
The Theory of Knowledge Spillover 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 constant the external context in which the individual finds herself. Thus, where the opportunities come from, or the source of entrepreneurial opportunities, is also implicitly taken as given. By contrast, in this paper an important source of entrepreneurial opportunities is identified – knowledge and ideas created in an incumbent organization. By commercializing knowledge that otherwise would remain uncommercialized through the start-up of a new venture, entrepreneurship serves as a conduit of knowledge spillovers. According to the theory of knowledge spillover entrepreneurship, a context with more knowledge will generate more entrepreneurial opportunities. By contrast, a context with less knowledge will generate fewer entrepreneurial opportunities. Based on a data set linking entrepreneurship to the knowledge context, empirical evidence is provided that is consistent with the proposition that entrepreneurial opportunities are not exogenous but rather systematically created by investments in knowledge by incumbent organizations.

INTRODUCTION

Both the motivation for, as well as the impact from, entrepreneurship has been a concern of management scholars.^[1] In particular, why is it that some individuals choose to start a new venture, while yet others abstain from entrepreneurial activity?^[2] According to Shane and Venkataraman (2000, p. 218), the field of entrepreneurship is concerned with ‘the sources of opportunities; the process of discovery, evaluation, and exploitation of opportunities; and the set of individuals who discover, evaluate, and exploit them’.^[3] Thus, entrepreneurship scholarship is focused on the recognition of opportunities and the cognitive process of deciding to act upon those opportunities (Venkataraman, 1997).^[4]

In asking the question of why some individuals act entrepreneurially, while others do not, scholars have remained fixated, on the one hand, on taking the existence of

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the entrepreneurial opportunity for granted, while, on the other hand, asking what individual-specific characteristics account for differences in entrepreneurial behaviour across individuals. For example, Krueger (2003, p. 105) concludes that '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?'

Thus, as Plummer et al. (2007) point out, 'a notable lack of research focused on the origins of opportunity'. Rather, the traditional approach to entrepreneurship essentially holds the entrepreneurial opportunity as given and fixed and proceeds to ask how the cognitive process inherent in the entrepreneurial decision varies across different individual characteristics and attributes (McClelland, 1961; Shaver, 2003). As Shane and Eckhardt (2003, p. 187) conclude, entrepreneurship has been primarily concerned with 'the process of opportunity discovery', thereby helping to explain 'why some actors are more likely to discover a given opportunity than others'. The entrepreneurial opportunity itself is taken as given and implicitly fixed, enabling variations in the propensity to become an entrepreneur across people to be explained by individual-specific characteristics, such as the need for autonomy, the willingness to incur risk, as well as a superior access to scarce and costly resources, such as financial capital, human capital and social capital.

While holding the entrepreneurial opportunity implicitly fixed and focusing on differences across individual characteristics has generated a number of valuable insights, such as the importance social networks, education and training, and familial influence (Acs and Audretsch, 2003), Compans and McMullen (2007), warn that, 'Despite the advances and the importance of entrepreneurial opportunities to strategy and entrepreneurship, there have been surprisingly few recent studies that explore the nature of opportunities . . . Currently, scholarly understanding of the origins of entrepreneurial opportunities remains limited owing to the fact that most studies have taken opportunities for granted when exploring strategic and entrepreneurial processes.'

The purpose of this paper is to provide one theory explaining a particular source of entrepreneurial opportunities. Rather than taking the entrepreneurial opportunity as exogenous and given, and then examining how variations across individual attributes shape the cognitive process underlying the decision to become an entrepreneur, this paper instead assumes the individual characteristics to be constant and then analyses how the cognitive process inducing the entrepreneurial decision is influenced by context, and in particular the opportunities for entrepreneurship afforded by the specific context. Thus, the approach and contribution of this paper is to invert the traditional approach prevalent in the entrepreneurship literature by holding the characteristics of the individual constant but allowing the extent of entrepreneurial opportunities to vary systematically.

