.43e-04	0.0156
pemp	Size of company *i*, measured by the number of employees in year *t*	10.9155	103.0299
Molds	Dummy for company in the molds industry	0.0022	0.0473
Vc	Dummy for company in an industry from the value chain of molds	0.0349	0.1835
Rel	Dummy for company in a skill-related industry and region	0.0008	0.0284
Moldsreg	Dummy for company located in the molds agglomerated region (Marinha Grande and Oliveira de Azeméis)	0.0355	0.1850
home	Dummy for entry in a *concelho* where at least one founder had a previous job (DV and IV)	0.7267	0.4460
pemp_f	Size of the entrant measured by the number of employees in the first year	6.5646	12.0122
molds	Dummy for company with at least one founder with a previous job in the molds industry	0.5761	0.4946
vc	Dummy for company with at least one founder with a previous job in an industry from the value chain of molds	0.2406	0.4278
rel	Dummy for company with at least one founder with a previous job in a skill-related industry and region	0.0949	0.2934
moldsreg	Dummy for company with at least one founder with a previous job in the molds agglomerated region (Marinha Grande and Oliveira de Azeméis)	0.5794	0.4941
agg	Dummy for company located in the molds agglomerated region (Marinha Grande and Oliveira de Azeméis)	0.5216	0.4998

The specifications of each model are presented below. Robust standard errors are used to correct for serial correlation and clustered standard errors in the spawning analysis.

The specification for model I, using the Cox proportional hazards model (frailty survival models use the same specifications) is:

$$\lambda(t|x;\theta) = \exp[\beta_1 \log(pemp\_f) + \beta_2 molds + \beta_3 vc + \beta_4 rel + \beta_5 agg + \beta_6 home]$$

The variables are:

pemp_f	Size of the entrant, measured by the number of employees in the year of entry
molds	Dummy for company with at least one entrepreneur with a previous job in the molds industry
vc	Dummy for company with at least one entrepreneur with a previous job in an industry from the value chain of molds
rel	Dummy for company with at least one entrepreneur with a previous job in a skill-related industry and region
agg	Dummy for company located in the molds agglomerated region (Marinha Grande and Oliveira de Azeméis)
home	Dummy for company with at least one entrepreneur with a previous job in the same concelho where it entered

Model II, looking at the likelihood an entrant will rank among the top one-third sellers within three years, uses the following specification:

$$P(TopSeller = 1|x) =$$

$$= \Lambda[\beta_1 \log(entry\ size) + \beta_2 molds + \beta_3 vc$$

$$+ \beta_4 rel + \beta_5 agg + \beta_6 home + \beta_7 year]$$

This model uses the same variables as the previous one (survival model). The analysis is based on a Logit model and cross-section data.

Among the descriptive models, Model III looks at the likelihood a firm will spawn a molds entrant. The Logit model estimates the probability of spawning, given the firm's specific background and controlling for economic growth cycles with year dummies.

$$P(spin_{it} = 1|x_{it}) =$$

$$= \Lambda[\beta_1 \log(pemp_{it}) + \beta_2 Molds + \beta_3 Vc + \beta_4 Rel + \beta_5 Moldsreg + \beta_6 Moldsmr$$

$$+ \beta_7 Vcmr + \beta_{8t} Year_t]$$

The variables are:

$spin_{it}$	Dummy for creation of molds spinoffs by company *i* in year *t*
$pemp_{it}$	Size of company *i*, measured by the number of employees in year *t*
$Molds_i$	Dummy for company in the molds industry
Vc_{it}	Dummy for company in an industry from the value chain of molds in year *t*
Rel_t	Dummy for company in a skill-related industry and region in year *t*
$Moldsreg_{it}$	Dummy for company in the agglomerated region (Marinha Grande and Oliveira de Azeméis) in year *t*
$Moldmr_t$	Dummy for company in molds industry located in the molds agglomerated region in year *t*
$Vcmr_t$	Dummy for company in an industry from the value chain of molds located in the molds agglomerated region in year *t*
$Year_t$	Year dummies from1986 to 2009

Model IV estimates the probability of home location, that is, the likelihood that a molds entrant will locate in a region (*concelho*) where at least one of the founders previously worked. Acknowledging that firms tend to locate in their home region, this model tests whether this tendency is stronger in the agglomerated region, using a Logit model and cross-section data.

The general Logit specification is:

$P(Home_i = 1|x_i) =$

$= \Lambda[\beta_1 \log\left(pemp_{f_i}\right) + \beta_2 molds_i + \beta_3 vc_i + \beta_4 rel_i + \beta_5 moldsreg_i + \beta_6 moldsmr_i$

$+ \beta_7 vcmr_i]$

The variables used in the Logit models are described below:

home	Dummy for entry in a *concelho* where at least one entrepreneur had a previous job
pemp_f	Size of the entrant, measured by the number of employees in the year of entry
molds	Dummy for company with at least one entrepreneur with a previous job in the molds industry
vc	Dummy for company with at least one entrepreneur with a previous job in an industry from the value chain of molds
rel	Dummy for company with at least one entrepreneur with a previous job in a skill-related industry and region
moldsreg	Dummy for company with at least one entrepreneur with a previous job in the molds agglomerated region (Marinha Grande and Oliveira de Azeméis)
moldsmr	Dummy for company with at least one entrepreneur with a previous job in the molds industry located in the molds agglomerated region (*molds* x *moldsreg*)
vcmr	Dummy for company with at least one entrepreneur with a previous job an industry from the value chain located in the molds agglomerated region (*vc* x *moldsreg*)

In addition to the variables of interest, related to the entrant's background in terms of location and industry, there is a control for the entrant's initial size in employees, as a proxy for their quality. Model 1 restricts the analysis to the entrepreneur's background in terms of industry and locating inside the molds agglomerated region. Model 2 adds interactions between industry and location.

Model V uses an OLS regression to look at the effects of entrant's background in terms of industry and its location on the volume of sales in Euros, referring to their third year in the market (using a logarithmic transformation).

$log(vvend3) =$

$$= \beta_0 + \beta_1 \log(pemp\_f) + \beta_2 molds + \beta_3 vc + \beta_4 rel + \beta_5 agg + \beta_6 home$$

The variables are the same as described for model with a cross-section sample of all entrants.

The analysis uses the sample of firms for whom we could identify the entrepreneur's background (location and industry of prior work experience), which contains 611 firms. There remain a substantial number of entrants for whom the entrepreneurs' backgrounds could not be traced (455 firms). We cannot exclude the possibility that this sample contains entrants with backgrounds in related industries; therefore we should be careful not to consider them as "de novo" entrants. Therefore, all estimations were additionally done with the dummy variable for firms of unknown background (*ub*) in separate models. This variable is equal to one when the company's founders are people whose work background we could not trace in our data. The aim of this specification is to test the robustness of the previous results. We are interested in knowing if the trends we observe in the first models are not biased by the exclusion of these entrants with unknown background. However the inclusion of these entrants adds information about their entry location (which we can detect) but does not add information about the entrepreneur's industry background. Therefore, results for these estimations will tend to strengthen the results of location and decrease the effects of industry backgrounds.

5.3 Results

This section presents the results of empirical estimation. Sub-sections refer to, respectively models I, II, and the descriptive models (III, IV, and V), while the last section presents the same models split over the cluster life cycle's stages. The estimations of all the Logit models present the marginal effects of the explanatory variables, as recommended by Wiersema and Bowen (2009). For a discrete explanatory variable, the marginal effect is the change in the dependent variable when the explanatory variable is incremented by one unit. Estimations for the survival analysis present hazard ratios (Table 8 and Table 9). A hazard ratio above one means that the variable has a negative impact on firm survival, while a hazard ratio below one indicates a variable that has a positive impact on survival.

5.3.1 Entrant performance

Model I analyses the probability of survival (Table 8 to Table 10) and Model II looks at sales and sales ranking. If spinoffs or startups originating in related industries are more likely to survive and have higher sales, then the prediction of the heritage theory is supported. If molds companies located in the agglomerated region are more likely to survive and sell more, regardless of their industry of origin, then the prediction of the agglomeration economies account is supported.

5.3.1.1 Survival

Table 8 presents results from the Cox proportional hazards model, while Table 9 presents the results for the same sample and same specification using frailty survival models, for comparison. Frailty models account for firm heterogeneity, so results should be more reliable. However, results from all survival models are very similar and show consistency in the findings.

Table 8 - Model I: Estimates of the Cox proportional hazards model for entrant survival†

VARIABLES	Hazard Ratio	
	(1)	(2)
Entrant's initial size (log(*pemp_f*))	0.9640 (0.0742)	0.9554 (0.0471)
Founder from molds (*molds*)	0.6529*** (0.0892)	0.7090*** (0.0932)
Founder from value chain (*vc*)	0.5044*** (0.0817)	0.5017*** (0.0801)
Founder from skill-related (*rel*)	1.6777*** (0.3308)	1.8944*** (0.3617)
Locating in the agglomerated region (*agg*)	0.7512** (0.1053)	0.5848*** (0.0537)
Locating in the home region (*home*)	1.2338 (0.1722)	1.2511 (0.1734)
Entrant with unknown background (*ub*)	-	1.2511*** (0.2250)
Observations	611	1,066
Log-likelihood	-1,588.90	-3,539.95

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

Table 9 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 this 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 Weibull distribution to account for multiplicative unobserved heterogeneity.

Table 9 – Model I: Estimates of the frailty models for entrant survival†

	Weibull distribution with GAMMA heterogeneity (1)	*Weibull distribution with INVERSE GAUSSIAN heterogeneity* (2)	*Weibull distribution with GAMMA heterogeneity* (3)	*Weibull distribution with INVERSE GAUSSIAN heterogeneity* (4)
VARIABLES	Hazard Ratio			
Entrant's initial size (log(*pemp_f*))	1.0555 (0.1155)	0.9636 (0.1274)	0.9647 (0.0771)	0.9264 (0.0754)
Founder from molds (*molds*)	0.4597*** (0.1041)	0.4620*** (0.1124)	0.5174*** (0.1157)	0.5602*** (0.1220)
Founder from value chain (*vc*)	0.3266*** (0.0845)	0.2944*** (0.0843)	0.3094*** (0.0814)	0.3128*** (0.0814)
Founder from skill-related (*rel*)	1.9891** (0.6250)	2.4942** (0.8922)	2.4768*** (0.8119)	2.8878*** (0.9516)
Locating in the agglom. region (*agg*)	0.6041** (0.1351)	0.5819** (0.1444)	0.3415*** (0.0617)	0.3753*** (0.0594)
Locating in the home region (*home*)	1.6087** (0.3583)	1.5159* (0.3735)	1.7894** (0.4151)	1.5550* (0.3561)
Entrant w/unknown background (*ub*)	-	-	2.4793*** (0.6465)	2.2751*** (0.5593)
Constant	0.0405*** (0.0127)	0.0589*** (0.0233)	0.0471*** (0.0129)	0.0647*** (0.0180)
Observations	611	611	1,066	1,066
Log-likelihood	-654.89	-653.13	-1,249.51	-1,249.09
Likelihood-ratio test of θ = 0	0.000	0.000	0.000	0.000

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

Across all models the results for the larger sample (including entrants with unknown background but known entry location and entry size) naturally tend to erode the impact and significance of the background variables in favor of the location variable. This is expected, considering that the additional observations only add information about location. Additionally, companies with unknown background seem to perform worse than companies whose background can be traced in the data. This may imply that QP data are biased to include more information on better firms, which are more likely to report to the authorities accurately and consistently. If this proposition is true, the sample with firms of unknown background may balance that but it may also add more noise by lowering the quality of the data. Therefore results should be assessed with caution.

Evidence from Model I is positive for both theories. Spinoffs and startups originating from the molds value chain industries have significantly greater chances of survival. This result supports the heritage account argument that spinoffs benefit from more pre-entry knowledge and therefore are more likely to survive.[27] However, molds firms located in the agglomerated region also have a greater probability of survival, regardless of their industry of origin, thus confirming the prediction of the agglomeration economies account (possibly resulting from reduction of transportation costs from suppliers and to customers, scale economies, labor pooling, access to supply of specialized goods, technological spillovers, or a combination of these effects). Nevertheless, the magnitude of the effects on firm survival is strongest for companies originating from the value chain or molds industries.

[27] 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.

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 agglomerated actually has a negative impact on survival (however, this ratio is not significant in the Cox proportional hazards model).

5.3.1.2 Sales ranking

In addition to firm survival we also consider other performance measures for molds entrants. To evaluate the performance of the entrants in the molds industry we look at the factors associated with the level of sales in the entrant's third year of activity. This analysis has a selection bias, considering that we only observe the companies that survived in the market for at least three years. However, the sample of firms with sales in their third year is large (losing only 11 firms out of 611 entrants with identified backgrounds and 27 for the full sample of entrants). Therefore, we believe these estimates are not severely biased and can provide information on the characteristics of high performing companies in the molds industry. It should also be acknowledged that sales are a measure of output that give no account of the input used to generate it; thus they are a poor measure of efficiency. However, the aim is to identify the companies with larger market shares, which could be considered top players in the industry.

Model II uses Logit estimation. The dependent variable for the Logit model is ranking in the top one-third companies in sales value in the same year. Columns 1 and 2 in Table 10 show the marginal effects for the sample without firms of unknown background, while columns 3 and 4 refer to the sample that includes those entrants.

Table 10 – Model II: Estimates of the Logit models for top sales in the third year – marginal effects†

VARIABLES	(1)	(2)	(3)	(4)
Entrant's initial size (log(*pemp_f*))	0.1936*** (0.0226)	0.1949*** (0.0225)	0.1737*** (0.0146)	0.1739*** (0.0145)
Founder from molds (*molds*)	0.1146*** (0.0431)	0.1442** (0.0621)	0.0928** (0.0382)	0.1278** (0.0517)
Founder from value chain (*vc*)	0.0967** (0.0477)	0.1488** (0.0640)	0.0846* (0.0432)	0.1317* (0.0529)
Founder from skill-related (*rel*)	-0.0461 (0.0683)	-0.0335 (0.0794)	-0.0362 (0.0602)	-0.0141 (0.0620)
Locating in the agglom. region (*agg*)	0.0304 (0.0434)	0.0920 (0.0794)	0.0489* (0.0292)	0.0838* (0.0381)
Locating in the home region (*home*)	0.0694* (0.0408)	0.0708* (0.0414)	0.0549 (0.0364)	0.0603 (0.0463)
Entrant w/unknown background (*ub*)	-	-	0.0153 (0.0463)	0.0204 (0.0463)
Molds industry and molds region (*molds*agg*)		-0.0580 (0.0893)		-0.0541 (0.0596)
Value-chain and molds region (*vc*agg*)		-0.1122 (0.0989)		-0.1070 (0.0771)
Observations	600	600	1,039	1,039
Log-pseudo likelihood	-336.15	-335.42	-525.14	-523.81
Pseudo R^2	0.1789	0.1807	0.2129	0.2149
Wald test	0.0000	0.0000	0.0000	0.0000

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

Results from the Logit model in Table 10 show that entrants with a background in the molds and value chain industries are significantly more likely to become top sellers across all models. Initial size, however, seems to be the strongest predictor of sales performance. Entrants locating in the molds agglomeration region only seem to be significantly more likely to perform better if we include the firms with unknown background, but even then, the coefficients are much lower than the ones associated with firm initial size or industry background. If we exclude the entrants with unknown background, entrants locating in the home region also tend to perform better. However, when we add entrants with unknown backgrounds the significance disappears. For both samples, the interaction variables are not significant, suggesting that firms with experienced background are not significantly more likely to perform better if they are located in the agglomerated region. Also, entrants that locate in the agglomerated region are not more likely to perform better for having a background in molds or the value-chain industries.

In summary, 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. However, for entrants with known background, the entrepreneur's industry experience (in the value chain or molds industries) has a stronger positive impact in firm survival. Moreover, prior experience in the molds industry seems to be the strongest predictor of the sales ranking in the third year of activity. The effect of locating in the molds agglomerated region is much smaller and only significant in the models with firms with unknown background.

While it is complex to determine causality for these performance results, there is no evidence that effects ascribable to sources other than agglomeration economies and organizational heritage are at play. However, the location effects could also be consistent with a self-reinforcing process occurring in the agglomerated region, which may not draw from Marshallian externalities, as argued by Golman and Klepper (2013). These could be due to many factors such as better access to international markets (foreign buyers are more likely to visit the agglomerated region), better access to financing, the entrepreneur demonstration effect, or higher flexibility due to the close relationships to subcontractors, etc.

5.3.2 Descriptive results

In this section we present estimations that help describe the molds cluster but cannot contribute significantly to the objective of identifying the mechanisms driving the clustering.

5.3.2.1 Probability of spawning a molds entrant

In Model III (Table 11), every firm identified in the database, regardless of region and industry, is a potential candidate to spawn a molds entrant. If molds and related industries located in the agglomerated region (Marinha Grande and Oliveira de Azeméis) are the ones more likely to spawn molds startups, then predictions one and two of the heritage theory are supported 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.

The first column in Table 11, presents estimates from a model of the probability of spawning a molds startup solely as a function of the founder's industry background. Findings show that firms in the molds industry are significantly more likely to spawn molds spinoffs. Since this is a dummy or binary variable 0/1, the marginal effect of this variable can be interpreted as meaning that the probability of a molds firm spawning a molds startup is, all else being equal, roughly 0.13 percentage points higher than that of a firm that is not in the molds industry.

Table 11 – Model III: Estimates of the molds spinoff Logit model – marginal effects†

VARIABLES	(1)	(2)	(3)
Size (log(*pemp*))	0.0002*** (9.20e-06)	0.0002*** (8.74e-06)	0.0002*** (9.02e-06)
Molds industry (*Molds*)	0.0013*** (5.39e-05)	0.0011*** (4.88e-05)	0.0012*** (5.55e-05)
Value chain industry (*Vc*)	0.0005*** (3.48e-05)	0.0004*** (3.41e-05)	0.0004*** (3.99e-05)
Skill-related Industry (*Rel*)	0.0002*** (4.92e-05)	0.0001 (4.35e-05)	0.0001** (4.34e-05)
Molds agglomerated region (*Moldsreg*)		0.0004*** (3.29e-05)	0.0006*** (3.90e-05)
Agglomeration in molds (*Molds*Moldsreg*)			-0.0004*** (4.97e-05)
Agglomeration in value chain (*Vc*Moldsreg*)			-0.0002*** (5.67e-05)
Observations	4,946,612	4,946,612	4,946,612
Log-pseudo likelihood	-7,021.03	-6,811.64	-6,767.79
Pseudo R^2	0.3744	0.3930	0.3969
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.

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 smaller for firms in skill-related industries. In the second column, a dummy variable equal to one when the firm is located in the agglomerated region (Marinha Grande and Oliveira de Azeméis) was added. Molds industry firms and value chain industry firms remain significantly more likely to spawn a molds startup, 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 0.04%). 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.

The third column introduces interaction terms between two dummy variables corresponding to industry of origin[28] and the dummy variable corresponding to location in the agglomerated region. The individual marginal effects remain significant for firms in molds as well as in industries in the molds value chain. However, the marginal effect of the interaction terms is significant but negative, meaning that the probability of molds and value chain companies to spawn a molds entrant is not higher if the company is located in the agglomerated region. These results show that molds firms and firms in the molds value chain are more likely to spawn spinoffs than firms in other industries. However, molds and value chain companies are less likely to spawn spinoffs if they are located in the agglomerated region.

The results suggest that the prevalence of spinoffs from parent companies remains important even 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

[28] Coefficients for interaction with skill-related industries were not estimated because the relatedness index refers to pairs of industry and *concelho,* and all but one combination are inside the agglomerated region.

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.

5.3.2.2 Probability of locating in the home region

Model IV (Table 12) estimates the probability of a new molds firm entering in the same region where the founder previously worked.

Table 12 – Model IV: 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*))	0.0315 (0.0213)	0.0317 (0.0213)
Founder from molds (*molds*)	0.0911** (0.0420)	0.1114* (0.0577)
Founder from value chain (*vc*)	0.0744* (0.0451)	0.0738 (0.0572)
Founder from skill-related (*rel*)	-0.0355 (0.0691)	-0.0407 (0.0706)
Molds agglomerated region (*moldsreg*)	0.1387*** (0.0421)	0.1620** (0.0723)
Molds industry and molds region (*molds*moldsreg*)		-0.0434 (0.0873)
Value-chain and molds region (*vc*moldsreg*)		0.0015 (0.0930)
Observations	611	611
Log-pseudo likelihood	-342.71	-342.56
Pseudo R2	0.0437	0.0441
Wald test	0.0000	0.0001

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

The first column in Table 12 estimates the probability of locating in the home region for molds startups, given their original location and industry of the parent firm. Estimates show 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 being equal, 9.1 percentage points more likely to locate in its home region than other companies, while a startup originating in the value chain is, all else being equal, 7.4 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 whose entrepreneurs have a background in the agglomerated region are 13.9 percentage points more likely to locate there, regardless of their industry of origin.

The second column in Table 12 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 suggests that 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 IV is that every kind of entrant 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; 2012). 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.

5.3.2.3 Sales

This section looks at OLS models of entrant's sales. The dependent variable for the OLS specifications is sales (log) in the third year after entry.

Table 13 – Model V: Estimates of the OLS models for sales (log) in the third year †

VARIABLES	(1)	(2)	(3)	(4)
Entrant's initial size (log(*pemp_f*))	0.4818 (0.2930)	0.5066* (0.2936)	0.8879*** (0.2123)	0.8887*** (0.2119)
Founder from molds (*molds*)	1.3376** (0.5243)	1.8265*** (0.6955)	1.0095** (0.5124)	1.3944** (0.6441)
Founder from value chain (*vc*)	0.8429 (0.5687)	1.8801*** (0.7121)	0.7874 (0.5768)	1.8393*** (0.6737)
Founder from skill-related (*rel*)	-0.5353 (0.7920)	-0.2881 (0.8210)	-0.5382 (0.7891)	-0.0778 (0.8351)
Locating in the agglom. region (*agg*)	-0.4860 (0.4979)	0.5802 (0.9166)	0.8658* (0.5090)	0.9182* (0.5211)
Locating in the home region (*home*)	1.0383** (0.5116)	1.0712** (0.5213)	-0.1063 (0.3673)	0.3440 (0.4764)
Entrant w/unknown background (*ub*)	-	-	-1.2998** (0.6114)	-1.1712* (0.6072)
Molds industry and molds region (*molds*agg*)		-0.9651 (1.0419)		-0.5150 (0.7539)
Value-chain and molds region (*vc*agg*)		-2.2641** (1.1497)		-2.3437** (1.0345)
Constant	7.5519*** (1.4982)	5.0560*** (1.7380)	9.1139*** (1.2063)	8.7693*** (1.2130)
Observations	600	600	1,039	1,039
R-squared	0.122	0.129	0.195	0.200

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

For the restricted sample the factors most strongly predicting higher performance are the industry background (molds in particular) and home location. Locating in the agglomerated region does not seem to be significantly associated with higher sales. Value-chain spinoffs seem to perform better if they are located outside the agglomerated region. One possible explanation could be the case of companies locating close to their customers in the domestic market or important suppliers, which would be located outside the agglomerated region.

When adding the companies with unknown background (columns 3 and 4 of Table 13) firm initial size and locating in the agglomerated region become more important, as expected. However, the results for industry background persist.

