EXTERNAL EFFECTS OF INNOVATION ON FIRM SURVIVAL: EVIDENCE FROM COMPUTER AND ELECTRONIC PRODUCT MANUFACTURING, AND HEALTHCARE

by

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ABSTRACT

ALEXANDRA A. TSVETKOVA. External effects of innovation on firm survival: evidence from computer and electronic product manufacturing and healthcare. (Under the direction of DR. JEAN-CLAUDE THILL)

This dissertation investigates the effects of innovation in the U.S. metropolitan statistical areas (MSA) on survival chances of standalone non-patenting firms. Extensive literature argues that knowledge spillovers are likely to be present in agglomerated regions with greater accumulated stock of knowledge. According to this view, firms exposed to knowledge spillovers should become more innovative and productive. Empirical research consistently finds a negative relationship between innovation and productivity, on the one hand, and the probability of exit, on the other. An alternative argument, going back to Schumpeterian 'creative destruction', contends that greater innovation leads to increased competition and forces less innovative firms to leave the market. The dissertation tests these contesting hypotheses by estimating the hazard rates faced by firms in two high-technology sectors, namely computer and electronic product manufacturing and healthcare services.

In the two sectors, all firms established within the continental U.S. MSAs in 1991 are identified and traceduntil a firm exits or year 2008, whichever happens first. Firms that are non-independent, have at least one patent, or exit via merger or acqusition are not included in the analysis. Two variables approximate the level of innovation in a metropolitan area, the population-adjusted number of patents, and the population-adjusted number of patentsin technological classes related to the sectors of interest.

Results of the non-parametric analysis suggest that in more innovative MSAs, computer and electronic product manufacturing firms tend to exit sooner, while healthcare firms enjoy greater likelihood of survival. In most dense metropolitan areas, however, relationship between innovation and firm survival becomes positive for manufacturing firms, and switches from positive to negative after about 12 years of operation for healthcare firms.

After controlling for a number of regional and firm-level characteristics in the semi-parametric and parametric analyses, this study implies that innovation in a MSA is either not significant, or forces non-patenting firms out of business in high-technology manufacturing, while it is not a significant predictor of firm longevity in healthcare. These results stay the same in the separate analyses by density groups or NAICS4 industries. In general, the dissertation presents support for the Schumpeterian hypothesis, while the knowledge spillover view is not supported.

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CHAPTER 1: INTRODUCTION

1.1. Public policy and firm survival

Policy process literature argues that natural limits of power[1]require local governments to concentrate on developmental policies, “those local programs which enhance the economic position of a community in its competition with others” (Peterson, 1981, p. 41). Economic development is also high on the state policy-makers’ agenda; it has been an important part of state planning for more than thirty years (Peters & Fisher, 2004). By implementing various economic growth programs, policy-makers attempt to increase employment and boost economic activity in their jurisdictions. In case of success, such programs are able to attract or generate money and capital, to amplify the visibility and bargaining power of a locality or a state, and to improve politicians’ chances of reelection.

In most general terms, economic development policies at both local and state levels involve the stimulation of economic activity through (1) increasing number of business establishments in a region, and (2) promoting better performance[2] of incumbent firms. The total number of companies in a region can grow as a result of new firm formation

[1] Limits of power refer to the fact that cities, states, and national governments are different in their ability to implement various policies. Local governments, for instance, cannot declare war, erect tariff barriers, or prevent people from moving to their jurisdictions.

[2] Definition of a ‘better’ performance can be different in every region depending on what economic outcomes are the most desirable/needed. The most common examples include increased employment, sales, high-tech output, and R&D but may also include export expansion and increased tax base.

locally, or attraction of business from outside the region. Numerous policies try to stimulate new firm entry, especially in strategic and high technology industries. These programs include seed grant funding, business incubation parks, and others.

Firm formation is extremely important for regional prosperity. Empirical literature shows that new firms disproportionally contribute to job creation (Acs & Armington, 2004), income and employment growth, and technological progress(Camp, 2005). Unfortunately, factors that promote firm formation may simultaneously facilitate firm exit, at least in selected industries (Sorenson & Audia, 2000; Stuart & Sorenson, 2003). The negative effects of some policies on business survival contribute to high overall exit rates among business start-ups. On average, about half the new companies exit within the first five years of operation, regardless of their industrial sector or region (Audretsch & Mahmood, 1995; Dunne, Roberts, & Samuelson, 1989; Johnson, 2005; Mata, Portugal, & Guimaraes, 1995).

Firm exit is a driving force of industry evolution, which ensures overall efficiency of an economy, because the most efficient companies are more likely to stay in business. This fact, however, is of limited relevance to regional policy-making for the following reason. Competition becomes a more global phenomenon and local companies mostly compete against outside businesses. If local firms have to exit, it weakens their regions' tax base and reduces employment and output, while considerations of national or world economic efficiency may be of little importance in such circumstances. Firm survival, then, becomes a more appropriate measure of entrepreneurship in a region for the purposes of regional economic policies (Renski, 2006). The importance of knowledge on business longevity determinants is reinforced during the times of economic hardships, when even efficient firms are more likely to exit.

Perhaps for this reason, firm survival has received much attention among scholars in the last decades. Recent research on business survival has produced somewhat satisfactory understanding of how companies' internal characteristics and activities, the nature of their industry and markets affect chances of business survival. Our knowledge of the determinants of firm longevity stemming from the regional setting of the firm is rather limited (Brixy & Grotz, 2007; Manjon-Antolın & Arauzo-Carod, 2008). This is rather surprising because the regional environment is a critical area that policy-makers can influence, while they are practically powerless to directly shape business characteristics and the set of routines that companies follow.

In the most complete account on the effects of regional external economies on business survival to date, Renski (2011), carefully examines for five manufacturing and three services industries the impacts that localization, urbanization, and diversity have on survival likelihood as proposed by agglomeration theory. Positive effects of these three determinants on firm survival found in several industries have been explained by knowledge spillovers, among other factors.

To continue on the importance of new knowledge, recent growth theories postulate that innovation, and the associated knowledge and technological spillovers, determine economic growth in general and firm performance in particular. Knowledge is the main strategic resource a firm has at its disposal in the modern economy (Spender, 1996). A business can either generate innovative knowledge via R&D and other practices, or learn from other firms, or both. Learning from others falls under the definition of knowledge spillovers, which increase productivity and may lead to increasing returns to scale. The empirical literature suggests that small firms are more likely to rely on knowledge spillovers, because their own ability to invest resources in knowledge production is usually limited (Audretsch & Vivarelli, 1996). This observation is relevant for this research because it concentrates on new firms, the majority of which are small[3].In general, newly established firms tend to be small (Birch, 1987); this means that, if innovativeness in a region has effect on small firms' performance, it is likely to influence the start-up performance as well.

1.2. Dissertation's contribution

Despite the widely held view echoed by agglomeration theory that external knowledge and innovation are important for firm performance in general, and business survival in particular, empirical evidence on this issue is lacking. No study has so far provided empirical insights into the relationship between regional innovative environment and firm longevity, although the perspective of regional innovative systems seems to have gained popularity in the last few years (Rodriguez-Pose & Crescenzi, 2008; Uyarra, 2010).

External effects of innovation on firm survival are not straightforward. The agglomeration literature suggests that accumulated stock of knowledge should translate into profitable market applications, and contribute to business productivity and innovation. If this is true, empirical analysis would reveal positive effects of innovative environments. This perspective, however, does not take into account increased

[3] The majority of the cases in this research are small firms. In computer and electronic product manufacturing, 34% of all establishments in the sample have one or two employees, 65% have five or less, and 85% have 10 or less employees. Among healthcare service firms in the sample, 27% of firms have one or two employees, 53% have five or less employees, and 72% have 10 or less employees

competition in the regions with more innovative economies, the so-called 'creative destruction' regime. According to this approach, the net effect of innovation in a region on firm survival within the same region is expected to be negative.

Using duration analysis, this dissertation research empirically tests the impact of innovative environments on survival likelihood of individual non-patenting firms in two industrial sectors, computer and electronic product manufacturing and healthcare services. These sectors represent the high technology end of the U.S. economy, which is crucial for economic competitiveness of the country.

1.3. Organization of the dissertation

The dissertation proceeds as follows. It starts in Chapter 2 with a brief overview of recent growth theories and agglomeration theory, which delineate the role that innovation and space play in the economic performance of firms and regions. In the discussion of agglomeration theory, specific emphasis is placed on the hypothesized positive effect of innovation on business longevity. The dissertation then presents the Schumpeterian perspective on the relationship between innovation and firm survival. Building on the previous chapter, Chapter 3 succinctly presents two alternative mechanisms of the relationship that follow from the theoretical discussion. Combination of these two mechanisms leads to the hypotheses tested in this research. The chapter concludes by an overview of the evidence on firm survival. Chapter 4 introduces the econometric problem of survival analysis. Chapter 5 explains how the dataset was assembled. It describes the sample selection process, the measurements of the variables, and data sources. The next two chapters are devoted to non-parametric, semi-parametric, and parametric estimations and their results. Chapter 8 interprets the results from the standpoint of public policy.

Chapter 9 draws attention to the limitations of this study. A brief conclusion is given in Chapter 10.

CHAPTER 2: EXTERNAL EFFECTS OF INNOVATION

Nowadays, technological change is broadly acknowledged as a primary driver of sustained growth. Extensive theoretical literature explains how aggregate growth happens as a result of knowledge accumulation and innovative efforts by firms. Besides benefiting an innovative firm, new technologies and innovation in general are also believed to enhance the performance of firms not engaged in research and development. So-called local knowledge spillovers (LKS) that are likely to happen in agglomerated geographical areas, may lead to increased productivity, and increasing returns to scale. A parallel perspective relates innovation to entrepreneurship and suggests that innovation is related to 'creative destruction', a process of market transformation characterized by the replacement of incumbent firms and existing technologies by the new ones[4].

This chapter briefly overviews theories that relate innovation and economic growth showing increasing acknowledgement of the role played by individual innovative firms. It then proceeds to the external effects of innovation, paying specific attention to agglomeration economies, knowledge spillovers, and concerns voiced in the literature regarding our possible over-fascination with LKS, which in reality may be non-existent. Finally, it presents the Schumpeterian view of entrepreneurship and innovation together

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[4] Marx and Engels coined the term 'creative destruction' in *The Communist Manifesto* first published in 1848. Here, I use the Schumpeterian perspective on creative destruction (Schumpeter derived his notion of 'creative destruction' from the Marxist definition), which has a different meaning from the one originally proposed.

with recent alternative perspectives on the role of entrepreneurs in the innovation process in general and individual firm performance in particular.

2.1. Focus on innovation: neoclassical, new growth theory and endogenous growth theory

The economic models of growth seek to explain the process of economic expansion by modeling a representative firm. Although the assumption of firm homogeneity is unrealistic, the theories provide useful conceptualization of the important inputs that are crucial for firm, and, therefore, for aggregate economic, growth. Generally, the field can be characterized by the increasing appreciation of technology, knowledge and skills as the key drivers of the increase in productivity. Over time, modeling of the knowledge accumulation process went from exogenous to endogenous. This means that, despite the representative firm assumption that treats all firms as having identical production functions, the importance of the firm as an agent of change and the cause of aggregate economic growth has been explicitly acknowledged.

In the neoclassical Solow-Swan (Solow, 1956) model, economic growth is the result of savings accumulation, population expansion, and of technological progress. The latter factor is the most crucial because savings and population growth are characterized by diminishing returns to scale; eventually their contribution to economic development diminishes (Koo, 2005b). The Solow-Swan model assumes a perfectly competitive environment in which information (and technology) is a public good. The model adopts the exogenous nature of technological advance. Exogenous growth is introduced to remedy the theoretical impossibility of sustainable development due to the decreasing returns to capital (Martin & Sunley, 1998). In fact, all growth parameters are given as 'manna from heaven' (Izushi, 2008) to accommodate the empirically observed process of economic expansion in many countries over decades, and even centuries. In this framework, firms cannot influence the aggregate level of growth and do not have an incentive to do so. In particular, there are no incentives to innovate as information is available to everyone and firms producing new knowledge have no chances to derive monopoly profits from the results of their innovative efforts.

The new growth theory (Lucas, 1988; Romer, 1986) takes a step toward making firms (and aggregate growth) sensitive to market incentives. In this view, investment in capital stock and human capital accumulation is the main source of expansion (Martin & Sunley, 1998). Economic growth is explained by workers' learning-by-doing and by other ways of accumulating economically useful knowledge. Workers accumulate and share knowledge via spillovers; thus, the Marshallian argument on the importance of proximity is validated. The model still assumes perfect competition and treats knowledge and technology as a public good (Koo, 2005b). In the new growth theory, investments in physical and human capital are crucial for the growth, while technological advance happens automatically, not as the result of purposeful activities of economic actors (Martin & Sunley, 1998).

It is obvious that technological change in many cases is the result of conscious efforts by economic agents (Parente, 2001). In order to model firms' decisions to develop new technologies and deliberately pursue the accumulation of economically valuable knowledge, the endogenous growth theory (Romer, 1990) abandoned the assumption of perfect competition and non-excludable technology. In this framework, technology is a non-rival input; it is partially excludable, while technological input drives economic growth (Koo, 2005b). Such formulation of the production function allows increasing returns to scale. Because of excludability, R&D becomes the source of competitive advantage and firms are able to enjoy above normal profits as a result of their successful innovative activities. This translates into incentives to invest in research and foster technological progress; technological change becomes endogenous (Acs & Varga, 2002).

2.2. Focus on externalities: space, agglomerations, and spillovers

In the past two decades, geography has come into prominence as an important consideration in the study of knowledge accumulation, firm performance, and economic growth and development. Nowadays, space is the meeting ground for many disciplines concerned with these issues. Some authors even propose a vision of spatially integrated social science (Goodchild, Anselin, Appelbaum, & Harthorn, 2000). Knowledge, which tends to accumulate in spatially bounded areas (at least in the short-run), is arguably the main reason why location became an essential part of many empirical pieces of research on economic growth. Moreover, public good-like properties of knowledge, which allow more than one firm to enjoy its benefits, further contribute to the importance of location in the areas where economically useful knowledge is available.

2.2.1. Why is space important?

Over the last decades, an extensive body of literature has emphasized the importance of geography as an important determinant of industrial performance. Regions influence innovation, firm entry, learning, and economic growth (Scott, 2006). The importance of space for regional economic performance is not a new idea. Back in the 1920s, Marshall articulated the advantages of locational externalities associated with geographically dense networks of suppliers and customers, the character of local labor pool, and pure spillovers from one business to another, which allow firms to become more innovative by employing (modified) designs and concepts of their peers (Ibrahim, Fallah, & Reilly, 2009).

Much in line with Marshall's argument on co-location, the new economic geography, or NEG (Krugman, 1991), explains the emergence and persistence of large urban agglomerations that rely on reduced transportation costs, increasing returns to scale, and benefit from interactions of closely related suppliers and consumers (Schmutzler, 1999). The intra-industry economies of localization, elaborated in the NEG, may occur through (1) economies of specialization; (2) labor market economies; and (3) knowledge spillovers (Breschi & Lissoni, 2001). The agglomeration effects are hypothesized to increase labor productivity and innovativeness of individual firms (J. Vernon Henderson, Shalizi, & Venables, 2001; Porter, 1990) in two possible ways. The first assumes that nearness is able to influence economic outcomes, by the sole virtue of being a part of a spatial business concentration leading to economies of scale (Gordon & McCann, 2000). The second views proximity as a facilitating condition for the exchange of resources among firms (Knoben & Oerlemans, 2006). As the benefits of locating close to concentrated business activity decline with distance, firms that are able to capitalize on the opportunities generated by agglomeration, should select their location appropriately. In addition to centripetal forces that draw firms to the areas with concentrated economic activity, there are centrifugal forces (such as congestion and increased competition) that impose pressure on business to leave agglomerations or prevent them from locating within them. The relative strength of these pull-push factors determines if an agglomeration emerges and persists[5].

The framework of the new economic geography has been applied to understand two types of related phenomena: agglomerations and regional growth, and convergence (Fujita & Thisse, 2009). The framework, however, remains highly theoretical with a lot of analytical modeling and limited empirical applications (Bosker & Garretsen, 2010; Martin, 1999). In addition, the new economic geography is mostly preoccupied with higher-level aggregation and is not particularly useful for the analysis of individual firm performance.

Cluster theory is a step from the primary interest in agglomerations and their formative forces toward a greater emphasis on the behavior of firms in the areas of concentrated economic activity. Cluster theory has incorporated the insights of Marshall and Krugman whose writings undoubtedly constitute building blocks of the theory (Cumbers & MacKinnon, 2004; Newlands, 2003; Palazuelos, 2005). Porter (1998, p. 78) defines a cluster as "geographic concentrations of interconnected companies and institutions in a particular field [that] encompass an array of linked industries and other entities important to competition". Porter (1998) pointed to three potential advantages of clusters. First, the proximity to inputs and customers, and associated with it cost reduction, should lead to productivity gains. Next, clusters may promote enhanced innovation and flexibility, and production of customized goods and services resulting from proximity to the costumers. Finally, clusters should attract new business due to locally available information on existing opportunities within a cluster.

[5] In many cases, historical incidents have triggered the emergence of agglomerations (Krugman, 1998).

A related concept that links regions and economic growth through knowledge creation and innovation is regional innovation systems or RIS (Uyarra, 2010). It starts with the proposition that '[i]nnovation is a territorially embedded process and cannot be fully understood independently of the social and institutional conditions of every space' (Rodriguez-Pose & Crescenzi, 2008, p. 54). Here, territorial actors and institutions are hypothesized to play an important role in regional growth. The competitive advantages of regions are also related to the institutional characteristics such as the level and structure of education and R&D activities, available financial services and so forth (Cassia, Colombelli, & Paleari, 2009). Regional innovative systems should enable regions to adjust to the existing conditions in a way that promotes sustained regional growth. Recent literature emphasizes that production and utilization of knowledge is a primary way to do so. Therefore, knowledge and the spillovers associated with it are essential for the regional economic development process (Stough & Nijkamp, 2009).

2.2.2. Agglomerations, localization, and diversity

Agglomerated economies[6] stimulate local knowledge spillovers leading to increasing returns to scale (Griliches, 1992; López-Bazo, Vayá, & Artís, 2004), and to improved regional and firm performance. Jacobs (1969) and Porter (1990) hypothesize that a greater number of firms favors knowledge spillovers more than a local monopoly. Evangelista and colleagues (Evangelista, Iammarino, Mastrostefano, & Silvani, 2002) argue that density and quality of interactions determine the innovative capacity of a

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[6] Several chapters of the *Handbook of Regional and Urban Economics, Volume 4: Cities and Geography* give a thorough overview of the sources, micro foundations, and nature of agglomerated economies (Duranton & Puga, 2004; Ottaviano & Thisse, 2004; Rosenthal & Strange, 2004).

region. Other researchers believe that agglomeration of firms is a necessary condition for the presence of LKS (Koo, 2005a; Varga, 2000). Besides enjoying the access to the ‘classical’ advantages of agglomerated economies, such as diversified and abundant labor pool and a dense network of suppliers and consumers, firms situated in agglomerations are likely to interact more often among themselves. This should promote trust and facilitate knowledge exchange.

Extensive empirical literature supports positive effects of agglomeration on the regional and firm-level economic performance. Rodriguez-Poseand Comptour (2012) argue that industrial clusters, if they happen to form in areas with highly trained and educated labor force, promote economic growth in the European regions. Lehto (2007) finds that closeness has a positive impact on productivity in a sample of Finnish firms. In a study of U.S. service sector firms across labor market areas (LMAs), the number of establishments per 1000 residents increases firm survival chances (Acs, Armington, & Zhang, 2007). Wennberg and Lindqvist (2010) discover positive association between population density and firm longevity in Swedish knowledge-intensive manufacturing and services. Location close to the national capital appears to promote firm survival in Greece (Fotopoulos & Louri, 2000).

On the other hand, agglomeration of businesses in a particular geographical area may be detrimental to firms located in these areas. Congestion and increased competition, which are common attributes of agglomerations, may lead to firm failure and exit. In the U.S., Buss and Lin (1990) find no difference between firm survival rates in urban and rural areas; while Renski (2009) concludes that firms located in urban core are more likely to exit. In Austria, survival rates of firms located close to the national capital are comparable to those of the firms in the rest of the country (Tödtling & Wansenböck, 2003). An alternative measure of urbanization, population density, is negatively related to economic growth (Funke & Niebuhr, 2005)and survival in manufacturing and business services (Brixy & Grotz, 2007) in West German regions. The latter result is in line with evidence from U.S. LMAs (Acs et al., 2007).

The magnitude and range of knowledge spillovers often depends on regional industrial landscapes (Glaeser, Kallal, Scheinkman, & Shleifer, 2002). A greater geographic concentration of a specific industry on a limited space may lead to more intensive knowledge exchange as spillovers are more likely to occur between homogenous firms[7] (Audretsch, 2003; Stel & Nieuwenhuijsen, 2004). An alternative view states that new knowledge is likely to emerge as a result of 'cross-fertilization' among industries. Firms from different industries are likely to enrich each other when they are concentrated within restricted territory (Jacobs, 1969).

The empirical literature that tests for MAR and Jacobian externalities does not come to a single conclusion. Investigations of Dutch regions suggest that industrial diversity stimulates higher spillovers and leads to greater economic output (Stel & Nieuwenhuijsen, 2004)and employment (Frenken, Oort, & Verburg, 2007). In both studies, MAR variables measured by industrial localization are statistically insignificant. Feldman and Audretsch (1999)count innovations at the four-digit SIC level in U.S. cities from the U.S. Small Business Administration's Innovation Database (Audretsch, 1995a). In this study, the location quotient of the industries that share knowledge base is a strong

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[7] Presence of externalities that occur within one industry was originally proposed by Marshall and later elaborated by Arrow and Romer. These externalities are called Marshallian or MAR externalities in the literature.

predictor of innovation count, while the location quotient of the industry itself is not significant. The researchers conclude that diversification promotes innovation, while specialization has no effect. The opposite evidence comes from another set of studies. Van der Panne (2004) shows that Dutch regions specializing in specific industries are more innovative in these industries, whereas industrial diversity does not contribute to innovation. Kelly and Hageman (1999) observe that innovation in the U.S. is related to regional employment in several sectors such as chemicals and allied products, primary metals, and machinery except electrical.

2.2.3. Local knowledge spillovers

It is almost a convention in the literature that accumulated local knowledge should translate into superior firm performance. Extensive research on local knowledge spillovers describes in great detail why this relationship is expected to hold and provides vast empirical evidence to support this claim. Ibrahim and co-authors (2009, p. 412, italics in original) define knowledge spillovers as the 'useful *local sources* of knowledge found in a region, that were obtained beyond the recipient's organization, and that affected the innovation of the recipient'. The scholarly debates on the issue went from implicit or explicit assumptions about presence of spillovers in the studies of the regional factors and their effects on economic performance and innovation (Howells, 2002) to (in some instances) questioning the very existence of externalities (Breschi & Lissoni, 2001; Tappeiner, Hauser, & Walde, 2008). Still, mainstream research takes spillovers for granted and mainly debates the exact mechanisms and the radius of these effects (Audretsch, 2003; Ibrahim et al., 2009).

The spillover literature models knowledge as a public good, which is at least partially non-rival and non-excludable. Knowledge tends to accumulate in spatially bounded areas and requires some sort of interactions to spread. The intensity of knowledge spillovers declines with distance (Adams & Jaffe, 1996; Bottazzi & Peri, 2003; Rodriguez-Pose & Crescenzi, 2008; Wang, Ma, Weng, & Wang, 2004). Firms located in the areas with intensive research by business and/or universities are expected to be more inventive and productive even though they do not participate in research activities (Koo, 2005b; Zachariadis, 2003).

Researchers attribute various observed relationships to the presence of spillovers. For example, total number of tenants in science parks, and presence of outliers, may increase the likelihood of patenting in this park, especially by small firms (Squicciarini, 2009). In the U.S., number of workers in small (less than 25 employees) firms is positively related to the number of start-ups per square mile (Rosenthal & Strange, 2003), while university investment in research and development appears to stimulate new firm formation (Kirchhoff, Newbert, Hasan, & Armington, 2007) and local innovation by facilitating industrial R&D spending (Jaffe, 1989). In the UK, university research funding (input) and scientific publications and human capital (output) stimulate business growth, especially in the initial stages of firm life cycle (Cassia et al., 2009). R&D spending and patent applications, when combined with a highly skilled labor pool, promote economic growth in the European regions (Rodriguez-Pose & Comptour, 2012). If knowledge spillovers happen via informal information sharing, participation in networks has been shown to contribute to firm post-entry performance (Mazzola & Bruni, 2000), survival prospects (Watson, 2007), greater levels of innovative output (Oerlemans, Meeus, & Boekema, 2001), sales, and stock growth (Collins & Clark, 2003).

In reality, the intensity of spillovers depends on industry and regional characteristics(Greunz, 2004; van der Panne, 2004), as well as functional and sectoral proximity among regions (Fischer, Scherngell, & Jansenberger, 2009; Maggioni & Uberti, 2009). Researchers use various techniques to document spillovers, which are in most cases unobservable (Jaffe, Trajtenberg, & Fogarty, 2000; Jaffe, Trajtenberg, & Henderson, 1993; Wallsten, 2001). Yet, some scholars point to the lack of knowledge about the mechanisms of externalities (Stel & Nieuwenhuijsen, 2004) and argue that the role of spillovers may be unjustifiably inflated (Gilbert, McDougall, & Audretsch, 2008). To illustrate this point, Bode(2004) demonstrates that only a small fraction of knowledge actually spills over. Ronde and Hussler (2005) argue that unintended knowledge flows are of minor importance in shaping regional innovative performance. Nieto and Quevedo (2005) report 'residual' spillover effects of Spanish manufacturing firms' innovative efforts.

With respect to firm survival, though, presence of LKS is likely to have divergent effects. On the one hand, firms may learn from others in order to become more productive and efficient. In this case, business operating in the areas with greater stock of knowledge should live longer. On the other hand, higher efficiency of firms intensifies competition because it happens among stronger competitors. If increased productivity promotes survival, a greater number of firms staying in business should intensify competition even further.

Abstracting from LKS, greater stock of knowledge in a region may contribute to a greater likelihood of exit via at least two other routes. The knowledge spillover theory of entrepreneurship postulates that more knowledge being produced (and unutilized) in a region should increase firm formation, thus increasing competition. At the same time, in the localities where more knowledge is generated, the incumbent firms are likely to be exposed to more business ideas. Firm owners might choose to sell off or to shut down their business in order to start something new that looks more promising. If competition intensifies or more entrepreneurs close their ventures, econometric analysis would reveal negative relationship between innovative activities and firm survival in a region.

Limited understanding of knowledge spillover mechanisms has been admitted (usually by mentioning in passing) by many researchers (Giuliani, 2007; Howells, 2002). A few studies, however, critically review the existing literature and/or perform independent investigations with the goal to propose explanations other than spillovers for the observed geographical patterns of knowledge diffusion. Perhaps the most solid account of why the role of spillovers may be overestimated comes from Breschi and Lissoni (2001). According to these researchers, the concept of localized knowledge spillovers is in fact a by-product of production functions used in neoclassical growth theory, and is not based on actual public good-like properties of scientific and technical knowledge. It means that, even if it is significant for economic outcomes, spatial proximity is likely to operate through a complex set of variables unrelated to pure spillovers. Companies not engaged in innovative activities are likely to use business consulting and other professional services, for example. The benefits of these market transactions, called 'pecuniary' or 'rent' externalities in the literature,

may be the true reason of improved business performance observed in innovative regions. At the same time, use of consulting and professional business services do not enter the datasets used to estimate local knowledge spillovers. This omission might lead to the conclusion that 'pure' spillovers take place. By reviewing the major studies on LKSs, Breschi and Lissoni (2001) demonstrate that the results attributed to externalities may be a consequence of pecuniary spillovers.

If this argument is correct, unavailability of data on the use of consulting and professional services by individual firms is the main reason why the results of market transactions are erroneously attributed to knowledge spillovers. Market mechanisms that facilitate knowledge diffusion in proximate regions include high skilled workers' mobility[8], consulting and accounting services, cooperation agreements, to name just a few. The role of mobile labor is particularly relevant in highly innovative industries and in the emerging industries where techniques of replication have not been formed yet, whereas the complex nature of the production process prevents information leaking through more conventional means (Breschi & Lissoni, 2001). In the early years of the biotechnology industry, for example, access to inventors and laboratories producing original knowledge was necessary in order to build on this knowledge. The 'traditional' transfer mechanisms, such as communications with university scientists, were rather useless (Zucker, Darby, & Brewer, 1998). Almeida and Kogut (1999) find that knowledge is indeed region-specific and tends to concentrate in certain areas; however,

[8] This type of knowledge transfer may be considered as 'pure externality' only if mobile workers create some pool of knowledge that everyone can benefit from (Breschi & Lissoni, 2001). Otherwise, we are dealing with the labor market mechanisms that (if efficient) pays marginal product of labor productivity in wages, i.e. the transactions are expressed in monetary terms and, thus, cannot be called externalities.

inter-firm mobility of engineers, not pure spillovers, is the major explanation for the knowledge transfer.

Universities have been praised as important sources of knowledge and technology spillovers for regional economies. Breschi and Lissoni (2001) contend that the positive role of higher educational institutions on local economic performance may be at least partly explained by market transactions between universities and local firms. Universities, which often commit to promoting regional economic growth in addition to education and research (Goldstein, 2010), provide valuable training and consultancy services to the local firms. University employees and students set up new businesses or move to private sector employment bringing 'university level' knowledge to firms operating in the area (Zucker, Darby, & Armstrong, 1998). Simmie (2002) shows that about 15 percent of all firms in his sample collaborated with universities during an innovation development stage.

Other notable mechanisms of knowledge transfer are consulting, and patent and license acquisitions. One study (Simmie, 2002) finds that about one third of small and medium enterprises use consultancy services from specialists in the area during the innovation development stage. Murray (2002) concludes that spillovers in the tissue engineering industry mostly occur via founding, consulting, licensing, and advising. In a microeconomic investigation of innovativeness in France, Negassi (2004) reports a significant positive impact of acquisition of machine tools, foreign patents, licenses, and other technological opportunities on innovation. The researcher directly calls these variables rent spillover measurements.

2.3. An alternative approach: innovation, entrepreneurship, and ‘creative destruction’

Literature on agglomeration and spillovers in general suggests mostly positive effects of innovation on firm business output and regional economic performance. In areas of concentrated business, both innovative and non-innovative, more interactions are expected to lead to knowledge sharing and increased productivity by all firms. For an individual company, though, this translates into the need to become more productive or go out of business. It is natural to expect many firms to fail to survive till the expansion phase. Schumpeter refers to increased destruction of insufficiently innovative firms and argues that it is an indispensable attribute of development.

2.3.1. Schumpeter’s perspective on firm performance and economic development

For Schumpeter, economic growth and economic development are two absolutely different phenomena. Economic growth is characterized by incremental change as a result of routine practices employed by managers in the economy[9]. Economic development, in contrast, is a leap-like progress, caused by entrepreneurs (Schumpeter, 2005). Entrepreneurs, according to the economist, are those who combine available resources in new ways in order to create novelty in products, production, markets, supply, and organization (Dodgson, 2011). A Schumpeterian entrepreneur has nothing to do with occupation, profession, or firm ownership *per se* (Witt, 2002). Entrepreneurship here means economic leadership in its ability to disrupt existing equilibrium from within and

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[9] Schumpeter calls economic routine that leads to growth a “circular flow”; this routine is carried out by “mere managers”. Disturbances caused by circular flow are just a change in economic data, not a real spontaneous change caused from within (Schumpeter, 1934).

to bring the economy to a new one, and industrial leadership in the form of promotion and implementation of new ideas into practice (Matis, 2008). In other words, the economist equates entrepreneurship to innovation; the Schumpeterian entrepreneur is called innovator nowadays.

Schumpeter has argued that resources are always present in the economy. It takes an entrepreneur to combine them in a new fashion to derive 'entrepreneurial profit' (McDaniel, 2005), which is social acclaim and satisfaction from achievement rather than money (Witt, 2002; Wunder, 2007). In turn, when new combinations are introduced to the market, they cause discontinuity in the steady state or, as Schumpeter calls it, development. Firms are usually innovative during the initial stages of their development when they try to find their niche in the market. Novelty helps new firms succeed in competition against incumbents. By driving the latters to reinvent themselves or to go out of business, entrepreneurial companies achieve some market power, which does not stimulate innovation. After a firm stops creating new combinations and settles in to running its business just like others, it looses entrepreneurial character and is likely to exit as new innovative firms keep introducing new combinations to the economy (Schumpeter, 1934). The process by which less entrepreneurial firms are driven out of business by more entrepreneurial ones is the nature of 'creative destruction'. More innovative regions should experience greater 'creative destruction': more firms entering and exiting the market, which is a necessary condition for development and increased productivity (Bosma, Stam, & Schutjens, 2011).

Schumpeter implied that new entrants are the major agents bringing novelty to the economy. He did not pay much attention to imitative entrepreneurs who are also important for regional economic performance (James A. Schmitz, 1989; Segerstrom, 1991). Assuming that a non-negligible fraction of start-ups are imitators, it becomes clear that entry by itself does not necessarily spur creative destruction, but rather innovation by both new and incumbent firms[10]. Following this logic, one should expect greater exit rates in more innovative, entrepreneurial in Schumpeterian terms, industries.

The creative destruction argument easily applies to regions as well. If a geographical region, not just an industry, is more innovative, one may expect greater business destruction. Empirical studies list numerous regional characteristics that are likely to translate into various levels of innovation in a region. These characteristics include dissimilar prevailing technologies or industry structure, specific knowledge stock, certain characteristics of economic actors and the degree of their geographic proximity. Empirical literature that relates regional attributes to Schumpeterian reasoning usually distinguishes between entrepreneurial (creative destruction) and routinized (creative accumulation) regimes (Fritsch, 2004). Entrepreneurial regime refers to a situation where new technologies replace the old ones frequently, resulting in shorter technological life cycles. According to Schumpeter, innovation is often associated with new firms; thus, in entrepreneurial regimes, barriers to entry are low and the level of entrepreneurship is high (Lin & Huang, 2008). In the routinized regime, technologies accumulate steadily and innovation gradually improves existing technologies. Experience is important in this situation and, consequently, entry barriers are more pronounced because incumbents have competitive advantage (Strotmann, 2007).