In particular, the entrepreneurial response to contexts that are rich in knowledge is compared to those with impoverished knowledge contexts. Alvarez (2003), Barney (1986) and Alvarez and Barney (2005, 2007) have provided a compelling theoretical basis suggesting that entrepreneurial opportunities tend to be greater in contexts characterized by a high degree of uncertainty as compared to risk. As we will explain in the second section of this paper, Arrow (1962), among other scholars, clearly identified economic activity based on knowledge as being inherently more uncertain. Thus, linking together the greater degree of uncertainty inherent in knowledge posited by Arrow (1962) with the greater

extent of entrepreneurial opportunities emanating from contexts characterized by high uncertainty by Alvarez (2003) and Alvarez and Barney (2005, 2007), the theory of knowledge spillover entrepreneurship (Acs and Armington, 2006; Acs et al., 2004; Audretsch et al., 2006) posits that those contexts rich in knowledge will inherently be characterized by a greater degree of uncertainty, leading to greater entrepreneurial opportunities. Thus, building on the uncertainty theory of Alvarez (2003) and Alvarez and Barney (2005, 2007), this paper suggests that entrepreneurship is an endogenous response to opportunities generated by investments in new knowledge made by incumbent firms and organizations but which are unable to completely and exhaustively commercialize. 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 uncertainty confronting incumbent firms (Alvarez, 2003; Alvarez and Barney, 2005, 2007), thus leading to incomplete commercialization of the new knowledge.

The next section explains how entrepreneurship combines the cognitive process of recognizing opportunities with pursuing those opportunities by starting a new venture. The third section explains the theory of knowledge spillover entrepreneurship, which links the greater entrepreneurial opportunities under uncertainty as compared to risk identified in Alvarez's (2003) theory of entrepreneurship with the greater degree of uncertainty inherent in knowledge-based economic activity, as identified by Arrow (1962). The fourth section provides an empirical test of the knowledge spillover entrepreneurship theory. Finally, a discussion of the main findings and their implications is provided in the last section. In particular, there is compelling empirical evidence consistent with the proposition that entrepreneurial opportunities are not exogenous but rather endogenously created by contexts rich in knowledge.

ENTREPRENEURSHIP AS OPPORTUNITY RECOGNITION AND NEW VENTURE CREATION

In this paper, entrepreneurship is operationalized according to the definition posited by Gartner and Carter (2003): 'Entrepreneurial behavior 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.' Krueger (2003) accordingly views entrepreneurial thinking and the cognitive process associated with the identification of an opportunity in conjunction with the decision to engage in entrepreneurial action. As Companys and McMullen (2007) point out, 'An *entrepreneurial* opportunity is more accurately described as an opportunity to engage in entrepreneurial action, in which entrepreneurial denotes a sub-class of some broader category of human action.'

The focal point of entrepreneurship research has been on the cognitive process by which the individual discovers a given entrepreneurial opportunity, combined with the decision to act on that opportunity. The existence of a perceived entrepreneurial opportunity and the intent to act on that opportunity triggers entrepreneurship. According to Companys and McMullen (2007), 'Opportunities then become the Where and When of entrepreneurial action – i.e., a situation in which one can attempt to profit by creating new goods or services.'

Most of the research examining why the propensity for entrepreneurship varies across people has focused on differences across individuals, and in particular, characteristics specific to those individuals. For example, personal attitudes and attributes such as self efficacy (the individual's sense of competence), collective efficacy, prior experience and social norms have all been found to influence the ability of an individual to perceive an entrepreneurial opportunity and then subsequently to act upon that opportunity (Shane, 2000). Similarly, Shane and Eckhardt (2003) show how the cognitive process in reaching the entrepreneurial decision is influenced by a differential access to information sources across individuals. In particular, heterogeneous access to information, along with differences in cognitive abilities, psychological differences, and access to financial and social capital all serve to explain why entrepreneurial activity varies across individuals. However, the entrepreneurial opportunity itself is implicitly assumed to be exogenously given and therefore implicitly constant across individuals.

Empirical studies examining why entrepreneurship varies across individuals also implicitly assume the entrepreneurial opportunity to be exogenous and therefore constant. For example, the Panel Study of Entrepreneurial Dynamics (PSED) provides longitudinal observations on individuals that were considering becoming entrepreneurs (Reynolds, 2007). The PSED has generated a number of studies enabling scholars to link characteristics specific to the individual, such as financial resources in the form of household income and wealth, and human capital, in the form of education, prior work experience, entrepreneurial experience, and influence from family and friends, to the decision to start a new business.