5.3.3 Life cycle stages

Considering that results suggest that different mechanisms play important roles at different stages of the cluster's life cycle, this section aims to take a more detailed look at what is happening in the cluster in different time periods. The molds cluster emerged in the 1950s and is believed to have grown substantially in the first three decades of its existence. However, we will again confine our analysis in the period of 1986 to 2009, due to the unavailability of earlier data. Figure 13 shows the evolution of the number of workers in the cluster, compared to the total for the country. The cluster continues to grow until 2005, when exports start slowing down. At this point production continues to increase, but it's mainly driven by a surge in internal demand (CEFAMOL 2010).

Figure 13 - Molds Industry and Cluster: 1989-2009

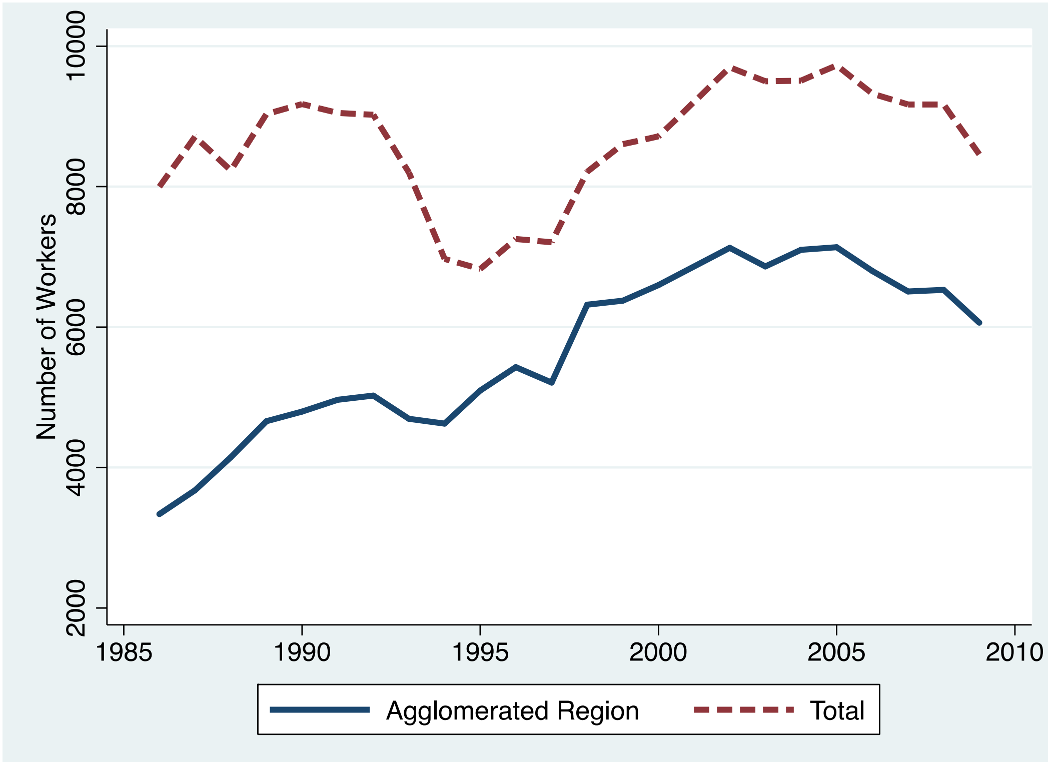
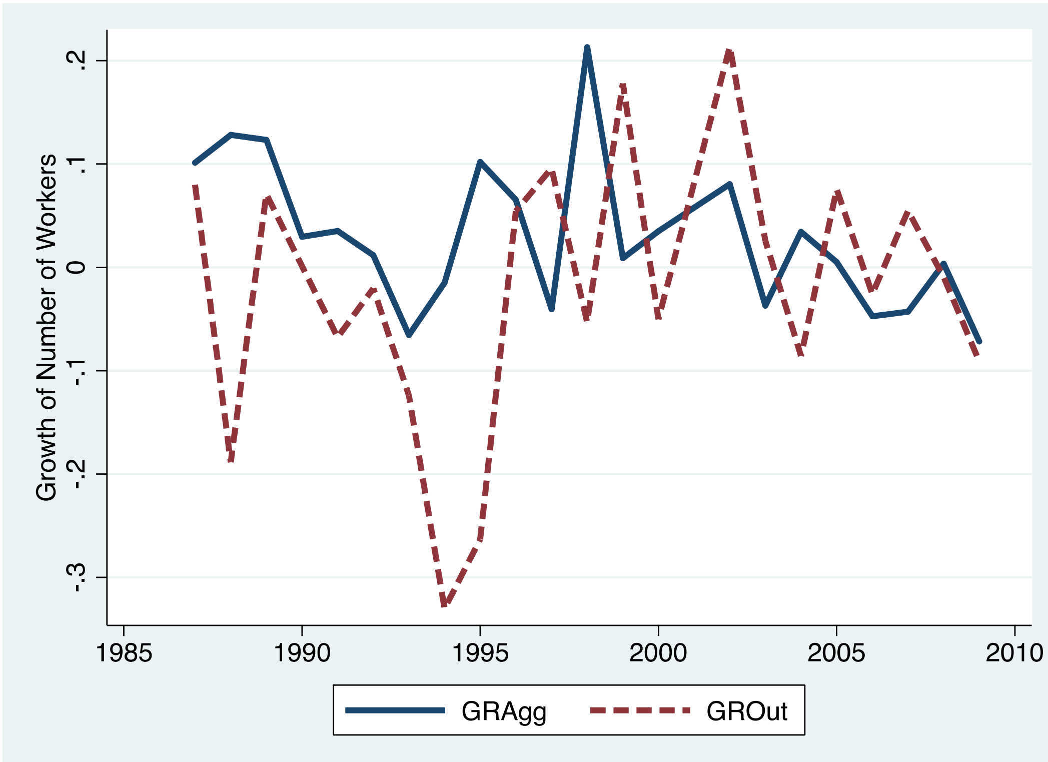


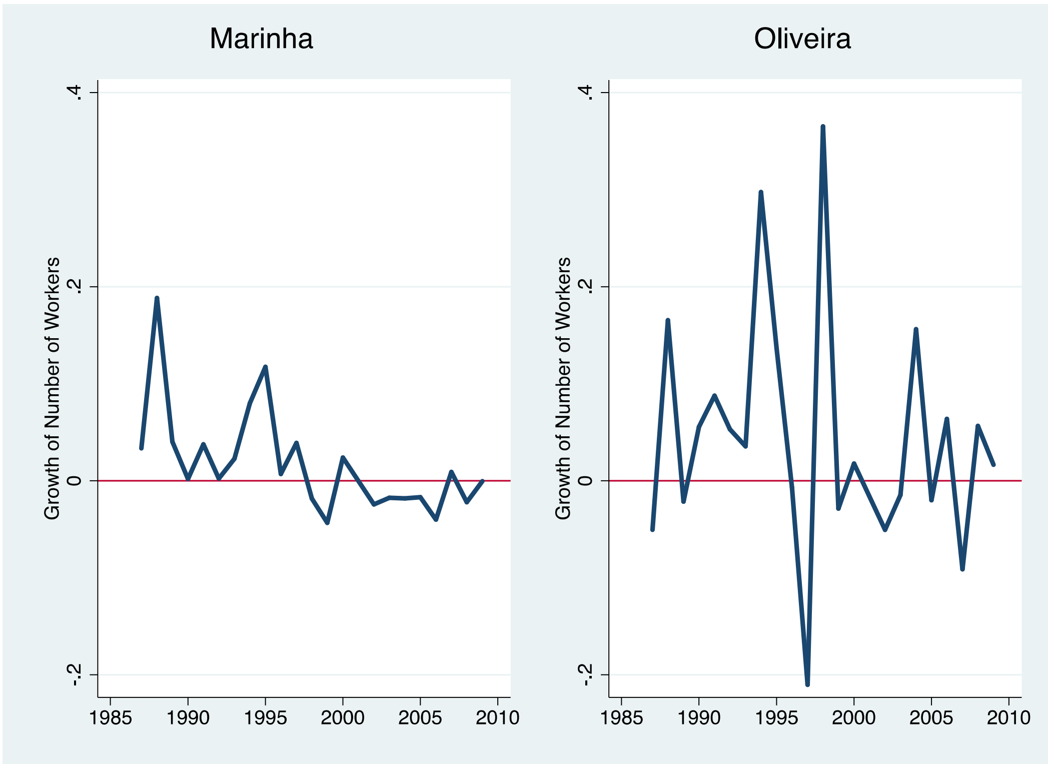
Figure 14 compares growth rates inside and outside the agglomerated region. Until 1996 the agglomerated region maintains a superior growth rate, and after that the difference is attenuated and on occasions surpassed by the rest of the country.

Figure 14 - Employee Growth Rates Inside and Outside the Agglomerated Region



Looking more closely at the growth of the regions of Marinha Grande and Oliveira de Azeméis in Figure 15, we see that in Marinha this superior performance is extended up until 1997 and that after 1997, the growth rate is mainly slower than for the total country. Oliveira shows a sharp decrease in 1997, balanced by an even larger growth in the following year. The increase in 1998 largely compensates the decrease in the prior year; therefore, this may have been a circumstantial spike in the data.

Figure 15 - Difference in Growth Rates Between The Agglomerated Regions and the Country Average: 1986-2009



Considering these data, the transition between the growth stage and the sustainment stage of the cluster may be situated between 1997 and 1998. Therefore, data can be separated into two different samples to test if it is possible to identify different agglomeration mechanisms at play in different stages of the life cycle. For the first part of the analysis the cluster's growth stage will be attributed to the period of 1986 to 1997 (Stage 1), while the sustainment stage will comprise the period from 1998 to 2009 (Stage 2).

Table 14 - Model I: Estimates of the Cox proportional hazards model for entrant survival (Stages 1 and 2) – hazard ratio †

VARIABLES	Growth Stage		Sustainment Stage	
	(1)	(2)	(3)	(4)
Entrant's initial size (log(*pemp_f*))	1.0061 (0.0943)	0.9361 (0.0529)	0.8385 (0.1223)	0.8978 (0.0963)
Founder from molds (*molds*)	0.6091*** (0.1053)	0.6886** (0.1123)	0.9118 (0.2353)	0.8763 (0.2240)
Founder from value chain (*vc*)	0.5163*** (0.0961)	0.5254*** (0.0964)	0.5434* (0.1807)	0.5526* (0.1819)
Founder from skill-related (*rel*)	1.7709** (0.4326)	2.0428*** (0.4804)	1.6964 (0.5786)	1.6035 (0.5354)
Locating in agglom. region (*agg*)	0.6987** (0.1241)	0.5159*** (0.0583)	0.9134 (0.2318)	1.0491 (0.1977)
Locating in the home region (*home*)	1.1273 (0.1864)	1.1251 (0.1844)	1.4918 (0.4088)	1.4151 (0.3828)
Entrant with unknown backg. (*ub*)	-	1.5691*** (0.2560)	-	1.3488 (0.4425)
Observations	317	590	294	476
Log-likelihood	-958.67	-2,351.11	-476.47	-873.39

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

Firm survival seems to suffer substantially different influences in the growth and the sustainment stages, if we consider the estimates from the Cox proportional hazards model in Table 14. The effects of industry background from value-chain industries appear to play the most important role in improving survival in both periods. Conversely, the background in the molds industry seems to have a strong impact in the growth stage but not in the sustainment stage. The same applies to locating in the agglomerated region. Results with mixed frailty models presented in Table 15 are consistent with these findings.

Table 15 – Model I: Estimates of the frailty models for entrant survival (Stages 1 and 2) – hazard ratio†

VARIABLES	*Gompertz distribution with INVERSE GAUSSIAN heterogeneity*			
	Growth Stage		Sustainment Stage	
	(1)	(2)	(3)	(4)
Entrant's initial size (log(*pemp_f*))	1.0458 (0.1192)	0.9368 (0.0632)	0.8152 (0.1199)	0.8829 (0.0950)
Founder from molds (*molds*)	0.4872*** (0.1150)	0.6172** (0.1224)	0.8886 (0.2300)	0.8618 (0.2208)
Founder from value chain (*vc*)	0.3950*** (0.1009)	0.4316*** (0.0968)	0.5240* (0.1752)	0.5365* (0.1775)
Founder from skill-related (*rel*)	2.2296** (0.7604)	2.4830*** (0.7270)	1.7291 (0.5925)	1.6071 (0.5381)
Locating in the agglom. region (*agg*)	0.5841** (0.1412)	0.4069*** (0.0611)	0.8620 (0.2196)	1.0216 (0.1926)
Locating in the home region (*home*)	1.2182 (0.2635)	1.1930 (0.2337)	1.5518 (0.4257)	1.4587 (0.3948)
Entrant w/unknown background (*ub*)	-	1.7959*** (0.3573)	-	1.3510 (0.4424)
Constant	0.0896*** (0.0268)	0.1124*** (0.0241)	0.0385*** (0.0144)	0.0415*** (0.0142)
Observations	317	590	294	476
Log-likelihood	-412.62	-829.33	-243.50	-419.60
Likelihood-ratio test of θ = 0	0.019	0.004	1.000	1.000

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

Results in Table 16 show the marginal effects for the likelihood to become a top one-third seller, in the third year of activity. During the growth stage (Stage 1) we find significant effects for the region; however, the marginal effect is not large (0.06 in the sample without entrants with unknown background and 0.08 when we include them). Nonetheless, during the sustainment stage (Stage 2) there is a significant effect for a background in the molds industry, even when considering the entrants with unknown background.

Table 16 - Model II: Estimates of the Logit models for top sales in the third year (Stages 1 and 2) – marginal effects†

VARIABLES	Growth Stage		Sustainment Stage	
	(1)	(2)	(3)	(4)
Entrant's initial size (log(*pemp_f*))	0.1386*** (0.0302)	0.1235*** (0.0185)	0.2686 *** (0.0297)	0.2559*** (0.0206)
Founder from molds (*molds*)	0.0192 (0.0606)	0.0385 (0.0482)	0.1614** (0.0641)	0.1513** (0.0620)
Founder from value chain (*vc*)	0.0261 (0.0640)	0.0167 (0.0529)	0.1164 (0.0727)	0.1074 (0.0681)
Founder from skill-related (*rel*)	-0.0742 (0.0931)	-0.0425 (0.0754)	0.0178 (0.1077)	0.0252 (0.1004)
Locating in the agglom. region (*agg*)	0.0602** (0.0434)	0.0794** (0.0382)	0.0310 (0.0637)	0.0334 (0.0455)
Locating in the home region (*home*)	0.0627 (0.0564)	0.0457 (0.0468)	-0.0166 (0.0613)	-0.0233 (0.0556)
Entrant w/unknown background (*ub*)	-	-0.1329** (0.0542)	-	0.0914 (0.0759)
Observations	317	590	283	449
Log-pseudo likelihood	-187.95	-303.31	-147.25	-223.42
Pseudo R^2	0.1414	0.1913	0.2231	0.2328
Wald test	0.0000	0.0000	0.0000	0.0000

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

In the remaining tables we present the results for the descriptive models. Table 17 presents the results for the model looking at the likelihood to spawn an entrant, separating the growth and sustainment stages.

Table 17 – Model III: Estimates of the molds spinoff Logit model (Stages 1 and 2) – marginal effects†

VARIABLES	Growth Stage			Sustainment Stage		
	(1)	(2)	(3)	(4)	(5)	(6)
Size (log(*pemp*))	0.0003*** (2.03e-05)	0.0003*** (1.97e-05)	0.0003*** (2.01e-05)	0.0001*** (8.06e-06)	0.0001*** (7.76e-06)	0.0001*** (8.25e-06)
Molds industry (*Molds*)	0.0021*** (1.14e-04)	0.0017*** (1.03e-04)	0.0018*** (1.22e-04)	0.0010*** (5.31e-05)	0.0007*** (5.36e-05)	0.0010*** (8.76e-04)
Value chain industry (*Vc*)	0.0007*** (7.37e-05)	0.0006*** (7.13e-05)	0.0006*** (8.06e-05)	0.0004*** (3.67e-05)	0.0003*** (3.86e-05)	0.0004*** (3.00e-04)
Skill-related Industry (*Rel*)	0.0003*** (9.79e-05)	0.0001 (9.04e-05)	0.0001 (9.14e-05)	0.0002*** (5.05e-05)	0.0001 (4.23e-05)	0.0001 (2.45e-05)
Molds agglom. region (*Moldsreg*)		0.0006*** (7.23e-05)	0.0008*** (9.42e-05)		0.0003*** (3.44e-05)	0.0005*** (4.22e-04)
Agglom. molds (*Molds*Moldsreg*)			-0.0003*** (1.24e-04)			-0.0004*** (4.72e-05)
Agglom. value chain (*Vc*Moldsreg*)			-0.0002 (1.35e-04)			-0.0002*** (3.57e-04)
Observations	1,667,800	1,667,800	1,667,800	3,278,812	3,278,812	3,278,812
Log-pseudo likelihood	-4,102.43	-4,005.38	-3,477.13	-2,862.31	-2,759.32	-2,696.56
Pseudo R^2	0.3201	0.3362	0.3373	0.4334	0.4538	0.4662
Wald test	0.0000	0.0000	0.0000	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.

The results seem to confirm that there are significant differences between these two periods. Companies from the molds industry are about twice more likely to spawn a molds entrants in the growth stage than later on. The magnitude of the difference is similar for the background in a value chain and also for the parents in the agglomerated region. This effect may be consistent with an attenuation of the agglomeration forces (either driven by heritage or agglomeration economies) in the sustainment stage. However, we must also note that sample of potential spawners doubles in the second period, while the number of entrants is smaller.

Firm size seems to be much more important in the period of 1986 to 1998 than later on. This is consistent with the generalized firm size reduction reported in Portugal over that period (Braguinsky, Branstetter, and Regateiro 2011).

Table 18 presents the results for the likelihood an entrant will locate in the same region as its parent company. We find no significant effects in the growth stage, while in the sustainment stage there are significant effects for the molds agglomeration region; therefore, entrants in this period whose parent company was located in the molds region were more likely than other companies to stay in the same region.

Table 18 – Model IV: Estimates of the Logit model of the likelihood of locating in the home region (Stages 1 and 2) – marginal effects†

VARIABLES	Growth Stage		Sustainment Stage	
	(1)	(2)	(3)	(4)
Entrant's initial size (log(*pemp_f*))	0.0429 (0.0297)	0.0418 (0.0302)	0.0269 (0.0327)	0.0249 (0.0328)
Founder from molds (*molds*)	0.1028 (0.0654)	0.0962 (0.0890)	0.0849 (0.0595)	0.1487* (0.0897)
Founder from value chain (*vc*)	0.0805 (0.0615)	0.0488 (0.0748)	0.0721 (0.0701)	0.1301 (0.0983)
Founder from skill-related (*rel*)	-0.0407 (0.0968)	-0.0565 (0.1007)	-0.0099 (0.1006)	-0.0177 (0.1016)
Molds agglomerated region (*moldsreg*)	0.1095 (0.0687)	0.0767 (0.1072)	0.1508*** (0.0526)	0.2436** (0.1072)
Molds industry and molds region (*molds*moldsreg*)		0.0239 (0.1345)		-0.1170 (0.1257)
Value-chain and molds region (*vc*moldsreg*)		0.0971 (0.1343)		-0.1078 (0.1367)
Observations	317	317	294	294
Log-pseudo likelihood	-186.35	-186.08	-155.55	-154.97
Pseudo R2	0.0414	0.0428	0.0429	0.0465
Wald test	0.0103	0.0369	0.0285	0.0436

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

Finally, Table 19 presents the results for the OLS model linking sales in Euros to the variables of interest.

Table 19 – Model V: Estimates of the OLS models for sales (log) in the third year (Stages 1 and 2) – coefficients†

VARIABLES	Growth Stage		Sustainment Stage	
	(1)	(2)	(3)	(4)
Entrant's initial size (log(*pemp_f*))	0.3442 (0.3998)	0.6351** (0.2733)	0.6945* (0.4097)	1.2505*** (0.3207)
Founder from molds (*molds*)	0.8092 (0.7322)	0.8999 (0.6934)	1.9248** (0.8105)	1.8809** (0.8274)
Founder from value chain (*vc*)	0.5806 (0.7708)	0.5750 (0.7687)	1.2790 (0.8779)	1.2166 (0.8884)
Founder from skill-related (*rel*)	-0.9001 (1.1358)	-0.8197 (1.1052)	-0.0200 (1.0639)	-0.0522 (1.0798)
Locating in the agglom. region (*agg*)	0.1944 (0.7263)	0.0203 (0.5015)	-1.0811 (0.7107)	-0.4901 (0.5578)
Locating in the home region (*home*)	0.9972 (0.7061)	0.9225 (0.6960)	1.3120* (0.7561)	0.9948 (0.7499)
Entrant w/unknown background (*ub*)	-	-2.4438*** (0.7465)	-	0.9065 (1.0730)
Constant	5.6070*** (1.5828)	4.9136*** (1.2007)	6.9252*** (1.6137)	7.7106*** (1.3520)
Observations	317	590	283	449
R-squared	0.096	0.186	0.131	0.120

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

In addition to the separation between the growth and sustainment stages of the life cycle, it could also be argued that we could separate the steeper growth stage that may still cover the first years of our data. Following this rationale, the following analysis separates the first three years of the data (1986 to 1989), when growth in the agglomerated region is higher, considering that they could be included in a growth stage with steeper rates (Growth I). The second growth period (1990 to 1997) has substantial growth but not as steep (Growth II).

Table 20 - Model I: Estimates of the Cox proportional hazards model for entrant survival (Stage 1) - hazard ratio †

VARIABLES	Growth I Stage		Growth II Stage	
	(1)	(2)	(3)	(4)
Entrant's initial size (log(*pemp_f*))	0.8449 (0.1346)	0.8390** (0.0705)	1.0531 (0.1178)	0.9965 (0.0784)
Founder from molds (*molds*)	0.4688** (0.1470)	0.5766* (0.1714)	0.6879* (0.1463)	0.7518 (0.1522)
Founder from value chain (*vc*)	0.2471*** (0.0804)	0.2646*** (0.0852)	0.7717 (0.1772)	0.7706 (0.1728)
Founder from skill-related (*rel*)	1.7474 (0.8298)	2.5089** (1.1183)	1.9895** (0.5751)	2.1569*** (0.6052)
Locating in agglom. region (*agg*)	0.6303 (0.1967)	0.3924*** (0.0767)	0.7480 (0.1628)	0.5936*** (0.0841)
Locating in the home region (*home*)	0.9577 (0.2855)	0.8563 (0.2391)	1.2771 (0.2628)	1.2762 (0.2619)
Entrant with unknown backg. (*ub*)	-	0.9290 (0.2369)	-	2.1484*** (0.4650)
Observations	95	216	222	374
Log-likelihood	-258.83	-794.02	-580.35	-1,282.33

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

Results from the Cox proportional hazards model presented in Table 20 also point to stronger and more significant impacts of industry of origin (and location for the sample with unknown background) in the early growth stage. In the late growth stage we also find a significant and positive effect for experience in the molds industry. Again, location in the agglomerated region is significant for the extended sample with firms of unknown background.

