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The Knowledge Spillover Theory of Entrepreneurship

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Abstract

Contemporary theories of entrepreneurship generally focus on the decision-making context of the individual. The recognition of opportunities and the decision to commercialize them is the focal concern. While the prevalent view in the entrepreneurship literature is that opportunities are exogenous, the most prevalent theory of innovation in the economics literature suggests that opportunities are endogenous. This paper bridges the gap between the entrepreneurship and economic literature on opportunity by developing a knowledge spillover theory of entrepreneurship. The basic argument is that knowledge created endogenously via R&D results in knowledge spillovers. Such spillovers give rise to opportunities to be identified and exploited by entrepreneurs. Our results show that there is a strong relationship between knowledge spillovers and new venture creation.

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Introduction

The field of entrepreneurship has been defined as the study of "how, by whom and with what consequences opportunities to produce future goods and services are discovered, evaluated and exploited" (Shane and Venkataraman, 2000). However, it can be argued that research has focused on discovery, exploitation, and their consequences without much attention to the nature and sources of opportunity itself. While some researchers argue that the subjectivity or socially constructed nature of opportunity makes it impossible to separate it from the individual, others contend opportunity is an objective construct visible only to the knowledgeable and attuned individuals. In either case, a set of weakly held assumptions appear to dominate this debate leaving the fundamental nature of opportunity vague and unresolved (Acs and Audretsch, 2005).

Schumpeter, like others, did not believe that the entrepreneur had to worry about where opportunities come from. But for the study of entrepreneurship as a field, the question where opportunities come from is central. While a generation of scholars spent the better part of a half-century trying to figure out the relationship among the entrepreneur, product development and technological innovation (Shane and Ulrich, 2004), a new generation of scholars was able to explain where opportunity themselves came from. Today we know that the technology opportunity set is endogenously created by investments in knowledge (Jones, 2002). However, not only does new knowledge contribute to technological opportunity, but it also spills over for use by third party firms, often-new ventures (Azoulay and Shane, 2001 and Archibald, Thomas Betts and Johnston, 2002).

The purpose of this paper is to propose and test a new theory of entrepreneurship that bridges the gap between the entrepreneurship and economic literature on opportunity by developing a knowledge spillover theory of entrepreneurship. The creation of new

knowledge gives rise to new opportunities; therefore, entrepreneurial activity does not involve simply the arbitrage of opportunities but also the exploitation of new ideas not appropriated by incumbent firms (Kirzner, 1973). The theory builds on the work of the early Schumpeter (1911 [1934]) who recognized the importance of the entrepreneur in exploiting opportunities but did not pay attention to where opportunities come from. Romer (1986) recognized and modeled the importance of technology and knowledge spillovers. This Romerian insight cast the early Schumpeter in a new light by raising two questions: first, Where do opportunities come from? And second, How are they discovered and exploited?

The paper is organized as follows. In the next section we discuss the nature of the individual opportunity nexus. In the third section we examine the question, Where do opportunities come from. There are many theories of entrepreneurship but none that focus on the role of knowledge and knowledge spillovers as an explanation of opportunity. We explore several prevailing theories of entrepreneurship and the evidence that supports them. We then present our own knowledge spillover theory of entrepreneurship and test an empirical model over the period 1981-2000. Our empirical results show that entrepreneurial activity is strongly influenced by knowledge spillovers from incumbent firms. An implication of our analysis is that it is important to understand what it is that gives rise to new opportunities for entrepreneurs.

The Individual-Opportunity Nexus

The Shane and Venkataraman (2000) interpretation of the field of entrepreneurship focuses on the discovery of opportunities and subsequent exploitation of such opportunities by individuals. However, just because opportunities exist does not mean that everyone perceives them. Only individuals with appropriate qualities will perceive them. In this framework,

entrepreneurial activity depends upon the interaction between the characteristics of opportunity and the characteristics of the people who exploit them.

The most common theories of entrepreneurship view entrepreneurial activity as arising from either differences among individuals in attitudes toward risk (Knight, 1921) or differences in individual capabilities (Carroll and Hannan, 2000). There has been a long tradition of work seeking to determine what makes entrepreneurs distinctive. McClellan (1961), a psychologist, examined the motivation of people who act in entrepreneurial ways, whether they are starting new ventures or are within established organizations. The stream of research that examines characteristics of entrepreneurs has sometimes been described as "traits" research. Often utilizing demographic and work experience data, it has compared particular groups of entrepreneurs with each other or with the larger population. However, this kind of research has come under sharp criticism. Gartner (1988) argued that the focus should be upon behavior, not traits.

Indeed, the field of entrepreneurship has moved away from the "traits and characteristics" type of studies that sought to answer the question, "Who is the Entrepreneur?" This research succeeded only in showing that the variance between entrepreneurs is as high as the variance between entrepreneurs and non-entrepreneurs (Gartner, 1989). The new cognition research is not about traits and characteristics (which are fixed and deterministic), but focuses on the mental thought processes that entrepreneurs engage in to discover, evaluate, and exploit opportunities, which are not fixed and may be taught. Since discovery is a cognitive process, it takes place at the individual level (Audretsch, 1995). Individuals, whether they are working in an existing organization or are retired or unemployed at the time of their discovery, are the entities that discover opportunities. The organizations that employ people are inanimate and cannot engage in *discovery*. Therefore, any explanation for the mode of opportunity exploitation must be based on choices made by individuals about how

they would like to exploit the opportunity that they have discovered. The collective process is meaningful only in discussions of execution, and exploitation, *but not in the discovery process itself* (Shane, 2003).

