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Entrepreneurship, Knowledge and Economic Growth[1]
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Abstract

Knowledge plays a critical role in economic development, still our understanding of how knowledge is created, diffused and converted into growth, is fragmented and partial. The neoclassical growth models disregarded the entrepreneur and viewed knowledge as an exogenous factor. Contemporary current knowledge-based growth models have re-introduced the notion of the entrepreneur, however stripped of its most typical characteristics, and the diffusion of knowledge is kept exogenous. It implies that the predictions and policy conclusions derived from these models may be flawed. This paper reviews the literature that addresses the issues of knowledge creation, knowledge diffusion and growth, and the role attributed the entrepreneur in such dynamic processes. I will explore how these insights can be integrated into existing growth models and suggest a more thorough microeconomic foundations from which empirically testable hypotheses can be derived.

1. Introduction

A society's ability to increase its wealth and welfare over time critically hinges on its potential to develop, exploit and diffuse knowledge, thereby influencing growth. The more pronounced step in the evolution of mankind has been preceded by discontinuous, or lumpy, augmentations of knowledge and technical progress. The stages of knowledge leaps were followed by economic development characterized by uncertainty, market experiments, redistribution of wealth, and the generation of new structures and industries. This pattern mirrors the evolution during the first and second industrial revolution in the 18th and 19th centuries, and is also a conspicuous feature of the "third", ongoing, digital revolution.

Despite the fact that there is a general presumption within the economic disciplines that micro-level processes play a vital role in the diffusion of knowledge, and thus the growth process, there is a lack of stringent theoretical framework but also of empirical analyses to support this allegation. The economic variables knowledge, entrepreneurship, and economic development has since long been treated as different and separate entities. It is not until the last 10-15 years that a literature has emerged that aims at integrating these economic concepts into a coherent framework. Different academic traditions and perspectives have contributed to ameliorate our understandings of how knowledge, entrepreneurship and growth are interrelated, and to draw adequate policy conclusions from these insights.

The main objective of this paper is hence to shed light on recent advances in our understanding of the forces that underpin the creation of knowledge, its diffusion and commercialization, and the role of the entrepreneur in these dynamic processes.[2] Moreover, I will explore how these insights are integrated into existing growth models. This implies a modified knowledge-based growth model that originates from more thorough microeconomic foundations from which empirically testable hypotheses can be derived regarding the

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[2] Previous surveys that allude to the topics addressed in this paper include contributions by Casson (1990), Livesay (1995), Goel (1997), Yu (1997), Glancy and McQuaid (2000), Sexton and Landström (2000), Weasthead and Wright (2000), Shane (2003) and Davidsson (2004). See also Acs and Audretsch (2003).

interaction and interdependencies between knowledge, entrepreneurship, industrial dynamics and growth at the regional and national level. Understanding growth thus requires a well-defined micro- to macro analytical framework.

Irrespective of the seminal contributions by Joseph Schumpeter in the early 20th century, issues related to economic impact of entrepreneurship has for a (too) long time been neglected in mainstream economics. The general equilibrium paradigm that dominated economics for at least half a century (and still does to large extent) left little room for the entrepreneur. In the last decade or so interest in the entrepreneur's contribution to industrial dynamics and the development of an economy has however revived among academicians and policy makers.[3] Interestingly enough, the processes described by Schumpeter (1911) suggest a link to the contemporary knowledge-based (endogenous) growth theory (Romer 1986, 1990). There is also a vein in the theoretical literature that seeks to introduce the entrepreneur into a growth context.

For instance, Schmitz (1989) develops a model where an increase in the proportion of entrepreneurs leads to an increase in long-run growth (through imitation). Lucas (1988) makes a direct link between entrepreneurs and "softer" values, emphasizing the externalities that stem from the special form of human capital called entrepreneurs. He also discusses to what extent this may mirror different growth rates across countries. The so called neo-Schumpeterian models in the endogenous growth literature – the "quality ladder" model – allowing for entry through new and improved qualities of products, is yet another attempt (Segerstrom et al. 1990, Segerstrom 1991, Aghion and Howitt 1992, Segerstrom 1995). Still, these latter models rather capture the behavior of large incumbent firms, involved in R&D-races, than the "genuine" entrepreneur.

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[3] The interest among policy makers in knowledge generation and diffusion, innovation and entrepreneurship is confirmed not least by the decision taken by the European Council in Lisbon 2000, that Europe by 2010 should be the most competitive knowledge economy in the world.

To comprehend the conditions, the characteristics, the drivers and the effects of knowledge creation, innovation and entrepreneurship, and the subsequent impact on industrial dynamics and growth, request insights from several disciplines. Those primarily concerned are economics, economic geography, business administration and management. The main trust of this paper relates to the economics literature with the objective to pin down the microeconomic foundation of growth, the extent to which contemporary models fail in that respect, and to suggest improvements.

Growth cannot be understood if the true "agents of change" – the entrepreneur – is dismissed from the process. It also means that micro founded evolutionary processes such as individual behavior, experiments and creative destruction becomes cornerstones in the understanding of growth. In this context Schumpeter (1947, p. 149), perhaps more than any other economist, is explicit about the specific economic function of the entrepreneur: "the inventor produces ideas, the entrepreneur 'gets things done' … an idea or scientific principle is not, by itself, of any importance for economic practice." Thus, Schumpeter envisioned a clear division between the entrepreneur and knowledge creation, defined in terms of scientific achievements.