Thus, the tradition in the entrepreneurship literature has been to take the entrepreneurial opportunity as exogenous, and then to link entrepreneurial activity to characteristics specific to the individual. However, virtually nothing is learned about where the entrepreneurial opportunity comes from in the first place, leading the reader with the uneasy feeling that entrepreneurial opportunities are simply ubiquitous and unbounded. Such a conclusion seemingly implies that variations in the likelihood of becoming an entrepreneur are attributable solely to differences in the propensities, proclivities, and inclinations of individuals. However, McMullen et al. (2007) warn against such a conclusion: 'For management scholars and economists alike a lack of clarity regarding entrepreneurial opportunity presents a significant theoretical dilemma. Specifically, without a clear understanding of the nature of opportunity, formulating logically consistent prescriptions for both policy and practice is problematic.' Thus, in the next section, a theory is introduced explicitly identifying where (at least some) entrepreneurial opportunities come from and why they may be systematically different for different individuals.

THE THEORY OF KNOWLEDGE SPILLOVER ENTREPRENEURSHIP

The entrepreneurship literature has generally focused on the key role played by the ability of the individual to discover exogenously given entrepreneurial opportunities and then to act upon them through undertaking entrepreneurial activity. Thus, variation in the observed propensity for entrepreneurship across people has generally been attributable to differences in measurable characteristics specific to individuals and not to any differences in the entrepreneurially opportunities available to individuals. That is,

virtually nothing is known about the actual *source* of such entrepreneurial opportunities, that is where entrepreneurial opportunities come from, and how and why entrepreneurial opportunities might vary systematically across individuals.

The theory of knowledge spillover entrepreneurship posits one source of entrepreneurial opportunities – new knowledge and ideas (Acs and Armington, 2006; Acs et al., 2004; Audretsch et al., 2006). According to the theory of knowledge spillover entrepreneurship, ideas and knowledge created in one organizational context such as a firm or university research laboratory, but left uncommercialized as a result of the uncertainty inherent in knowledge, serve as a source of knowledge generating entrepreneurial opportunities. In this paper we refer to this knowledge source as being characterized by *incomplete commercialization* in incumbent organizations. When such incomplete commercialized knowledge in incumbent organizations serves as the basis for the entrepreneurial opportunity, the actual entrepreneurial activity, that is the start-up of a new venture, provides the conduit for the spillover of knowledge from the source organization creating that knowledge to the new, entrepreneurial organization (venture) actually exploiting and commercializing that knowledge. Thus, just as the incomplete knowledge generated in an incumbent organization generates the entrepreneurial opportunity, the entrepreneurial activity provides, in turn, the conduit facilitating the spillover and commercialization of that knowledge.

Knowledge

In his path-breaking paper, Arrow (1962) pointed out that knowledge was distinct from the traditional factors, or resources, available for economic activity, in that it is characterized by two fundamental conditions. The first involves non-excludability, or the inability to exclude others from accessing and using that knowledge. The second involves the non-exhaustibility of knowledge. Use of ideas by one party does not preclude others from using that same knowledge. An important implication of Arrow's propositions concerning knowledge was pointed out by Griliches (1992) – that in contrast to investments in traditional resources, such as physical capital, investments in knowledge have a high propensity to spill over for commercialization by third-party firms which do not pay for the full cost of accessing and implementing those ideas. Thus, a crucial distinction between the firm resource of knowledge and the more traditional resources is the high propensity for knowledge to spill over.

The preoccupation with the non-excludability and non-exhaustibility of knowledge first identified by Arrow (1962), which Griliches (1992) and others identified as resulting in knowledge spillovers, neglects another key insight in the original Arrow (1962) article. Arrow (1962) also identified another dimension by which knowledge differs from the traditional factors of production. This other dimension involves the greater degree of *uncertainty* and larger extent of *asymmetries*, and greater *cost of transacting* new ideas. First, the outcome associated with any new idea is more highly uncertain than would be associated with the deployment of traditional resources for firms, such as physical capital. 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 (1962) 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.

Thus, an important implication emanating from Arrow's (1962) paper is that as knowledge becomes more important as a source of competitive advantage, the degree of uncertainty involving economic activity also increases. However, as the next sub-sections suggest, the organizational form of economic activity is not neutral with respect to a greater degree of uncertainty. Rather, as Alvarez (2003) and Alvarez and Barney (2005, 2007) suggest, as the extent of uncertainty increases, the organizational form of entrepreneurship tends to gain the competitive advantage. This is because some of the opportunities generated by new knowledge manifest themselves in the form of entrepreneurial opportunities in that they are rejected and not perceived and pursued as opportunities by incumbent firms.