[10] Although some authors argue that Schumpeterian innovation means organizational rather than technical change (Foster, 2000), Schumpeter himself defined innovation as invention commercialization (McDaniel, 2005), while ‘dime a dozen’ innovations do not count as important drivers of development (Witt, 2002).

2.3.2. Knowledge entrepreneurship

Schumpeter put forth the notion of an entrepreneur as an engine of economic development, who introduces innovations to the market, thus moving it forward from a static equilibrium (Braunerhjelm & Svensson, 2010). Consistent empirical support for the positive relationship between entrepreneurial activity and regional economic performance (Acs & Armington, 2004) fits logically into the Schumpeterian argument. In this 'classical' framework, innovation is considered a tool of entrepreneurship (McDaniel, 2000). The last two decades have brought broad revival of interest in the active role that innovation and entrepreneurship play in economic development and growth. Entrepreneurial firms, allegedly due to their innovativeness, have been shown to create more new jobs, to facilitate productivity growth, and to produce and commercialize high-quality innovations (C.Mirjam van Praag & Versloot, 2007). Some authors talk about emergence of 'the entrepreneurial society' (Audretsch, 2009), and elucidate the importance of entrepreneurial capital for economic growth (Audretsch, 2007; Audretsch & Keilbach, 2004a) in addition to championing an entrepreneurship-based theory of the firm (Casson, 2005).

According to some recent contributions, entrepreneurs are media of knowledge transfer as they penetrate the so-called knowledge filter (Acs, Plummer, & Sutter, 2009; Audretsch, 2007). In other words, entrepreneurs are able to turn knowledge into economically useful knowledge, the one that is put to work to generate positive economic outcomes. For example, knowledge spillover theory of entrepreneurship (Acs, Braunerhjelm, Audretsch, & Carlsson, 2009) postulates that entrepreneurs set up new firms in order to capitalize on knowledge produced in a region that remains unutilized.

According to this theory, incumbent firms produce new ideas, methods and technologies in the course of trial and error. In the process, the firms have to decide what new ideas or technologies are likely to be successful in the market. Once the 'winners' have been chosen, incumbent firms concentrate on their further development, while other technologies and ideas are disregarded, although they might have market potential as well[11] (Audretsch & Keilbach, 2007). This happens because the new knowledge is highly uncertain and asymmetric (Arrow, 1962), with substantial variation in the expected returns anticipated by the different parties involved in the R&D process. If incumbents do not commercialize newly created knowledge, an entrepreneur (e.g. an employee of the incumbent firm), may set up a new firm that exploits the idea (Agarwal, Audretsch, & Sarkar, 2007). The overall prediction of the theory is that innovative efforts by firms should lead to greater firm formation in a region. For firm survival it means greater competition and, possibly, higher likelihood of exit, much in line with Schumpeterian view of creative destruction.

Regardless of the perspective taken, researchers agree that more entrepreneurial regions should enjoy greater competition. Intensified competition is likely to increase hazard faced by an average firm. This is a powerful incentive for businesses to become more innovative, or entrepreneurial in Schumpeterian words. Empirical research confirms that companies that manage to adjust to competitive pressures, are more likely to survive (Scott, 2006).

[11] This reasoning goes nicely together with the idea of disruptive (or inferior) technologies/innovations developed by Clayton Christensen in his book 'The innovator's dilemma' (1997).

2.3.3. Resource-based view of the firm and evolutionary framework

For Schumpeter, there is no equilibrium, only movement toward one (Schumpeter, 1939). Economic development means constant disequilibrium as new combinations of resources disrupt the steady state and bring the economy to a new productivity level. In this sense, his views depart from the neo-classical static modeling paradigm with its focus on analysis of equilibrium. Many researchers track a relatively new discipline of evolutionary economics back to Schumpeter (Pichler, 2010; Witt, 2002; Wunder, 2007), although the economist avoided references to evolution in his writings (Witt, 2002). Evolutionary economics is preoccupied with the dynamic state of the economy, which is in constant move between equilibria. The evolutionary framework also includes a dynamic view of the firm, which is perceived as a process unfolding over time. The resource-based view (RBV) of the firm looks specifically at the characteristics and processes of firms in order to explain their performance; this perspective is in many respects closely related to the evolutionary framework (Foss, Knudsen, & Montgomery, 1995). Since both RBV and the evolutionary framework are of relevance to firm survival, which is the focus of this research, I briefly review them one after another below.

Resource-based theory[12] seeks to explain superior firm performance on efficiency grounds (as opposed to the market-power approach of the neoclassical economic theory and of game-theoretical perspective). RBV postulates that a firm should be understood as a dual entity. On the one hand, a firm is an administrative structure set up to link and to coordinate activities of individuals and groups of individuals in order to achieve a specified goal. On the other, a firm is a bundle of resources that are used via

[12] I use the terms ‘resource-based view’ and ‘resource-based theory’ interchangeably.

administrative structure and transformed into valuable goods and services (Penrose, 1959). The central premise is that a set of the firm's resources and capabilities[13], i.e. firm's management skills, information, technology, knowledge it controls, and organizational processes and routines, are the main contributors to competitive advantage (Barney, 2001). An entrepreneurial firm, following the Schumpeterian argument, is able to ensure its competitive advantage by combining resources and capabilities in a new way and introducing this novelty to market.

Resources and capabilities have to possess the following four characteristics (Barney & Clark, 2007). They must be valuable (able to exploit opportunities or/and neutralize threats of the environment), rare (not readily available or available in limited quantity to the competitors), imperfectly imitable (competitors should not be able to replicate the resources and capabilities), and exploitable (firm should be able to take advantage of those resources). Resources may be tangible or intangible, as well as static or dynamic (Hunt, 1997); in addition, they can change over time (Helfat & Peteraf, 2003).

Every business is unique in its combination of specific resources and capabilities; thus, RBV allows firm heterogeneity and unequal chances of success. The specific amalgamation of firm abilities and how they are aligned with demand is crucially important for firm performance (Thornhill & Amit, 2003). If the valuable resources cannot be easily replicated by competitors, they become the source of sustained competitive advantage (Lockett & Thompson, 2001).

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[13] Some authors talk about competences in addition to resources and capabilities. As this distinction is made relatively seldom, I stick to the most widely used dual one.

Despite the fact that the resource-based theory of the firm was originally developed to understand the sources of a superior business performance, it can be successfully applied to the study of below-normal performance (Thornhill & Amit, 2003). In fact, this framework is often used to explain firm survival, although authors do not always explicitly refer to RBV. Numerous studies model hazard rates and probability of exit as a function of initial resources (Aspelund, Berg-Utbya, & Skjevdal, 2005), pre-entry and post-entry experience (Bayus & Agarwal, 2007; Fontana & Nesta, 2010), characteristics and qualities of the founder and management teams (Arribas & Vila, 2007), and the range of networks, knowledge and innovation (Buddelmeyer, Jensen, & Webster, 2010; Jensen, Webster, & Buddelmeyer, 2008; Marsili & Cefis, 2005). All these factors are resources or capabilities in the RBV parlance.

In the last decades, knowledge has become the most important strategic factor of production, at least in the developed nations (Spender, 1996). According to Penrose (1959), knowledge flows inside firms determine the uniqueness of each business, and not their physical resources,. It comes as no surprise that there are numerous attempts to look at firm performance through the lens of knowledge available to a firm. Although some authors claim that the knowledge-based approach to firm is separate from the RBV (Grant, 1996), in essence it falls within the resource-based view of the firm, with a specific focus on several resources and capabilities rather than their totality (Barney & Clark, 2007). The knowledge framework of the firm is an indispensable part of RBV (Conner & Prahalad, 1996) because knowledge, innovation and entrepreneurship are valuable capabilities important for business performance.

Firms can extend their control of knowledge assets in two ways. They can employ knowledgeable people, and accumulate and develop the existing stock of knowledge through a number of incremental processes, such as learning-by-doing, learning-by-using, learning-by-searching. Alvarez and Busenitz (2001) argue that the ability to identify market opportunities, to organize resources, and to coordinate knowledge in order to exploit these opportunities together with entrepreneurial cognition is the essential part of turning inputs into heterogeneous outputs. Another type of knowledge is the expertise with goods and services that emerges from purposeful research and development activities or replication of the existing products.

The evolutionary framework of firm performance[14] is, in a sense, a complement of the RBV (Foss et al., 1995). In the RBV, in contrast to the neoclassical economic theory, firms are heterogeneous in their characteristics and ability to prosper. The resource-based view of the firm, however, does not explain where the differences come from. This is the question evolutionary perspective is able to answer.

In general, the evolutionary account of firm performance relies heavily on biological analogies as developed in Nelson and Winter (1982). The economic world in this view is heterogeneous and consists of multiple agents endowed with specific knowledge obtained in the environment of radical uncertainty within their bounded ability to learn and process information. This knowledge gets transferred into the custom routines (analogy to genes) that differ among agents and determine their success

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[14] A number of researchers doubt the applicability of the notions from evolutionary biology to the socio-economic world. Edith Penrose (1952, p. 804) was one of the early skeptics. She argued that 'biological analogies contribute little either to the theory of price or to the theory of growth and development of firms in general and tend to confuse the nature of the important things'. Ironically, some proponents of the evolutionary framework of firm growth claim an antecedent in her seminal book *The Theory of the Growth of the Firm*. The meaningfulness of relying on biology in explaining economic phenomena was recently questioned by, for example, Lawson (2003) and Castelacci (2006).

(Castellaci, 2007). The routines are formed by the experience knowledge and tacit knowledge. In addition, they can be firm-specific, i.e. the ones applied by a firm to all its products, and product-specific, i.e. utilized in producing specific goods (Frenken & Boschma, 2007). The routines are ‘sticky’ (change slowly and incrementally); therefore, the development of a firm is path-dependent. With respect to business survival, this implies that conditions during the founding period are likely to affect its performance throughout its life. The evolutionary framework also implies, in general, that past experiences and circumstances determine business performance in the future (Delmar & Wennberg, 2010). Selection in the market happens on the basis of fit between the set of the routines each firm possesses and the requirements of the environment (Boschma & Lamboy, 1999). All in all, while the RBV attempts to explain firm growth by concentrating on resources business controls, the evolutionary approach relies on the view of a firm as a dynamic entity that gradually ‘unfolds’ in time (Foss et al., 1995). Analysis of the evolutionary framework through the lens of Schumpeterian argument, however, reveals that the evolutionary approach, in its general form, depicts a ‘circular flow’, an antithesis of creative destruction regime.

2.4. Summary

Innovation is a multi-faceted phenomenon that is directly and indirectly related to the performance of firms, regions, and nations. Abstracting form the effects of a firm’s own innovative activities, this research focuses on the relationship between the innovativeness of a metropolitan economy and the likelihood of business survival in high-technology manufacturing and services. This research question has not been addressed in the literature but various strands of both theoretical and empirical research are relevant as they lay the ground for the inquiry performed in this dissertation. Since the pertinent literature is rather extensive, this subsection briefly summarizes the main points presented in Chapter 2.

- The central role of innovation in the process of economic growth was explained by several theories, most notably by the Solow-Swan model, the new growth, and the endogenous growth theories.
- A number of theories (NEG, cluster theory) and hypotheses (Marshallian localization effects) relate regional and firm-level economic performance to the peculiarities embedded in a region smaller that a nation, usually a city or a metropolitan area. A special emphasis is placed on the benefits of agglomerations that facilitates superior business performance by granting access to deeper labor pools, specialized input suppliers, and the opportunity to learn from other firms, the so-called local knowledge spillovers.
- Many researchers believe that LKS, which are likely to exist in the geographical areas with high concentration of business and/or population, ensure higher labor productivity, increased innovation, and faster economic growth.
- Some researchers, however, do not share a seemingly prevalent fascination with the knowledge spillovers and argue that the associations are caused by other mechanisms such as migration of labor and market transactions.
- The Schumpeterian perspective that acknowledges the central role of innovation in economic development suggests a negative relationship between innovation and firm survival as a result of ‘creative destruction’.

- Several more recent frameworks that are in line or are related to the Schumpeterian view imply diverging effects of innovation on firm survival probability.
    - The knowledge spillover theory of entrepreneurship postulates that the greater levels of innovativeness in a geographical area should lead to more intensive firm creation. This is likely to increase competitive pressure and the probability of exit.
    - In the resource-based view of the firm, as long as a business is able to combine its resources and capabilities in an innovative way that enhances the fit between the market demands and the firm's business activities, it should enjoy a competitive advantage and thus live longer.
    - The evolutionary framework of firm performance stresses path-dependence in the firm's activities and stickiness of its routines. This approach echoes Schumpeter's conclusion that inertia and the lack of innovation that usually characterizes well-established firms would eventually lead to such firms being ousted from the market by the more innovative new entrants.
- To conclude, the existing research suggests that the external effects of innovation on business survival can be both positive and negative. The literature proposes several different mechanisms of this relationship that can work at the levels of a firm, a region, or a nation.

CHAPTER 3: FIRM SURVIVAL

Knowledge of firm survival determinants is of practical importance for policy-makers as they implement programs designed to stimulate economic activity (Renski, 2011). The desired outcomes of such policies are increased firm formation and, most importantly, successful performance of the start-ups. Empirical research shows that start-ups contribute more than incumbent firms to job creation (Acs & Armington, 2004). In the long run, their role in technological evolution is crucial (Fritsch & Mueller, 2004). Many firms, however, fail to reach the growth stage as only about a half of them survive beyond five years (Audretsch & Mahmood, 1995; Dunne et al., 1989; Johnson, 2005; Mata et al., 1995). In addition, factors that promote business entry, including economic programs, may hamper business survival (Sorenson & Audia, 2000; Stuart & Sorenson, 2003).

3.1. Research question and logical model

Empirical studies have long been concerned with factors facilitating or hampering firm longevity. Analysis of both the theoretical and empirical literatures suggests that, on a grand scale, reasons for exit are either related to inefficiency (failure to achieve required level of profitability) or to various types of entry mistakes (high uncertainty). Arguably, more information about most efficient production techniques or challenges and personal rewards associated with certain business activities may mitigate both problems and increase business survival chances. Table 1 summarizes major reasons for closure by exit mode and provides brief explanation of how every reason is related to either a mistake or inefficiency.

Table 1. Business exit modes and common reasons for exit

Exit mode	Reason for exit	Explanation
Going out of business	Low productivity/ insufficient profits	- Entry mistake (overestimation firm's ability to prosper, insufficient knowledge of market conditions) - Failure to achieve necessary/desired efficiency level (poor management and resource utilization)
	Business activity does not bring personal satisfaction to the owner	- Entry mistake (over-fascination with chosen business activity)
	The firm is shut down in order to start another firm	- Entry mistake (insufficient knowledge of available market opportunities)
Bankruptcy	Low productivity/ insufficient profits	- Entry mistake (overestimation firm's ability to prosper, insufficient knowledge of market conditions) - Failure to achieve necessary/desired efficiency level (poor management and resource utilization)
M&A	Underperformance given a firm's potential	Inability to ensure maximum profits due to lack of resources or for other reasons

Source: author's construction based on literature review

Extensive empirical research, summarized in more detail in the next subsection, identifies three major types of firm survival determinants. They are (1) owner- and firm-specific characteristics, (2) industry and market factors, and (3) regional and macroeconomic factors (Figure 1, based on Renski (2006) with modifications). The intersection of all three types of factors shapes business viability.

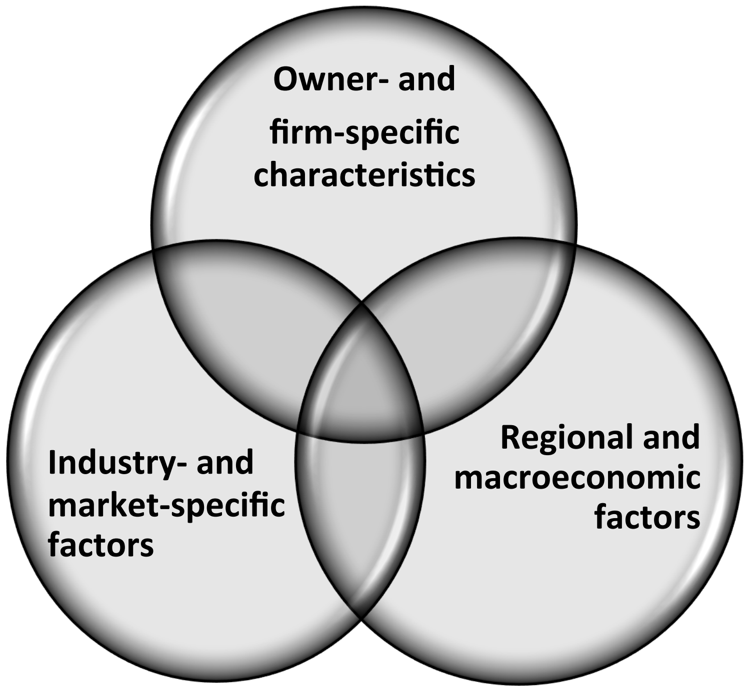

Figure 1. Determinants of firm survival

The literature provides a detailed account of the relationship between firm-specific factors, industry-, and market characteristics on the one hand, and probability of exit on the other. There is considerably less understanding of the regional factors of firm survival. New firm survival rates differ substantially across regions perhaps because regional conditions determine the local resource base a firm may draw upon in order to survive and prosper (Acs et al., 2007). The stock of knowledge accumulated in a region, and the regional scientific environment are the most valuable assets in a modern economy (Paci & Usai, 2009). In geographical areas with more intensive private and government-funded research and development activities, economies tend to grow faster (Cassia et al., 2009; Stough & Nijkamp, 2009), while firms on average are likely to be more innovative (Coronado & Acosta, 2005). The latter was shown in the literature to promote firm survival (Cefis & Marsili, 2005, 2006).

The literature on business survival, however, does not provide any account of the relationship between the innovative environment of a region (as opposed to firm's own inventions) and survival probability. The most comprehensive study of regional factors determining business longevity to date (Renski, 2006)explores effects of localization, urbanization, and industrial diversity in five manufacturing and three business and professional service industries in the continental U.S. The discussion is framed within arguments put forth by Marshall (1920 [1890]) and Jacobs (1969). Innovation and knowledge, including knowledge spillovers, are mentioned as important components of observed relationships but the paper does not test the effects of innovation directly. It suggests two paths, via which external economies may affect firm survival, namely local knowledge spillovers (greater likelihood of survival) and increased competition (increased hazard). The empirical results of the study are mixed and depend on industry, sector, and the geographic radius of the effects taken into account.

This dissertation looks at the two potential mechanisms of the relationship between regional innovative environment and firm longevity in greater detail. The next subsections present the two contesting perspectives on the relationship between innovation in a region and firm survival, followed by hypotheses statement.

3.1.1. Marshallian externalities

Extensive literature argues that technological change and innovation are the major drivers of productivity and economic growth. At both regional and individual firm levels, greater accumulation of knowledge in a region is hypothesized to contribute to superior economic performance directly and indirectly (via knowledge spillovers). Empirical studies report increased productivity and innovation in the regions with intensive R&D.

At a firm level, knowledge spillovers should enhance survival chances as firms face less uncertainty, and are likely to learn from experience of others (Maskell, 2001; Minniti, 2005). For example, observing others may reduce the likelihood of an entry mistake when a firm owner overestimates either his ability to run a business successfully, or his fascination with the activity chosen. Companies may also learn from businesses in proximity about new technologies, products, and procedures and absorb tacit knowledge[15]. This type of knowledge, as opposed to the codified one, cannot be expressed via written means due to its subtle nature. Nevertheless, it is an important part of any production process and, if economically useful, gives its possessors a competitive advantage. If learning and knowledge spillovers occur, firms located in the areas with intensive innovative activities, and formally not engaged in R&D, should become more efficient and innovative, face less uncertainty, and enjoy higher likelihood of survival (Figure 2).

[15] Polanyi (1966) defines tacit knowledge as a type of useful or valuable knowledge, which a person possesses but cannot articulate. However, this knowledge can be shared in course of shared experiences and collaboration.

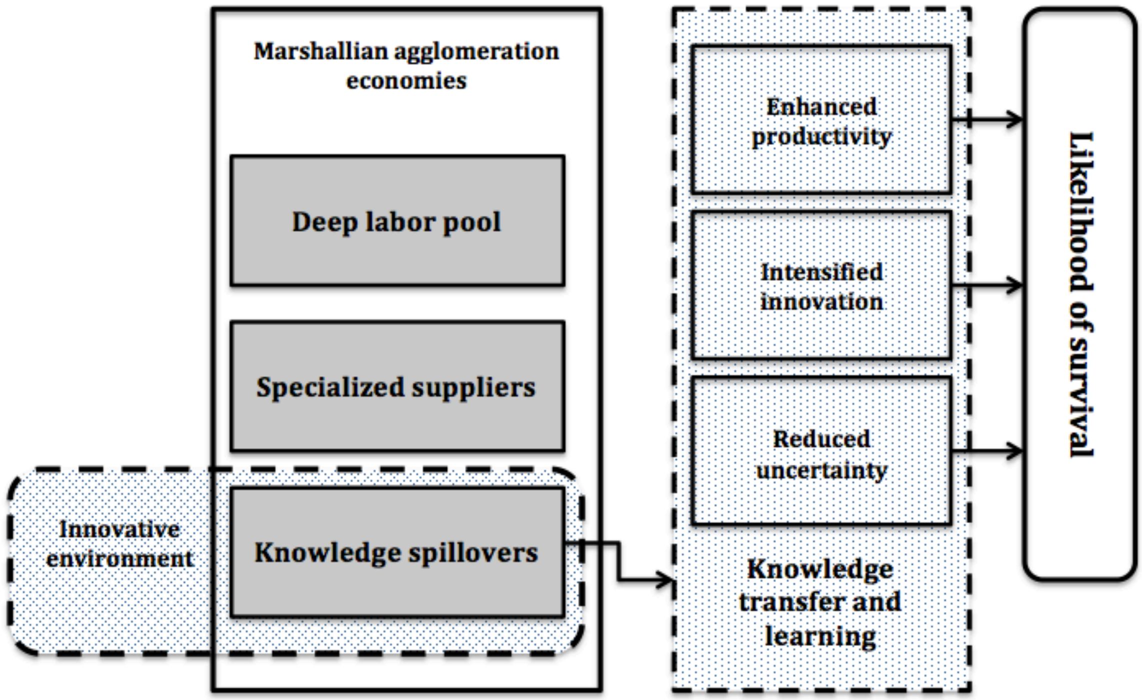

Figure 2. Schematic representation of the relationship between innovation and firm survival as it follows from the literature on knowledge spillovers

3.1.2. Schumpeterian destruction and other hazard-increasing mechanisms

One should not expect a positive relationship between innovation and business survival if Schumpeterian ‘creative destruction’ takes place. In fact, companies formally not involved in the innovation process in the localities with active R&D efforts may face greater hazard. First of all, innovative firms are strong competitors for non-innovative firms. If both types of firms are present in an industry and market demand does not increase, non-innovative firms may be disadvantaged and face a higher hazard. Simultaneously, if knowledge spillovers take place, non-innovative firms become more productive on average, meaning that there are stronger competitors in the market and, thus, competitive pressure goes up. If the demand side of the market does not change, non-innovative firms that failed to benefit from knowledge spillovers have to compete against both their more successful counterparts that have benefited from knowledge spillovers, and innovative firms. This increases the likelihood of exit for a fraction of non-innovative firms. Second, as suggested by the knowledge spillover theory of entrepreneurship (Acs, Braunerhjelm, et al., 2009), regions with vigorous knowledge creation should experience higher levels of firm formation. A greater number of entrants in a market intensifies competition and may reduce survival chances of firms (Sorenson & Audia, 2000; Stuart & Sorenson, 2003). Figure 3 depicts the hypothesized relationship between innovation and firm longevity taking into account effects of increased competition.

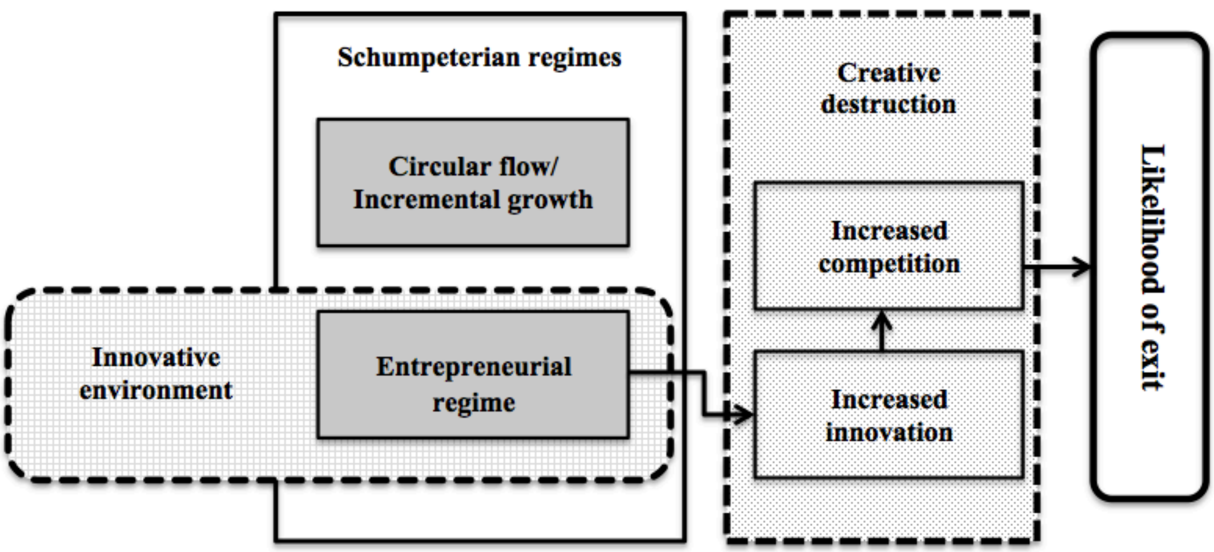

Figure 3. Schematic representation of the relationship between innovation and firm survival as follows from the literature on creative destruction

Lastly, research-intensive regions may offer greater and more plentiful business opportunities. If some business owners believe that they would be better off by shutting down their existing businesses in order to start something new, this

would contribute to a greater likelihood of business exit in such regions16.

3.1.3. Hypotheses

It follows from the discussion above that both positive and negative effects of innovation on firm survival are possible. Figure 4combines the ‘spillover’ and ‘creative destruction’ perspectives on the relationship between innovative activities and business longevity in a simplified form, and adds a possibility of exit in order to start another firm, as discussed in the previous subsection.

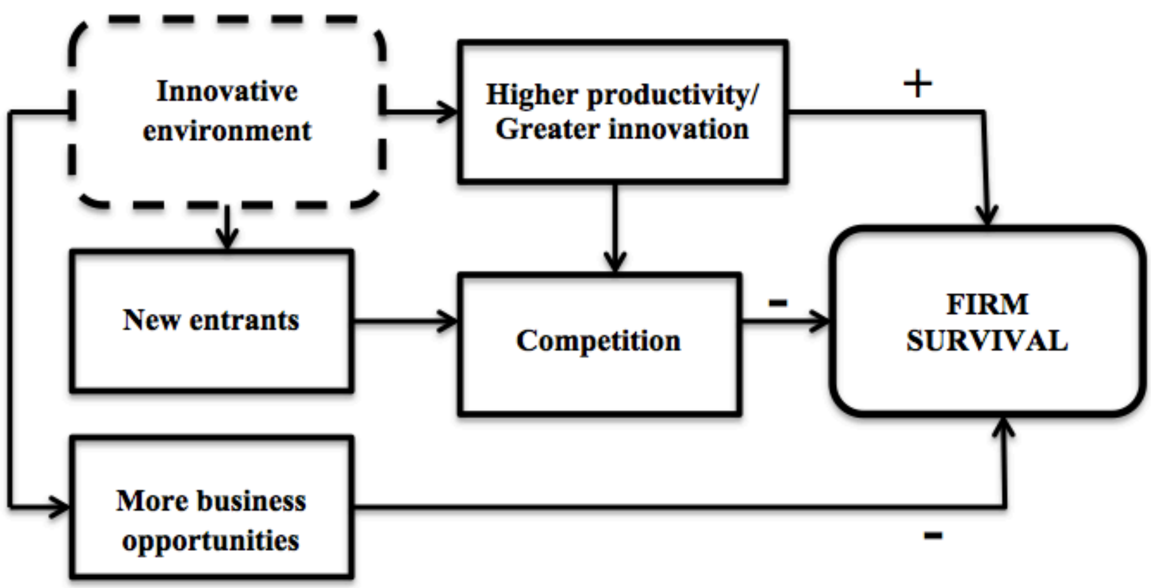

Figure 4. Logical model of the relationship between innovation in a region and firm survival

[16] In practice, business owners have at least three choices when they decide to change their business activity. They may re-profile the existing firm, to sell the existing firm off, or to shut it down. Only in the latter case greater business opportunities in a region may contribute to increased exit rates as a result of entrepreneurs switching to other business activities.

Two competing hypotheses are tested here:

H0. Innovation in a region promotes firm survival *ceteris paribus*;

HA. Innovation in a region hampers firm survival *ceteris paribus.*

3.2. Empirical evidence

The literature-based discussion in Chapter 2 articulates the importance of innovation in general, and innovation in a geographical area in particular, for business survival. The discussion also presents the counteracting mechanisms that are likely to determine the relationship between firm longevity and the level of innovativeness in a region. This literature overview was necessary to formulate research hypotheses. Before proceeding to the empirical testing of the hypothesized relationships, a review of a separate body of literature is required. An extensive research that studies firm survival determinants is briefly summarized below in order t o identify the control variables and to place current research within the existing business survival literature.

For decades, empirical research considered firm survival as a side issue in the debates on firm growth, entry and exit. In the 1990s, however, business survival became a separate topic of empirical investigations (Fotopoulos & Louri, 2000). Despite opinion occasionally voiced in the literature that firm failure is a natural part of the 'survival of the fittest' process, with exits being a consequence of 'entry mistakes' (Jovanovic, 1982), the need for understanding the determinants of firm survival is apparent, as exemplified by the considerable amount of empirical work done in the last two decades. Understanding the relationship between regional characteristics and ability of new firms to survive beyond initial years of operation into business growth stage is of practical importance to local and state policy-makers. As Renski (2011) notes, active entry may reduce survival chances because of increased competition. In this sense, numerous programs that stimulate firm creation via seed grants, tax breaks, and subsidized rent in business parks are incomplete if they do not foster viable firms in the (relatively) long run. Knowledge of the local factors important for start-up survival is therefore crucial for designing effective entrepreneurial policies.

Policy-makers should be concerned about the ability of firms to survive till the growth stage because the majority of entrants go out of business during the first years of operations shedding jobs and decreasing the tax base of a region. Geroski (Geroski, 1995, p. 435) concludes that exit is 'the most palpable consequence of entry'. Empirical studies confirm this supposition. In Europe, the likelihood of exit is the highest during the two initial years of operation with about half of the new firms not surviving a five-year mark (Audretsch, Santarelli, & Vivarelli, 1999; Bartelsman, Scarpetta, & Schivardi, 2005; Box, 2008; Brüderl, Preisendörfer, & Ziegler, 1992; Littunen, 2000). In the United States, exit rates are likewise high. Typically, between five and ten percent of all firms in a given market exit every year (Agarwal & Gort, 2002). Analysis of manufacturing, services, and retail sectors using BITS (business information tracking series) of the US Census Bureau suggests that 66 percent of new establishments survive for at least two years, half of all start-ups live four years or longer, and only 40 percent continue after a six-year time span (Headd, 2003). In general, roughly 50 percent of new firms, regardless of the country or sector, exit within five years (Audretsch & Mahmood, 1995; Dunne et al., 1989; Johnson, 2005; Mata et al., 1995).

3.2.1. Owner- and firm-specific determinants of firm survival

To a significant degree, qualities of a firm owner, managers and employees, as well as firm-specific characteristics determine business performance. Empirical research shows that the age of a founder or key employees is usually positively correlated with firm survival (Headd, 2003; Nafziger & Terrell, 1996; Persson, 2004), but is not significant in some cases (Saridakis, Mole, & Storey, 2008). Gender of an owner has negligible or no impact on the probability of exit in the U.S. and Great Britain (Headd, 2003; Saridakis et al., 2008), while Arribas and Vila (2007) find that Spanish service firms established by men face a lower probability of exit. The evidence on the effects of race or ethnicity is also mixed. Nafziger and Terrell (1996) report higher survival rates among Indian firms established by representatives of higher casts; Bates (1989) argues that ethnicity of an owner affects the likelihood of exit in the U.S. This conclusion does not hold, however, in a later study of US manufacturing, services and retail business, which shows no significant relationship (Headd, 2003).

Founders' psychological dispositions affect business success as well. Small firms in Ontario, Canada, established by people who are 'overconfident' about their ability to manage day-to-day business operations, tend to survive longer (LeBrasseur & Zinger, 2005). Motivations for starting a business are another important factor. The desire of a founder to be more independent and to enjoy a more flexible schedule corresponds to greater longevity of his/her company in a study of U.S. manufacturing, services and retail sectors (Headd, 2003). On the other hand, firms set up in order to avoid unemployment do not live as long (Pfeiffer & Reize, 2000). This type of firm formation exhibits a counter-cyclical nature, with more companies established during economic downturns (Storey, 1991). It is unclear, though, if the owner's motivation or adverse economic conditions contribute most to the likelihood of exit. A number of studies show that start-ups founded during crises and closer to recessions are less likely to survive (Box, 2008; Dahl & Reichstein, 2005; Fotopoulos & Louri, 2000).

Human capital available to a firm is perhaps the most decisive performance factor among individual characteristics. Relevant experience of an owner or a manager consistently decreases hazard faced by a firm (Arribas & Vila, 2007; Headd, 2003; Wilbon, 2002). The size and diverse backgrounds of the co-founders or a management teams usually translates into increased probability to stay in business (Aspelund et al., 2005; Headd, 2003; Littunen, 2000). The effect of education differs across industries and regions. In the U.S., and in knowledge intensive industries in Europe, general and specific education levels tend to decrease hazard rates (Colombo & Grilli, 2007; Headd, 2003; Santarelli & Vivarelli, 2007; Saridakis et al., 2008). On the other extreme, several studies report negative or insignificant relationship between educational attainment and survival prospects (Arribas & Vila, 2007; Nafziger & Terrell, 1996; Persson, 2004). In fact, entrepreneurs with an education level below average establish a substantial share of firms (Christensen, 1997; Dahl & Reichstein, 2005).

