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The Knowledge Spillover Theory of Entrepreneurship

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The Knowledge Spillover Theory of Entrepreneurship

Abstract

Contemporary theories of entrepreneurship generally focus on the recognition of opportunities and the decision to exploit them. While the prevailing view in the entrepreneurship literature is that opportunities are exogenous, the most prevalent theory of economic growth suggests that opportunities are endogenous. This paper bridges the gap between the entrepreneurship and economic growth literatures by developing a knowledge spillover theory of entrepreneurship. Knowledge created endogenously results in knowledge spillovers that give rise to opportunities to be identified and exploited by entrepreneurs.

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I. Introduction

A modern synthesis of the entrepreneur is someone who specializes in taking judgmental decisions about the coordination of scarce resources (Lazear, 2005). In this definition, the term "someone" emphasizes that the entrepreneur is an individual. 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. As G.L.S. Shackle wrote (1982, vii), "Any course of action must expose the chooser to numberless different sequels, rival hypotheses, some desired and some counter-desired…The entrepreneur is a maker of history, but his guide in making it is his judgment of possibilities and not a calculation of certainties." Therefore, the modern theory of entrepreneurship is that opportunities are real and independent of the entrepreneurs that perceive them (Casson, 2005).

In this framework, entrepreneurial activity depends upon the interaction between the characteristics of opportunity and the characteristics of the people who exploit them. Since discovery is a cognitive process, it can take place only at the individual level. Individuals, whether they are working in an existing organization or unemployed at the time of their discovery, are the entities that discover opportunities. [2] The organizations that employ people are inanimate and cannot engage in *discovery*. Therefore, any explanation for the mode of opportunity discovery must be based on choices made by individuals about how they would like to exploit the opportunity that they have discovered.

The idea that opportunities are objective but the perception of opportunities is subjective has a long history in economic theory. It is stated most clearly in Hayek (1937) where the empirical content of economics relates to the adjustment towards equilibrium. This process involves the acquisition and communication of knowledge. Hayek visualizes a world in which there is a continuous process of

[2] For a survey of the literature on cognition see Camerer, Loewenstein, and Prelec, (2005).

discovery. By contrast, Schumpeter has a different view 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.

While clearly interested in opportunity exploitation, Schumpeter 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)."

So where do opportunities come from? It is tempting to argue that they "are in the air." However, while the causes generating opportunities are unexplained in the entrepreneurship literature, 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). Today we know that the technology opportunity set is endogenously created by investments in new knowledge (Warsh, 2006). However, not only does new knowledge contribute to technological change, it also creates opportunities for use by third party firms (Jaffe, 1989), often-new ventures (Shane, 2001). The creation of new knowledge gives rise to new opportunities through knowledge spillovers; therefore, entrepreneurial activity does not involve simply the arbitrage of opportunities

(Kirzner, 1973) but also the exploitation of new opportunities created but not appropriated by incumbent organizations (Acs, Audretsch and Feldman, 1994).[3]

The purpose of this paper is to develop a theory that 'bridges the gap' between the subjective literature on entrepreneurship and the objective literature on the sources of opportunities by shifting the unit of analysis from organizations (firms, universities and research laboratories) endogenously creating new knowledge, to economic agents in possession of knowledge spillovers. 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 and Romer (1990) who recognized and modeled the importance of endogenous technical change and long run economic growth (Romer, 1986) but ignored the entrepreneur.[4] This Romerian insight—Schumpeter after Romer—casts the early Schumpeter in a new light by answering the questions: "Where do technological opportunities come from?" And, "Why are knowledge spillovers important for the theory of entrepreneurship?" Thus, while the entrepreneurship literature considers opportunity to exist exogenously, in the new economic growth 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. The theory provides at least some reconciliation between the two different views by providing the *missing link* between opportunity and economic growth (Acs, et al, 2004). This approach according to Romer (1996, 204), "…removes the dead end in neoclassical theory and links microeconomic observations on routines, machine designs, and the like with macroeconomic discussions of technology."

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[3] The theory also sheds light on and helps sort out the debate in the entrepreneurship literature on whether opportunities are created or discovered.

The model presented below is one where new product innovations can come from either incumbent organizations or from new entrepreneurial ventures. Incumbent firms innovate using knowledge flows and new entrants take advantage of knowledge spillover from the stock of knowledge (Acs and Audretsch, 1989). The primary theoretical predictions of the model are:

1.An increase in the stock of knowledge has a positive effect on the level of entrepreneurship.

2.The more efficient incumbents are at exploiting knowledge flows the smaller the effect of new knowledge on entrepreneurship.

