The Knowledge Spillover Theory of Entrepreneurship

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Abstract

The prevailing theories of entrepreneurship have typically revolved around the ability of individuals to recognize opportunities and then to act on them by starting a new venture. This has generated a literature asking why entrepreneurial behaviour varies across individuals with different characteristics while implicitly holding the external context in which the individual finds herself to be constant. Thus, where the opportunities come from, or the source of entrepreneurial opportunities, are also implicitly taken as given. By contrast, we provide a theory identifying at least one source of entrepreneurial opportunity – new knowledge and ideas that are not fully commercialized by the organization actually investing in the creation of that knowledge. The knowledge spillover theory of entrepreneurship holds individual characteristics as given but rather lets the context vary. In particular, high knowledge contexts are found to generate more entrepreneurial opportunities, where the entrepreneur serves as a conduit for knowledge spillovers. By contrast, impoverished knowledge contexts are found to generate fewer entrepreneurial opportunities.

By serving as a conduit for knowledge spillovers, entrepreneurship is the missing link between investments in new knowledge and economic growth. Thus, the knowledge spillover theory of entrepreneurship provides not just an explanation of why entrepreneurship has become more prevalent as the factor of knowledge has emerged as a crucial source for comparative advantage, but also why entrepreneurship plays a vital role in generating economic growth. Entrepreneurship is an important mechanism permeating the knowledge filter to facilitate the spill over of knowledge and ultimately generate economic growth.

1.Introduction

Why do (some) people start firms? And if they do, what impact will this have on employment, growth and prosperity? These questions have been at the heart of considerable research, not just in economics, but throughout the social sciences. Herbert and Link (1989) have identified three distinct intellectual traditions in the development of the entrepreneurship literature. These three traditions can be characterized as the German Tradition, based on von Thuenen and Schumpeter, the Chicago Tradition, based on Knight and Schultz, and the Austrian Tradition, based on von Mises, Kirzner and Shackle.

It is a virtual consensus that entrepreneurship revolves around the recognition of opportunities and the pursuit of those opportunities (Venkataraman, 1997). Much of the more contemporary thinking about entrepreneurship has focused on the cognitive process by which individuals reach the decision to start a new firm. According to Sarasvathy, Dew, Velamuri and Venkataraman (2003, p. 142), "An entrepreurial opportunity consists of a set of ideas, beliefs and actions that enable the creation of future goods and services in the absence of current markets for them". Sarasvathy, Dew, Velamuri and Venkataraman provide a typology of entrepreneurial opportunities as consisting of opportunity recognition, opportunity discovery and opportunity creation.

In asking the question of why some do it, while others don't, scholars have focused on differences across individuals. As Krueger (2003, p. 105) observes, "The heart of entrepreneurship is an orientation toward seeing opportunities," which frames the research questions, "What is the nature of entrepreneurial thinking and what cognitive phenomena are associated with seeing and acting on opportunities?" The traditional approach to entrepreneurship essentially holds the context constant and then asks how the cognitive process inherent in the entrepreneurial decision varies across different individual

characteristics and attributes (Shaver, 2003; McClelland, 1961). As Shane and Eckhardt (2003, p 187) summarize this literature in introducing the individual-opportunity nexus, "We discussed the process of opportunity discovery and explained why some actors are more likely to discover a given opportunity than others." Some of these differences involve the willingness to incur risk, others involve the preference for autonomy and self-direction, still others involve differential access to scarce and expensive resources, such as financial capital, human capital, social capital and experiential capital. This approach focusing on individual cognition in the entrepreneurial process has generated a number of important and valuable insights, such as the contribution made by social networks, education and training, and familial influence (Acs and Audretsch, 2003). The literature certainly leaves the impression that entrepreneurship is personal matter largely determined by DNA, familial status and access to crucial resources.

The purpose of this paper is to invert the traditional approach to entrepreneurship. Rather than taking the context to be given and then ask how variations across individual attributes shapes the cognitive process underlying the decision to become an entrepreneur, this paper instead assumes the individual characteristics to be constant and then analyzes how the cognitive process inducing the entrepreneurial decision is influenced by placing that same individual in different contexts. In particular, we compare high knowledge contexts with impoverished knowledge contexts. This leads to a very different view of entrepreneurship. Instead of being a phenomenon that is exogenously determined by pre-conditioned personal attributes and family history, entrepreneurship instead emerges as an endogenous response to opportunities generated by investments in new knowledge made by incumbent firms and organizations, combined with their inability to fully and completely exhaust the ensuing opportunities to commercialize that knowledge. In this paper, we show how entrepreneurship

can be an endogenous response to investments in new knowledge where commercialization of that knowledge is constrained by the existence of a formidable knowledge filter.

Not only does holding the individual attributes constant but varying the knowledge context give rise to the knowledge theory of entrepreneurship, but the view of entrepreneurship as an endogenous response to the incomplete commercialization of new knowledge results in entrepreneurship as providing the missing link in economic growth models. By serving as a conduit of knowledge spillovers, entrepreneurship serves as an important source of economic growth that otherwise will remain missing. Thus, entrepreneurship is the mechanism by which society more fully appropriates its investments in creating new knowledge, such as research and education.

The next section explains how entrepreneurship combines the cognitive process of recognizing opportunities with pursuing those opportunities by starting a new firm. The third section introduces the knowledge spillover theory of entrepreneurship, which suggests that entrepreneurship is an endogenous response to investments in knowledge that are not fully appropriated by incumbent firms. The fourth section links endogenous entrepreneurship based on knowledge spillovers to economic growth. Finally, a summary and conclusions are provided in the last section. In particular, this paper proposes four main hypotheses at the heart of the knowledge spillover theory of endogenous growth, which will be empirically tested in the subsequent four papers.

2. Entrepreneurship as Opportunity Recognition and Action

The starting point for analyzing the determinants of entrepreneurship has been at the level of the individual. These studies have crossed a broad spectrum of academic disciplines, ranging from psychology to sociology and economics. While the early studies centered in North America, they have also been duplicated and extended to Europe.

Within the economics literature, the prevalent theoretical framework has been the general model of income choice, which has been at times referred to as the general model of entrepreneurial choice. The model of income or entrepreneurial choice dates back at least to Knight (1921), but was more recently extended and updated by Lucas (1978), Kihlstrom and Laffont (1979), Holmes and Schmidt (1990) and Jovanovic (1994). In its most basic rendition, individuals are confronted with a choice of earning their income either from wages earned through employment in an incumbent enterprise or else from profits accrued by starting a new firm. The essence of the income choice is made by comparing the wage an individual expects to earn through employment, W*, with the profits that are expected to accrue from a new-firm startup, P*. Thus, the probability of starting a new firm, Pr(s), can be represented as

(1) $Pr(s) = f(P^*-W^*)$

The model of income choice has been extended by Kihlstrom and Laffont (1979) to incorporate aversion to risk, and by Lucas (1978) and Jovanovic (1994) to explain why firms of varying size exist, and has served as the basis for empirical studies of the decision to start a new firm by Blau (1987), Evans and Leighton (1989a, 1989b and 1990), Evans and Jovanovic (1989), Blanchflower and Oswald (1990) and Blanchflower and Meyer (1994).

Empirical tests of the model of income or entrepreneurial choice have focused on personal characteristics with respect to labour market conditions. For example, using U.S. data, Evans and Leighton (1989a, 1989b and 1990), link personal characteristics, such as education, experience and age, as well as employment status, of almost 4,000 white males to the decision to start a new firm. Other studies, such as Bates (1990), also using U.S. data, and Blanchflower and Meyer (1994), emphasize human capital in the income choice. This approach places particular emphasis on the employment status of individuals in making the income choice. Certain ambiguities exist in linking unemployment to the decision to start a new firm (Storey, 1991). In particular, Storey (1991) observed that consistent results tended to

emerge from cross-section studies, just as consistency is found in time series analysis. That is the discrepancy in results appeared to be along the lines of methodology, i.e., whether a time series or cross-sectional approach was undertaken. Storey (1991, p. 177) concludes that, "The broad consensus is that time series analysis point to unemployment being, ceteris paribus, positively associated with indices of new firm formation, whereas cross-sectional, or pooled cross-sectional studies appear to indicate the reverse. Attempts to reconcile these differences have not been wholly successful. They may reflect possible specification errors in the estimating equations, since none include all the independent variables which have been shown to be significant in the existing literature. In particular we suggest that more attention is given to the issue of taxation, savings and state benefits than has been the case in the past."

Evans and Leighton (1990) found unequivocal evidence that, for U.S. young white males, the probability of starting a new firm tends to rise as a worker loses his job. In the European context, Foti and Vivarelli (1994) analyze self-employment data in Italy and find that unemployment has a positive impact entry into self-employment. However, as for the national unemployment rate, the relationship is reversed – low unemployment and high levels of macroeconomic growth increase the likelihood of starting a new firm. The evidence linking regional unemployment to the likelihood of starting a new firm is ambiguous.

Using data from the United Kingdom, Westhead and Birley (1995) find that owner-manager characteristics at startup, including human capital factors, do not have much influence on the employment growth of the firm.

A study by the ADT (1998) found that the number of spinoffs from research institutes has increased dramatically in Germany, from 30 in 1990 to 167 in 1997. The study classifies scientific workers at the main German scientific research institutes as being either a "potential entrepreneur" or not a potential entrepreneur. The work values for potential entrepreneurs working at scientific research institutes differ considerably from their colleagues who are not classified as being a potential entrepreneur. Potential entrepreneurs place a higher value on being responsible for their own future, having a position of responsibility, having less of a hierarchical organization, and independence than do those scientific workers with no

entrepreneurial interest. By contrast, the potential entrepreneurs place less of an importance on the work values of a secure income and a secure pension than do those with no entrepreneurial potential.

Colombo and Delmastro (2001) examine the characteristics of high-tech entrepreneurs in Italy. In particular, they identify differences in the characteristics found between the internet sector and other ICT industries. Their findings suggest that entrepreneurs who started firms in internet based businesses are systematically younger than their counterparts in other ICT industries.

Klofsten and Jones-Evans (2000) compare academic entrepreneurship, or the process by which professors and university researchers start and develop technology-based firms in the European context. They find that personal characteristics such as gender, age, previous entrepreneurial experience, work experience and the university environment all contribute to academic entrepreneurial activities in Sweden and Ireland. This view of entrepreneurship corresponds to that in a different scholarly tradition- management- provided by Gartner and Carter (2003), "Entrepreneurial behaviour involves the activities of individuals who are associated with creating new organizations rather than the activities of individuals who are involved with maintaining or changing the operations of on-going established organizations."