A number of firm characteristics are strongly related to its likelihood of survival. Size and age, in general, decrease probability of exit (Geroski, 1995; Manjon-Antolın & Arauzo-Carod, 2008). The consistency of this relationship allowed researchers to coin two terms, 'liability of smallness' and 'liability of newness'[17]. Numerous studies use

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[17] 'Liability of newness' holds for specific industries. In a number of cases, 'liability of adolescence' determines firm survival.

business size to measure the ability of a firm to achieve minimum efficient size (MES), to benefit from some market power, and to access crucial resources, most notably capital and high-quality labor pool[18] (Aldrich & Auster, 1986; Audretsch, Houweling, & Thurik, 2000; Audretsch & Mahmood, 1995; Audretsch et al., 1999; Oliveira & Fortunato, 2006; Saridakis et al., 2008). The latter captures a greater likelihood of exit among young firms who have to deal with greater uncertainty about best management practices, their own level of efficiency, market conditions, and novelty in production (Fertala, 2008; Jovanovic, 1982; Shepherd, Douglas, & Shanley, 2000). As time passes, uncertainty subsides, and probability to survive increases in a non-linear fashion up to a point. After some time, a firm is likely to confront a greater hazard due to erosion of products and markets, organizational inertia, inability to respond to new technological challenges, and for other reasons.

Empirical research consistently confirms the ‘liability of smallness’ phenomenon(Box, 2008; Esteve-Perez, Sanchis-Llopis, & Sanchis-Llopis, 2004, 2010; Jensen et al., 2008; Persson, 2004), which in some cases is non-linear or marginal (Fotopoulos & Louri, 2000; Strotmann, 2007). The specific nature of the relationship, however, in many instances depends on the sector, industry and technology (Agarwal & Audretsch, 2001; Fritsch, Brixy, & Falck, 2006); stages of industry life cycle (Agarwal, Sarkar, & Echambadi, 2002); time horizon of a study (Audretsch, 1995b; Audretsch et al., 2000; Fritsch et al., 2006); and the degree of engagement in innovative activities

[18] Empirical research shows that firms tend to be larger in the regions characterized by higher business concentration (Holmes & Stevens, 2002) and that industries with larger average plant size are more likely to be spatially concentrated (Holmes & Stevens, 2004). These conclusions are drawn from multi-industry investigation at a county level. In this dissertation, however, size is unlikely to reflect the level of agglomeration because the larger and denser MSAs are included in the analysis, which is performed separately by industry and density group.

(Cefis & Marsili, 2006). The number of employees, either at start-up or current, is the most widely used approximation for a firm size. While the majority of empirical studies find a negative effect of firm size on hazard (Audretsch et al., 2000; Fotopoulos & Louri, 2000; Kaniovski & Peneder, 2008; Levitas, McFadyen, & Loree, 2006; Mata et al., 1995; Persson, 2004; Segarra & Callejón, 2002; Strotmann, 2007), in a few instances it is not statistically significant (Audretsch et al., 1999; Saridakis et al., 2008), which may be due to the specific characteristics of the estimated samples (Segarra & Callejón, 2002).

Age is another factor widely accepted as an important determinant of firm survival. Although age by itself is arguably irrelevant to the probability of exit and rather reflects a range of 'true' causes (Buddelmeyer et al., 2010), the challenge to determine and measure these 'true' factors leads researchers to employ simple and easily understandable age variables. This practically means that once all relevant characteristics are accounted for, age should become insignificant. Empirical studies find negative linear (Fontana & Nesta, 2010; Lin & Huang, 2008), inverse U-shaped (Agarwal & Gort, 2002; Esteve-Pérez & Mañez-Castillejo, 2008; Esteve-Perez et al., 2004; Kaniovski & Peneder, 2008; Nikolaeva, 2007), and insignificant (Agarwal et al., 2002; Buddelmeyer et al., 2010; Levitas et al., 2006) relationship between a firm's age and the likelihood of exit. In addition to being an important proxy for the unobservable determinants of firm life expectancy, age can influence the effects of other survival determinants such as technological activity (Agarwal, 1997), market selection mechanisms (Bellone, Musso, Nesta, & Quéré, 2008), and market fluctuations (Boeri & Bellmann, 1995).

Innovation, a firm's ability to come up with new solutions[19], plays a crucial role in superior business performance (Santarelli & Vivarelli, 2007) leading to greater productivity, sales, and profit (Morbey & Reithner, 1990; Zahra, 1996). Innovation may take various forms from developing revolutionary new products and corresponding markets to gradual improvements in operations, technology and management. Maintaining research efforts is a crucial element of a successful technological strategy (Christensen, 1992; Mitchell & Hamilton, 1988) that allows a firm to become and remain an industry leader (Wilbon, 2002). On the other hand, innovation imposes risks associated with potential liquidity constraints, inability to capitalize on the research results, lack of patent protection and others.

Empirical investigations suggest that innovation increases firm market value (Hall, Jaffe, & Trajtenberg, 2005), and reduces probability of exit (Audretsch, 1991; Esteve-Pérez & Mañez-Castillejo, 2008; Esteve-Perez et al., 2004; Fontana & Nesta, 2010; Huergo & Jaumandreu, 2004). In a number of cases, the effect of R&D is conditional on the type of innovation, product or process, a firm is engaged in (Manjon-Antolın & Arauzo-Carod, 2008), with process innovation promoting survival (Cefis & Marsili, 2006). Another important distinction is between innovative inputs and innovative outputs. While the former increase risks, the latter enhance business longevity (Buddelmeyer et al., 2010; Wilbon, 2002). In addition, R&D has dissimilar effect on various modes of exit (Esteve-Perez et al., 2010; Srinivasan, Lilien, & Rangaswamy, 2008).

A number of other factors contribute to business longevity. Firm profitability and productivity, in general, contribute to a longer life expectancy (Bellone et al., 2008;

[19] In this sense, innovation is closely related to the notion of Schumpeterian entrepreneurship.

Esteve-Pérez & Mañez-Castillejo, 2008; Esteve-Perez et al., 2010; Fotopoulos & Louri, 2000; Segarra & Callejón, 2002), and so does exporting (Esteve-Pérez & Mañez-Castillejo, 2008; Esteve-Perez et al., 2004, 2010). Likewise, pre-entry experience is usually associated with lower hazard(Bayus & Agarwal, 2007; Buenstorf, 2007; Fontana & Nesta, 2010; Persson, 2004) because spin-offs, branches, subsidiaries, and establishments with foreign participation can expect their parent or partner firms to grant access to additional resources during the time of hardships (Bridges & Guariglia, 2008; Chung, Lu, & Beamish, 2008; Delios & Beamish, 2001). In certain circumstances, nevertheless, subsidiaries are more likely to exit (Buddelmeyer et al., 2010), spin-offs to closely follow the fate of their parent (Dahl & Reichstein, 2005), while foreign-owned firms might not differ from the domestic ones in terms of survival (Mata & Portugal, 2004). Venture capital (VC), and venture capitalists' experience is another resource that may be available to a firm (Jain & Kini, 2000; Manigart, Baeyens, & Hyfte, 2002). VC-backed firms are more likely to be innovative in their operations and products (Hellmann & Puri, 2002; Kortum & Lerner, 2000), and to survive longer (Jain & Kini, 2000). In contrast, financial constraints increase hazard (Bridges & Guariglia, 2008; Fotopoulos & Louri, 2000; Headd, 2003; Musso & Schiavo, 2008; Saridakis et al., 2008).

3.2.2. Industry- and market-specific factors

Industrial and market characteristics significantly affect a firm's ability to live longer (Audretsch, 1991, 1995b). One reason is that market turbulence, which affects survival, is heavily dependent on industry type(Segarra & Callejón, 2002). International studies suggest that it is relatively easy for the entrants to survive in larger industries (see Bellone et al., 2008 for the case example of French manufacturing), and more difficult in older industries (see Kaniovski & Peneder, 2008 for the case example of Australian firms). There is some evidence that firms in high-trade industries live longer (see Álvarez & Vergara, 2010 for the case example of Chili), and that entrepreneurial regime, as described by Schumpeterian ‘creative destruction’, promotes improved performance and longer operation, particularly among new firms (see Lin & Huang, 2008 for the case example of Taiwan). Specific determinants important for firm survival include capital intensity, innovative and technological intensity, market concentration, level of competition, as well as industry and product life cycle.

The empirical relationship between capital intensity of an industry and business survival can be both positive and negative. On average, new companies in capital-intensive sectors tend not to live as long (Audretsch et al., 2000; Audretsch & Mahmood, 1995; Fotopoulos & Louri, 2000; Lin & Huang, 2008), perhaps due to their inability to achieve minimum efficient size and to realize economies of scale (Mata & Portugal, 2004). A firm may overestimate its ability to operate successfully in a capital intensive industry and will have to exit soon after it enters the market (Geroski & Mazzucato, 2001). More resourceful firms, on the other hand, may prefer to inter capital-intensive industries in a hope of less competition. This self-selection process is likely to translate into higher survival chances (Doms, Dunne, & Roberts, 1995).

In a similar vein, market competition reduces survival chances; however, if firms self-select, empirical studies find a positive relationship. Market concentration and market power, a possible approximation for the competition level, may promote (Lin & Huang, 2008; Segarra & Callejón, 2002) or hamper (Bellone et al., 2008; Strotmann, 2005) business longevity, depending on specific circumstances. Active industry entry decreases average business life expectancy (Kaniovski & Peneder, 2008). Highly technological and innovative industries exert greater competitive pressure on both entrants and incumbents (Agarwal & Gort, 2002; Audretsch, 1995b; Segarra & Callejón, 2002) but the way it translates into business longevity depends on a region, sector, and firm characteristics. The relationship between industrial technological intensity and hazard may be insignificant (Audretsch et al., 2000), negative (Kaniovski & Peneder, 2008), and positive for incumbents, while negative for young firms (Buddelmeyer et al., 2010). Often young, small, and highly innovative firms survive longer in technology-intensive sectors (Agarwal, 1997; Aspelund et al., 2005). Recent studies (Esteve-Perez et al., 2010; Fontana & Nesta, 2010) report a higher probability of acquisition in technologically intensive industries and a higher probability of liquidation in low-technology sectors. Furthermore, industrial technological intensity (Cefis & Marsili, 2005) and the degree of competition (Srinivasan et al., 2008) may moderate the effects of firm characteristics on business survival.

Probability of firm exit may depend on industry life cycle and the time of entry. The literature in most cases reports positive effects of industrial expansion on survival probability (Bellone et al., 2008; Kaniovski & Peneder, 2008; Mata et al., 1995; Segarra & Callejón, 2002). A few scholars, however, find a negative relationship (Audretsch et al., 2000). Moreover, as the industry matures, new firms become more likely to fail (Agarwal & Gort, 2002; Manjon-Antolın & Arauzo-Carod, 2008). One study finds that first entrants tend to be short-lived in markets with revolutionary product, and to enjoy first mover advantage in terms of life expectancy in the markets with incremental innovations (Min, Kalwani, & Robinson, 2006).

3.2.3. Regional and macroeconomic factors

Among firm survival determinants, regional factors are the least understood (Brixy & Grotz, 2007; Fertala, 2008; Fritsch et al., 2006; Manjon-Antolın & Arauzo-Carod, 2008). Regional characteristics are likely to have complex effects on firm survival. By facilitating a more efficient business performance that may be conducive to greater longevity, they are likely to intensify competitive pressure, which increases the likelihood of exit (Stuart & Sorenson, 2003). In addition, regional traits are likely to affect business survival indirectly via other variables; however, the ability of regional characteristics to shape firm performance depends on the industry (Broekel & Brenner, 2011), and the specific level of firm operation (Acs, Plummer, et al., 2009).

Effects of agglomeration and proximity to urban areas are perhaps the most studied determinants. Access to a labor pool of higher quality, proximity to suppliers, consumers and other firms is likely to improve the business prospects of a firm (Strotmann, 2007), its productivity and innovation (Stephan, 2011). Renski (2011) shows that industrial specialization of a region is associated with lower exit probability in a number of U.S. industries. Fotopoulos and Louri (2000) report a positive impact of proximity to Athens on the survival rates in the Greek manufacturing sector. On the other hand, overcrowding, higher rent and wage level may translate into shorter expected lifespan (Headd, 2003; Strotmann, 2007). The observed relationship usually depends on industry, region, and other conditions. For example, urbanization promotes firm longevity in two U.S. industries (computer and data processing and measuring, and controlling devices) but increases hazard in two others (drugs, and farm and garden machinery) (Renski, 2011). A few studies find insignificant or very limited impact of proximity to urban areas (Globerman, Shapiro, & Vining, 2005; Littunen, 2000).

The opposite of regional specialization, industrial diversity, and the corollary of urban economy, population density, also may influence business survival. Diversity, a proxy for Jacobian externalities, extends expected firm lifespan in knowledge-intensive industries in this country (Renski, 2011). As for the effect of population density, empirical studies find positive (Brixy & Grotz, 2007; Fertala, 2008), negative (Fritsch et al., 2006), and insignificant effect of density on firm longevity. Investigation of U.S. manufacturing shows a complex relationship between population density, firm survival, order of entry, and industry life cycle. A U-shape relationship between density and survival exists during the growth phase of an industry. In mature phases, this relationship holds only for mature phase entrants. The relationship is insignificant for growth phase entrants (Agarwal et al., 2002).

In general, business is responsive to macroeconomic conditions and national economic performance. Economic expansion ensures greater demand for almost all goods and services, thus creating favorable conditions for firm performance. Greater GDP is associated with lower hazard (Box, 2008; Klapper & Richmond, 2009; Nikolaeva, 2007). Higher NASDAQ index (Nikolaeva, 2007) and lower discount rates (Box, 2008) have similar effect. Boeri and Bellmann (1995), however, conclude that exits are not responsive to the overall business fluctuations in Germany.

CHAPTER 4: THE PROBLEM OF SURVIVAL ANALYSIS

Survival analysis is a technique that models time until a certain event happens. It provides tools to analyze time only or time as a function of covariates. For the purpose of this research, the unit of observation is a stand-alone firm; event means a firm exit, and survival time is the time a firm stayed in the market (from its birth to the event).

The problem of survival analysis incorporates several fundamental mathematical components[20]. Survival time is conventionally denoted by *T*, a positive continuous random variable with the following cumulative distribution function (CDF):

$$F(t) = \int_0^t f(u)d(u) = \Pr(T \leq t). \tag{1}$$

The CDF determines the probability that the actual survival time is equal or less than some arbitrary value *t* (a realization of random variable *T*), i.e. actual survival time of a unit of observation. *F(t)* is assumed to be differentiable, which means that a density function is defined by

$$f(t) = \frac{dF(t)}{d(t)} = F'(t) = \lim_{\Delta t \to 0} \frac{F(t+\Delta t) - F(t)}{\Delta t} \tag{2}$$

f(t) is an unconditional failure rate during some short period t. The density function can also be expressed in terms of probability:

$$f(t) = \lim_{\Delta t \to 0} \frac{\Pr(t \leq T \leq T + \Delta t)}{\Delta t}. \tag{3}$$

[20] Discussion in this chapter is based on Box-Steffensmeier and Jones (2007) and Cleves et al. (Cleves, Gutierrez, Gould, & Marchenko, 2010)

Another important component of the survival analysis problem is the survivor function *S(t):*

$$S(t) = 1 - F(t) = \Pr\,(T \geq t). \qquad (4)$$

S(t) denotes the probability that the survival time lasts longer than some arbitrary value *t*. Alternatively, it can be interpreted as the proportion of units that survive beyond point *t.* If we divide the failure rate at specific point in time by the total number of survivors up to and including this point, we would get the hazard rate:

$$h(t) = \frac{f(t)}{S(t)},$$

which also can be expressed in terms of probability:

$$h(t) = \lim_{\Delta t \to 0} \frac{\Pr\,(t \leq T \leq t + \Delta t | T \geq t)}{\Delta t} \qquad (5)$$

The hazard rate describes the probability of a unit to fail in certain period of time provided that it has survived up to this point. Failure depends on survival and eventually depends on time. To allow for dependency on covariates, (5) can be written as follows:

$$h(t|\boldsymbol{X}) = \lim_{\Delta t \to 0} \frac{\Pr\,(t \leq T \leq t + \Delta t | T \geq t, \boldsymbol{X})}{\Delta t} \qquad (6)$$

The hazard function can range from zero to infinity. Given one of these functions(cumulative distribution function, density function, survival function, hazard function), the other three are completely defined.

To estimate (6) one can use semi-parametric or parametric techniques. The Cox proportional hazards regression is a semi-parametric model that does not make any assumptions about distribution of failure times[21]. Hazard may be increasing, decreasing,

[21] It is called semi-parametric because it assumes a functional relationship between covariates and the event.

constant or changing direction; the model leaves it unspecified (Cleves et al., 2010) and is usually used as a default one because of its flexibility (Allison, 2010). For the Cox regression results to be valid, proportionality assumption has to be satisfied, i.e. the covariates should shift the baseline hazard function in a proportional way.If proportionality assumption is violated[22], parametric models have to be used. This class of models assumes that failure times are distributed following specific distribution such as exponential, Weibull, log-normal, and log-logistic among others. If the functional assumption is correct, parametric analysis is more efficient than semi-parametric because the former uses data in all periods, even when no failures happen.

For the purposes of this research, I use a semi-parametric Cox regression model when the proportionality assumption holds and a log-logistic regression when it does not. Chapter 7 describes both techniques in greater detail.

[22] In addition, parametric models are better suited to estimate data with left censoring and interval censoring; they are also able to predict failure times.

CHAPTER 5: CONSTRUCTING THE DATASET

5.1. National Establishment Time-Series (NETS) Database

The NETS Database is created by Walls & Associates from the Dun and Bradstreet's (D&B) DUNS Marketing Information archive[23]. The database consists of yearly snapshots of the U.S. economy (all firms recoded by D&B to be active) performed every January since 1990. The database is updated every summer. If an establishment goes out of business, its last year of operation is indicated but the record is not removed. This allows for study of active companies, and establishments that have exited. The NETS file available for this research is a subset of the original Database. The file contains longitudinal information about each establishment started in 1991 including company name, county FIPS code, years of operation (first and last years in the dataset, year the business has started), industry classification (6-digit NAICS code), type of establishment (standalone, branch, headquarter), and estimated number of employees.

5.2. Establishments

One way to approximate business longevity in a region is by calculating the average age of all existing establishments or to classify establishments in age groups (Cefis & Marsili, 2006). A related firm-level approach involves tracing survival of existing businesses through time (Lin & Huang, 2008). Focus on existing firms in

[23] D&B is a public company that collects and licenses information on businesses, which is used in credit decisions. More information is available at www.dnb.com

survival analysis, so-called stock sampling, excludes firms that have
exited before the study commenced. This may lead to biased results, as long-living firms are overrepresented. Another approach is to divide the number of firms that survived past a certain age (usually three years) by the total number of entrants. Several studies use this method (Acs et al., 2007; Brixy & Grotz, 2007). Perhaps the most robust way is to track individual firms from their birth to exit, or until the end of the study period. Renski (2011) follows this approach. He uses a longitudinal database (LDB) of the U.S. Bureau of Labor Statistics to investigate the effects of regional economies of localization, industrialization, and industrial diversity on firm survival. The author observes firms established in 1994 and 1995in selected manufacturing and service industries for seven years.

The latter approach is followed in this research. In the NETS Database, I identify all establishments[24] created in the U.S. MSAs[25]in year 1991 (variable YEARSTART=1991[26]) in selected industries[27]. An establishment is assumed to be alive until the last year it was recorded in the Database (YEARLAST). I track the selected companies until the last year in the database or year 2008, whichever happens first. As a

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[24] The NETS Database includes records of all establishments (not firms or companies) reported by D&B. It has relationship indicators, which identify a headquarter organization for each establishment. Only stand-alone establishments (DUNS Number, primary Database identifier, is the same in ID and HEADQUARTER fields of the NETS Database) are included in the estimation; therefore, I use terms ‘establishment’, ‘firm’, and ‘company’ interchangeably.

[25] Establishments started outside of metropolitan areas as defined by the November 2008 definition of MSAs by the Office of Management and Budget are excluded from the analysis.

[26] A number of establishments have YEARSTART=1991 but appear in the database after year 1992. Such observations have up to 16 years of missing data; they were not used in the estimation.

[27] The next subsection explains the industry selection process and presents descriptive statistics of the firm sample by industry.

result, there are up to 17 observations for each firm. Focusing on seventeen consecutive years of firm life gives plenty of variation in the survival rates, explanatory, and control variables to capture statistically significant patterns and relationships. Most importantly, the study tracks establishments during the years that are, according to the literature, most troubled in terms of survival. The majority of exits occur in the first five to six years of operation. After this, the hazard rate is relatively low and close to being flat, at least for some time. At more 'senior' years, a firm can experience the so-called liability of senescence, which starts in some cases after 50 years of being on the market (Esteve-Perez et al., 2004).

The survival literature suggests that firm exit does not necessarily represent failure. Mergers and acquisitions (M&A) are often regarded as a successful exit. Different factors are likely to lead to each exit mode, or common determinants may have dissimilar effects (Esteve-Perez et al., 2010). If a firm enters a market with profit expectations and exits for reasons other than M&A, it likely has failed to achieve required profitability. This may be the result of its poor performance, or of any entry mistake when a business does not know market conditions or its own efficiency level (Jovanovic, 1982). In geographic areas with greater accumulated stock of economically useful knowledge (Acs & Plummer, 2005) and spatial proximity, knowledge spillover should increase productivity as a result of increased innovation and adoption of new technologies (Feldman & Audretsch, 1999; Jaffe et al., 1993; Koo, 2005a). The agglomeration literature suggests that, when knowledge spillovers take place, more information about business opportunities should be available (Porter, 1998), thus reducing the likelihood of an entry mistake. If innovation in a metropolitan area has positive external effects on firm survival, it should manifest itself through a lower probability of all exit modes but M&A. To ensure that various exit modes do not contaminate the estimation results, I exclude establishments that went through M&A from my analysis and retain only the exit cases that can be viewed as a failure. Information from the Deal Pipeline, Wharton Research Data Services, and Alacra Store were utilized to determine an exit mode for each firm in the datasets.

This research focuses on establishments located in the continental U.S. MSAs. Scott (2006) argues that creativity and innovation manifest themselves most meaningfully at the urban and regional level. External effects of innovation, if present, are likely to be most pronounced in urban areas for a number of reasons. A disproportionate share of innovative activity takes place in metropolitan areas (Acs, Anselin, & Varga, 2002; Bettencourt, Lobo, & Strumsky, 2007). Second, knowledge spillovers, necessary for positive effects of innovation on non-inventive firms' performance, depend on density and agglomerations (Griliches, 1992; Koo, 2005b; López-Bazo et al., 2004). Lastly, to identify regional effects, one needs to use a geographic region with meaningful boundaries that encompass economic activity. States, counties, and cities are inappropriate choice for such purpose as their limits are likely to be arbitrary with regard to the existing patterns of economic activity (Acs et al., 2007). U.S. Metropolitan Statistical Areas[28] are a better choice. A county of at least 50,000 residents or an urbanized area (a group of adjacent counties) with at least 100,000 residents is called a MSA if stable and significant commuting patterns, economic and social links exist within this area. The definitions (boundaries) of MSAs are constantly re-defined by the Office of

[28] I follow the November 2008 definition of MSAs by the Office of Management and Budget.

Management and Budget (OMB) to reflect the current state of economic linkages in U.S. urban areas.

To factor out the effects of firms' own R&D efforts on survival (Cefis & Marsili, 2005), firms with at least one patent filed before year 2009 are not included in the estimation. To identify such firms, the U.S. Patents and Trademark Office (www.uspto.gov) database was searched by entering a firm's name in the Assignee Name filter, and its state in the Assignee State filter. Absolute matches were removed.

According to the literature, survival dynamics differs among stand-alone firms, and firms that are branches or headquarters (Bridges & Guariglia, 2008; Chung et al., 2008; Delios & Beamish, 2001). The latter are usually hedged by the resources and experience their associated companies have (Agarwal, Echambadi, Franco, & Sarkar, 2004; Balconi & Fontana, 2011; Buenstorf, 2007). In addition, existing firms' spin-offs usually represent an attempt to capitalize on economies of scale rather then to pursue promising market opportunities. As a consequence, the ability of dependent firms to promote structural change is limited (Koster, 2011). For these reasons, headquarters and branches of existing firms are excluded from estimation. Large firms (with more than 100 employees in the first year of operation) are also excluded. These companies are likely to be qualitatively different from the small ones (Aldrich & Auster, 1986; Audretsch et al., 1999). Besides, large start-up companies might be miscoded branches or spin-offs of other enterprises (Renski, 2011). Table 2 presents all categories that were removed from the estimation file, and firm counts by category.

Table 2. Total number of start-ups in 1991, and establishments in the estimation file

Description	High technology manufacturing[29]	High technology services
Total number of start-ups in 1991	**2,658**	**2,162**
Outside of continental USA	11	20
Outside MSAs	229	113
Not independent	261	329
Have at least one patent	172	8
Experienced M&A	12	9
Have more than 100 employees in 1992	6	32
Outliers	1	10
Missing/erroneous data in NETS	325	293
Total establishments in the sample	**1,641**	**1,348**

Source: NETS Database, U.S. PTO, The Deal Pipeline, WRDS, Alacra Store

According to the NETS Database, 2,658 establishments were started in 1991 in computer and electronic product manufacturing, which represents the high-tech manufacturing (HTM) sector as defined in this research (5.8% of all 1991 start-ups in the country). Firm formation in healthcare, representing high-technology services (HTS), considered in this dissertation was somewhat lower. Only 2,162 establishments started operation in 1991 (this constitutes 4.7% of total number of start-ups in the country). More than 30% of the newly created firms in each sector are excluded from estimation for various reasons. Figures5 and 6 show the geographic distributions of 1991 start-ups in computer and electronic manufacturing and healthcare, respectively.

[29] The next subsection describes high-tech manufacturing and high-tech services.

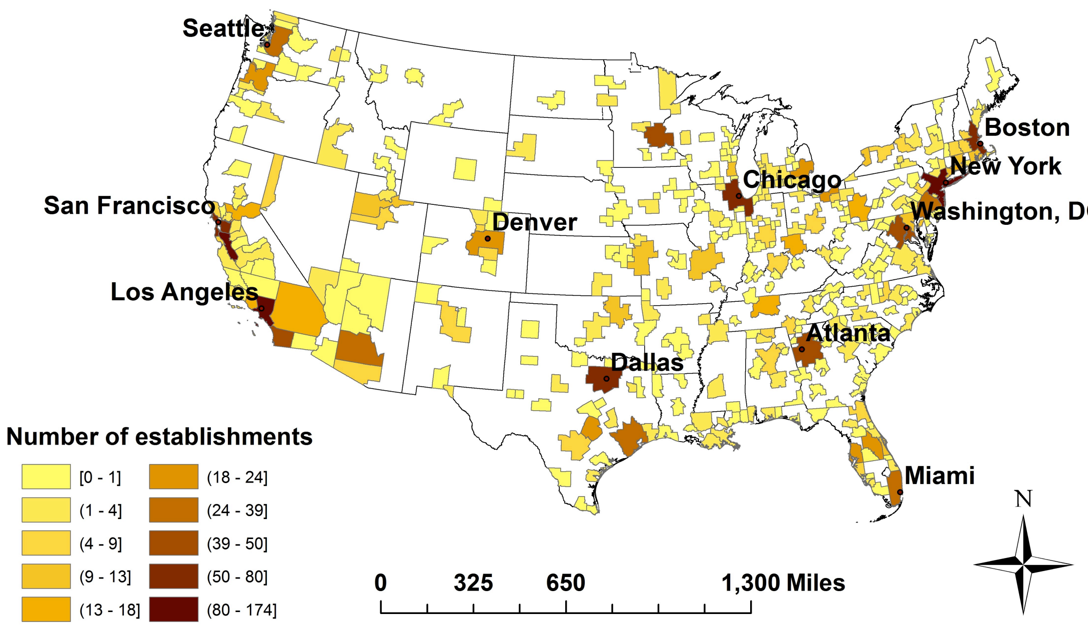

Figure 5. Total number of computer and electronic product manufacturing start-ups in continental MSAs in 1991

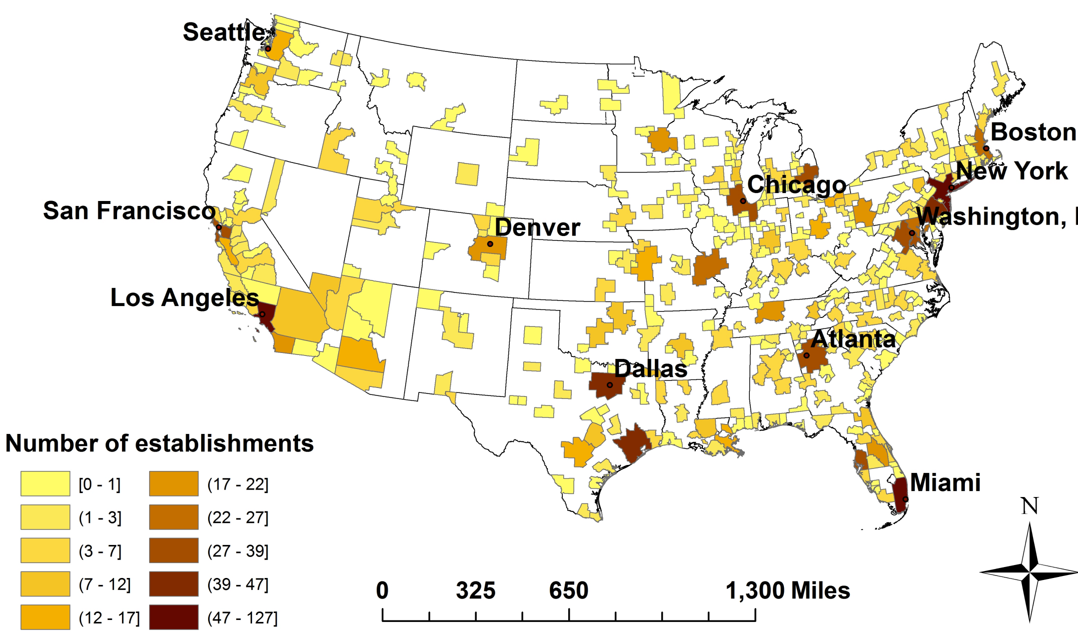

Figure 6. Total number of healthcare services start-ups in continental MSAs in 1991

New firms in high technology manufacturing clearly tend to locate in largest MSAs. All major U.S. cities enjoyed a large number of start-ups in computer and electronic

product manufacturing. Firms in healthcare, although somewhat
gravitating to large metropolitan regions, are more located in the East and in the South of the country.

Figure 7 and Figure 8 present firm formation in the sectors of interest per 100,000 residents. The distributions clearly differ from the ones presented in the previous two figures.

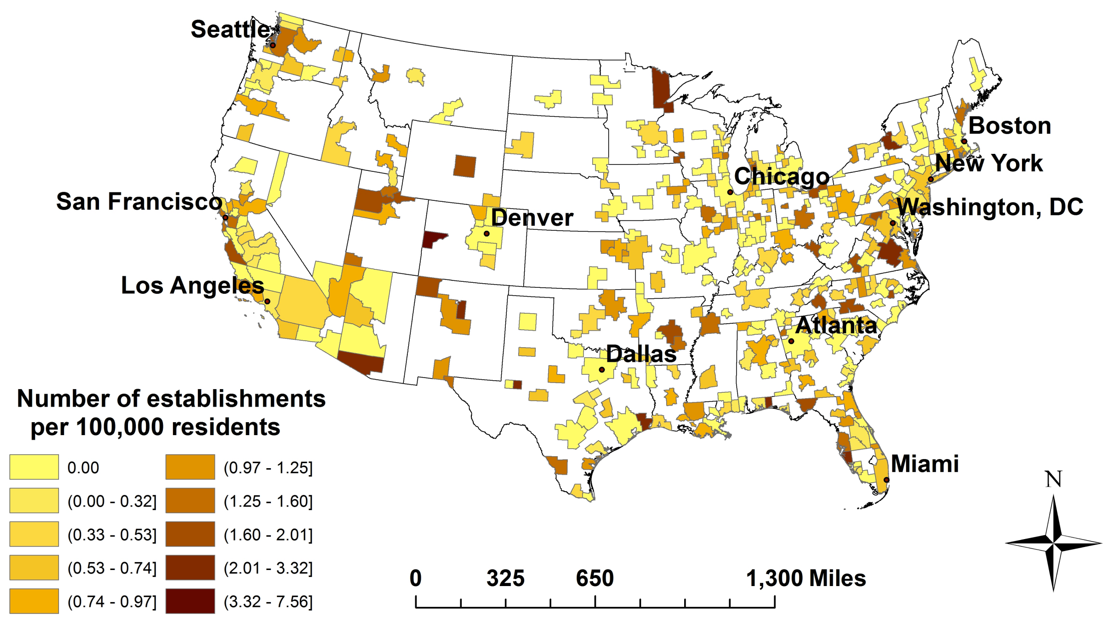

Figure 7. Number of computer and electronic product manufacturing start-ups per 100,000 residents in continental MSAs in 1991

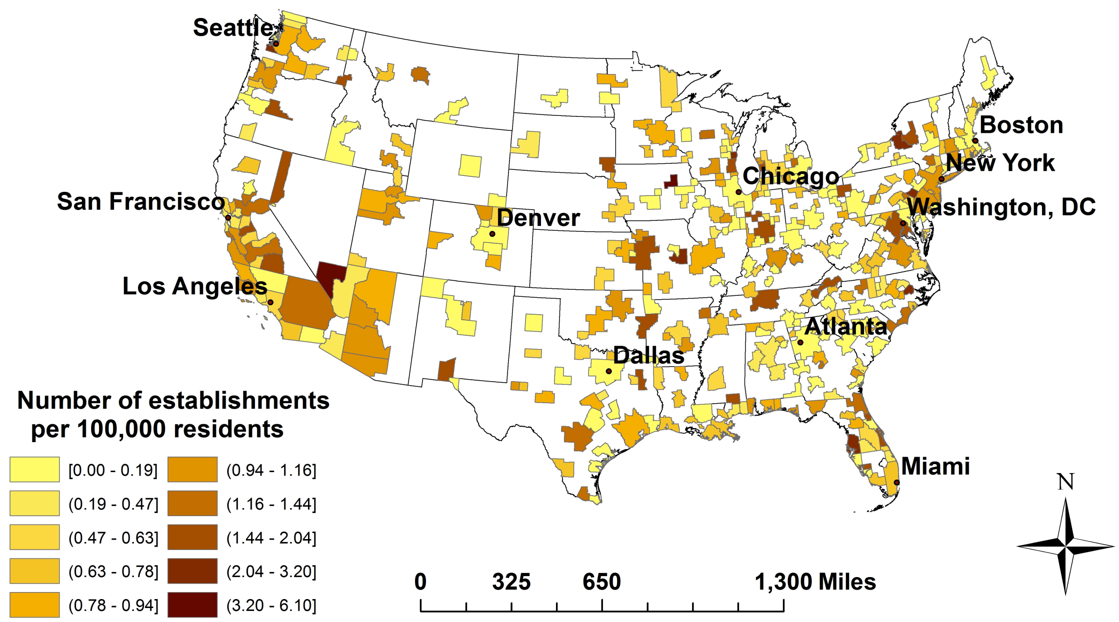

Figure 8. Total number of healthcare start-ups per 100,000 residents in continental MSAs in 1991

5.3. Selected industries

The effects of the innovative environment on firm survival differ among industries (Audretsch, 1995b). Highly innovative industries, which employ people inclined to pick up new ideas from the surrounding and to promptly introduce them into practice, are likely to be more perceptive to the overall innovativeness of a geographic region. Likewise, industries with a production process that allows quick implementation of innovations and experimenting without excessive sunk costs should be expected to benefit more from the level of invention in an area. Due to their individual specificities, other industries might be less sensitive to the 'innovative atmosphere'. In general, the intensity of spillovers depends on the industry (Glaeser et al., 2002).