In this framework, entrepreneurial activity depends upon the interaction between the characteristics of opportunity and the characteristics of the people who exploit them (Casson, 2005). The idea that opportunities are objective but the perception of opportunities is subjective has a long history in the theory of entrepreneurship. It is stated most clearly in Hayek (1937). Knight (1921) expressed the same idea in somewhat different language when he introduced his distinction between risk, which is objective, and uncertainty, which is subjective, and identified uncertainty-bearing as the economic function of the entrepreneur. Knight identified the entrepreneur as a recipient of pure profit. Profit is the residual income available after all contractual payments have been deducted from the revenues of the enterprise. It is the reward to the entrepreneur for bearing the costs of uncertainty. Knight identified uncertainty with a situation where the probabilities of alternative outcomes cannot be determined either by a priori reasoning or by statistical inferences. Knight was mainly concerned to show how markets, together with institutions such as the large corporation, contribute to specializing uncertainty bearing in the hands of those best equipped to make decisions under uncertainty. The main quality required for making production decisions is foresight. Individuals differ in the amount of foresight they have, and competition ensures that individuals with the greatest degree of foresight specialize in making production decisions.

A modern synthesis of the entrepreneur is someone who specializes in taking judgmental decisions about the coordination of scarce resources (Casson, 1982). In this definition, the term “someone” emphasizes that the entrepreneur is an individual. Here it is the individual and not the firm that is the basic unit of analysis. Judgmental decisions are

decisions for which no obvious correct procedure exists – a judgmental decision cannot be made simply by plugging available numbers into a scientific formula and acting on the basis of the number that comes out. Therefore, the modern theory of entrepreneurship is that opportunities are real and independent of the entrepreneurs that perceive them. For example, Shane and Venkataraman (2000), along with Casson (2003), define entrepreneurial opportunities as the discovery of novel means-ends relationships, through which new goods, services, resources and agency are created. However, the causes generating opportunities need to be explained. As Companys writes, "By employing the opportunity construct, scholars have made enormous contributions to the study of strategic management and entrepreneurship. Unfortunately, the opportunity construct that scholars have used in their research remains poorly understood. By explaining how scholars have addressed these questions, one may be able to show the progress that has been made in explaining the opportunity construct and the enormous work still left to do by scholars in this area, as the source of such entrepreneurial opportunities has been largely neglected or overlooked" (Companys, 2005).

Where Do Opportunities Come From?

In this section we examine existing schools of entrepreneurship with respect to their perspective on the existence of opportunity. We review the literature on entrepreneurship from the perspective of the market process theory of Hayek and Kirzner, the innovation theory of Schumpeter, and the transaction cost economics of Williamson. A fundamental question is, "If opportunities are objective, where do they come from?" When studying the literature on entrepreneurship it turns out that this is a good way to identify implicit but fundamental differences among theories.

The Austrian School: Arbitrage

The Austrian School's main contribution to the theory of the entrepreneur is to point out that the absence of entrepreneurs in neoclassical economics is intimately associated with the assumption of market equilibrium. According to Hayek, the empirical content of economics relates to the process of adjustment toward equilibrium. This process involves the acquisition and communication of knowledge. Hayek visualizes a world in which there is a continuous process of discovery – not usually major discoveries but mostly minor discoveries about individual wants at particular times and places. But Hayek stops short of modeling the process by which prices are set and by which they are adjusted toward equilibrium.

For Kirzner the adjustment of prices is the main role of the entrepreneur. If the wrong price prevails in the market, then an opportunity for profit exists. If differentiated prices prevail in the same market, there is scope for profitable arbitrage between the segments of the market. Accordingly, alertness to disequilibrium is the distinguishing characteristic of the entrepreneur. Alertness enables some individuals to intervene in the market by changing the price while other individuals simply respond by changing their buying and selling plans. Thus, the main function of the entrepreneur is to serve as an arbitrageur who equilibrates markets. For the Austrians, therefore, the primary role of economic theory is to explain behavior in terms of purposeful human action, and to consider to what extent purposeful human action can interact to produce unexpected outcomes.

The theory assumes that since the market is always in disequilibrium, opportunities are always objective and always available. As far as economic growth is concerned, for the Austrians entrepreneurship will lead to greater economic welfare as entrepreneurs adjust prices. However, Austrian theory says very little about where opportunities come from that are of a more technical nature. As far as technical knowledge is concerned, the Austrian

approach suggests that entrepreneurs merely discover knowledge rather than creating new opportunities.

Schumpeter: Innovation

Schumpeter, perhaps more than any other writer, is explicit about the economic function of the entrepreneur. The entrepreneur is the prime mover in economic development, and his function is to innovate, or to carry out new combinations. Anyone who performs this function is an entrepreneur, whether they are independent or dependent employees of a company. Schumpeter is adamant that the entrepreneur is not a risk bearer. Risk bearing is the function of the capitalist who lends his funds to the entrepreneur.

The climate most favorable to innovation is when the economy is approaching equilibrium, for then the future seems relatively easy to foresee. The first innovations, made by the most talented entrepreneurs, prove successful, and this encourages less talented entrepreneurs to follow suit. Because they are adapting ideas that the pioneers have already tried out, the risks that the capitalists perceive in backing the less talented entrepreneurs are relatively low. A wave of innovation follows which then, for a variety of reasons, quickly recedes. Schumpeter, like Knight, believed that talented entrepreneurs were scarce. Their scarcity lies not so much in their alertness or in their professionalism as in their psychology.

Schumpeter, while clearly interested in innovation, believed that the creation of opportunity is not the domain of the entrepreneur. Therefore, he is silent on the question of where opportunities come from. As pointed out by Nelson (1992, 90):

> In his *Theory of Economic Development*, Schumpeter is curiously uninterested in where the basic ideas for innovations, be they technological or organizational, come from. Schumpeter does not view the entrepreneur as having anything to do with their generation:

> "It is not part of his function to "find" or "create" new possibilities. They are always present, abundantly accumulated by all sorts of people. Often they are generally known and being discussed by scientific or literary writers. In other cases there is nothing to discuss about them, because they are quite obvious" (Schumpeter, 1911 [1934], 88).

In this sense Schumpeter is unlike Schmookler who believed, based on case studies, that entrepreneurs create opportunities rather than merely discover promising opportunities. Thus, like the other views of entrepreneurship, the Schumpeterian perspective takes opportunities as exogenous.