Uncertainty

In developing the uncertainty theory of entrepreneurship, Alvarez (2003) makes a sharp distinction between uncertainty and risk. Risk is calculable, and an expected value can be imputed for a distribution of outcomes. By contrast, under uncertainty, no such distribution of outcomes or expected value can be calculated. As Alvarez (2003) and Alvarez and Barney (2005, 2007) emphasize, a high level of uncertainty makes it difficult, if not impossible, for firms to assign an expected value to various outcomes. According to Alvarez, decision making under uncertainty is more likely to trigger entrepreneurship in the form of creating a new organization or firm. While decision making under risk enables the incumbent firm to calculate expected outcomes along with a probability distribution associated with those outcomes, decision-making under uncertainty more typically is associated with organizational inertia. Confronted with uncertainty, decision-making hierarchies tend towards maintaining the status quo rather than choosing to act upon new ideas for which no expected value and commensurate probability distribution corresponding to possible outcomes can be calculated.

The inertia inherent in decision-making under uncertainty within incumbent organizations reflects what has been termed as the knowledge filter (Acs et al., 2004; Audretsch et al., 2006). Because new ideas and knowledge are characterized by uncertainty, they may not be pursued and will remain uncommercialized by incumbent firms. The knowledge filter is a consequence of the basic conditions inherent in new knowledge.

Knowledge Spillovers as Entrepreneurial Opportunities

As Alvarez (2003) and Alvarez and Barney (2005, 2007) emphasize, it is the uncertainty inherent in new ideas and knowledge that creates opportunities for entrepreneurship. If the incumbent organization making the investments to create new ideas and knowledge chooses not to commercialize those ideas, an opportunity is created for someone to start a new firm in order to commercialize that knowledge. According to the theory of knowledge spillover entrepreneurship, opportunities for entrepreneurship are the duality of the knowledge filter. The greater 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 and commercialized by incumbent firms. That is, not only do investments in knowledge generate new opportunities, but because of the knowledge filter, some subset of these opportunities constitute entrepreneurial opportunities. Thus, the source of the knowledge and ideas and the organization actually making (at least some of) the investments to produce that knowledge may not be the same as the organization actually attempting to commercialize and appropriate the value of that knowledge (e.g. the new venture). 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 venture is a mechanism for knowledge spillovers. The act of founding a new venture to commercialize knowledge generated in an incumbent organization serves as a conduit for the spillover of knowledge.

This discrepancy between the organization *creating* opportunities and the new venture actually *exploiting* the opportunities was pointed out by Audretsch (1995), who introduced the knowledge spillover theory of entrepreneurship. In posing the question, 'How are these small and frequently new firms able to generate innovative output when undertaken a generally negligible amount of investment into knowledge-generating inputs, such as R&D? One answer is apparently through exploiting knowledge created by expenditures on research in universities and on R&D in large corporations', he concludes that these 'findings challenge an assumption implicit to the knowledge production function – that firms exist exogenously and then endogenously seek out and apply knowledge inputs to generate innovative output . . . It is the knowledge in the possession of economic agents that is exogenous, and in an effort to appropriate the returns from that knowledge, the spillover of knowledge from its producing entity involves endogenously creating a new firm' (Audretsch, 1995, pp. 179–80).

The empirical evidence supporting the theory of knowledge spillover entrepreneurship was provided by analysing how different industries reflecting different underlying knowledge contexts impacted entrepreneurial activity in that industry, as reflected by new-firm start-ups. The empirical results provided compelling evidence suggesting that entrepreneurial activity was systematically greater in those industries with a greater investment in new knowledge, but lower in industries with low investments in knowledge.

Thus, compelling evidence was provided suggesting that entrepreneurship is an endogenous response to opportunities created but not exploited by the incumbent firms, which we refer to in this paper as incomplete commercialization. This involved an organizational dimension involving the mechanism transmitting knowledge spillovers, the start-up of a new venture.