3.Entrepreneurial activities are decreasing in the face of what is termed here as the knowledge filter, which includes but is not limited to higher regulations, administrative barriers and governmental market intervention.

The paper is organized as follows. The next section looks at knowledge spillovers as a source of entrepreneurial opportunity. We then present a formal model of the Knowledge Spillover Theory of Entrepreneurship. Section four tests an empirical model over the period 1981-2000. Our empirical results show that entrepreneurial activity is strongly influenced by knowledge created but not exploited by organizations. The final section has the conclusions.

II. Knowledge Spillovers as a Source of Opportunity

The Knowledge Spillover Theory of Entrepreneurship challenges two of the fundamental assumptions implicitly driving the results of the endogenous growth models. The first is that knowledge is automatically equated with economic knowledge. In fact as Arrow (1962) emphasised, knowledge is inherently different from the traditional factors of production, resulting in a gap between knowledge and what he called economic knowledge. The second involves the assumed spillover of knowledge.

[4] Just like Schumpeter who was ahead of his time, Romer's work is also ahead of its time. The reason for this is that while markets exist for "things" they do not exist for "ideas", or are incomplete. Once we have complete markets for "ideas" the

The existence of the factor of knowledge is equated with its automatic spillover, yielding endogenous growth. In the Knowledge Spillover Theory of Entrepreneurship, the *knowledge filter* imposes a gap between new knowledge and economic knowledge and results in a lower level of knowledge spillovers (Acs et al, 2004).

The new growth theory, formalized by Romer (1986), assumes that firms exist exogenously and then engage in the pursuit of new economic knowledge as input into the process of generating endogenous growth.[5] Technological change plays a central role in the explanation of economic growth, since on the steady state growth path the rate of per capita GDP growth equals the rate of technological change. The particular functional form of knowledge production is explained by the assumption that the efficiency of knowledge production is enhanced by the historically developed stock of scientific-technological knowledge. Even the same number of researchers becomes more productive if the stock of knowledge increases over time (Jones, 1995).[6]

The most original contribution of Romer is the separation of economically useful scientific-technological knowledge into two parts. The total set of knowledge consists of the subsets of non-rival, partially excludable knowledge elements that can practically be considered as public goods, and the rival, excludable elements of knowledge. Codified knowledge published in books, scientific papers or in patent documentations belongs to the first group. This knowledge is non-rival since eventually it can be used by several actors at the same time and many times historically. On the other hand it is only partially excludable, since only the right of applying a technology for the production of a particular

knowledge economy might become much more efficient.

[5] The model of the knowledge production function, formalized by Griliches (1979), also assumes that firms exist exogenously and then engage in the pursuit of new economic knowledge as input into the process of generating innovative activity.

[6] The spillover from the stock of knowledge is not equal to unity. Moreover, each time an entrepreneur introduces a new variety it makes part of the existing knowledge stock obsolete.

good can be guaranteed by patenting, while the same technology can spill over to further potential economic applications as others learn from the patent documentation. Rival, excludable knowledge elements are primarily the personalized (tacit) knowledge of individuals and groups, including particular experiences and insights developed and owned by researchers and business people.

However, this theory does not go far enough. The process by which knowledge spills over from the organizations producing it for use by another firm is exogenous in the model proposed by Romer (1990). That model focused on the influence of knowledge spillovers on technological change without specifying *why* and *how* new knowledge spills over.[7] Yet, the critical issue in modeling knowledge-based growth rests on this spillover of knowledge. New Growth theory offers no insight into what role, if any, entrepreneurial activity and agglomeration effects play in the spillover of tacit knowledge.[8] While the new growth theory is a step forward in our understanding of the growth process, the essence of the Schumpeterian entrepreneur is missed. As pointed out by Schumpeter (1942, 149) "the inventor produces ideas, the entrepreneur 'gets things done' … an idea or scientific principle is not, by itself, of any importance for economic practice." Indeed, the Schumpeterian entrepreneur, by and large, remains absent in those models.

Consequently, despite the gains in terms of transparency and technical ease obtained by imposing strong assumptions in the endogenous growth models, these advantages have to be measured in relation to the drawbacks of deviations from real world behavior. In our view, the result has been that the endogenous model fails to incorporate one of the most crucial elements in the growth process; transmission of knowledge through entrepreneurship, entry and exit, and the spatial dimension of

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[7] Knowledge spillovers 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. Most innovations take place in high technology opportunity industries and not in low technology opportunity industries (Scherer, 1965). The extent to which the results of innovation can be appropriated by incumbent firms also varies among industries.

[8] For a discussion of the theoretical insights on agglomeration see Krugman (1991).

growth. The presence of these activities is especially important at the early stages of the life cycle while technology is still fluid.

