ENTREPRENEURSHIP, INDUSTRY EVOLUTION AND ECONOMIC GROWTH

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ABSTRACT

The purpose of this paper is to provide a link between entrepreneurial activity on the one hand, and industry evolution and economic growth on the other. The role that entrepreneurship plays in innovative activity is explained. The link between entrepreneurship and industry evolution through the spillover of knowledge in generating entrepreneurial activity is analyzed. This implies that the relationship between entrepreneurship and growth is identified. In particular, this paper finds that entrepreneurship generates a positive pulse in the evolution of industries in such a way that fosters economic growth.

1. INTRODUCTION

Explanations for economic growth have generally been restricted to the realm of macroeconomics (Krugman, 1991; Romer, 1990). However, a different scholarly tradition linking growth to industrial organization dates back at least to Schumpeter (1934). In his 1911 classic treatise, *Theorie der wirtschaftlichen Entwicklung*, Schumpeter proposed a theory of creative destruction, where new firms with entrepreneurial spirit displace the tired old incumbents, ultimately leading to a higher degree of economic growth. Even in his 1942 classic, *Capitalism, Socialism*

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and Democracy, Schumpeter (1942, p. 13) still argued that entrenched large corporations tend to resist change, forcing entrepreneurs to start new firms in order to pursue innovative activity, "The function of entrepreneurs is to reform or revolutionize the pattern of production by exploring an invention, or more generally, an untried technological possibility for producing a new commodity or producing an old one in a new way . . . To undertake such new things is difficult and constitutes a distinct economic function, first because they lie outside of the routine tasks which everybody understands, and secondly, because the environment resists in many ways."

The purpose of this paper is to provide a link between entrepreneurial activity on the one hand, and industry evolution and economic growth on the other. In Section 2 of this paper, the role that entrepreneurship plays in innovative activity is explained. The link between entrepreneurship and industry evolution is the focus of Section 3. In Section 4, the spillover of knowledge in generating entrepreneurial activity is analyzed. In Section 5, the relationship between entrepreneurship and growth is identified. Finally, in Section 6 conclusions are presented. In particular, this paper finds that entrepreneurship generates a positive pulse in the evolution of industries in such a way that fosters economic growth.

2. INNOVATION AND ENTREPRENEURSHIP

The increased importance of knowledge as a source of competitiveness for OECD countries suggests that the organization of industries most conducive to innovative activity will be linked to higher growth rates (Audretsch & Thurik, 2000, 2001). The starting point for most theories of innovation is the firm. In such theories the firms are exogenous and their performance in generating technological change is endogenous. For example, in the most prevalent model found in the literature of technological change, the model of the *knowledge production function*, formalized by Griliches (1979), firms exist exogenously and then engage in the pursuit of new economic knowledge as an input into the process of generating innovative activity.

The most decisive input in the knowledge production function is new economic knowledge. And as Cohen and Klepper (1991, 1992) conclude, the greatest source generating new economic knowledge is generally considered to be R&D. Certainly a large body of empirical work has found a strong and positive relationship between knowledge inputs, such as R&D, on the one hand, and innovative outputs on the other hand.

The knowledge production function has been found to hold most strongly at broader levels of aggregation. The most innovative countries are those with the greatest investments to R&D. Little innovative output is associated with less developed countries, which are characterized by a paucity of production of new economic knowledge. Similarly, the most innovative industries, also tend to be characterized by considerable investments in R&D and new economic knowledge. Not only are industries such as computers, pharmaceuticals and instruments high in R&D inputs that generate new economic knowledge, but also in terms of innovative outputs (Audretsch, 1995). By contrast, industries with little R&D, such as wood products, textiles and paper, also tend to produce only a negligible amount of innovative output. Thus, the knowledge production model linking knowledge generating inputs to outputs certainly holds at the more aggregated levels of economic activity.

Where the relationship becomes less compelling is at the disaggregated microeconomic level of the enterprise, establishment, or even line of business. For example, while Acs and Audretsch (1990) found that the simple correlation between R&D inputs and innovative output was 0.84 for four-digit standard industrial classification (SIC) manufacturing industries in the United States, it was only about half, 0.40 among the largest U.S. corporations.