At the same time, the competition regime is likely to be unique in every industry, as should be the impact of innovation on firm longevity via competition (Fritsch et al., 2006;

Segarra & Callejón, 2002). This necessitates testing for external effects of innovation on business life expectancy separately by industry. To encompass both manufacturing and service ends of the U.S. economy, I study a high-technology manufacturing sector and a high-technology service sector. The focus on high-technology industries is determined by their substantial contribution to the national welfare and growth (Koo, 2005b). According to the BLS[30], computer and electronic product manufacturing is of particular importance to the national economy, and the importance is likely to grow in the future. The technology used, and manufacturing processes employed in this industry are rather unique and make it different from other, extensively studied in the literature, manufacturing. Healthcare services are provided by trained healthcare practitioners, often with the highest level of education. In many instances, the sector uses high-technology armamentarium and advanced techniques of health care provision. If any of the services sectors are perceptive to the innovative environment, healthcare is likely to be the one. In addition, the sector is a fast growing one and this trend will continue, suggesting ever increasing role of the healthcare services in the future. Focusing on both computer and electronic product manufacturing and healthcare services allows capture different dynamics of the two sectors determined by dissimilar characteristics. The list of industries in each sector identified by the 4-digit NAICS codes is given in Table 3.

Table 3. Industries included in each sector by 4-digit NAICS classification

Code	**Industry**
High-technology manufacturing sector	
NAICS3341	Computer and Peripheral Equipment Manufacturing

[30] Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook, 2012-13 Edition*, Career Guide to Industries, on the Internet at http://www.bls.gov/ooh/about/career-guide-to-industries.htm (visited June 13, 2012).

Table 3 (continued)

NAICS3342	Communications Equipment Manufacturing
NAICS3343	Audio and Video Equipment Manufacturing
NAICS3344	Semiconductor and Other Electronic Component Manufacturing
NAICS3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing
NAICS3346	Manufacturing and Reproducing Magnetic and Optical Media
High-technology services sector	
NAICS6214	Outpatient Care Centers
NAICS6215	Medical and Diagnostic Laboratories
NAICS6216	Home Health Care Services
NAICS6221	General Medical and Surgical Hospitals
NAICS6222	Psychiatric and Substance Abuse Hospitals
NAICS6223	Specialty (except Psychiatric and Substance Abuse) Hospitals

5.3.1. Computer and electronic product manufacturing

According to the classification followed by the Bureau of Labor Statistics, all industries indicated in Table 2 under the high-technology manufacturing label belong to the computer and electronic product manufacturing (in what follows, high-technology manufacturing, and computer and electronic product manufacturing are used interchangeably). This sector is one of the most innovative in the U.S. economy[31]. Its advances are largely based on the development and introduction of new products, technologies, and software. There is a high pressure on the companies in this sector to innovate, thus explicit emphasis on R&D in the day-to-day operations. A relatively small fraction of the employees is production workers, as opposed to other, more 'traditional' industries. The sector is predominantly comprised of small and medium size companies with a few very large companies, which often dominate the market.

[31] The discussion in this sub-section is mainly based on *Career Guide to Industries* by the U.S. BLS (Bureau of Labor Statistics, U.S. Department of Labor, *Career Guide to Industries, 2010-11 Edition*, Computer and Electronic Product Manufacturing, on the Internet at http://www.bls.gov/oco/cg/cgs010.htm, visited August 18, 2011)

In 1991, according to the NETS Dataset, 2,658 establishments were started. Out of those, 1,641 are included in the analysis. Only 601 of them managed to survive through year 2008. From 12 to 141 establishments per year exited during 1992-2008 (Figure 9).

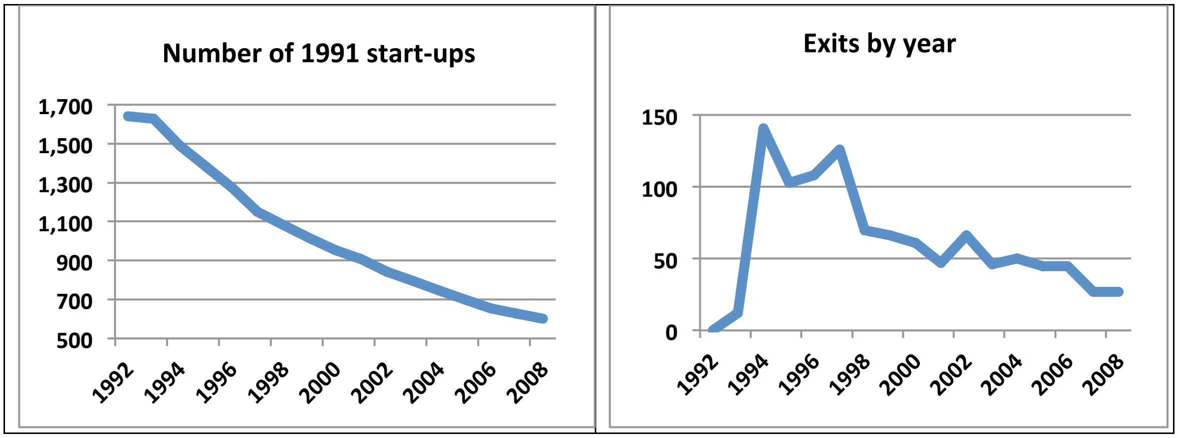

Figure 9. Number of exits and surviving firms started in 1991 in computer and electronic product manufacturing

Source: NETS Database, own calculations

5.3.2. Healthcare

I include six 4-digit NAICS healthcare industries in the high-technology service. This sector is one of the fastest growing. This trend is likely to persist due to population aging in this country[32]. The firm size profile of the sector is very diverse. Usually hospitals (about 1 percent of all healthcare companies) are large entities employing about a third of healthcare employees. At the same time, the majority of establishments are

[32]The discussion in this sub-section is mainly based on *Career Guide to Industries* by the U.S. BLS (Bureau of Labor Statistics, U.S. Department of Labor, *Career Guide to Industries, 2010-11 Edition*, Computer and Electronic Product Manufacturing, on the Internet at http://www.bls.gov/oco/cg/cgs035.htm (visited August 18, 2011).)

small, with almost half of all establishments employing up to 5 workers. Technological advances have improved the quality of U.S. healthcare considerably; however, the speed of innovation implementation is likely to be lower than in the computer and electronic component manufacturing where it defines firm survival and market success.

1,348 healthcare establishments started in 1991 enter the analysis. Less than half of those managed to survive till the end of the observation period (658 total). The pattern of exits differs from that of computer and electronic component manufacturing. On average, fewer firms go out of business and the number of exits is less variable (Figure 10).

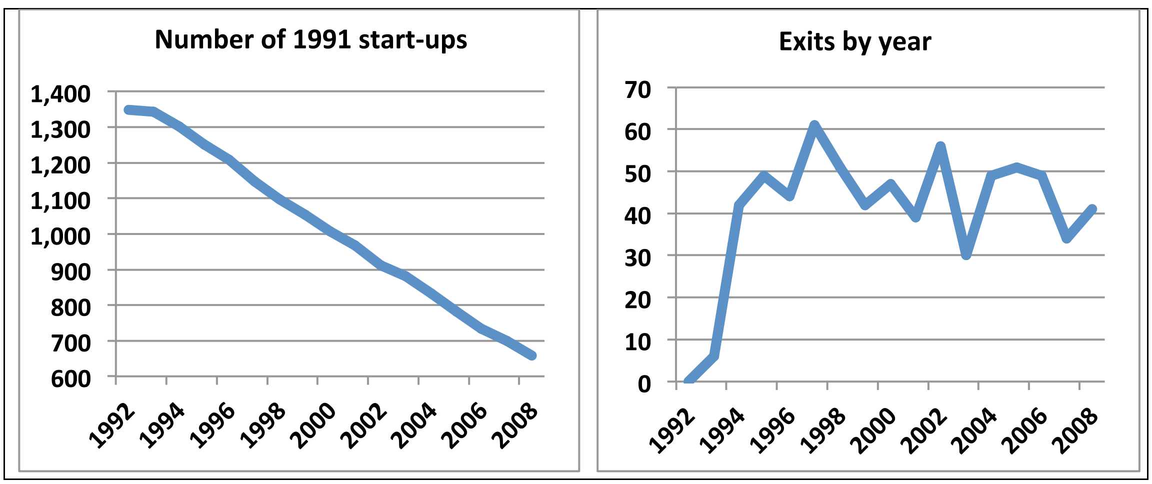

Figure 10. Number of exits and surviving firms started in 1991 in healthcare
Source: NETS Database, own calculations

5.3.3. Sample properties by industry

My estimation samples contain 1,641 start-ups in computer and electronic component industry and 1,349 start-ups in healthcare. More than half of these establishments exit during the time of the study; however, the patterns of entry and survival differ in the two sectors. Computer and electronic product manufacturing firms have greater chances to earn abnormal profits as a result of new ideas and technical advances that can be marketed relatively easy. This attracts more entrants; however, the new opportunities may be illusory or exhaust themselves in a short time. In my sample, this is reflected in high entry and exit rates. Healthcare firms enjoy more stable markets with limited opportunities of abnormal profits. Fewer firms enter this industry but the exit rates are also lower (Figure 11).

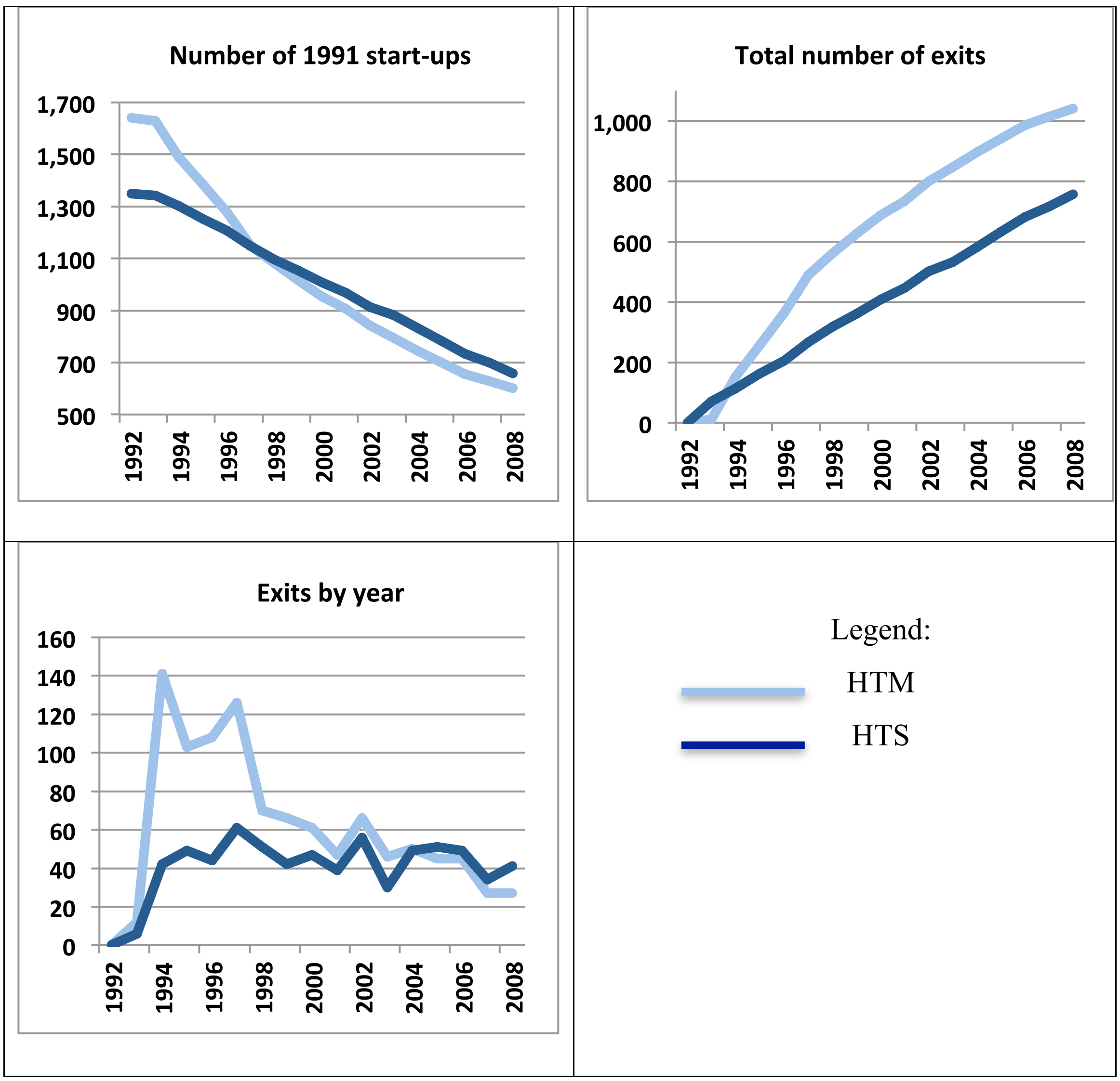

Figure 11. Total number of firms, exits, and exit dynamics in high-tech manufacturing and high-tech services
Source: NETS Database, own calculations

Different patterns of entry and exit in the two sectors translate into specific distribution of average age of the 1991 cohorts in high-tech manufacturing and healthcare displayed in Figures 12 and 13 respectively. To calculate the average age of the 1991 start-ups in each metropolitan area, the average age of all surviving companies was determined for every MSA-year pair. Summing over each MSA and dividing by the total number of years produces data that underlies the maps below.

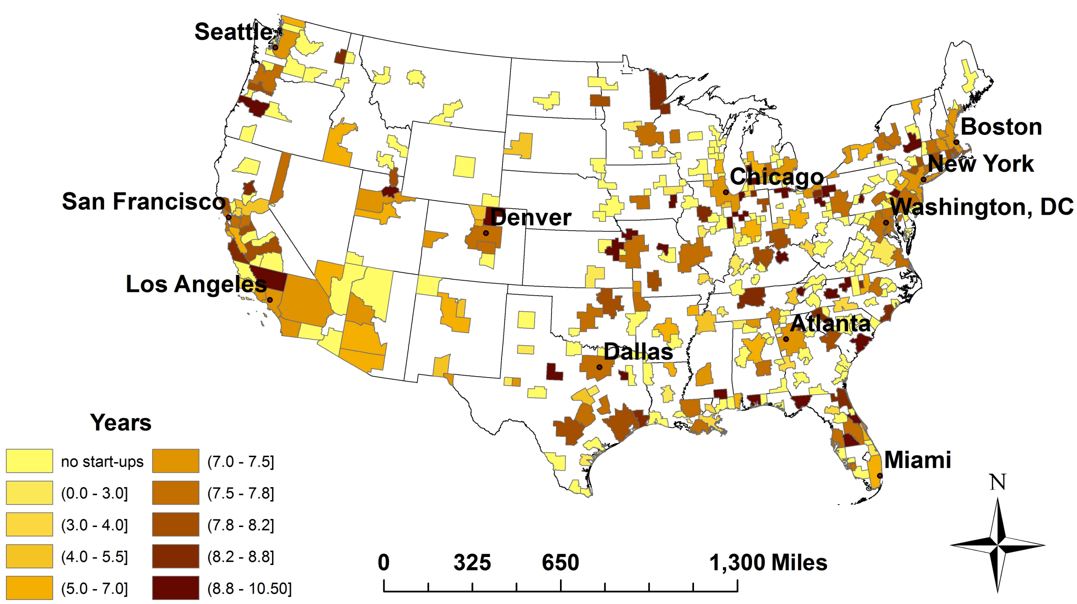

Figure 12. Average age of 1991 computer and electronic product manufacturing start-ups during the study period

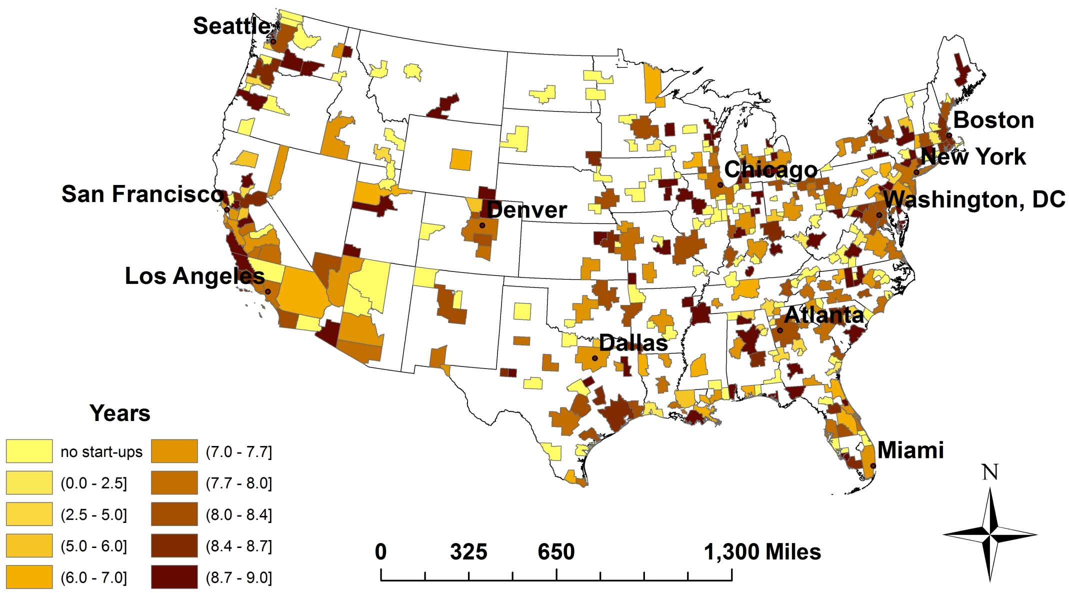

Figure 13. Average age of 1991 healthcare services start-ups during the study period

In general, the survival rate of new entrants is usually low. After analyzing Longitudinal Database collected by U.S. BLS, Knaup (2005) reports 84% one-year survival rate, and 57% 3-year survival rate among manufacturing firms started in 1998. Another study examines survival rates of stand-alone manufacturing firms using the NETS Database (Audretsch, 1995a). It finds that 63% of all firms survive for four years, and only 37% live for more than eight years. In general, manufacturing survival rates in my sample are higher than the survival rates reported by the previous research. Almost 78% of establishments in high-technology manufacturing live for at least five years, and 55% survive till 10 years. The discrepancy may result from differences in industry selection. Survival rates in healthcare are even higher, with 89% and 72% of 1991 start-ups still in business after five and10 years respectively (Figure 14).

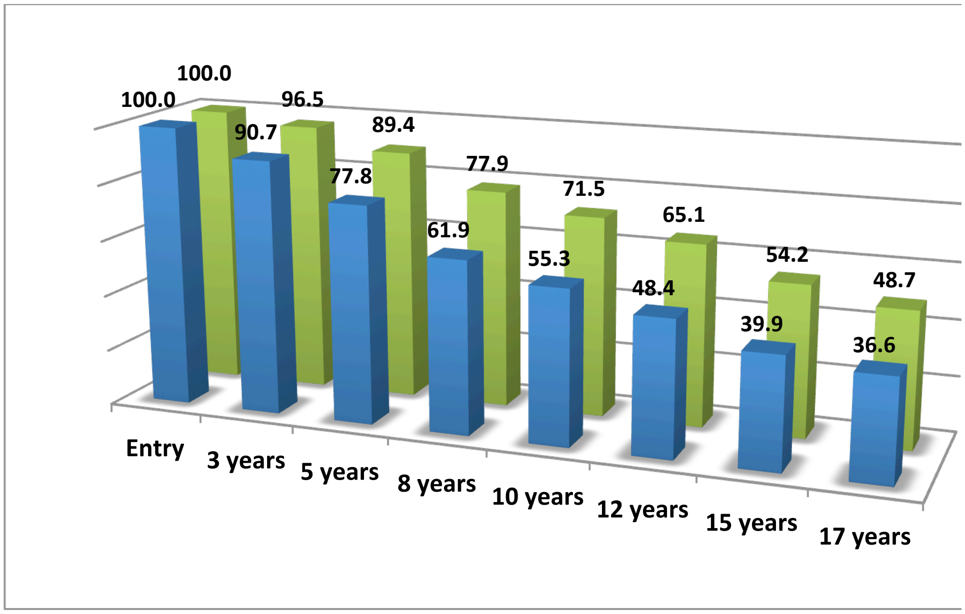

Figure 14. Survival rates in computer and electronic component manufacturing and healthcare
Source: NETS Database, own calculations

Another way to examine the survival dynamics of firms in an industry is to look at empirical hazard functions[33]. The hazard function, *h(t)*, is the instantaneous rate of failure, which measures, in its limit, the probability of failure in a given period conditional on survival to that period. Re-writing (6) from the previous chapter:

$$h(t) = \lim_{\Delta t \to 0} \frac{\Pr(t + \Delta t > T > t | T > t)}{\Delta t}$$

where *T* is a non-negative random variable that denotes time to failure. The cumulative hazard function, *H(t),* measures total expected number of failures in a time period up to time *t* if failures can repeat.

[33] I use continuous time survival models to estimate the relationship between innovativeness in MSA and business longevity. In general, firm exit can happen in any moment in time, which makes it a continuous phenomenon. A firm's survival time, however, is recorded in discrete intervals (years) but discrete-time modeling is not an appropriate technique due to a continuous nature of the underlying process.

$$H(t) = \int_0^t h(u)du \qquad (7)$$

Cumulative hazard function is estimated using the Nelson-Aalen estimator:

$$H_{N-A}(t) = \sum_{j|t_j \leq t} \frac{d_j}{n_j} \quad (8)$$

where n_j is the number of subjects at risk at time t_j, d_j is the number of failures at time t_j, and summation is over all possible failure times up to t (Cleves et al., 2010).It follows from (2) that the hazard function is a first order derivative of the cumulative hazard function *H(t).* The Nelson-Aalen estimator produces a step function, which cannot be directly differentiated to obtain instantaneous hazard function *h(t)*. I use the Stata command `sts graph, hazard` to plot empirical hazard functions. It employs the kernel smoother suggested by Muller and Wang (1994)[34].

Figure 15 presents smoothed empirical hazard estimates for computer and electronic component manufacturing (solid curve), and healthcare services (dashed curve). Companies belonging to high-technology manufacturing face greater hazard across the entire study period. The gap between the hazards reaches its maximum at around six years and converges nonlinearly after this mark. The highest hazard in high-technology manufacturing occurs between five and six years with the second peak at the age of 10 years. After that date, the likelihood of exit rapidly declines. The hazard faced by high-technology service firms steadily increases from the founding year until a firm reaches the age of 12-13 years. If a business managed to survive past this point, the

[34] $\hat{h}(t) = b^{-1} \sum_{j=1}^{D} K_t\left(\frac{t-t_j}{b}\right) \Delta\hat{H}(t_j)$, where D denotes all possible failure times t_j, $K_t(\bullet)$ is some kernel function, b is a bandwidth, and $\Delta\hat{H}(t_j) = \hat{H}(t_j) - \hat{H}(t_{j-1})$is the estimated hazard contribution at each failure time t_j(Cleves et al., 2010).

likelihood of exit gradually decreases. The parabolic shape of the hazard functions support the 'liability of newness' combined with 'liability of adolescence' hypotheses advanced in the survival literature (Agarwal & Gort, 2002; Esteve-Pérez & Mañez-Castillejo, 2008; Esteve-Perez et al., 2004; Fontana & Nesta, 2010; Kaniovski & Peneder, 2008; Lin & Huang, 2008; Nikolaeva, 2007).

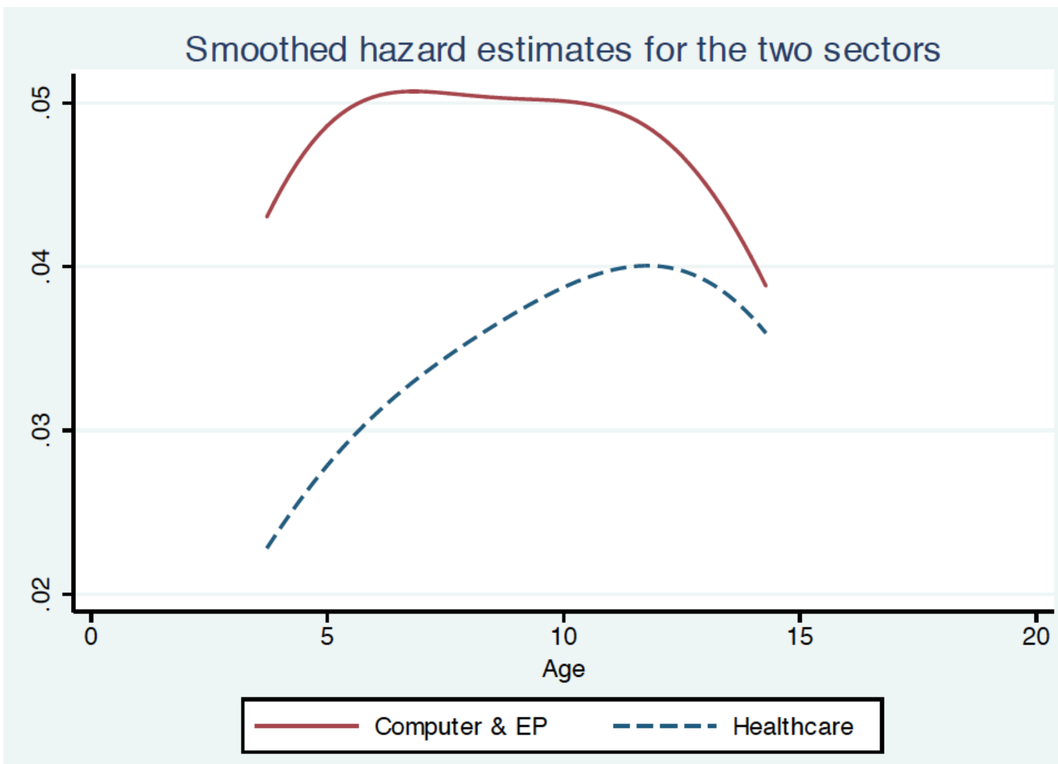

Figure 15. Empirical hazard rates in each sector

The two sectors differ also in terms of geographical patterns of firm formation. New computer and electronic product manufacturing firms were established in 197 MSAs in 1991, 8.3 companies per MSA on average. In 56 metropolitan areas (28% of the 197) only one new firm started operating. Two MSAs had more than 100 establishments set up in 1991. Table 4 lists the six metropolitan areas with the highest high-tech manufacturing firm formation.

Table 4. Top six MSAs in firm formation in computer and electronic component manufacturing in 1991

MSA	Number of start-ups	% of all start-ups[35]
Los Angeles-Long Beach-Santa Ana, CA	155	9.45
New York-Northern New Jersey-Long Island, NY-NJ-PA	124	7.56
San Jose-Sunnyvale-Santa Clara, CA	96	5.85
San Francisco-Oakland-Fremont, CA	69	4.20
Dallas-Fort Worth-Arlington, TX	57	3.47
Chicago-Joliet-Naperville, IL-IN-WI	57	3.47
Total	**558**	**34.00**

Source: NETS Database

In the healthcare sector, fewer firms were established in 1991 on average (5.6 per MSA), but new establishments started operating in 246 metropolitan areas. 77 MSAs (31% of 246) had one new healthcare firm. Table 5 presents the five top MSAs in healthcare firm formation in 1991.

Table 5. Top five MSAs in firm formation in healthcare in 1991

MSA	Number of start-ups	% of all start-ups
New York-Northern New Jersey-Long Island, NY-NJ-PA	111	7.85
Miami-Fort Lauderdale-Pompano Beach, FL	75	5.30
Los Angeles-Long Beach-Santa Ana, CA	74	5.23
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	43	3.04
Chicago-Joliet-Naperville, IL-IN-WI	37	2.62
Total	**340**	**24.04**

Source: NETS Database

[35]Percentage of all start-ups in a corresponding sector (as opposed to start-ups in all industries). The same applies to Table 5.

Rosenthal and Strange (2003) show that if an industry is well-represented in a region (has more workers), new firms belonging to the industry are more likely to be established in such a region. This supposition is confirmed in present research. The number of existing firms in an industry, total number of firms in a MSA, and patenting activity are correlated with the total number of start-ups in a MSA (Table 6)[36]. More populated metro areas and metro areas with larger economies enjoy highest firm formation rates.

Table 6. Pairwise correlations between 1991 start-ups and MSA economic characteristics

MSA characteristics	**Number of HTM start-ups**	**Number of HTS start-ups**
Population	0.8729 (0.000)	0.9245 (0.000)
Total number of firms in a corresponding sector	0.983 (0.000)	0.941 (0.000)
Firm density in a corresponding sector	0.145 (0.006)	0.063 (0.231)
Total number of firms	0.841 (0.000)	0.940 (0.000)
Total number of new firms	0.825 (0.000)	0.943 (0.000)
Overall business density	0.133 (0.011)	0.092 (0.079)
Total number of patents	0.952 (0.000)	0.747 (0.000)
Total number of patents per 1000 residents	0.370 (0.000)	0.115 (0.028)
Total number of related patents	0.815 (0.000)	0.765 (0.000)
Total number of related patents per 1000 residents	0.387 (0.000)	0.137 (0.009)

Source: NETS Database, U.S. PTO, BEA

[36] In calculation of MSA characteristics that include number of firms, 1991 start-ups in the sectors of interest were subtracted in order to avoid double counting.

Figures 16 and 17 present the maps of the new start-ups as a percentage of the total number of incumbent firms in the same sector.

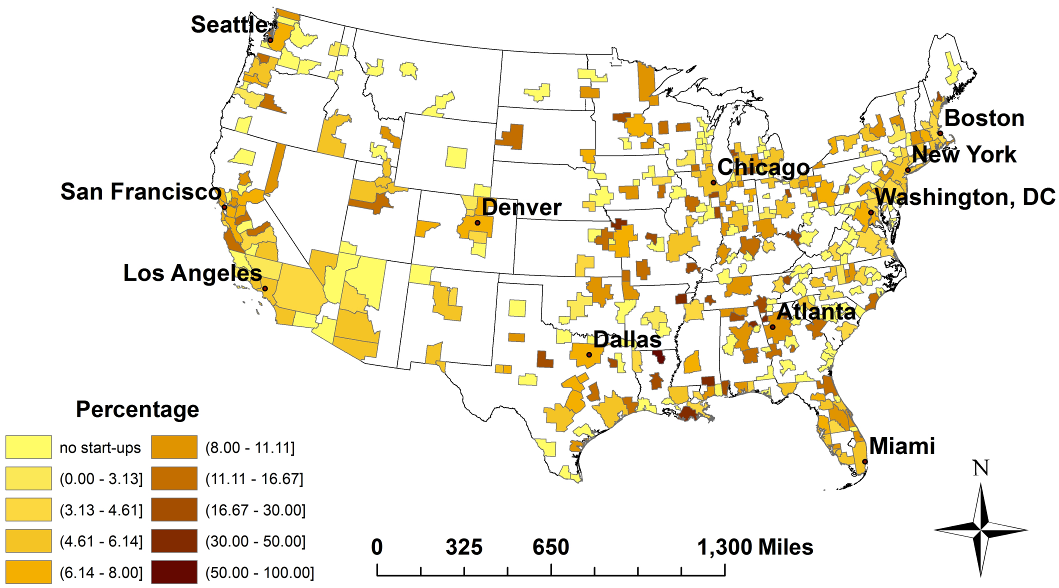

Figure 16. Computer and electronic product manufacturing start-ups as a percentage of the incumbent firms in the same sector

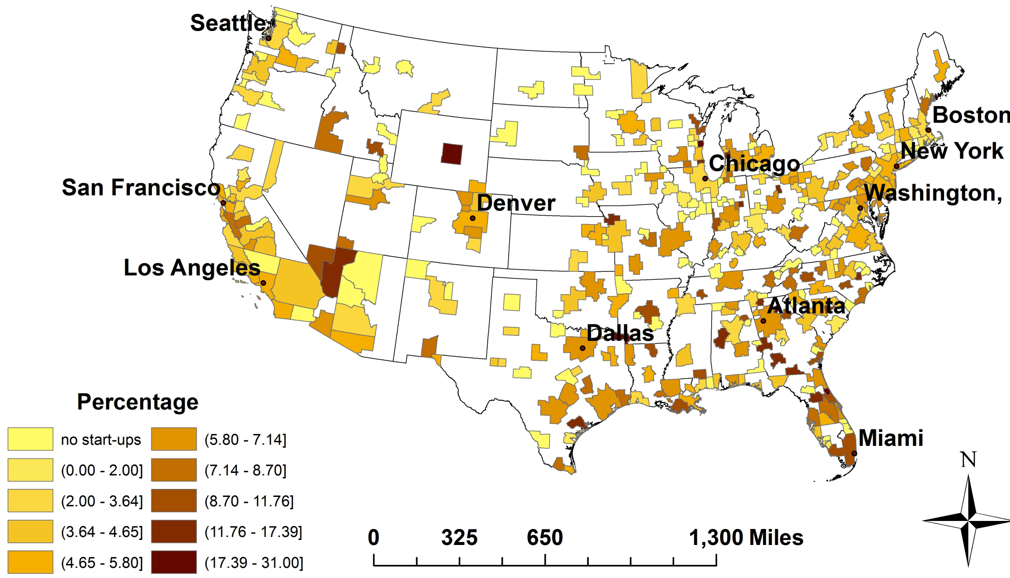

Figure 17. Healthcare services start-ups as a percentage of the incumbent firms in the same sector

5.4. Measuring innovation in a region

There are numerous ways to measure innovation in a region. The most common ones include R&D expenditures, share of employment in knowledge-intensive industries, and patent counts. When using patent counts as an approximation for the innovativeness of a regional economy, one has to understand what exactly this statistic measures and what it does not measure. By definition, patent counts are able to account only for inventions that have been assessed and granted a patent by the U.S. PTO. Innovations that go ‘unnoticed’ by this governmental authority, and innovations that are denied a patent, are not captured by the patent count variable. In addition, the economic value of each patent (and, thus, its usefulness) differs greatly(Griliches, 1979; Pakes & Griliches, 1980). Despite this fact, patent count is perhaps the best readily available indicator of underlying inventive activity in a region (Acs et al., 2002; Feser, 2002; Griliches, 1990).