Knowledge Spillover Entrepreneurship

In the lens provided by the theory of knowledge spillover entrepreneurship, the knowledge filter will impede and pre-empt at least some of the knowledge from being completely commercialized, which in turn generates entrepreneurial opportunities. An important implication is that entrepreneurial opportunities will be systematically greater

in those contexts characterized by more knowledge. By contrast, entrepreneurial opportunities will be systematically lower in those contexts characterized by less knowledge. This would suggest that for any particular context, observing a high rate of entrepreneurial activity may not necessarily reflect an underlying population of people who are inherently different in their attitudes, capabilities and proclivities towards entrepreneurship than are their counterparts in contexts exhibiting less entrepreneurial activity. Rather, the greater extent of entrepreneurial activity in the former context may reflect a higher prevalence of entrepreneurial opportunities generated by an abundance of knowledge. Thus, the main proposition to emerge from the theory of knowledge spillover entrepreneurship is:

Knowledge Spillover Entrepreneurship Proposition: Contexts rich in knowledge should generate more entrepreneurship, reflecting more extensive entrepreneurial opportunities. By contrast, contexts impoverished in knowledge should generate less entrepreneurship, reflecting less extensive entrepreneurial opportunities.

EMPIRICAL EVIDENCE

The Spatial Context

In this section, empirical evidence is provided in support of the knowledge spillover entrepreneurship proposition. This test is made by linking the knowledge investments within a spatial context, that is a region, to the start-up activity associated with that region.

Combining the insight of Arrow (1962) that knowledge is characterized by a greater degree of uncertainty with that of Alvarez (2003) and Alvarez and Barney (2005, 2007), that greater uncertainty tends to bestow the competitive advantage to new ventures, leads to the central proposition emanating from the theory of knowledge spillover of entrepreneurship, that contexts richer in knowledge investment will generate more entrepreneurial activity than those contexts that are poor in knowledge. But which type or dimension of context is most relevant to testing this proposition?

One insight is provided by Jaffe (1989) and Audretsch and Feldman (1996), who found that knowledge spillovers tend to be spatially bounded within close geographical proximity to the source of that knowledge. Since we have just identified one such mechanism by which knowledge spillovers are transmitted, the start-up of a new venture, it follows that knowledge spillover entrepreneurship is also spatially bounded in that local access is required to access the knowledge facilitating the entrepreneurial start-up. Thus, one important way to test the knowledge spillover entrepreneurship proposition is by linking measures of entrepreneurial activity to knowledge investments within the context afforded by geography corresponding to the dimension found to spatially bound knowledge spillovers – regions.

Measurement and Model Specification

The dependent variable is entrepreneurial activity, which is measured by the start-up rate, and is defined and measured the number of start-ups divided by the population

in each German region between 1998 and 2000.^[5] To test the knowledge spillover entrepreneurship proposition, four alternative measures of entrepreneurship are used. These four different measures allow for variation in the scope of what is included in the definition and measure of entrepreneurial activity. The first measure includes new-firm start-ups in all industries and is therefore the more general. The second measure includes only new-firm start-ups in high-technology industries, which are defined as having a mean R&D-sales ratio exceeding 2.5 per cent.^[6] The third measure includes only new-firm start-ups in the ICT-industries, which includes both manufacturing and service industries. Finally, the fourth measure includes new-firm start-ups in low-tech industries. It should be emphasized that the label of 'low-tech' refers to the degree of R&D intensity of the industry and not to the capabilities or extent of human capital of the founder(s).

The theory of knowledge spillover entrepreneurship does not imply that knowledge spillovers, alone, are the only factor influencing the extent of entrepreneurial activity in a region. Rather, the traditional factors that both are conducive to as well as impede regional entrepreneurship need to be controlled for. In fact, considerable insight has been made identifying factors influencing regional entrepreneurial activity.

A rich literature has accumulated linking start-up rates to regional-specific characteristics, such as growth, population density, unemployment, and the skill levels of the labour force. The empirical evidence accumulated from this literature has generally found a positive impact on entrepreneurial activity by population density, growth, skill and human capital levels of the labour force. The empirical evidence concerning the relationship between unemployment rates and start-up activity is considerably more ambiguous (Reynolds et al., 1994; Storey, 1991).

Entrepreneurial activity has been found to be greater in regions with higher growth than in those with less growth. In the model tested in this study, regional growth is measured as the percentage change in regional gross domestic product between 1992 and 2000. A positive regression coefficient would suggest that entrepreneurship is enhanced in higher growth regions. The regional rates of unemployment are also included in the estimation model. However, as Storey (1991) concludes, a vast literature has identified an ambiguous relationship between unemployment and entrepreneurship, which has been interpreted to reflect the contradictory impacts of lower opportunity costs associated with entrepreneurship by the unemployed on the one hand, but the reduced entrepreneurial opportunities on the other hand in regions with high unemployment.