The model of the knowledge production function becomes even less compelling in view of the recent wave of studies revealing that small enterprises serve as the engine of innovative activity in certain industries. These results are startling, because as Scherer (1991) observes, the bulk of industrial R&D is undertaken in the largest corporations; small enterprises account only for a minor share of R&D inputs. Thus the knowledge production function seemingly implies that, as the *Schumpeterian Hypothesis* predicts, innovative activity favors those organizations with access to knowledge-producing inputs – the large incumbent organization. The more recent evidence identifying the strong innovative activity raises the question, "Where do new and small firms get the innovation producing inputs, that is the knowledge?"

One answer, proposed by Audretsch (1995), is that, although the model of the knowledge production function may still be valid, the implicitly assumed unit of observation – at the level of the firm – may be less valid. The reason why the knowledge production function holds more closely for more aggregated degrees of observation may be that investment in R&D and other sources of new knowledge spills over for economic exploitation by third-party firms.

This spillover can occur in various ways: social interaction, change of employer and, the main focus of this paper, the exploitation of that knowledge in a new organization. Stinchcombe (1965) distinguishes five conditions under which people will be motivated to form an organization. First of all, they know a better way of doing things that are not easily done within the existing organization. Second, they believe that the new organization will be profitable enough to pay for the trouble of building it. Third, they will receive some of the benefits. Fourth, they can lay hold of the resources and, finally, they can defeat, or at least avoid being defeated by their opponents.

Concerning the second condition, a large literature has emerged focusing on what has become known as the *appropriability problem*. The underlying issue revolves around how firms that invest in the creation of new economic knowledge can best appropriate the economic returns from that knowledge (Arrow, 1962). Audretsch (1995) proposes shifting the unit of observation away from exogenously assumed firms to individuals – agents with endowments of new economic knowledge. But when the lens is shifted away from focusing upon the firm as the relevant unit of observation to individuals, the relevant question becomes, *How can economic agents with a given endowment of new knowledge best appropriate the returns from that knowledge?*

The appropriability problem confronting the individual may converge with that confronting the firm. Economic agents can and do work for firms, and even if they do not, they can potentially be employed by an incumbent firm. In fact, in a model of perfect information with no agency costs, any positive economies of scale or scope will ensure that the appropriability problems of the firm and individual converge. If an agent has an idea for doing something different than is currently being practiced by the incumbent enterprises – both in terms of a new product or process and in terms of organization – the idea, which can be termed as an innovation, will be presented to the incumbent enterprise. Because of the assumption of perfect knowledge, both the firm and the agent would agree upon the expected value of the innovation. But to the degree that any economies of scale or scope exist, the expected value of implementing the innovation within the incumbent enterprise will exceed that of taking the innovation outside of the incumbent firm to start a new enterprise. Thus, the incumbent firm and the inventor of the idea would be expected to reach a bargain splitting the value added to the firm contributed by the innovation. The payment to the inventor – either in terms of a higher wage or some other means of remuneration – would be bounded between the expected value of the innovation if it implemented by the incumbent enterprise on the upper end, and by the return that the agent could expect to earn if he used it to launch a new enterprise on the lower end. Thus, each economic agent would choose how to best appropriate the value of his endowment of economic knowledge by comparing the wage he would earn if he remains employed by an incumbent enterprise, w, to the expected net present discounted value of the profits accruing from starting a new firm, π. If these two values are relatively close, the probability that he would choose to appropriate the value of his knowledge through an external mechanism such as starting a new firm, $Pr(e)$, would be relatively low. On the other hand, as the gap between w and π becomes larger, the likelihood of an agent choosing to appropriate the value of his knowledge externally through starting a new enterprise becomes greater, or

$$\Pr(e) = f(\pi - w) \tag{1}$$

This model refocuses the unit of observation away from firms deciding whether to increase their output from a level of zero to some positive amount in a new industry, to individual agents in possession of new knowledge that, due to uncertainty, may or may not have some positive economic value. Once one drops the assumption of perfect information, both firm and economic agent are confronted with uncertainty. It is this uncertainty inherent in new economic knowledge, combined with asymmetries between the agent possessing that knowledge and the decision making vertical hierarchy of the incumbent organization with respect to its expected value, that potentially leads to a gap between the valuation of that knowledge.