Regions differ in their patenting activity, with large MSAs being the main contributors to innovation measured by the total number of patents (Figure 18).

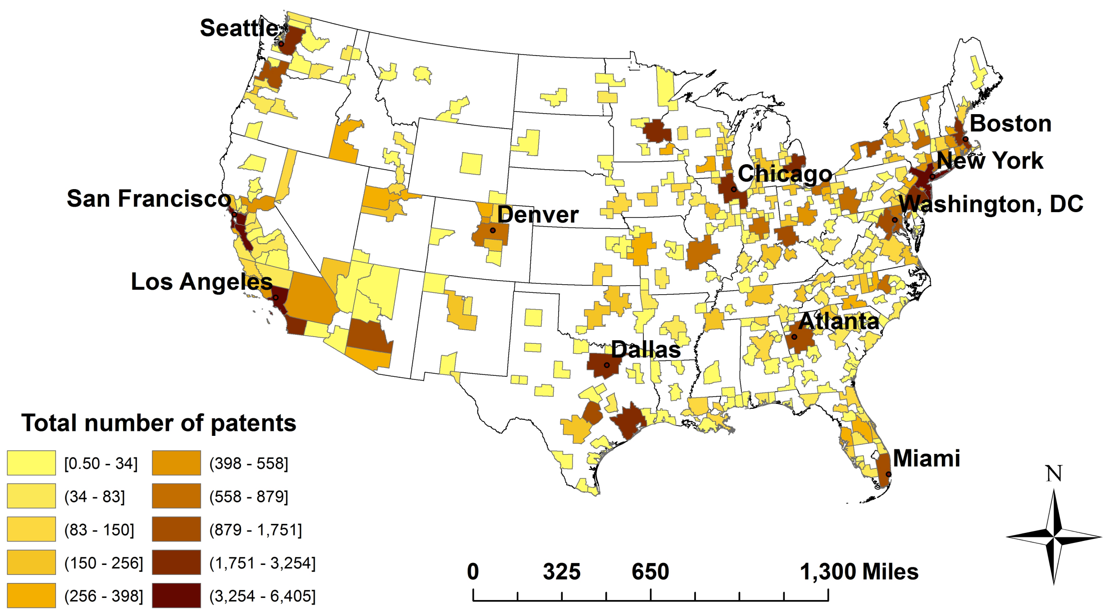

Figure 18. Patenting in continental MSAs (averaged over 1992 - 2008)

Population adjusted patenting activity in the country exhibits a different pattern. Large MSAs are still important contributors, but the differences between least innovative and most innovative metropolitan areas are less pronounced (Figure 19).

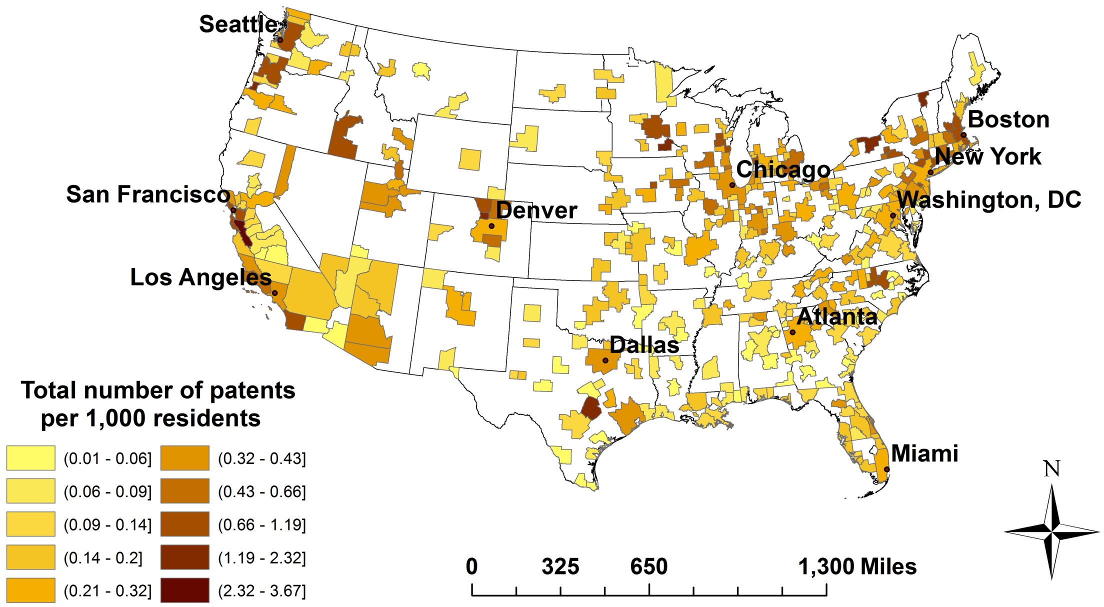

Figure 19. Population adjusted patenting in continental MSAs (averaged over 1992 - 2008)

Patent count in a MSA per 1,000 residents is the main explanatory variable in this research. The U.S. PTO maintains a patent database spanning centuries of innovation in this country. For the purposes of this study, each patent was attributed to a MSA on the basis of the inventor's reported address. If inventors residing in different MSAs are listed on a patent, corresponding share was assigned to each metro area. The patent year was determined by the application date. Because of the processing and reporting delay, the patent data for the last several years are incomplete. I try to mitigate this problem by adjusting the total patent counts for the years 2006, 2007, and 2008 by 5%, 10%, and 15% respectively[37] using the following formula:

---

[37] To the best of my knowledge, no study adjusted the patent counts using a validated and well-defined method. There is no information in the literature as to what fraction of the successful patent applications is left out of the U.S. PTO database each year. It means that the adjustment values have to be picked up at a researcher's discretion. To keep the estimation conservative and not to overinflate innovativeness of the U.S. MSAs, I selected 5%, 10%, and 15%.

$$\widehat{Patents}_{jt} = Patents_{jt} + y\overline{Patents_j} \qquad (9)$$

where$\widehat{Patents}_{jt}$ is the calculated total number of patents in MSA j applied for in year t. This number, standardized by population count in a MSA, *Patents*, is used in estimation. $Patents_{jt}$is a patent count in MSA j reported by U.S. PTO for year *t*. $\overline{Patents_j}$ is the average patent count in MSA j over years 1992-2005. $t \in [2006, 2008]$; $y = 0.05$ if t=2006, $y = 0.1$ if t=2007, $y = 0.15$ if t=2008.Table 7 presents the descriptive statistics of U.S. patenting activity by year at the MSA levelas reported by the U.S. PTO.

Table 7. Description of the U.S. patenting activity by MSA over 1992-2008

Year	**Number of observations**	**Mean**	**Standard Deviation**	**Min**	**Max**
1992	364	158.52	442.45	0.00	4627.98
1993	364	167.9	465.25	0.33	4714.02
1994	364	190.4	530.99	0.25	5528.93
1995	364	226.68	647.28	0.33	6388.23
1996	364	218.03	626.58	0.00	5934.29
1997	364	254.76	756.7	0.00	7195.75
1998	364	253.91	746.13	0.00	6984.04
1999	364	268.53	799.21	0.00	7655.39
2000	364	285.91	852.94	1.50	8572.2
2001	364	288.78	866.98	0.00	8943.53
2002	364	289.27	877.8	0.00	9173.12
2003	364	279.8	830.05	0.00	8479.73
2004	364	263.23	801.52	0.00	8394.73
2005	364	248.75	763.73	0.00	7989.95
2006	364	219.36	669.01	0.00	6978.2
2007	364	180.43	543.13	0.00	5563.03
2008	364	112.21	332.46	0.00	2992.39

Source: U.S. PTO

As Table 7shows, the average number of patents granted to inventors residing in the U.S. MSAs has an upward trend reaching its peak in years 2001-2002. After that time, the average number decreases and plummets after 2005. Presumably, processing and reporting delay causes this decrease. If so, the actual patent counts are greater after 2005 then reported counts. Table 8 shows descriptive statistics of the patent counts adjusted using formula (9).

Table 8. Description of the adjusted patenting activity by MSA over 1992-2008

Year	**Number of observations**	**Mean**	**Standard Deviation**	**Min**	**Max**
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2003	364	279.8	830.05	0.00	8479.73
2004	364	263.23	801.52	0.00	8394.73
2005	364	248.75	763.73	0.00	7989.95
2006	364	*231.48*	*703.86*	*0.02*	*7304.53*
2007	364	*204.68*	*613.13*	*0.30*	*6215.69*
2008	364	*148.58*	*437.6*	*0.51*	*3971.38*

Source: U.S. PTO, own calculations

5.5. Control variables

The interplay of firm-, industry-, and locality-specific factors determines firm performance. To estimate the effect of innovativeness in an MSA on firm survival, I control for a number of firm attributes, MSA demographic and economic characteristics.

5.5.1. Firm size (*lnSize*)

Firm size is perhaps the most widely studied determinant of firm survival. There are several ways to measure a firm's size. Researchers use the number of employees, assets, and sales volume as indicators of firm size. As a rule, the results are not very sensitive to the choice of the size measure (Agarwal et al., 2002). Mata, Portugal and Guimaraes (1995) argue that current size is a predictor superior to start-up size. They utilize both measures in a study of Portuguese manufacturing and find negative relationship between start-up and current size, on the one hand, and hazard rate, on the other. A number of studies that use a model allowing for time-varying covariates find a somewhat less straightforward relationship between firm size and the likelihood of exit. The negative relationship is 'somewhat weak' in a sample of Greek manufacturing firms (Fotopoulos & Louri, 2000), and is heavily dependent on the industry life cycle stage, and the stage of entry in a sample of American manufacturers (Agarwal et al., 2002). Levitas, McFadyen and Loree (2006) use the log transformation of the firm size in each year to remove possible non-linearity. Their results are in line with the studies that report positive effect between establishment size and business longevity(Box, 2008; Persson, 2004).

Table 9. Size distribution by year and sector

	HTM					HTS				
Year	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max
1992	1,641	6.63	9.17	1	97	1,348	9.91	14.09	1	100
1993	1,629	6.65	9.28	1	97	1,342	10.09	14.82	1	150
1994	1,488	7.26	21.78	1	762	1,298	10.40	15.55	1	150
1995	1,385	7.18	10.96	1	135	1,251	10.92	16.23	1	150
1996	1,277	7.46	11.32	1	135	1,207	11.21	16.65	1	150
1997	1,151	7.87	12.70	1	170	1,146	11.93	19.24	1	252
1998	1,081	8.11	13.35	1	170	1,095	12.19	20.37	1	252
1999	1,015	8.64	14.95	1	170	1,053	12.44	21.95	1	300
2000	954	9.20	18.59	1	315	1,006	12.41	22.56	1	300
2001	907	9.59	18.67	1	200	967	13.54	29.81	1	567
2002	841	9.98	21.61	1	350	911	13.83	30.81	1	567
2003	795	10.03	22.00	1	350	882	14.31	31.77	1	567
2004	745	9.95	22.13	1	350	833	14.58	32.33	1	567
2005	700	9.92	21.51	1	350	782	14.42	31.58	1	567
2006	655	10.08	22.79	1	350	733	14.46	31.62	1	567
2007	628	10.29	23.00	1	350	699	15.08	32.64	1	567
2008	601	10.63	24.42	1	350	658	16.56	43.90	1	754

Source: NETS Database

I use the current number of employees to measure the size of an establishment. Firms with more than 100 employees at start-up are excluded from the sample. In healthcare, firms tend to be larger then in computer and electronic component manufacturing. Firm growth rate, however, is approximately the same in the two sectors over the study period (Table 10). The NETS Database is the data source. To ensure a better linear fit, I use a log function of firm size in estimation.

5.5.2. Change in size (*Expand*)

Post-entry performance is as important for business longevity as the entry process (Audretsch & Mata, 1995). As Table 11 suggests, changes in the average firm size are industry-dependent. The 1991 healthcare start-ups in this sample tend to grow over the years. In computer and electronic product manufacturing, the average

firm size is relatively stable with slight growth in the beginning of the study period, and slight reduction in the average number of employees at the end of the period. Theoretically, the relationship between the average firm size change and survival can be both positive and negative. On the one hand, expansion is likely to signal that the business has a greater potential. On the other, growth involves new challenges and some firms might be unable to cope with growth. Likewise, firm contraction may be a signal of either hardships, or greater efficiency. I include variable *Expand* to capture firm internal changes that manifest themselves in size adjustments. *Expand* is the change in the number of employees between the current year and the previous year as reported by the NETS Database. Descriptive statistics of the variable by year and industry is given in Table 10.

Table 10. Size change distribution by year and sector

	HTM					**HTS**				
Year	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
1992	1,641	6.63	9.17	1	97	1,348	9.91	14.09	1	100
1993	1,629	0.04	0.95	-2	35	1,342	0.15	3.96	-2	109
1994	1,488	0.83	19.83	-16	758	1,298	0.27	3.19	-45	55
1995	1,385	0.48	4.54	-23	100	1,251	0.54	4.47	-45	57
1996	1,277	0.34	3.10	-40	42	1,207	0.37	3.26	-29	49
1997	1,151	0.48	4.57	-40	92	1,146	0.81	8.84	-20	242
1998	1,081	0.41	3.11	-17	38	1,095	0.45	5.47	-32	125
1999	1,015	0.49	4.53	-41	80	1,053	0.47	10.11	-45	295
2000	954	0.49	10.88	-54	306	1,006	0.25	5.53	-69	150
2001	907	0.80	9.24	-30	196	967	1.09	12.58	-10	267
2002	841	0.24	10.12	-195	150	911	0.28	6.32	-40	130
2003	795	0.03	4.69	-70	75	882	0.32	4.23	-40	50
2004	745	-0.24	3.44	-70	14	833	0.34	3.86	-32	70
2005	700	-0.21	5.25	-85	30	782	0.21	4.50	-25	95

Table 10 (continued)

2006	655	0.05	4.26	-88	55	733	0.14	2.40	-20	45
2007	628	-0.06	2.46	-33	20	699	0.25	2.74	-8	42
2008	601	0.32	6.83	-33	140	658	0.99	28.31	-75	729

Source: NETS Database

5.5.3. Educational attainment (*lnGrad*)

The average level of education in a MSA serves as a good approximation for the quality of the labor pool and human capital available in an area. I include the total number of graduates with a bachelor degree or higher per 1,000 residents to control for the level of educational attainment in a metropolitan area. Variable *lnGrad* is calculated using the Integrated Postsecondary Education Data System files available at http://nces.ed.gov/ipeds/datacenter/. The Data System reports the total number of completions and their level for each post-secondary educational institution among other indicators. Completions with level five or higher were aggregated using locational information into a MSA-level variable. To ensure a better linear fit of the model, a natural logarithm of the variable is used in estimation[38]. Table 12 presents the distribution of the number of graduates with Bachelor's degree or higher used to model the two industrial sectors under study[39].

[38]MSAs that had zero graduates of required level were assigned 0.001graduates (approximately 5% of the smallest actual number) in order for the logarithm to be determined.

[39] Each estimation file contains a subset of all MSAs, which depends on the geographical distribution of 1991 start-ups in a corresponding sector and their survival pattern. Distribution of the graduates in all U.S. MSAs is different from what it reported in Table 11.

Table 11. Distribution of graduation counts (Bachelor's degree and higher) by year and sector

	HTM					HTS				
Year	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
1992	1,641	43.51	39.24	0.00	458.94	1,348	42.03	41.96	0.00	785.26
1993	1,629	40.71	40.43	0.00	460.84	1,342	38.80	42.59	0.00	768.26
1994	1,488	45.20	40.44	0.00	435.52	1,298	43.42	41.94	0.00	748.89
1995	1,385	45.07	40.42	0.00	429.24	1,251	43.15	41.44	0.00	732.70
1996	1,277	45.10	40.61	0.00	424.93	1,207	43.03	41.43	0.00	720.94
1997	1,151	45.02	40.83	0.00	502.86	1,146	43.51	41.28	0.00	731.04
1998	1,081	45.66	41.83	0.00	494.99	1,095	44.32	42.54	0.00	738.84
1999	1,015	45.70	41.77	0.00	500.97	1,053	44.28	43.46	0.00	787.83
2000	954	46.51	41.19	0.00	469.36	1,006	45.60	44.22	0.00	791.47
2001	907	47.56	42.58	0.00	491.29	967	46.83	45.53	0.00	780.93
2002	841	31.87	24.49	4.18	284.55	911	31.52	26.18	0.00	450.60
2003	795	51.55	47.05	0.00	510.47	882	50.69	49.22	0.00	750.45
2004	745	54.75	49.14	0.00	521.31	833	53.39	51.06	0.00	772.54
2005	700	55.45	49.07	0.00	542.15	782	53.77	45.35	0.00	436.51
2006	655	56.00	47.41	3.80	534.35	733	55.18	46.53	0.00	437.92
2007	628	56.44	47.98	8.98	525.84	699	55.91	45.49	0.00	436.88
2008	601	57.45	48.49	8.53	495.52	658	57.32	45.64	0.00	430.87

Source: IPEDS

5.5.4. Average expenditures per pupil (*AvExp*)

Another education-related variable, *AvExp*, approximates educational opportunities in a MSA and, indirectly, educational attainment. The variable is calculated form the U.S. Census data available at http://www.census.gov//govs/school/ by calculating total expenditures in a metropolitan area and total number of students, and by dividing the former by the latter. The expenditures are adjusted for inflation using CPI index reported by the BLS (ftp://ftp.bls.gov/pub/special.requests/cpi/cpiai.txt). The recent research shows that average spending is positively related to schooling outcomes but its effects differ among various groups of students (Holmlund, McNally, & Viarengo, 2010; Webber, 2012). Table 12 presents summary statistics for *AvExp*.

Table 12. Distribution of average expenditures per student by year and sector (inflation adjusted thousand dollars)

	HTM					HTS				
Year	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
1992	1,641	5.96	1.40	3.20	9.86	1,348	5.90	1.44	3.20	10.79
1993	1,629	5.95	1.35	3.20	11.13	1,342	5.86	1.40	3.24	13.70
1994	1,488	5.96	1.41	3.35	9.79	1,298	5.90	1.48	3.35	12.77
1995	1,385	5.94	1.35	3.34	10.05	1,251	5.89	1.40	3.34	10.05
1996	1,277	5.92	1.30	3.36	10.16	1,207	5.83	1.29	3.36	10.16
1997	1,151	5.95	1.29	3.56	8.89	1,146	5.87	1.30	3.65	9.53
1998	1,081	6.16	1.26	3.57	9.84	1,095	6.06	1.28	3.77	9.66
1999	1,015	6.37	1.30	3.57	9.39	1,053	6.28	1.32	3.57	10.39
2000	954	6.52	1.24	3.58	9.35	1,006	6.40	1.28	3.58	10.15
2001	907	6.78	1.35	3.72	9.99	967	6.62	1.42	3.88	10.47
2002	841	7.05	1.44	3.84	10.23	911	6.84	1.48	4.11	11.30
2003	795	7.07	1.47	3.86	10.44	882	6.88	1.55	3.99	12.53
2004	745	7.09	1.55	4.08	10.76	833	6.88	1.62	4.10	12.75
2005	700	7.13	1.59	3.92	10.97	782	6.92	1.64	3.92	12.62
2006	655	7.21	1.65	3.86	11.41	733	7.07	1.69	4.12	11.41
2007	628	7.40	1.74	4.04	11.87	699	7.24	1.75	3.94	12.82
2008	601	7.47	1.69	4.17	12.01	658	7.34	1.75	3.80	12.50

Source: U.S. Census, BLS

5.5.5. Income (*lnInc*)

I control for the size[40] and performance of a metropolitan economy by including the estimated average income in the models. Average income is related to local prosperity

[40]Gross Metropolitan Product (GMP), a more traditional approximation for the size of a metro economy, is available for years 2001-2008 only. Presumably GMP and MSA income are calculated using the same methodology and indicators. Correlation between income in the U.S. MSAs and GMP in 2001 – 2008 period is above 0.99.This makes these two measures practically identical for the estimation purposes.

and market depth. In theory, it can be related to firm survival both positively and negatively. MSAs with higher income may promote firm longevity by ensuring greater demand, more resources, and business possibilities. At the same time, costs of doing business in such metropolitan areas are likely to be higher. The U.S. Bureau of Economic Analysis compiles per capita income estimates, which are available at http://www.bea.gov/regional/downloadzip.cfm for years 1967 - 2009.Estimated per capita income in logarithmic form is used in estimation. Table 13 presents distribution of the variable before transformation.

Table 13. Distribution of average annual income by year and sector(thousand dollars)

	HTM					HTS				
Year	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
1992	1,641	23.07	3.61	13.30	37.93	1,348	21.92	3.73	10.24	37.93
1993	1,629	22.86	3.49	13.35	37.29	1,342	21.80	3.63	10.17	37.29
1994	1,488	23.08	3.45	13.46	37.07	1,298	22.05	3.62	10.32	37.07
1995	1,385	23.47	3.65	13.62	38.62	1,251	22.36	3.75	10.19	38.62
1996	1,277	23.96	3.83	13.65	39.78	1,207	22.73	3.90	10.32	39.78
1997	1,151	24.54	4.05	13.89	41.25	1,146	23.23	4.04	10.54	41.25
1998	1,081	25.73	4.34	14.56	44.60	1,095	24.35	4.35	10.78	44.60
1999	1,015	26.36	4.73	14.52	45.58	1,053	24.80	4.65	10.84	45.58
2000	954	27.60	5.81	14.53	48.08	1,006	25.72	5.25	11.07	48.08
2001	907	27.20	5.27	15.37	49.04	967	25.61	5.05	11.44	49.04
2002	841	26.81	4.78	15.01	46.81	911	25.44	4.74	11.51	46.81
2003	795	26.71	4.66	15.00	45.51	882	25.38	4.59	11.52	45.51
2004	745	27.39	4.99	14.62	48.34	833	26.11	4.94	11.71	48.34
2005	700	27.90	5.27	15.16	49.60	782	26.49	5.25	12.11	49.60
2006	655	28.78	5.73	15.08	52.75	733	27.29	5.52	12.10	52.75
2007	628	29.46	6.10	14.67	55.20	699	27.90	5.81	12.39	55.20
2008	601	28.92	5.96	14.18	53.61	658	27.50	5.72	12.63	53.61

Source: BEA

5.5.6. Population (*lnPop*)

Population is an important determinant of firm performance in the agglomeration and knowledge spillover literature. Population may approximate market opportunities as demand for goods and services is likely to be higher in more populated areas. Population size is usually positively related to firm entry (Audretsch & Fritsch, 1994). In my dataset, pairwise correlation between 1991 start-ups and population is 0.87 in computer and electronic product manufacturing, and 0.92 in healthcare (Table 6). Researchers use the population variable to measure urbanization (Acs et al., 2007), and agglomeration (J. Vernon Henderson, 1986; Moomaw, 1988). Some studies use population change (Renski, 2011), and population density (Feser, 2002)as approximation for market and labor pool expansion, and urban diseconomies respectively. In addition, population size is related to inventive activity in metropolitan areas(Bettencourt et al., 2007).

I include the logged form of population in the models[41]. The data come from the BEA. Descriptive statistics are given in Table 14.Inspection of the table suggests that firms in computer and electronic product manufacturing tend to locate in more populated metropolitan areas.

Table 14. Distribution of population size (million residents) by year and sector

	HTM					**HTS**				
Year	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
1992	1,641	4.34	4.86	0.08	17.11	1,348	3.78	4.79	0.03	17.11
1993	1,629	4.39	4.91	0.08	17.27	1,342	3.83	4.84	0.04	17.27
1994	1,488	4.46	4.96	0.08	17.41	1,298	3.86	4.89	0.04	17.41

[41] Alternative measures such as population density, total employment density, and employment density in corresponding industries produce similar estimation results.

Table 14 (continued)

1995	1,385	4.49	4.97	0.09	17.54	1,251	3.88	4.93	0.04	17.54
1996	1,277	4.59	5.07	0.09	17.68	1,207	3.91	4.95	0.04	17.68
1997	1,151	4.64	5.10	0.09	17.84	1,146	3.93	4.97	0.04	17.84
1998	1,081	4.67	5.14	0.08	18.01	1,095	4.00	5.07	0.05	18.01
1999	1,015	4.71	5.20	0.08	18.19	1,053	4.05	5.15	0.05	18.19
2000	954	4.69	5.18	0.08	18.35	1,006	4.10	5.24	0.05	18.35
2001	907	4.77	5.22	0.08	18.49	967	4.15	5.29	0.05	18.49
2002	841	4.82	5.28	0.08	18.59	911	4.16	5.27	0.06	18.59
2003	795	4.84	5.28	0.08	18.68	882	4.22	5.32	0.06	18.68
2004	745	4.83	5.29	0.08	18.76	833	4.27	5.33	0.07	18.76
2005	700	4.89	5.33	0.08	18.81	782	4.29	5.30	0.08	18.81
2006	655	4.88	5.25	0.08	18.85	733	4.35	5.34	0.08	18.85
2007	628	4.95	5.29	0.08	18.92	699	4.32	5.25	0.09	18.92
2008	601	4.83	5.21	0.08	19.01	658	4.32	5.27	0.09	19.01

Source: BEA

5.5.7. Unemployment

Another parsimonious measure of economic conditions in a MSA is the average unemployment rate. This characteristic of a regional economy is rarely used in business survival studies, which often focus on the (un)employment status of a firm owner prior to starting a business. Van Praag (C. Mirjam van Praag, 2003) includes both unemployment rate in a region and unemployment status of a firm owner into her analysis. She finds that a business established by an unemployed young person in the U.S. is likely to be short-lived, while unemployment rate does not affect survival chances. A study from Italy shows that on average, firms tend stay in business longer during the spells of unemployment (Santarelli, Carree, & Verheul, 2009).

I use information provided by BLS (http://www.bls.gov/lau) to calculate average unemployment rate in a MSA from county-level data. Table 15 describes the distribution of the variable by sector and by year.

Table 15. Distribution of average unemployment rate by year and sector

	HTM					HTS				
Year	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
1992	1,641	7.62	1.89	2.80	16.60	1,348	7.65	2.15	3.03	26.10
1993	1,629	7.03	1.96	3.10	16.90	1,342	7.01	2.20	2.88	27.90
1994	1,488	6.11	1.81	2.85	15.90	1,298	6.19	2.15	2.73	31.10
1995	1,385	5.55	1.66	2.70	15.50	1,251	5.66	2.07	2.58	29.70
1996	1,277	5.20	1.47	2.20	14.40	1,207	5.37	1.94	2.20	30.90
1997	1,151	4.67	1.42	2.00	13.60	1,146	4.90	1.85	2.00	27.30
1998	1,081	4.20	1.40	1.80	14.30	1,095	4.45	1.87	1.80	29.00
1999	1,015	3.85	1.25	1.60	13.60	1,053	4.12	1.73	1.60	30.10
2000	954	3.75	0.88	2.00	10.40	1,006	3.91	1.08	2.00	16.60
2001	907	4.52	0.90	2.45	10.70	967	4.65	1.08	2.45	16.50
2002	841	5.73	1.10	2.95	11.50	911	5.69	1.17	2.83	16.80
2003	795	5.93	1.16	3.25	11.80	882	5.87	1.23	3.05	16.80
2004	745	5.41	1.02	3.10	10.50	833	5.40	1.13	3.30	15.60
2005	700	4.93	0.91	2.70	9.00	782	4.97	1.10	3.05	15.90
2006	655	4.49	0.85	2.20	8.00	733	4.53	1.07	2.75	14.60
2007	628	4.53	0.86	2.50	8.70	699	4.57	1.07	2.60	13.50
2008	601	5.83	1.14	3.20	11.00	658	5.78	1.35	2.90	17.90

Source: BLS

5.5.8. Industrial diversity (*Diversity*)

Industrial diversity promotes recombination of ideas and innovation (Feldman & Audretsch, 1999; Jacobs, 1969). Besides, diversification of the economy can alleviate negative economic trends and promote spillover effects (Stel & Nieuwenhuijsen, 2004). Renski (2011) finds that industrial diversity has a positive effect on firm survival, especially in knowledge intensive industries.

Following a number of studies (Attaran, 1986; Bishop & Gripaios, 2007), I use the entropy measure to approximate the diversification of the economy in each metro area.

As suggested by Bishop and Gripaios(2007, p. 1745), total diversity is calculated using the following formula.

$$TD = \sum_1^n S_i \ln\left(\frac{1}{s_i}\right) \quad (10)$$

where S_i stands for the share of the 3-digit NAICS category in a MSA employment and there are *n* such categories. The total diversity index is zero if all employment is concentrated in one sector and it is maximized if employment is distributed evenly among the sectors. The measure is also dependent on the total number of sectors with the share of each sector to be weighted by the logarithmic function. I calculate this index from the NETS Database using NAICS 3-digit classification and firm level employment that is aggregated into total MSA employment. Table 16 contains descriptive statistics for variable *Diversity*.

Table 16. Descriptive statistics for *Diversity* by year and sector

	HTM					**HTS**				
Year	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
1992	1,641	3.82	0.16	2.61	3.98	1,348	3.82	0.14	2.85	3.98
1993	1,629	3.82	0.16	2.74	3.98	1,342	3.82	0.14	2.94	3.98
1994	1,488	3.82	0.15	2.77	3.99	1,298	3.82	0.15	2.49	3.99
1995	1,385	3.82	0.15	2.75	3.99	1,251	3.82	0.14	2.51	3.99
1996	1,277	3.82	0.15	2.74	3.98	1,207	3.82	0.14	2.53	3.98
1997	1,151	3.82	0.14	2.80	3.98	1,146	3.82	0.15	2.59	3.98
1998	1,081	3.83	0.14	2.80	3.97	1,095	3.82	0.14	2.67	3.97
1999	1,015	3.82	0.14	2.76	3.98	1,053	3.81	0.14	2.71	3.98
2000	954	3.82	0.14	2.79	3.97	1,006	3.81	0.14	2.71	3.97
2001	907	3.83	0.13	3.15	3.97	967	3.81	0.13	2.68	3.97
2002	841	3.82	0.12	3.06	3.97	911	3.81	0.12	2.76	3.97
2003	795	3.82	0.11	3.02	3.95	882	3.81	0.12	2.71	3.95
2004	745	3.82	0.11	3.04	3.96	833	3.81	0.12	2.73	3.96
2005	700	3.82	0.12	3.05	3.95	782	3.81	0.12	3.05	3.98
2006	655	3.81	0.12	3.00	3.95	733	3.80	0.12	3.00	3.95

Table 16 (continued)

2007	628	3.81	0.11	2.99	3.94	699	3.79	0.11	2.99	3.94
2008	601	3.79	0.11	2.96	3.94	658	3.78	0.10	2.96	3.94

Source: NETS Database

5.5.9. Industrial density (*Density*)

Industrial concentration may affect performance of firms in a corresponding industry. Higher localization may signal the availability of necessary resources, qualified labor pool, and other favorable conditions. At the same time, localized economies are likely to impose competitive pressure and to increase the hazard. The survival literature reports both positive (Renski, 2011; Wennberg & Lindqvist, 2010) and negative (Acs et al., 2007; Sorenson & Audia, 2000; Stuart & Sorenson, 2003) effects of industrial concentration on firm survival.

I calculate variable *Density* by dividing the total number of establishments in a sector of interest by the MSA land area. Firm count is derived from the NETS Database by aggregating establishment-level data into MSA-level variables. Land area data at a county level is available from the U.S. Census Bureau. MSA land area is calculated by adding together land areas of counties belonging to a MSA according to the November 2008 definition of MSAs by the Office of Management and Budget. Descriptive statistics for *Density* are given in Table 17.