Table 21 – Model I: Estimates of the frailty models for entrant survival (Stage 1) – hazard ratio†

	Gompertz distribution with INVERSE GAUSSIAN heterogeneity			
	Growth I Stage		Growth II Stage	
VARIABLES	(1)	(2)	(3)	(4)
Entrant's initial size (log(*pemp_f*))	0.8453 (0.1575)	0.8241** (0.0800)	1.1237 (0.1618)	1.0376 (0.1006)
Founder from molds (*molds*)	0.3417** (0.1479)	0.4849** (0.1723)	0.5628* (0.1680)	0.6627 (0.1707)
Founder from value chain (*vc*)	0.1624*** (0.0775)	0.1927*** (0.0766)	0.6235 (0.1977)	0.6490 (0.1837)
Founder from skill-related (*rel*)	2.0946 (1.2084)	3.2501** (1.7204)	2.8087** (1.2228)	2.7819*** (1.0468)
Locating in the agglom. region (*agg*)	0.5990 (0.2249)	0.3068*** (0.0764)	0.5577* (0.1721)	0.4432*** (0.0862)
Locating in the home region (*home*)	1.0080 (0.3617)	0.8802 (0.2871)	1.4446 (0.4101)	1.4002 (0.3588)
Entrant w/unknown background (*ub*)	-	0.9664 (0.2920)	-	2.6886*** (0.7469)
Constant	0.1452*** (0.0665)	0.2139***) (0.0713	0.0702*** (0.0268)	0.0776*** (0.0227)
Observations	95	216	222	374
Log-likelihood	-119.31	-300.57	-284.41	-518.84
Likelihood-ratio test of θ = 0	0.114[29]	0.057	0.020	0.006

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

Results from the frailty survival models in Table 21 are consistent with the previous Cox proportional hazards models.

[29] Models with Weibull distribution with Gamma heterogeneity, Weibull distribution with Inverse Gaussian heterogeneity, and Gompertz distribution with Gamma heterogeneity have results with the same significance and order of impacts (with significant values for the Likelihood-ratio test of θ = 0: 0.006, 0.027, and 0.025, respectively).

Table 22 – Model II: Estimates of the Logit models for top sales in the third year (Stage 1) – marginal effects†

VARIABLES	Growth I Stage		Growth II Stage	
	(1)	(2)	(3)	(4)
Entrant's initial size (log(*pemp_f*))	0.2310*** (0.0448)	0.1766*** (0.0283)	0.1211*** (0.0337)	0.0954*** (0.0236)
Founder from molds (*molds*)	0.0866 (0.1018)	0.0548 (0.0806)	0.0136 (0.0723)	0.0293 (0.0587)
Founder from value chain (*vc*)	0.2208** (0.0931)	0.1845** (0.0784)	0.0200 (0.0795)	0.0117 (0.0665)
Founder from skill-related (*rel*)	0.0752 (0.1351)	0.0370 (0.1139)	-0.1943 (0.1199)	-0.1470 (0.0991)
Locating in the agglom. region (*agg*)	-0.0951 (0.1133)	-0.0451 (0.0634)	0.1144 (0.0726)	0.0920* (0.0495)
Locating in the home region (*home*)	0.2965*** (0.1137)	0.2252*** (0.0844)	0.0084 (0.0662)	0.0024 (0.0558)
Entrant w/unknown background (*ub*)	-	0.0224 (0.1021)	-	-0.1775*** (0.0664)
Observations	95	216	283	374
Log-pseudo likelihood	-46.55	-95.25	-147.25	-195.10
Pseudo R^2	0.2926	0.3072	0.2231	0.1789
Wald test	0.0007	0.0000	0.0000	0.0000

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

Table 22 shows the results about sales performance in the Growth I and II stages. During Growth I we find significant and strong effects for a background in the value-chain. In the second growth stage there is a significant effect for location, but only in the sample including entrants with unknown background. At this stage there are no significant effects associated with background.

Table 23 – Model III: Estimates of the molds spinoff Logit model (Stage 1) – marginal effects†

VARIABLES	Growth I Stage			Growth II Stage		
	(1)	(2)	(3)	(4)	(5)	(6)
Size (log(*pemp*))	0.0005*** (4.67e-05)	0.0005*** (4.61e-05)	0.0005*** (4.62e-05)	0.0003*** (1.95e-05)	0.0003*** (1.91e-05)	0.0003*** (1.97e-05)
Molds industry (*Molds*)	0.0025*** (2.55e-04)	0.0021*** (2.21e-04)	0.0021*** (2.83e-04)	0.0018*** (1.16e-04)	0.00015*** (1.09e-04)	0.0017*** (1.22e-04)
Value chain industry (*Vc*)	0.0011*** (1.77e-04)	0.0009*** (1.63e-04)	0.0010*** (1.84e-04)	0.0006*** (6.94e-05)	0.0005*** (6.75e-05)	0.0005*** (8.48e-05)
Skill-related Industry (*Rel*)	0.0005** (2.21e-04)	0.0001 (2.15e-04)	0.0001 (2.26e-04)	0.0004*** (1.00e-04)	0.0002** (8.91e-05)	0.0002*** (8.65e-05)
Molds agglom. region (*Moldsreg*)		0.0008*** (1.63e-04)	0.0010*** (1.84e-04)		0.0005*** (7.26e-05)	0.0007*** (8.88e-05)
Agglom. molds (*Molds*Moldsreg*)			-0.0001 (3.09e-04)			-0.0004*** (1.13e-03)
Agglom. value chain (*Vc*Moldsreg*)			-0.0005 (3.52e-04)			-4.56e-05 (1.25e-04)
Observations	457,223	457,223	457,223	1,210,577	1,210,577	1,210,577
Log-pseudo likelihood	-1,656.10	-1,625.08	-1,622.82	-2,412.24	-2,356.02	-2,342.62
Pseudo R^2	0.2704	0.2840	0.2850	0.3553	0.3704	0.3739
Wald test	0.0000	0.0000	0.0000	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.

Estimates in Table 23 aim to highlight the differences in the likelihood to spawn a molds entrant in Growth I and Growth II stages of the cluster's life cycle. Again the magnitude of the overall effects is much stronger in the earlier stage. Moreover, in the early growth stage the interaction for companies in the molds industry located in the molds region is not significant, while in later stages they become significant and negative.

A joint test of significance for the molds region and its interaction with the molds industry yields a positive and significant coefficient (for the specification in column 4).

Table 24 – Model IV: Estimates of the Logit model of the likelihood of locating in the home region (Stage 1) – marginal effects†

VARIABLES	Growth I Stage		Growth II Stage	
	(1)	(2)	(3)	(4)
Entrant's initial size (log(*pemp_f*))	0.0522 (0.0609)	0.0492 (0.0623)	0.0330 (0.0343)	0.0317 (0.0347)
Founder from molds (*molds*)	0.2277 (0.1609)	0.1481 (0.2312)	0.1097 (0.0763)	0.1283 (0.1018)
Founder from value chain (*vc*)	0.0489 (0.1074)	0.0302 (0.1200)	0.0933 (0.0763)	0.0687 (0.0961)
Founder from skill-related (*rel*)	omitted	omitted	-0.1513 (0.1083)	-0.1634 (0.1104)
Molds agglomerated region (*moldsreg*)	-0.0156 (0.1418)	-0.0803 (0.1770)	0.1473* (0.0783)	0.1564 (0.1362)
Molds industry and molds region (*molds*moldsreg*)		0.1546 (0.3090)		-0.0392 (0.1625)
Value-chain and molds region (*vc*moldsreg*)		0.0979 (0.2797)		0.0640 (0.1583)
Observations	84	84	222	222
Log-pseudo likelihood	-47.24	-47.09	-133.50	-154.97
Pseudo R2	0.0420	0.0450	0.0505	0.0516
Wald test	0.6145	0.8144	0.0190	0.0535

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

Table 24 displays the estimates for the likelihood an entrant will locate in its home region. However, results for the Growth I stage are not significant, and the model does not pass the Wald test for significance. Sample size is a relevant concern in the early growth stage. For the late growth stage, only entrants that locate in the molds region seem to be significantly more likely to locate home, independently of their industry of origin.

Table 25 – Model V: Estimates of the OLS models for sales (log) in the third year (Stage 1) – coefficients†

VARIABLES	Growth I Stage		Growth II Stage	
	(1)	(2)	(3)	(4)
Entrant's initial size (log(*pemp_f*))	0.9586 (0.6467)	1.3567*** (0.4306)	0.0516 (0.4791)	0.1022 (0.3481)
Founder from molds (*molds*)	2.9716** (1.2213)	2.5386** (1.1867)	-0.0407 (0.8838)	0.2033 (0.8337)
Founder from value chain (*vc*)	1.4531 (1.1944)	1.6421 (1.2237)	0.3666 (0.9550)	0.2962 (0.9378)
Founder from skill-related (*rel*)	1.0806 (1.9124)	0.4455 (1.8007)	-2.1171 (1.3474)	-1.9641 (1.3182)
Locating in the agglom. region (*agg*)	-2.1720 (1.3068)	-1.2914 (0.8096)	1.0866 (0.8434)	0.7257 (0.6149)
Locating in the home region (*home*)	1.8349 (1.2700)	1.8585 (1.2608)	0.5543 (0.8324)	0.4757 (0.8178)
Entrant w/unknown background (*ub*)	-	-0.8656 (1.2893)	-	-3.4724*** (0.9051)
Constant	4.5624** (1.9291)	3.0588** (1.5033)	7.3346*** (1.6153)	6.0898*** (1.3217)
Observations	95	216	222	374
R-squared	0.169	0.227	0.114	0.199

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

The OLS models show in Growth I a significant effect for a background in molds, while in Growth II there are no significant effects of either location or background.

Finally, the sustainment stage can also be divided into two periods, before and after the decline in the number of workers in the agglomerated region. As mentioned before, in 2005 the molds exports started to decrease, and this trend was intensified for the remaining years of data. This pattern is consistent with the sustainment stage, considering that the decline in the number of workers is not very strong. However, it could also be the beginning of the decline stage. It seems to be too soon to tell with the existing data, but we can analyze if the results for the sustainment stage remain unchanged if one removes the later years. Therefore, the ensuing analysis separates the first period of sustainment, from 1998 to 2004, and the second period, which could potentially be considered part of the decline stage of the cluster's life cycle.

Table 26 - Model I: Estimates of the Cox proportional hazards model for entrant survival (Stage 2) - hazard ratio †

VARIABLES	Sustainment Stage		Decline Stage	
	(1)	(2)	(3)	(4)
Entrant's initial size (log(*pemp_f*))	0.8228 (0.1280)	0.8972 (0.1052)	0.9919 (0.4414)	0.9740 (0.2638)
Founder from molds (*molds*)	0.9921 (0.2778)	0.9453 (0.2621)	0.5196 (0.3703)	0.5149 (0.3615)
Founder from value chain (*vc*)	0.5157* (0.1864)	0.5163* (0.1853)	0.8059 (0.7295)	0.8684 (0.7699)
Founder from skill-related (*rel*)	1.7464 (0.6276)	1.6465 (0.5805)	2.0257 (2.4924)	2.0197 (2.2943)
Locating in agglom. region (*agg*)	0.8903 (0.2425)	1.0265 (0.2144)	1.2462 (1.0365)	1.6581 (0.7915)
Locating in the home region (*home*)	1.7097* (0.5078)	1.6309* (0.4790)	0.5147 (0.4477)	0.4282 (0.3399)
Entrant with unknown backg. (*ub*)	-	1.4276 (0.5189)	-	0.6979 (0.5815)
Observations	239	374	55	102
Log-likelihood	-413.06	-721.12	-37.06	-96.44

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

Results in Table 26 share the same caveats from the previous model. Significant effects persist in the sustainment stage for the industry background in value chain industries. Furthermore, in the sustainment stage there is a negative effect on survival to firms locating in their home region. During the decline stage no significant effects on survival persist. Table 27 presents similar results for the frailty survival models but with the same caveats.

Table 27 – Model I: Estimates of the frailty models for entrant survival (Stage 2) – hazard ratio†

	Gompertz distribution with INVERSE GAUSSIAN heterogeneity			
	Sustainment Stage		Decline Stage	
VARIABLES	(1)	(2)	(3)	(4)
Entrant's initial size (log(*pemp_f*))	0.7981 (0.1249)	0.8815 (0.1035)	0.9927 (0.4444)	0.9370 (0.3182)
Founder from molds (*molds*)	0.9614 (0.2697)	0.9228 (0.2561)	0.4357 (0.3085)	0.4071 (0.3297)
Founder from value chain (*vc*)	0.4969* (0.1803)	0.5028* (0.1812)	0.8529 (0.7431)	0.9443 (0.8865)
Founder from skill-related (*rel*)	1.7888 (0.6460)	1.6522 (0.5841)	1.9990 (2.3504)	1.9542 (2.5345)
Locating in the agglom. region (*agg*)	0.8361 (0.2288)	1.0059 (0.2102)	1.3610 (1.1493)	1.9703 (1.1811)
Locating in the home region (*home*)	1.7732* (0.5273)	1.6678* (0.4901)	0.4609 (0.4076)	0.3528 (0.3351)
Entrant w/unknown background (*ub*)	-	1.4116 (0.5111)	-	0.5972 (0.5539)
Constant	0.0314*** (0.0127)	0.0330*** (0.0124)	0.0905** (0.0973)	0.0645*** (0.0635)
Observations	239	374	55	102
Log-likelihood	-209.70	-350.57	-30.63	-60.59
Likelihood-ratio test of θ = 0	1.000	1.000	1.000	0.355

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

Table 28 presents the results for the sales Logit model in the sustainment and decline stages (Stage 2). In both stages there is a significant and growing effect of the background in the molds industry. Therefore, even excluding the final years of the data (of possible decline stage) the effects of the molds background persists in this later stage.

Table 28 – Model II: Estimates of the Logit models for top sales in the third year (Stage 2) – marginal effects†

VARIABLES	Sustainment Stage		Decline Stage	
	(1)	(2)	(3)	(4)
Entrant's initial size (log(*pemp_f*))	0.2686*** (0.0324)	0.2370*** (0.0232)	0.2627*** (0.0916)	0.2922*** (0.0440)
Founder from molds (*molds*)	0.1151* (0.0696)	0.1111* (0.0637)	0.4751** (0.1852)	0.4611** (0.1966)
Founder from value chain (*vc*)	0.1128 (0.0802)	0.1026 (0.0729)	0.2179 (0.1828)	0.2111 (0.1947)
Founder from skill-related (*rel*)	-0.0109 (0.1108)	0.0038 (0.0987)	0.1520 (0.2731)	0.0768 (0.2784)
Locating in the agglom. region (*agg*)	0.0529 (0.0683)	0.0412 (0.0499)	-0.0294 (0.1705)	0.0651 (0.1045)
Locating in the home region (*home*)	-0.0277 (0.0658)	-0.0269 (0.0588)	0.2395 (0.1688)	0.1794 (0.1398)
Entrant w/unknown background (*ub*)	-	0.0136 (0.0807)	-	0.5504*** (0.1979)
Observations	239	374	44	75
Log-pseudo likelihood	-123.24	-183.93	-21.87	-37.08
Pseudo R^2	0.2262	0.2259	0.2828	0.2823
Wald test	0.0000	0.0000	0.1525	0.0021

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

Table 29 shows that the likelihood to spawn new entrants in the molds industry during the decline stage is overall lower than in the previous stages, as expected. Furthermore, the magnitude of the effects during the sustainment stage is stronger than for the overall sample including all data. In both the sustainment and the decline stages, there are significant and negative interactions for both molds and value chain companies located in the molds region.

Table 29 – Model III: Estimates of the molds spinoff Logit model (Stage 2) – marginal effects†

VARIABLES	Sustainment Stage			Decline Stage		
	(1)	(2)	(3)	(4)	(5)	(6)
Size (log(*pemp*))	0.0002*** (1.41e-05)	0.0002*** (1.35e-05)	0.0002*** (1.45e-05)	3.6e-05*** (6.28e-06)	3.4e-05*** (6.21e-06)	3.6e-05*** (6.52e-06)
Molds industry (*Molds*)	0.0016*** (9.07e-05)	0.0012*** (9.16e-05)	0.0016*** (1.04e-04)	0.0004*** (4.75e-05)	0.00003*** (4.84e-05)	0.0004*** (5.45e-05)
Value chain industry (*Vc*)	0.0006*** (5.98e-05)	0.0005*** (6.28e-05)	0.0006*** (7.76e-05)	0.0002*** (3.24e-05)	0.0001*** (3.41e-05)	0.0002*** (4.41e-05)
Skill-related Industry (*Rel*)	0.0004*** (9.50e-05)	0.0002*** (6.15e-05)	0.0002*** (7.61e-05)	-2.0e-05 (5.78e-05)	-5.2e-05 (5.65e-05)	-4.60e-05 (5.75e-05)
Molds agglom. region (*Moldsreg*)		0.0004*** (1.63e-04)	0.0008*** (7.24e-05)		0.0001*** (2.90e-05)	0.0002*** (3.59e-05)
Agglom. molds (*Molds*Moldsreg*)			-0.0007*** (8.58e-05)			-0.0002*** (4.86e-05)
Agglom. value chain (*Vc*Moldsreg*)			-0.0004*** (9.42e-05)			-0.0001*** (4.86e-05)
Observations	1,597,831	1,597,831	1,597,831	1,680,981	1,680,981	1,680,981
Log-pseudo likelihood	-2,222.11	-2,138.28	-2,092.08	-636.91	-617.61	-600.44
Pseudo R^2	0.4313	0.4527	0.4645	0.3781	0.3970	0.4137
Wald test	0.0000	0.0000	0.0000	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.

In Table 30 we can find the estimates for the factors impacting the likelihood an entrant will locate in its home region. The sample size in the decline stage is very small, and the Wald tests for all models are not significant. With this important caveat, we find stronger effects for entrants originating from the molds agglomerated region in the decline stage, which are also relevant in the sustainment stage. Experience in the molds industry is also significant in the decline stage (for the sample without firms with unknown background).

Table 30 – Model IV: Estimates of the Logit model of the likelihood of locating in the home region (Stage 2) – marginal effects†

VARIABLES	Sustainment Stage		Decline Stage	
	(1)	(2)	(3)	(4)
Entrant's initial size (log(*pemp_f*))	0.0276 (0.0371)	0.0257 (0.0376)	-0.0212 (0.0904)	-0.0345 (0.0889)
Founder from molds (*molds*)	0.0567 (0.0715)	0.1250 (0.1087)	0.2053** (0.0799)	0.2431 (0.1508)
Founder from value chain (*vc*)	0.1248 (0.0854)	0.1580 (0.1180)	-0.0795 (0.1096)	0.0956 (0.1594)
Founder from skill-related (*rel*)	-0.0359 (0.1052)	-0.0485 (0.1070)	omitted	omitted
Molds agglomerated region (*moldsreg*)	0.1410** (0.0617)	0.2256* (0.1273)	0.2193** (0.1007)	0.3450** (0.1506)
Molds industry and molds region (*molds*moldsreg*)		-0.1241 (0.1511)		0.0332 (0.2567)
Value-chain and molds region (*vc*moldsreg*)		-0.0579 (0.1702)		-0.4233** (0.1881)
Observations	239	239	52	52
Log-pseudo likelihood	-128.96	-128.54	-21.60	-19.82
Pseudo R2	0.0345	0.0376	0.0138	0.2944
Wald test	0.1488	0.2161	0.2311	0.1966

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

Finally, results from the OLS estimation of sales in the third year of activity, in Table 31, show no significant effects for background or location in the sustainment stage. However, in the decline stage there are significant and positive effects for a background in molds. Nevertheless, there are also significant but negative effects for locating inside the cluster.

Table 31 – Model V: Estimates of the OLS models for sales (log) in the third year (Stage 2) – coefficients†

VARIABLES	Sustainment Stage		Decline Stage	
	(1)	(2)	(3)	(4)
Entrant's initial size (log(*pemp_f*))	0.7754* (0.4598)	1.3084*** (0.3635)	-0.1630 (0.9537)	0.7873 (0.7647)
Founder from molds (*molds*)	1.3991 (0.8718)	1.4204 (0.8887)	4.8876** (2.1527)	4.2977* (2.2456)
Founder from value chain (*vc*)	1.3233 (0.9534)	1.2936 (0.9709)	0.1949 (2.2571)	-0.0035 (2.2150)
Founder from skill-related (*rel*)	-0.2212 (1.1418)	-0.0687 (1.1569)	1.7219 (3.2638)	-0.3580 (3.2981)
Locating in the agglom. region (*agg*)	-0.8687 (0.7767)	-0.1138 (0.6159)	-2.8757* (1.6456)	-2.4823* (1.3160)
Locating in the home region (*home*)	1.0181 (0.8097)	0.6850 (0.8120)	3.1381* (1.7454)	2.9729 (1.8269)
Entrant w/unknown background (*ub*)	-	0.3659 (1.1641)	-	3.7414 (2.5057)
Constant	7.1923*** (1.6669)	7.8920*** (1.4155)	7.2156*** (2.3019)	4.6128* (2.4428)
Observations	239	374	44	75
R-squared	0.119	0.120	0.311	0.183

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

In summary, the analyses over separate stages of the molds cluster's life cycle, albeit facing data limitations, are consistent with different effects and magnitudes affecting entry, location, and firm survival. However, results do not show a clear separation in time for the effects associated with heritage and the effects associated with agglomeration economies. Nevertheless, there remain weak effects of background persisting in the sustainment stage, while location effects do not.

Results on the survival of the entrants suggest that the effects of background are stronger and more persistent, even in the sustainment stage (for value chain). Overall, having a related industry background (molds and value chain) has a stronger positive impact on survival than locating in the molds region. Location effects only seem to be advantageous in the growth stage, but when we separate it into two stages (Growth I and Growth II) we find that, for Growth I stage, locating in the agglomerated region only has an effect if we include firms with unknown backgrounds. For firms whose backgrounds we could trace, locating in the agglomerated region proves to increase survival only in Growth II stage, and only in the mixed frailty model.

Regarding the likelihood to spawn a molds entrant, the molds companies seem to have a much higher likelihood in the early growth stage. We can also see that the effect for all variables fade over time. However, the molds and value chain effect on the spawning likelihood persist even in the decline stage. A similar, but much weaker, effect can be attributed to the companies locating in the molds agglomerated region. The negative and significant interactions, representing companies in the molds and value chain industries located in the molds region, are not significant in the early growth stage. These results suggest that the industry prevails as the most important predictor to spawning. Moreover, it suggests that in the earlier stages molds and value chain are not significantly less likely to spawn if they are located in the agglomerated region.

During the growth stage the likelihood to locate in the home region is significantly higher for companies with backgrounds in related industries and whose parents were located in the agglomerated region. In the sustainment stage, only the effects for backgrounds in the value chain persist. The samples for the late growth and decline stages are too small to elaborate on. However, overall, it seems that the attraction of the agglomerated region is more important in the sustainment stage.

Our findings seem to be consistent with the view that heritage effects have a stronger and more persistent effect on performance.