How the economic agent chooses to appropriate the value of his knowledge, that is either within an incumbent firm or by starting or joining a new enterprise will be shaped by the knowledge conditions underlying the industry. Under what Nelson and Winter (1982) term as the routinized technological regime the knowledge conditions will be favorable to innovation by established firms. Secrecy, patent protection or difficulties to imitate will tend the agent to appropriate the value of his new ideas within the boundaries of incumbent firms. Thus, the propensity for new firms to be started should be relatively low in industries characterized by the routinized technological regime.

By contrast, under the entrepreneurial regime the agent will tend to appropriate the value of his new ideas outside of the boundaries of incumbent firms by starting a new enterprise. Thus, the propensity for new firms to enter should be relatively high in industries characterized by the entrepreneurial regime.

Audretsch (1995) suggests that divergences in the expected value regarding new knowledge will, under certain conditions, lead an agent to exercise what Albert O. Hirschman (1970) has termed as *exit* rather than *voice*, and depart from an incumbent enterprise to launch a new firm. But who is right, the departing agents or those agents remaining in the organizational decision making hierarchy who, by assigning the new idea a relatively low value, have effectively driven the agent with the potential innovation away? *Ex post* the answer may not be too difficult. But given the uncertainty inherent in new knowledge, the answer is anything but trivial a priori.

Thus, when a new firm is launched, its prospects are shrouded in uncertainty. If the new firm is built around a new idea, i.e. potential innovation, it is uncertain whether there is sufficient demand for the new idea or if some competitor will have the same or even a superior idea. Even if the new firm is formed to be an exact replica of a successful incumbent enterprise, it is uncertain whether sufficient demand for a new clone, or even for the existing incumbent, will prevail in the future. Tastes can change, and new ideas emerging from other firms will certainty influence those tastes.

Finally, an additional layer of uncertainty pervades a new enterprise. Stinchcombe (1965) named four conditions that make up his "liability of newness"; social conditions that affect the survival rate of new organizations. These conditions are: the ease of obtaining skills; the degree of initiative and responsibility within the workforce; the trustworthiness of strangers; and finally, the strength of the ties between customers and established firms.

In our modern society, with extensive law and emancipated customers, the third and fourth condition are such that they usually do not affect the survival rate in a negative way. But the first two conditions still remain. It is not known how competent the new firm really is, in terms of management, organization, and workforce. At least incumbent enterprises know something about their underlying competencies from past experience. Which is to say that a new enterprise is burdened with uncertainty as to whether it can produce and market the intended product as well as sell it. In both cases the degree of uncertainty will typically exceed that confronting incumbent enterprises.

3. INDUSTRY EVOLUTION

This initial condition of not just uncertainty, but greater degree of uncertainty vis-à-vis incumbent enterprises in the industry is captured in the theory of firm selection and industry evolution proposed by Boyan Jovanovic (1982). Jovanovic presents a model in which the new firms, which he terms *entrepreneurs*, face costs that are not only random but also differ across firms. A central feature of the model is that a new firm does not know what its cost function is, that is its relative efficiency, but rather discovers this through the process of learning from its actual post-entry performance. In particular, Jovanovic (1982) assumes that entrepreneurs are unsure about their ability to manage a new-firm startup and therefore their prospects for success. Although entrepreneurs may launch a new firm based on a vague sense of expected post-entry performance, they only discover their true ability – in terms of managerial competence and of having based the firm on an idea that is viable on the market – once their business is established. Those entrepreneurs who discover that their ability exceeds their expectations expand the scale of their business, whereas those discovering that their post-entry performance is less than commensurate with their expectations will contact the scale of output and possibly exit from the industry. Thus, Jovanovic's model is a theory of *noisy selection*, where efficient firms grow and survive and inefficient firms decline and fail.

The theory of firm selection is particularly appealing in view of the rather startling size of most new firms. For example, the mean size of more than 11,000 new-firm startups in the manufacturing sector in the United States was found to be fewer than eight workers per firm (Audretsch, 1995). While the minimum efficient scale (MES) varies substantially across industries, and even to some degree across various product classes within any given industry, the observed size of most new firms is sufficiently small to ensure that the bulk of new firms will be operating at a suboptimal scale of output. Why would an entrepreneur start a new firm that would immediately be confronted by scale disadvantages?