Transaction Cost Economics

If agents who discover promising opportunities and invest in R&D create opportunities, then it might be worthwhile to examine theories of the firm. One of the most prevalent theories in the field of strategy is transaction cost economics (Williamson (1975). However, one of the weaknesses of transaction cost economics is that its emphasis is on a static comparative analysis and on identifying generalized boundary conditions that exist between firms and markets. In fact, transaction cost theories of the firm have traditionally been more effective at explaining the scope of manufacturing firms than service or knowledge firms such as R&D or consulting firms (Liebeskind (1996), and transaction cost theory has evolved to more of a theory of contracts than a theory of the firm (Joskow; 1987). In fact, Williamson (1985) argued that innovation is more likely to occur in smaller firms, while larger firms are more effective at manufacturing and distribution of innovations. Acs and Audretsch (1987) found that in industries that are innovative, small firms appear to have an advantage, while in capital-intensive industries large firms have an advantage. The implications of this argument have not been addressed in the strategy literature.

Resource-Based View of the Firm

Strategy researchers have become increasingly aware of the importance of heterogeneous firm assets in achieving a firm's sustainable competitive advantage (Barney, 1986). The resource-based view of the firm was the first to recognize the importance of tacit socially complex assets. Paradoxically, while the importance of resource heterogeneity among firms has been acknowledged, strategists have given scant attention to the process by which these resources are discovered, turned from inputs into heterogeneous outputs and exploited to extract greater profits. Entrepreneurship should inform strategic management about the process of how resources are discovered and recombined to provide more complex unique resources that lead to sustained competitive advantage (Alvarez, 2003).

Resource-based logic identifies the kinds of resources and capabilities that require specific investment in order for their full economic value to be realized – resources and capabilities that are socially complex, path dependent, and tacit (Barney, 1995). Thus, when the realization of the economic values associated with an entrepreneurial opportunity depends on the use of socially complex, path dependent or tacit resources and capabilities, it is more likely that hierarchical governance – a firm – will be used to realize this value than non-hierarchical governance (Alvarez, 2003, p. 258).

Thus, transaction cost theories and resource-based theories of the firm recognize the importance of firms as well as the importance of heterogeneous firm-specific knowledge for competitive advantage, while the Austrian school and Schumpeter focus on the individual entrepreneur. In the next section we link entrepreneurial opportunity to knowledge creation by incumbent firms.

Knowledge as a Source of Entrepreneurial Opportunity

While the prevalent view in the entrepreneurship literature is that opportunities are exogenous, the most prevalent theory of innovation in the economics literature suggests that opportunities are, in fact endogenous. The model of the knowledge production function, formalized by Zvi Griliches (1979), assumes that firms exist exogenously and then engage in the pursuit of new economic knowledge as an input into the process of generating endogenous innovative activity. Thus, according to this strand of literature opportunities are not exogenous. Rather, entrepreneurial opportunities are created endogenously; they are more prevalent in some industries than in others. They operate more strongly in some parts of the economy than others and so there are particular characteristics that tend to be associated with locations – such as high tech industries – where opportunities are found. High-technology opportunity is more, not less, prevalent than low-technology opportunity. Most innovations take place in high technology opportunity industries and not in low technology opportunity industries (Scherer, 1965; Geroski, 1989; Audretsch, 1995). The extent to which the results of innovation can be appropriated by incumbent firms also varies among industries.

One way to reconcile the difference in the view of opportunities between literatures of entrepreneurship and the economics of innovation is the unit of analysis. While the entrepreneurship literature focuses on the individual as the decision-making unit of analysis, the literature on the economics of innovation focuses on the firm as the decision-making unit of analysis.

The starting point for the most prevalent theory of innovation is at the level of the firm. In such theories the firm is viewed as being exogenous and its performance in generating technological change is endogenous. The most decisive input in the knowledge production

function is new economic knowledge. As Cohen and Klepper concluded, the greatest source generating new economic knowledge is generally considered to be R&D (Cohen and Klepper, 1991 and 1992.

Thus, while the entrepreneurship literature considers opportunity to exist exogenously, in the economics literature opportunities are systematically and endogenously created through the purposeful investment in new knowledge. The former focuses on the cognitive context of the individual while the latter is concerned with the decision-making of the firm. This provides at least some reconciliation between the two different views.

The technology opportunity set consists of all the technological possibilities that have been currently identified (Weiss, 1965). Investment in new knowledge increases the technology opportunity set and sharpens our ability to gaze into the future (Cohen and Levinthal, 1989). It is here that the entrepreneur resides, and where individuals play a crucial role. As G.L.S. Shackle wrote, "The entrepreneur is a maker of history, but his guide in making it is his judgment of possibilities and not a calculation of certainties" (Acs and Audretsch, 2003).

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 also emphasized that knowledge is characterized by a greater degree of uncertainty and asymmetry than are 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 its development and commercialization, other economic agents, either within or outside of the firm, may instead assign a higher expected value to 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 to new firm formation (Shane 2001a and 2001b).

Such entrepreneurial opportunities should be greater in contexts where new knowledge plays a greater role, since this would increase the degree of uncertainty and asymmetries involved in making decisions, and therefore, ceteris paribus, induce a higher propensity for economic agents to start new firms in order to appropriate the value of their (potential) economic knowledge. An important contribution of Zvi Griliches (1986) in formalizing what he termed the knowledge production model of innovation is that knowledge inputs are required to generate innovative output. Subsequent research (Jaffe, 1989) demonstrated that not only do such investments in knowledge lead to innovative output in the firm making those knowledge investments, but knowledge also spills over and generates innovative output in third-party firms.

Since, as the studies measuring knowledge spillovers show, knowledge spillovers tend to be greater in the presence of higher investments in knowledge, it follows that entrepreneurial opportunities based on exploiting such knowledge spillovers will also be greater in the presence of knowledge investments. The knowledge spillover theory of entrepreneurship 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. In a low knowledge context, the lack of new ideas will not generate entrepreneurial opportunities based on potential knowledge spillovers. By contrast, in a high knowledge context, new ideas will generate entrepreneurial opportunities by exploiting (potential) spillovers of that knowledge.