Both the field of management and psychology have provided insights into the decision process leading individuals to start a new firm. This research trajectory focuses on the emergence and evolution of entrepreneurial cognition. Stevenson and Jarillo (1990) assume that entrepreneurship is an orientation towards opportunity recognition. Central to this research agenda are the questions, *"How do entrepreneurs perceive opportunities and how do these opportunities manifest themselves as being credible versus being an illusion?"* Kruger (2003) examines the nature of entrepreneurial thinking and the cognitive process associated with opportunity identification and the decision to undertake entrepreneurial action. The focal point of this research is on the cognitive process identifying the entrepreneurial opportunity along with the decision to start a new firm. Thus, a perceived opportunity and intent to pursue that opportunity are the necessary and sufficient conditions for entrepreneurial activity to take

place. The perception of an opportunity is shaped by a sense of the anticipated rewards accruing from and costs of becoming an entrepreneur. Some of the research focuses on the role of personal attitudes and characteristics, such as self efficacy (the individual's sense of competence), collective efficacy, and social norms. Shane (2000) has identified how prior experience and the ability to apply specific skills influence the perception of future opportunities. The concept of the entrepreneurial decision resulting from the cognitive processes of opportunity recognition and ensuing action is introduced by Shane and Eckhardt (2003). They suggest that an equilibrium view of entrepreneurship stems from the assumption of perfect information. By contrast, imperfect information generates divergences in perceived opportunities across different people. The sources of heterogeneity across individuals include different access to information, as well cognitive abilities, psychological differences, and access to financial and social capital.

One of the best data sources available to analyze the cognitive process triggering the entrepreneurial decision is provided by the Panel Study of Entrepreneurial Dynamics (PSED), which consists of a longitudinal survey study on 830 individuals that were identified while they were in the process of starting a new business. The unique feature of the data base is that it provides information on how the entrepreneurial opportunity and action was conceived and operationalized (Gartner and Carter, 2003). Kim, Aldrich and Keister (2004) use the PSED to test the theory that access to resources, in the form of financial resources, such as household income and wealth, and human capital, in the form of education, prior work experience, entrepreneurial experience, and influence from family and friends, affect the decision to become an entrepreneur.

As the Kim, Aldrich and Keister (2003) paper suggests, the external environment has been found to strongly influence the entrepreneurial decision. The greatest focus of research has been on the influence of networks on the cognitive process involving entrepreneurship. Thornton and Flynn (2003) argue that geographic proximity leads to networking, which both creates opportunities as well as the capacity to recognize and act on those opportunities. They suggest that networks in which trust is fostered involve a context facilitating the transmission

of tacit knowledge. In comparing Route 128 around Boston with Silicon Valley, Saxenian (1994) documented how entrepreneurial advantages are based on differences in network structures and social capital.

Accordingly, there is a solid research tradition focusing on the decision confronting individuals to start a firm. Theory and empirical evidence provide compelling reasons to conclude that characteristics specific to the individual help shape the cognitive processes guiding the entrepreneurial decision which is characterized by the model of income or entrepreneurial choice.

3. Knowledge Spillovers as Entrepreneurial Opportunities

While much has been made about the key role played by the recognition of opportunities in the cognitive process underlying the decision to become an entrepreneur, relatively little has been written about the actual source of such entrepreneurial opportunities. The knowledge spillover theory of entrepreneurship identifies one source of entrepreneurial opportunities – new knowledge and ideas. In particular, the knowledge spillover theory of entrepreneurship posits that it is new knowledge and ideas created in one context but left uncommercialized or not vigorously pursued by the source actually creating those ideas, such as a research laboratory in a large corporation or research undertaken by a university, that serves as the source of knowledge generating entrepreneurial opportunities. Thus, in this view, one mechanism for recognizing new opportunities and actually implementing them by starting a new firm involves the spillover of knowledge. The source of the knowledge and ideas, and the organization actually making (at least some of) the investments to produce that knowledge is not the same as the organization actually attempting to commercialize and appropriate the value of that knowledge – the new firm. If the use of that knowledge by the entrepreneur does not involve full payment to the firm making the investment that originally

produced that knowledge, such as a license or royalty, then the entrepreneurial act of starting a new firm serves as a mechanism for knowledge spillovers.

Why should entrepreneurship play an important role in the spillover of new knowledge and ideas? And why should new knowledge play an important role in creating entrepreneurial opportunities? In the Romer model of endogenous growth new technological knowledge is assumed to automatically spill over. Investment in new technological knowledge is automatically accessed by third-party firms and economic agents, resulting in the automatic spill over of knowledge. The assumption that knowledge automatically spills over is, of course, consistent with the important insight by Arrow (1962) that knowledge differs from the traditional factors of production – physical capital and (unskilled) labor – in that it is non-excludable and non-exhaustive. When the firm or economic agent uses the knowledge, it is neither exhausted nor can it be, in the absence of legal protection, precluded from use by third-party firms or other economic agents. Thus, in the spirit of the Romer model, drawing on the earlier insights about knowledge from Arrow, a large and vigorous literature has emerged obsessed with the links between intellectual property protection and the incentives for firms to invest in the creation of new knowledge through R&D and investments in human capital.

However, the preoccupation with the non-excludability and non-exhaustability of knowledge first identified by Arrow and later carried forward and assumed in the Romer model, neglects another key insight in the original Arrow (1962) article. Arrow also identified another dimension by which knowledge differs from the traditional factors of production. This other dimension involves the greater degree of uncertainty, higher extent of asymmetries, and greater cost of transacting new ideas. The expected value of any new idea is highly uncertain, and as Arrow pointed out, has a much greater variance than would be associated with the deployment of traditional factors of production. After all, there is relative certainty about what

a standard piece of capital equipment can do, or what an (unskilled) worker can contribute to a mass-production assembly line. By contrast, Arrow emphasized that when it comes to innovation, there is uncertainty about whether the new product can be produced, how it can be produced, and whether sufficient demand for that visualized new product might actually materialize.

In addition, new ideas are typically associated with considerable asymmetries. In order to evaluate a proposed new idea concerning a new biotechnology product, the decision maker might not only need to have a PhD. in biotechnology, but also a specialization in the exact scientific area. Such divergences in education, background and experience can result in a divergence in the expected value of a new project or the variance in outcomes anticipated from pursuing that new idea, both of which can lead to divergences in the recognition and evaluation of opportunities across economic agents and decision-making hierarchies. Such divergences in the valuation of new ideas will become greater if the new idea is not consistent with the core competence and technological trajectory of the incumbent firm.

Thus, because of the conditions inherent in knowledge – high uncertainty, asymmetries and transactions cost – decision making hierarchies can reach the decision not to pursue and try to commercialize new ideas that individual economic agents, or groups or teams of economic agents think are potentially valuable and should be pursued. The basic conditions characterizing new knowledge, combined with a broad spectrum of institutions, rules and regulations impose what Acs et al. (2004) term *the knowledge filter*. The knowledge filter is the gap between new knowledge and what Arrow (1962) referred to as economic knowledge or commercialized knowledge. The greater is the knowledge filter, the more pronounced is this gap between new knowledge and new economic, or commercialized, knowledge.

The knowledge filter is a consequence of the basic conditions inherent in new knowledge. Similarly, it is the knowledge filter that creates the opportunity for entrepreneurship in the knowledge spillover theory of entrepreneurship. According to this theory, opportunities for entrepreneurship are the duality of the knowledge filter. The higher is the knowledge filter, the greater are the divergences in the valuation of new ideas across economic agents and the decision-making hierarchies of incumbent firms. Entrepreneurial opportunities are generated not just by investments in new knowledge and ideas, but in the propensity for only a distinct subset of those opportunities to be fully pursued by incumbent firms.

Thus, the knowledge theory of entrepreneurship shifts the fundamental decision making unit of observation in the model of the knowledge production function away from exogenously assumed firms to individuals, such as scientists, engineers or other knowledge workers – agents with endowments of new economic knowledge. When the lens is shifted away from the firm to the individual as the relevant unit of observation, the appropriability issue remains, but the question becomes, *How can economic agents with a given endowment of new knowledge best appropriate the returns from that knowledge?* If the scientist or engineer can pursue the new idea within the organizational structure of the firm developing the knowledge and appropriate roughly the expected value of that knowledge, she has no reason to leave the firm. On the other hand, if she places a greater value on his ideas than do the decision-making bureaucracy of the incumbent firm, he may choose to start a new firm to appropriate the value of his knowledge.

In the knowledge spillover theory of entrepreneurship the knowledge production function is actually reversed. The knowledge is exogenous and embodied in a worker. The firm is created endogenously in the worker's effort to appropriate the value of his knowledge through innovative activity. Typically an employee from an established large corporation,

often a scientist or engineer working in a research laboratory, will have an idea for an invention and ultimately for an innovation. Accompanying this potential innovation is an expected net return from the new product. The inventor would expect to be compensated for his/her potential innovation accordingly. If the company has a different, presumably lower, valuation of the potential innovation, it may decide either not to pursue its development, or that it merits a lower level of compensation than that expected by the employee.

In either case, the employee will weigh the alternative of starting his/her own firm. If the gap in the expected return accruing from the potential innovation between the inventor and the corporate decision maker is sufficiently large, and if the cost of starting a new firm is sufficiently low, the employee may decide to leave the large corporation and establish a new enterprise. Since the knowledge was generated in the established corporation, the new start-up is considered to be a spin-off from the existing firm. Such start-ups typically do not have direct access to a large R&D laboratory. Rather, the entrepreneurial opportunity emanates fromg the knowledge and experience accrued from the R&D laboratories with their previous employers. Thus the knowledge spillover view of entrepreneurship is actually a theory of endogenous entrepreneurship, where entrepreneurship is an endogenous response to opportunities created by investments in new knowledge that are not commercialized because of the knowledge filter.

4. Endogenous Entrepreneurship

The knowledge spillover theory of entrepreneurship challenges two of the fundamental assumptions implicitly driving the results of the endogenous growth models. The first is that knowledge is automatically equated with economic knowledge. In fact, as Arrow (1962) emphasized, knowledge is inherently different from the traditional factors of production,

resulting in a gap between knowledge and what he termed as economic knowledge, or economically valuable knowledge.

The second involves the assumed spillover of knowledge. The existence of the factor of knowledge is equated with its automatic spillover, yielding endogenous growth. In the knowledge spillover theory of entrepreneurship the existence of the knowledge filter imposes a gap between new knowledge and new economic knowledge, and results in a lower level of knowledge spillovers.

Thus, as a result of the knowledge filter, entrepreneurship becomes central to generating economic growth by serving as a conduit for knowledge spillovers. The process involved in recognizing new opportunities emanating from investments in knowledge and new ideas, and attempting to commercialize those new ideas through the process of starting a new firm is the mechanism by which at least some knowledge spillovers occur. In the counterfactual situation, that is in the absence of such entrepreneurship, the new ideas would not be pursued, and the knowledge would not be commercialized. Thus, entrepreneurs serve an important mechanism in the process of economic growth. An entrepreneur is an agent of change, who recognizes an opportunity, in this case generated by the creation of knowledge not adequately pursued (in the view of the entrepreneur) by incumbent organizations, and ultimately chooses to act on that opportunity by starting a new firm.

Recognition of what Arrow (1962) termed as the non-excludability of knowledge inherent in spillovers has led to a focus on issues concerning the appropriability of such investments in knowledge and the need for the protection of intellectual property. However, Arrow (1962) also emphasized that knowledge is also characterized by a greater degree of uncertainty and asymmetry that is other types of economic goods. Not only will the mean expected value of any new idea vary across economic agents, but the variance will also differ across economic agents. Thus, if an incumbent firm reaches the decision that the expected

economic value of a new idea is not sufficiently high to warrant the development and commercialization of that idea, other economic agents, either within or outside of the firm, may instead assign a higher expected value of the idea. Such divergences in the valuation of new knowledge can lead to the start up of a new firm in an effort by economic agents to appropriate the value of knowledge. Since the knowledge inducing the decision to start the new firm is generated by investments made by an incumbent organization, such as in R&D by an incumbent firm or research at a university, the startup serves as the mechanism by which knowledge spills over from the sources producing that knowledge to the (new) organizational form in which that knowledge is actually commercialized. Thus, entrepreneurship serves as a conduit, albeit not the sole conduit, by which knowledge spills over.