An implication of the theory of firm selection is that new firms may begin at a small, even suboptimal, scale of output, and then if merited by subsequent performance expand. Those new firms that are successful will grow, whereas those that are not successful will remain small and may ultimately be forced to exit from the industry if they are operating at a suboptimal scale of output. See Audretsch, van Leeuwen, Menkveld and Thurik (2001).

An important implication of the dynamic process of firm selection and industry evolution is that new firms are more likely to be operating at a suboptimal scale of output if the underlying technological conditions are such that there is a greater chance of making an innovation, that is under the entrepreneurial regime. If new firms successfully learn and adapt, or are just plain lucky, they grow into viably sized enterprises. If not, they stagnate and may ultimately exit from the industry. This suggests, that entry and the startup of new firms may not be greatly deterred in the presence of scale economies. As long as entrepreneurs perceive that there is some prospect for growth and ultimately survival, such entry will occur. Thus, in industries where the MES is high, it follows from the observed general small size of new-firm startups that the growth rate of the surviving firms would presumably be relatively high.

At the same time, those new firms not able to grow and attain the MES level of output would presumably be forced to exit from the industry, resulting in a relatively low likelihood of survival. In industries characterized by a low MES, neither the need for growth, nor the consequences of its absence are as severe, so that relatively lower growth rates but higher survival rates would be expected. Similarly, in industries where the probability of innovating is greater, more entrepreneurs may actually take a chance that they will succeed by growing into a viably sized enterprise. In such industries, one would expect that the growth of successful enterprises would be greater, but that the likelihood of survival would be correspondingly lower.

How are the new firms, many of which operate at a suboptimal scale of output, able to exist? The answer according to the studies on post-entry survival and growth is that they cannot – at least not indefinitely. Rather, they must growth to at least approach the MES level of output. An alternative answer is provided by recent studies focusing on the relationship between firm size, age and employee compensation (Audretsch, 1995). By deploying a strategy of *compensating factor differentials*, where factor inputs are both deployed and remunerated differently than they are by the larger incumbent enterprises, suboptimal scale enterprises are to some extent able to offset their size-related cost disadvantages.

Just as it has been found that the gap between the MES and firm size lowers the likelihood of survival, there is evidence suggesting that factors of production, and in particular labor, tend to be used more intensively (that is, in terms of hours worked) and remunerated at lower levels (in terms of employee compensation). Taken together, the empirical evidence on survival and growth combined with that on wages and firm size suggests how it is that small, suboptimal scale enterprises are able to exist in the short run. In the initial period of learning, during which time the entrepreneur discovers whether he has the *right stuff* and whether he is able to adapt to market conditions, new firms are apparently able to reduce the cost of production in order to compensate for their small scale of production.

In the current debate on the relationship between employment and wages it is typically argued that the existence of small firms which are sub-optimal within the organization of an industry represents a loss in economic efficiency. This argument is based on a static analysis, however. When viewed through a dynamic lens a different conclusion emerges. One of the most striking results is the finding of a positive impact of firm age on productivity and employee compensation, even after controlling for the size of the firm. Given the strongly confirmed stylized fact linking both firm size and age to a negative rate of growth (that is the smaller and younger a firm, that faster it will grow but the lower is its likelihood of survival), this new finding linking firm age to employee compensation and productivity suggests that not only will some of the small and sub-optimal firms of today become the large and optimal firms of tomorrow, but there is at least a tendency for the low productivity and wage of today to become the high productivity and wage of tomorrow.