Why should entrepreneurship play an important role in the spillover of new knowledge? In the Romer (1986) model of endogenous growth new technological knowledge is assumed to automatically spill over. Third-party firms and economic agents, resulting in the automatic spill over of knowledge, automatically access investment in new technological knowledge. The assumption that knowledge automatically spills over is, of course, consistent with the important insight of Arrow (1962) that knowledge differs from the traditional factors of production in that it is non-excludable and non-rivelrous. When the firm or economic agent used the knowledge, it is neither exhausted nor can it be, in the absence of legal protection, precluded from use by third-party firms or other economic agents Thus, in the spirit of the Romer model, drawing on the earlier insights about knowledge from Arrow, a large and vigorous literature has emerged obsessed with the links between intellectual property protection and the incentives for firms to invest in the creation of new knowledge through R&D and investment in human capital.

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.

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

The knowledge filter is a consequence of the basic conditions inherent in new knowledge. Similarly, it is the knowledge filter that creates the opportunity for entrepreneurship in the Knowledge Spillover Theory of Entrepreneurship. According to this theory, opportunities for entrepreneurship are the duality of the knowledge filter. The more impenetrable 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 investment in new knowledge and ideas, but in the propensity for only a distinct subset of those opportunities to be fully pursued by incumbent firms.

One way to reconcile the difference in the view of opportunities between literatures of entrepreneurship and endogenous growth is the unit of analysis. While the entrepreneurship literature focuses on the individual as the decision-making unit of analysis, the literature on endogenous growth focuses on the firm as the decision-making unit of analysis. In such theories the firm is viewed as being exogenous and its performance in generating technological change is endogenous. The Knowledge Spillover Theory of Entrepreneurship shifts the fundamental decision making unit of analysis in the model of the knowledge production function away from exogenously assumed firms to individual agents with endowments of new economic knowledge. As Audretsch (1995) pointed out, when the lens is shifted away from the firm to the individual as the relevant unit of observation, the appropriability issue remains, but the question becomes, *How can economic agents with a given endowment of new knowledge best appropriate the returns from that knowledge?*

In the Knowledge Spillover Theory of Entrepreneurship the knowledge production function is actually reversed. The stock of knowledge is exogenous and embodied in people. The firm is created endogenously in the agent's effort to appropriate the value of his knowledge through innovative activity. Accompanying this potential innovation is an expected net return from the new product. The inventor would expect to be compensated for her potential innovation accordingly. If the company has a different, presumably lower, valuation of the potential innovation, it may decide either not to pursue its development, or that it merits a lower level of compensation than that expected by the employee (Evans and Jovanovic, 1989).

In either case, the employee will weigh the alternative of starting her own firm. If the gap in the expected return accruing from the potential innovation between the inventor and the corporate decision maker is sufficiently large, and if the cost of starting a new firm is sufficiently low, the employee may decide to leave the large corporation and establish a new enterprise. Since the knowledge was generated in the established corporation, the new start-up is considered to be a spin-off from the existing firm (Klepper, 2006). Such start-ups typically do not have direct access to a large R&D laboratory. Rather, the entrepreneurial opportunity emanates from the knowledge and experience accrued from the R&D laboratories with their previous employers. Thus, the knowledge spillover view of entrepreneurship is actually a theory of endogenous entrepreneurship, where entrepreneurship is an endogenous response to opportunities created by investments in new knowledge that was not commercialized because of the knowledge filter.

Thus, as a result of the knowledge filter, entrepreneurship becomes central to generating economic growth by serving as a conduit, albeit not the sole conduit, by which knowledge created by incumbent organizations spills over to agents who endogenously create a new orgnaization. [9] Therefore, 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.[10] 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.

III. The Model

Consider an economy consisting of a demand side, a supply side, and a financial market.[11] There are two types of firms: incumbents that undertake R&D to improve existing products, and entrepreneurial

[9] Acs and Audretsch (1989) found that, *ceteris paribus*, the greater extent to which an industry is composed of large firms, the greater will be the innovative activity, but that increased innovative activity will tend to emanate more form the small firms than from the large firms.

[10] See for example, Jaffe (1989)and Acs, Audretsch and Feldman (1994).

[11] For details, see Intriligator (1971), Dinopoulous (1998) and Aghion and Howitt (1992)

start-ups that exploit the existing stock of knowledge to innovate new products. Firms that come up with an improved or new variety that is demanded by consumers are rewarded by temporary monopoly profits until new products out-compete the old one.