5.4 Discussion

This research sought to examine the mechanisms that drive firm performance in regional clustering of the plastic injection molding industry in Portugal by examining two alternative (though not necessarily mutually exclusive) theories: agglomeration economies and organizational heritage. The Portuguese molds industry started taking shape in 1946, developing two clusters: Marinha Grande (the first, and considerably larger one) and Oliveira de Azeméis. 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, the methodology was based on detailed data on firms and founders for the period 1987–2009 (when entry remained pervasive) is used 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 Grande was dictated by the presence of precursor industries, glass and glass molds, in a process of industrial heritage similar to what occurred, among others, in the case of the automobile industry in Detroit (Klepper 2001; 2007) and the case of 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. 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 independent 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 Grande. 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.

The 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 heritage theory remain valid at the sustainment stage, data suggests that agglomeration economies may contribute to 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. While the transmission of specific knowledge from parent firms continues to represent a significant mechanism for clustering and enhanced performance, agglomeration benefits also play an important role in firm performance.

These findings provide support to the observations about the role played by heritage and agglomeration economies theories over a cluster's 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 the cluster, and it remains very important in later stages. 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 is strongly consistent with 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 cluster 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.

6 Collocation of Related Industries: The Molds and Plastics Industries in Portugal

This section addresses the second research question: what mechanisms drive the collocation and performance of related industries in the same region? The methodological approach to address this question is based on an econometric analysis of detailed data on firms, founders, and workers in the Portuguese molds and plastics industries covering the period 1986-2009.

The empirical analysis focuses on the relationship between the molds and the plastics injection industries in Portugal, and their supplier-customer link. Inside their value-chain, the plastics industry is the industry with the strongest vertical relationship with the agglomerated molds industry in the Portuguese territory. The majority of other important inputs (like steel) are imported. In addition, although the plastics industry is not agglomerated, a large number of companies collocate in the molds agglomerated region.

One main prediction emerges from the agglomeration economies theoretical approach discussed in Section 2. If agglomeration theories better describe the main drivers of industry collocation, then:

- firms from related industries collocating in the agglomerated region[30] will perform better than firms located elsewhere, independently of their background.

Likewise, two main predictions emerge from the heritage theory approach. If heritage better describes the main drivers of the industry collocation process, then:

[30] Agglomeration refers to the presence of the agglomerated industry and the related industry.

- spinoffs originating from the same industry and cross-industry spinoffs from a related industry perform better than other startups; spinoffs originating from the same or a related industry from better quality parents perform better.

We would also expect to find, according to heritage theory, that incumbents from an agglomerated industry (and a related industry) spawn more entrants in that industry than incumbents in other industries, independently of the region where they are located. The analysis will explore this prediction, although it does not contribute to determining which mechanism is driving collocation and enhancing the performance of collocating industries.

The empirical study is divided in three parts: the first part concerns the probability of firms generating startups in both related industries and the existence of cross-effects; the second part focuses on the survival of companies in both related industries and the way it is influenced by the background of the entrepreneurs and the worker density in the region; the third part looks at another measure of firm performance by analyzing the factors influencing the likelihood the molds and plastics entrants will become top one-third sellers in their third year of activity.

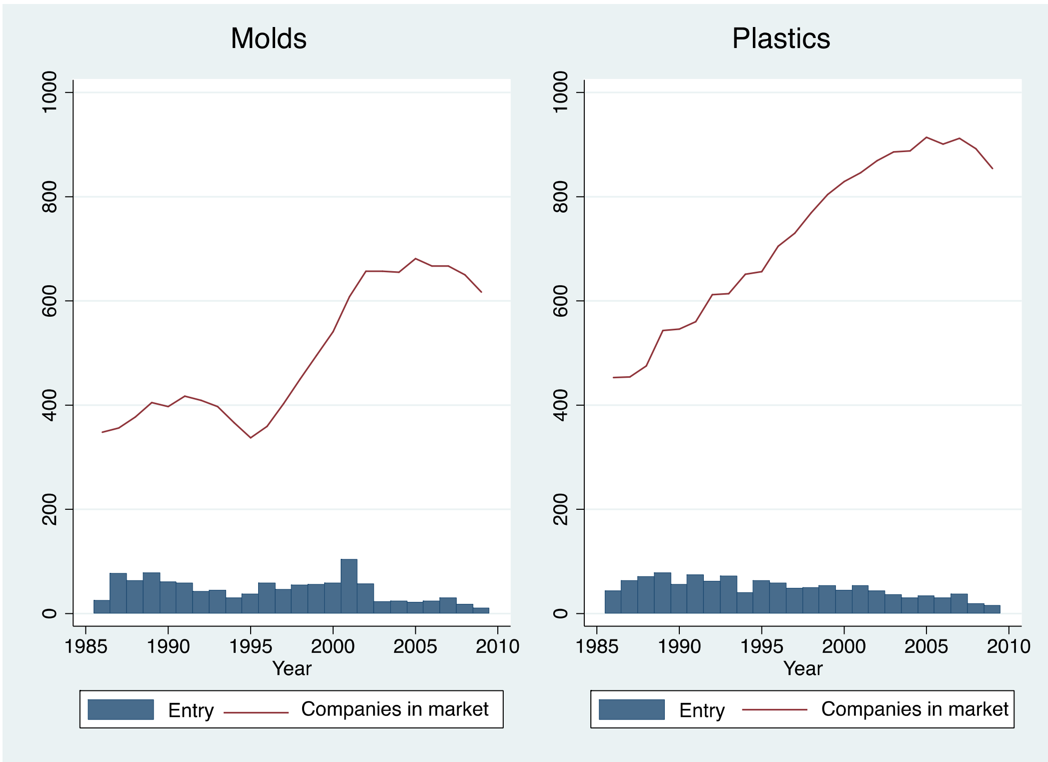
In addition, there are additional analyses aiming to describe the factors influencing the location decision of new entrants in both related industries.

6.1 Molds and Plastics Industries Data

The sample of the plastics industry active in the period of analysis includes 1,710 companies. Average entry by year is 49 companies, while average net entry is 25, but in

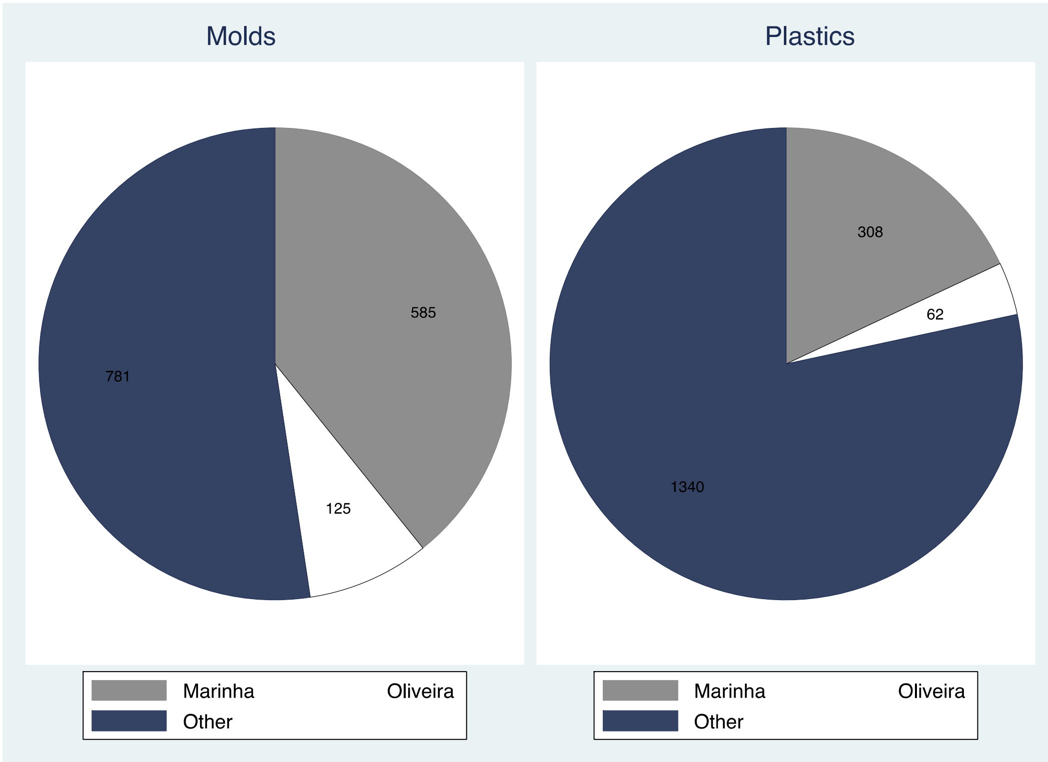
2009 only 15 companies entered the industry. The total number of companies in the market rose up until 2005, when there were 914 companies in the sample (Figure 16).

Figure 16 - Entry and Number of Companies in the Molds and Plastics Industries



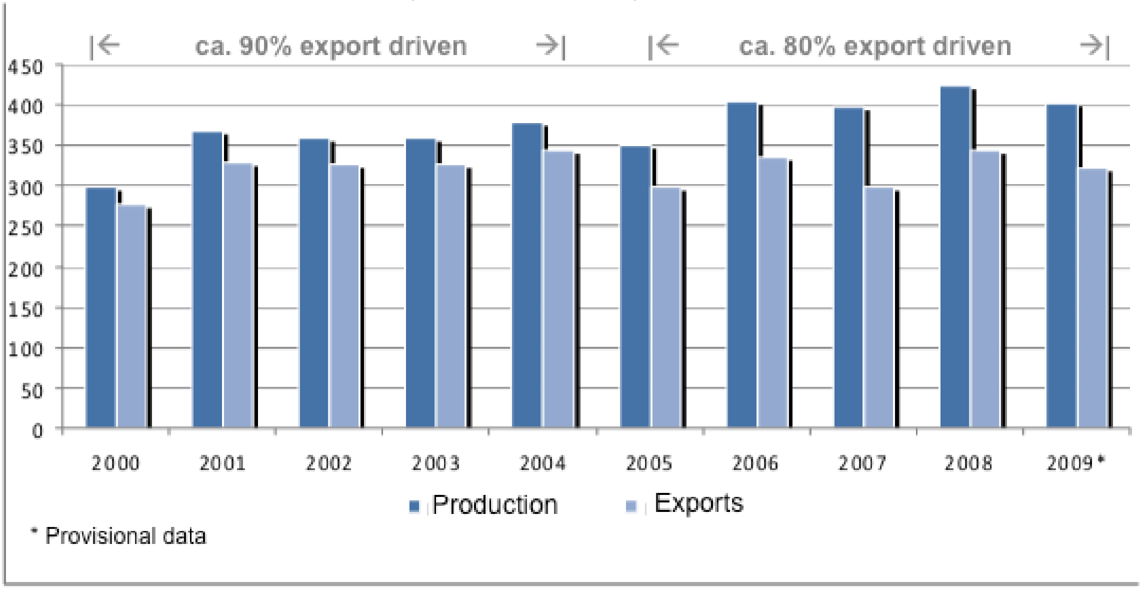
The molds industry agglomerates in Marinha Grande and Oliveira de Azeméis regions. The plastics industry is less concentrated but also has a high proportion of companies in Marinha Grande region. Figure 17 shows that 21.64% of the plastics companies are located in the molds agglomerated region (Marinha Grande and Oliveira de Azeméis), while the remaining companies are scattered in other 140 *concelhos* (14.39% are located in Lisbon and Porto). 47.62% of the molds companies are located in Marinha Grande and Oliveira de Azeméis regions (39.23% in Marinha Grande region).

Figure 17 - Location of Molds and Plastics Companies



The plastics industry had a close relationship with their local molds suppliers during the emergence of the industry. However, from the mid 1950s the molds industry started exporting intensely, and soon the local plastics customers represented only a small part of their market. The molds industry consistently exported about 90% of its production. However, for the plastics industry, the local molds suppliers continued to be important, as Portuguese plastics firms bought about half of their molds from domestic suppliers. Nevertheless, in recent years (from 2005 on), the growth of molds production has been closely associated with the increase in domestic demand. Figure 18 shows this recent trend.

Figure 18 – Molds Production and Exports (in million Euros)



Source: CEFAMOL and ICEP

6.1.1 Main variables

For the present analysis, companies in the plastics industry are identified as companies that use mainly plastic injection technology to produce plastic products (see Appendix I for further detail).

For each entrant in the molds and plastics industries from 1987-2009,[31] the founder(s) were then identified. Previous occupations of each founder in the previous five years of available data were identified. Among the entrants it was possible to distinguish between same-industry spinoffs, cross-industry spinoffs, diversifiers, and "de novo" entrants. Diversifiers were defined as new establishments in the plastics industry created by companies in other industries (molds, and others).

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

In the scope of the analysis, related industries are supplier or buyer industries of an agglomerated industry. These industries are important elements of the value chain of the agglomerated industry. The analysis will focus on the linkage between the plastics injection industry and the molds industry in Portugal and their tendency to collocate.

To assess the level of industry agglomeration across regions the location quotient was used. The location quotient has long been applied to estimate the strength of regional economic activities (see for example Isserman 1977). Building on the dartboard approach developed by Ellison and Glaeser (1997) that removes agglomeration driven by random independent location decisions, Guimarães *et al.* (2009) develop significance tests for the location quotient.

The location quotient (L) is the ratio of two shares: the employment share of a particular industry in a region and the employment share of that industry in the country, as shown below:

$$L_{jk} = \frac{w_{jk}/w_k}{x_j/x}$$

Where:

j − region

k − industry

w_k − total employment in industry k

w_{jk} − employment in industry k and region j

x − total manufacturing employment in the economy

x_j − total manufacturing employment in region j

As generally considered in the literature, the shares of the industries were weighted using the number of employees, in order to attribute more importance to the location decision of larger plants. Researchers usually assume that if the quotient is above one, then the industry is concentrated in the region. Using the significance tests introduced by Guimarães *et al.* (2009) it can be can verified if the location quotients show evidence of geographic concentration in excess of what would be expected to happen randomly. The test statistic (*W*) is given by the expression:

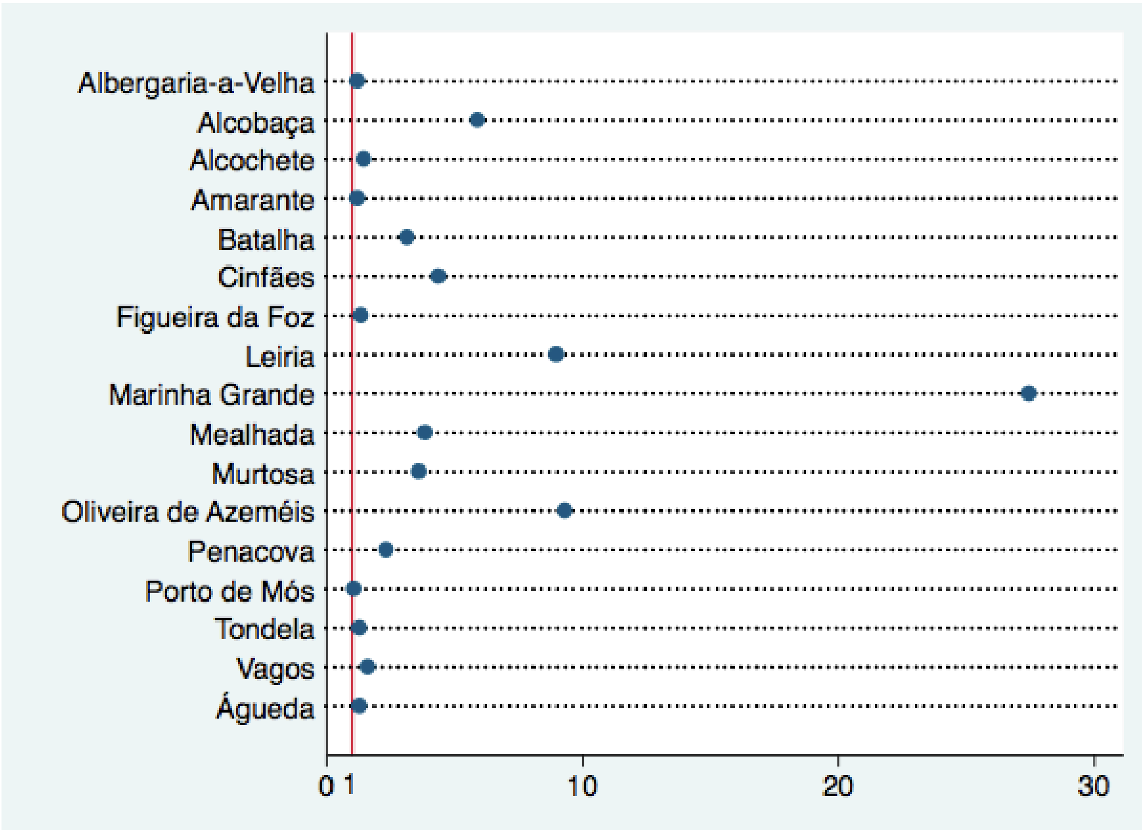
$$W_{jk} = \frac{J\left[log\left(L_{jk}\right)\right]^2}{(J-2)w_{jk}^{-1} + \overline{\overline{w_k^{-1}}}} \approx \chi_1^2$$

Where:

$J -$ total number of regions in the country (275 *concelhos*)

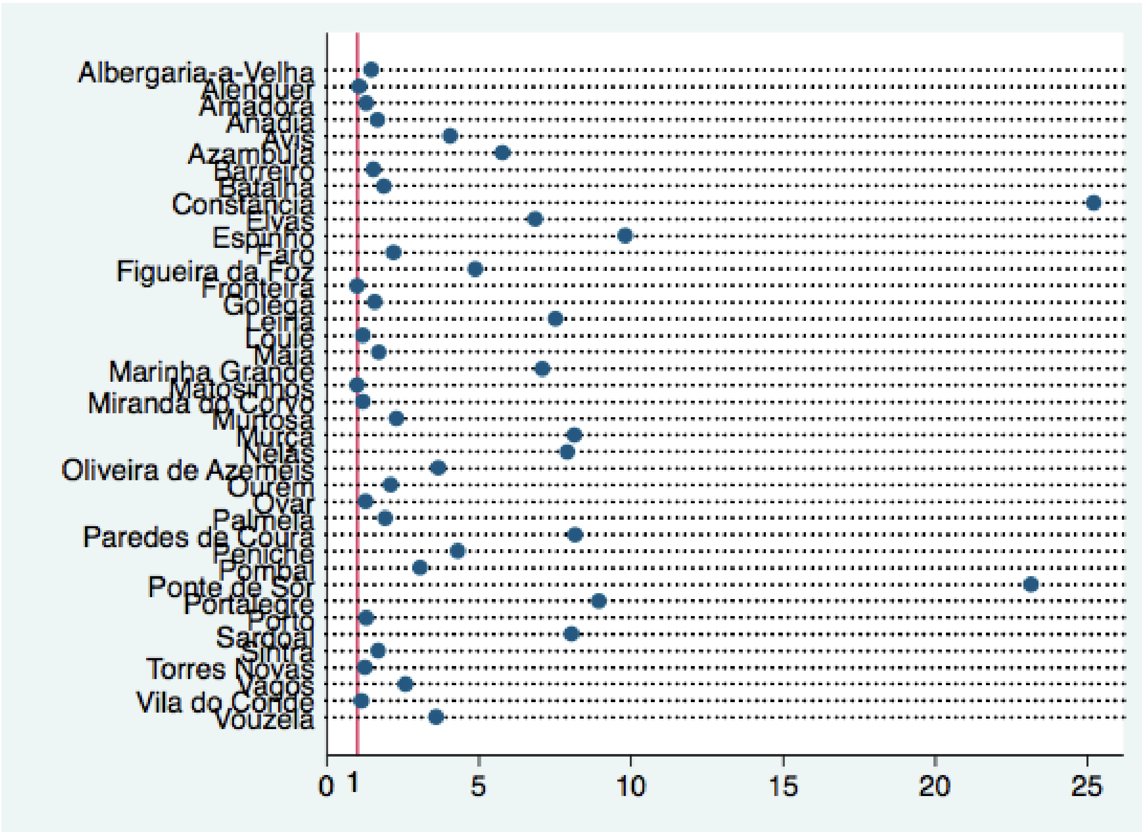
Data in QP from 1986 to 2009 were used to estimate significant location quotients for the molds and the plastics industries, and also a joint location quotient for both. Results show that the molds industry is concentrated in fewer *concelhos*, while the plastics industry has a strong presence in a large number of *concelhos*. The average location quotient across *concelhos* for the molds industry is 0.58, and 1.26 for the plastics industry. As expected, the highest location quotient for the molds industry was for Marinha Grande (27.46), as shown in Figure 19. Nearby *concelhos* like Leiria, Alcobaça and Batalha also rank high. Oliveira de Azeméis is another *concelho* acknowledged as having a strong presence of large molds companies, further north.

Figure 19 – *Concelhos* with Significant Concentration in the Molds Industry: 1986-2009



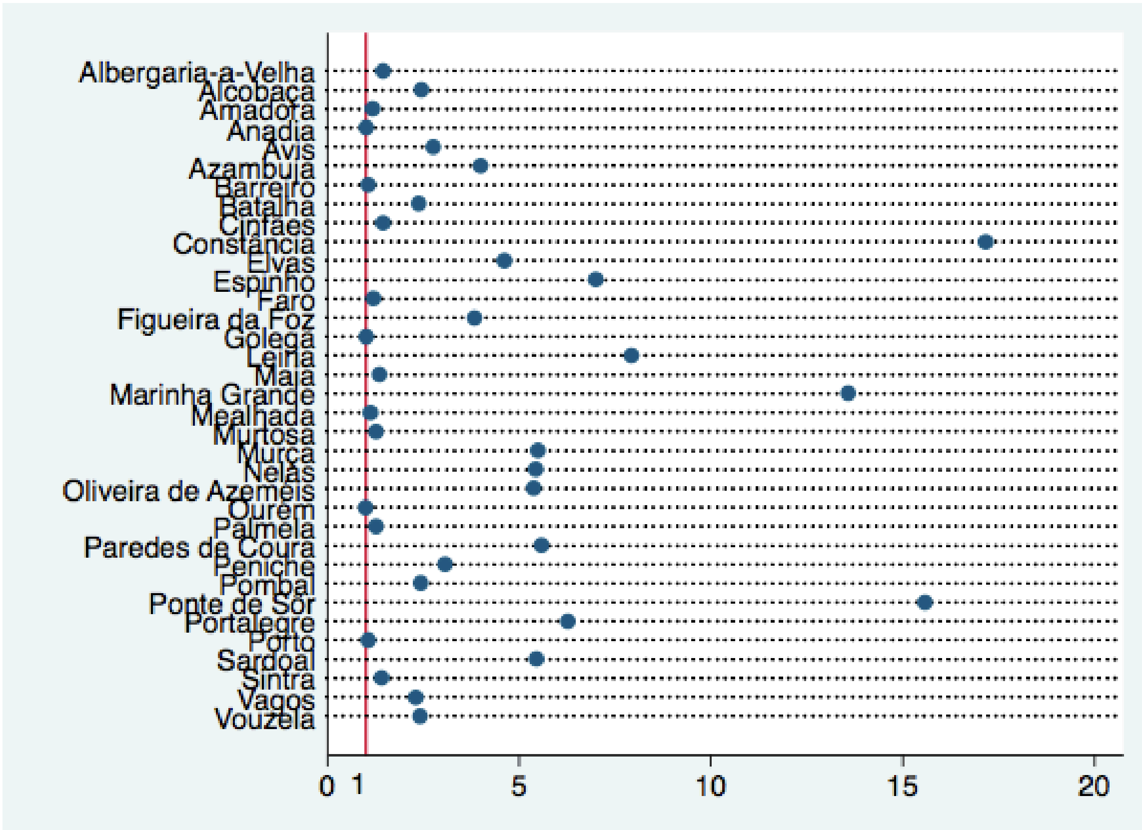
The highest location quotient for the plastics industry was for the *concelhos* of Constância (25.22) and Ponte de Sôr (23.16), while for Marinha Grande (7.09) and nearby Leiria (7.52) concentration levels are still high and well above average (see Figure 20). However, if weights for number of companies were used instead of employment, the concentration level for Marinha Grande and Leiria in the plastics industry would rank higher (6th and 4th, respectively), suggesting that these regions have a large number of small companies.