What emerges from the new theories and empirical evidence on innovation and industry evolution is that markets are in motion, with many firms entering the industry and a large number of firms exiting from the industry. But is this motion horizontal, in that the bulk of firms exiting are comprised of firms that had entered relatively recently, or vertical, in that a significant share of the exiting firms had been established incumbents that were displaced by younger firms? In trying to shed some light on this question, Audretsch (1995) proposes two different models of the evolutionary process of industries over time. Some industries can be best characterized by the model of the conical revolving door, where new businesses enter, but where there is a high propensity to subsequently exit from the market. Other industries may be better characterized by the metaphor of the forest, where incumbent establishments are displaced by new entrants. Which view is more applicable apparently depends on three major factors – the underlying technological conditions, scale economies, and demand. Where scale economies play an important role, the model of the revolving door seems to be more applicable. While the rather starting result discussed above that the startup and entry of new businesses is apparently not deterred by the presence of high scale economies, a process of firm selection analogous to a revolving door ensures that only those establishments successful enough to grow will be able to survive beyond more than a few years. Thus, the bulk of new entrants that are not so successful ultimately exit within a few years subsequent to entry.

There is at least some evidence also suggesting that the underlying technological regime influences the process of firm selection and therefore the type of firm with a higher propensity to exit. Under the entrepreneurial regime new entrants have a greater likelihood of making an innovation. Thus, they are less likely to decide to exit from the industry, even in the face of negative profits. By contrast, under the routinized regime the incumbent businesses tend to have the innovative advantage, so that a higher portion of exiting businesses tend to be new entrants. Thus, the model of the revolving door is more applicable under technological conditions consistent with the routinized regime, and the metaphor of the forest, where the new entrants displace the incumbents – is more applicable to the entrepreneurial regime.

Why is the general shape of the firm-size distribution not only strikingly similar across virtually every industry – that is, skewed with only a few large enterprises and numerous small ones – but has persisted with tenacity not only across developed countries but even over a long period of time? The evolutionary view of the process of industry evolution is that new firms typically start at a very small scale of output. They are motivated by the desire to appropriate the expected value of new economic knowledge. But, depending upon the extent of scale economies in the industry, the firm may not be able to remain viable indefinitely at its startup size. Rather, if scale economies are anything other than negligible, the new firm is likely to have to grow to survival. The temporary survival of new firms is presumably supported through the deployment of a strategy of compensating factor differentials that enables the firm to discover whether or not it has a viable product.

The empirical evidence supports such an evolutionary view of the role of new firms in manufacturing, because the post-entry growth of firms that survive tends to be spurred by the extent to which there is a gap between the MES level of output and the size of the firm. However, the likelihood of any particular new firm surviving tends to decrease as this gap increases. Such new suboptimal scale firms are apparently engaged in the selection process. Only those firms offering a viable product that can be produced efficiently will grow and ultimately approach or attain the MES level of output. The remainder will stagnate, and depending upon the severity of the other selection mechanism – the extent of scale economies – may ultimately be forced to exit out of the industry. Thus, the persistence of an asymmetric firm-size distribution biased towards small-scale enterprise reflects the continuing process of the entry of new firms into industries and not necessarily the permanence of such small and sub-optimal enterprises over the long run. Although the skewed size distribution of firms persists with remarkable stability over long periods of time, a constant set of small and suboptimal scale firms does not appear to be responsible for this skewed distribution.

4. KNOWLEDGE SPILLOVERS

The recent wave of studies revealing that small enterprises serve as the engine of innovative activity in certain industries (Acs & Audretsch, 1988, 1990; Audretsch, 1995) is particularly startling, because the bulk of industrial R&D is undertaken in the largest corporations; small enterprises account for only a minor share of R&D inputs (Cohen & Klepper, 1992; Scherer, 1992). Thus, the model of the knowledge production function seemingly implies that innovative activity favors those organizations with access to knowledge-producing inputs – large organizations. The more recent evidence identifying the role of small firms as a source of innovative activity raises the question, *Where do entrepreneurial small firms get the innovation producing inputs, that is the knowledge?*

One suggested answer is that although the model of the knowledge production function may certainly be valid, the implicitly assumed unit of observation which links the knowledge inputs with the innovative outputs – at the level of the establishment or firm – may be less valid. Instead, a new literature suggests that knowledge spills over from the firm or research institute producing it to a different firm commercializing that knowledge (Griliches, 1992). This view is supported by theoretical models which have focused on the role that spillovers of knowledge across firms play in generating increasing returns and ultimately economic growth (Krugman, 1991; Romer, 1986).