III.I Demand side

Starting with the demand side, consumers maximize standard linear intertemporal utility,

$$U = \int_0^\infty e^{-\rho t} \ln[h(x)]dt , \qquad (1)$$

where ρt > 0 equals consumers' rate of time preferences (discount rate) and h is the sub-utility function. Assume that the different varieties of the x-goods are perfect substitutes and that ν^I refers to the most recent innovated product or variety, containing the improved quality or the novel features of the product. If $\nu \ p_t < p_{t-1}$, then all consumers will prefer the new product,

$$h(x_o, x_1, x_2......) \quad = \sum_{I=0}^{\infty} \nu^{\ I} x_I , \quad \nu > 1. \qquad (2)$$

The novel products/qualities demanded by consumers may range from highly research-intensive varieties to products characterized by a combination of existing knowledge. Hence, high R&D intensity by itself does not guarantee successful introduction of a new product.

III.II Supply side

Turning to the production side, new products/qualities can either be invented by incumbent firms investing in R&D by hiring labor that undertakes research, or by entrepreneurs through innovative entry.[12] The only production factor is labor, which is distributed among three different activities: in R&D production (L_R), in self-employment through entrepreneurial start-ups, (L_E) or in a residual sector employing R&D-findings and producing final goods (L_F),

$$L_R + L_E + L_F = \overline{L}. \qquad (3)$$

Perfect mobility across sectors assures that wages are equalized.[13] Initial profit conditions for firms/products that successfully enter the market are,

$$\pi = (p_I - 1)Y / p_I = (\nu - 1)Y / \nu, \qquad \nu \equiv p_I \qquad (4)$$

where p_I represents price of the new good, corresponding to the quality improvement (ν), and wage is set equal to one. Total consumption expenditure is captured by Y, that is, demand for a new variety. In the long run, entry implies that profits are zero. Hence, in the period preceding entry of a new product/firm, prices equal wage-costs which are set to one. The first- order condition implies that $\nu \equiv p_I \geq 1$.

Entry occurs either through R&D-outlays by incumbents or through entrepreneurial start-ups where existing knowledge is combined in innovative ways. The latter type of entry does not require any investment in R&D. Instead, individuals combine their given entrepreneurial ability ($\overline{e}_j$) with the overall knowledge stock (K) within an economy to discover commercial opportunities. The societal knowledge stock is a composite of previous knowledge stemming from activities by incumbents and start-ups, i.e., knowledge refers not only to scientific discoveries but also to knowledge associated

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[12] The general production function is $x = AL^{\gamma}, \quad 0 < \gamma \leq 1$.

[13] The final good sector is not modelled in order to enhance transparency. It could be viewed as a constant returns to scale sector where labor embodied with the findings in the R&D-sector at each given time t is employed (i.e., labor does not possess skills related to ongoing R&D).

with novel ways of producing and distributing in traditional businesses, changing business models, new marketing strategies, etc. Both types of entry are assumed to occur through a Poisson process.

Hence, the first type of entry occurs due to increased R&D-expenditures, i.e. it is a *flow* variable, taking previous scientific knowledge as the departure point, while the second type of entry draws on the overall *stock* of knowledge and applies it in a novel way. All entry implies that some fixed costs are incurred, such as for R&D or marketing. Entry is thus modelled in a way that follows real world behaviour.

Starting with incumbents, the aggregate probability of a successful entry (μ) is increasing in an economy's R&D-outlays, measured as R&D-employees.[14] As shown above, labor is the only input. The production technology is characterized by decreasing returns to scale ($0<\gamma\ <1$), i.e., a doubling of R&D-resources does not translate into a doubling of R&D-based entry. At the firm level, each firm i's probability of successfully launching a new product at the market is increasing in higher R&D-investments. Thus, entry by incumbents can be modeled as

$$\mu\ (\sum(r\ \&\ d)dt \equiv \mu\ (\sum_{i=1}^{L} l_R)^{\gamma}\, dt = \sigma(L_R)^{\gamma}\, dt \qquad (5)$$

where *dt* refers to an infinitesimal increment of time and (σ) refers to an efficiency parameter that reflects how smoothly a new discovery is introduced to the market (the knowledge filter).

The second type of entry occurs in a similar way through innovative Schumpeterian firms, where the probability of successful entry (η) is related to the given knowledge stock $\overline{K}$ (at each point in time) times the average entrepreneurial ability ($\hat{e}$) in the economy,

$$\eta \left[(\sum_{j=1}^{L} \overline{e}_j)\ \ \overline{K} \right] dt = (\hat{e}\overline{K})dt \equiv \sigma(\overline{\mathrm{K}})^{\gamma}\, dt\,. \qquad (6)$$

At the individual level, the probability of success depends on each individual *j's* given endowment of entrepreneurial talent which is unevenly distributed across the population of L individuals in an economy (Lucas, 1978).[15] Also here decreasing returns to scale ($0<\gamma<1$) prevail since an increase in entrepreneurial ability will not translate into a proportional increase in entries.[16]

The total entry rate within an economy can now be calculated by taking advantage of the additive property of Poisson distributions,

$$\kappa\ dt = \mu\ dt + \eta\ dt = \sigma(\overline{\mathrm{K}} + L_R)^{\gamma}\, dt\,. \qquad (7)$$

Hence, incumbents may now be replaced by either other firms engaged in an R&D-race or by knowledge-based entrepreneurship.