Jacobs (1979) has argued that the degree of diversity in the workforce is an important source of entrepreneurship. People with different backgrounds and experiences will tend to evaluate any given set of information differently. Thus, entrepreneurial activity should be greater in regions with a more diverse population, since more entrepreneurial opportunities would be expected to be identified as a result of diversity. One aspect of diversity is reflected by social diversity, which is measured by an entropy index of the voting behaviour on the occasion of the 1998 parliament election. The entropy index is normalized to range between zero and one, where zero indicates the absence of diversity and one indicates the maximum extent of diversity. The extent of human capital diversity is measured by constructing a Herfindahl index for the share of three different levels of

vocational education – no formal vocational education, high level of vocational education (college degree or master craftsmanship), or intermediate level (neither of the other two categories).

Spatial agglomerations facilitate the flow of ideas (Audretsch and Stephan, 1996; Feldman and Audretsch, 1999). Hence, entrepreneurial activity should be greater in agglomerations, or more densely populated regions, than in less agglomerated regions. The provision of ancillary services and inputs is also greater in agglomerated regions. The extent of regional agglomeration is measured by the regional population density. A positive coefficient would reflect a positive relationship between the extent to which a region is agglomerated and entrepreneurial activity. Regions that are attractive to people may also be more conducive to entrepreneurial activity. However, while controlling for locational attractiveness may be important, measurement is anything but obvious. Locational attractiveness is measured by the number of hotel beds in the region relative to the total surface area. A positive relationship between locational attractiveness and entrepreneurship is expected.

To these different control measures, a variable reflecting the regional knowledge context is also included. The amount of investment in knowledge in the region is measured by R&D intensity, or the share of the regional labour force accounted for by scientists and engineers. According to the *Knowledge Spillover Entrepreneurship Proposition*, those geographical contexts, or regions, which are rich in knowledge, should generate more entrepreneurial opportunities, and therefore exhibit higher rates of observed entrepreneurship. By contrast, those geographical contexts, or regions, which are poor in knowledge, will generate fewer entrepreneurial opportunities, and therefore should exhibit lower rates of observed entrepreneurship.

Results

The knowledge spillover entrepreneurship proposition is tested by linking knowledge within the spatial context of the region to entrepreneurship using OLS estimation for regional entrepreneurship rates. The empirical results are presented in Table I. The results estimating general entrepreneurship are presented in the first column, high-technology entrepreneurship in the second column, ICT entrepreneurship in the third column, and low-technology entrepreneurship in the fourth column.

As the positive and statistically significant coefficients on knowledge suggest, those regions which are rich in knowledge also exhibit higher rates of both high-technology and ICT entrepreneurship. Thus, there is evidence supporting the *Knowledge Spillover Entrepreneurship Proposition*, but the evidence is limited to knowledge-based entrepreneurship. In fact, no statistically significant relationship can be inferred for the measures of general entrepreneurship and low-technology entrepreneurship. Of course, it should also be emphasized that it is exactly these results that are implied by the theory of knowledge spillover entrepreneurship. Only those types of new ventures based on knowledge and ideas generated in the organizational context of an existing incumbent firm or other organization would be expected to be endogenously induced. More general new ventures, and low-technology new ventures in particular, would not be expected to be influenced by potential knowledge spillovers, which is consistent with the findings in Table I.

Table I. Regression results for entrepreneurship (OLS)

	<i>General</i>	<i>High-technology</i>	<i>ICT</i>	<i>Low-technology</i>
Regional growth	2.631*** (2.83)	0.388*** (3.99)	0.170 (1.58)	2.073** (2.54)
Knowledge	1.828 (0.21)	4.359*** (4.84)	4.313*** (4.32)	-6.845 (-0.90)
Unemployment	-0.003 (-0.13)	-0.034*** (-11.89)	-0.034*** (-10.90)	0.065*** (2.71)
Agglomeration	6.874*** (2.80)	1.447*** (5.64)	1.138*** (4.00)	4.290** (1.99)
Location attractiveness	1.787 (1.61)	0.099 (0.85)	0.285** (2.22)	1.402 (1.44)
Social diversity	-0.807 (-0.66)	-0.792*** (-6.22)	-0.116 (-0.82)	0.100 (0.09)
Skill diversity	8.931*** (6.71)	0.855*** (6.15)	0.968*** (6.28)	7.109*** (6.08)
Constant	-3.921* (-1.81)	0.242 (1.07)	-0.308 (-1.23)	-3.855** (-2.03)
R ²	0.2490	0.5256	0.5221	0.2052

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.