An important theoretical development is that geography may provide a relevant unit of observation within which knowledge spillovers occur. The theory of localization suggests that because geographic proximity is needed to transmit knowledge and especially tacit knowledge, knowledge spillovers tend to be localized within a geographic region. The importance of geographic proximity for knowledge spillovers has been supported in a wave of recent empirical studies by Jaffe

(1989), Jaffe, Trajtenberg and Henderson (1993), Acs, Audretsch and Feldman (1992, 1994), Audretsch and Feldman (1996) and Audretsch and Stephan (1996).

That knowledge spills over is barely disputed. In disputing the importance of knowledge externalities in explaining the geographic concentration of economic activity, Krugman (1991) and others do not question the existence or importance of such knowledge spillovers. In fact, they argue that such knowledge externalities are so important and forceful that there is no compelling reason for a geographic boundary to limit the spatial extent of the spillover. According to this line of thinking, the concern is not that knowledge does not spill over but that it should stop spilling over just because it hits a geographic border, such as a city limit, state line, or national boundary. The claim that geographic location is important to the process linking knowledge spillovers to innovative activity in a world of e-mail, fax machines and cyberspace may seem surprising and even paradoxical. The resolution to the paradox posed by the localization of knowledge spillovers in an era where the telecommunications revolution has drastically reduced the cost of communication lies in a distinction between knowledge and information. *Information*, such as the price of gold on the New York Stock Exchange, or the value of the Yen in London, can be easily codified and has a singular meaning and interpretation. By contrast, *knowledge* is vague, difficult to codify and often only serendipitously recognized. While the marginal cost of transmitting information across geographic space has been rendered invariant by the telecommunications revolution, the marginal cost of transmitting knowledge, and especially tacit knowledge, rises with distance.

Von Hipple (1994) demonstrates that high context, uncertain knowledge, or what he terms as sticky knowledge, is best transmitted via face-to-face interaction and through frequent and repeated contact. Geographic proximity matters in transmitting knowledge, because as Kenneth Arrow (1962) pointed out some three decades ago, such tacit knowledge is inherently non-rival in nature, and knowledge developed for any particular application can easily spill over and have economic value in very different applications. As Glaeser, Kallal, Scheinkman and Shleifer (1992, p. 1126) have observed, "intellectual breakthroughs must cross hallways and streets more easily than oceans and continents."

The importance of local proximity for the transmission of knowledge spillovers has been observed in many different contexts. It has been pointed out that, "business is a social activity, and you have to be where important work is taking place."[1] A survey of nearly one thousand executives located in America's sixty largest metropolitan areas ranked Raleigh/Durham as the best city for knowledge workers and for innovative activity.[2] The reason is that "A lot of brainy types who made their way to Raleigh/Durham were drawn by three top research universities . . . U.S. businesses, especially those whose success depends on staying at the top of new technologies and processes, increasingly want to be where hot new ideas are percolating. A presence in brain-power centers like Raleigh/Durham pays off in new products and new ways of doing business. Dozens of small biotechnology and software operations are starting up each year and growing like *kudzu* in the fertile climate."[3] Almeida (1996) shows that foreign firms use local plants to tap in to local knowledge.

Not only did Krugman (1991, p. 53) doubt that knowledge spillovers are not geographically constrained but he also argued that they were impossible to measure because "knowledge flows are invisible, they leave no paper trail by which they may be measured and tracked." However, an emerging literature (Jaffe, Trajtenberg & Henderson, 1993) has overcome data constraints to measure the extent of knowledge spillovers and link them to the geography of innovative activity. Jaffe (1989), Feldman (1994) and Audretsch and Feldman (1996) modified the model of the knowledge production function to include an explicit specification for both the spatial and product dimensions. Jaffe (1989) used the number of inventions registered with the United States patent office as a measure of innovative activity. By contrast, Audretsch and Feldman (1996) and Acs, Audretsch and Feldman (1992) developed a direct measure of innovative output consisting of new product introductions.