As investments in new knowledge increase, entrepreneurial opportunities will also increase. Contexts where new knowledge plays an important role are associated with a greater degree of uncertainty and asymmetries across economic agents evaluating the potential value of new ideas. Thus, a context involving more new knowledge will also impose a greater divergence in the evaluation of that knowledge across economic agents, resulting in a greater variance in the outcome expected from commercializing those ideas. It is this gap in the valuation of new ideas across economic agents, or between economic agents and decision-making hierarchies of incumbent enterprises, that creates the entrepreneurial opportunity

As already discussed, a vigorous literature has already identified that knowledge spillovers are greater in the presence of knowledge investments. Just as Jaffe, (1989) and Audretsch and Feldman (1996) show, those regions with high knowledge investments experience a high level of knowledge spillovers, and those regions with a low amount of knowledge investments experience a low level of knowledge spillovers, since there is less knowledge to be spilled over.

The knowledge spillover theory of entrepreneurship analogously suggests that, ceteris paribus, entrepreneurial activity will tend to be greater in contexts where investments in new knowledge are relatively high, since the new firm will be started from knowledge that has spilled over from the source actually producing that new knowledge. A paucity of new ideas in an impoverished knowledge context will generate only limited entrepreneurial opportunities. By contrast, in a high knowledge context, new ideas will generate entrepreneurial opportunities by exploiting (potential) spillovers of that knowledge. Thus, the knowledge spillover view of entrepreneurship provides a clear link, or prediction that entrepreneurial activity will result from investments in new knowledge.

The starting point for models of economic growth in the Solow tradition is that the factors of production are exogenous. Adding the factor of knowledge, as in the Romer, Lucas and Jones models,

(2) $Qi = h(t)f(Ci, Li, Ki)$

where Q represents economic output, C is the stock of capital, L the labor force and K is knowledge capital. As the plethora of studies have shown, the inclusion of the factor of new knowledge in the model, shifts the spatial unit of observation towards a more localized unit of analysis, which is represented by the subscript i. In the Romer, Lucas and Jones models, knowledge automatically spills over and is commercialized, reflecting the Arrow observation about the non-excludability and non-exhaustive properties of new knowledge. Thus, investments in R&D and human capital not only automatically impact output, but in a multiplicative manner, because of its external properties, suggesting that new knowledge, K, is tatamont to economic knowledge, K^c

(3) $K = K^c$

As discussed above, the emphasis on, or rather assumption about the non-excludability property is better suited for information rather than knowledge. Information has, by its definition, a very low level of uncertainty and its value is not greatly influenced or shaped by asymmetries across economic agents possessing that information. Thus, information can certainly be characterized as being non-excludable and non-exhaustive. By contrast, as Arrow points out, there is a gap between new knowledge and what actually becomes commercialized, or new economic knowledge, $K - K^c > 0$. In fact, the knowledge filter, θ, is defined as the gap existing between investments in knowledge and the commercialization of knowledge, or economic knowledge.

(4) $\theta = K^c/K$

It is the existence of the knowledge filter, or knowledge not commercialized by incumbent enterprises, that generates the knowledge spillover entrepreneurial opportunities. As long as the incumbent enterprises cannot exhaust all of the commercialization opportunities arising from their investments in knowledge, opportunities will be generated for potential entrepreneurs to commercialize that knowledge by starting a new firm. By applying knowledge created in one organizational context to create a new organizational context – a new firm – the new entrepreneurial start up serves as a vehicle for the spillover of knowledge, λ, where

(5) $\lambda = E/K$

and E reflects entrepreneurial startups commercializing knowledge spilling over from an incumbent firm, university or other source investing in the production of new knowledge.

The observation that knowledge conditions dictate the relative advantages in taking advantage of opportunities arising from investments in knowledge of incumbents versus small and large enterprises is, of course, not new. Nelson and Winter (1982) for example,

distinguished between two knowledge regimes. What they term as the routinized technological regime reflects knowledge conditions where the large incumbent firms have the innovative advantage. By contrast, in the entrepreneurial technological regime the knowledge conditions bestow the innovative advantage on small enterprises (Winter, 1984).

There are, however, two important distinctions to emphasize. The first is the view that, in the entrepreneurial regime, the small firms exist and will commercialize the new knowledge or innovate. In the lens provided by the spillover theory of entrepreneurship, the new firm is endogenously created via entrepreneurship, or the recognition of an opportunity and pursuit by an economic agent (or team of economic agents) to appropriate the value of their knowledge. These knowledge bearing economic agents use the organizational context of creating a new firm to attempt to appropriate their endowments of knowledge.

The second distinction is that the knowledge will be commercialized, either by large or small firms. In the lens provided by the knowledge spillover theory of entrepreneurship, the knowledge filter will impede and preempt at least some of the spillover and commercialization of knowledge. Only certain spillover mechanisms, such as entrepreneurship, can to some extent permeate the knowledge filter. But this is not a forgone conclusion, but rather will vary across specific contexts, and depends on a broad range of factors, spanning individual characteristics, institutions, culture, laws, and is characterized by what we term in paper four as Entrepreneurship Capital. Thus, to merely explain E as the residual from K-Kc assumes that all opportunities left uncommercialized will automatically result in the commercialized spill over of knowledge via entrepreneurship. This was clearly not the case in the former Soviet Union and her Eastern European allies, just as, according to AnnaLee Saxenien, in Regional Advantage (1994), this was not equally the case between Silicon Valley and Route 128. That is, the capacity of each context, or *Standort*, to commercialize the residual investments in knowledge created by the knowledge filter through

entrepreneurship is not at all the same. Rather, it depends on the capacity of that context, or *Standort*, to generate an entrepreneurial response to permeate the knowledge filter and create a conduit for transmitting knowledge spillovers.

Both the West and the former Soviet Union invested in the creation of new knowledge. Both the West and the former Soviet Union innovated in what Nelson and Winter characterized as the routinized regime. The divergence in growth and economic performance emanated from difference in the knowledge filter and the capacity for that knowledge filter to be overcome. Just as the West proved to have the institutional context to generate entrepreneurial spillovers and commercialize a far greater amount of knowledge investments, Saxenien documents how the organizational structure and social capital of Silicon Valley provided a more fertile context than did Route 128 for the spillover of knowledge through entrepreneurship. Both Silicon Valley and Route 128 had the requisite knowledge inputs to generate innovative output. The main conclusion of Saxenien is that it is the institutional differences between the two *Standorte* that resulted in a greater degree of knowledge spillovers and commercialization in Silicon Valley than in Route 128. Thus, just as the knowledge filter should not be assumed to be zero, the capacity of a *Standort* to generate knowledge spillovers via entrepreneurship to permeate the knowledge filter should also not be assumed to be automatic. Rather, entrepreneurship, whether it emanates from opportunities from knowledge spillovers or from some other source, is the result of a cognitive process made by an individual within the institutional context of a particular *Standort*.

This cognitive process of recognizing and acting on perceived opportunities, emanating from knowledge spillovers as well as other sources, E, is characterized by the model of occupational (or entrepreneurial) choice, where E reflects the decision to become an entrepreneur, π^* is the profits expected to be accrue from starting a new firm, and w is the anticipated wage that would be earned from employment in an incumbent enterprise.

(6)E = ($\pi^* - w$)

But what exactly is the source of these entrepreneurial opportunities, based on expected profits accruing from entrepreneurship? As discussed above, most of the theoretical and empirical focus has been on characteristics of the individual, such as attitudes towards risk, access to financial capital and social capital. Thus, the entrepreneurial opportunities are created by variation in individual characteristics within a context that is being held constant. Entrepreneurial opportunities are generated because individuals are different, leading to variation in the ability of individuals to recognize opportunities and their willingness to act upon those opportunities. Thus, the focus on entrepreneurship, and why it varies across contexts, or *Standorte*, seemingly leads to the conclusion that the individuals must differ across the different contexts.

In the view presented here, we invert this analysis. Instead of holding the context constant and asking how individuals endowed with different characteristics will behave differently, we instead take all of the characteristics of the individual, all of her various propensities, proclivities and peculiarities as given. We will let the context, or *Standort*, in which she finds herself vary and then ask, *Holding the (characteristics of the) individual constant, how will behavior change as the context changes?*

Of course, guided by the knowledge spillover theory of entrepreneurship, the contextual variation of interest is knowledge. We want to know whether and how, in principle, the same individual(s) with the same attributes, characteristics and proclivities will be influenced in terms of the cognitive process of making the entrepreneurial choice, as the knowledge context differs. In particular, some contexts are rich in knowledge, while others are impoverished in knowledge. Does the knowledge context alter the cognitive process weighing the entrepreneurial choice?

According to the knowledge spillover theory of entrepreneurship it will. We certainly do not claim that knowledge spillovers account for all entrepreneurial opportunities, or that any of the existing explanations of entrepreneurship are any less valid. The major contextual variable that has been previously considered is growth, and especially unanticipated growth. If there is any time of constraint in expanding the capacity of incumbent enterprises to meet (unexpected) demand, then growth, g, will generate entrepreneurial opportunities, which have nothing to do with new knowledge, or

(7) $\bar{E} = (\pi^*(g,K, \theta) - w)$

Where $\bar{E}$ represents entrepreneurship from traditional sources of opportunity, or non-knowledge sources, such as growth. However, as argued above, the presence of knowledge in the context will generate entrepreneurial opportunities. Such entrepreneurial opportunities are shaped by two sources. The first is the amount of new knowledge being produced. The second is the magnitude of the knowledge filter, which limits the spillover of that knowledge for commercialization by incumbent firms. If there was no new knowledge being generated, there would be no spillover opportunities for potential entrepreneurs to consider. There might be entrepreneurship triggered by other factors, but not by knowledge opportunities.

Similarly, in the absence of a knowledge filter, all of the opportunities for appropriating the value of that knowledge would be pursued and commercialized by incumbent firms. In this case, knowledge spillovers would be considerable, just not from entrepreneurship.

Thus, two factors shape knowledge spillover entrepreneurship – the amount of investment in creating new knowledge, K, and the magnitude of the knowledge filter, θ. Thus, knowledge spillover entrepreneurship, E* is the attempt to appropriate profit opportunities accruing from the commercialization of knowledge not commercialized by the incumbent firms, or 1- θ,

(8)$E^* = (\pi^*(K, \theta) - w)$

Equation (8) implicitly suggests that the only contextual influence on entrepreneurship emanating from knowledge spillovers is the extent of knowledge investments and magnitude of the knowledge filter. Such a simple assumption neglects the basic conclusion from Saxenian (1994) that some contexts, such as Route 128 have institutional and social barriers to entrepreneurship, while other contexts, such as Silicon Valley, have institutions and social networks that actually promote entrepreneurship. The exact nature of such impediments to entrepreneurship spans a broad spectrum of financial, institutional, and individual characteristics (Acs and Audretsch, 2003). Incorporating such impediments or barriers to entrepreneurship, ß, yields

(9) $E^* = (1/\beta)(\pi^*(K, \theta) - w)$

where β represents those institutional and individual barriers to entrepreneurship, spanning factors such as financing constraints, risk aversion, legal restrictions, bureaucratic and red tape constraints, labor market rigidities, lack of social acceptance, etc (Lundstrom and Stevenson, 2005). While we do not explicitly specific these specific entrepreneurial barriers, we duly note that they reflect a wide range of institutional and individual characteristics, which, when taken together, constitute barriers to entrepreneurship. The existence of such barriers, or a greater value of β, explains why economic agents would choose not to enter into entrepreneurship, even when endowed with knowledge that would otherwise generate a potentially profitable opportunity through entrepreneurship.