The knowledge spillover theory of entrepreneurship

The degree to which economic agents recognize entrepreneurial opportunities emanating from knowledge spillovers and the decision to commercialize them through the startup of a new firm is captured by the equation reflecting occupational (or entrepreneurial) choice,

(1) $E = \gamma(\pi^* - w)$

where E reflects the decision to become an entrepreneur (generally stated in terms of probabilities), π^* is the profits expected to be earned from entering into entrepreneurship, w is the wage that would be earned from employment in an incumbent enterprise and γ represents all other variables that influence entrepreneurship (Parker, 2004; Evans and Jovanovic, 1989).

Since the expected profit opportunities accruing from entrepreneurship are the result of knowledge not commercialized by the incumbent firms, entrepreneurial opportunities will be shaped by the magnitude of new knowledge but constrained by the commercialization capabilities of incumbent firms.[2] Knowledge opportunities can be expressed as K^{θ}, where K is the aggregate stock of knowledge and θ $(0 < \theta < 1)$ refers to the share of knowledge not exploited by incumbents,

[2] Since we are not interested in arbitrage, prices can be viewed as constant, e.g. monopolistic competition leads to equalize prices on differentiated products within an industry.

(2) $E = \gamma(\pi^*(K^\theta) - w)$.

The opportunity space for potential entrepreneurs is thus dependent on the efficiency of incumbents in exploiting new knowledge who are assumed incapable of fully exhausting the opportunities provided by new knowledge.

Equation (2) implicitly assumes away any institutional or individual barriers to entrepreneurship. Yet, as a rich literature suggests (Parker, 2004), there is a compelling array of financial, institutional, and individual barriers to entrepreneurship, which result in a modification of the entrepreneurial choice equation,

(3) $E = \gamma \ (\pi^*(K^\theta) - w)/\beta$

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. While we do not explicitly specify these specific entrepreneurial barriers, we note that they span a broad spectrum of institutional and individual characteristics, which, when taken together, constitute barriers to entrepreneurship. The existence of such barriers, i.e., a high value of β, explains why economic agents would choose not to enter into entrepreneurship, even when confronted with knowledge that would otherwise generate a potentially profitable opportunity.

Based on this simple model, originating in standard assumptions applied in microeconomics, we present the following three propositions, given that the entrepreneurial activity exceeds zero:

Proposition 1: An increase in the stock of knowledge has a positive effect on the degree of entrepreneurship. The extent of the impact is however determined by the efficiency of incumbents to exploit knowledge: the more efficient incumbents are, the smaller is θ and the smaller the effect of new knowledge on entrepreneurship.

Proof: From equation 3 taking the partial derivative of entrepreneurship with respect to knowledge yields

(4) $$E_K = 1/\beta(\theta K^{\theta-1})\gamma > 0, \quad E_{KK} = 1/\beta(\theta^2 - \theta)K^{\theta-2}\gamma < 0,$$

implying that an increase in the stock of knowledge (K) positively affects entrepreneurship, albeit at a decreasing rate, as suggested by the second derivative. Hence, there are diminishing returns to scale in knowledge with respect to entrepreneurial activity.

Proposition 2: Entrepreneurial activities are decreasing in higher regulations, administrative barriers and governmental market intervention.

Proof: The impact of such barriers to entrepreneurship – increasing β - can be derived in the following way,

(5) $$E_\beta = -1/\beta^2(\pi^*(K^\alpha/\theta) - w)\gamma < 0, \quad E_{\beta\beta} > 0,$$

i.e., given that entrepreneurial activity exceeds zero, an increase in β has a negative effect on entrepreneurship. In addition, the second derivative reveals a convex association between the extent of such barriers and the level of entrepreneurship, i.e. increasing barriers will deter entrepreneurship at an increasing rate.

Proposition 3: A higher wage level can be expected to monotonically reduce entrepreneurship.

Proof: The partial derivatives with respect to the wage level imply a monotonically negative effect on entrepreneurship in this simple model according to equation 3,

(6) $$E_w = -(1/\beta)\gamma < 0, \quad E_{ww} = 0 .$$

Hence, our model explains entrepreneurship as a function of the following factors: the knowledge stock (K) and the efficiency of incumbents to exploit knowledge which both influence the knowledge opportunity space, the barriers to entry captured by β, and the level of wages w,

(7) $$E = f(K, \theta, \beta, w) .$$

An Empirical Test of the Knowledge Based Entrepreneurship Model

The aim of the empirical section is thus to test the theory in the previous section. In particular, we will examine whether there is statistical evidence to support the allegation that higher levels of investment in knowledge, after controlling for the other key factors, result in a greater degree of entrepreneurial activity (Acs et al, 2004).

Entrepreneurship is influenced by culture, traditions, institutions, i.e. more or less non-measurable factors, together with strictly economic factors that are more easily identified. "Inherited" and persistent customs and legal frameworks drive the first set of factors, often

quite different across countries. To capture these differences we estimate the following equation using a fixed effect panel regression technique,[3]

$$ENT_{j,t} = \alpha_j + \alpha_1 KSTOCK_{j,t} + \alpha_2 BARR_{j,t} + \alpha_3 WAGE + \alpha_4 INC_{j,t} + \alpha_5 Z_{j,t} + \varepsilon_{j,t} \quad (8)$$

where *j* denotes country, *t* represents time and the error term is expected to exhibit standard properties; that is, $\varepsilon_{j,t}$ is assumed to be independently and identically distributed with a zero mean and variance σ^2 for all *j* and *t*.

The dependent variable – entrepreneurship (ENT) - is approximated by a country's share of self-employed as a percentage of the labor force.[4] This is the best available measure that can be implemented in a cross-country analysis and serves as an acceptable approximation for entrepreneurship.

Turning to the explanatory variables, our main focus in explaining entrepreneurship is on knowledge endowment within an economy. It is defined as a stock measure, where the flows of R&D in each country - assumed to depreciate at the rate of ten percent per annum - have been accumulated to obtain knowledge stocks (KSTOCK). In accordance with the theoretical framework outlined above, we expect an increase in the relative knowledge endowment to increase the profitability of entrepreneurial activity by facilitating the recognition of entrepreneurial opportunities. The knowledge variable is normalized by GDP.