The consistent empirical evidence supports the notion knowledge spills over for third-party use from university research laboratories as well as industry R&D laboratories. This empirical evidence suggests that location and proximity clearly matter in exploiting knowledge spillovers. Not only have Jaffe, Trajtenberg and Henderson (1993) found that patent citations tend to occur more frequently within the state in which they were patented than outside of that state, but Audretsch and Feldman (1996) found that the propensity of innovative activity to cluster geographically tends to be greater in industries where new economic knowledge plays a more important role. Prevezer (1997) and Zucker, Darby and Armstrong (1994) show that in biotechnology, which is an industry based almost exclusively on new knowledge, the firms tend to cluster together in just a handful of locations. This finding is supported by Audretsch and Stephan (1996) who examine the geographic relationships of scientists working with biotechnology firms. The importance of geographic proximity is clearly shaped by the role played by the scientist. The scientist is more likely to be located in the same region as the firm when the relationship involves the transfer of new economic knowledge. However, when the scientist is providing a service to the company that does not involve knowledge transfer, local proximity becomes much less important. Zucker, Darby and Armstrong (1998) show that the most productive scientists in the California biotechnology are connected to firms through employment or ownership. Spillovers occur in this industry for the scientist to financially exploit his knowledge.

There is reason to believe that knowledge spillovers are not homogeneous across firms. In analyzing the role of spillovers for large and small enterprises separately, Acs, Audretsch and Feldman (1994) provide some insight into the puzzle posed by the recent wave of studies identifying vigorous innovative activity emanating from small firms in certain industries. How are these small, and frequently new, firms able to generate innovative output while undertaking generally negligible amounts of investment into knowledge generating inputs, such as R&D? The answer appears to be through exploiting knowledge created by expenditures on research in universities and on R&D in large corporations. Their findings suggest that the innovative output of all firms rises along with an increase in the amount of R&D inputs, both in private corporations as well as in university laboratories. However, R&D expenditures made by private companies play a particularly important role in providing knowledge inputs to the innovative activity of large firms, while expenditures on research made by universities serve as an especially key input for generating innovative activity in small enterprises. Apparently large firms are more adept at exploiting knowledge created in their own laboratories, while their smaller counterparts have a comparative advantage at exploiting spillovers from university laboratories.

In addressing the questions how and why knowledge spills over, an assumption implicit to the model of the knowledge production function is challenged – that firms exist *exogenously* and then *endogenously* seek out and apply knowledge inputs to generate innovative output. Although this may be valid some, if not most of the time, the evidence from biotechnology suggests that, at least in some cases, it is the knowledge in the possession of economic agents that is *exogenous*. In an effort to appropriate the returns from that knowledge, the scientist then *endogenously* creates a new firm. Thus, the spillover of knowledge from the source creating it, such as a university, research institute, or industrial corporation, to a new-firm startup facilitates the appropriation of knowledge for the individual scientist(s) but not necessarily for the organization creating that new knowledge in the first place (Audretsch & Stephan, 1996).

While Romer (1990, 1994) and Krugman (1991) identified the role that knowledge spillovers and externalities play in generating endogenous growth, they are less precise about the actual mechanism by which knowledge spills over. Entrepreneurial small firms are one such mechanism transmitting the spillover of knowledge. Thus, an increase in the role of entrepreneurship activity may facilitate such knowledge spillovers and therefore subsequent growth.

5. ECONOMIC GROWTH

There is a considerable gap of research linking entrepreneurship to economic growth. The reasons for this void in the state of knowledge about the impact of entrepreneurship on economic growth may be attributable to a paucity of theoretical frameworks linking entrepreneurship to growth as well as severe constraints in measuring entrepreneurship, let alone entrepreneurship within a cross-national context. See Audretsch and Thurik (2000) and Carree and Thurik (2003) for an extensive review to the literature.

The last two decades have seen an explosion in studies analyzing the determinants of entrepreneurship. While some of these studies are theoretical (Holmes & Schmitz, 1990), others are empirical (Evans & Jovanovic, 1989; Evans & Leighton, 1990; Reynolds, 1997) or eclectic (Audretsch & Thurik, 2001; Audretsch, Thurik, Verheul & Wennekers, 2002). What they have in common is to pose the questions, "Why do people start firms and what determines who becomes an entrepreneur?"