Since $\bar{E} < E$, the total amount of entrepreneurial activity exceeds that generated by knowledge spillovers. Combining entrepreneurial activity from such traditional sources with knowledge spillover entrepreneurship yields the total amount of entrepreneurship,,

(10) $E = \bar{E} + E^*$

or

(11) $E = (1/\beta)(\pi^*(g,K,\theta) - w)$

Thus, the first hypothesis to emerge from the knowledge spillover theory of entrepreneurship is that $\frac{dE}{dK} \geq 0$, or what we term as the Endogenous Entrepreneurship Hypothesis

> ***Endogenous Entrepreneurship Hypothesis:*** *Entrepreneurship will be greater in the presence of higher investments in new knowledge, ceteris parabus. Entrepreneurial activity is an endogenous response to higher investments in new knowledge, reflecting greater entrepreneurial opportunities generated by knowledge investments.*

The second hypothesis emerging from the knowledge spillover theory of entrepreneurship has to do with the location of the entrepreneurial activity. Access to knowledge spillovers requires spatial proximity. While Jaffe (1989) and Audretsch and Feldman (1996) made it clear that spatial proximity is a prerequisite to accessing such knowledge spillovers, they provided no insight about the actual mechanism transmitting such knowledge spillovers. As for the Romer, Lucas and Jones models, investment in new knowledge automatically generates knowledge spillovers. The only additional insight involves the spatial dimension – knowledge spills over but the spillovers are spatially bounded. Since we have just identified one such mechanism by which knowledge spillovers are transmitted – the startup of a new firm – it follows that knowledge spillover entrepreneurship is also spatially bounded in that local access is required to access the knowledge facilitating the entrepreneurial startup:

Localization Hypothesis: *Knowledge spillover entrepreneurship will tend to be spatially located within close geographic proximity to the source of knowledge actually producing that knowledge. Thus, in order to access spillovers, new firm startups will tend to locate close to knowledge sources, such as universities.*

5. Linking Endogenous Entrepreneurship to Growth

The knowledge spillover theory of entrepreneurship, which focuses on how new knowledge can influence the cognitive decision making process inherent in the entrepreneurial decision links entrepreneurship and economic growth, is consistent with theories of industry evolution (Jovanovic, 1982; Ericson and Pakes, 1995; Audretsch, 1995; Hopenhayn, 1992; Lambson, 1991 and Klepper, 1996). While traditional theories suggest that small firms will retard economic growth, by imposing a drag on productive efficiency, these evolutionary theories suggest exactly the opposite – that entrepreneurship will stimulate and generate growth. The reason for these theoretical discrepancies lies in the context of the underlying theory. In the traditional theory, new knowledge plays no role; rather, static efficiency, determined largely by the ability to exhaust scale economies dictates growth. By contrast, the evolutionary models are dynamic in nature and emphasize the role that knowledge plays. Because knowledge is inherently uncertain, asymmetric and associated with high costs of transactions, divergences emerge concerning the expected value of new ideas. Economic agents therefore have an incentive to leave an incumbent firm and start a new firm in an attempt to commercialize the perceived value of their knowledge. Entrepreneurship is the vehicle by which (the most radical) ideas are sometimes implemented and commercialized.

A distinguishing feature of these evolutionary theories is the focus on change as a central phenomenon. Innovative activity, one of the central manifestations of change, is at the heart of much of this work. Entry, growth, survival, and the way firms and entire industries change over time are linked to innovation. The dynamic performance of regions and even entire economies, that is the *Standort*, is linked to the efficacy of transforming investments in new knowledge into innovative activity.

Why are new firms started? The traditional, equilibrium-based view is that new firms in an industry, whether they be startups or firms diversifying from other industries, enter when incumbent firms in the industry earn supranormal profits. By expanding industry supply, entry depresses price and restores profits to their long-run equilibrium level. Thus, in equilibrium-based theories entry serves as a mechanism to discipline incumbent firms. By contrast, the new theories of industry evolution develop and evaluate alternative characterizations of entrepreneurship based on innovation and costs of firm growth. These new evolutionary theories correspond to the disequilibrating theory of entrepreneurship proposed by Shane and Eckhardt (2003)

For example, Audretsch (1995) analyzes the factors that influence the rate of new firm startups. He finds that such startups are more likely in industries in which small firms account for a greater percentage of the industry's innovations. This suggests that firms are started to capitalize on distinctive knowledge about innovation that originates from sources outside of an industry's leaders. 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 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 links between entrepreneurship on the one hand and growth and survival on the other have been found across a number of social science disciplines, including economics, sociology and regional studies.

A series of survey articles by Sutton (1997), Caves (1998) and Geroski (1995) summarize the findings from a plethora of empirical studies examining the relationship between firm size and growth within the North American context. The early studies were undertaken using data from the U.S. These studies (Mansfield, 1962; Hall, 1987; Dunne, Roberts and Samuelson, 1989; and Audretsch, 1991) established not only that the likelihood of a new entrant surviving is quite low, but that the likelihood of survival is positively related to firm size and age. A *stylized result* (Geroski, 1995) emerging from this literature is that, when a broad spectrum of firm sizes is included in samples of U.S. enterprises, smaller firms exhibit systematically higher growth rates than their larger counterparts. The growth advantage of small and new firms vis-à-vis large enterprises has been shown to be even greater in high technology industries (Audretsch, 1995).

These so-called stylized results between firm size and age on the one hand, and growth and survival on the other hand were subsequently confirmed for a number of European countries A wave of studies have confirmed these findings for different European countries,

including Portugal (Mata, Portugal and Guimaraes, 1994; and Mata, 1994), Germany (Wagner, 1992), Tveteras and Edide (2000) and Klette and Mathiassen (1996) for Norway, and Italy (Audretsch, Santarelli and Vivarelli, 1999). However, the links between firm size and growth and firm age and growth are somewhat more ambiguous within the European context. Most studies have found results in the European context which are strikingly similar to what has been found in the U.S. (Almus and Nerlinger, 2000; and Harhoff, Stahl and Woywode, 1998). Using a large comprehensive panel data set from the ZEW-foundation Panel (West), "Gibrat's Law" is rejected for the group of young firms belonging to technology intensive branches as well as those operating in non-technology intensive branches (Almus and Nerlinger, 2000), indicating that the smaller enterprises grow faster than their larger counterparts.

Heshmati (2001) has examined the relationship between firm size, age and growth for a large sample of small firms in Sweden between 1993 and 1998. The results indicate that, in Sweden, firm size and age are negatively related to employment growth, which is consistent with the findings for the U.S. However, in terms of sales growth, a positive relationship emerges, suggesting that, at least over this period, larger firms generated more growth in terms of sales than in terms of employment.

Wagner (2001 and 1995) tracked analyzed the performance of small (and large) firms prior to exit. He used a longitudinal data base identifying the pre-exit performance of cohorts of firms exiting in 1990, 1991 and 1992. One striking result he found was that more than half of the exiting firms (between 53 percent and 61 percent) were founded prior to 1979, making them over 11 years old. He also found that young firms, which were classified as being younger than five years old, accounted for about a quarter of all exits, and three-quarters of exiting businesses were from middle-aged firms. At the same time he found that the likelihood of survival increases with firm size.

Almus and Nerlinger (2000) also use a large panel data base to examine how the post-entry performance of new firms varies across sectors. In particular, they find that the growth rates of new firms tends to be greater in very high-tech industries than in high-tech industries and other manufacturing industries. This mirrors the results found in the North American context.

In particular, Almus and Nerlinger (1999) examine why entrepreneurial growth varies between what they term as new technology-based firms (NTBFs) and non-innovative startups. They perform multivariate analyses on the impact of characteristics specific to the entrepreneur as well as the industry on subsequent firm growth. They use a database provided by the largest German credit ratting agency, CREDITREFORM. This data base is analogous to the Dun and Bradstreet database for the United States. Firms enter the CREDITREFORM data base for two reasons. First, a customer or supplier may inquire about the financial situation of the respective firm. Second, credit rating agencies exploit economies of scale by gathering information proactively, systematically recording publicly available information on new firms (Harhoff, Stahl, and Woywode, 1998). The CREDITREFORM data base contains a linked panel data base consisting of more than 580,000 firms in West Germany. The authors find that the growth of new-firm startups is shaped by characteristics specific to the founder, the firm, as well as the industry environment. For example, they find that large and mature firms have lower growth rates than do small and young firms, both innovative and non-innovative. In particular, they find that the greater the degree of human capital of the founder, the greater is the growth rate, especially in innovative industries.

Using firm-level data from Italy, Audretsch, Santarelli and Vivarelli (1999) find that growth rates are negatively related to firm size. In addition, they find that the likelihood of survival is greater in the startup year than in the second year, but subsequently increases over time. Similarly, Tveteras and Eide (2000) provide evidence for Norwegian manufacturing using the estimation technique of a semi-proportional Cox Model that the likelihood of survival is lower for smaller and younger establishments. Bruederl and Preisendoerfer (1998) examine a data base consisting of 1,700 new-firm startups in Germany and find that the

subsequent performance, measured in terms of likelihood of survival and growth, is greater for those entrepreneurs that (1) participate in a network with other entrepreneurs, (2) receive active help from their spouse, and (3) receive emotional support from their spouse. In addition, they find that entrepreneurial success is positively influenced by the ethnic background which of the entrepreneur, educational background, type of work experience, and whether the entrepreneur already had entrepreneurial experience. Their most striking finding is that entrepreneurial success is the highest within the context of a network with other entrepreneurs.

The performance of small and new firms is also conditional upon location. Fotopulos and Louri (2000) examine the impact that location within an agglomeration has on the likelihood of survival for Greek firms. They find that location in the Greater Athens area has a positive impact on the likelihood of survival, particularly for smaller enterprises.

Based on a panel data set consisting of firm-level observations, Scarpetta et al. (2002) provide evidence that there is a lower degree of firm turbulence, or what they call "churning" in Europe than in the U.S. In particular, they identify that the distinguishing features of European SMEs from their American counterparts is that they start up at a larger size, have a higher level of labor productivity, and a lower level of employment growth subsequent to entry.

Thus, while there is somewhat more ambiguity in the studies linking growth and survival to firm size and growth, the results for Europe generally mirror the so-called "Stylized Results" found within the North American context:

1. Growth rates are higher for smaller enterprises
2. Growth rates are higher for younger enterprises
3. Growth rates are even higher for small and young enterprises in knowledge-intensive industries
4. The likelihood of survival is lower for smaller enterprises
5. The likelihood of survival is lower for younger enterprises
6. The likelihood of survival is even lower for small and young enterprises in knowledge-intensive industries.

What emerges from the new evolutionary theories and corroborative empirical evidence on the role of entrepreneurial small firms is that firms are in motion, with a lot of new firms entering the industry and a lot of firms exiting out of the industry. The evolutionary view of entrepreneurship 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 (Audretsch et al., 2002).