We use two variables to capture the extent of barriers to entry in an economy: First we incorporate public expenditure in relation to GDP (GEXP) as an approximation of the total tax pressure and the extent to which an economy is subjected to regulations that stem from

[3] The choice of empirical model is based on an F-test to check the validity of using a fixed effect regression technique as compared to OLS. The test clearly rejects the null hypotheses of all fixed effects jointly being zero.

[4] The agricultural sector has been excluded.

governmental interventions into the economy. Second, as an alternative we include the tax share in GDP, both individual (TAXPERS) and corporate (TAXCORP). If incentive structures are distorted through high taxes, entrepreneurial start-ups are less likely to occur (Kirzner 1997; Fölster, 1998). For these reasons we expect these variables to be negatively associated with the level of entrepreneurship.

For the individual the wage level represents the opportunity cost of starting a new venture. A higher level of wages implies a smaller relative reward of starting a new firm, presumably deterring entrepreneurial activities.[5] Thus, we expect a negative sign. The wage variable (WAGE) is defined as the annual average wage at the economy level.[6]

The most intricate and difficult variable to model empirically is incumbents' exploitation of the knowledge stock. There are no data that directly measure such exploitation. However, we use two variables that are important indicators of the extent to which incumbents draw on an economy's knowledge stock. The first is the number of patents (PATENTS) in relation to population where we claim that a higher proportion implies that incumbents use more of the existing knowledge stock. The second approximation refers to the level of value added produced in an economy, lagged one year (LVA). The argument is that a higher level of value-added can be interpreted as a more extensive exploitation of the knowledge base, assuming that value-added is positively associated with the knowledge content of production. Both of these variables are assumed to influence entrepreneurship negatively.

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[5] We have also included the interest rate within the respective economy as an approximation for the level of profits in one of the regressions, where the underlying argument is that profits on average over time should approach the return to other assets. Still, the role of entrepreneurs is not consistent with that view since entrepreneurs are expected to identify opportunities that generate profits above the average level.

[6] We have also tried trade unionization within countries as an institutional variable, capturing labor market rigidities and more general obstacles for entrepreneurs. However, the trade union variable did not affect the results and were non-significant in most regressions and was therefore excluded from the empirical results reported here.

In addition to the above variables, which closely relate to our model, we also insert a number of control variables where previous research has shown an influence on entrepreneurship. First, part of public sector expenditure is devoted to education, and education has been shown to be positively associated with entrepreneurship. Our education variable is defined as public expenditure on education (EDU) in relation to GDP.[7] A more educated population should be more able to identify entrepreneurial opportunities, suggesting a positive relationship to entrepreneurship. Still, it is conceivable that the effect of education may go either way. In the technology-based sector it should have a positive effect, but in less skill-intensive activities it is likely to have a negative impact. The more advanced, high technology sectors are generally small even in developed countries. Moreover, institutional factors may affect the distribution of more educated people across sectors and occupations.

Another variable assumed to influence entrepreneurship is GDP growth. Higher growth is linked to increased market opportunities. Therefore, we control for growth, defined as a five-year moving average (GROWTH) in order to smooth out business fluctuations. Higher growth rates are expected to positively impact profit opportunities, reduce risks and enhance the propensity for individuals to engage in entrepreneurial activities.

Numerous studies also claim that urban environments are particularly conducive to entrepreneurial activities, innovation and growth (Acs and Armington, 2004). Information flows are much denser in cities, different competencies and financial resources are more accessible, and proximity to the market is obvious. All of these features work to widen the opportunity set in urban regions. We therefore include a variable that captures the share of a country's population that lives in urbanized regions (URBAN). We expect a higher degree of urbanization to be reflected in higher entrepreneurial activities.

[7] The level of education is probably a relatively poor indicator of human capital. The reason is that we lack information on quality of education.

Similarly, studies using demographic variables conclude that individuals in the age cohort 30 to 44 are most likely to undertake entrepreneurial activities (REFERENCE). To account for this, we regress the share of the population in the age cohort (AGE) 30 to 44 on self-employed. A large share of the population belonging to that age cohort is expected to relate positively to the share of entrepreneurs within an economy. Finally, time-specific effects are controlled for by implementing a time dummy for the 1980s (DUMMY-80).

All the regressions are based on data comprising 17 countries over the period 1981 to 1998. The data sources stem predominantly from the OECD but also other sources will be used (see Table 1). Only developed countries are included in our sample.[8] Table 2 summarizes some statistics of the variables used in the empirical analysis.

Regression results

The regression results estimating the entrepreneurship rate, ENT, are presented in Tables 3 and 4. Table 3 spans the entire time period, 1981-1998, and Table 4 includes only 1990-1998. The 1990s represent a period of increased technological change and entrepreneurial activity as argued by Jorgenson (2004). As the positive and statistically significant coefficients of the knowledge stock suggest, entrepreneurial activity tends to be greater in those countries where knowledge is more prevalent. These results are certainly consistent with the knowledge spillover theory of entrepreneurship. Entrepreneurial opportunities do not appear to be exogenous but rather systematically created by a high presence of knowledge.

There is also at least some evidence that a larger presence of the government, as measured in terms of public expenditures, serves as a barrier to entrepreneurship. Similarly, while the negative and statistically significant coefficient of the personal tax rate indicates that

[8] The following countries are included in the analysis: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Japan, Netherlands, New Zealand, Norway, Spain, Sweden, U.K. and the U.S. For some variables where missing values appear we have used the closest year available.

personal taxes pose a barrier to entrepreneurship, the positive and statistically significant coefficient of the corporate tax rate may actually indicate that a higher rate of corporate taxes reduces the propensity for incumbent firms to appropriate the returns from opportunities, thereby generating more entrepreneurial opportunities.

The coefficients of the wage rate are positive and statistically significant for the entire period in Table 3, suggesting that higher wages do not serve to deter the decision to become an entrepreneur. However, the signs of the coefficients of the wage rate actually reverse in Table 4, which might indicate that in the 1990s entrepreneurial higher wage levels in fact reduced activity. This is likely to reflect two forces: first, for already employed individuals the alternative costs of starting a new venture increase, and, second, high wages may be interpreted by potential entrepreneurs as an obstacle to future expansion of the firm.