Table 17. Distribution of variable *Density* by year and sector

	HTM					**HTS**				
Year	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
1992	1,641	0.23	0.23	0.00	0.68	1,348	0.15	0.19	0.00	0.68

Table 17 (continued)

1993	1,629	0.25	0.26	0.00	0.74	1,342	0.16	0.21	0.00	0.74
1994	1,488	0.25	0.25	0.00	0.75	1,298	0.16	0.21	0.00	0.75
1995	1,385	0.25	0.26	0.00	0.76	1,251	0.17	0.21	0.00	0.76
1996	1,277	0.26	0.26	0.00	0.77	1,207	0.17	0.21	0.00	0.77
1997	1,151	0.26	0.27	0.00	0.79	1,146	0.17	0.22	0.00	0.79
1998	1,081	0.27	0.27	0.00	0.80	1,095	0.18	0.22	0.00	0.80
1999	1,015	0.27	0.27	0.00	0.81	1,053	0.18	0.22	0.00	0.81
2000	954	0.27	0.27	0.00	0.83	1,006	0.19	0.22	0.00	0.83
2001	907	0.27	0.28	0.00	0.85	967	0.19	0.23	0.00	0.85
2002	841	0.28	0.28	0.00	0.89	911	0.20	0.24	0.00	0.89
2003	795	0.28	0.28	0.00	0.90	882	0.20	0.24	0.00	0.90
2004	745	0.27	0.28	0.00	0.88	833	0.20	0.23	0.00	0.88
2005	700	0.28	0.28	0.00	0.89	782	0.20	0.24	0.00	0.89
2006	655	0.28	0.29	0.00	0.92	733	0.21	0.24	0.00	0.92
2007	628	0.29	0.29	0.00	0.93	699	0.21	0.24	0.00	0.93
2008	601	0.29	0.30	0.00	0.95	658	0.21	0.25	0.00	0.95

Source: NETS Database, U.S. Census Bureau

5.5.10. Firm formation (entrepreneurship) in a sector (*EntComp* and *EntHealth*)

The level of entrepreneurship in a region is potentially a strong predictor of firm performance but its effect is not straightforward. If entrepreneurial spirit translates into a better fit between a firm's activities and market demand, entrepreneurship should facilitate firm survival. On the other hand, a greater number of new firms, a common measure of entrepreneurship, is likely to lead to fiercer competition and thus reduce business survival chances. Population-adjusted total number of start-ups in a MSA turns to be insignificant predictor of business longevity in this research. A better measure, closely related to the Schumpeterian argument on creative destruction, is the number of start-ups in a sector of interest. This variable approximates a favorable or unfavorable environment for firm formation, as well as the level of competition in certain industries.

The variables *EntComp* and *EntHealth* are a population-adjusted number of start-ups in a corresponding sector in a MSA in a given year. The NETS Database and the U.S. Census Bureau are the data sources. Table 18 contains basic description of both variables by year.

Table 18. Descriptive statistics for *EntComp* and *EntHealth* by year (number of new firms per million residents)

	HTM					HTS				
Year	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**
1992	1,641	22.53	23.28	1.55	110.81	1,348	15.38	6.88	3.39	89.53
1993	1,629	38.79	36.09	0.00	168.69	1,342	39.28	12.44	0.00	115.40
1994	1,488	23.32	20.99	0.00	102.99	1,298	19.16	9.09	0.00	60.16
1995	1,385	26.85	24.19	0.00	122.03	1,251	35.74	16.92	0.00	122.65
1996	1,277	26.43	26.01	0.00	130.68	1,207	24.88	12.10	0.00	126.22
1997	1,151	32.25	26.70	0.00	141.91	1,146	35.82	13.87	0.00	152.79
1998	1,081	28.10	22.64	0.00	125.88	1,095	28.80	12.59	0.00	97.00
1999	1,015	25.11	22.29	0.00	124.78	1,053	23.91	10.15	0.00	69.51
2000	954	26.26	23.90	0.00	135.63	1,006	32.40	10.88	0.00	124.07
2001	907	28.34	24.46	0.00	136.28	967	30.00	11.50	2.68	99.88
2002	841	29.39	22.60	0.00	127.72	911	27.91	10.95	0.00	132.73
2003	795	19.07	13.70	0.00	78.20	882	24.41	9.69	0.00	102.10
2004	745	17.42	13.94	0.00	81.00	833	19.31	8.07	0.00	50.08
2005	700	17.38	14.42	0.00	82.62	782	23.33	12.02	0.00	217.61
2006	655	20.48	14.17	0.00	80.58	733	36.20	11.82	7.58	77.18
2007	628	15.74	12.68	0.00	69.97	699	41.66	20.14	0.00	117.98
2008	601	13.95	10.68	0.00	57.17	658	20.20	8.20	0.00	59.04

Source: NETS Database, U.S. Census Bureau

5.5.11. Industry dummies

In addition to the controls described above, the models include a set of dichotomous variables that identify industry affiliation of each firm at 4-digit NAICS level. In computer and electronic product manufacturing, NAICS 3341, Computer and

Peripheral Equipment Manufacturing, is the reference category. The following dummies enter the models: *NAICS3342* (Communications Equipment Manufacturing), *NAICS3343* (Audio and Video Equipment Manufacturing), *NAICS3344* (Semiconductor and Other Electronic Component Manufacturing), *NAICS3345* (Navigational, Measuring, Electromedical, and Control Instruments Manufacturing), and *NAICS3346* (Manufacturing and Reproducing Magnetic and Optical Media).

In healthcare, NAICS 6214, Outpatient Care Centers, is the reference category. Dichotomous variables *NAICS6215* (Medical and Diagnostic Laboratories), *NAICS6216* (Home Health Care Services), *NAICS6221* (General Medical and Surgical Hospitals), *NAICS6222* (Psychiatric and Substance Abuse Hospitals), and *NAICS6223* (Specialty (except Psychiatric and Substance Abuse) Hospitals) are included in the models.

5.5.12. Variables excluded from the analysis

A number of control variables, as well as alternative measures of the explanatory and control variables, entered the preliminary analysis and were later discarded for various reasons. This section briefly describes these variables and the reasons for exclusion.

An earlier version of the dissertation included an alternative measure of innovation, population-adjusted number of patents technologically related to the sector of interest. This variable was included in order to test whether new knowledge, relevant to the production process a sector employs, is more likely to be absorbed and to become a basis of increased survival. To select patent classes that were included in the separate patent counts for computer and electronic product manufacturing, and healthcare services, each subclass' relevance to the sector of interest was evaluated using descriptions provided by the U.S. PTO. The estimated effect was insignificant in all model specifications and the variable was omitted.

I do not control for age, a survival determinant commonly referred to in the literature. All firms in my sample were set up in year 1991. It means they are of equal age in each year during the study period. A regression model, therefore, cannot factor out the effect of age due to the lack of variation. Another factor potentially related to firm survival in a region is entrepreneurship. In more entrepreneurial regions, one can argue, firms should be better able to adjust to the market conditions and to live longer. On the other hand, entrepreneurship is commonly related to a greater number of new firms, which should increase competitive pressure on existing firms. A common measure of entrepreneurship, a population-adjusted number of new firms, was insignificant in all models and was dropped from the analysis. Venture capital (VC) financing of a firm, although potentially a strong predictor of survival, could not be used to obtain reliable estimates. Only seven establishments in the high-tech manufacturing dataset, and only five in high-tech services dataset, had VC backing. When included in the model and the model converged, the VC dummy was mostly significant with extremely large negative estimated impact on firm survival. In a separate analysis by industry, this result was robust even when only one firm in the dataset had the VC dummy = 1.

I tried simultaneous and consecutive inclusion of several alternative educational attainment measures in the models. Highly trained labor force in engineering and technical occupations may contribute to stable business performance and reduce hazard for high-tech manufacturing firms. The total number of graduates (Bachelor's degree or higher) in communications technologies and support services (IPEDS CIP code 10), in computer and information sciences and support services (IPEDS CIP code 11), in engineering (IPEDS CIP code 14), and in engineering technologies and support services (IPEDS CIP code 15) adjusted by MSA population was included in the estimation models for the high-technology manufacturing sector. A corresponding variable for the knowledge-intensive service sector included graduates (BA level or higher) in biological and biomedical sciences (IPEDS CIP code 26), and health professions, and related clinical sciences (IPEDS CIP code 51). Neither of the measures was significant when the total number of graduates, *lnGrad*, was included. The variables were either insignificant or had the same sign as *lnGrad* if included independently. In addition, I included population-adjusted number of graduates with a BA or higher degree in business management, marketing and related support services (IPEDS CIP code 52) to control for the possible relationship between formal training in economics and management and higher survival chances (Colombo & Grilli, 2007). This variable was not statistically insignificant in any models.

In addition to industry density, preliminary models included population density, overall employment density, employment density in corresponding industries, industry location quotient, and the Herfindahl-Hirschman index to measure market power. These variables were excluded due to the multicollinearity problem they posed. When included in the analysis separately, the parameter estimates were consistent with the results for the measure of industrial density included in the models.

CHAPTER 6: NON-PARAMETRIC ANALYSIS

Non-parametric analysis techniques assume neither a specific distribution of failure times, nor a functional form of the relationship between survival and independent variables. Although non-parametric analysis is unable to adequately deal with complex relationships involving many covariates, it is a powerful tool for preliminary exploration and visualization of the survival patterns observed in the data. If the sample can be divided into groups based on a variable of interest, non-parametric methods compare survival experiences across groups.

6.1. Group descriptions

The non-parametric analysis in this study compares more innovative MSAs to less innovative ones, where innovation is measured by the total population-adjusted number of patents, and by the total population-adjusted number of patents in technological classes related to the industries of interest. This analysis is then repeated separately for the groups of metropolitan areas divided by business density. This subsection describes the groups in greater detail.

6.1.1. Innovation

The main explanatory variable in this research is innovation in a metropolitan area measured by overall patenting activity. The measure of innovation, *lnPat*, is a continuous variable, which means that there is no natural way to divide MSAs into groups based on some specific values of the variables. I calculate median values[42] of

patent counts per 1,000 residents for each year across the MSAs in each data set. I then compare MSAs that have above median level of innovation to MSAs that are below[43]. Median values of the population adjusted patent counts (averaged over 17 years) are given in Table 19[44].

Table 19. Median values of innovativeness measures in each data set averaged over years

Innovativeness measure	HTM	HTS
Patent count, per 1,000 residents	0.361	0.301
Patent count in related technologies, per 1,000 residents	0.043	0.024

Source: U.S. PTO, BEA

One should expect greater knowledge spillovers in the areas with higher innovation. Firms located in such regions are likely to be more productive due to faster learning from other companies and entities involved in R&D (Feser, 2002). If this is the case, the survival rate should be higher in the group of MSAs above median on innovativeness

[42] A more traditional classification into groups using standard deviation cannot be used in the case of patent counts because of extremely skewed distribution with the majority of the MSAs characterized by low patenting activity.

[43] Start-ups in 1991 tended to locate in more innovative MSAs, with just a few or no new firms in metro areas with low patenting activity. If MSAs were assigned into groups based on patenting intensity across all areas, groups in lower percentiles would not have enough observations to perform non-parametric analysis. To avoid this, the percentiles were calculated for each estimation file separately and only for the MSAs that are in each file (197 in manufacturing and 246 for services).

[44] Table 19 presents the average values over 1992 – 2008 period. Actual numbers used to divide MSAs into groups are unique for each year.

scale. Table 20 lists the 5 most innovative and the 5 least innovative metropolitan areas in the samples during the study period[45].

Table 20. Most and least inventive MSAs in the samples

Variable	MSAs
High-technology manufacturing	
Patent count per 1,000 residents, top 5 (from most innovative to less innovative)	San Jose-Sunnyvale-Santa Clara, CA; Boulder, CO; Burlington-South Burlington, VT; Rochester, NY; Austin-Round Rock-San Marcos, TX
Patent count per 1,000 residents, bottom 5 (from least innovative to more innovative)	St. Joseph, MO-KS; Abilene, TX; El Paso Columbus, GA-AL; Killeen-Temple-Fort Hood, TX
Patent count in related technologies per 1,000 residents, top 5 (from most innovative to less innovative)	San Jose-Sunnyvale-Santa Clara, CA; Austin-Round Rock-San Marcos, TX; Burlington-South Burlington, VT; Boulder, CO; Santa Cruz-Watsonville, CA
Patent count in related technologies per 1,000 residents, bottom 5 (from least innovative to more innovative)	Terre Haute, IN; Jackson, TN; Corpus Christi, TX; Jonesboro, AR; Evansville, IN-KY
High-technology services	
Patent count, per 1,000 residents, top 5 (from most innovative to less innovative)	San Jose-Sunnyvale-Santa Clara, CA; Boulder, CO; Rochester, NY; Austin-Round Rock-San Marcos, TX; Ann Arbor, MI
Patent count, per 1,000 residents, bottom 5 (from least innovative to more innovative)	McAllen-Edinburg-Mission, TX; Brownsville-Harlingen, TX; Hanford-Corcoran, CA: Fayetteville, NC; St. Joseph, MO-KS
Patent count in related technologies per 1,000 residents, top 5 (from most innovative to less innovative)	Trenton-Ewing, NJ; San Jose-Sunnyvale-Santa Clara, CA; Boulder, CO; Durham-Chapel Hill, NC; Ann Arbor, MI
Patent count in related technologies per 1,000 residents, bottom 5 (from least innovative to more innovative)	Brunswick, GA; Gadsden, AL; Merced, CA; Yuma, AZ; Rome, GA

Source: U.S. PTO, BEA

[45] Appendix A lists the 5 most innovative and the 5 least innovative MSAs during the study period overall.

6.1.2. Business concentration

Agglomeration and urbanization are essential conditions for knowledge spillovers(Koo, 2005b). The empirical literature shows that agglomeration increases firm productivity (F. Andersson, Burgess, & Lane, 2007; M. Andersson & Lööf, 2011); metropolitan size is disproportionally related to innovation (Bettencourt et al., 2007), while private sector employment is positively associated with firm survival in a number of industries (Renski, 2011).Business density increases the likelihood of communications and knowledge sharing, a necessary prerequisite for knowledge spillovers. If there are external positive effects of innovation on firm performance, and survival in particular, these effects are most likely to be observed in the MSAs with high business concentration.

There are various ways to approximate the level of agglomeration and urbanization of a region. Possible measures include firm density, population density, private sector employment density, and logged population to name just a few. Firm density and employment density are more intuitive variables that capture agglomeration. Using the NETS Database, I calculate the number of establishments per square mile in each MSA in every year[46]. I then calculate the 25th, 50th, and 75th percentiles for each year and divide all metropolitan areas into four groups depending on the value of business density variable in a given year[47]. Table 21 presents approximate boundaries of the

---

[46] Business density and employment density in a MSA in a given year are identical for the purposes of estimation. Pairwise correlation between the two is 0.99.

[47] The group assignment in this case is valid for the sample of MSAs that are in the estimation files only. In other words, firms in computer and electronics product manufacturing, and healthcare were assigned into groups using dissimilar scales of business density. A ‘universal’ scale based on business density in all MSAs cannot be used in estimation because the number of observations in the groups with low density is not sufficient to produce reliable results.

groups[48].MSAs with highest and lowest concentration of business in the samples are listed in Table 22[49].

Table 21. 25th, 50th, and 75th percentile of business density measure (number of establishments per square mile) in each data set averaged over years

Sector	25th percentile	50th percentile	75th percentile
High-technology manufacturing	49.14	88.94	222.45
High-technology services	32.17	82.47	191.07

Source: NETS Database

Table 22. MSAs with most and least business density in the samples

Variable	MSAs
Business density, top 5 (from the most dense to less dense)	New York-Northern New Jersey-Long Island, NY-NJ-PA; Los Angeles-Long Beach-Santa Ana, CA; Trenton-Ewing, NJ; Miami-Fort Lauderdale-Pompano Beach, FL; Cleveland-Elyria-Mentor, OH
Business density, bottom 5 (from the least dense to more dense)	Anchorage, AK; Prescott, AZ; Las Cruces, NM; Rapid City, SD; Boise City-Nampa, ID

Source: NETS Database

6.2. Testing for equality of survival functions

A number of non-parametric tests allow for the comparison of overall survival functions across groups. The tests compare expected number of failures to the observed number of failures at each specific time and combine the comparisons over all times

[48] Like Table 19, Table 21 is for reference only. It presents averages over 1992 – 2008 period. Actual numbers used to divide MSAs into groups are year-specific with a minor variation.

[49] MSAs with the highest and the lowest concentration of business overall are listed in Appendix B.

when failure occurred. Stata calculates test statistic $\mathbf{u'V^{-1}u}$(distributed as $\chi^2$with *r-1* degrees of freedom under the null of no difference in survival among *r* groups) using[50]

$$\boldsymbol{u'} = \sum_{j=1}^{k} W(t_j)\,(d_{1j} - E_{1j}, \dots, d_{rj} - E_{rj}) \quad (11)$$

$$V_{il} = \sum_{j=1}^{k} \frac{W^2(t_j) n_{ij} d_j (n_j - d_j)}{n_j(n_j-1)} \left(\delta_{il} - \frac{n_{ij}}{n_j}\right) \quad (12)$$

where k is the number of failure times t_j, $t \in [1, k]$, n_j is the number of subjects at risk at each time t_j, d_j is the number of subjects that failed, $(n_j - d_j)$ is the number of subjects that survived, and $E_{ij}=n_{ij}d_j/h_j$is the expected number of failures at time $t_j$in group i. There are up to r groups ($i = 1, \dots, r$; $l = 1, \dots, r$); and $\delta_{il} = 1$ if $i = l$ and 0 otherwise.

Each test uses a specific weight matrix $W(t_j)$ that determines the relative importance of each failure time (early exits vs. late exits) when calculating overall statistics. The log-rank test is the simplest one with $W(t_j)$=1 if an establishment is alive, and zero otherwise. The Peto-Peto-Prentice test, not sensitive to the potential differences in censoring among groups, is calculated using $W(t_j) = \hat{S}(t_j)$where $\hat{S}(t_j)$denotes a survival function estimate similar to the Kaplan-Meier estimator. Table 23 presents the test results for the comparison of actual and expected failures across MSAs grouped by the level of patenting intensity.

[50] The discussion here is based on Cleves et al. (2010).

Table 23. Test results for the equality of survival functions

Measure of Innovation	Gr	Log-rank test			Peto-Peto-Prentice test		
		Exits observed	Exits expected	χ2(1) / Pr>χ2	Exits observed	Exits expected	χ2(1) / Pr>χ2
HTM							
Patent count, per 1,000 residents	1	363	390.44	4.100	363	390.44	3.030
	2	419	391.56	0.043**	419	391.56	0.082*
Patent count in related technologies, per 1,000 residents	1	363	395.92	5.870	363	395.92	5.890
	2	419	386.08	0.015**	419	386.08	0.015**
HTS							
Patent count, per 1,000 residents	1	314	286.09	5.770	314	286.09	5.520
	2	248	275.91	0.016**	248	275.91	0.019**
Patent count in related technologies, per 1,000 residents	1	310	281.93	5.820	310	281.93	5.740
		252	280.07	0.016**	252	280.07	0.017**

** - significant at 0.05 level, * - significant at 0.1 level; Gr. 1 consists of MSAs below median value of a corresponding innovativeness measure, Gr. 2 consists of MSAs above median value of a corresponding innovativeness measure

Source: U.S. PTO, BEA

Test results suggest that survival functions are statistically different in the MSAs below median value of an innovativeness measure and the MSAs above. The hypothesis of survival functions equality is rejected at 95% confidence level in all the cases except for patent count per 1,000 residents in computer and electronic product manufacturing. The null is rejected at 90% and 95% confidence levels by the Peto-Peto-Prentice and log-rank tests respectively.

Non-parametric analysis suggests that MSAs with higher innovative activities promote firm survival in healthcare only. For both measures of innovation, observed number of exits is significantly smaller than expected number of exits in metropolitan areas with more intensive patenting. Computer and electronic product manufacturing, however, reveal the opposite pattern. Firms tend to go out of business sooner in more innovative MSAs. Possible explanations include different industry dynamics where high-technology manufacturing is a more volatile sector characterized by fierce competition and pressure to innovate. Presumably, in this sector, knowledge accumulated in a region promotes competition more than it promotes greater level of productivity and profitability.

6.3. Empirical hazard functions

This subsection presents empirical hazard functions[51] by group for each sector separately. A hazard function visualizes simple patterns present in the data. It is not able to account for possible multivariate relationships, which are analyzed in the next chapter.

6.3.1. Computer and electronic product manufacturing

Figure 20 plots smoothed hazard functions for firms located in more innovative and less innovative MSAs measured by the total number of patents per 1,000 residents (left graph) and by the number of related patents per 1,000 residents (right graph). The graphs are in line with the results of survival functions equality tests. High-tech manufacturing companies in more innovative metropolitan areas exit sooner then their counterparts in less innovative MSAs.

[51] Hazard functions are calculated as in 4.3.3.

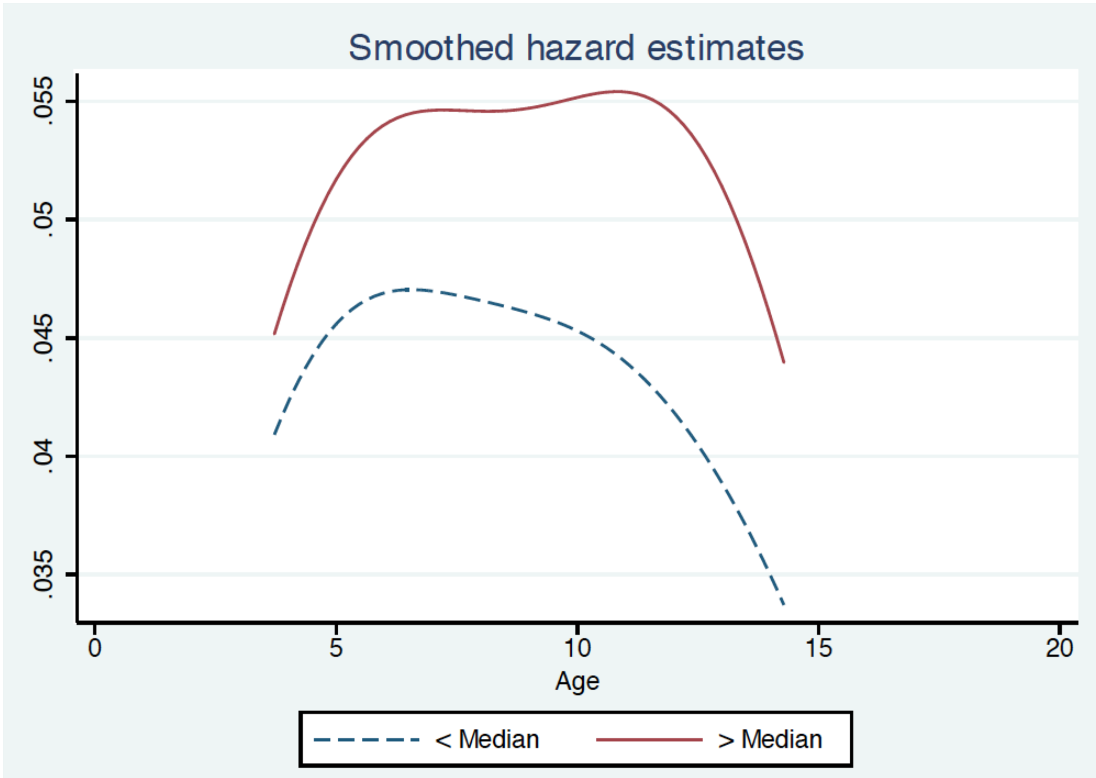

Figure 20. Computer and electronic product manufacturing smoothed hazard estimates
Note: Solid line represents more inventive MSAs; dashed line represents less inventive MSAs

On average, metropolitan areas with a greater number of patents also tend to be larger in terms of both population and business activity. This should increase competition and impose greater pressure on high-tech manufacturing firms to be innovative and efficient. In addition, greater stock of accumulated knowledge is likely to make firms more efficient and further increase competition. Businesses that fail to achieve the necessary level of efficiency or productivity have to exit, leaving only highly productive firms in the market. This may be the reason why the empirical literature consistently finds a positive relationship between economies of agglomeration and efficiency (F. Andersson et al., 2007; M. Andersson & Lööf, 2011).

In general, highly inventive MSAs enjoy high level of business density despite greater failure rates, which are compensated by a large number of start-ups in such metropolises. Agglomeration theory suggests that the likelihood of positive knowledge spillovers is positively associated with business density. Figure 21 juxtaposes smoothed hazard estimates for high technology manufacturing firms located in metropolitan areas with the highest and the lowest business density[52]. The hazard functions are drawn for more and less inventive MSAs separately.

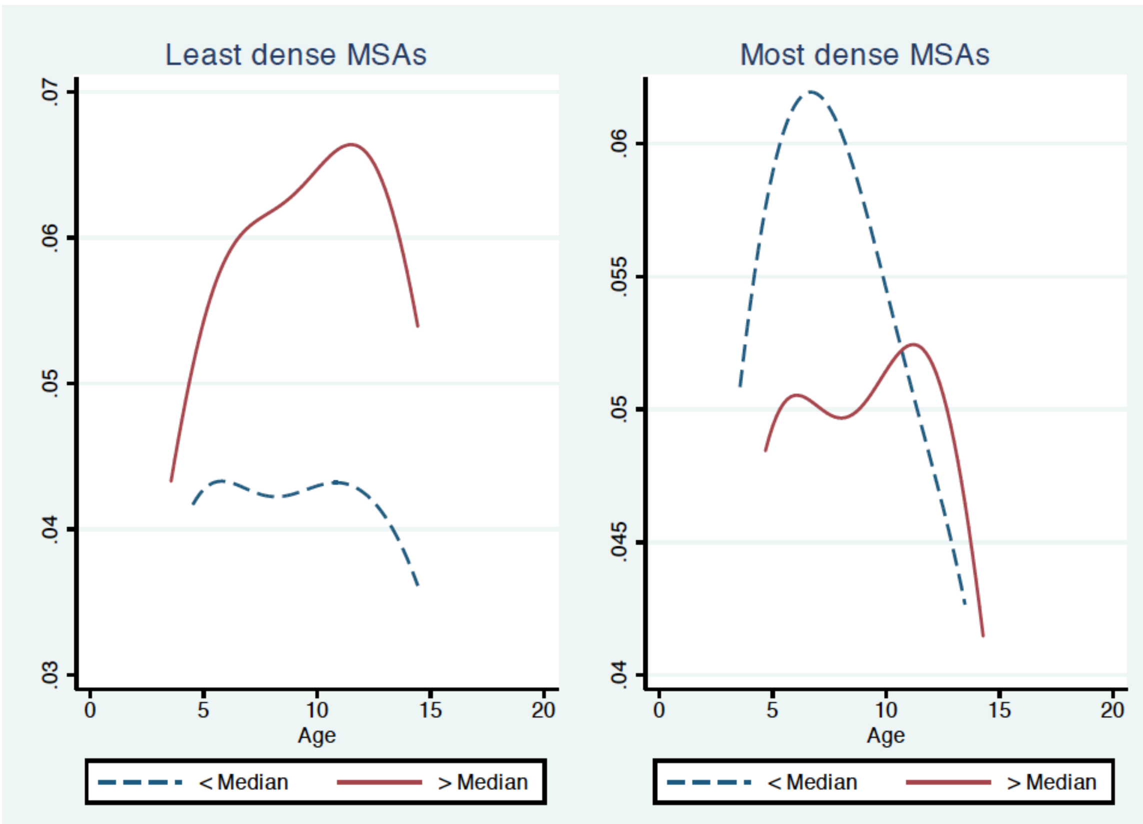

Figure 21. Computer and electronic product manufacturing smoothed hazard estimates by level of innovation and industrial density.

Note: Solid line represents more inventive MSAs; dashed line represents less inventive MSAs

52 Appendix 5 contains smoothed hazard plots for all four MSA groups divided by business density.

The hazard faced by firms in more inventive MSAs in this sample constantly increases till year 14 and decreases afterwards. Hazard faced by firms in less inventive metropolitan areas has two peaks at approximately 5 and 14 years. In the left graph, firms located in less innovative metropolitan areas (measured by total number of patents per 1,000 residents) face higher hazard at all times. In contrast, inventiveness promotes firm longevity in metropolitan areas with high industrial density, at least during the first decade of operation. After year 11, hazard functions cross and firms located in more inventive MSAs face higher hazard than their counterparts in less inventive metropolitan areas.

6.3.2. Healthcare services

As suggested by test results in Table 23, healthcare firms started in 1991 in more inventive MSAs enjoy longer life expectancy. Figure 22 confirms this result. Regardless of the measure, firms in less inventive metropolitan areas face greater estimated hazard at all time periods.

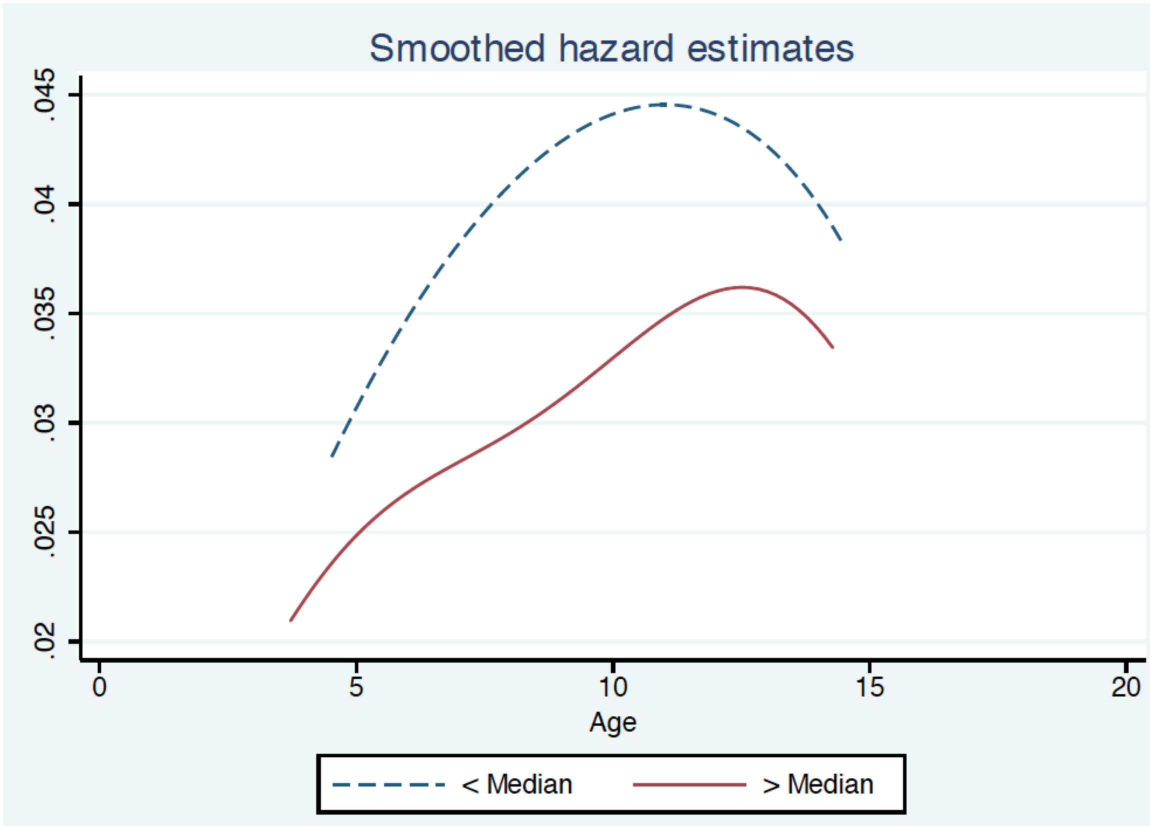

Figure 22. Healthcare smoothed hazard estimates

Note: Solid line represents more inventive MSAs; dashed line represents less inventive MSAs

The results differ drastically when MSAs in different business density quartiles are considered separately. In the least dense metropolitan areas, firms in less inventive regions are less likely to survive at all times, while in the most dense MSAs, hazard curves intersect between 12 and 13 years. After that time, firms in more inventive metropolitan areas face greater hazard[53].

[53] Appendix D contains smoothed hazard plots for all four MSA groups divided by business density.

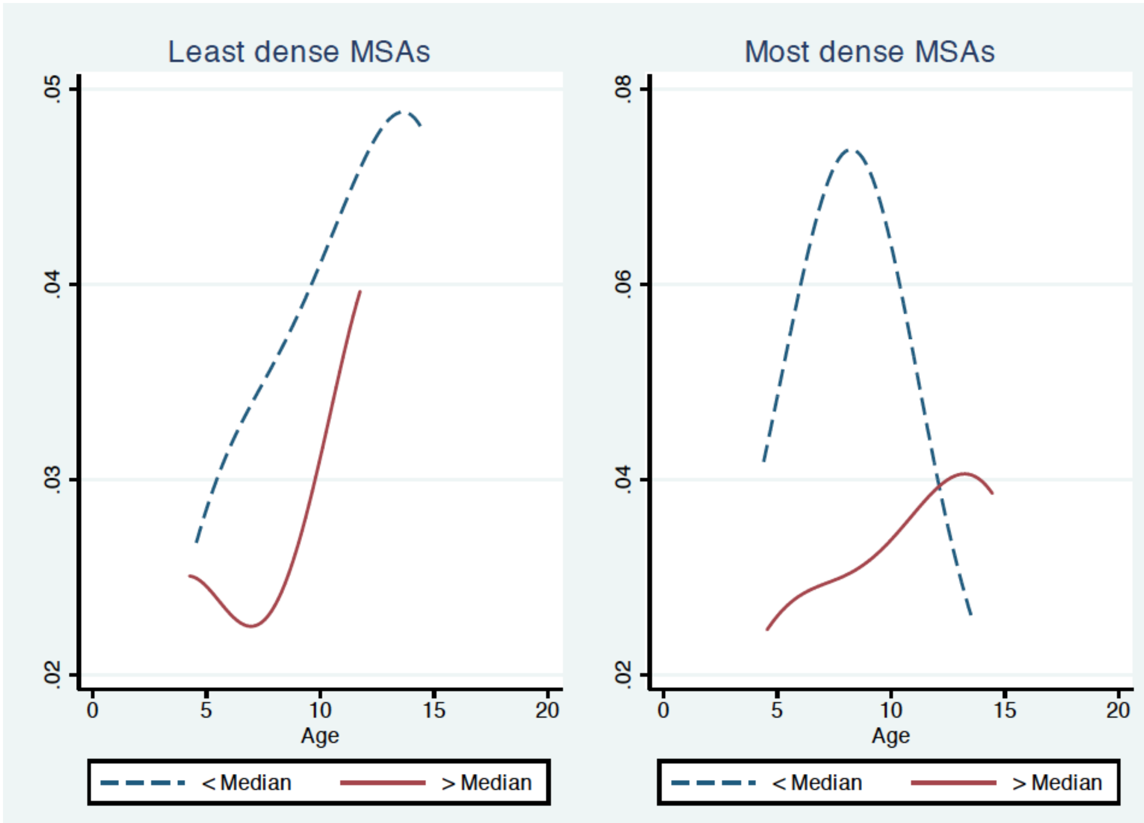

Figure 23. Healthcare smoothed hazard estimates by level of innovation and industrial density

Note: Solid line represents more inventive MSAs; dashed line represents less inventive MSAs

CHAPTER 7: MULTIVARIATE ANALYSIS

7.1. Semi-parametric Cox regression model[54]

In the study of social phenomena, which usually emerge as a result of a multitude of varied forces and factors, making assumptions about underlying distributions of events may be a difficult task. For this reason, less parameterization is always preferred to more parameterization (Box-Steffensmeier & Jones, 2007). I use semi-parametric analysis as the primary estimation technique.