III.III The financial market

To cover investment costs in R&D, or other entry costs such as marketing, both incumbents and Schumpeterian entrepreneurs have to turn to the financial market (Gompers and Lerner, 1999).[17] Investors take a risk since new entrants may replace firms, or entrepreneurs may fail in launching their novel products. Entrepreneurial firms are included in investors' portfolios prior to entering the market.

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[14] The assumed Poisson entry process means that the time frequency with which entry will occur is a random variable whose distribution is exponential with parameter μ , i.e. μ is the probability per unit of time.

[15] We follow Lucas (1978) who assumes that managerial talent is distinct from labor talent. Lazear (2005) assumes that workers and managers have the same two skills, just in different combinations. Those with more balanced skills are more likely than others to become entrepreneurs. Those who have varied work and educational backgrounds are much more likely to start their own businesses than those who have focused on one role at work or concentrated in one subject at school. The implications for the size distribution of firms are similar in the two models.

[16] Moreover, it would be sub-optimal for all economic activities to be undertaken by entrepreneurs.

[17] 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.

Assume that investors buy shares in all firms to minimize risk, implying a riskless return of $r(t)$. Investors calculate the expected return on their investments over time in the following way. First, a firm's instantaneous profits $\left(\pi = (p_I - 1)(Y / p_I)\right)$ and the discounted return (V) – or the value of the firm - are linked through the financial market. The (expected) discounted profit is simply the value of the firm at a given time, times the probability that it will succeed in inventing (μ_j) or innovating (η_j) new varieties, minus the incurred labor costs.

In each period of time (dt) the shareholder receives a dividend which is related to profits, and the firm then appreciates in value $\dot{V}(t)\ dt = (dV / dt)dt$. However, incumbents, whether R&D-based or of the entrepreneurial type, run the risk of being replaced by the introduction of new qualities (κ),

$$\left[\pi(t)/V(t)\right]dt + \dot{V}(t)/V(t)\left[1-\kappa dt\right]dt + \left[(V(t)-0)/V(t)\right]\kappa dt = r(t)dt \quad (8)$$

where ($1-\kappa\ dt$) is the probability that the firm survives and $\kappa\ dt$ represents the probability that the firm will be forced out of business. Consequently, investors will incur losses on their previous investments. From equation 8, as dt goes to zero,

$$\dot{V}(t)/V(t) + \pi / V(t) = r(t) + \kappa, \qquad \dot{V}(t) = 0 \qquad (9)$$

$$\pi / V(t) = r(t) + \kappa \equiv \tilde{r} \qquad (10)$$

i.e., the higher risks associated with an investment in incumbents (because they may become replaced and a capital loss may be incurred) require a higher return in steady state.

III.IV Equilibrium

To close the model we have to link intertemporal consumption to intertemporal production – i.e. entry of new goods and firms that is reliant upon access to capital, i.e., investment. To do that we maximize the dynamic consumption, taking consumers' budget constraint into account,

$$\mathrm{U} = \max\left\{\int_0^\infty e^{-\rho t} \ln C(t)dt + Exp\int_0^\infty e^{-\rho t}(\nu - 1)\ln \nu \ dt \ \right\} \qquad (11)$$

s.t. $\dot{Y}(t) = \tilde{r}(t)A(t) + 1 - C(t)$,

where the second term in the utility maximization expression refers to expected quality improvements ν, which can be disregarded since it does not refer to income or assets held by consumers. The budget constraint consists of the return on savings (shares or loans to finance new goods), and the wage that is – as above – set to one. To solve this dynamic optimization problem we define the discounted Hamiltonian (H) as,[18]

$$H = \ln C(t) + \lambda \ (t)\left[\tilde{r}(t)A(t) + 1 - C(t)\right], \qquad (12)$$

where the first order condition requires marginal utility of consumption to equal the shadow value of increasing investments (λ),

$$\delta \ H / \delta \ C = (1/C) - \lambda = 0, \quad (1/C) = \lambda \,. \qquad (13)$$

The shadow value of investing (λ) over time that is compatible with 13 is determined by the Euler equation,[19]

$$\rho\lambda = (\delta \ H / \delta \ A) + \ \dot{\lambda} = \tilde{r}(t)\lambda + \ \dot{\lambda} \,. \qquad (14)$$

where $\dot{\lambda}$ refers to the time derivative of the shadow value of increased investment in shares. The expression on the right-hand side gives the incremental increase in income from additional

[18] This is the standard solution to a dynamic optimization problem and we will not go into details. For a full specification of the technique, see Aghion and Howitt (1998).