Regarding both the levels of value-added and patent activity, the results indicate that extensive knowledge exploitation by incumbents is negatively related to the degree of entrepreneurial activity. Hence, to the degree that the incumbent firms can take advantage of opportunities, there will be less entrepreneurial activity. By contrast, both expenditures on education and economic growth are positively related to entrepreneurship. There is little evidence linking the degree of urbanization to entrepreneurial activity, but demographics, as represented by the share of the population accounted for by people between 30 and 44 does have a significant impact on entrepreneurship. The rate of interest is not significantly related to entrepreneurial activity.

Thus, the empirical findings that entrepreneurship tends to be systematically greater in the presence of knowledge are strikingly robust. While the significance and even sign of some of the control variables are more sensitive to the time period and the specification, entrepreneurial activity is found to respond positively to economic knowledge regardless of the specification and time period estimated.

Conclusions

The field of entrepreneurship has been defined as the study of how, by whom and with what consequences opportunities to produce future goods and services are discovered, evaluated and exploited. However, it can be argued that entrepreneurship research has focused on discovery, exploitation, and their consequences without much attention to the nature and sources of opportunity itself. The most common theories of entrepreneurship view entrepreneurial activity as arising from either differences among individuals in attitudes toward risk or differences in individual capabilities. This paper has developed a knowledge spillover theory of entrepreneurship in which the creation of new knowledge expands the technological opportunity set. Therefore, entrepreneurial activity does not involve simply the arbitrage of opportunities, but the exploitation of new ideas not appropriated by incumbent firms.

The model suggests that the stock of knowledge yields knowledge spillovers and that there is a strong relationship between such spillovers and entrepreneurial activity. If incumbent firms appropriated all the results of R&D, there would be no knowledge spillover. The fact that there is a positive relationship between investments in R&D and entrepreneurship indicates that at least some portion of these investments spill over to new entrants. This provides at least one explanation for what gives rise to new business opportunities.

Our results show that there is a strongly positive relationship between entrepreneurship and the stock of knowledge, and that the relationship remains strong when we control for institutional, market, and individual factors. When we restrict the regressions to the 1990s, the knowledge stock variable becomes more significant and the wage variable becomes negative and statistically significant as suggested by the theory. These results are

consistent with the increasing importance of entrepreneurship, knowledge creation, and knowledge spillovers in the 1990s.

There are several implications of these findings for management. First, these results help us sort out theories of entrepreneurship. Entrepreneurship theories need to be able to explain where opportunities come from, how knowledge spillovers occur and how occupational choice arises in existing corporations that lead to new firm formation. Prevailing theories of the firm are not able to answer these questions. Second, more micro-economic studies are required to fully understand the channels and mechanisms through which knowledge spillovers occur from corporate R&D as well as from academic research, and to measure spillovers more directly.

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Table 1. Definition of variables and data source.

Variable	Definition	Sources
ENT	Dependent variable. Non-agricultural self-employed, as percentage of total non-agricultural employment.	OECD, Statistical Compendium via Internet 2003-10-09 (Labour Market Statistics).
KSTOCK	Gross domestic expenditure on R&D as percentage of GDP. Each new year add its value to the existing stock. The depreciation rate is 10 percent, so that after 10 years the input value does no longer impact the stock. All values in constant 1995 prices and PPP.	OECD, Statistical Compendium via Internet 2004-10-29 (GDP data: National Accounts vol 1. R&D data: Research and Development Statistics).
GEXP	Government expenditures as percentage of GDP.	OECD, Statistical Compendium via Internet 2004-03-04 (Historical Statistics).
TAXPERS	Taxes on personal income, as percentage of GDP.	OECD, Statistical Compendium via Internet 2004-09-22 (OECD Revenue Statistics).
TAXCORP	Taxes on coporate income, as percentage of GDP.	OECD, Statistical Compendium via Internet 2004-09-22 (OECD Revenue Statistics).
WAGE	Mean wage rates in the total economy at constant 1995 prices and PPP (U.S. Dollars), divided by 1000. Wage rates are wages and salaries including employees' social security contributions per employee.	OECD, Statistical Compendium via Internet 2004-11-15 (OECD Labour market statistics).
LVA	Value added (volume, 1995=100) for the whole economy, values lagged one year.	OECD, Statistical Compendium via Internet 2005-03-29 (OECD STAN Data Base).
PATENT	The number of EPO patent applications (by date of grant) per 10 000 inhabitants.	OECD, Data base via Internet 2004-09-20. (Technology and Patents Data base).
EDSPEND	Public spending on education, as percentage of GDP.	World Bank (2002), World Development Indicators CD-ROM. Washington: World Bank.
GROWTH	Five year moving average of gross domestic product growth (at the price levels and PPPs of 1995). Values in yearly differences.	OECD, Statistical Compendium via Internet 2003-10-09 (National Accounts vol1, and own calculations).
URBAN	The share of the total population living in urban areas.	World Bank (2002), World Development Indicators CD-ROM. Washington: World Bank.
AGE	Share of population between 30 and 44 years of age.	UN (1997), The Sex and Age Distribution of the World Populations. New York: United Nations.
INTEREST	Short-term interest rate, in percent.	OECD, Statistical Compendium via Internet 2005-03-24 (OECD Business Sector Data Base).
DUMMY-90	Time dummy that assumes the value one if year>1989 and zero otherwise.	Own calculations.