The consequences of entrepreneurship, in terms of economic performance, have also generated a large literature. However, this literature has been restricted to two units of observations – at the level of the establishment or enterprise, and for regions. Noticeably absent are studies linking the impact of entrepreneurship on performance for the unit of observation of the country (Audretsch, Carree & Thurik, 2001). In fact, a large literature has emerged analyzing the impact of entrepreneurship on economic performance at the level of the firm or establishment. These studies typically measure economic performance in terms of enterprise growth and survival (Audretsch, 1995; Caves, 1998; Sutton, 1997). The compelling stylized facts that have emerged from this literature is that entrepreneurial activity, measured in terms of firm size and age, is positively related to growth. The growth of new firms and small firms is systematically greater than for large and established incumbents. These findings hold across OECD countries and across time periods.

The link between entrepreneurship and performance has also been extended beyond the unit of observation of the firm to include a geographic region. A rich literature exists linking measures of entrepreneurial activity for regions to the economic performance of those regions (Audretsch & Fritsch, 2002; Reynolds, Miller & Maki, 1995; Reynolds, Storey & Westhead, 1994). While Reynolds, Miller and Maki (1995) find that the degree of entrepreneurship has a positive impact on regional economic growth in the U.S., Audretsch and Fritsch (2002) find that for Germany the relationship shifted from negative in the 1980s to positive in the 1990s.

However, when it comes to linking entrepreneurship to growth at the national level, only a few studies exist. Audretsch et al. (2002) and Carree and Thurik (1999) offer two distinct approaches, based on two different measures of entrepreneurship – the relative share of economic activity accounted for by small firms, and the self-employment rate. In addition, two different measures of performance of economic activity are also analyzed – economic growth and reduction of unemployment – to link changes in entrepreneurship to changes in economic performance. Different samples including OECD countries over different time periods reach consistent results – increases in entrepreneurial activity tends to result in higher subsequent growth rates and a reduction of unemployment. Audretsch et al. (2001) provide empirical evidence for a panel of OECD countries, which suggests that those countries that have experienced an increase in entrepreneurial activity have also enjoyed higher rates of growth and greater reductions in unemployment. By contrast, those countries that have not increased the degree of entrepreneurial activity have had less growth and less reductions in unemployment.

Entrepreneurship generates growth because it serves as a vehicle for innovation and change, and therefore as a conduit for knowledge spillovers. Thus, in a regime of increased globalization, where the comparative advantage of the leading developed countries is shifting towards knowledge-based economic activity, not only does entrepreneurship play a more important role, but the impact of that entrepreneurship is to generate growth.

6. CONCLUSIONS

While economic growth has traditionally remained in the analytic domain of macroeconomics, the lens of evolutionary economics provides linkages across multiple units of observation, spanning the individual, the firm, the industry, and ultimately macroeconomic growth. Entrepreneurship plays a central role in the growth process, because it is the assessment of ideas that leads not just to change and growth, but also does this through the mechanism of starting a new firm. Higher rates of entrepreneurship tend to generate a greater degree of turbulence within industries. Not only do more firms enter industries, but the exit rates are also greater, reflecting a greater degree of search activity relative to routinized activity.

The positive relationships found between entrepreneurship and industry turbulence do not necessarily imply a superior economic performance. However, an emerging body of empirical evidence clearly suggests a positive link between entrepreneurship and growth that holds not just for firms, but also for geographic units of observation, including the city, region and even country. Those regions and countries that have a greater degree of entrepreneurial activity also enjoy higher rates of growth.

A question still to be answered is from where does the new knowledge originate. Is it the R&D activities within the young firm, synergies within networks of small firms, spillovers from universities or from larger incumbent firms. A follow-up question is why and how these spillovers occur and how they can be stimulated.

The eclectic framework of the determinants of entrepreneurship as presented in Audretsch, Thurik, Verheul and Wennekers (2002) may be a starting point for investigating the mechanisms and stimulation of these spillovers.

NOTES

1. "The Best Cities for Knowledge Workers," *Fortune*, 15 November, 1993, p. 44.
2. The survey was carried out in 1993 by the management consulting firm of Moran, Stahl and Boyer of New York City.
3. "The Best Cities for Knowledge Workers," *Fortune*, 15 November, 1993, p. 44.

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