Figure 20 - *Concelhos* with Significant Concentration in the Plastics Industry: 1986-2009



Considering that the average employment in the molds industry for the period was 8,599 employees, while it was 18,233 employees in the plastics industry, the joint location quotient is, not surprisingly, dominated by the regions where the plastics industry has a stronger presence. Therefore, the joint location quotient for the molds and plastics industries is higher for Constância (17.18), followed by Ponte de Sôr (15.60), Marinha Grande (13.58), and Leiria (7.94) – see Figure 21.

Figure 21 - *Concelhos* with Significant Concentration in the Molds and Plastics Industries: 1986-2009



Location quotient estimates were then used to proxy for agglomeration of these industries across *concelhos* in continental Portugal. The value of the quotient was used when the estimate was significant and replaced it by zero when the test failed to confirm localization above what one would expect to find randomly.

Table 32 lists the variables used in the empirical analysis of industry collocation.

Table 32 - Variable definitions

Variable	Definition
spin	Dummy for creation of molds or plastics spinoffs by company *i* in year *t* (DV)
pemp	Size of company *i*, measured by the number of employees in year *t*
plast	Dummy for company with at least one founder with a previous job in the plastics industry
molds	Dummy for company with at least one founder with a previous job in the molds industry
Ljmp_e	Location quotient for molds and plastics, weighted by employment
Ljmolds_e	Location quotient for molds, weighted by employment
Ljplast_e	Location quotient for plastics, weighted by employment
chosenloc	Dummy for *concelho* of location at entry (DV)
home	Dummy for entry in a *concelho* where at least one founder had a previous job
pemp_f	Size of the entrant measured by the number of employees in the first year
sis	Dummy for a spinoff in the same industry as the previous job of at least one founder
cis	Dummy for a spinoff in the other industry (molds or plastics) as the previous job of at least one founder
div	Dummy for new establishment created by companies in all other industries

6.2 Methodology

This work is divided in three main parts: the first part concerns the probability of firms generating startups in the related industry; the second part focuses on how company survival is influenced by spinoffs and agglomeration externalities; and the third part concerns the influence of spinoffs and agglomeration externalities on the likelihood the entrants in collocating industries will become top one-third sellers in their third year of activity. Additional models add to a descriptive characterization of the collocating industries by looking at the location decision of new firms and the factors associated with variations in sales. In order to test the predictions derived from both the agglomeration theory and the organizational heritage theory, three main types of models are estimated regarding:

I. the incidence of firms in molds and plastics industries cross-spawning entrants in those industries is analyzed. The aim is to examine the likelihood that a plastics entrant is spawned by a molds company and vice-versa, and the likelihood that entrants will locate in the agglomerated region. The analysis focuses on firm quality (measured by firm size in employees) bearing on the rate of spawning startups, and also the role of location in affecting the spawning rate. If the incidence of spawning is greater for more successful firms independent of location, heritage predictions are supported;

II. the determinants of the performance of entrants, according to their origin, using survival analysis. The analysis focuses on the effect on survival of the background of entrants in the plastics and molds industries (in particular if they are cross-industry spinoffs). The analysis controls for the backgrounds of entrants (i.e. the career paths of founders), and also the extent of activity in the entrants' region in its own industry and in the related industry. In this way, a test of whether survival of firms that enter plastics and molds is more influenced by the background of founders (i.e. the type of entrants and the links to related industries, and the performance of parent companies) or by the concentration of molds producers in the region and the concentration of plastics producers in the region is performed. If backgrounds play a greater role, heritage theory is supported; if region plays a greater role, agglomeration theory is supported;

III. performance determinants, but this time by analyzing the factors influencing the likelihood an entrant will become a top one-third seller in its third year of activity. The objective is to test whether the sales ranking of an entrant is influenced by the background of the entrepreneurs in the plastics and molds industries (supporting the heritage theory predictions), or by the concentration of molds producers and plastics producers in the region (supporting the predictions of agglomeration theory).

In addition we present results from additional descriptive models regarding:

IV. where spinoffs of molds firms that enter plastics and spinoffs of plastics firms that enter molds locate, given the geographic origin of the entrepreneurs. The goal here is to see whether there is company movement from all regions toward the agglomerated region or whether entrants are more likely to stay in the home region of founders;

V. the association between higher sales in the third year of activity and the industry background of the entrepreneurs, and the concentration of molds producers and plastics producers in the region.

6.3 Results

This section presents the empirical estimation results. The estimations of the cross-industry spawning Logit models (in Table 33) and for the sales ranking Logit model (in Table 37) present the marginal effects of the explanatory variables, again as recommended by Wiersema and Bowen (2009). For a discrete explanatory variable, the marginal effect is the change in the dependent variable when the explanatory variable is incremented by one unit. Estimations for the survival analysis present hazard ratios (Table 34 and Table 35). Table 39 presents the coefficients from the Conditional Logit model.

6.3.1 Probability of spawning a cross-industry entrant

Model I addresses the effect of parent firm quality on the probability of generating startups measured by firm size and sales growth rate (however, the later does not have significant effects). Other possible measures of firm quality were tested but revealed low explanatory power. The effect of regional quality (i.e. industry density, as measured by the location quotient) is also addressed, while controlling for economic cycles with year dummies.

Table 33 – Model I: Estimates of the spinoff Logit model - marginal effects†

VARIABLES	(1) Molds and Plastics entrants from all origins	(2) Cross-industry Plastics spinoffs		(3) Cross-industry Molds spinoffs	
Size in employees *(log(pemp))*	0.000294*** (0.000012)	0.004305*** (0.000811)	0.004281*** (0.000824)	0.003002*** (0.000708)	0.003079*** (0.000644)
Sales growth rate *(sgr)*	-2.35e-07 (2.14e-07)	-0.000055 (0.000142)	-0.000537 (0.000142)	-0.000652 (0.000514)	-0.000671 (0.000526)
Plastics Industry *(plast)*	0.000978*** (0.000053)				
Molds Industry *(molds)*	0.001405*** (0.000057)				
Location Quotient M & P *(Ljmp_e)*	0.000041*** (3.57e-06)				
Location Quotient Molds *(Ljmolds_e)*		0.000033 (0.000074)			0.000327*** (0.000064)
Location Quotient Plastics (*Ljplast_e*)			0.000315 (0.000318)	0.000101 (0.000112)	
Log p-likelihood	-11,940.995	-350.361	-349.891	-351.884	-334.773
Pseudo R^2	0.2767	0.0889	0.0901	0.0929	0.1371
Observations	4,775,473	8,901	8,901	13,000	13,000

† Cluster standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Year dummies omitted

Table 33 reports results of Logit models of the probability of startup spawning (Model I). Column 1 looks at the probability of any firm in the Portuguese economy spawning a startup in either molds or plastics. Dummy variables equal one if the firm is in molds or plastics have positive effects, thus confirming that same or related industry spinoffs are more likely to occur than startups coming from other industries. Both firm quality (as measured by size) and regional density in molds and plastics have positive effects on the probability of spawning, so startups are both more likely to come from better (larger) firms and to locate in regions that have greater agglomerations of molds and plastics. However the industry effects are much stronger than regional density effects.

The marginal effect for firms in the molds industry (0.00141) is much larger than the marginal effect for firms in the plastics industry (0.00098), suggesting that molds firms are more involved in the creation of spinoffs in both industries than the plastics companies. This result suggests that employees in the molds industry may have more access to tacit knowledge that would give them an advantage when creating their own company in the same or a related industry. Other possible reasons for this lower engagement in the spinoff process may be associated with barriers to entry in the industry, considering that plastics firms tend to be larger than molds firms. In any case, this would suggest that the spinoff prevalence associated with the heritage of knowledge embodied in the molds workers who become entrepreneurs in the same or a related industry seems to be weaker in the plastics industry.

When looking specifically at collocation, however, a different picture emerges. Column 2 reports results on the probability of molds firms spawning plastics spinoffs, while column 3 reports results on the probability of plastics firms spawning molds spinoffs. In both cases, firm quality, as measured by size, has a positive effect on the probability of spinoff spawning, but regional density only has significant impact for the molds spinoffs. Moreover, it refers to the molds location density, while the density of the plastics industry is not significant. These results suggest that, while heritage theory helps to explain the collocation of the two industries (better firms generate more spinoffs, which locate near their parents), agglomeration economies do not seem to explain collocation, as cross-industry spinoffs are not more likely in more agglomerated regions when parent firm quality is controlled for. Findings point to same industry location density effects for the molds spinoffs but no significant effects for cross-industry influence.

6.3.2 Entrant performance

Model II analyses the probability of survival and Model III looks at sales ranking. If spinoffs or startups originating in related industries are more likely to survive and have higher sales, then the prediction of the heritage theory is supported. If molds companies located in the agglomerated region are more likely to survive and sell more, regardless of their industry of origin, then the prediction of the agglomeration economies account is supported.

Entrants are classified as same-industry spinoff (with experience in the same industry), cross-industry spinoffs (with experience in the other industry: plastics or molds), diversifiers (new establishments in molds or plastics from companies that are not in those industries), "de novo" entrants (entrants with identified background that is not in a related industry), and entrants with unknown backgrounds (omitted baseline category).

6.3.2.1 Survival

The goal is to examine the probability of firm survival in plastics and molds as a function of the firm's background (i.e. whether it is a same or cross-industry spinoff, and diversifiers) and of the density (location quotient) of the region where it locates. If related backgrounds play a greater role, heritage theory is supported; if region plays a greater role, agglomeration theory is supported. The analysis includes a control for the quality of the parent company, thus examining whether factors conditioning survival operate immediately at the birth of entrants, reflecting that they influence the innate ability of entrants to compete. It also controls for the entrant's initial size. We use two types of survival models: Cox proportional hazards and mixed Frailty models.

Table 34 displays the results of Cox proportional hazards survival models. Looking at entrants in both plastics and molds (column 1), there are significant effects from entrant background, both from the same industry and cross-industry. However, agglomeration also has a significant positive, though weaker, effect on survival, in particular when looking at the joint molds and plastics location density. When only molds entrants are examined (column 3) a similar pattern emerges, with positive and significant effects from background of the entrepreneur on survival (i.e. same industry, but even stronger impact from cross-industry spinoffs coming from plastics, that are less likely to exit), lending support to both heritage and agglomeration accounts. Survival of molds spinoffs seems to be most positively affected by entrepreneur background in the plastics industry (lower hazard ratios from cross-industry spinoffs than for same industry spinoffs). However, collocation with their customers in the plastics industry also has a positive, although weaker, effect on survival.

Findings are quite different for the plastics entrants (column 2), since there are only significant effects for same industry background. An entrepreneur background in the molds industry does not have a significant influence on plastics entrants' survival. Furthermore, there are no significant effects of locating in *concelhos* where the molds industry agglomerates or even where both industries agglomerate, so results are very much against the agglomeration economies account.

"De novo" entrants seem to perform surprisingly well in the plastics industry. Indeed, "de novo" plastics entrants survive longer than entrants with a background in the same industry. This trend however, does not apply in the case of the molds entrants. This would suggest that prior industry knowledge has a much stronger impact on firm survival in the molds industry than in the plastics industry. This conclusion is also consistent with the lower intensity of spawning in the plastics industry observed in Model I. Both results would suggest that the nature of knowledge in these industries is not comparable and that the heritage mechanisms would not play a very important role in the plastics industry.

However we must note that this "de novo" categorization may not correspond entirely to the classification usually found in the literature. Our sample of entrants with unknown background may contain entrants who are also "de novo" entrants (or other types of entrants) but we were unable to confirm that in the data.

Table 34 – Model II: Estimates of the Survival Cox Proportional Hazards model – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.952* (0.028)	0.953* (0.028)	0.924* (0.040)	0.922* (0.040)	1.003 (0.042)	1.006 (0.042)
Size of spinoff's parent *(parent)*	0.993 (0.042)	0.990 (0.042)	0.989 (0.069)	0.984 (0.068)	1.007 (0.054)	1.007 (0.053)
Same industry spinoffs *(sis)*	0.589*** (0.090)	0.588*** (0.090)	0.656* (0.159)	0.663* (0.160)	0.491*** (0.098)	0.495*** (0.099)
Cross-industry spinoffs *(cis)*	0.593** (0.150)	0.595** (0.151)	0.647 (0.204)	0.654 (0.206)	0.400** (0.153)	0.409** (0.155)
Diversifiers *(div)*	5.057*** (0.503)	5.099*** (0.506)	5.939*** (1.160)	5.920*** (1.154)	3.979*** (0.493)	3.980*** (0.493)
"De novo" entrants *(dnv)*	0.632*** (0.049)	0.636*** (0.049)	0.587*** (0.065)	0.592*** (0.065)	0.674*** (0.073)	0.679*** (0.073)
LQ Molds and Plastics *(Ljmp_e)*	0.981*** (0.007)		0.978* (0.012)		0.969*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.993** (0.003)		0.991 (0.006)		
LQ Plast *(Ljplast_e)*						0.950*** (0.013)
Log Likelihood	-8,691.7	-8,693.5	-3,634.5	-3,635.1	-4,278.1	-4,278.2
Observations	2,307	2,307	1,157	1,157	1,182	1,182

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 35 presents estimation results for the same specifications using frailty survival models. These models account for firm heterogeneity so we would expect to obtain more accurate results. Nevertheless results are very similar to the Cox proportional hazards models results.

Table 35 – Model II: Estimates of the Survival Frailty Model, Gompertz distribution (Gamma heterogeneity) – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics		(3) Molds	
Size at entry *(log(pemp_f))*	0.947* (0.028)	0.947* (0.029)	0.912* (0.043)	0.910** (0.043)	1.006 (0.042)	1.010 (0.042)
Size spinoff's parent *(parent)*	0.988 (0.042)	0.984 (0.042)	0.984 (0.074)	0.978 (0.074)	1.000 (0.053)	0.999 (0.053)
Same industry spinoffs *(sis)*	0.587*** (0.091)	0.585*** (0.091)	0.609* (0.166)	0.612* (0.167)	0.492*** (0.099)	0.496*** (0.099)
Cross-industry spinoffs *(cis)*	0.588** (0.151)	0.588** (0.151)	0.593 (0.207)	0.594 (0.209)	0.396** (0.152)	0.406** (0.154)
Diversifiers *(div)*	6.094*** (0.674)	6.194*** (0.687)	7.694*** (1.816)	7.780*** (1.854)	4.767*** (0.577)	4.767*** (0.576)
"*De novo*" *(dnv)*	0.618*** (0.049)	0.620*** (0.050)	0.544*** (0.075)	0.546*** (0.075)	0.656*** (0.071)	0.662*** (0.071)
LQ M & P *(Ljmp_e)*	0.979*** (0.007)		0.979 (0.013)		0.967*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.992** (0.003)		0.992 (0.007)		
LQ Plast *(Ljplast_e)*						0.946*** (0.013)
Constant	0.087*** (0.006)	0.085*** (0.006)	0.073*** (0.008)	0.071*** (0.007)	0.108*** (0.010)	0.108*** (0.010)
Observations	2,307	2,307	1,157	1,168	1,182	1,182
Log-likelihood	-2,745.1	-2,747.3	-1,312.3	-1,319.8	-1,435.5	-1,435.7
Lh ratio test θ=0	0.000	0.000	0.000	0.000	0.000	0.000

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In order to analyze different proxies for parent quality we tested a number of alternative variables (see Appendix IV). Table 36 presents results for a model using the base wage residuals as proxy for parent quality, using the Cox proportional hazards model. The rationale for this proxy is that firm quality may be assessed through the precision level of the molds it produces or uses. The level of precision a molds company is able to apply in its products would be a good indicator of its quality, and precision levels should be positively related to workers' skills and, therefore, wage levels. The evolution of plastics and molds industries led to a market segmentation with different levels of knowledge that can be revealed by the level of precision used. More qualified companies would be able to produce or use more precise molds. Such high quality firms hire better and more qualified workers, with higher education levels and higher wages. By comparing wage levels across molds and plastics companies, it should be possible to identify the top wage payers. “Best parents” would be the firms with higher wage levels.

Regressing average wages for middle hierarchical levels - 4, 5, and 6 (highly-skilled professionals, skilled professionals, and semi-skilled professionals) and controlling for firm size [since larger companies tend to pay higher wages (see Lentz and Mortensen 2010)]. Middle hierarchical levels are expected to include the majority of skilled workers, and empirically this category shows a better fit with the data (see Appendix IV). The predicted residual for each company would be a measure of the firm’s level of precision, a good indicator of its quality level as a possible parent for a spinoff.

The coefficients for this parent quality proxy (or any of the remaining alternatives used from the available data – see Appendix IV) are not significant in the survival models, however. In addition, results of survival models using this variable do not change significantly from the analysis using firm size.

Table 36 – Model II: Estimates of the Survival Cox Proportional Hazards model with base-wage residuals as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.952* (0.028)	0.952* (0.028)	0.922* (0.040)	0.920* (0.039)	1.004 (0.042)	1.008 (0.042)
Base wage residuals spinoff's parent *(bwr1)*	7.59e-33 (8.4e-25)	2.49e-29 (3.7e-22)	2.63e-24 (1.4e-17)	2.19e-28 (1.4e-20)	1.06e-34 (3.3e-26)	2.71e-28 (2.5e-21)
Same industry spinoffs *(sis)*	0.583*** (0.047)	0.577*** (0.046)	0.635*** (0.079)	0.631*** (0.079)	0.512*** (0.054)	0.514*** (0.055)
Cros-industry spinoffs *(cis)*	0.593** (0.121)	0.589*** (0.120)	0.646* (0.158)	0.644* (0.158)	0.412*** (0.127)	0.420*** (0.130)
Diversifiers *(div)*	5.066*** (0.504)	5.107*** (0.507)	5.946*** (1.160)	5.928*** (1.155)	3.990*** (0.495)	3.992*** (0.494)
"*De novo*" *(dnv)*	0.633*** (0.049)	0.636*** (0.049)	0.588*** (0.065)	0.592*** (0.065)	0.674*** (0.073)	0.679*** (0.073)
LQ Molds and Plastics *(Ljmp_e)*	0.982*** (0.007)		0.979* (0.011)		0.970*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.993** (0.003)		0.991 (0.006)		
LQ Plast *(Ljplast_e)*						0.952*** (0.014)
Log Likelihood	-8,688.5	-8,690.2	-3,633.9	-3,634.5	-4,275.5	-4,275.6
Observations	2,307	2,307	1,157	1,157	1,182	1,182

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6.3.2.2 Sales ranking

The estimates from Model III, the Logit model, in Table 37 show the marginal effects for the likelihood to become a top one-third seller by the third year in the market, while Table 38 shows the estimates for the specification with wage levels as proxy for parent quality. In this case both specifications present very similar results, with no significant effects for parent quality. Same-industry and cross-industry spinoffs, both from molds and plastics, are significantly more likely to become top sellers. For the molds industry, "de novo" entrants are much less likely to rank in the top-third sellers than spinoffs. Location does not have an impact on the likelihood a plastics entrant will become a top seller, but it has a significant, although very small, effect for molds entrants, in particular locating close to plastics companies.

Table 37 – Model III: Estimates of the Logit models for top sales in the third year – marginal effects†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry (log(pemp_f))	0.132*** (0.009)	0.132*** (0.009)	0.135*** (0.013)	0.135*** (0.013)	0.134*** (0.012)	0.135*** (0.012)
Size spinoff's parent *(parent)*	-0.002 (0.011)	-0.001 (0.011)	-0.004 (0.019)	-0.002 (0.019)	0.001 (0.013)	0.001 (0.013)
Same industry spinoffs *(sis)*	0.178*** (0.039)	0.180*** (0.039)	0.172*** (0.064)	0.170*** (0.064)	0.175*** (0.048)	0.169*** (0.048)
Cross-industry spinoffs *(cis)*	0.181*** (0.066)	0.181*** (0.066)	0.165* (0.092)	0.165* (0.092)	0.189** (0.096)	0.183* (0.096)
"*De novo*" *(dnv)*	0.122*** (0.021)	0.121*** (0.021)	0.142** (0.029)	0.141*** (0.029)	0.099*** (0.032)	0.098*** (0.032)
LQ M & P *(Ljmp_e)*	0.005*** (0.002)		0.005 (0.004)		0.005** (0.003)	
LQ Molds *(Ljmolds_e)*		0.002* (0.001)		0.001 (0.002)		
LQ Plast *(Ljplast_e)*						0.011** (0.004)
Observations	2,271	2,271	1,122	1,122	1,170	1,170
Log-pseudo likelihood	-1,177.21	-1,179.19	-613.70	-614.41	-566.31	-565.08
Pseudo R^2	0.1678	0.1664	0.1398	0.1389	0.2122	0.2140
Wald test	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

† Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Year dummies omitted

Table 38 – Model III: Estimates of the Logit models for top sales in the third year with base wage residuals as proxy for parent quality – marginal effects†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry (log(pemp_f))	0.132*** (0.009)	0.132*** (0.009)	0.136*** (0.013)	0.136*** (0.013)	0.133*** (0.012)	0.135*** (0.012)
Base wage residuals spinoff's parent *(bwr1)*	0.372 (0.269)	0.398 (0.276)	-	-	0.178 (0.201)	0.162 (0.194)
Same industry spinoffs *(sis)*	0.171*** (0.021)	0.176*** (0.021)	0.160*** (0.034)	0.163*** (0.034)	0.175*** (0.027)	0.170*** (0.027)
Cross-industry spinoffs *(cis)*	0.170*** (0.054)	0.174*** (0.054)	0.132* (0.074)	0.137* (0.073)	0.192** (0.082)	0.186** (0.082)
"*De novo*" *(dnv)*	0.121*** (0.021)	0.121*** (0.021)	0.142*** (0.029)	0.140*** (0.029)	0.099*** (0.032)	0.098*** (0.032)
LQ M & P *(Ljmp_e)*	0.005*** (0.002)		0.004 (0.004)		0.005** (0.003)	
LQ Molds *(Ljmolds_e)*		0.002* (0.001)		0.001 (0.002)		
LQ Plast *(Ljplast_e)*						0.011** (0.004)
Observations	2,271	2,271	1,121	1,121	1,170	1,170
Log-pseudo likelihood	-1,176.32	-1,178.18	-612.15	-612.73	-566.09	-564.89
Pseudo R^2	0.1685	0.1672	0.1407	0.1399	0.2126	0.2142
Wald test	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

† Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Year dummies omitted

6.3.3 Descriptive results

In this section we present estimations that help describe the collocation of the molds and plastics industries but do not aim to contribute to the objective of identifying the mechanisms driving collocation.