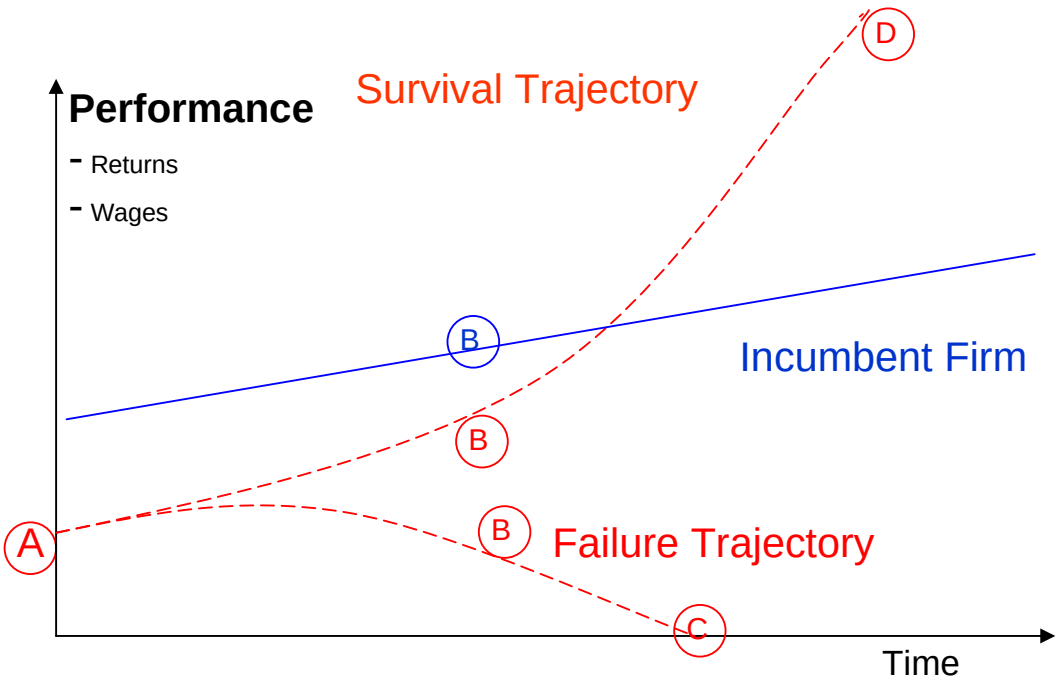
The empirical evidence described above supports such an evolutionary view of the role of new firms in manufacturing, because the post-entry growth of firms that survive tends to be spurred by the extent to which there is a gap between the minimum efficient scale (MES) level of output and the size of 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.. Rather, by serving as agents of change, entrepreneurial firms provide an essential source of new ideas and experimentation that otherwise would remain untapped in the economy. The impact of entrepreneurship is therefore manifested by growth – at the levels of the firm, the region and even at the national level.

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. Some contexts can be best characterized by the model of the conical revolving door, where new businesses are started, but there is also a high propensity to subsequently exit from the market. Other contexts 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 startling result 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 startups that are not so successful ultimately exit within a few years subsequent to entry. By serving as agents of change, new firms provide an essential conduit of knowledge spillovers commercializing new ideas through experimentation that otherwise would remain untapped in the economy.

Figure 1

Entrepreneurship and Growth



The knowledge spillover theory entrepreneurship is depicted in figure 1. The production of new knowledge and ideas in the context of an incumbent organization, such as the research and development lab of a large corporation, or the research laboratory at a university, creates knowledge embodied in an individual knowledge worker, or team of knowledge workers. If divergences in the expected value or outcome from this new knowledge lead to the decision by the incumbent firms not to commercialize the new knowledge, the economic agent could remain employed by an incumbent firm and expect to earn incremental additions to her income over time, as depicted by the positive, linear incumbent earnings profile.

Alternatively, as a result of her endowment of ideas and knowledge that is not being appropriated or rewarded within the context of the incumbent organization, the knowledge agent could reach the decision to start a new firm, which is represented by point A. Why

would a rationale economic agent choose to settle for a lower return at point A than could be earned from a wage paid by an incumbent firm? Because of the expectation that there is some likelihood that the ideas upon which the firm is started will prove to be valuable, resulting in a growth of the firm and associated returns along the survival trajectory. As the evolutionary theories and systematic empirical evidence, shows, the likelihood of a new startup surviving is low. It is even lower for a knowledge-based startup. However, as discussed above, the same literature has provided theoretical insights and compelling empirical evidence showing that those knowledge-based startups that do survive will actually experience higher growth rates.

The likelihood that the new idea spawning the entrepreneurial startup is not compatible with market viability and sustainability is high. Thus, the evolutionary interpretation linking knowledge to entrepreneurship and ultimately economic growth suggests that the entrepreneurial act is to learn from the market about the vaiability and compatibility of a new idea that was rejected, or undervalued by incumbent organizations. The new startup serves as a conduit for knowledge spillovers from the source producing that knowledge to commercialization in a new firm.

One of the important findings of Glaeser et al. (1992) and Feldman and Audretsch (1999) is that economic performance is promoted by knowledge spillovers. However, their findings, as well as the corroborative results from a plethora of studies, focused on a spatial unit of observation, such as cities, regions and states. For example, Glaeser et al. (1992) found compelling empirical evidence suggesting that a greater degree of knowledge spillover leads to higher growth rates of cities. If the existence of higher knowledge spillovers bestow higher growth rates for cities, this relationship should also hold for the unit of observation of the (knowledge) firm. The performance of entrepreneurial firms accessing knowledge spillovers should exhibit a superior performance. Thus, the performance hypothesis states

Entrepreneurial Performance Hypothesis: *The performance of knowledge-based startups should be superior when they are able to access knowledge spillovers through geographic proximity to knowledge sources, such as universities, when compared to their counterparts without a close geographic proximity to a knowledge source.*

It could be claimed that the high failure rates for entrepreneurship more than negate the greater growth rates. There are at least two important externalities associated with entrepreneurial firms that hold just as strongly for failed startups as for successful entrepreneurial firms. The first is that the entrepreneurial experience can spawn subsequent entrepreneurial startups. For example, the catalyst for Silicon Valley was the founding of Fairchild Semiconductor in 1957, which is credited with being the pioneering semiconductor firm. Although Fairchild faded, it spawned an impressive host of spin-offs, including Intel, which was started by Bob Noyce. Noyce and other Fairchild employees clearly gained knowledge through their experiences at Fairchild. Although Fairschild Semiconductor had "possibly the most potent management and technical team ever assembled" (Gilder, 1989, p. 89), "Noyce couldn't get Fairchilds eastern owners to accept the idea that stock options should be part of compensation for all employees, not just for management. He wanted to tie everyone, from janitors to bosses, into the overall success of the company…This management style still sets the standard for every computer, software, and semiconductor company in the Valley today…Every CEO still wants to think that the place is being run the way Bob Noyce would have run it" (Cringley, 1993, p. 39).

The second important externality is that new knowledge is generated in entrepreneurial failures. This knowledge can be valuable for other firms, both startups and large incumbent enterprises. Even if the knowledge is restricted to learning about new ideas that are not viable, this can have a positive value.

A third important externality from entrepreneurship is the increased competition for knowledge workers. Jacobs (1969) and Porter (1990) argue that localized competition is more conducive to knowledge externalities than is local monopoly. It should be emphasized that by local competition Jacobs does not mean competition within product markets as has traditionally been envisioned within the industrial organization literature. Rather, Jacobs is referring to the competition for the new ideas embodied in economic agents. Not only do an increased number of firms provide greater competition for new ideas, but in addition, greater competition for new ideas elevates the return accruing to economic agents investing in human capital and new knowledge.

Taken together, these three externalities may contribute to an impact on economic growth that is actually greater outside of the boundaries of the entrepreneurial firms than is contributed by the direct growth measured within the boundaries of entrepreneurial startups. Thus, Figure 1 should not be interpreted as attributing the entire impact of entrepreneurship on growth to be restricted to the growth of entrepreneurial firms themselves. Such an extreme assumption of no external impacts is implicit in the analyses of new and small enterprises found in the path breaking Birch (1979) study, as well as the more recent Davis et al. (1996a) update. While there is severe methodological disagreement between the Davis et al. and Birch approaches to measuring the impact of small firms on economic performance, both implicitly agree in an absence of external impact. Thus, in a type of statistical apartheid or segregation, in the Birch and Davis et al. studies, the impact of small and new firms is measured only within that set of firms. By contrast, here we emphasize that the impact of entrepreneurship on economic performance generally, or growth more specifically, is not constrained to be limited to manifest itself solely in those entrepreneurial firms, but rather has an external impact of far greater significance. As the *Growth Hypothesis* suggests, ceteris paribus, a *Standort* endowed with a higher degree of what is termed in the next paper as Entrepreneurship Capital, will

facilitate knowledge spillovers and the commercialization of knowledge, thereby generating greater economic growth.

> ***Growth Hypothesis:*** *Given a level of knowledge investment and severity of the knowledge filter, higher levels of economic growth should result from greater entrepreneurial activity, since entrepreneurship serves as a mechanism facilitating the spillover and commercialization of knowledge.*

The impact of entrepreneurship capital on economic growth leads to a modification of Equation (2), with the recognition that an addition factor, entrepreneurship capital, E, can, along with the traditional factors also make an important contribution to economic growth

(13) Qi = h(t)f (Ci, Li, Ki, Ei)

The exact nature of the impact of entrepreneurship capital, if in fact any, is the focus of the following section.

6 . Empirical Evidence

6.1 Testing the *Growth Hypothesis*

This *growth hypothesis* introduced in the previous section suggests that entrepreneurship capital should contribute to economic performance. In this section empirical evidence is provided for testing this hypothesis. We estimate a regression model where the first equation is a Cobb-Douglas function of the form

(14) $Y_i = K_i^{\alpha} L_i^{\beta} R_i^{\eta} E_i^{y}$,

where Y is economic performance of region i, measured as GDP, K is the region's i endowment with capital, L is labor and E represents the region's endowment *entrepreneurship capital*. Hence, this specifies formally that entrepreneurship capital contributes to the economic output of regions.

As already emphasized in the previous section, the concept of entrepreneurship capital is unobservable. However, as an unobservable variable, entrepreneurship capital, is reflected by the number of startups in the respective region. Thus, we use the number of startups as a proxy measure or indicator of entrepreneurship.

The variables used to estimate equation (14) are

Output is measured as Gross Value Added corrected for purchases of goods and services, VAT and shipping costs, measured in year 2000. Statistics are published every two years for *Kreise* by the Working Group of the Statistical Offices of the German Länder, under "Volkswirtschaftliche Gesamtrechnungen der Länder'".

Physical Capital: The stock of capital used in the manufacturing sector of the *Kreise* has been estimated using a perpetual inventory method, which computes the stock of capital as a weighted sum of investments done in the producing sector in the period 1980 to 2000. In the estimates we used a β-distribution with p=9 and a mean age of q=14. For a detailed description of this procedure see e.g. Audretsch and Keilbach (2004).

Labor: Data on labor is published by the Federal Labor Office, Nürnberg that reports number of employees liable to social insurance by *Kreise*.