In most general terms, semi-parametric analysis is a combination of separate binary-outcome analyses performed at ordered individual failure times separately. This approach does not assume any distribution of the failure times (only order matters) but it still assumes some distribution of the effects of the covariates, hence the name 'semi-parametric.' Let us re-write (6) from chapter 4 in a different form:

$$h_j(t) = g(t, \beta_0 + \boldsymbol{x}_j \boldsymbol{\beta}_x) \quad (13)$$

where hazard, $h_j(t)$,is the intensity with which failure occurs for subject j during time t. Hazard is some function of time and covariates. The Cox proportional hazards regression model assumes that independent variables shift (but do not change) the hazard everyone faces. This hazard is called the baseline hazard and is denoted by $h_0(t)$. Incorporating $h_0(t)$ in (13) and assuming the exponential functional form, we get

[54] Discussion in this subsection is based on Cleves et al. (2010).

$$h_j(t) = h_0(t)\exp\left(\beta_0 + \boldsymbol{x}_j\boldsymbol{\beta}_x\right) \Leftrightarrow$$

$$h\left(t|\boldsymbol{x}_j\right) = h_0(t)\exp\left(\beta_0 + \boldsymbol{x}_j\boldsymbol{\beta}_x\right). \quad (14)$$

Since the shape of the baseline function is presumed to be the same for everyone, in calculations it cancels out and remains unspecified. The Cox model has no intercept because it is absorbed in the baseline hazard function. The model also does not use information from the time periods when no failures happen.

7.2. Checking assumptions

7.2.1. Proportionality

The Cox model assumes proportionality of the baseline hazard function. I use Stata's `estat phtest` command, which tests for the relationship between Schoenfeld residuals[55] from the Cox regression and a smooth function of time(Cleves et al., 2010). Two conclusions emerge from the test. First, small firms and large firms have different baseline hazard functions regardless of the sector[56]. In addition, the baseline hazard function differs across the NAICS4 codes in both sectors. Second, in healthcare services, firms located in more populous and less populous MSAs, respectively, have dissimilar baseline hazard functions. The same holds true for the healthcare firms located in metropolitan areas with various levels of business density(Table 24).

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[55]Schoenfeld residuals are the difference between the value of a covariate and its expected value. The residuals are calculated for each establishment that has exited for each covariate. If the hazard is indeed proportional, the Schoenfeld residuals for a covariate should not be related to survival time (Kleinbaum & Klein, 2005).

[56]According to Klette and Kortum (2004), different hazard faced by small and large firms is a well-known phenomenon. The authors state it as a stylized fact.

Table 24. Proportionality assumption test based on Schoenfeld residuals

HTM		**HTS**	
	Prob>χ2		**Prob> χ2**
lnPat	*0.6827*	*lnPat*	*0.6054*
lnSize	*0.0003*	*lnSize*	*0.0000*
Expand	*0.4113*	*Expand*	*0.9323*
lnGrad	*0.7427*	*lnGrad*	*0.7355*
AvExp	*0.8658*	*AvExp*	*0.8762*
lnInc	*0.3321*	*lnInc*	*0.5813*
lnPop	*0.5659*	*lnPop*	*0.0064*
Diversity	*0.7990*	*Diversity*	*0.4436*
Density	*0.9487*	*Density*	*0.0504*
EntComp	*0.9462*	*EntHealth*	*0.1652*
Unemployment	*0.5390*	*Unemployment*	*0.4666*
NAICS3342	*0.5366*	*NAICS6215*	*0.0311*
NAICS3343	*0.6512*	*NAICS6216*	*0.4676*
NAICS3344	*0.7787*	*NAICS6221*	*0.0080*
NAICS3345	*0.1653*	*NAICS6222*	*0.0063*
NAICS3346	*0.0017*	*NAICS6223*	*0.5011*
Global test	**0.0012**	**Global test**	**0.0000**

Further tests by NAICS4 industry code suggest that the hazard functions still differ by firm size in some industries, but globally the hazard functions are proportional in both sectors (Appendix E). Separate tests by the level of industrial density in a MSA reveal non-proportionality of the hazard functions in half of the cases (Appendix F). I use parametric techniques to estimate the relationship between innovativeness and firm survival when Cox regression cannot be used.

7.2.2. Functional form and outliers

The functional form of the independent variables is determined graphically by plotting each variable and its several transformations against martingale residuals[57]. The form providing the closest approximation of a linear relationship is included in estimation. Out of eleven independent non-dummy variables, seven give a better linear fit in logarithmic form. The other controls enter the models without transformation.

To look for potential outliers that unjustifiably affect estimation results, I usethe LMAX statistics, which measures the relative influence of individual observations on the overall fit of the model(Gharibvand & Fernandez, 2007). Plotting LMAX statistic values against time for each sector separately reveals one influential subject in computer and electronic product manufacturing, and 10 outliers in healthcare services. These firms are dropped from the analysis.

7.2.3. Pairwise correlations and VIF statistics

The Cox regression is, in essence, a combination of logistic analyses and multicollinearity is a potential problem. Usually, estimation software does not offer multicollinearity tests for survival analysis, but traditional linear methods are valid because the problem itself concerns linear relations among covariates (Allison, 2010).Table 25 contains pairwise correlations between regressors for both sectors.

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[57] Martingale residuals are a linear transformation of Cox-Snell residuals and are widely used in proportional Cox model diagnostic. In most general terms, martingale residuals are the difference between the actual and predicted number of failures. Plotting martingale residuals against each independent variable reveals if this variable needs to be transformed in order to improve the fit (Cleves et al., 2010).

Table 25. Pairwise correlations between independent variables

	lnPat	*lnSize*	*Expand*	*lnGrad*	*AvExp*	*lnInc*	*lnPop*	*Diversity*	*Density*	*Ent*	*Unem*
lnPat	1	**-0.03**	**-0.01**	**0.23**	**0.29**	**0.60**	**0.44**	**0.11**	**0.24**	**-0.11**	**-0.26**
lnSize	**0.13**	1	**0.19**	**0.01**	**0.01**	**-0.01**	**-0.02**	**-0.01**	**-0.00**	**0.03**	**0.01**
Expand	**-0.01**	**0.18**	1	**-0.01**	**-0.03**	**-0.03**	**0.00**	**-0.00**	**-0.02**	**-0.07**	**0.08**
lnGrad	**0.11**	**-0.01**	**0.00**	1	**0.08**	**0.19**	**0.21**	**0.04**	**0.10**	-0.00	**-0.22**
AvExp	**0.16**	**0.04**	**-0.03**	**0.02**	1	**0.63**	**0.46**	**0.02**	**0.60**	**-0.18**	**-0.07**
lnInc	**0.56**	**0.11**	**-0.03**	**0.01**	**0.58**	1	**0.65**	**0.18**	**0.56**	**-0.07**	**-0.35**
lnPop	**0.18**	**0.09**	**-0.00**	**-0.09**	**0.39**	**0.50**	1	**0.41**	**0.74**	**-0.04**	**-0.04**
Diversity	**-0.27**	**-0.04**	**-0.00**	**-0.15**	**-0.00**	**-0.02**	**0.42**	1	**0.21**	**-0.02**	**-0.01**
Density	**0.07**	**0.06**	**-0.02**	**-0.05**	**0.54**	**0.46**	**0.74**	**0.23**	1	**0.01**	**-0.01**
Ent	**0.66**	**0.11**	**0.00**	**0.01**	**-0.16**	**0.30**	**0.03**	**-0.46**	**-0.06**	1	**-0.07**
Unemp	**-0.01**	**0.03**	**0.08**	**-0.18**	**-0.08**	**-0.19**	**0.04**	**-0.13**	**0.01**	**0.29**	1

Note: Entries below the diagonal are for computer and electronic product manufacturing (shaded); areas above the diagonal are for healthcare services. Correlations in **bold** are significant at the 0.05 level

Inspection of Table 25 reveals several potentially troublesome correlations. Most populous MSAs tend to enjoy high industrial density (correlation is 0.74). The correlation between *lnPat* and the number of start-ups in computer and electronic product manufacturing is 0.66, and correlation between *lnPat* and *lnInc* is 0.56. Average expenditures per pupil are positively and strongly correlated with average income and industrial density. In the healthcare services model, average income is strongly related to *AvExp, lnPop*, and *Density*. The correlation coefficient between average schooling expenditures and industrial density is 0.6.

The variance inflation factor (VIF) statistics calculated after regressing age of a firm on the eleven independent variables (excluding industry dummies), as suggested by Allison (2010), is presented in Table 26. VIF for all variables is below 10, which is perhaps the most widely used critical value to detect multicollinearity. Since a part of the analysis is carried out separately by industry and density group, VIF statistics was checked separately for each group. In all instances the value is below 10.

Table 26. Variance inflation factor statistics by sector

HTM			HTS		
Variable	**VIF**	**1/VIF**	**Variable**	**VIF**	**1/VIF**
lnPop	3.29	0.30	*lnPop*	3.66	0.27
EntComp	3.17	0.31	*lnInc*	3.44	0.29
lnInc	3.03	0.33	*Density*	3.01	0.33
Density	2.78	0.36	*AvExp*	2.23	0.45
lnPat	2.61	0.38	*lnPat*	1.74	0.58
AvExp	2.37	0.42	*Unemployment*	1.33	0.75
Diversity	1.97	0.51	*Diversity*	1.29	0.78
Unemployment	1.4	0.71	*lnGrad*	1.12	0.89
lnGrad	1.09	0.92	*EntHealth*	1.09	0.92
lnSize	1.06	0.94	*Expand*	1.05	0.95
Expand	1.04	0.96	*lnSize*	1.04	0.96
Mean VIF	**2.16**		**Mean VIF**	**1.87**	

7.3. Parametric analysis

When hazard functions are not proportional, the Cox regression is not appropriate and parametric estimation has to be used. Parametric models assume a specific distribution of failure times, i.e. all information (even when no failure happened) is used. If the choice of a distribution is correct, parametric estimators are more efficient.

Analysis of the literature together with visual inspection of smoothed hazard functions in the previous chapter, as well as exit patterns by year in Chapter 5, suggest increasing and then decreasing hazard faced by firms in the sectors of interest. Two distributions are able to accommodate the non-monotonic hazard functions, log-normal and log-logistic[58].I use the latter to model the effect of innovative environment on firm survival in computer and electronic product manufacturing and healthcare services.

The hazard function in log-logistic regression is assumed to be of the form[59]

$$h(t|x_j) = \frac{-\frac{d}{dt}S(t|x_j)}{S(t|x_j)} \quad (15)$$

where $S(t|x_j)$ is the survival function that depends on time t and covariates x.The log-logistic model is an accelerated failure time (AFT) model. Covariates accelerate time to failure by the acceleration parameter $exp(-x_j\beta_x)$, thus,

$$S(t_j|x_j) = S_0\left\{\exp\left(-\boldsymbol{x}_j\boldsymbol{\beta}_x\right)t_j\right\} \quad (16)$$

A function of failure time t_j,$\tau_j = exp(-x_j\beta_x)t_j$is assumed to be distributed as log-logistic with mean β_0 and variance γ.

7.4. Estimation results

This section presents multivariate estimation results obtained from the semi-parametric and parametric hazard analyses. In the next subsection the effect of innovation on survival is determined using all observations. The following two subsections are devoted to the separate analyses by industry at the NAICS4 level and by the degree of industrial density in a MSA.

Whenever possible, the Cox regression is used. The proportionality assumption check performed in 7.2.1., however, suggests dissimilar baseline hazard functions for companies of different size, and for firms belonging to different industries. In such casesa

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[58] They are practically indistinguishable for the purposes of estimation.

[59] Discussion in this subsection is based on Cleves et al. (2010)

parametric approach is used. The coefficients derived from the log-logistic regression indicate the effect of an independent variable on **survival** likelihood, while coefficients reported by the Cox regression show the effect on the **hazard ratio.** A positive parameter estimate in the parametric analysis suggests a positive relationship between the associated independent variable and business survival. Conversely, a coefficient greater than one in the semi-parametric analysis implies a negative relationship between this variable and survival.

7.4.1. Pooled estimation results (log-logistic regression)

Table 27 displays overall parametric estimation results for computer and electronic product manufacturing (left panel), and healthcare services (right panel).It follows from the table that manufacturing firms face higher hazard in more innovative MSAs. This result is in line with the conclusions of non-parametric analysis and indirectly confirms the Schumpeterian argument of 'creative destruction'. In healthcare services, innovation appears not to be statistically related to the likelihood of firm survival. After controlling for several individual, industrial, and regional characteristics, the coefficient of innovation is negative for healthcare services, contrary to the non-parametric analysis results, and insignificant.

Table 27. Log-logistic regression results for computer and electronic product manufacturing and healthcare services

HTM			**HTS**		
Variable	**Coef.**	**Robust Std. Err.**	**Variable**	**Coef.**	**Robust Std. Err.**
lnPat	-0.160***	0.062	*lnPat*	-0.021	0.050
lnSize	-0.056**	0.026	*lnSize*	-0.063***	0.021
Expand	-0.002***	0.001	*Expand*	0.005	0.004

Table 27 (continued)

lnGrad	0.056***	0.009	*lnGrad*	0.003	0.013
AvExp	-0.008	0.024	*AvExp*	0.025	0.036
lnInc	1.375***	0.263	*lnInc*	0.740**	0.343
lnPop	-0.088**	0.038	*lnPop*	-0.114***	0.041
Diversity	0.010	0.268	*Diversity*	-0.290	0.208
Density	0.000	0.000	*Density*	0.001	0.000
EntComp	-0.003*	0.002	*EntHealth*	-0.001	0.002
Unemployment	-0.027	0.018	*Unemployment*	-0.008	0.016
NAICS3342	0.126	0.092	*NAICS6215*	-0.338***	0.078
NAICS3343	0.246**	0.104	*NAICS6216*	-0.206***	0.066
NAICS3344	0.347***	0.082	*NAICS6221*	0.117	0.140
NAICS3345	0.303***	0.073	*NAICS6222*	0.048	0.084
NAICS3346	0.663***	0.071	*NAICS6223*	-0.072	0.084
Constant	-0.780	0.941	Constant	1.766	1.276
Gamma	0.517	0.017	Gamma	0.476	0.021
Wald $\chi2$ (16)	664.02		Wald $\chi2$ (16)	133.63	
Prob>$\chi2$	0.000		Prob>$\chi2$	0.000	
# of subjects	1,641		# of subjects	1,348	
# of observations	17,477		# of observations	17,204	
# of exits	782		# of exits	532	

*** - significant at 0.01 level; ** - significant at 0.05 level; * - significant at 0.1 level. Note: standard errors adjusted for clusters in MSA

In the left panel of Table 27, almost all retained control variables are significant. Both firm-level characteristics appear to affect business survival. The analysis suggests that larger firms, as well as companies that have expanded in the previous year, are more likely to exit. This result, however, should be interpreted with caution. Independent companies usually start small and grow over time. As time passes, the likelihood of exit is likely to increase, as is the likelihood of expansion. The observed negative effect of the size and expansion may be an artifact of this relationship. An alternative explanation is that larger firms might be more difficult to manage, which results in insufficient productivity per worker. At the same time, expansion can impose challenges associated with managing firm growth and may increase hazard.

A number of metropolitan traits are statistically associated with business longevity. Average income in a metropolitan area, and educational attainment seem to promote survival. The former characteristic approximates the depth of the market and resources available to the firms located in the more affluent MSAs. The latter signals the quality of the labor pool a company may draw upon. High-technology firms tend to live less in more populated metropolitan areas, while industrial density and diversity are not significant. The entry of new firms in computer and electronic product manufacturing increases hazard.

The significance of the industrial dummy variables suggests different survival dynamics depending on the NAICS4 industry in focus. Numerous empirical studies demonstrate that firm performance varies by industry, sector, and stage of a product's life cycle (Agarwal, 1997; Agarwal & Gort, 2002; Renski, 2009). Industries included in this analysis, Computer and Peripheral Equipment Manufacturing (NAICS3341), Communications Equipment Manufacturing (NAICS3342), Audio and Video Equipment Manufacturing (NAICS3343), Semiconductor and Other Electronic Component Manufacturing (NAICS3344), Navigational, Measuring, Electromedical, and Control Instruments Manufacturing (NAICS3345), and Manufacturing and Reproducing Magnetic and Optical Media (NAICS3346), represent a variety of technological processes, market and industrial characteristics, and life cycle stages of the main products produced. Significance of industrial indicators in this case is expected and warrants an industry-specific analysis, performed in the next subsection.

In the right panel of Table 27, only a few variables are statistically significant. The size of healthcare firms is negatively related to survival likelihood. Increase in the number of employees from the previous year is not significant. On average, business establishments in healthcare services sector live longer in more affluent metropolitan areas, and exit sooner in more populous MSAs.

The high-tech service sector in this study consists of six industries defined at NAICS 4-digit level, Outpatient Care Centers (NAICS6214), Medical and Diagnostic Laboratories (NAICS6215), Home Health Care Services (NAICS6216), General Medical and Surgical Hospitals (NAICS6221), Psychiatric and Substance Abuse Hospitals (NAICS6222), and Specialty (except Psychiatric and Substance Abuse) Hospitals (NAICS6223). Only two out of five industrial dummies are significant. Medical and diagnostic laboratories and home healthcare services have survival dynamics different from outpatient care centers, the reference category. All other industries, which include various types of hospitals, are identical to outpatient care centers in terms of survival.

7.4.2. Estimation by NAICS4 codes (Cox regression)

Innovation in the U.S. MSAs either is not a statistically significant predictor of business survival or increases hazard faced by firms in computer and electronic product manufacturing and healthcare services. Table 27 implies that industrial affiliation is significantly related to business survival in a number of cases. This subsection performs separate analyses by industry.

Proportionality tests performed earlier reveal (globally) parallel baseline hazards within each industry at NAICS 4-digit level. The models in this subsection are estimated using the semi-parametric Cox regression, which does not assume any distribution of the failure times. Table 28 reports estimation results for computer and electronic product manufacturing. A hazard rate greater than one indicates that a variable increases the likelihood of exit, and a hazard rate below one means that the covariate promotes survival.

A quick inspection of Table 28 suggests that effects of explanatory and control variables differ by industry. Innovation appears to be a significant predictor of firm exit only in Communications Equipment Manufacturing (NAICS 3342). It is not statistically related to the hazard faced by companies in all other industries. Firms in Communications Equipment Manufacturing face higher hazard in more innovative metropolitan areas.

Table 28. Cox regression results (hazard ratios) for computer and electronic product manufacturing by NAICS4 industry code

Var.\NAICS	**3341**	**3342**	**3343**	**3344**	**3345**	**3346**
lnPat	1.264 (0.192)	1.819** (0.481)	1.295 (0.417)	1.113 (0.204)	0.902 (0.130)	1.201 (0.220)
lnSize	1.112* (0.064)	1.010 (0.096)	1.455*** (0.198)	0.953 (0.059)	1.112 (0.078)	1.180 (0.121)
Expand	0.995 (0.006)	0.991 (0.009)	0.977 (0.030)	0.998 (0.006)	1.004*** (0.001)	0.997 (0.010)
lnGrad	0.967 (0.036)	1.020 (0.058)	1.211 (0.208)	0.856*** (0.039)	0.929 (0.047)	0.870*** (0.047)
AvExp	1.129** (0.057)	1.056 (0.095)	0.849 (0.105)	0.999 (0.078)	0.964 (0.068)	0.877 (0.080)
lnInc	0.241** (0.159)	0.0472** (0.059)	0.178 (0.303)	0.202** (0.145)	1.811 (1.238)	1.611 (1.655)
lnPop	1.249** (0.128)	0.858 (0.132)	1.112 (0.218)	1.1438 (0.137)	0.952 (0.080)	0.965 (0.156)
Diversity	0.787 (0.542)	1.016 (1.518)	1.230 (1.639)	0.432 (0.290)	1.232 (0.819)	0.646 (0.575)
Density	0.999 (0.001)	1.002** (0.001)	1.002 (0.001)	1.000 (0.001)	1.000 (0.001)	1.001 (0.001)
EntComp	1.005 (0.004)	0.997 (0.007)	0.982 (0.017)	1.005 (0.005)	1.005 (0.005)	0.994 (0.008)
Unemployment	0.953 (0.053)	1.140 (0.092)	0.984 (0.178)	0.955 (0.049)	1.029 (0.056)	1.093 (0.090)
Wald $\chi 2$ (16)	61.25	40,36	47.94	52.58	78.78	21.70
Prob>$\chi 2$	0.000	0.000	0.000	0.000	0.000	0.027

Table 28 (continued)

# of subjects	373	162	92	345	366	303
# of observations	3,304	1,589	1,023	3,725	4,046	3,790
# of exits	216	87	47	161	177	94

*** - significant at 0.01 level; ** - significant at 0.05 level; * - significant at 0.1 level. Note: standard errors (in parentheses) adjusted for MSAs

Larger companies are more likely to exit only in two industries, Computer and Peripheral Equipment Manufacturing (NAICS 3341), and Audio and Video Equipment Manufacturing (NAICS 3342). Expansion is negatively related to survival in Navigational, Measuring, Electromedical, and Control Instruments Manufacturing (NAICS 3345), and in Manufacturing and Reproducing Magnetic and Optical Media (NAICS 3346). These two variables are insignificant in the other industries. Firms in NAICS3344and NAICS3346 enjoy somewhat greater expected longevity in metropolitan areas with higher level of education, while companies in NAICS 3341 exit sooner in MSAs with greater per pupil public spending. Business establishments in NAICS 3341, NAICS 3342, and NAICS3344 appear to live longer in the MSAs with greater average per capita income. The size of the metropolitan population has negative effect on firm longevity in NAICS3341, while industrial density somewhat hinders survival in NAICS3342.

Table 29 shows that survival dynamics in healthcare services is mostly driven by factors other than the ones included in the analysis. Among the models below, estimation for Medical and Diagnostic Laboratories (NAICS 6215) is significant at the 90% confidence level, and estimation for Specialty (except Psychiatric and Substance Abuse) Hospitals (NAICS 6223) is significant at 95% confidence level. The Cox regression results suggest that NAICS 6215 firms face higher hazard in more populous MSAs, while

NAICS 6233 companies enjoy greater survival chances if they increased the number of employees over the previous year, or if they locate in metropolitan areas characterized by greater number of graduates, or higher unemployment level. All other variables fail to be significant.

Table 29. Cox regression results (hazard ratios) for healthcare services by NAICS4 industry code

Var.\NAICS	6214	6215	6216	6221	6222	6223
lnPat	0.970 (0.160)	1.035 (0.179)	0.925 (0.112)	0.371* (0.213)	0.885 (0.193)	0.944 (0.242)
lnSize	1.018 (0.069)	1.108 (0.087)	1.083 (0.054)	1.404 (0.294)	1.092 (0.177)	1.209 (0.157)
Expand	0.998 (0.009)	0.976 (0.0157)	0.999 (0.005)	0.779 (0.128)	0.985 (0.023)	0.908* (0.045)
lnGrad	1.038 (0.048)	1.092 (0.091)	0.996 (0.040)	1.0812 (0.847)	1.149** (0.070)	0.884** (0.052)
AvExp	0.953 (0.093)	0.994 (0.090)	0.965 (0.071)	1.276 (0.389)	1.039 (0.202)	0.911 (0.102)
lnInc	0.461 (0.487)	0.140 (0.172)	0.951 (0.752)	14.890 (53.586)	0.505 (0.775)	2.296 (2.728)
lnPop	0.997 (0.141)	1.363** (0.194)	1.141 (0.123)	0.715 (0.240)	0.996 (0.247)	1.060 (0.174)
Diversity	1.606 (1.079)	0.425 (0.301)	2.649 (2.014)	16.681 (60.523)	3.966 (4.743)	1.120 (1.145)
Density	1.000 (0.001)	0.999 (0.001)	0.999 (0.001)	0.999 (0.003)	0.999 (0.002)	1.000 (0.001)
EntHealth	1.0072 (0.007)	0.994 (0.007)	1.008 (0.005)	1.012 (0.030)	0.988 (0.0199)	0.997 (0.0108)
Unemployment	1.0780 (0.073)	0.973 (0.060)	1.015 (0.053)	0.968 (0.388)	1.005 (0.171)	0.844* (0.082)
Wald $\chi2$ (16)	14.99	19.38	13.49	13.70	15.70	19.89
Prob>$\chi2$	0.183	0.055	0.262	0.250	0.153	0.045
# of subjects	369	266	382	45	119	167
# of observations	5,006	3,060	4,812	527	1,709	2,090
# of exits	123	124	177	12	41	55

*** - significant at 0.01 level; ** - significant at 0.05 level; * - significant at 0.1 level. Note: standard errors (in parentheses) adjusted for MSAs

7.4.3. Estimation by industrial density level (log-logistic and Cox regressions)

Knowledge spillovers require the existence of agglomerated economies that tend to characterize denser urban environments. Non-parametric analysis above indicates a change in the relationship between innovation and firm survival in the densest MSAs. This subsection reports results of multivariate survival analysis performed separately by density level inthe metropolitan areas. Table 30presents the Cox regression estimates (the least dense and the most dense MSAs), and parametric estimation results (the less dense and the more dense MSAs) for computer and electronic product manufacturing. According to Table 30, innovation is associated with greater likelihood of exit in the least dense metropolitan areas. In other density groups, innovation is unrelated to business survival.

Table 30. Estimation results for computer and electronic product manufacturing by density group

Variable	**Group 1 (Cox)**	**Group 2 (Log-Logistic)**	**Group 3 (Log-Logistic)**	**Group 4 (Cox)**
lnPat	1.333** (0.176)	-0.073 (0.101)	-0.085 (0.101)	1.000 (0.239)
lnSize	0.973 (0.070)	-0.052* (0.030)	-0.069 (0.048)	1.110*** (0.044)
Expand	1.005*** (0.001)	0.001 (0.002)	0.024 (0.019)	0.994** (0.002)
lnGrad	0.916 (0.049)	0.168** (0.084)	-0.191** (0.095)	0.914*** (0.014)
AvExp	0.871** (0.062)	-0.007 (0.054)	-0.131** (0.058)	0.986 (0.059)
lnInc	0.521 (0.295)	1.223** (0.599)	2.395*** (0.531)	0.647 (0.316)
lnPop	1.026 (0.097)	-0.190** (0.090)	-0.298*** (0.084)	0.532*** (0.043)
Diversity	0.881 (0.458)	-0.012 (0.467)	1.457*** (0.436)	0.547 (1.059)
Density	1.000 (0.007)	0.014*** (0.004)	0.004** (0.002)	1.004*** (0.001)

Table 30 (continued)

EntComp	1.004 (0.006)	-0.004 (0.003)	-0.015*** (0.006)	1.005 (0.007)
Unemployment	0.972 (0.048)	-0.074*** (0.027)	-0.091*** (0.034)	1.385*** (0.113)
NAICS3342	1.304 (0.393)	0.075 (0.085)	0.628*** (0.208)	0.955 (0.196)
NAICS3343	1.085 (0.308)	0.335* (0.202)	0.549** (0.275)	0.851 (0.201)
NAICS3344	0.993 (0.184)	0.218** (0.104)	0.497*** (0.171)	0.476*** (0.067)
NAICS3345	0.867 (0.162)	0.183* (0.105)	0.415*** (0.102)	0.622** (0.132)
NAICS3346	0.487*** (0.119)	0.439*** (0.115)	0.822*** (0.145)	0.492*** (0.069)
Constant	----	0.320 (1.946)	-4.890 (2.415)	----
Gamma	----	0.383 (0.073)	0.426 (0.032)	----
Wald $\chi2$ (16)	145.50	663.56	98.35	148,292.08
Prob>$\chi2$	0.000	0.000	0.000	0.000
# of subjects	454	504	513	447
# of observations	4,382	4,256	4,515	4,324
# of exits	189	194	185	214

*** - significant at 0.01 level; ** - significant at 0.05 level; * - significant at 0.1 level. Note: standard errors (in parentheses) adjusted for MSAs; the second and the last columns present the Cox estimation results (hazard ratios) in the least dense (Group 1) and the densest (Group 4) MSAs; columns three and four present log-logistic regression results (likelihood of survival) in the less dense (Group 2) and the more dense (Group 3) MSAs

In the least dense group, expansion increases the probability of exit, although the coefficient is small. Companies located in the metropolitan areas with higher per pupil expenditures tend to survive longer. This effect, however, can hardly be attributed to the quality of public schools *per se*. The combination of low competition for resources together with relatively high income is likely to drive the result.

In the less dense MSAs (Group 2), firm size appears to hinder survival. Metropolitan population size and the rate of unemployment are negatively related to business longevity as well. On the contrary, educational attainment,

average income, and industrial density have a positive effect on the likelihood of business survival in computer and electronic product manufacturing. Industrial affiliation also affects survival; four out of five industrial dummies are significant.

An interesting result is that the explanatory power of the models considerably increases with the level of industrial density. In the denser MSAs (Group 3) only *lnSize* and *Expand* are insignificant. All regional characteristics and industrial dummies are related to business survival. Firms, on average, exit sooner in the metropolitan areas with greater number of graduates; with greater average per pupil expenditures; in more populous MSAs; in the areas with higher unemployment rate and with increased firm formation in computer and electronic product manufacturing. Industrial density and diversity, as well as local prosperity, appear to promote survival chances.

In the densest MSAs (Group 4), larger firms are more likely to exit, while companies that just expanded are slightly less likely to go out of business. Educational attainment and population size promote firm survival. Industrial density and unemployment, on the other hand, hinder it. Three industrial dummies are statistically significant.

Table 31 is devoted to the relationship between innovation and business survivalin healthcare services conditional on industrial density. The table presents hazard ratios derived using the Cox regression for the denser and the densest MSAs (Group 3 and Group 4, respectively), and coefficients of the log-logistic regression for the less and the least dense metropolitan areas (Group 2 and Group 1 respectively). Parametric analysis for Group 2 suggests negative relationship between patenting intensity in a metropolitan area and business longevity.

Table 31. Cox regression results (hazard ratios) for healthcare in denser (Group 3) and the densest (Group 4) MSAs

Variable	Group 1 (Log-Logistic)	Group 2 (Log-Logistic)	Group 3 (Cox)	Group 4 (Cox)
lnPat	0.050 (0.071)	-0.149*** (0.055)	1.103 (0.220)	1.341 (0.353)
lnSize	0.001 (0.037)	-0.062* (0.036)	1.101** (0.044)	1.187*** (0.066)
Expand	-0.000 (0.004)	0.006 (0.006)	0.996 (0.006)	0.976 (0.040)
lnGrad	-0.000 (0.015)	0.044** (0.021)	1.072 (0.107)	2.673** (1.189)
AvExp	0.054 (0.065)	0.102*** (0.035)	1.123 (0.125)	0.924 (0.067)
lnInc	0.253 (0.403)	1.498*** (0.459)	0.157 (0.183)	2.941 (3.433)
lnPop	-0.208*** (0.045)	-0.205*** (0.067)	1.092 (0.139)	0.812 (0.224)
Diversity	-0.420* (0.228)	-0.021 (0.388)	1.330 (1.531)	7.381 (32.266)
Density	0.009 (0.006)	0.001 (0.003)	1.003 (0.004)	1.000 (0.002)
EntHealth	-0.004 (0.003)	-0.001 (0.003)	0.998 (0.009)	1.002 (0.008)
Unemployment	-0.004 (0.019)	0.026 (0.026)	1.040 (0.078)	1.753 (0.499)
NAICS6215	-0.448*** (0.175)	-0.114 (0.124)	2.079*** (0.540)	1.650*** (0.200)
NAICS6216	-0.208 (0.147)	-0.165* (0.090)	1.430 (0.408)	1.433** (0.234)
NAICS6221	-0.127 (0.372)	0.072 (0.183)	0.802 (0.419)	0.951 (0.502)
NAICS6222	-0.023 (0.154)	0.243 (0.155)	1.432 (0.345)	0.707 (0.209)
NAICS6223	-0.056 (0.173)	0.032 (0.100)	1.348 (0.402)	1.432** (0.237)
Constant	3.405 (1.443)	-2.779 (1.982)	----	----

Table 31 (continued)

Gamma	0.429 (0.037)	0.386 (0.039)	----	----
Wald $\chi2$ (16)	55.12	43.74	94.74	40,242.91
Prob>$\chi2$	0.000	0.000	0.000	0.000
# of subjects	365	419	405	350
# of observations	4,936	4,437	4,403	3,968
# of exits	147	146	114	125

*** - significant at 0.01 level; ** - significant at 0.05 level; * - significant at 0.1 level. Note: standard errors (in parentheses) adjusted for MSAs; the second and the third columns present the log-logistic estimation results (likelihood of survival) in the least dense (Group 1) and the less dense (Group 2) MSAs; columns four and five present the Cox regression results (hazard ratios) in the denser (Group 3) and the densest (Group 4) MSAs

Companies located in the least dense MSAs (Group 1) face higher hazard in larger metropolitan areas. In addition, medical and diagnostic laboratories (NAICS 6215) are less likely to survive than the reference category, outpatient care centers (NAICS 6214). In Group 2, bigger firms exit sooner, as well as establishments in more populous MSAs. Both education-related variables and average per capita income are positively related to the likelihood of survival in this density group. In the denser regions (Group 3), firm size negatively affects survival chances. Identical to Group 1, outpatient care centers enjoy greater survival prospects compared to medical and diagnostic laboratories. In the densest MSAs, firm size reduces expected longevity, and so does educational attainment in a region. Companies in three industries (Medical and Diagnostic Laboratories, Home Health Care Services, and Specialty (except Psychiatric and Substance Abuse) Hospitals) tend to live less than the firms in the reference industry.