6.3.3.1 Location choice of entrants

The alternative-specific conditional Logit (McFadden's choice) model was used to examine the location choice of entrants (Model IV). This model allows analyzing a multiple choice frame including both attributes for the choice (locations to choose from) and characteristics of the firm.

Table 39 – Model IV: Estimates of the alternative-specific location choice conditional Logit model – odds ratio†

VARIABLES	(1) Molds and Plastics entrants	(2) Plastics entrants	(3) Molds entrants
Home *concelho* *(home)*	64.639*** (5.531)	67.936*** (8.056)	55.349*** (7.136)
Location Quotient for Molds and Plastics (*Ljmp_e*)	0.934*** (0.015)		
Location Quotient for Molds (*Ljmolds_e)*		1.007 (0.023)	
Location Quotient for Plastics (*Ljplast_e*)			0.874*** (0.022)
Observations	634,425	308,000	326,425
Cases	2,307	1,120	1,187
Log pseudolikelihood	-7,296.190	-3,830.475	-3,258.342
Wald test	0.0000	0.0000	0.0000

† Robust cluster errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 39 reports the effects of home region and regional agglomeration on location choice. Column 1 provides results for all entrants in molds and plastics, while column 2 looks at entrants in plastics and column 3 looks at entrants in molds. In all cases, new entrants are significantly more likely to locate in the home region of one of the founders, i.e. the same region as a parent firm. Regional agglomeration as measured by the location quotient has a much smaller effect for the joint sample, which is no longer significant when one considers spinoffs of each industry separately. These results support the heritage theory's contention that spinoffs locate primarily near their parent firms [thus confirming the results of Figueiredo *et al.* (2002), among others]. The agglomeration economies do not seem to play an important role, as cross-industry spinoffs do not seem to choose to locate in a region based on industry density.

6.3.3.2 Sales

Finally, in Model V we also estimate the factors influencing sales volume in the third year of activity (with an OLS model).

Table 40 – Model V: Estimates of the OLS models for sales (log) in the third year †

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry (log(pemp_f))	1.203*** (0.146)	1.196*** (0.146)	1.326*** (0.197)	1.327*** (0.197)	0.951*** (0.212)	0.969*** (0.211)
Size spinoff's parent *(parent)*	-0.122 (0.159)	-0.113 (0.159)	-0.048 (0.268)	-0.037 (0.268)	-0.139 (0.197)	-0.142 (0.198)
Same industry spinoffs *(sis)*	2.976*** (0.558)	2.990*** (0.558)	2.348*** (0.909)	2.336** (0.908)	3.381*** (0.706)	3.318*** (0.711)
Cross-industry spinoffs *(cis)*	2.674*** (0.920)	2.684*** (0.921)	2.190* (1.249)	2.219* (1.250)	3.141** (1.450)	3.103** (1.458)
"*De novo*" *(dnv)*	2.072*** (0.308)	2.063*** (0.308)	2.129*** (0.417)	2.115*** (0.416)	2.080*** (0.457)	2.075*** (0.457)
LQ M & P *(Ljmp_e)*	0.019 (0.027)		0.016 (0.049)		0.027 (0.034)	
LQ Molds *(Ljmolds_e)*		-0.002 (0.013)		-0.003 (0.026)		
LQ Plast *(Ljplast_e)*						0.091 (0.058)
Constant	5.819*** (0.812)	5.902*** (0.808)	5.855*** (1.160)	5.909*** (1.156)	11.392*** (0.565)	11.028*** (0.556)
Observations	2,092	2,092	1,087	1,087	1,040	1,040
R-squared	0.151	0.150	0.135	0.135	0.192	0.194

† Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$
Year dummies omitted

Results of the estimates of the OLS model presented in Table 40 show that industry backgrounds have, in general, a positive effect on the entrant sales turnover. Locating in regions where the same or a related industry has a high density does not seem to have an impact on sales. In particular for the molds entrants, same industry and cross-industry spinoff tend to have higher sales volumes. That impact is lower for entrants in the plastics industry. Entry size appears to also have a significant impact on future sales, but this effect is more pronounced in the plastics industry, where indeed companies are, on average, larger. Parent quality, with proxies by parent size, is not significant in any sample.

Table 41 presents the same OLS models with parent quality with proxies by wage levels. We find strong and significant effects of parent quality on sales levels. This effect is significant for both for the plastics and the molds industries, but much stronger for the former. This result appears to be consistent with heritage theory's prediction that spinoffs from better parents also perform better. The effects of same industry and cross-industry backgrounds persist, as in the previous specification. Again, there are no significant effects for the Location Quotients. The difference between coefficients for same-industry and cross-industry backgrounds and "de novo" entrants is wider for the molds entrants than for the plastics entrants, suggesting that background has a stronger impact in the performance of the agglomerated industry. Cross-industry spinoffs in the plastics industry do not seem to be as successful as the same-industry spinoffs. In the molds industry that difference is smaller, suggesting that molds entrants acquire more relevant capabilities in their experience in the plastics industry that the plastics entrants are able to acquire in a prior experience in the molds industry.

Table 41 – Model V: Estimates of the OLS models for sales (log) in the third year with base_wage residuals as proxy for parent quality - coefficients†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry (log(pemp_f))	1.196*** (0.146)	1.189*** (0.146)	1.328*** (0.198)	1.329*** (0.198)	0.941*** (0.212)	0.960*** (0.211)
Base wage residuals spinoff's parent *(bwr1)*	6.197*** (1.529)	6.428*** (1.534)	11.533*** (2.432)	11.938*** (2.418)	5.103*** (1.521)	4.931*** (1.443)
Same industry spinoffs *(sis)*	2.581*** (0.308)	2.620*** (0.307)	2.210*** (0.477)	2.229*** (0.476)	2.910*** (0.408)	2.839*** (0.410)
Cross-industry spinoffs *(cis)*	2.197*** (0.795)	2.236*** (0.794)	1.865* (1.034)	1.924* (1.033)	2.592** (1.304)	2.543* (1.312)
"*De novo*" *(dnv)*	2.073*** (0.308)	2.065*** (0.308)	2.127*** (0.417)	2.114*** (0.416)	2.085*** (0.457)	2.080*** (0.457)
LQ M & P *(Ljmp_e)*	0.013 (0.028)		0.011 (0.049)		0.022 (0.034)	
LQ Molds *(Ljmolds_e)*		-0.004 (0.013)		-0.006 (0.026)		
LQ Plast *(Ljplast_e)*						0.085 (0.058)
Constant	5.882*** (0.810)	5.960*** (0.806)	5.870*** (1.159)	5.921*** (1.154)	11.464*** (0.568)	11.087*** (0.558)
Observations	2,092	2,092	1,087	1,087	1,040	1,040
R-squared	0.152	0.151	0.136	0.136	0.193	0.195

† Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Year dummies omitted

6.4 Discussion

Results unequivocally show that heritage through the transmission of capabilities from parent firms in the related industry to spinoffs locating in the same region is a very important driver of collocation of the molds and plastic injection industries, thus supporting the findings of Klepper (2010), and Buenstorf and Klepper (2009), even when we look mainly at a cluster's growth and sustainment stages. Cross-industry spinoffs between molds and plastics are more likely to occur for larger (i.e. better) parent firms, while spinoffs are more likely to locate in the same region as their parent company. Location choice is not influenced by attraction to the agglomerated region. Results on the performance of new firms in the molds and plastics industries show some support for heritage theory (in the case of molds), and evidence is only weakly supportive of the agglomeration economies theory.

It appears that the choice of the plastics entrants to locate in the molds agglomerated region is driven by the fact that molds firms are more likely to spawn plastics firms and that entrepreneurs tend to locate in their home region, therefore collocating with their supplier industry. However, the performance of the plastics companies does not seem to improve with collocation with the suppliers from the molds industry. For molds entrants, collocation with plastics again arises from the higher likelihood that plastics companies will spawn molds spinoffs, and that those spinoffs tend to locate close to the parent firm. In the case of molds spinoffs, knowledge learned from the same industry, and even from the customer plastics industry, seems to positively influence firm performance (survival and sales). Collocation with plastics customers only marginally improves survival, but has a stronger impact on the likelihood to become a top one-third seller. We also find a positive and significant impact of parent quality (measured by its wage levels) on the sales volume of entrants in their third year in the market (in particular for plastics entrants).

Klepper's (2010) account of the geography of organizational knowledge is consistent with the collocation patterns between the molds and plastics industries, while agglomeration economies accounts do not seem to significantly explain collocation. This study contributes to the understanding of the process of causation associated with industry collocation patterns in industrial clusters, concluding for the prevalence of organizational heritage effects over agglomeration economies accounts.

The finding that collocation effects seem to have a positive, although weak, effect on the survival of molds but not plastics firms may be explained by the fact that for the plastics industry spawning is not prevalent. Golman and Klepper (2013) propose that positive location externalities may enhance spinoff performance in a cluster, while they would have a weaker impact on other types of firms that would not have the necessary inherited knowledge to benefit from them. This claim would be consistent with our results, showing that only in the molds industry, where spinoffs are prevalent and perform better, firms are able to benefit from collocation with plastics companies. On the other hand, our results do not support the impact of agglomeration economies on collocating industries. Ellison *et al.* (2010) claim that input-output linkages and labor pooling are good predictors of coagglomeration. We would suggest that these agglomeration economies may (or may not) induce collocation but they are not enhancing firm performance per se. Industry characteristics seem again, to play an important role in their ability to gain from collocation. In the case of the plastics industry, where tacit knowledge is not dominant, it appears unlikely that true clustering would occur, due to the absence of significant heritage effects.

7 Conclusions

This research aims to contribute to the understanding of the mechanisms driving the performance of industries clustering in specific regions and their ability to benefit from collocating with related industries. The case of the molds industry in Portugal is an example of a successful cluster that emerged in the 1950s and is still prevalent today. Quantitative data are available from 1986 to 2009; therefore, there is an opportunity to examine the cluster's growth and sustainment stages (while using an historical account to describe the cluster's emergence and early growth stages). This research also extends the analysis to more than one industry by including the cross-industry relationships with related industries (in particular with its main customers in the plastics industry, but also with other industries in the value-chain, and skill-related industries).

The qualitative analysis of the emergence of the molds cluster resonates with heritage theory accounts of spinoffs emerging out of an innovative incumbent (A.H.A.), in successive waves of employees who become entrepreneurs. This pattern is similar what was identified in the semiconductor, tire, and automotive industries in the US (Klepper 2007; 2010; Buenstorf and Klepper 2009; 2010). This would suggest that molds spinoffs inherited knowledge from their high quality parents and located in the same region as their parents. However, this does not exclude the possibility that the clustering process of these spinoffs was not motivated by their intention to benefit from agglomeration economies in the region. Therefore, although spinoffs and the entrepreneurship environment they generated played a very important role in the emergence of the Portuguese molds cluster, it is less clear to discern the motivations that led to their location choice, resulting in the accumulation of spinoffs in Marinha Grande and Oliveira de Azeméis regions.

Heritage theory proposes that entrants in general tend to locate home and. Therefore, spinoffs would naturally locate in the same region as their parents (Buenstorf and Klepper 2009; Buenstorf and Klepper 2010). Golman and Klepper (2013) model spinoff-driven cluster growth and development, based on perceived new opportunities detection associated with innovation, occurring in the absence of agglomeration economies. Spinoff motivations for home preference could range from the possibility to hire ex-coworkers from the parent firm (Carias and Klepper 2010), the opportunity to exploit their local social capital (Dahl and Sorenson 2012), the non-Marshallian externalities associated with the entrepreneurship demonstration effect (Nanda and Sörensen 2010), to even the simple desire to locate close to family and friends (Dahl and Sorenson 2010), among others not part of or inherent in traditional agglomeration economies.

Nevertheless, researchers arguing in favor of agglomeration economies recognize that entrepreneurship plays a significant role in the emergence of a cluster's development (Glaeser and Kerr 2009; Feldman, Francis, and Bercovitz 2005; Rosenthal and Strange 2010). Glaeser *et al.* (2010) point out that traditional agglomeration spillovers could also influence entrepreneurship and spinoffs' decision to locate in proximity to their parents. In that case, location choice would be influenced by the possibility to benefit from input sharing and labor pooling and the opportunity to learn from their neighbors.

Without quantitative data from the emergence and early growth stages of the molds cluster in Portugal for further analysis, the reasons that motivated spinoffs to locate home in this specific case cannot be determined with traditional econometric methods and their confidence measures. We therefore focused on the later stages to analyze the persistence of heritage or agglomeration economies effects that would affect entry, location choice, and, foremost, the performance of the entrants.

When focusing on the molds cluster's late growth and sustainment stages (making use of available quantitative data) results point to the persistence of heritage effects even in the later stages. However, agglomeration economies effects also seem to play a role in the late growth and sustainment stages of the cluster's life cycle, likely because this is a cluster where scale economies are not prevalent, tacit knowledge is important, and networks of vertical disintegrated companies interact. Nevertheless, the factor with most impact on firm survival, even in the growth and development stages of the molds cluster, seems to be the origin of the entrepreneur. Such findings suggest that agglomeration economies effects, although significant, are not the main drivers of firm performance in the cluster, whether in the, growth, or sustainement stages of the cluster's development. Moreover, agglomeration economies seem to complement the effect of heritage in the late growth and sustainment stages of the cluster's life cycle, but there is no evidence that those effects would be able to cause agglomeration on their own. However, results point to significant effects attributed to agglomeration economies, which cannot be ignored.

Our results are concordant with the work by Boschma and Wenting (2007) who studied the automotive industry in Britain and concluded that there are complementarities between agglomeration economies and spinoff linkages driving the industry's agglomeration. In the early stage of the British automotive industry's development, during its first twelve years, the entrepreneur's prior experience in related industries seemed to be the best predictor of survival. When examining the whole 74 years of

British automotive industry data, experience remained important but the spinoff effect became the strongest performance driver, but only if it was from a successful parent.

Broadening this view, this research also contemplated the phenomenon of industry collocation, or why a significant number of plastics companies chose to locate in the molds agglomerated region and what effect that had in the molds industry itself. In the study of the cross-industry effects driving collocation, again in a post-emergence stage, results point to even stronger effects of heritage and mild but significant effects of agglomeration economies. Molds spinoffs with entrepreneurs from the plastics or the molds industries seem to perform better, while collocating with their customer industry only has a weak positive effect. Moreover, the plastics companies did not seem to benefit from collocating with their suppliers. This results could be explained by the inability of firms that do not possess advantages associated with inherited tacit knowledge to benefit from the externalities associated with collocation. Again, the main factor driving performance for the industries seems to lie on the effect of industry background, associated with the tendency to locate home, as proposed by Buenstorf and Klepper (2009).

The present study has several limitations that have already been noted but should be restated. First, detailed data are not available for the formative era of the industry, which does not allow the use of econometric techniques to test the predictions of the two theories under consideration for the period 1946–1986.

Regarding the econometric study, tracing backgrounds of entrepreneurs is not always possible when dealing with the data, although a sizable and representative sample of molds startups entering over 24 years was assembled. Also, the unavailability of firm-specific data other than size imposed serious limits to the 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 molding industry). A final difficulty lay 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 that was not accessible, compelling us to resort to published lists of industries.

These findings have implications for both practitioners and policy makers. For practitioners, the findings seem to confirm that access to external capabilities can substitute for vertical integration in localized networks of firms. The findings are also informative for firm location choice, suggesting that firms may benefit from locating in the agglomerated region.

For policy makers, the results suggest that industrial districts remain a valid model for regional growth, at least in industries where tacit knowledge plays a greater role than scale. However, results suggest that the main driver for successful cluster emergence and growth is linked to the spinoff process, implying that policies fostering spinoffs may be more effective than generalized entrant attraction incentives. Examples would be policies not allowing or enforcing non-compete clauses in labor contracts and promoting an entrepreneurship-supportive environment. This research also shows that not all types of industries can benefit from clustering. The benefits of clustering seem to be closely associated with industries where tacit knowledge is an important asset. The importance of tacit knowledge, however, appears to be associated with the fact that it enables spawning. Workers who embody significant tacit knowledge in an industry where that type of knowledge is critical are better candidates to create successful spinoffs that in other types of industries. Evidence from the plastics industry shows that this lower preponderance of tacit knowledge leads to lower rates of spawning and, therefore, to a lower ability to profit from collocating with a supplier. For policy makers this shows that the type of industries that can benefit from clustering is limited to industries where tacit knowledge is prevalent.

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9 Appendix

Appendix I - Molds and Plastics Industries Definition

Appendix II – Empirical Definition of Entrepreneur

Appendix III – Congestion Costs

Appendix IV - Alternative Parent Quality Proxies in the Survival Analysis (collocation study)

Appendix I

Molds and Plastics Industries Definition

The definition of the molds industry in this research applies to companies that, for at least one year, reported the following CAE codes:

- 381990 - Manufacture of other metal products, not specified (Rev. 1), and they exited the database before 1995;
- 382490 - Manufacture of industrial machinery, not specified (Rev. 1) and they exited the database before 1995;
- 29563 - Manufacture of metal molds (Rev. 2 or Rev. 2.1);
- 25734 - Manufacture of metal molds (Rev. 3).

The definition of plastics industry applied in this research incorporates the companies that use plastic injection technology, i.e. companies that, for at least one year observed in the data, reported the following CAE (Portuguese Economic Activities Classification) codes:

- 356000 - Production of Plastic Materials (Rev. 1), and they exited the database before 1995;
- 25220 - Manufacture of plastic packing goods (Rev. 2 and 2.1);
- 25230 - Manufacture of plastic builders' ware goods (Rev. 2 and 2.1);
- 25240 - Manufacture of other plastic products (Rev. 2 and 2.1);
- 22220 - Manufacture of plastic packing goods (Rev. 3);

- 22230 - Manufacture of builders' ware of plastic (Rev. 3);
- 22291 - Manufacture of plastic parts of footwear (Rev. 3);
- 22292 - Manufacture of other plastic products, n.c.e. (Rev. 3).

During the period of analysis there were four different versions of the CAE codes. Revision 1 was used from the first year in the data up until 1995. It was followed by Revisions 2 and 2.1, which are very similar to each other, and Revision 3 that was introduced in 2007. Newer versions of the CAE codes are more detailed and more comparable to the international standards.

Appendix II

Empirical Definition of Entrepreneur

Prior research using QP to identify entrepreneurs of new companies in Portugal and trace their backgrounds generally report low rates of identification, due to data quality issues. Figueiredo *et al* (2002) report a rate of only 19% of companies for whom they could identify the backgrounds of the entrepreneurs (home location), for a sample of entrants from all industries in the dataset, from 1995 to 1997. Besides the companies that did not name the "employer", they also excluded companies with foreign or public investors (page 347). They matched not only the employee number but also his birth date. Carias and Klepper (Carias and Klepper 2010) obtain a sample of 12% of the population of entrants from 1996 to 2004, again for all industries (except agriculture, energy distribution, public administration, schools, social services, and non-profit organizations). Their sample excluded companies whose first year of data did not match the year of constitution, companies with no reported employees in the first year, foreign owned companies and companies with more than one establishment. The sample considered the entrepreneurs declared in the first year, or the second year if there was none in the first year, and examined their work history for the prior four years.

Such low rate of companies with a traceable background brings a concern for our research that aims to focus on only one or two specific industries over a long period of time and propose an overall understanding of the agglomeration mechanisms and their impacts on performance. Our aim was to obtain a representable and unbiased sample for the industries in the study, in spite of the data quality and misreporting issues. We attempted to exclude the minimum amount of companies in order to obtain a representative sample, however ensuring we maintained data reliability and quality.

Data about employees in QP is missing for the years of 1990 and 2001. If our analysis were restricted to the entrepreneurs declared in the first year of activity, we would immediately exclude all companies who entered the market in those years (60 and 103 molds entrants in 1990 and 2001, respectively). In addition, data accuracy improves over time in QP, therefore there is a larger incidence of misreporting in the earlier years of data, or in this case, for the earlier entrants in these industries. Therefore, if we consider only the data for the first observation (year of entry), the sample will be biased, loosing a higher proportion of early entrants (reduced sample). The mean entry date for the full sample of molds entrants is 1996, while for the reduced sample of companies with data reported in the first year[32] the mean is 1998. The distribution of entry dates is depicted in Figure 22. However this is an important problem since the agglomeration mechanisms may differ over time and this sample misrepresents earlier entrants.

Because for this research we aim to obtain a sample that is large enough and that adequately represents entrants from all periods of time, we attempted to compensate for misreporting by resorting to alternative ways to identify the entrepreneur. Therefore, in this research entrepreneurs of new molds and plastics firms were empirically defined as:

[32] Entrepreneurs empirically defined as the person(s) listed as "employer" in the company's observation referring to the first year of activity, or, if none were listed, the top managers in the same year, if reported. Sample: 231 molds entrants with information on the background of the entrepreneur (21.7% of all molds entrants identified, comparing to 57.2% in the corrected sample we used) – excluding new establishment diversifiers.

- The person(s) listed as "employer" in the observation referring to the first year of activity.

If none were listed, then we considered:

- The top manager(s) in the same year, if reported (which were likely to be indeed the "employer");
- The person(s) listed as "employer" in the company's observation referring to the first of the first ten years of activity where the "employer" is identified.

Figure 22 – Comparative Box Plot of the Distribution of Entry Dates in Two Samples (Molds Industry)

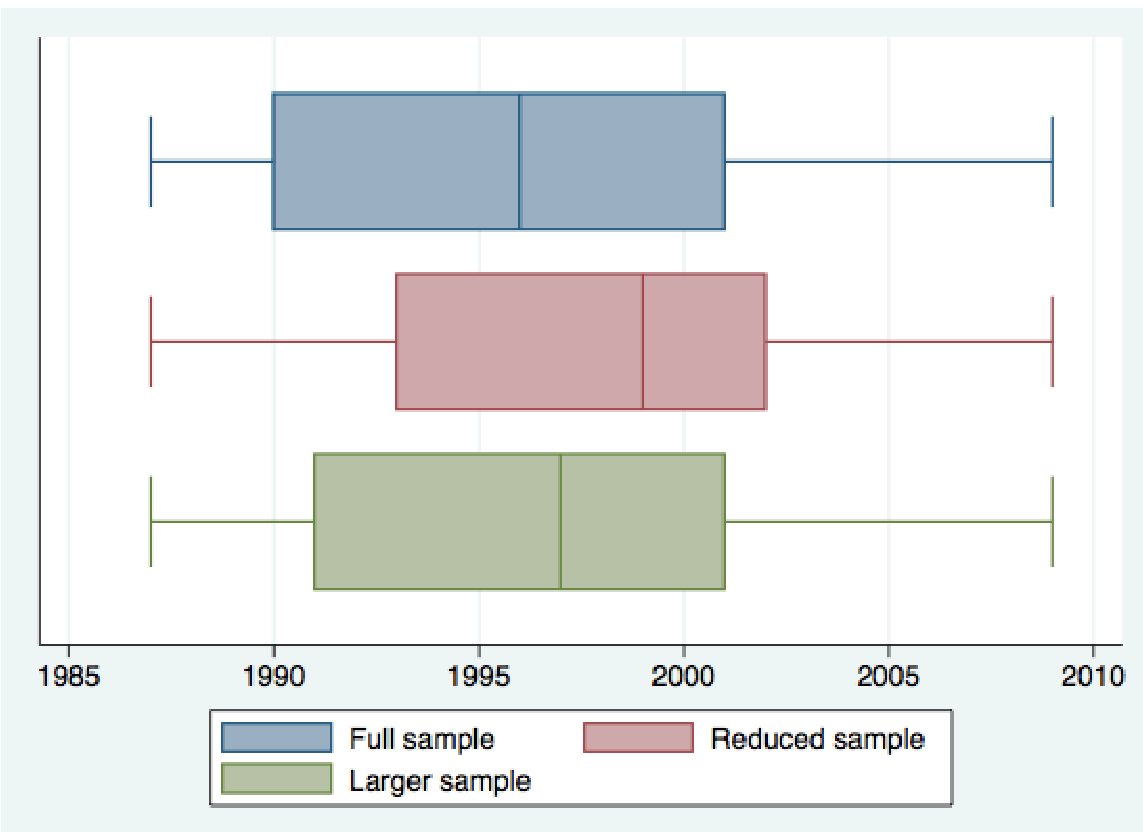


Table 42 shows the comparison between the sample of 611 entrants obtained using this definition with the population of identified entrants (1,066 entrants) and the reduced sample if we use a more restrictive empirical definition of entrepreneur (231 entrants).