Knowledge Capital (Ki) is expressed as *number of employees engaged in R&D* in the public (1992) and in the private sector (1991). With this approach we follow the examples of Griliches (1979), Jaffe (1989), and Audretsch and Feldman (1996). Data has been communicated by the *Stifterverband für die Wissenschaft* under obligation of secrecy. With

these data, it was impossible to make a distinction between R&D-employees in the producing and non-producing sectors. Regression results therefore will implicitly include spillovers from R&D of the non-producing sector to the producing sectors. We presume however that this effect is rather low.

Entrepreneurship Capital: Measurement of entrepreneurship capital is no less complicated than is measuring the traditional factors of production. Just as measuring capital and labor invokes numerous assumptions and simplifications, creating an entrepreneurship capital metric also presents a challenge. Many of the elements that determine entrepreneurship capital in our definition defy quantification. In any case, entrepreneurship capital, like all of the other types of capital, is multifaceted and heterogeneous. However, entrepreneurship capital manifests itself in a singular way – the startup of new enterprises. Thus, we propose using new-firm startup rates as an indicator of entrepreneurship capital, the latter being an unobservable (i.e. latent) variable. *Ceteris paribus*, higher startup rates reflect higher levels of entrepreneurship capital. We compute entrepreneurship capital as the *number of startups in the respective region relative to its population*, which reflects the propensity of inhabitants of a region to start a new firm. From the background of our definition of entrepreneurship capital, alternative measures would be possible. A number of aspects of this definition being difficult to quantify, a natural candidate would be a region's stock of young firms. However, this measure would implicitly reflect exit and shakeout dynamics. Hence a measure along these lines would inevitably be influenced by factors external to entrepreneurship capital such as quality of management or business ides and thus be biased. We therefore consider the number of startups as being the most appropriate measure of entrepreneurship capital.

The data on startups is taken from the ZEW foundation panels that are based on data provided biannually by *Creditreform*, the largest German credit-rating agency. This data contains virtually all entries – hence startups – in the German Trade Register, especially for

firms with large credit requirements as e.g. high-technology firms.[1] As of 2000, there were 1.6 million entries for Western-Germany. Since number of startups is subject to a greater level of stochastic disturbance over short time periods, it is prudent to compute the measure of entrepreneurship capital based on startup rates over a longer time period. We therefore used the number of startups from 1998 to 2000.

While we argue in this paper that entrepreneurship capital should include startup activity in any industry, some scholars have suggested that it should only apply to startups involved in high-technology activity. Therefore, we compute two additional measures of entrepreneurship. The first one restricts entrepreneurship capital to include only startup activity in high-technology manufacturing industries (whose R&D-intensity is above 2.5%). The second measure restricts entrepreneurship capital to include only startup activity in the ICT industries, i.e. firms in the hard- and software business. Some of these industries are also classified under high-technology manufacturing; hence there exists an intersection between these two measures. These two measures will place more emphasis on the aspect of risk involved in our definition of entrepreneurship capital, since R&D-intensive activities are more uncertain in outcome, and since a larger financial commitment is necessary to engage into R&D intensive industries. Therefore, the expected value of the monetary loss is larger.

[1] Firms with low credit requirements, with a low number of employees or with illimited legal forms are registered only with a time lag. These are typically retail stores or catering firms.

Table 1: The Impact of Entrepreneurship on West German Regional Growth

Constant	-0.6855***	-0.5434**	-0.7844***	-0.7252***
	(-3.35)	(-2.46)	(-3.55)	(-3.47)
Physical Capital	0.7697***	0.1876***	0.1882***	0.1677***
	(6.23)	(6.98)	(6.88)	(6.09)
Labor	0.7095***	0.6889***	0.6867***	0.7073***
	(20.16)	(20.15)	(19.69)	(19.95)
Knowledge Capital	0.0478***	0.0388***	0.0470***	0.0521***
	(5.07)	(3.84)	(4.68)	(5.62)
General Entrepreneurship	0.1549***			
	(4.26)			
High-Tech Entrepreneurship		0.1064***		
		(4.54)		
ICT Entrepreneurship			0.0796***	
			(3.09)	
Low Entrepreneurship				0.1388***
				(3.83)
R^2 (adj.)	0.9508	0.9512	0.9495	0.9503

Notes: *t-statistic in brackets.*
* Statistically significant at the two-tailed test for 90% level of confidence
** Statistically significant at the two-tailed test for 95% level of confidence
*** Statistically significant at the two-tailed test for 99% level of confidence

Table 1 shows the regression results from estimating equation 1. As the positive and statistically significant coefficients of capital and labor indicate, both of the traditional factors contribute to economic growth. Similarly, the coefficients of the three different measures of entrepreneurship are also positive and statistically significant, suggesting that entrepreneurship capital also contributes to economic performance, at least in the case of German regions. Thus, taking entrepreneurship capital as exogenous, the results from Table 1 suggest that not only do the traditional factors of production positively influence economic growth, but entrepreneurship capital also has a positive impact on economic performance as well.

6.2 Endogenizing Entrepreneurship

6.2.1 Specification

An important qualification of the results from the previous section is that the measure of entrepreneurship is assumed to be exogenous. Thus, while the empirical results from Table 1 provide evidence that entrepreneurship capital has a positive impact on regional economic performance, there are no insights as to how policy could influence entrepreneurship capital. This assumption that entrepreneurship capital is exogenous is particularly bothersome given the earlier literature (Reynolds, Storey and Westhead, 1994), suggesting the entrepreneurship is influenced by regional specific characteristics. For example, Reynolds, Storey and Westhead (1994), along with the survey by Storey (1991), suggest that the empirical evidence has been generally unambiguous with respect to the findings for population density (a positive impact on startup rates), population growth (positive impact on startup rates), skill and human capital levels of the labor force (positive impact), and mean establishment size (negative impact on startup rates) We therefore specify a second equation in order to take this recursive structure explicitly into account. In its general form, this equation takes the form

$$(15)\ E_i = f(\mathbf{Y}_i, \mathbf{X}_i),$$

where $\mathbf{Y}_i$ is a matrix of measures of region's i economic performance and $\mathbf{X}_i$ is a matrix of other variables influencing entrepreneurial activity. These specific measures are specified in detail in the following section.

If a simultaneous set of equations specifies variables are used as exogenous in one equation and as endogenous in the other equation, estimation will not be consistent, leading estimates to be biased (e.g. Intriligator et al., 1992). Therefore, we estimate this system of equations using three stage least squared estimations.

Do contexts rich in knowledge investment actually generate more entrepreneurship than those contexts that are knowledge impoverished, as the *Endogenous Entrepreneurship Hypothesis* predicts? To answer this question, ß and γ, or the factors both conducive to as well as impeding entrepreneurial activity need to be identified and controlled for.

Considerable insight has been made identifying factors influencing entrepreneurial opportunities as well as barriers to entrepreneurship, or γ and ß. As made clear in the introduction of this paper, entrepreneurship theory has been on the existence of opportunities combined with the capacity to pursue them through the creation of a new organization. The plethora of empirical studies analyzing the spatial pattern of start-up rates has generally incorporated factors reflecting sources of entrepreneurial opportunities and factors facilitating or hindering entrepreneurial capabilities.

For example, each country study included in the special issued of *Regional Studies* on "Regional Variations in New Firm Formation", edited by Reynolds, Storey and Westhead (1994), along with the survey by Storey (1991), links regional startup rates to regional-specific characteristics such as population density, growth, unemployment, skill levels of the labor force, and mean establishment size. In particular, these studies suggest that the empirical evidence has been generally unambiguous with respect to the findings for population density (a positive impact on startup rates), growth (positive impact on startup rates), skill levels of the labor force (positive impact), and mean establishment size (negative impact on startup rates). Country studies produced ambiguous and inconsistent results with respect to the relationship between unemployment rates and startup activity.

While the specification of the estimated regressions was somewhat *ad hoc*, one interpretation of their approach and findings is that these variables reflected various elements of ß and γ, or entrepreneurial barriers and entrepreneurial opportunities. For example, the systematic and positive relationship between population density and startup activity could be

interpreted as bestowing entrepreneurial opportunities from the three sources of agglomeration identified by Alfred Marshall – labor market pooling, non-pecuniary economies, and knowledge externalities.

The systematic finding of a positive relationship between startup rates and growth is consistent with the theory of small business flexibility, introduced by Mills and Schumann (1985), who explicitly identified growth as a factor generating opportunities that would not be met by incumbent firms, as long as there exists a positive cost of adjusting capacity by the incumbent. Thus, economic growth can be interpreted as a source of entrepreneurial opportunity in the Mills and Schumann model, but only because of the existence of capacity constraints and positive costs to capacity adjustment.

The finding of a positive relationship between the level of skills in the labor force and startup rates can be interpreted as indicating that entrepreneurial capabilities are positively related to the level of skilled labor. Similarly, the negative relationship between mean establishment size and startup activity can be interpreted as reflecting both entrepreneurial capabilities and opportunities in regions with a large share of small establishments, where workers have accumulated learning and experiences in small firms and there is a large network of small enterprises with which a new startup can potentially interact.

That unemployment is linked to entrepreneurship dates back to Knight's (1921) view that individuals make a decision among three states – unemployment, self-employment and employment. The actual decision is shaped by the relative prices of these three activities but there was a clear prediction that entrepreneurship would be positively related to unemployment. However, as Storey (1991) documents, the empirical evidence linking unemployment to entrepreneurship is fraught with ambiguities. While some studies find that greater unemployment serves as a catalyst for startup activity (Reynolds, Miller and Makai, 1995; Reynolds, Storey and Westhead, 1994; Highfield and Smiley, 1987, and Yamawaki,

1990; Evans and Leighton, 1989b and 1990), still others have found that unemployment reduces the amount of entrepreneurial activity (Audretsch and Fritsch, 1994; Audretsch, 1995).

The failure of an unambiguous relationship to be found between unemployment and startup rates may reflect the two polar impacts of unemployment on entrepreneurship. On the one hand, it increases the attractiveness of existing entrepreneurial opportunities. On the other hand, it may also reflect a paucity of entrepreneurial capabilities (Storey, 1991).

In addition to these measures found in the cross-regional country studies compiled by Reynolds, Storey and Westhead (1994), other studies have also uncovered locational specific characteristics that might influence γ and ß, or entrepreneurial opportunities and barriers. One such variable creating entrepreneurial opportunities is the demographic composition of the region. Demographic elements that can be classified as being marginal or outsiders to the main social groups may not possess the requisite social capital for their knowledge to be applicable in and compatible with incumbent organizations. This would suggest that such marginal groups will have a higher propensity to resort to entrepreneurship to appropriate the expected value of their ideas. In particular, immigrants as well as young people have been found to have a greater propensity to start new businesses. A third demographic characteristic influencing economic growth is the degree of diversity in the workforce. Jacobs (1979) argued that the degree of diversity in the workforce is an important source of knowledge spillovers. According to Jacobs (1979), it is the exchange of complementary knowledge across diverse firms and economic agents, which yields a greater return on new economic knowledge. She develops a theory that emphasizes that the heterogeneity of people within a geographic region promotes knowledge externalities and ultimately innovative activity and economic growth. Thus, entrepreneurial opportunities should be greater in regions with a

more diverse population, since more new ideas would be expected to be generated as a result of social diversity.