[19] The Euler equation which together with the transversality condition (all invested assets must at some time be consumed) gives the dynamic path of investments that fulfils the condition in equation 13. See Aghion and Howitt (1998).

investments given that the initial holding of assets A is known. Equilibrium occurs when the shadow value is constant ($\dot{\lambda} = 0$), implying

$$\rho - \tilde{r} = 0, \quad \rho = \tilde{r} \qquad (15)$$

which is the classical dynamic equilibrium condition. Thus, when consumers' rate of time-preferences ρ – i.e. the rate of consumption – exactly matches the rate of return $\tilde{r}$ of investments, then the capital flow to the financial market which is invested in new ventures (start-ups or new products in incumbents) corresponds precisely to demand by intertemporally utility-maximizing consumers. Note that this does not imply a continuous flow of entry each period of time.

We have shown that utility is increasing in new and high quality goods. Either incumbents or new firms, implementing a production technology that only requires labor, supply such goods. However, incumbents will employ labor in R&D whereas new firms will engage in entrepreneurial production drawing on the existing stock of knowledge. Both types of firms are dependent on capital injections to finance entry that is supplied by the financial market and equals savings by households. Since firms may be overturned due to entry investors require a risk-adjusted rate of return to invest in either incumbents that provide new goods, or in new firms that are about to enter the market. Equilibrium at the labor market is assured by the assumption of free mobility across sectors while free entry in the long-run drives profits down to zero.

III.V Innovation

When firms introduce new products these may be thought of as innovations. No mention in the model is made of the type of innovation. We can think of incumbent firms that rely on the *flow* of knowledge to innovate focus on incremental innovation, i.e. product improvements. New entrepreneurial firms, that have access to knowledge spillovers from the *stock* of knowledge and entrepreneurial talent, are more likely to be engaged in radical innovation that lead to new industries or completely replace existing products. De novo entrepreneurial entry played a major role in radical innovations like software, semiconductors, biotechnology and the information and communications technologies (Baumol, 2004).

IV. The Empirical Framework

According to the above model, expected profit opportunities accruing from entrepreneurship is enhanced by the magnitude of new knowledge but constrained by the commercialization capabilities of incumbent firms.[20] To illustrate how this influences entrepreneurship equation (7) can be rewritten as

$$\eta\ (\mathrm{K}, L_R, \sigma)dt = \sigma(\overline{\mathrm{K}})^{\gamma}\, dt - \mu dt = \sigma(\overline{\mathrm{K}} - L_R)^{\gamma}\, dt \qquad (16)$$

where entrepreneurial entry is a function of the knowledge stock (weighted by average entrepreneurial ability) and R&D-investments by incumbents. In addition, barriers to entrepreneurship that impacts how efficiently the economy filters ideas into new ventures is captured by the variable σ. It embraces factors such as financing constraints, risk aversion, legal restrictions, bureaucratic and red tape constraints, labor market rigidities, taxes, lack of social acceptance, etc. (Parker, 2004). The existence of such barriers, i.e., a low value of $\sigma \equiv 1/\beta$, explains why economic agents would choose not to enter

[20] 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.

into entrepreneurship, even when confronted with knowledge that would otherwise generate a potentially profitable opportunity.

IV.I The Hypotheses

Using equation (16), this model generates three propositions from which testable hypotheses can be derived, given that entrepreneurial activity exceeds zero:

Proposition 1: An increase in the stock of knowledge has a positive effect on the degree of entrepreneurship.

Proposition 2: The more efficient incumbents are at exploiting knowledge flows the smaller the effect of new knowledge on entrepreneurship.

Proposition 3: Entrepreneurial activities are decreasing in higher regulations, administrative barriers and governmental market intervention.