Table 2a. Statistics of variables

	ENT			KSTOCK			GEXP			TAXPERS		
Country	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Australia	11.7	12.5	13.5	.9	5.7	7.7	34.5	37.5	40.0	11.2	12.5	14.0
Austria	6.0	7.0	8.6	1.1	6.2	9.1	52.1	54.6	57.9	8.0	9.3	10.4
Belgium	11.6	13.0	14.1	1.4	7.4	10.0	49.4	55.3	63.7	13.3	14.7	16.4
Canada	6.5	8.0	10.0	1.2	6.8	8.9	41.2	46.8	53.3	11.1	13.0	14.8
Denmark	6.3	7.1	8.5	1.1	6.9	10.8	53.7	57.9	61.7	22.9	25.1	26.8
Finland	6.0	8.7	10.3	1.2	8.7	14.9	42.3	51.8	64.4	14.1	16.1	18.4
France	8.0	9.2	10.2	2.0	10.0	12.4	49.4	52.8	55.5	4.5	5.6	8.2
Germany	7.0	8.5	9.4	2.2	10.6	12.6	44.0	47.5	50.3	8.9	9.8	10.6
Ireland	9.7	12.4	14.0	.7	3.7	5.4	31.9	44.8	54.5	8.9	10.6	12.9
Japan	9.4	11.4	13.6	2.3	12.1	15.6	30.5	33.7	38.6	4.9	6.5	8.1
Netherlands	7.7	8.7	10.0	1.8	8.7	10.4	45.3	53.8	59.9	6.2	8.8	11.8
New Zealand	8.9	15.0	16.8	1.0	4.1	5.4	36.1	39.5	45.2	14.2	16.9	20.1
Norway	4.8	6.1	7.8	1.2	6.8	8.5	43.5	50.3	56.3	9.7	10.8	12.1
Spain	16.1	17.8	18.8	.4	3.1	4.4	36.9	42.4	49.4	4.9	6.8	8.1
Sweden	4.2	7.1	9.3	2.2	13.2	18.8	56.9	62.9	73.0	16.2	18.1	20.3
U.K.	8.0	11.0	12.4	2.4	9.3	11.4	37.0	43.5	47.8	8.7	10.0	11.3
U.S.	6.6	7.4	8.0	2.3	11.3	13.8	33.6	35.9	38.0	9.5	10.5	12.6

Table 2b. Statistics of variables, continued.

	TAXCORP			WAGE			LVA			PATENT		
Country	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Australia	2.5	3.8	6.5	24552	26635	30657	61.9	86.9	108.1	.01	.06	.10
Austria	1.2	1.6	3.1	19152	21856	24261	69.1	88.6	103.6	.07	.40	.73
Belgium	2.0	2.8	3.9	23846	26224	29023	75.4	90.8	104.2	.05	.25	.45
Canada	1.8	2.8	4.0	26462	27964	30658	69.5	90.7	105.7	.01	.07	.14
Denmark	1.1	2.1	3.1	22543	24797	27333	77.2	93.4	105.2	.02	.26	.57
Finland	.2	2.3	5.6	16055	19867	22690	76.1	97.0	110.5	.01	.26	.64
France	1.9	2.3	3.4	21176	22151	23787	73.8	92.3	102.6	.08	.42	.62
Germany	.6	1.6	2.1	21757	23198	25094	70.6	88.6	103.1	.24	.80	1.18
Ireland	1.1	2.3	3.8	22013	26057	29817				.01	.06	.14
Japan	3.4	5.1	7.3	22708	24877	26211	61.0	86.8	105.5	.01	.37	.79
Netherlands	2.5	3.4	4.4	25484	27464	29128	71.8	90.7	106.8	.07	.47	.73
New Zealand	1.9	3.2	4.4	18649	19081	20055	71.5	89.8	105.4	.02	.04	.06
Norway	2.2	4.8	9.4	19381	21345	25064	63.3	87.0	110.5	.01	.14	.31
Spain	1.1	2.1	3.0	17296	18436	19574	70.8	91.0	105.6	.00	.02	.04
Sweden	1.4	2.3	3.9	16607	18772	22376	76.0	93.0	104.5	.04	.54	.78
U.K.	2.4	3.7	4.8	17978	21854	25554	68.5	89.9	106.3	.04	.25	.39
U.S.	1.5	2.2	2.7	26692	28996	33625	65.0	89.0	108.2	.03	.22	.38

Table 2c. Statistics of variables, continued.

	EDSPEND			GROWTH			URBAN			AGE		
Country	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Australia	4.5	5.1	5.4	-.0084	.0008	.0160	84.69	85.13	85.70	20.0	22.1	23.4
Austria	5.3	5.6	6.3	-.0098	.0000	.0076	64.30	64.56	64.86	19.8	21.3	23.5
Belgium	3.0	4.9	6.0	-.0114	.0006	.0088	95.52	96.41	97.18	19.0	21.3	23.2
Canada	5.6	6.5	7.3	-.0092	.0012	.0143	75.80	76.47	76.93	20.2	23.3	25.7
Denmark	6.6	7.3	8.2	-.0067	.0007	.0121	83.82	84.63	85.10	21.1	21.9	22.4
Finland	4.9	6.0	7.7	-.0174	.0003	.0205	59.80	61.96	66.14	21.8	23.2	24.7
France	5.2	5.6	5.9	-.0110	.0004	.0085	73.38	74.14	75.24	19.1	21.1	22.4
Germany	4.5	4.7	4.7	-.0096	.0003	.0070	82.89	85.10	87.10	20.1	21.5	23.6
Ireland	4.5	5.2	6.2	-.0075	.0039	.0153	55.50	56.96	58.56	16.5	18.5	19.9
Japan	3.4	4.3	5.7	-.0121	-.0015	.0084	76.30	77.35	78.52	19.9	22.5	24.1
Netherlands	4.9	5.8	7.2	-.0046	.0014	.0069	88.42	88.72	89.24	20.8	22.8	24.1
New Zealand	4.4	6.0	7.3	-.0120	.0002	.0129	83.48	84.73	86.50	18.9	21.0	22.4
Norway	5.8	6.9	8.1	-.0099	-.0000	.0088	70.66	72.34	74.78	18.8	20.9	22.1
Spain	2.3	3.8	4.7	-.0122	.0016	.0107	73.08	75.21	77.16	18.2	19.6	21.7
Sweden	6.3	7.5	8.6	-.0100	.0008	.0109	83.10	83.11	83.22	20.1	20.9	22.2
U.K.	4.6	5.1	5.6	-.0106	.0010	.0114	88.82	89.06	89.38	19.3	20.5	21.6
U.S.	4.8	5.4	6.6	-.0077	.0010	.0108	73.89	75.22	76.76	19.2	22.4	24.6

Table 2d. Statistics of variables, continued.