Florida (2002) has argued that the attractiveness of a *Standort* will facilitate both entrepreneurial capabilities and opportunities by attracting what he terms as the creative class. Those locations that are more attractive to knowledge workers, or the creative class, should also exhibit higher startup rates, *ceteris paribus*.

Social diversity has been found to promote the generation of entrepreneurial opportunities by enhancing new ideas and the spillover of knowledge. Florida (2002) has argued that social diversity in a society is a proxy for the openness or tolerance of this society with respect to new ideas. Such openness is important in an environment where new ideas are transformed into business ideas and ultimatively to new firm startups. Thus, openness is an important asset to the generation of entrepreneurial opportunities.

Glaeser et al. (1992) argued that spatial density, hence proximity, facilitates knowledge spillovers. Similarly, we expect that in densely populated regions, ideas and knowledge flow faster; therefore entrepreneurial opportunities are generated faster and can be appropriated more easily by economic agents. Hence, entrepreneurial opportunities should be greater in agglomerations, or more densely populated regions, than in less agglomerated regions. Both entrepreneurial opportunities and the ability of economic agents to appropriate those opportunities through entrepreneurship should be greater in more highly agglomerated regions where knowledge spillovers are greater and the provision of ancillary services and inputs is also greater.

The composition of economic activity at the *Standort* may also influence entrepreneurial opportunities. In the 1990s there was a debate on how the spatial composition of economic activity facilitated knowledge spillovers. While some studies found that a

stronger specialization of economic activity within a single industry at a *Standort* was more conducive to knowledge spillovers, or what has been termed the Marshall-Arrow-Romer' type of externality, other studies argued for (Porter 1990, and Jacobs 1979) and found evidence (Audretsch and Feldman, 1999; Glaeser et al., 1992) suggesting that instead diversity among complementary types of economic activity is more conducive to knowledge spillovers, or what has been termed as the Jacobs externality. While the theory and empirical evidence did not specifically identify the link between the composition of economic activity and entrepreneurial opportunities, the focus on knowledge spillovers implicitly suggests that entrepreneurial opportunities should also be related to the degree of specialization or diversity of economic activity at the *Standort*.

Public policy can also influence both entrepreneurial opportunities and the ability of economic agents to take advantage of them. While some public policies impacting entrepreneurship may be more obvious, such as taxes, legal barriers, bureaucratic barriers, early stage finance, procurement, or tax credits, as Lundstroem and Stevenson (2005) point out, public policy impacting entrepreneurship spans a broad spectrum of instruments. Lundstroem and Stevenson identify public policies designed to encourage entrepreneurship ranging from immigration to education. This makes operationalizing public policy to promote entrepreneurship into a measurable variable that can be measured challenging, if not impossible.

To these different measures reflecting various aspects of entrepreneurial opportunities and entrepreneurial barriers, we also include a measure of investment in new knowledge. According to the *Endogenous Entrepreneurship Hypothesis*, those contexts, or regions, with a greater investment in new knowledge, should generate more entrepreneurial opportunities, and therefore exhibit higher rates of observed entrepreneurship. By contrast, those contexts, or regions, with impoverished investments in new knowledge, will generate fewer

entrepreneurial opportunities, and therefore should exhibit lower rates of observed entrepreneurship.

6.2.2 Measurement

To measure the dependent variable, the regional entrepreneurship rate, we use the same measure of entrepreneurship as used above, the number of startups divided by the number of firms in each German region. Since the number of startups is subject to a greater level of stochastic disturbance over short time periods, it is prudent to compute the measure of entrepreneurial activity based on startup rates over a longer time period. We therefore used the number of startups from 1998 to 2000.

While opportunity recognition is probably inherent in most if not all of entrepreneurship, the type of endogenous entrepreneurship emanating from knowledge spillovers that is the focus of this paper suggests a sharper focus on knowledge-based and technology entrepreneurship. Thus, four different measures of entrepreneurship are used and compared in testing the *Endogenous Entrepreneurship Hypothesis*. The first measure of entrepreneurship is the more general and includes start-ups in *all* industries. More than 50 percent of these start-ups are in the retail and catering sectors, i.e. shops and restaurants.

We then consider two knowledge based measures of entrepreneurship, the first being start-ups in the high-tech industries, i.e. industries with an average R&D-intensity of more than 2.5%.[2] Start-ups in these industries account for 7.5% of all start-ups in average, ranging from 1.6% to 17.9% within German counties (*Kreise*). A second measure of knowledge based entrepreneurship is start-ups in the ICT-industries. This measure represents a mix of startups in ICT oriented manufacturing and service industries. ICT entrepreneurship accounts for 7.7

[2] Here, we follow the classification used in the reports of the Federal Ministry of Education and Research.

percent of all startups, with a high regional variation, ranging from 1.5% to 19.0% over the regions.

As a "counterfactual" we consider a fourth measure of entrepreneurship, the residual, or the aggregate of the remaining industries, which we denote "low-tech" entrepreneurship. The notion "low-tech" refers to the low R&D intensity of the industry and not to the degree of education or human capital of the founders.

Both knowledge-based measures of entrepreneurship are highly correlated with each other, while the correlations between the two measures of knowledge entrepreneurship and the "low-tech" measure is much weaker. The measure of general entrepreneurship and the "low-tech" entrepreneurship measure are highly correlated. This presumably reflects the high share of low-tech entrepreneurship contained in the general entrepreneurship measure. It should also be pointed out that while all of the measures of entrepreneurship are significantly correlated with the regional population density of regions, the correlations between the knowledge-based entrepreneurship measures and population density are considerably stronger.

The theoretical reasons, along with some of the empirical findings from previous studies, for including location-specific characteristics as influencing regional entrepreneurship was explained in the previous section. As was emphasized in the previous section, each explanatory variable should reflect an aspect of either entrepreneurial opportunity, γ , or barrier to entrepreneurship, ß.

Growth: Regional growth is measured as $g_y = \ln(y_{t1} - y_{t0})$, between 1992-2000, where g is the regional growth rate, and yt1 is the regional gross domestic product in 2000, and ytO is the regional gross domestic product in 1992. This variable measures each region's growth between the years 1992 and 2000. The aim of this variable is to identify the degree to which

regional economic growth generates entrepreneurial opportunities and therefore increases the propensity for starting up new businesses.

Investment: This variable measures the investment in physical capital in the producing sector (without the mining industry) of firms with more than 20 employees (measured in 1999). Given a level of regional growth, a greater degree of investment by incumbent firms may reflect a higher value of θ, or the propensity for the incumbent firms to appropriate and commercialize existing opportunities. Clearly if Investment were zero this would indicate that the incumbents were not pursuing existing opportunities. By contrast, holding regional growth constant, as Investment increases this might reflect a greater capacity for the incumbents to pursue new opportunities.

Policy: Public policy at both the regional and national levels can both create entrepreneurial opportunities as well as provide access to scarce entrepreneurial resources, such as finance. In fact, a complex web of policy instruments are deployed in Germany to promote startup activity. Actual start-up funding is only one among a large number of policy instruments, albeit one of the largest ones in Germany of the late 1990s. We have created a composite measure reflecting a broad spectrum of instruments designed to foster entrepreneurship and encourage the startup of new firms in each region.[3]

Taxes: As Carlton (1983) argues, taxes can pose a barrier to entrepreneurship by reducing the returns from pursuing new opportunities. A measure of the mean regional tax rate is included. The German tax system does not generally make regional distinctions with the exception of the Business Tax, which is set at the regional level. The variable Business

[3] This composite policy measure is based on the subsidies per capita in the region, which includes a number of instruments with broader goals than encouraging new firms startups.

Tax per person measures the actual tax revenue relative to the corresponding regional population.

Unemployment: The regional rates of unemployment are included to identify the impact that unemployment has on startup rates in the German context..

Standort Attractiveness: Measuring locational attractiveness is important but not obvious. Locational attractiveness is measured by the number of hotel beds in the region relative to the total surface. Presumably regions with more hotel capacity, *ceteris paribus*, are more attractive. We would expect a positive relationship between *Standort Attractiveness* and Entrepreneurship.

Knowledge: The amount of investment in knowledge in the region is measured by R&D intensity, or the share of the regional labor force accounted for by scientists and engineers. A positive coefficient on this variable would be consistent with the *Endogenous Entrepreneurship Hypothesis*.

Agglomeration: The contribution of agglomeration economies to creating entrepreneurial opportunities is measured by including the regional population density. As population density increases we expect more entrepreneurial opportunities to be created, and therefore expect a positive coefficient on Agglomeration.

Social diversity: We employ a measure of social diversity by using an entropy index of the voting behavior on the occasion of the last parliament vote (1998). The measure takes into account all major political parties but also smaller ones. We transform the entropy index to

[0,1] such that 0 indicates maximum and 1 indicates no variety. A positive coefficient would be consistent with the hypothesis that social diversity promotes entrepreneurial opportunities.

Industrial Diversity: The degree to which a region is characterized by a diverse industrial structure is measured by including a Herfindahl index reflecting the composition of economic activity in the region. A positive coefficient on Industrial Diversity would be consistent with the Porter-Jacobs Hypothesis that regional diversity, rather than specialization, generates more spillovers. We take this relationship a step further here, and suggest that as a result of the greater degree of spillovers, more entrepreneurial opportunities will be generated.

6.2.3Results

The results of OLS estimation for regional entrepreneurship rates are presented in Table 2. The first column reports the results estimating general entrepreneurship, the second column for high-technology entrepreneurship, the third column for ICT entrepreneurship, and the last column for low-technology entrepreneurship. Regional growth is found to have a positive and statistically significant impact only on high-technology entrepreneurship. As the negative and statistically significant coefficients for Investment in the second and third columns indicate, holding the level of regional growth constant, increases in investment apparently result in less knowledge-based entrepreneurship. This might suggest that Investment reflects at least some aspect of θ, or the capability of the incumbent firms to pursue and commercialize existing opportunities. In regions with high growth but relatively low investment, knowledge entrepreneurship tends to be higher.

Table 2 Regression Results for Entrepreneurship Rates (OLS)

	Entrepreneurship Rate			
	General	*High-Technology*	*ICT*	*Low-Tech*
Constant	-6.1071***	-10.0216***	-8.6433***	-6.1732***
	(-19.71)	(-22.73)	(-20.53)	(-19.34)
Growth	-0.1334	0.4546*	0.2708	-0.2393
	(-0.72)	(1.73)	(1.08)	(-1.26)
Investment	-0.0013	-0.0027**	-0.0021*	-0.0010
	(-1.43)	(-2.07)	(-1.68)	(-1.06)
Unemployment	-0.0002	-0.0468***	-0.0398***	0.0079
	(-0.04)	(-5.41)	(-4.83)	(1.27)
Agglomeration	0.0001	0.0001***	0.0001***	-6.54e-06
	(0.53)	(4.01)	(3.21)	(-0.19)
Standort Attractiveness	0.1688	-0.0252	0.3044*	0.1503
	(1.38)	(-0.15)	(1.84)	(1.20)
Social Diversity	0.0181	1.3284***	0.4933**	-0.1293
	(0.11)	(5.54)	(2.15)	(-0.74)
Policy	-0.0001	-0.0001	-0.0001***	-0.0001
	(-1.33)	(-1.41)	(-3.22)	(-1.01)
Taxes	0.0007***	0.0005**	0.0006***	0.0007***
	(3.76)	(2.19)	(2.66)	(3.71)
Knowledge	0.4757	8.4073**	5.1599*	-1.1515
	(0.21)	(2.57)	(1.65)	(-0.49)
Human Capital Diversity	0.3229	0.7195	-0.4467	0.2712
	(0.93)	(1.46)	(-0.95)	(0.76)
Industrial Diversity	0.8793***	0.8102***	0.8553***	0.8950***
	(4.64)	(3.01)	(3.32)	(4.59)
R^2	0.3203	0.5341	0.4454	0.2692

The negative and statistically significant coefficients of unemployment on High-Technology Entrepreneurship as well as on ICT Entrepreneurship suggest that regions exhibiting high rates of unemployment are not conducive to generating knowledge entrepreneurship.