As for the control variables, regional growth is found to have a positive and statistically significant impact, with the exception of ICT entrepreneurship. 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 spillover entrepreneurship. By contrast, the positive and statistically significant coefficient on low-technology entrepreneurship suggests that unemployment has a positive impact on low-technology entrepreneurship.

Agglomeration, as measured by population density, is found to have a positive and statistically significant effect on all four of the measures of entrepreneurship. There is at least some evidence suggesting that the attractiveness of a location will generate more entrepreneurship.

There is also at least some evidence suggesting that social diversity is conducive to entrepreneurship, albeit only high-technology entrepreneurship. Finally, the diversity of human capital, as measured by labour skills, is found to have a significant impact on all four measures of entrepreneurship.

DISCUSSION

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 considerable insights into why entrepreneurial behaviour varies across individuals. In particular, the literature has focused on variations of individual-specific characteristics to explain why some individuals become entrepreneurs, 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, is also implicitly taken as given.

This paper has posited a theory suggesting a key source of entrepreneurial opportunities – knowledge created in an incumbent firm or organization but not completely or exhaustively commercialized by that organization. In particular, the theory of knowledge spillover entrepreneurship suggests that knowledge and new ideas created but not completely or exhaustively commercialized by incumbent firms and organizations provide an important source of entrepreneurial opportunities.

Based on a data set linking entrepreneurial activity to the extent of knowledge within the spatial context of geographical regions, higher knowledge contexts are found to generate more entrepreneurial opportunities, where the new venture serves as a conduit for knowledge spillovers. By contrast, lower knowledge contexts are found to generate fewer entrepreneurial opportunities. Thus, the empirical evidence is consistent with the proposition that entrepreneurial opportunities are not exogenous but rather systematically created by investments in knowledge by incumbent organizations.

NOTES

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- [1] Examples of how this concern for entrepreneurship has been manifested within the various scholarly disciplines are included in Acs and Audretsch (2003).
- [2] Link and Herbert (2007) identify three distinct scholarly traditions that form the intellectual basis of the modern entrepreneurship literature. The German Tradition is based on von Thuenen and Schumpeter, the Chicago Tradition is based on Knight and Schultz, and the Austrian Tradition is based on von Mises, Kirzner and Shackle.
- [3] According to Shane and Venkataraman (2000), entrepreneurial opportunities involve the discovery of new means–ends relationships in which resources are combined to generate economic value that otherwise would not have existed.
- [4] According to Sarasvathy et al. (2003, p. 142), ‘An entrepreneurial 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.’
- [5] The data on start-ups are provided by the ZEW (Mannheim) foundation panels. This database was created from biannual observations by *Creditreform*, which is analogous to Dun and Bradstreet and ranks among the largest German credit-rating agencies. Virtually all businesses are included in the database, including start-ups, in the German Trade Register.
- [6] The classification provided by the Federal Ministry of Education and Research is followed.

REFERENCES

- Acs, Z. J. and Armington, C. (2006). *Entrepreneurship, Agglomeration and US Regional Growth*. Cambridge: Cambridge University Press.
- Acs, Z. J. and Audretsch, D. B. (Eds) (2003). *Handbook of Entrepreneurship Research*. New York: Springer.
- Acs, Z. J., Audretsch, D. B., Braunerhjelm, P. and Carlsson, B. (2004). *The Missing Link: The Knowledge Filter and Entrepreneurship in Endogenous Growth*. Centre for Economic Policy Research (CEPR) Discussion Paper. London: Centre for Economic Policy Research.