CHAPTER 8: DISCUSSION AND POLICY IMPLICATIONS

8.1. General notes

An impressive body of empirical and theoretical work relates entrepreneurship to regional economic performance measured by productivity (Audretsch & Keilbach, 2004b), employment (Acs & Armington, 2004), innovation, and income (Camp, 2005). New firm formation is the most common measure of entrepreneurship in a region, perhaps due to its simplicity and immediate availability for research and analysis purposes(Sousa, 2012). Renski (2006)argues that firm survival is a more relevant measure for the purposes of policy-making. Although business entry and exit represent a natural selection process, which ensures overall economic efficiency, as only the 'fittest' stay alive, for regional policy makers it may be of little consolation. In a situation when local firms compete with other businesses located outside of the region, market selection contributes nothing to the regional income and employment growth if local firms have to exit because they are unable to compete against their outside counterparts. In such a situation, survival may be a better measure of entrepreneurship and economic competitiveness of a region and should be a focus of economic policies. Analysis of the literature also suggests that firm performance, including survival, depends on regional factors, which can be shaped by policy-makers, at least to some degree.

This research produced a number of conclusions about the relationship between firm-specific and regional characteristics on the one hand and firm survival on the other, which are of relevance for public policy. Most importantly, an attempt to find empirical evidence of knowledge spillovers manifested in a greater likelihood of business survival in the two industrial sectors(Acs et al., 2002; Feser, 2002)has failed. Non-parametric analysis, at the first blush, seems to suggest presence of knowledge spillovers. In high-technology manufacturing, a negative relationship between innovation and business survival reverses in the densest MSAs, suggesting presence of positive spillovers. In healthcare services, firms located in more innovative metropolitan areas appear to live longer. Agglomeration theory and pure knowledge spillovers suggested by Marshall would be a possible explanation for the observed patterns if they were robust to inclusion of control variables in the analysis. The multivariate analysis, however, does not support the non-parametric results. In contrast to the postulates of agglomeration theory, innovation in a region measured by patenting intensity has negative, or no relationship to firm survival in high-technology manufacturing. There is no statistically significant relationship between patenting in the MSAs and business longevity in healthcare services. The next two subsections discuss in greater detail the applications of these findings to specific types of policies used in this country.

Another important conclusion of this study is that innovation in a region affects survival probability of non-patenting high-tech manufacturing firms differently, depending on the industry. Companies in Communications Equipment Manufacturing tend to exit sooner in the MSAs with higher level of patenting activity. All other industries considered in this research do not appear to be sensitive to the innovative environment. In healthcare services, companies located in less dense MSAs on average live less as compared to other metropolitan areas.

The companies in this study have dissimilar hazard functions depending on firm size and industrial affiliation. It is not surprising given the accumulated knowledge on the industrial dynamics and evolution(Agarwal et al., 2002; Fritsch et al., 2006; Molle, 1977), and differences between small and large firms (O'Farrell & Hitchens, 1988). For policy-makers, it is important to keep in mind the divergent effects the same policy may have on companies of various sizes, and on firms belonging to different industries. Deep knowledge of the industry in focus should help avoid inefficiency or waste of resources when designing and implementing programs aimed at specific industries or sectors.

In general, the analysis above confirms what Malecki (1994) calls a sectoral bias: start-ups are not uniformly distributed across the country. This study suggests that it is especially true for the high-technology manufacturing. In 1991, 197 continental MSAs had at least one start-up in computer and electronic product manufacturing, and 246 metropolitan areas had at least one new firm in healthcare services. Presence of a corresponding industry in the area is a very strong predictor of firm formation (Cooper, 1985; Malecki, 1985). In this research, pairwise correlations between the number of 1991 start-ups and the number of incumbent firms are around 0.94 for both sectors. For healthcare, the total number of firms in a metropolitan area appears to be equally important.

Separate multivariate analyses by the level of industrial density imply that the relationship between regional characteristics and firm survival becomes stronger in the densest MSAs. In these areas, some factors that do not appear important in less dense areas achieve statistical significance. The effect of other factors may also change. This result suggests that economic programs implemented in the areas of various urbanization degrees are likely to have different effects depending on the level of agglomeration in the target region.

8.2. Policies stimulating economic activity

New firms are critically important for the prosperity of regional economies, as they disproportionally contribute to job creation (Acs & Armington, 2004), and innovation (Acs & Audretsch, 1987, 1990). Numerous programs at state and local levels stimulate firm formation and business attraction to regions and localities. These policies include business incubators[60] that help new firms during the first years of their operation, seed funding[61], and others.

Current literature on firm survival suggests that these policies may be to a degree one-sided. Firm formation does not guarantee achieving common goals of economic programs, income and employment growth in a region, if newly founded firms exit during the first few years of operation, before they get to the growth stage. Quick exit in this situation is particularly undesirable as public money that helped a failing firm to start its operation would be wasted.

The policy-makers' task to stimulate economic activity and to help new business to survive and to grow is complicated by the fact that factors conducive to business formation may increase hazard faced by firms (Sorenson & Audia, 2000; Stuart &

[60] The National Business Incubation Association (NBIA) reports that more than 50% of business incubators in North America are sponsored by economic development organizations and governments of various levels. Another 20% are sponsored by universities (information retrieved from the NBIA website at http://www.nbia.org/resource_library/faq/#5).

[61] For example, NSF has been active in providing seed grants via a number of universities for research in emerging materials.

Sorenson, 2003). The results of this study suggest that high-tech manufacturing firms with no patenting potential should not be publicly supported in innovative regions, as these firms are more likely to exit. To state it differently, non-patenting firms founded in metropolitan areas with high patenting intensity may require greater or longer support in order to live through the most turbulent first years of operation. In healthcare, innovativeness of the region has no effect on survival; therefore, policies targeted at this sector should be designed keeping in mind factors other than overall level of innovation in the geographical area.

8.3. Cluster policies

It has long been known that new firms' formation and prosperity depends on the region they locate in. Not every locality is able to sustain successful business activities as effectively. With relatively small differences in basic infrastructure available to companies across the regions, the primary component of a nourishing environment is "the diverse assortment of information and other knowledge necessary for firm formation and business success" (Malecki, 1994, p. 125). This reasoning is in line with the vast body of knowledge called agglomeration theory. According to it, the concentration of business activity, including metropolitan areas, should facilitate knowledge exchange and spillovers that lead to improved business performance (Palazuelos, 2005).

Belief in the ability of agglomerations to promote business performance made cluster policies rather popular with policy-makers in this country[62]. Some researchers note that clusters have become a focus of contemporary debates on urban and regional

[62] Examples of state-level economic programs that support clusters include *Twin Cities Industry Cluster Project* in Minnesota, *Strategic Partnership for Economic Development (*ASPED*)* in Arizona, *Joint Venture: Silicon Valley* in California, and others.

economic development (Aziz & Norhashim, 2008; Cumbers & MacKinnon, 2004). Policy-makers appear to strongly believe in the ability of clusters to provide better (or cheaper) access to land, information and knowledge; as well as faster (or cheaper) access to the suppliers of inputs, to institutions, and to public goods for the firms (Oerlemans et al., 2001). The common expectations are that all those characteristics of clusters would inevitably translate into technological spillovers and increased innovation and learning (McDonald, Tsagdis, & Huang, 2006)

Despite expanding evidence on ineffectiveness of cluster policies (McDonald, Huang, Tsagdis, & Tüselmannc, 2007; McDonald et al., 2006; Palazuelos, 2005), the National Governors' Association in cooperation with the Council on Competitiveness has been active in promoting the ideas of cluster-based economic growth. The NGA called for greater application of cluster concepts as a way to increase state competitiveness in the global economy(Finkle, 2002). The Association released *A Governor's Guide to Cluster-Based Economic Growth*(NGA, 2002), and *Cluster-Based Strategies for Growing State Economics*(NGA, 2007), which explained to policy-makers how to sustain and to grow a successful cluster.

Knowledge spillovers are believed to be a crucial condition for a cluster success. Results of this research, however, add to the literature, which is skeptical about the effectiveness of cluster policies. Several studies find no evidence of increased interactions, a hypothesized mechanism of spillovers, in clusters across Europe (McDonald et al., 2007; McDonald et al., 2006). The negative relationship between innovativeness in the U.S. MSAs and survival of independent non-patenting firms suggests that positive knowledge spillovers either do not happen, or do not result in greater business longevity. Another possible explanation is that the positive effect of innovation might be outweighed by the negative effect of increased competition and of other hazard-increasing factors. The main conclusions of this study, combined with existing literature, suggest that policy-makers should not assume automatic cluster formation as a result of cluster policies (Aziz & Norhashim, 2008; Wolfe & Gertler, 2004), and that clusters do not guarantee firm survival as a result of spillovers.

8.4. The effects of educational attainment

In computer and electronic product manufacturing, higher educational attainment reduces hazard faced by firms in general as suggested by parametric pooled analysis, and by the companies in Semiconductor and Other Electronic Component Manufacturing (NAICS3344) and Manufacturing and Reproducing Magnetic and Optical Media (NAICS3346). In addition, the number of graduates positively affects the survival likelihood in all density groups except Group 2 (less dense MSAs).

In healthcare services, newly established specialty (except psychiatric and substance abuse) hospitals (NAICS6223) live longer in the metropolitan areas with a greater number of graduates. Educational attainment is positively related to business survival in less dense MSAs, but negatively related to firm survival in the densest metropolitan areas. Most likely, competition for resources and costumers is greater in the areas with high concentration of population and businesses.

The results of this analysis provide a nice refinement to the policy recommendations above. Although the hope for spatial spillovers in more innovative MSAs, which would help firms to live till the growth stage and to contribute to the local economic prosperity, might be somewhat premature, firms do tend to live longer in the areas with highly qualified labor pool. This suggests that policies aimed at firm creation in such areas are more likely to bring about viable firms able to operate longer.

CHAPTER 9: LIMITATIONS OF THE STUDY

This study has a number of limitations, which have to be kept in mind when interpreting and using the results of this research. This chapter discusses major threats to validity of conclusions presented above, and what has been done to minimize these threats.

9.1. Unobserved heterogeneity

Unobserved heterogeneity is perhaps the greatest concern in any study of entrepreneurship in general, and firm entry and exit in particular. Abilities of a founder and his career aspirations are a common example of factors that are important for firm performance but are difficult to collect information about (Delmar & Wennberg, 2010). A few studies provide insight in the relationship between founder or manager educational background, experience, aspirations, psychological traits and firm survival(Arribas & Vila, 2007; Colombo & Grilli, 2007; Headd, 2003; LeBrasseur & Zinger, 2005). Such studies usually rely on surveys prone to a number of flaws and limitations. Among the most important ones are the inability to cover a large population, and possible failure to be representative.

The problem of unobserved heterogeneity is likely to be the most severe in observational data, especially when the whole population is included in the analysis. Delmar and Wennberg(2010) suggest strategic selection of the estimation sample in order to reduce or minimize the threat. The estimation sample in this research excludes companies that are by definition more capable (patenting firms), and the companies that are either more capable or are better positioned than other firms for future growth (those undergoing M&A). The non-independent establishments, which are likely to enjoy expertise and resources of their affiliated organizations, are excluded as well. Companies located in non-metropolitan areas may have different starting conditions and available resources, and have also been excluded from the analysis.

Perhaps the easiest way to control for many firm-specific invariant factors is to include company fixed effects. Unfortunately, such a strategy was not feasible for this study. The software package used (Stata/IC) could not handle calculation because of the large number of firms in the samples[63]. Attempts to run estimation with fixed effects on a random subset of observations did not succeed, as the procedure did not converge.

In addition to the sample selection, alternative specifications were used to check if other plausible covariates have an explanatory power in the models. Variables measuring the level of entrepreneurship, population density, industrial location quotient, venture capital funding of a firm, as well as population unadjusted patent counts were included in the preliminary models. These characteristics were either insignificant, or highly correlated with included variables creating multicollinearity problems. Besides additional controls, a number of interaction terms were included in regressions. In some models, up to three interactions appeared to be significant. Their significance disappeared after other insignificant interaction terms were excluded. Most importantly, presence of interaction terms did not change the direction and significance of the main explanatory variables.

[63]Stata/IC allows up to 798 right-hand-side variables, whereas in this research firm-fixed effects would add more than 1,000 dummies to the equation.

9.2. Endogeneity

Endogeneity bias, rather common in aggregated data research, should not be a problem in a firm level analysis. In this research, such a possibility is precluded by the construction of the dataset and by the nature of the dependent variable. Survival of non-patenting firms cannot affect patenting intensity in the region where they are located. Another possible source of endogeneity bias, business self-selection to more innovative metropolitan areas, could be of greater concern. In theory, if more viable firms tend to locate in less innovative areas, the observed relationship between innovation and business survival may bean artifact of a self-selection process and not related to the external effects of innovation. This scenario, however, is not likely to be the case forat least two reasons. First, independent establishments usually have insufficient resources for optimizing behavior in inter-regional site selection. New firms usually locate where their founders live or work (Figueiredo, Guimaraes, & Woodward, 2002), as inter-regional location decisions of such firms are in most cases exogenous (Renski, 2006). Next, a case may be made that successful high-tech firms become less dependent on the resources innovative and agglomerated economies have to offer, and tend to locate everywhere, including less innovative MSAs (Acs, Parsons, & Tracy, 2008). This statement, though, contradicts what is observed in the data used for this research: new firms, especially in high technology manufacturing, tend to locate in more innovative and populated metropolitan areas.

9.3. Measures

Construct validity is another validity threat in empirical analysis. If variables used do not measure what they are supposed to measure, the results may be meaningless or misleading. This is particularly worrisome when no direct measures are readily available and a researcher has to come up with approximations. One needs to be especially careful with measures of dependent and main explanatory variables. In the survival research in general, the correct measure of the dependent variable may be a concern when onset of risk cannot be easily identified. This is mostly relevant to clinical research (Cleves et al., 2010). In the studies of business longevity, choosing onset of the risk and the time of an event (exit) is more straightforward. In this research, the risk begins accumulating when a firm is first recorded in the NETS Database. It is right censored in 2008 or exits before it. The NETS Database indicates the year of exit as YEARLAST. Exit here means termination of business operations, which is reflected in the NETS Database as zero employment after the YEARLAST[64].

Innovation measure may require a more extended explanation and justification. Apparently, it is not the patents, or R&D expenditures, or share of R&D employees in the economy that directly increase productivity, makes regional economy more innovative and prosperous. These variables are the widely used approximations for the stock of knowledge generated in a region. New ideas cannot be measured, they do not leave a paper trail, to repeat Krugman's(Krugman, 1991) famous saying, but the fruitful applications of the new ideas (combinations of resources as Schumpeter puts it) in the market is the main driver of economic success demonstrated by companies and regional economies. Patent counts as an approximation for the stock of new profitable ideas has its

[64]NETS does not stop reporting establishments when they change headquarters. An establishment's unique D&B number is associated with its headquarters' D&B number in each year. If establishment continues operations, change in the ownership is reflected in the field that stores headquarters' D&B number. This scenario, though, is not a concern in this research, as only independent establishments are included in the analysis.

weaknesses and limitations. Patents do not cover all new ideas created in the economy; perhaps the majority of them go unpatented. On the other hand, not every patent is utilized in the market promoting productivity and innovation. The number of patents as a measure of innovation is unable to reflect market value of each patent, which are likely to differ greatly(Levitas et al., 2006). Despite all these concerns, researchers argue that patent count is perhaps the best measure of innovation (Griliches, 1990) because it is superior to other available measures (Feser, 2002) and is an appropriate approximation for the stock of knowledge generated in an urban region (Acs et al., 2002). The sample in this research includes larger and more inventive metropolitan areas, the main ‘producers’ of patented knowledge. It is hoped that patent count is an appropriate measure of innovation in this case. Besides, an alternative measure of innovation, number of patents technologically related to the industries of interest, was used in the preliminary analysis. The variable was dropped because it did not achieve statistical significance in any of the models.

9.4. Data

Any large array of data is inherently prone to possible erroneous records. This is equally true for aggregated and individual data, although in the former case a researcher may hope that random mistakes would not affect the results. Given current data collection technologies, gathering and maintaining a complete and perfectly accurate database of all businesses in this country is practically impossible. The NETS Database, the main source of data for this research, has its share of inaccuracies. The most important one is that a considerable number of establishments with YEARSTART=1991 actually enter the dataset in the later years, with dozens of firms being recorded for the first time in year

2008. 325 computer and electronic manufacturing establishments, and 227 healthcare establishments were removed from the estimation file for that reason.

While collecting information on exit modes and venture financing of the firms in the sample, it was revealed that NETS contained several erroneous exit dates. If a firm in the NETS Database was recorded alive after it has exited in reality, the actual exit year was marked as EVENT=1 in the estimation dataset, i.e. the following years were disregarded for the analysis purposes. A handful of establishments were alive after NETS reported their exit. EVENT variable in the estimation file was recorded accordingly and firm specific control variables were copied from the last available year in the dataset.

Another important limitation of the NETS Database is its bias toward larger firms. If small firms have a different survival dynamics, the results of this research would be valid for larger firms only and should not be generalized to small companies.

9.5. External validity

Findings in this research are valid for high-technology manufacturing and high technology services represented by the twelve NAICS 4-digit codes as specified in Section 5.3. Although an attempt has been made to capture the high-tech end of the U.S. economy by analyzing sectors that belong to both high technology manufacturing and high technology services, the results are unlikely to be generalizable to other industries. The conclusions may be somewhat generalizable to the industries technologically close to those considered, but not applicable to the industries that are technologically far apart.

The results also cannot be generalized to the less dense and less innovative MSAs, which do not enter the estimation sample. Companies belonging to the industries considered in this dissertation do operate in these metropolitan areas. The regression coefficients in this research, however, were derived using different set of localities. Applying results of this study to the metropolitan areas, which do not enter the analysis, would be erroneous, as regression function does not have data support in such localities. On a related note, the majority of the MSAs considered ‘less innovative’, ‘lease dense’, or ‘less dense’ in this dissertation would be in the middle of innovation and density distributions if all metropolitan areas in this country were included. Such uneven representation results from the fact that computer and electronic product manufacturing and healthcare startups in 1991 tended to locate in more innovative and denser MSAs.

This study does not pay special attention to possible unique characteristics of the 1991 and the following years; neither does it compare these years to any set of other time frames. If year 1991 was particular in its effects on firm survival, the results of this study may also be inapplicable to other cohorts of companies started in the sectors of interest. Business survival literature, however, does not provide any indication of a special character year 1991 could have.

CHAPTER 10. CONCLUSIONS

The purpose of this dissertation project was to estimate external effects of innovation, one of the major determinants of regional and business performance, on firm survival. Justification for the relationship between regional innovation and business longevity primarily comes from the agglomeration literature. It postulates that in the areas of business concentration, knowledge spillovers are likely to happen increasing productivity and innovativeness of companies not engaged in purposeful generation of new knowledge. Empirical studies relate these two factors to greater likelihood of survival. The testing procedure involved identifying all standalone startups in 1991 in continental MSAs that belong to 12 industries defined at NAICS 4-digit level representing high technology manufacturing and high technology services. After excluding firms that had at least one successful patent application before year 2009, and those eventually undergoing M&A, the establishments were tracked till their exit or year 2008, whichever happened first.

Multivariate duration analysis tested if innovativeness of a MSA, measured by population-adjusted patent count, enhanced, hindered, or had no effect on firm survival. The results imply that if statistically significant relationship exists, it is negative. Overall innovativeness in a metropolitan area appears to impose competitive pressure and force independent non-patenting companies to exit sooner in Communications Equipment Manufacturing and healthcare services firms located in the less dense MSAs. In all other industries and density groups considered, both manufacturing and services, the relationship is not statistically meaningful, although the coefficients in the majority of the cases indicate increased hazard in more innovative MSAs.

From the standpoint of agglomeration theory, findings in this dissertation imply that knowledge spillovers, if present, do not translate into increased survival chances for standalone non-patenting establishments. These results, however, are nicely in line with the Schumpeterian perspective on innovation. According to the economist, more innovative environments should impose greater competitive pressure on all businesses, and should stimulate firm exit, which is observed in the data in this research. Another possibility is that both mechanisms promoting longevity and enhancing hazard work simultaneously and produce zero net effect in the majority of industries.

A logical future step would be to include low-technology manufacturing and low-technology services in the analysis. The insignificant or inhibiting effects of innovation on firm survival uncovered in the high-technology sectors allows to hypothesize that the low-tech end of the U.S. economy is likely to be even less perceptive of the innovative environment.

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APPENDIX A: MOST AND LEAST INVENTIVE MSAS (AVERAGE OVER 1992 – 2008)

1. Most inventive MSAs

Inventiveness measure	Top 5 MSAs
Patents total	San Jose – Sunnyvale – Santa Clara, CA; New York – Northern New Jersey – Long Island, NY-NJ-PA; Los Angeles – Long Beach – Santa Ana, CA; San Francisco – Oakland – Fremont, CA; Boston – Cambridge – Quincy, MA-NH
Patents per 1000 residents	San Jose – Sunnyvale – Santa Clara, CA; Rochester, MN; Corvallis, OR; Burlington – South Burlington, VT; Boulder, CO

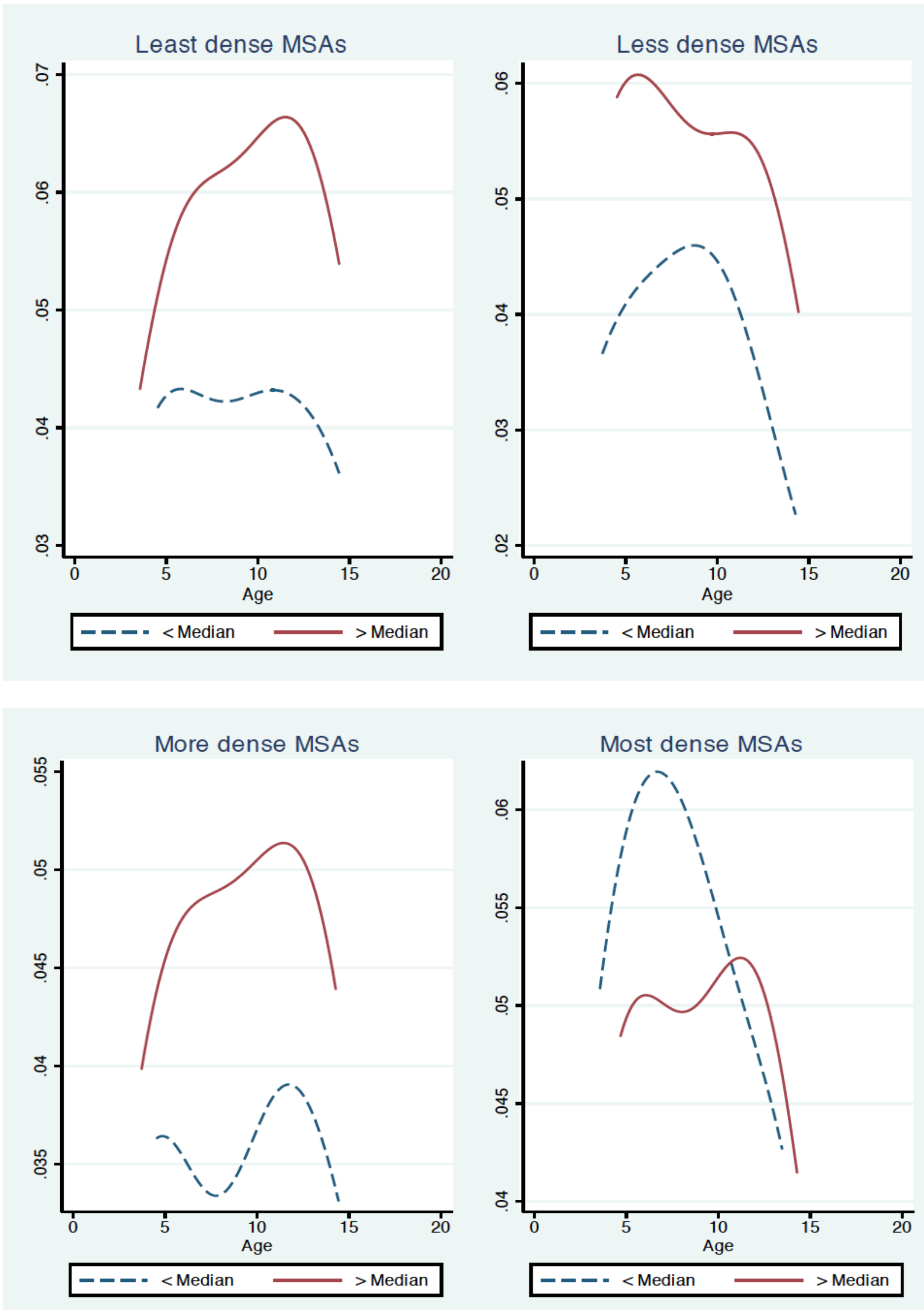
2. Least inventive MSAs

Inventiveness measure	Bottom 5 MSAs
Patents total	Hinesville – Fort Stewart, GA; Laredo, TX; Pine Bluff, AR; El Centro, CA; Lawton, OK
Patents per 1000 residents	Hinesville – Fort Stewart, GA; Laredo, TX; McAllen – Edinburg – Mission, TX; El Centro, CA; Jacksonville, NC

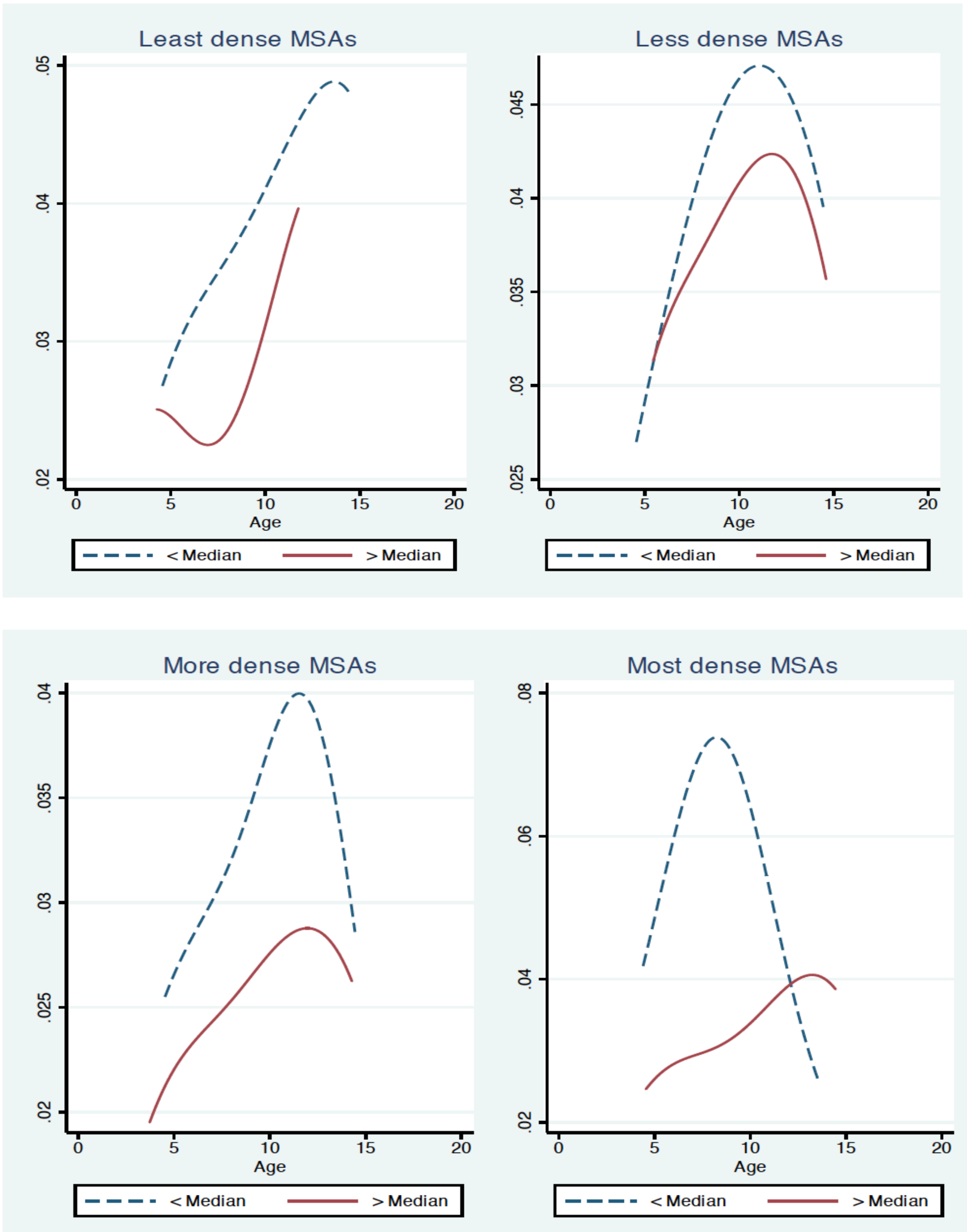
APPENDIX B: MSAS WITH HIGHEST AND LOWEST BUSINESS DENSITY

Variable	**MSAs**
Business density, top 5 (from most dense to less dense)	New York-Northern New Jersey-Long Island, NY-NJ-PA; Los Angeles-Long Beach-Santa Ana, CA; Trenton-Ewing, NJ; Miami-Fort Lauderdale-Pompano Beach, FL; Cleveland-Elyria-Mentor, OH
Business density, bottom 5 (from least dense to more dense)	Flagstaff, AZ; Anchorage, AK; Fairbanks, AK; Lake Havasu City – Kingman, AZ, El Centro, CA

APPENDIX C: SMOOTHED HAZARD ESTIMATES IN COMPUTER AND ELECTRONIC PRODUCT MANUFACTURING BY BUSINESS DENSITY



APPENDIX D: SMOOTHED HAZARD ESTIMATES IN HEALTHCARE SERVICES BY BUSINESS DENSITY



APPENDIX E: PROPORTIONALITY ASSUMPTION CHECK BY NAICS4 CODES

1. Computer and electronic product manufacturing

Var.\NAICS	**3341**	**3342**	**3343**	**3344**	**3345**	**3346**
lnPat	0.60	0.08	0.31	0.09	0.56	0.89
lnSize	0.05	0.05	0.28	0.26	0.07	0.23
Expand	0.77	0.33	1.00	0.35	0.25	0.72
lnGrad	0.37	0.82	0.39	0.22	0.41	0.84
AvExp	0.37	0.72	0.78	0.67	0.54	0.40
lnInc	0.29	0.83	0.82	0.75	0.10	0.60
lnPop	0.88	0.57	0.58	0.88	0.59	0.95
Diversity	0.20	0.57	0.54	0.93	0.91	0.26
Density	0.83	0.92	0.79	0.72	0.12	0.08
EntComp	0.86	0.07	1.00	0.05	0.42	0.40
Unemployment	0.11	0.22	0.45	0.44	0.46	0.71
Global test	**0.26**	**0.36**	**0.85**	**0.60**	**0.40**	**0.45**

2. Healthcare

Var.\NAICS	**6214**	**6215**	**6216**	**6221**	**6222**	**6223**
lnPat	0.13	0.31	0.24	0.90	0.46	0.19
lnSize	0.02	0.01	0.01	0.17	0.03	0.11
Expand	0.67	0.77	0.99	0.69	0.87	0.48
lnGrad	0.62	0.46	0.52	0.19	0.90	0.74
AvExp	0.32	0.20	0.44	0.78	0.00	0.60
lnInc	0.73	0.33	0.68	0.62	0.04	0.73
lnPop	0.26	0.34	0.13	0.56	0.25	0.36
Diversity	0.18	0.99	0.61	0.08	0.37	0.66
Density	0.18	0.39	0.55	0.97	0.08	0.35
EntHealth	0.24	0.92	0.80	0.28	0.45	0.17
Unemployment	0.91	0.63	0.27	0.19	0.70	0.60
Global test	**0.08**	**0.40**	**0.23**	**0.73**	**0.09**	**0.67**

APPENDIX F: PROPORTIONALITY ASSUMPTION CHECK BY THE LEVEL OF INDUSTRIAL DENSITY

1. Computer and electronic product manufacturing

	Group 1	**Group 2**	**Group 3**	**Group 4**
lnPat	0.83	0.51	0.01	0.22
lnSize	0.26	0.02	0.04	0.08
Expand	0.40	0.96	0.18	0.50
lnGrad	0.33	0.22	0.75	0.98
AvExp	0.35	0.54	0.09	0.14
lnInc	0.74	0.83	0.01	0.11
lnPop	0.35	0.34	0.07	0.96
Diversity	0.81	0.25	0.17	0.47
Density	0.26	0.07	0.06	0.85
EntComp	0.69	0.75	0.83	0.52
Unemployment	0.83	0.87	0.07	0.46
NAICS3342	0.13	0.68	0.69	0.87
NAICS3343	0.89	0.45	0.54	0.26
NAICS3344	0.43	0.65	0.26	0.48
NAICS3345	0.79	0.86	0.34	0.02
NAICS3346	0.18	0.02	0.02	0.42
Global test	**0.57**	**0.04**	**0.04**	**0.24**

2. Healthcare

	Group 1	**Group 2**	**Group 3**	**Group 4**
lnPat	0.50	0.15	0.68	0.12
lnSize	0.02	0.05	0.01	0.02
Expand	0.88	0.66	0.76	0.95
lnGrad	0.14	0.49	0.25	0.72
AvExp	0.17	0.19	0.29	0.07
lnInc	0.61	0.80	1.00	0.39
lnPop	0.04	0.31	0.58	0.73
Diversity	0.13	0.32	0.10	0.66
Density	0.49	0.63	0.59	0.74
EntHealth	0.20	0.80	0.04	0.16
Unemployment	0.38	0.41	0.11	0.26
NAICS6215	0.25	0.31	0.15	0.61
NAICS6216	0.82	0.97	0.87	0.19

APPENDIX F (cont'd)

NAICS6221	0.05	0.08	0.93	0.06
NAICS6222	0.12	0.07	0.71	0.33
NAICS6223	0.71	0.10	0.83	0.26
Global test	**0.01**	**0.04**	**0.17**	**0.10**