	INTEREST		
Country	Min	Mean	Max
Australia	5.00	11.10	17.69
Austria	3.73	6.37	11.36
Belgium	3.21	8.25	15.27
Canada	3.53	8.63	18.33
Denmark	3.67	9.46	16.76
Finland	3.23	10.16	16.50
France	3.46	8.86	15.25
Germany	3.31	6.27	12.11
Ireland	5.41	10.30	16.32
Japan	.59	4.53	7.72
Netherlands	2.99	6.37	11.60
New Zealand	6.33	12.76	23.31
Norway	3.73	10.45	15.36
Spain	4.24	12.31	20.05
Sweden	4.11	9.89	14.17
U.K.	5.49	9.86	14.76
U.S.	3.24	7.67	16.82

Table 3. Regression results, fixed effect panel regressions, 1981-1998.

Dependent variable: ENT	Reg 1	Reg 2	Reg 3	Reg 4	Reg 5
KSTOCK	.08**	.05*	.07*	.14***	.14***
	(2.32)	(1.79)	(1.85)	(3.91)	(3.21)
GEXP	-.06***		-.06**	-.06**	-.06**
	(-2.61)		(-2.61)	(-2.45)	(2.45)
TAXPERS		-.23***			
		(-3.90)			
TAXCORP		.31***			
		(4.16)			
WAGE	.16**	.18***	.19***	.25***	.17***
	(2.47)	(3.21)	(2.89)	(3.55)	(2.64)
LVA				-.06***	
				(-4.55)	
PATENT					-1.76**
					(-2.23)
EDSPEND	.36***	.33***	.37***	.29**	.29**
	(2.82)	(3.21)	(2.92)	(2.33)	(2.20)
GROWTH	34.59***	26.10***	37.39***	16.63	36.02***
	(3.40)	(2.79)	(3.52)	(1.48)	(3.56)
URBAN	.02	.01	.07	.14	.08
	(.19)	(.14)	(.72)	(1.45)	(.86)
AGE	.16***	.20***	.18***	.22***	.11**
	(3.14)	(4.19)	(3.42)	(4.17)	(1.96)
INTEREST				0.03	
				(1.14)	
DUMMY-90	-.42**	-.51***	-.43**	.13	-.24
	(-2.08)	(-2.71)	(-2.17)	(.55)	(-1.15)
Constant	1.94	.15	3.05	-6.07	-1.87
	(.29)	(.02)	(-.42)	(-.84)	(-.27)
R^2	.24	.31	.24	.25	.25
F	10.16	13.08	9.16	9.21	9.72
No. of obs.	289	291	288	271	289

Note: t-statistics in parentheses. *, ** and *** denote the significance at the 10, 5 and 1 percent level, respectively.

Table 4.
Regression results, fixed effect panel regressions,1990 – 1998.

Dependent variable: ENT	Reg 1	Reg 2	Reg 3	Reg 4	Reg 5
KSTOCK	.44***	.30***	.40****	.53***	.45***
	(4.43)	(3.25)	(3.54)	(5.15)	(4.41)
GEXP	-.05**		-.04*	-.07***	-.04*
	(-2.11)		(-1.91)	(-3.02)	(-1.96)
TAXPERS		-.18***			
		(-3.68)			
TAXCORP		.32***			
		(3.96)			
WAGE	-.11*	-.07	-.12**	-.08	-.10*
	(-1.88)	(-1.24)	(-2.01)	(-1.11)	(-1.76)
LVA				-.02	
				(-1.24)	
PATENT					-.31
					(-.45)
EDSPEND	-.12	-.01	-.11	-.17	-.13
	(-1.03)	(-.09)	(-1.00)	(-1.44)	(-1.10)
GROWTH	16.52*	15.29*	13.65	16.96	16.78*
	(1.73)	(1.83)	(1.35)	(1.65)	(1.75)
URBAN	-.04	-.16*	-.08	.03	-.02
	(-.46)	(-1.78)	(-.79)	(.32)	(-.19)
AGE	.31***	.33***	.31***	.33***	.31***
	(4.57)	(5.17)	(4.40)	(4.67)	(4.36)
INTEREST				-.02	
				((-1.24)	
Constant	7.94	15.35**	11.47	2.53	6.18
	(1.07)	(2.29)	(1.36)	(.30)	(.74)
R^2	.31	.43	.31	.36	.31
F	7.85	11.55	6.95	8.08	6.85
No. of obs.	147	148	147	138	147

Note: t-statistics in parentheses. *, ** and *** denote the significance at the 10, 5 and 1 percent level, respectively.

Table 5a.Correlation matrix. independent variables.

	KSTOCK	GEXP	TAXPERS	TAXCORP	WAGE	LVA	PATENT
KSTOCK	1.0000						
GEXP	0.0548	1.0000					
TAXPERS	-0.0575	0.4690	1.0000				
TAXCORP	0.0977	-0.4495	-0.2086	1.0000			
WAGE	0.2738	-0.2572	-0.0224	0.1675	1.0000		
LVA	0.5001	0.1230	0.1374	-0.0330	0.1785	1.0000	
PATENT	0.7380	0.3128	-0.0727	-0.1742	0.1004	0.4245	1.0000
EDSPEND	0.0212	0.6061	0.6195	-0.1184	-0.0981	0.0590	-0.0336
GROWTH	-0.1016	0.1859	-0.0074	-0.1928	-0.0784	-0.2023	-0.0407
URBAN	0.1224	0.0488	0.2015	0.1908	0.3090	0.0416	0.1295
AGE	0.3359	-0.0927	0.1593	0.1080	0.4785	0.5103	0.1302
INTEREST	-0.5285	0.0292	0.1629	-0.1398	-0.4086	-0.4839	-0.5154

Table 5b.Correlation matrix. independent variables, continued.

	EDSPEND	GROWTH	URBAN	AGE	INTEREST
EDSPEND	1.0000				
GROWTH	0.1614	1.0000			
URBAN	-0.0576	-0.0031	1.0000		
AGE	0.1188	-0.0673	-0.0492	1.0000	
INTEREST	0.0233	-0.1021	-0.0657	-0.4228	1.0000