The reduced sample covers only the companies with entrepreneurs defined as the person(s) listed as "employer" in the company's observation referring to the first year of activity, or, if none were listed, the top managers in the same year, if reported.

Table 42 - Sample Comparison: Observations by Year of Entry in the Molds Industry

Year of Entry	Population	Reduced Sample	Full Sample	%Dif-Red	%Dif-Full
1987	76	13	41	8%	4%
1988	63	8	21	7%	5%
1989	77	14	33	8%	5%
1990	60	0	30	7%	4%
1991	58	10	28	6%	4%
1992	42	9	23	4%	2%
1993	44	11	26	4%	2%
1994	29	6	19	3%	1%
1995	37	3	19	4%	2%
1996	58	9	41	6%	2%
1997	46	14	36	4%	1%
1998	54	13	33	5%	3%
1999	56	13	34	5%	3%
2000	58	24	42	4%	2%
2001	103	0	62	12%	5%
2002	57	29	36	3%	3%
2003	22	7	14	2%	1%
2004	24	12	18	1%	1%
2005	21	8	14	2%	1%
2006	24	12	16	1%	1%
2007	30	8	14	3%	2%
2008	17	7	10	1%	1%
2009	10	1	1	1%	1%
Total Obs.	**1,066**	**231**	**611**		

We checked the background of the entrepreneurs in their employment experience for ten years prior to the company creation.

We did robustness check of the estimations using the reduced sample. Results are significantly different for the reduced sample but we believe this is due to the time of entry bias and not because of data quality. This is consistent with our analysis of two separate periods throughout the cluster life cycle.

Robustness Check for the Minimal Sample

In this test, entrepreneurs were empirically defined as the person(s) listed as "employer" in the company's observation referring to the first year of activity, or, if none were listed, the top managers in the same year, if reported (reduced sample).

Study 1

Using the restricted sample.

We ran the estimations for all models using the reduced sample, as presented in the following tables (the first table is for the initial results and the second table is for the results with the test sample).

Table 43 - Model I: Test estimates of the Cox proportional hazards model for entrant survival†

VARIABLES	Hazard Ratio
Entrant's initial size (log(*pemp_f*))	1.1363 (0.1233)
Locating in the agglomerated region (*agg*)	0.6321** (0.1380)
Locating in the home region (*home*)	1.1429 (0.2573)
Founder from molds (*molds*)	0.4456*** (0.0941)
Founder from value chain (*vc*)	0.4289*** (0.1182)
Founder from skill-related (*rel*)	1.7794* (0.5871)
Observations	231
Log-likelihood	-572.61

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

Table 44 – Model I: Test estimates of the frailty models for entrant survival†

	Weibull distribution with GAMMA heterogeneity (NOT CONVERGED) (1)	*Weibull distribution with INVERSE GAUSSIAN heterogeneity (2)*
VARIABLES	Hazard Ratio	
Entrant's initial size (log(*pemp_f*))	1.1983 (0.2203)	1.2349 (0.2296)
Locating in the agglom. region (*agg*)	0.4342* (0.1853)	0.4420** (0.1623)
Locating in the home region (*home*)	1.3021 (0.4924)	1.3312* (0.4952)
Founder from molds (*molds*)	0.2608*** (0.1034)	0.2475*** (0.0958)
Founder from value chain (*vc*)	0.3103*** (0.1399)	0.2465*** (0.1172)
Founder from skill-related (*rel*)	2.9640* (1.8218)	2.7654* (1.4999)
Observations	231	231
Log-likelihood	-269.74	-269.40
Likelihood-ratio test of $\theta = 0$	0.002	0.002

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

Table 45 – Model III: Test estimates of the molds spinoff Logit model – marginal effects†

VARIABLES	(1)	(2)	(3)
Size (log(*pemp*))	0.000054*** (0.000006)	0.000052*** (0.000006)	0.000054*** (0.000006)
Molds industry (*Molds*)	0.000470*** (0.000036)	0.000391*** (0.000034)	0.000464*** (0.000036)
Value chain industry (*Vc*)	0.000167*** (0.000021)	0.000147*** (0.000022)	0.000152*** (0.000027)
Skill-related Industry (*Rel*)	0.000074*** (0.000023)	0.000031 (0.000022)	0.000042* (0.000022)
Molds agglomerated region (*Moldsreg*)		0.000116*** (0.000020)	0.000201*** (0.000023)
Agglomeration in molds (*Molds*Moldsreg*)			-0.000155*** (0.000028)
Agglomeration in value chain (*Vc*Moldsreg*)			-0.000060* (0.000034)
Observations	4,610,047	4,610,047	4,610,047
Log-pseudo likelihood	-2,645.01	-2,594.04	-2,570.42
Pseudo R^2	0.3229	0.3359	0.3420
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 46 – Model IV: Test 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*))	0.0111 (0.0349)	0.0137 (0.0343)
Founder from molds (*molds*)	0.0317 (0.0639)	0.1279 (0.0870)
Founder from value chain (*vc*)	-0.1045 (0.0704)	-0.1097 (0.0881)
Founder from skill-related (*rel*)	0.0554 (0.1211)	0.0313 (0.1190)
Molds agglomerated region (*moldsreg*)	0.1051* (0.0629)	0.2655** (0.1279)
Molds industry and molds region (*molds*moldsreg*)		-0.2548* (0.1444)
Value-chain and molds region (*vc*moldsreg*)		-0.0377 (0.1473)
Observations	231	231
Log-pseudo likelihood	-128.09	-126.41
Pseudo R2	0.0320	0.0446
Wald test	0.1783	0.0949

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

Test for moldreg + moldmr: 0.5758**

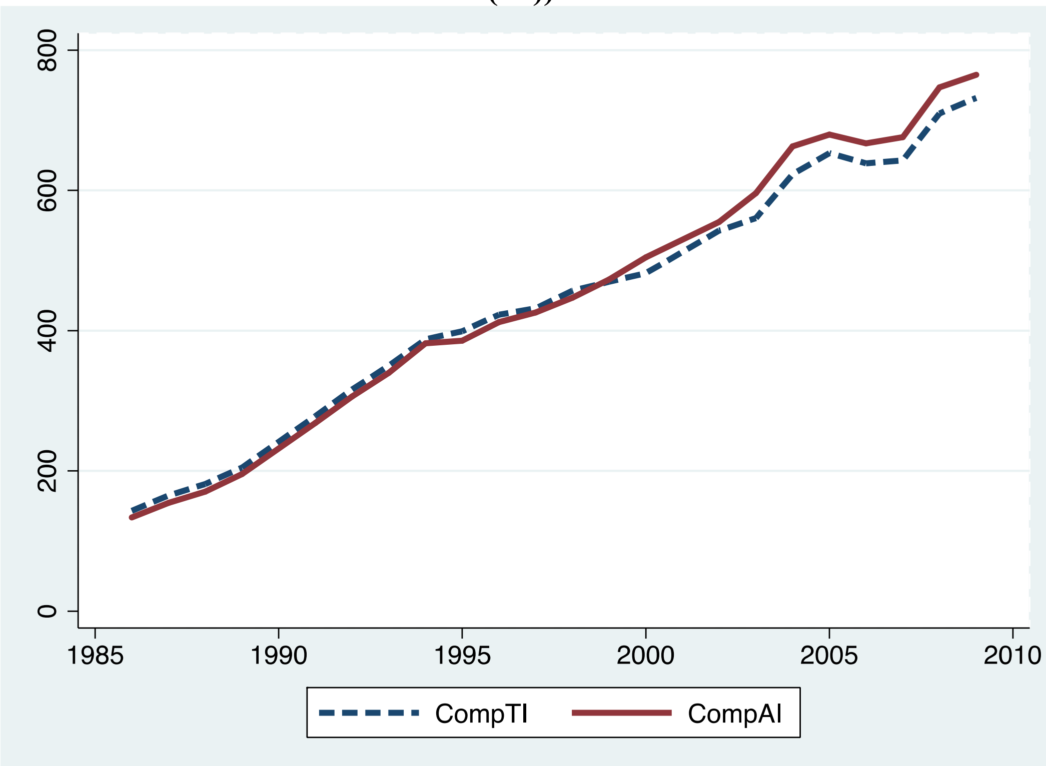
Appendix III

Congestion Costs

We claim that our analysis focuses on the sustainment stage of the industry's life-cycle, where organizational reproduction still has a strong effect and agglomeration economies begin to emerge. In order to support this claim we have to show that the decline stage of the cluster, driven by congestion costs, is not dominant in the period of analysis. To show that the decline stage of the cluster, driven by congestion costs, is not dominant in the period of analysis the evolution of wages was analyzed.

Regarding the wages, and using data from Quadros de Pessoal, we compared the evolution of wages inside and outside the molds agglomerated region, as shown in Figure 23 and in Table 47 and Table 48, where we regress the log of wages, in all industries and then in the molds industry alone, on a dummy for location in the molds region, controlling for education, tenure, and employment situation.

Figure 23 - Evolution of Average Industry Wages (Comparison between Total Industry (TI) and Industry in the Agglomerated region (AI))*



*Average wages excluding part time workers.

After 1999 average industry wages in the agglomerated region were consistently higher than the average of the country, however only by a margin below 5%.

Table 47 - Regression of Base Wage in Industry

VARIABLES	Log(Base Wage)
Education: <=4 years	-0.556*** (0.00314)
Education: >4 years & <=12 years	-0.363*** (0.00315)
Education: >12 years	0.0465*** (0.00315)
Tenure (years in same company)	0.00579*** (1.20e-05)
Situation (employer, employee, other)	-0.0159*** (0.000712)
Working in the molds region	0.0732*** (0.000761)
Constant	6.131*** (0.00380)
Observations	10,687,975
R-squared	0.166

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Regressing wage of workers in the manufacturing industry on location, and controlling for education, tenure, and employment situation, we find that wages are 7% higher inside the agglomerated region.

Table 48 - Regression of Base Wage in the Molds Industry

VARIABLES	
Education: <=4 years	-0.759*** (0.0307)
Education: >4 years & <=12 years	-0.585*** (0.0307)
Education: >12 years	-0.337*** (0.0306)
Tenure (years in same company)	0.00690*** (0.000158)
Situation (employer, employee, other)	0.00693 (0.00831)
Working in the molds region	0.350*** (0.00424)
Constant	6.294*** (0.0395)
Observations	100,578
R-squared	0.163

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

However, if we do the same analysis for the molds industry alone, we find a much stronger effect: 35% higher wages in the agglomerated region (33% if we remove tenure; 16% if we add year dummies and a gender dummy).

Appendix IV

Alternative Parent Quality Proxies in the Survival Analysis (collocation study)

This appendix presents the alternative specifications used in the collocation survival analysis, in an attempt to identify an adequate proxy for spinoff parent quality.

The spinoff parent quality proxies are related to the company's size, sales, sales per employee, sales quota, sales growth ratio, top sellers, and level of precision. The level of precision molds a company is able to apply in its products would be a good indicator of its quality. The industry's evolution lead to market segmentation with different levels of knowledge that can be revealed by the level of precision used. More qualified companies would be able to produced or use more precise molds. Therefore such high quality firms would hire better and more qualifies workers, with higher education levels and higher wages. The aim would then be to compare wage levels across molds and plastics companies in order to identify the top wage payers, controlling for firm size since larger companies tend to pay higher wages. "Best parents" would be the firms with top level wages. An alternative would be to regress average wages on the lower or middle hierarchical levels controlling for the log of the number of employees. Then one can obtain the residuals and compare them. Residuals could be used as independent variable. Alternatively, one could use a dummy variable for companies with a significantly positive residual.

In order to obtain a proxy for parent quality based on wage levels we used several approaches. We consider both the average base wage and the average complete wage (base wage + extra hours wage), and we computed those wages for three different groups of workers:

- Default: All workers (including supervisors and team leaders, intermediary managers, top managers, and others);
- Alternative 1: Workers in middle hierarchical levels - 4, 5, and 6 (highly-skilled professionals, skilled professionals, and semi-skilled professionals);
- Alternative 2: Workers in middle and low hierarchical levels - 4, 5, 6, 7, and 8 (highly-skilled professionals, skilled professionals, and semi-skilled professionals, non-skilled professionals, and apprentices).

The generic model for wage levels (for molds and plastics industries separately) is the following:

$$\log(Wage) = \propto + \beta \log(Size) + \varepsilon$$

Where:

Wage is defined in two different ways for each of the three different groups of workers mentioned above:

- Average Base wage;
- Average Complete wage (Base + Extra hours).

Size is measured by the number of employees in the year

$\boldsymbol{\varepsilon}$ are the residuals of the regression

We identified the variables for spinoff parents in the same year the spinoff was created or the prior year. The wage regression would give a measure of the wage level of the company, controlling for firm size because wage levels tend to vary according to firm size. The predicted residuals for each company would be a measure of the firm's level of precision, a good indicator of its quality level as a possible parent for a spinoff.

Tables Table 49 and Table 50 present the regression results for base and complete wages, respectively.

Table 49 - Regressions for Base wage†

VARIABLES	Molds			Plastics		
	Default	Alt 1	Alt 2	Default	Alt 1	Alt 2
Size *(log(pemp))*	-0.054** (0.023)	-0.153*** (0.024)	-0.113*** (0.022)	-0.090*** (0.016)	-0.149*** (0.015)	-0.127*** (0.014)
Constant	5.368*** (0.047)	5.905*** (0.052)	5.669*** (0.044)	5.452*** (0.036)	5.904*** (0.038)	5.685*** (0.033)
R-squared	0.004	0.043	0.023	0.021	0.089	0.057
Observations	1,191	934	1,136	1,468	993	1,299

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 50 - Regressions for Complete wage†

VARIABLES	Molds			Plastics		
	Default	Alt 1	Alt 2	Default	Alt 1	Alt 2
Size *(log(pemp))*	-0.054** (0.023)	-0.154*** (0.024)	-0.113*** (0.022)	-0.089*** (0.016)	-0.147*** (0.015)	-0.125*** (0.014)
Constant	5.375*** (0.047)	5.913*** (0.052)	5.676*** (0.045)	5.454*** (0.036)	5.904*** (0.038)	5.685*** (0.033)
R-squared	0.005	0.043	0.023	0.020	0.086	0.054
Observations	1,191	934	1,136	1,468	993	1,299

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 51 presents the variable definitions for both the variables used in the survival analysis and the different alternative proxies for spinoff parent quality.

Table 51 – Variable definitions

Variable	Definition
sis	Dummy for a spinoff in the same industry as the previous job of at least one founder
cis	Dummy for a spinoff in the other industry (molds or plastics) as the previous job of at least one founder
div	Dummy for new establishment created by companies in all other industries
Ljmp_e	Location quotient for molds and plastics, weighted by employment
Ljmolds_e	Location quotient for molds, weighted by employment
Ljplast_e	Location quotient for plastics, weighted by employment
pemp_f	Size of the entrant measured by the number of employees in the first year
parent	Size of spinoff's parent measured by the number of employees (proxy for parent quality)
sp	Sales of spinoff's parent at the time of the spinoff's creation (proxy for parent quality)
spe	Sales per employee of spinoff's parent at the time of the spinoff's creation (proxy for parent quality)
sqp	Sales quota of spinoff's parent at the time of the spinoff's creation (sales divided by total sales of all companies in the industry) (proxy for parent quality)
sgr	Sales growth rate of spinoff's parent at the time of the spinoff's creation (proxy for parent quality)
tp	Dummy for top 10 spinoff's parent at the time of the spinoff's creation (proxy for parent quality)
tbw	Top base wage dummy for spinoff's parent (proxy for parent quality)
tcw	Top complete wage (base wage + extra hours wage) dummy for spinoff's parent (proxy for parent quality)
bwr	Base wage residuals of spinoff's parent (proxy for parent quality)
bwr1	Base wage residuals 1 of spinoff's parent (proxy for parent quality)
bwr2	Base wage residuals 2 of spinoff's parent (proxy for parent quality)
bcwrd	Dummy for positive base wage residuals of spinoff's parent (proxy for parent quality)
bwr1d	Dummy for positive base wage residuals 1 of spinoff's parent (proxy for parent quality)
bwr2d	Dummy for positive base wage residuals 2 of spinoff's parent (proxy for parent quality)
cwr	Complete wage residuals of spinoff's parent (proxy for parent quality)

cwr1	Complete wage residuals 1 of spinoff's parent (proxy for parent quality)
cwr2	Complete wage residuals 2 of spinoff's parent (proxy for parent quality)
cwrd	Dummy for positive complete wage residuals of spinoff's parent (proxy for parent quality)
cwr1d	Dummy for positive complete wage residuals 1 of spinoff's parent (proxy for parent quality)
cwr2d	Dummy for positive complete wage residuals 2 of spinoff's parent (proxy for parent quality)

Results are very similar for all three hierarchical groups used and also for type of wage considered (Base or Complete). Contrary to general findings in literature, smaller firms in the molds and plastics industries in Portugal pay higher average wages. However this is not surprising since companies in these industries in Portugal tend to be small. The average size of our sample (1986-2009) in the molds industry is 10 workers and 26 workers for the plastics industry. This could also be explained by existence of a higher proportion of less skilled workers in larger firms, assuming a pyramidal hierarchical structure. However the size variable is significant across all models.

Below, in Tables Table 52 to Table 71 we present the results for the spinoff parent quality proxies proposed. In terms of precision-related spinoff parent quality proxies we present results using Cox Proportional Hazards models. We used three different types of proxies:

- Dummy for top 1/3 average wage companies in the molds and plastics industries for all hierarchical levels (*tbw*, *tcw*);
- Predicted residuals of the wage regressions (*bwr*, *bwr1*, *bwr2*, *cwr*, *cwr1*, *cwr2*);

- Dummy for positive predicted residuals in the wage regressions (*bwrd*, *bwr1d*, *bwr2d*, *cwrd*, *cwr1d*, *cwr2d*).