Proof: Taking the partial derivative of entrepreneurship with respect to the knowledge stock (K), R&D by incumbents (L_R) and the efficiency parameter (σ),

$$\eta_K = \sigma\gamma \mathrm{K}^{\gamma-1} > 0, \quad \eta_{KK} = \sigma(\gamma-1)\gamma \mathrm{K}^{\gamma-2} < 0 \qquad (\gamma < 1), \tag{17a}$$

$$\eta_{L_R} = -\gamma\sigma L_R^{\gamma-1} < 0, \quad \eta_{L_R L_R} = -\sigma(\gamma-1)\gamma L_R^{\gamma-2} > 0 \qquad (\gamma < 1), \tag{17b}$$

$$\eta_\sigma = -\mathrm{K}^\gamma / \beta^2 < 0, \qquad \eta_{\sigma\sigma} = 2\mathrm{K}^\gamma / \beta > 0 . \tag{17c}$$

As shown in 17a, entrepreneurship is increasing in (K) but at a decreasing rate, whereas higher R&D-spending by incumbents (17b) and lower efficiency in the economy $(\sigma \equiv 1/\beta)$ reduces entrepreneurship, but at a decreasing rate.

Hence, our model explains entrepreneurship as a function of the following factors: the knowledge stock (K) and R&D-investments by incumbents, which both influence the knowledge opportunity space, and the barriers to entrepreneurship captured by β. In addition, culture, traditions and institutions, i.e. more or less non-measurable factors, together with strictly economic factors that are more easily identified, influence entrepreneurship. "Inherited" and persistent customs and legal frameworks drive the first set of factors, often quite different across countries. To capture these country-specific differences we estimate the following reduced form equation using a fixed effect panel regression technique,[21]

$$ENT_{j,t} = \alpha_j + \alpha_1 KSTOCK_{j,t} + \alpha_2 BARR_{j,t} + \alpha_3 INC_{j,t} + \alpha_4 Z_{j,t} + \varepsilon_{j,t} \qquad (18)$$

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*.

IV.II The variables

The dependent variable, entrepreneurship (ENT), is approximated by a country's share of self-employed as a percentage of the labor force.[22] This is the best available measure that can be

[21] 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.

[22] The agricultural sector has been excluded.

implemented in a cross-country analysis and serves as an acceptable approximation for entrepreneurship (Evans and Leighton, 1989).

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 model 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.

The most intricate and difficult variable to model empirically is incumbents' exploitation of knowledge flows. 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 flows. 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 flows. 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.

We use two variables to capture the extent of barriers to entrepreneurship 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 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). For these reasons we expect these variables to be negatively associated with the level of entrepreneurship.

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. GDP 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). As shown in Table 1 the simple correlation between entrepreneurship and urban is 0.28. We expect a higher degree of urbanization to be reflected in higher entrepreneurial activities.

Similarly, studies using demographic variables conclude that individuals in the age cohort 30 to 44 are most likely to undertake entrepreneurial activities. 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

1990s (DUMMY-90). The 1990s represent a period of increased technological change and entrepreneurial activity as argued by Jorgenson (2001).

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 Appendix A).[23] The summary statistics are reported in Table 2.

V. 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. As the positive and statistically significant coefficients of the knowledge stock suggest, entrepreneurial activity tends to be greater 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 spillovers.

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. The lower the ability of incumbents to appropriate new knowledge, the more knowledge will spillover to third parties as predicted by the theory. Hence, to the degree that the incumbent firms can take advantage of opportunities, there will be less entrepreneurial activity.

There is also at least some evidence that the knowledge filter, 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 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.

Thus, the empirical findings that entrepreneurship tends to be systematically greater in the presence of knowledge spillovers 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.

VI. Conclusions

This paper has developed a new 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 knowledge spillovers not appropriated by incumbent firms. The Knowledge Spillover Theory of Entrepreneurship shifts the fundamental decision making unit of analysis in the model of economic growth away from exogenously assumed firms to individual agents with endowments of new economic knowledge. Agents with new knowledge endogenously pursue the exploitation of knowledge suggesting 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.

[23] 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.

There are several implications of these findings. First, the theory helps us bridge the gap between the subjective literature on entrepreneurship and the objective literature on the sources of opportunity. Entrepreneurship theories need to be able to explain where opportunities come from, how knowledge spillovers occur and how occupational choice arises in the context of existing corporations that lead to new firm formation. Prevailing theories of entrepreneurship are not able to answer these questions. Second, the theory helps us better understand the contradictions in Smith's *Wealth of Nations* between increasing returns (the pin factory) and how the market economy can harness self interest to the common good leading each individual to an end which was no part of his intention (the invisible hand). The real challenge in endogenous growth theory is not that the firm will not invest enough in new knowledge, but how to balance increasing returns with competition. The Knowledge Spillover Theory of Entrepreneurship provides an explanation between the role of the individual in the economy and the firm. If Romer provided us with a new economics of knowledge—Schumpeter after Romer—brings us a step closer to understanding the essential role of the entrepreneur in a market economy.

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Appendix A. Definition of variables and data source.