Agglomeration, as measured by population density is found to have a positive and statistically significant effect on High-Technology Entrepreneurship and ICT Entrepreneurship, but not on general or Low-Technology Entrepreneurship. There is at least

some evidence suggesting that the attractiveness of the *Standort* will generate more entrepreneurship.

Similarly, there is also at least some evidence suggesting that social diversity is conducive to entrepreneurship, albeit only knowledge-based entrepreneurship. As the positive and statistically significant coefficients indicate, both high-technology and ICT entrepreneurship is greater in regions with a greater degree of social diversity. By contrast, there is no statistical evidence that public policy measures are positively related to entrepreneurial activity.

Taxes are found to have a significant impact on all four types of entrepreneurship measured here. However, the effect is positive, which does not provide evidence that, at least in the context of regional differences in Germany, taxes pose as a barrier to entrepreneurship. One interpretation of the positive sign may be the relatively high level of taxes in every region combined with too little variance in tax rates across regions.

While the diversity of human capital is not found to have a significant impact on entrepreneurship, industry diversity is found to be positively related to entrepreneurship. Those regions with a more diverse composition of economic activity exhibit higher rates of entrepreneurship than do regions that are more specialized. These results hold for general entrepreneurship, high-technology entrepreneurship, ICT entrepreneurship, and Low-Technology Entrepreneurship.

Finally, as the positive and statistically significant coefficients on Knowledge suggest, those regions where there is a greater investment in knowledge, as measured by R&D, also exhibit higher rates of high-technology as well as ICT entrepreneurship. However, no statistically significant relationship can be inferred for the measures of general entrepreneurship and low-technology entrepreneurship. Thus, there is evidence supporting the

Endogenous Entrepreneurship Hypothesis, but the evidence is limited to knowledge spillover entrepreneurship. Of course, it should also be emphasized that it is exactly these results that are implied by the Knowledge Spillover Theory of Entrepreneurship. Only those types of startups using the knowledge produced from the R&D investments by incumbent firms and other organizations would be expected to be endogenously induced. More general entrepreneurship, and low-technology entrepreneurship in particular, should remain unaffected by knowledge spillovers, which is consistent with the findings in Table 5-2.

6.3 Simultaneous Equations Model

The above findings make it clear that the assumption of Entrepreneurship Capital being exogenous is a simplifying assumption at best. In particular, we have already found that entrepreneurial opportunities are created by the context, and in particular, by investments in new knowledge. This would suggest that both Entrepreneurship Capital and economic performance are endogenous and that simultaneous estimation is appropriate. In this section, we therefore combine estimation of regional output, based on estimating the production function model, with estimation of entrepreneurship rates, as was done in the previous section.

If a simultaneous set of equations specifies variables are used as exogenous in one equation and as endogenous in the other equation, the estimation will not be consistent, leading estimates to be biased (e.g. Intriligator et al., 1992 or Greene, 2002). Therefore, we estimate this system of equations with regional output and the entrepreneurship rate as the two dependent variables.

Table 3: Estimating Entrepreneurship and Economic Performance (3SLS)

	Dependent Variable: Regional Output			
Constant	1.0003***	0.5316*	0.645*	1.0061***
	(3.00)	(1.73)	(1.94)	(2.79)
Capital	0.2001***	0.2022***	0.2069***	0.1923***
	(7.07)	(7.69)	(7.76)	(6.52)
Labor	0.7045***	0.6854***	0.6835***	0.7075***
	(18.54)	(20.53)	(20.06)	(17.94)
Knowledge	0.0244**	0.0200*	0.0246**	0.0334***
	(2.29)	(1.73)	(2.13)	(3.27)
General Entrepreneurship	0.5230***			
	(6.84)			
High Tech Entrepreneurship		0.2496***		
		(6.38)		
ICT Entrepreneurship			0.2767***	
			(5.85)	
Low Tech Entrepreneurship				0.5078***
				(6.33)
R^2	0.9336	0.9453	0.9402	0.9326
	Dependent Variable: Entrepreneurship			
	General	*High Technology*	*ICT*	*Low Technology*
Constant	-5.9748***	-9.7557***	-8.6529***	-6.1225***
	(-22.86)	(-25.28)	(-24.13)	(-22.32)
Growth	0.2765*	0.7999***	0.6481***	0.2061
	(1.81)	(3.51)	(3.05)	(1.27)
Investment	-0.0034***	-0.0049***	-0.0047***	-0.0031***
	(-4.28)	(-4.24)	(-4.33)	(-3.78)
Unemployment	0.0010	-0.0320***	-0.0277***	0.0064
	(0.18)	(-4.04)	(-3.72)	(1.15)
Agglomeration	0.00003	0.0002***	0.0001***	0.00001
	(1.05)	(3.98)	(3.38)	(0.40)
Standort Attractivenss	0.0648	-0.0617	0.1759	0.0597
	(0.65)	(-0.42)	(1.27)	(0.57)
Social Diversity	0.0495	1.0475***	0.4013**	-0.0508
	(0.35)	(4.90)	(2.03)	(-0.34)
Policy	-0.00003	-0.00004	-0.0001**	-0.00002
	(-0.83)	(-0.83)	(-2.52)	(-0.62)
Taxes	0.0007***	0.0008***	0.0008***	0.0007***
	(4.30)	(3.78)	(4.05)	(4.02)
Knowledge	0.3293	1.0435***	0.7908***	0.1581
	(1.59)	(3.45)	(2.77)	(0.73)
Human Capital Diversity	0.1264	0.5968	-0.4222	0.0997
	(0.44)	(1.40)	(-1.06)	(0.33)
Industrial Diversity	0.7544***	0.7385***	0.8147***	0.8016***
	(4.98)	(3.36)	(3.94)	(5.02)
R^2	0.3024	0.5248	0.4253	0.2423

Notes: t-statistic in brackets.

* Statistically significant at the two-tailed test for 90% level of confidence
** Statistically significant at the two-tailed test for 95% level of confidence
*** *Statistically significant at the two-tailed test for 99% level of confidence*

The results from endogenous estimation using 3SLS are presented in Table 5-3. Estimating regional output using 3SLS to endogenize entrepreneurship capital leaves the results presented from OLS estimation virtually changed. All of the factors of production, physical capital, labor, knowledge capital, and entrepreneurship capital have a similar impact on regional economic output as was found from OLS estimation. However, it should be emphasized that the estimated coefficients of the four measures of entrepreneurship capital are all considerably higher along with their levels of significance in Table 5-3 than was estimated from OLS estimation. Thus, the impact of entrepreneurship capital on economic performance is even greater, when entrepreneurship is estimated endogenously, instead of under the assumption of exogenous entrepreneurship capital, as was the case for OLS estimation.

The results from 3SLS estimation for the four different measures of entrepreneurship are presented in the bottom part of Table 2.[4] While most of the results are not substantially different from the OLS estimation, one difference should be pointed out. The positive relationship between growth and entrepreneurship, as well as the negative relationship between investment and entrepreneurship, now holds for all of the four measures of entrepreneurship, whereas for the OLS estimation it only held for the two measures of knowledge entrepreneurship, high-technology entrepreneurship and ICT entrepreneurship. The empirical evidence from both estimating entrepreneurship in the context of both OLS as well as 3SLS estimation confirms that entrepreneurial activity tends to be greater in those contexts, i.e. regions, with more knowledge. These findings provide support for the *Endogenous Entrepreneurship Hypothesis*.

[4] Similar results including the East German counties are included in the appendix. Because the data for East Germany is of questionable reliability, the results are presented only for very qualified interpretation.

7. Conclusions

The prevalent and traditional theories of entrepreneurship have typically held the context constant and then examined how characteristics specific to the individual impact the cognitive process inherent in the model of entrepreneurial choice. This often leads to the view that is remarkably analogous to that concerning technical change in the Solow model – given a distribution of personality characteristics, proclivities, preferences and tastes, entrepreneurship is exogenous. One of the great conventional wisdoms in entrepreneurship is "*Entrepreneurs are born not made*". Either you have it or you don't. This leaves virtually no room for policy or for altering what nature has created.

This paper has presented an alternative view. We hold the individual attributes constant and instead focus on variations in the context. In particular, we consider how the knowledge context will impact the cognitive process underlying the entrepreneurial choice model. The result is a theory of endogenous entrepreneurship, where (knowledge) workers respond to opportunities generated by new knowledge by starting a new firm. In this view entrepreneurship is a rationale choice made by economic agents to appropriate the expected value of their endowment of knowledge. Thus, the creation of a new firm is the endogenous response to investments in knowledge that have not been entirely or exhaustively appropriated by the incumbent firm.

In the endogenous theory of entrepreneurship, the spillover of knowledge and the creation of a new, knowledge-based firm are virtually synonymous. Of course, there are many other important mechanisms facilitating the spill over of knowledge that have nothing to do with entrepreneurship, such as the mobility of scientists and workers, and informal networks, linkages and interactions. Similarly, there are certainly new firms started that have nothing to do with the spillover of knowledge. Still, the spillover theory of entrepreneurship suggests that there will be additional entrepreneurial activity as a rationale and cognitive response to

the creation of new knowledge. Those contexts with greater investment in knowledge should also experience a higher degree of entrepreneurship, *ceteris paribus*. Perhaps it is true that entrepreneurs are made. But more of them will discover what they are made of in a high-knowledge context than in an impoverished knowledge context. Thus, we are inclined to restate the conventional wisdom and instead propose that entrepreneurs are not necessarily made, bur are rather a response – and in particular a response to high knowledge contexts that are especially fertile in spawning entrepreneurial opportunities.

By endogenously facilitating the spill over of knowledge created in a different organization and perhaps for a different application, entrepreneurship may serve as *the missing link* to economic growth. Confronted with a formidable *knowledge filter*, public policy instruments emerging from the new growth theory, such as investments in human capital, R&D, and university research may not adequately result in satisfactory economic growth. One interpretation of the *European Paradox*, where such investments in new knowledge have certainly been vigorous and sustained, is that the presence of such an imposing knowledge filter chokes off the commercialization of those new investments, resulting in diminished innovative activity and ultimately stagnant growth.

By serving as a conduit for knowledge spillovers, entrepreneurship is the missing link between investments in new knowledge and economic growth. Thus, the knowledge spillover theory of entrepreneurship provides not just an explanation of why entrepreneurship has become more prevalent as the factor of knowledge has emerged as a crucial source for comparative advantage, but also why entrepreneurship plays a vital role in generating economic growth. Entrepreneurship is an important mechanism permeating the knowledge filter to facilitate the spill over of knowledge and ultimately generate economic growth.

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