- Alvarez, S. A. (2003). 'Resources and hierarchies: intersections between entrepreneurship and business strategy'. In Acs, Z. J. and Audretsch, D. B. (Eds), *Handbook of Entrepreneurship Research*. New York: Springer, 247–66.
- Alvarez, S. A. and Barney, J. B. (2005). 'How do entrepreneurs organize under conditions of uncertainty?'. *Journal of Management*, **31**, 776–93.
- Alvarez, S. A. and Barney, J. B. (2007). 'Guest editors' introduction: The entrepreneurial theory of the firm'. *Journal of Management Studies*, **44**, 1057–63.
- Arrow, K. J. (1962). 'Economic welfare and the allocation of resources for invention'. In Nelson, R. R. (Ed.), *The Rate and Direction of Inventive Activity*. Princeton, NJ: Princeton University Press, 609–26.
- Audretsch, D. B. (1995). *Innovation and Industry Evolution*. Cambridge, MA: MIT Press.
- Audretsch, D. B. and Feldman, M. P. (1996). 'R&D spillovers and the geography of innovation and production'. *American Economic Review*, **86**, 630–40.
- Audretsch, D. B. and Stephan, P. E. (1996). 'Company-scientist locational links: the case of biotechnology'. *American Economic Review*, **86**, 641–52.
- Audretsch, D. B., Keilbach, M. and Lehmann, E. (2006). *Entrepreneurship and Economic Growth*. New York: Oxford University Press.
- Barney, J. E. (1986). 'Strategic factor markets: expectations, luck and business strategy'. *Management Science*, **42**, 1231–41.
- Compans, Y. R. and McMullen, J. S. (2007). 'Strategic entrepreneurs at work: the nature, discovery, and exploitation of entrepreneurial opportunities'. *Small Business Economics*, **28**, 302–22.
- Feldman, M. and Audretsch, D. (1999). 'Innovation in cities: science-based diversity, specialization and localized competition'. *European Economic Review*, **43**, 409–29.
- Gartner, W. B. and Carter, N. M. (2003). 'Entrepreneurial behaviour and firm organizing processes'. In Acs, Z. J. and Audretsch, D. B. (Eds), *Handbook of Entrepreneurship Research*. New York: Springer, 195–222.
- Griliches, Z. (1992). 'The search for R&D spillovers'. *Scandinavian Journal of Economics*, **94**, 29–47.
- Jacobs, J. (1979). *The Economy of Cities*. New York: Vintage Books.
- Jaffe, A. B. (1989). 'Real effects of academic research'. *American Economic Review*, **79**, 957–70.
- Krueger, N. F. Jr (2003). 'The cognitive psychology of entrepreneurship'. In Acs, Z. J. and Audretsch, D. B. (Eds), *Handbook of Entrepreneurship Research*. New York: Springer, 105–40.
- Link, A. and Hebert, R. F. (2007). 'Historical perspectives on the entrepreneur'. *Foundations and Trends in Entrepreneurship*, **2**, 4, 1–86.
- McClelland, D. (1961). *The Achieving Society*. New York: Free Press.
- McMullen, J. S., Plummer, L. A. and Acs, Z. J. (2007). 'What is an entrepreneurial opportunity?'. *Small Business Economics*, **28**, 273–83.
- Plummer, L. A., Haynie, J. M. and Godesiabois, J. (2007). 'An essay on the origins of entrepreneurial opportunity'. *Small Business Economics*, **28**, 363–9.
- Reynolds, P. (2007). 'Firm creation in the United States: a PSID I overview'. *Foundations and Trends in Entrepreneurship*, **3**, 1–164.
- Reynolds, P., Storey, D. J. and Westhead, P. (1994). 'Cross-national comparisons of the variation in new firm formation rates'. *Regional Studies*, **28**, 443–56.
- Sarasvathy, S. D., Dew, N. S., Velamuri, R. and Venkataraman, S. (2003). 'Three views of entrepreneurial opportunity'. In Acs, Z. J. and Audretsch, D. B. (Eds), *Handbook of Entrepreneurship Research*. New York: Springer, 141–60.
- Shane, S. (2000). 'Prior knowledge and the discovery of entrepreneurial opportunities'. *Organizational Science*, **11**, 448–69.
- Shane, S. and Eckhardt, J. (2003). 'The individual-opportunity nexus'. In Acs, Z. J. and Audretsch, D. B. (Eds), *Handbook of Entrepreneurship Research*. New York: Springer, 161–94.
- Shane, S. and Venkataraman, S. (2000). 'The promise of entrepreneurship as a field of research'. *Academy of Management Review*, **25**, 218–28.
- Shaver, K. G. (2003). 'The social psychology of entrepreneurial behaviour'. In Acs, Z. J. and Audretsch, D. B. (Eds), *Handbook of Entrepreneurship Research*. New York: Springer, 331–58.
- Storey, D. J. (1991). 'The birth of new firms – does unemployment make a difference? A review of the evidence'. *Small Business Economics*, **3**, 167–78.
- Venkataraman, S. (1997). 'The distinctive domain of entrepreneurship research'. In Katz, J. and Brockhaus, R. (Eds), *Advance in Entrepreneurship, Firm Emergence, and Growth*. Greenwich, CT: JAI Press, 119–38.