Variable	Definition	Sources	Comment
ENT	Dependent variable. Non-agricultural self-employed, as percentage of total non-agricultural employment.	OECD, Statistical Compendium via Internet 2003-10-09 (Labor 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 corporate income, as percentage of GDP.	OECD, Statistical Compendium via Internet 2004-09-22 (OECD Revenue Statistics).	

GROWTH	Five year moving average of gross domestic product growth (at the price levels and PPPs of 1995).	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.	Values only available for the years 1978, 1985, 1990, 1994 and 1998. Values in between are approximated by assuming the same value as the last observation.
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).	Original value is divided by 1 000 before regression in order to get more presentable coefficient estimates.
L. VALUEADD	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).	
DUMMY-90	Time dummy that assumes the value one if year>1989 and zero otherwise.	Own calculations.	

Table 2. Descriptive statistics.

Variable	Min	Mean	Max	Std. Deviation	Observations
ENT	4.23	11.02	23.35	4.42	337
KSTOCK	.25	7.13	17.08	3.93	342
GEXP	30.52	48.38	72.96	8.61	332
TAXPERS	4.00	11.79	26.8	4.86	334
TAXCORP	.20	334	7.4	1.24	334
GROWTH	-.03	.02	.09	.01	342
URBAN	30.96	76.04	97.18	12.23	334
AGE	16.55	21.31	25.72	1.89	342
PATENT	.00	1.25	10.02	2.27	338
L. VALUEADD	61.07	86.57	110.46	11.76	324

Table 3. Regression results, fixed effect panel regressions1981–1998.

Dependent variable: ENT	Reg 1	Reg 2	Reg 3	Reg 4
KSTOCK	.05*	.04	.04*	.15***
	(1.82)	(1.52)	(1.67)	(4.92)
GEXP	.00			-.00
	(.26)			(-.16)
TAXPERS		-.18***		
		(-3.15)		
TAXCORP		.29***		
		(3.63)		
GROWTH	16.58***	5.74	16.01***	9.58*
	(3.64)	(1.14)	(3.49)	(1.97)
URBAN	.07***	.10**	.07***	.08***
	(2.94)	(2.18)	(2.96)	(2.67)
AGE	.16***	.19***	.17***	.11**
	(3.14)	(3.72)	(3.41)	(2.15)
PATENT				-.29***
				(-5.81)
L.VALUEADD				-.02*
				(-1.77)
DUMMY-90	.04	.01	.09	.42
	(.24)	(.07)	(.55)	(.53)
Constant	.89	-.71	.55	2.89
	(.43)	(-.19)	(.26)	(1.24)
R^2	.23	.27	.24	.29
F	15.17	15.84	19.28	14.12
No. of obs.	323	322	329	302

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 regressions1990 – 1998.

Dependent variable: ENT	Reg 1	Reg 2	Reg 3	Reg 4
KSTOCK	.20**	.21**	.20**	.28***
	(2.18)	(2.40)	(2.24)	(2.83)
GEXP	-.00			-.02
	(-.12)			(-1.37)
TAXPERS		-.15***		
		(-3.41)		
TAXCORP		.09		
		(1.34)		
GROWTH	11.77***	7.10	12.63***	18.37***
	(2.71)	(1.58)	(3.03)	(4.24)
URBAN	.04	.04	.04	.06*
	(1.34)	(1.18)	(1.42)	(1.96)
AGE	.32***	.35***	.32***	.30***
	(5.06)	(5.68)	(5.00)	(4.82)
PATENT				-.14**
				(-2.35)
L.VALUEADD				-.01
				(-1.53)
Constant	-1.41	-.18	-1.68	-.74
	(-.47)	(-.06)	(-.58)	(-.26)
R^2	.33	.39	.34	.44
F	14.24	15.45	18.35	15.00
No. of obs.	164	165	165	155

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

Table 1. Correlation matrix

	ENT	KSTOCK	GEXP	TAXPERS	TAXCORP	GROWTH
KSTOCK	-.2548					
GEXP	-.3973	.0781				
TAXPERS	-.2746	-.0287	.4642			
TAXCORP	.1537	.0833	-.4309	-.1981		
GROWTH	.1488	-.0994	-.1309	-.1057	.3504	
URBAN	.2762	.1286	.0689	.2022	.1804	-.1223
AGE	-.1224	.3772	-.0837	.1653	.1066	-.0026
PATENT	-.1418	.6039	-.3609	-.3382	-.0093	-.1893
L.VALUEADD	.0540	.5596	.1512	.1538	-.0514	-.0638

Table 1. Correlation matrix

	URBAN	AGE	PATENT	L.VALUEADD
AGE	-.0429			
PATENT	.0469	.1465		
L.VALUEADD	.0537	.5240	.2376	