Table 52 - Estimates of the Survival Cox Proportional Hazards model with size of parent as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.914*** (0.027)	0.914*** (0.027)	0.887*** (0.037)	0.886*** (0.037)	0.967 (0.042)	0.971 (0.042)
Size of spinoff's parent *(parent)*	0.982 (0.045)	0.982 (0.045)	0.957 (0.068)	0.956 (0.068)	1.012 (0.059)	1.009 (0.058)
Same industry spinoffs *(sis)*	0.716** (0.114)	0.708** (0.113)	0.872 (0.211)	0.869 (0.210)	0.560*** (0.116)	0.567*** (0.117)
Cros-industry spinoffs *(cis)*	0.750 (0.191)	0.743 (0.189)	0.883 (0.285)	0.882 (0.286)	0.465** (0.173)	0.478** (0.177)
Diversifiers *(div)*	5.243*** (0.554)	5.248*** (0.554)	6.421*** (1.117)	6.402*** (1.113)	3.400*** (0.544)	3.995*** (0.543)
LQ Molds and Plastics *(Ljmp_e)*	0.984** (0.007)		0.985 (0.011)		0.971*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.994* (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.953*** (0.013)
Log Likelihood	-8,521.4	-8,522.8	-3,712.8	-3,713.0	-4,060.7	-4,060.5
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 53- Estimates of the Survival Cox Proportional Hazards model with sales of parent as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.913*** (0.027)	0.914*** (0.027)	0.885*** (0.037)	0.884*** (0.037)	0.968 (0.042)	0.971 (0.042)
Sales of spinoff's parent *(sp)*	1.000 (5.4e-10)	1.000 (5.4e-10)	1.000 (3.9e-08)	1.000 (3.9e-08)	1.000 (5.4e-10)	1.000 (5.4e-10)
Same industry spinoffs *(sis)*	0.676*** (0.052)	0.668*** (0.052)	0.817 (0.109)	0.811 (0.108)	0.579*** (0.059)	0.580*** (0.059)
Cros-industry spinoffs *(cis)*	0.704* (0.143)	0.696* (0.142)	0.808 (0.199)	0.804 (0.199)	0.483** (0.148)	0.490** (0.151)
Diversifiers *(div)*	5.248*** (0.555)	5.253*** (0.555)	6.427*** (1.118)	6.408*** (1.113)	3.400*** (0.544)	3.995*** (0.543)
LQ Molds and Plastics *(Ljmp_e)*	0.984** (0.007)		0.985 (0.011)		0.971*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.994* (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.953*** (0.013)
Log Likelihood	-8,521.3	-8,522.7	-3,712.3	-3,712.6	-4,060.5	-4,060.4
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 54 - Estimates of the Survival Cox Proportional Hazards model with sales per employee of parent as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.913*** (0.027)	0.914*** (0.027)	0.884*** (0.037)	0.883*** (0.037)	0.968 (0.042)	0.971 (0.042)
Sales per employee of spinoff's parent *(spe)*	1.000 (5.9e-07)	1.000 (5.8e-07)	1.000 (1.1e-06)	1.000 (1.1e-06)	1.000 (7.1e-07)	1.000 (7.2e-07)
Same industry spinoffs *(sis)*	0.681*** (0.056)	0.673*** (0.055)	0.764** (0.1664)	0.758** (0.100)	0.584*** (0.061)	0.586*** (0.062)
Cros-industry spinoffs *(cis)*	0.709* (0.145)	0.701* (0.144)	0.773 (0.190)	0.770 (0.190)	0.489** (0.151)	0.496** (0.153)
Diversifiers *(div)*	5.247*** (0.555)	5.252*** (0.555)	6.443*** (1.120)	6.424*** (1.116)	3.998*** (0.544)	3.993*** (0.543)
LQ Molds and Plastics *(Ljmp_e)*	0.984** (0.007)		0.985 (0.011)		0.971*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.994* (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.953*** (0.013)
Log Likelihood	-8,521.4	-8,522.9	-3,713.0	-3,713.2	-4,060.7	-4,060.5
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 55 - Estimates of the Survival Cox Proportional Hazards model with <u>sales growth rate of parent</u> as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.913*** (0.027)	0.915*** (0.027)	0.884*** (0.037)	0.884*** (0.037)	0.968 (0.042)	0.971 (0.042)
Sales growth rate of spinoff's parent *(sgr)*	1.000 (0.001)	1.001 (0.001)	1.001 (0.001)	1.001 (0.001)	0.976 (0.033)	0.976 (0.032)
Same industry spinoffs *(sis)*	0.677*** (0.052)	0.678*** (0.053)	0.758** (0.092)	0.758** (0.092)	0.589*** (0.060)	0.590*** (0.060)
Cros-industry spinoffs *(cis)*	0.701* (0.143)	0.700* (0.143)	0.773 (0.188)	0.757 (0.183)	0.530** (0.163)	0.540** (0.166)
Diversifiers *(div)*	5.248*** (0.555)	5.224*** (0.552)	6.448*** (1.121)	6.402*** (1.112)	3.999*** (0.544)	3.994*** (0.543)
LQ Molds and Plastics *(Ljmp_e)*	0.984** (0.007)		0.985 (0.011)		0.971*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.974** (0.010)		0.984 (0.015)		
LQ Plast *(Ljplast_e)*						0.952*** (0.013)
Log Likelihood	-8,521.4	-8,521.0	-3,712.5	-3,712.8	-4,059.5	-4,059.3
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 56 - Estimates of the Survival Cox Proportional Hazards model with <u>sales quota of parent</u> as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.913*** (0.027)	0.914*** (0.027)	0.885*** (0.037)	0.884*** (0.037)	0.968 (0.042)	0.972 (0.042)
Sales quota of spinoff's parent *(sqp)*	0.981 (0.041)	0.980 (0.041)	0.648 (0.350)	0.641 (0.348)	0.980 (0.041)	0.979 (0.042)
Same industry spinoffs *(sis)*	0.682*** (0.054)	0.674*** (0.053)	0.770** (0.093)	0.765** (0.092)	0.588*** (0.060)	0.589*** (0.061)
Cros-industry spinoffs *(cis)*	0.709* (0.144)	0.701* (0.143)	0.856 (0.229)	0.855 (0.230)	0.486** (0.149)	0.493** (0.151)
Diversifiers *(div)*	5.247*** (0.555)	5.253*** (0.555)	6.432*** (1.118)	6.414*** (1.114)	3.998*** (0.544)	3.993*** (0.543)
LQ Molds and Plastics *(Ljmp_e)*	0.984** (0.007)		0.985 (0.011)		0.971*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.994* (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.953*** (0.013)
Log Likelihood	-8,521.3	-8,522.7	-3,712.5	-3,712.8	-4,060.5	-4,060.4
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 57 - Estimates of the Survival Cox Proportional Hazards model with <u>top 10 seller parents</u> as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.915*** (0.027)	0.916*** (0.027)	0.886*** (0.037)	0.885*** (0.037)	0.973 (0.043)	0.977** (0.042)
Top 10 spinoff's parent *(tp)*	0.581 (0.240)	0.581 (0.241)	9.5e-18 (2.4e-09)	2.3e-20 (.)	0.631 (0.265)	0.609 (0.255)
Same industry spinoffs *(sis)*	0.689*** (0.054)	0.681*** (0.053)	0.768** (0.093)	0.763** (0.092)	0.595*** (0.061)	0.598*** (0.061)
Cros-industry spinoffs *(cis)*	0.720 (0.147)	0.713* (0.145)	0.826 (0.201)	0.827 (0.202)	0.484** (0.149)	0.491** (0.151)
Diversifiers *(div)*	5.237*** (0.554)	5.242*** (0.554)	6.432*** (1.118)	6.416*** (1.115)	3.982*** (0.542)	3.974*** (0.541)
LQ Molds and Plastics *(Ljmp_e)*	0.984** (0.007)		0.985 (0.011)		0.971*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.994* (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.953*** (0.013)
Log Likelihood	-8,520.4	-8,521.8	-3,711.3	-3,711.6	-4,060.0	-4,059.7
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 58 - Estimates of the Survival Cox Proportional Hazards model with <u>top base wage dummy</u> as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.914*** (0.027)	0.914*** (0.027)	0.884*** (0.037)	0.883*** (0.037)	0.967 (0.042)	0.970 (0.042)
Top Base wage of spinoff parent *(tbw)*	0.513 (0.514)	0.511 (0.513)	8.1e-14 (4.2e-07)	8.2e-14 (4.3e-07)	0.673 (0.676)	0.660 (0.662)
Same industry spinoffs *(sis)*	0.678*** (0.053)	0.671*** (0.052)	0.762** (0.092)	0.757** (0.091)	0.583*** (0.059)	0.585*** (0.059)
Cros-industry spinoffs *(cis)*	0.685* (0.140)	0.678* (0.138)	0.748 (0.182)	0.745 (0.182)	0.486** (0.149)	0.493** (0.151)
Diversifiers *(div)*	5.217*** (0.550)	5.226*** (0.550)	6.424*** (1.116)	6.406*** (1.112)	4.006*** (0.546)	3.995*** (0.544)
LQ Molds and Plastics *(Ljmp_e)*	0.984** (0.007)		0.985 (0.011)		0.971*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.994* (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.953*** (0.013)
Log Likelihood	-8,521.3	-8,522.7	-3,712.2	-3,712.5	-4,060.6	-4,060.5
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 59 - Estimates of the Survival Cox Proportional Hazards model with top complete wage dummy as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.914*** (0.027)	0.914*** (0.027)	0.884*** (0.037)	0.883*** (0.037)	0.967 (0.042)	0.970 (0.042)
Top Complete wage of spinoff parent *(tcw)*	0.513 (0.514)	0.511 (0.513)	8.1e-14 (4.2e-07)	8.2e-14 (4.3e-07)	0.673 (0.676)	0.660 (0.662)
Same industry spinoffs *(sis)*	0.678*** (0.053)	0.671*** (0.052)	0.762** (0.092)	0.757** (0.091)	0.583*** (0.059)	0.585*** (0.059)
Cros-industry spinoffs *(cis)*	0.685* (0.140)	0.678* (0.138)	0.748 (0.182)	0.745 (0.182)	0.486** (0.149)	0.493** (0.151)
Diversifiers *(div)*	5.217*** (0.550)	5.226*** (0.550)	6.424*** (1.116)	6.406*** (1.112)	4.006*** (0.546)	3.995*** (0.544)
LQ Molds and Plastics *(Ljmp_e)*	0.984** (0.007)		0.985 (0.011)		0.971*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.994* (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.953*** (0.013)
Log Likelihood	-8,521.3	-8,522.7	-3,712.2	-3,712.5	-4,060.5	-4,060.5
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 60 - Estimates of the Survival Cox Proportional Hazards model with base wage residuals as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.914*** (0.027)	0.914*** (0.027)	0.884*** (0.037)	0.883*** (0.037)	0.967 (0.042)	0.970 (0.042)
Base wage residuals of spinoff's parent *(bwr)*	0.270 (0.365)	0.270 (0.364)	2.0e-08 (0.063)	3.7e-08 (0.068)	0.326 (0.481)	0.307 (0.454)
Same industry spinoffs *(sis)*	0.680*** (0.053)	0.672*** (0.053)	0.762** (0.092)	0.757** (0.091)	0.586*** (0.059)	0.587*** (0.059)
Cros-industry spinoffs *(cis)*	0.690* (0.141)	0.684* (0.139)	0.748 (0.182)	0.745 (0.182)	0.486** (0.149)	0.493** (0.151)
Diversifiers *(div)*	5.217*** (0.550)	5.226*** (0.550)	6.424*** (1.116)	6.406*** (1.112)	4.008*** (0.546)	3.996*** (0.545)
LQ Molds and Plastics *(Ljmp_e)*	0.984** (0.007)		0.985 (0.011)		0.971*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.994* (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.953*** (0.013)
Log Likelihood	-8,520.8	-8,522.1	-3,712.2	-3,712.5	-4,060.3	-4,060.1
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 61 - Estimates of the Survival Cox Proportional Hazards model with complete wage residuals as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.914*** (0.027)	0.915*** (0.027)	0.884*** (0.037)	0.883*** (0.037)	0.967 (0.042)	0.970 (0.042)
Comp. wage residuals spinoff's parent *(cwr)*	0.273 (0.363)	0.273 (0.362)	1.1e-08 (0.055)	2.0e-08 (0.060)	0.328 (0.476)	0.308 (0.449)
Same industry spinoffs *(sis)*	0.680*** (0.053)	0.672*** (0.052)	0.762** (0.092)	0.757** (0.091)	0.586*** (0.059)	0.588*** (0.059)
Cros-industry spinoffs *(cis)*	0.690* (0.141)	0.684* (0.139)	0.748 (0.182)	0.745 (0.182)	0.586** (0.149)	0.493** (0.151)
Diversifiers *(div)*	5.217*** (0.550)	5.226*** (0.550)	6.424*** (1.116)	6.406*** (1.112)	4.008*** (0.546)	3.996*** (0.544)
LQ Molds and Plastics *(Ljmp_e)*	0.984** (0.007)		0.985 (0.011)		0.971*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.994* (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.953*** (0.013)
Log Likelihood	-8,520.8	-8,522.1	-3,712.2	-3,712.5	-4,060.2	-4,060.1
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 62 - Estimates of the Survival Cox Proportional Hazards model with base wage 1 residuals as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.914*** (0.027)	0.915*** (0.027)	0.884*** (0.037)	0.883*** (0.037)	0.967 (0.042)	0.970 (0.042)
Base wage residuals1 spinoff's parent *(bwr1)*	3.5e-06 (0.000)	2.4e-06 (0.000)	1.1e-08 (0.035)	1.1e-08 (0.035)	0.000 (0.001)	0.000 (0.001)
Same industry spinoffs *(sis)*	0.678*** (0.053)	0.671*** (0.052)	0.762** (0.092)	0.757** (0.091)	0.584*** (0.059)	0.586*** (0.059)
Cros-industry spinoffs *(cis)*	0.692* (0.141)	0.685* (0.139)	0.748 (0.182)	0.745 (0.182)	0.486** (0.149)	0.493** (0.151)
Diversifiers *(div)*	5.218*** (0.550)	5.227*** (0.550)	6.424*** (1.116)	6.406*** (1.112)	4.011*** (0.547)	3.999*** (0.545)
LQ Molds and Plastics *(Ljmp_e)*	0.985** (0.007)		0.985 (0.011)		0.972*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.995 (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.954*** (0.013)
Log Likelihood	-8,519.6	-8,521.0	-3,712.2	-3,712.5	-4,059.3	-4,059.1
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 63 - Estimates of the Survival Cox Proportional Hazards model with complete wage 1 residuals as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.914*** (0.027)	0.915*** (0.027)	0.884*** (0.037)	0.883*** (0.037)	0.967 (0.042)	0.970 (0.042)
Comp. wage residuals1 spinoff's parent *(cwr1)*	0.000 (0.000)	9.2e-06 (0.000)	1.0e-08 (0.033)	1.0e-08 (0.033)	0.000 (0.002)	0.000 (0.002)
Same industry spinoffs *(sis)*	0.678*** (0.053)	0.671*** (0.052)	0.762** (0.092)	0.757** (0.091)	0.584*** (0.059)	0.586*** (0.059)
Cros-industry spinoffs *(cis)*	0.692* (0.141)	0.685* (0.139)	0.748 (0.182)	0.745 (0.182)	0.486** (0.149)	0.493** (0.151)
Diversifiers *(div)*	5.218*** (0.550)	5.227*** (0.550)	6.424*** (1.116)	6.406*** (1.112)	4.011*** (0.547)	4.000*** (0.545)
LQ Molds and Plastics *(Ljmp_e)*	0.985** (0.007)		0.985 (0.011)		0.972*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.995 (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.954*** (0.013)
Log Likelihood	-8,519.6	-8,521.0	-3,712.2	-3,712.5	-4,059.3	-4,059.1
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 64- Estimates of the Survival Cox Proportional Hazards model with base wage 2 residuals as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.914*** (0.027)	0.915*** (0.027)	0.884*** (0.037)	0.884*** (0.037)	0.967 (0.042)	0.970 (0.042)
Base wage residuals2 spinoff's parent *(bwr2)*	0.112 (0.252)	0.113 (0.252)	1.6e-09 (0.009)	3.0e-09 (0.010)	0.126 (0.311)	0.114 (0.281)
Same industry spinoffs *(sis)*	0.680*** (0.053)	0.672*** (0.052)	0.762** (0.092)	0.757** (0.091)	0.586*** (0.059)	0.588*** (0.059)
Cros-industry spinoffs *(cis)*	0.691* (0.141)	0.684* (0.139)	0.748 (0.182)	0.745 (0.182)	0.486** (0.149)	0.493** (0.151)
Diversifiers *(div)*	5.217*** (0.550)	5.226*** (0.550)	6.424*** (1.116)	6.406*** (1.112)	4.009*** (0.546)	3.997*** (0.545)
LQ Molds and Plastics *(Ljmp_e)*	0.984** (0.007)		0.985 (0.011)		0.971*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.995* (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.953*** (0.013)
Log Likelihood	-8,520.5	-8,521.9	-3,712.2	-3,712.5	-4,060.1	-4,059.9
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 65 - Estimates of the Survival Cox Proportional Hazards model with complete wage 2 residuals as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.914*** (0.027)	0.915*** (0.027)	0.884*** (0.037)	0.883*** (0.037)	0.967 (0.042)	0.970 (0.042)
Comp. wage residuals2 spinoff's parent *(cwr2)*	0.124 (0.263)	0.124 (0.263)	2.8e-09 (0.010)	2.9e-09 (0.010)	0.141 (0.329)	0.128 (0.298)
Same industry spinoffs *(sis)*	0.680*** (0.053)	0.672*** (0.052)	0.762** (0.092)	0.757** (0.091)	0.586*** (0.059)	0.588*** (0.059)
Cros-industry spinoffs *(cis)*	0.691* (0.141)	0.684* (0.139)	0.748 (0.182)	0.745 (0.182)	0.586** (0.149)	0.493** (0.151)
Diversifiers *(div)*	5.217*** (0.550)	5.226*** (0.550)	6.424*** (1.116)	6.406*** (1.112)	4.009*** (0.546)	3.997*** (0.545)
LQ Molds and Plastics *(Ljmp_e)*	0.984** (0.007)		0.985 (0.011)		0.971*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.995* (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.953*** (0.013)
Log Likelihood	-8,520.5	-8,521.9	-3,712.2	-3,712.5	-4,060.1	-4,059.9
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 66 - Estimates of the Survival Cox Proportional Hazards model with base wage residuals dummy as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.914*** (0.027)	0.914*** (0.027)	0.884*** (0.037)	0.883*** (0.037)	0.967 (0.042)	0.970 (0.042)
Base wage residuals of spinoff's parent *(bwrd)*	0.704 (0.500)	0.707 (0.502)	8.1e-14 (4.2e-07)	8.2e-14 (4.3e-07)	0.830 (0.592)	0.790 (0.563)
Same industry spinoffs *(sis)*	0.678*** (0.053)	0.670*** (0.052)	0.762** (0.092)	0.757** (0.091)	0.583*** (0.059)	0.585*** (0.059)
Cros-industry spinoffs *(cis)*	0.682* (0.139)	0.675* (0.138)	0.748 (0.182)	0.745 (0.182)	0.486** (0.149)	0.493** (0.151)
Diversifiers *(div)*	5.217*** (0.550)	5.226*** (0.550)	6.424*** (1.116)	6.406*** (1.112)	4.006*** (0.546)	3.995*** (0.544)
LQ Molds and Plastics *(Ljmp_e)*	0.984** (0.007)		0.985 (0.011)		0.971*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.994* (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.953*** (0.013)
Log Likelihood	-8,521.5	-8,522.9	-3,712.2	-3,712.5	-4,060.6	-4,060.5
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 67 - Estimates of the Survival Cox Proportional Hazards model with complete wage residuals dummy as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.914*** (0.027)	0.914*** (0.027)	0.884*** (0.037)	0.883*** (0.037)	0.967 (0.042)	0.970 (0.042)
Comp. wage residuals spinoff's parent *(cwrd)*	0.704 (0.500)	0.707 (0.502)	8.1e-14 (4.2e-07)	8.2e-14 (4.3e-07)	0.830 (0.592)	0.790 (0.563)
Same industry spinoffs *(sis)*	0.678*** (0.053)	0.670*** (0.052)	0.762** (0.092)	0.757** (0.091)	0.583*** (0.059)	0.585*** (0.059)
Cros-industry spinoffs *(cis)*	0.682* (0.139)	0.675* (0.138)	0.748 (0.182)	0.745 (0.182)	0.486** (0.149)	0.493** (0.151)
Diversifiers *(div)*	5.217*** (0.550)	5.226*** (0.550)	6.424*** (1.116)	6.406*** (1.112)	4.006*** (0.546)	3.995*** (0.544)
LQ Molds and Plastics *(Ljmp_e)*	0.984** (0.007)		0.985 (0.011)		0.971*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.994* (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.953*** (0.013)
Log Likelihood	-8,521.5	-8,522.9	-3,712.2	-3,712.5	-4,060.6	-4,060.5
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 68 - Estimates of the Survival Cox Proportional Hazards model with base wage 1 residuals dummy as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.914*** (0.027)	0.915*** (0.027)	0.884*** (0.037)	0.883*** (0.037)	0.967 (0.042)	0.970 (0.042)
Base wage residuals1 spinoff's parent*(bwr1d)*	5.7e-16 (1.8e-08)	2.3e-13 (3.5e-07)	8.1e-14 (4.2e-07)	8.2e-14 (4.3e-07)	4.9e-15 (6.2e-08)	2.8e-20 (.)
Same industry spinoffs *(sis)*	0.680*** (0.053)	0.672*** (0.052)	0.762** (0.092)	0.757** (0.091)	0.586*** (0.059)	0.588*** (0.059)
Cros-industry spinoffs *(cis)*	0.692* (0.141)	0.685* (0.139)	0.748 (0.182)	0.745 (0.182)	0.486** (0.149)	0.493** (0.151)
Diversifiers *(div)*	5.218*** (0.550)	5.227*** (0.550)	6.424*** (1.116)	6.406*** (1.112)	4.011*** (0.547)	3.998*** (0.545)
LQ Molds and Plastics *(Ljmp_e)*	0.985** (0.007)		0.985 (0.011)		0.971*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.995 (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.954*** (0.013)
Log Likelihood	-8,519.8	-8,521.4	-3,712.2	-3,712.5	-4,059.4	-4,059.2
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 69 - Estimates of the Survival Cox Proportional Hazards model with complete wage 1 residuals dummy as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.914*** (0.027)	0.915*** (0.027)	0.884*** (0.037)	0.883*** (0.037)	0.967 (0.042)	0.970 (0.042)
Comp. wage residuals1 spinoff's parent*(cwr1d)*	5.7e-16 (1.8e-08)	2.3e-13 (0.000)	8.1e-14 (4.2e-07)	8.1e-14 (4.3e-07)	4.9e-15 (6.2e-08)	2.8e-20 (.)
Same industry spinoffs *(sis)*	0.680*** (0.053)	0.672*** (0.052)	0.762** (0.092)	0.757** (0.091)	0.586*** (0.059)	0.588*** (0.059)
Cros-industry spinoffs *(cis)*	0.692* (0.141)	0.685* (0.139)	0.748 (0.182)	0.745 (0.182)	0.486** (0.149)	0.493** (0.151)
Diversifiers *(div)*	5.218*** (0.550)	5.227*** (0.550)	6.424*** (1.116)	6.406*** (1.112)	4.011*** (0.547)	3.998*** (0.545)
LQ Molds and Plastics *(Ljmp_e)*	0.985** (0.007)		0.985 (0.011)		0.971*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.995 (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.954*** (0.013)
Log Likelihood	-8,519.8	-8,521.1	-3,712.2	-3,712.5	-4,059.4	-4,059.2
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 70 - Estimates of the Survival Cox Proportional Hazards model with base wage 2 residuals dummy as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.914*** (0.027)	0.914*** (0.027)	0.884*** (0.037)	0.883*** (0.037)	0.967 (0.042)	0.970 (0.042)
Base wage residuals2 spinoff's parent*(bwr2d)*	0.704 (0.500)	0.707 (0.502)	8.1e-14 (4.2e-07)	8.2e-14 (4.3e-07)	0.830 (0.592)	0.790 (0.563)
Same industry spinoffs *(sis)*	0.678*** (0.053)	0.670*** (0.052)	0.762** (0.092)	0.757** (0.091)	0.583*** (0.059)	0.585*** (0.059)
Cros-industry spinoffs *(cis)*	0.682* (0.139)	0.675* (0.138)	0.748 (0.182)	0.745 (0.182)	0.486** (0.149)	0.493** (0.151)
Diversifiers *(div)*	5.217*** (0.550)	5.226*** (0.550)	6.424*** (1.116)	6.406*** (1.112)	4.006*** (0.546)	3.995*** (0.544)
LQ Molds and Plastics *(Ljmp_e)*	0.984** (0.007)		0.985 (0.011)		0.971*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.994* (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.953*** (0.013)
Log Likelihood	-8,521.5	-8,522.9	-3,712.2	-3,712.5	-4,060.6	-4,060.5
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 71 - Estimates of the Survival Cox Proportional Hazards model with complete wage 2 residuals dummy as proxy for parent quality – hazard ratio†

VARIABLES	(1) Molds and Plastics		(2) Plastics entrants		(3) Molds entrants	
Size at entry *(log(pemp_f))*	0.914*** (0.027)	0.914*** (0.027)	0.884*** (0.037)	0.883*** (0.037)	0.967 (0.042)	0.970 (0.042)
Comp. wage residuals2 spinoff's parent*(cwr2d)*	0.704 (0.500)	0.707 (0.502)	8.1e-14 (4.2e-07)	8.2e-14 (4.3e-07)	0.830 (0.592)	0.790 (0.563)
Same industry spinoffs *(sis)*	0.678*** (0.053)	0.670*** (0.052)	0.762** (0.092)	0.757** (0.091)	0.583*** (0.059)	0.585*** (0.059)
Cros-industry spinoffs *(cis)*	0.682* (0.139)	0.675* (0.138)	0.748 (0.182)	0.745 (0.182)	0.486** (0.149)	0.493** (0.151)
Diversifiers *(div)*	5.217*** (0.550)	5.226*** (0.550)	6.424*** (1.116)	6.406*** (1.112)	4.006*** (0.546)	3.995*** (0.544)
LQ Molds and Plastics *(Ljmp_e)*	0.984** (0.007)		0.985 (0.011)		0.971*** (0.008)	
LQ Molds *(Ljmolds_e)*		0.994* (0.003)		0.993 (0.006)		
LQ Plast *(Ljplast_e)*						0.953*** (0.013)
Log Likelihood	-8,521.5	-8,522.9	-3,712.2	-3,712.5	-4,060.6	-4,060.5
Observations	2,278	2,278	1,168	1,168	1,146	1,146

† Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Again, none of the spinoff's parent quality proxies is significant. However hazard ratios seem more reasonable and log likelihood reaches higher values.

Moreover, results with the new models are consistent with prior models and even between all wage quality proxies. This shows that the relevant results and the conclusions of our analysis are robust and that it is not likely that spinoff parent quality is playing a very important role in firm survival.

The model using base wage residuals for workers in the middle hierarchical level (*bwr1*) as proxy for spinoff's parent quality (Table 68), presents the highest log-likelihood. Other models with high log-likelihood use *cwr1, brw2, crw2, bwr, cwr*, or even top parent (*tp* – based on sales).