The view that entrepreneurship could play an important role in a knowledge-based economy seems to contrast much of the conventional wisdom. According to for instance Gailbraith (1967), Williamson (1968) and Chandler (1977), it seemed inevitable that exploitation of economies of scale by large corporations would become the main engine of innovation and technical change. But also the "late" Joseph Schumpeter (1942) shared these views, albeit he was considerably more skeptical about the beneficial outcome than his colleagues. Rather, Schumpeter feared that the replacement of small and medium sized enterprise by large firms would negatively influence entrepreneurial values, innovation and technological change. Despite these early prophecies of prominent scholar, there is ample

empirical evidence that the development has actually reversed since the early 1970s for most industrialized countries (Evans 1991, Loveman and Sengenberger 1991, Brown et al., 1990). The tide has turned and the risk prone entrepreneur is increasingly seen as indispensable to economic growth and prosperity, even among former skeptics.

The rest of this survey is organized into four separate parts. The next section 2 considers the theoretical aspects of entrepreneurship, knowledge, growth at the regional and national levels, and the implications of agglomerated structures on growth. It draws on the advances made in the fields of economic geography and endogenous growth, together with findings in evolutionary, entrepreneurial, institutional and regional economics. The following section 3 is basically organized in the same way but present the empirical findings, emphasizing the interfaces between entrepreneurship, knowledge and growth. In Section 4 the policy implications are discussed and the progress in terms of understanding how policies should be designed to jointly foster knowledge accumulation, its diffusion and growth. The subsequent Section 5 aims at defining some of the most urgent knowledge gaps that needs to be addressed by future research while the final Section 6 concludes.

2. The Theoretical Platform

2.1 The Entrepreneurship Theory

"The theoretical firm is entrepreneurless – the Prince of Denmark has been expunged from the discussion of Hamlet" (Baumol 1968, p.66)[4]

The development and dynamics of any society, economy or organization requires micro-level actors – individuals – who have the ability and persistence to make change

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[4] As noted by Warsh (2006, p.120) Schumpeter used almost the exact wording, even though this citation is attributed Baumol.

happen. Institutions as well as market and organizational structures do not create change in the absence of human actors. It is the unique knowledge, perceptions and goals of individuals equipped with the drive to take action accordingly that initiate novelty. In order for such entrepreneurial initiatives to have lasting impact, however, they need to create value. The question is then what characterizes these individuals and how to define them?

Theoretical definitions of entrepreneurs span a wide range. For instance, Wennekers and Thurik (1999) mention 13 different definitions, while Glancey and McQuaig (2000) limits their enumeration to five. This section will survey the most prevalent definitions of the entrepreneur, thereafter discuss the sources of opportunity, the economic meaning of knowledge and its relation to opportunity and, finally, present the basic structure of the knowledge spillover theory of entrepreneurship, introduced by Acs et al. (2006).

2.1.1 How to define an entrepreneur?

Most contemporary theories of entrepreneurship build on the seminal contributions by either Schumpeter (1911), Knight (1921) or Kirzner (1973).[5] Schumpeter stressed the importance of entrepreneurs as the main vehicle to move an economy forward from static equilibrium through innovations and by inducing processes of creative destruction, challenging existing structures and distorting economic equilibrium.[6] Anyone who performs this function is an entrepreneur, whether they are independent or dependent employees of a company. Schumpeter was also clear on the different roles between the inventor and the innovator:

"Economic leadership in particular must hence be distinguished from 'invention'. As long as they are not carried into practice, inventions are economically irrelevant. And to carry

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[5] Hébert and Link (1989) have identified three distinct intellectual traditions in the development of the entrepreneurship literature. These three traditions can be characterized as the German Tradition, based on von Thünen (1826) and Schumpeter (1911), the Chicago Tradition, based on Knight (1921, 1944) and Schultz (1980), and the Austrian Tradition, based on von Mises (1949), Kirzner (1973) and Shackle (1982).

[6] Schumpeter (1911/34, p. 66) distinguishes between five types of entrepreneurial acts: introducing a new good, a new method, a new market, and a new source of supply of intermediate goods or a new organization.

any improvement into effect is a task entirely different from the inventing of it, and a task, moreover, requiring entirely different kinds of aptitudes. Although entrepreneurs of course may be inventors just as they may be capitalists, they are inventors not by nature of their function but by coincidence and vice versa ... it is, therefore, not advisable, and it may be downright misleading, to stress the element of invention as much as many writers do". (Schumpeter 1911, pp. 88-89)

That did not preclude Schumpeter foreseeing possible situations when the inventor role may coincide with the innovator, albeit such situations were considered to be exceptions to the rule.

The Schumpeterian distinction between inventor and entrepreneur was challenged by Schmookler (1966) and Teece (1968), whom, based on case studies, believed that entrepreneurs discover opportunities to do promising R&D rather than merely discovering promising outcomes of R&D that has been conducted by others. On a more aggregate level, the merging of the inventive and innovative stages is clearly stated in the neo-Schumpeterian growth models (Aghion and Howitt, 1992, 1998). These models, however, share the later Schumpeter's (1942) view of innovation as becoming routinized, where markets are dominated by a limited number of large firms. Hence, this specific approach would not be well designed to analyze the aspects of entrepreneurship addressed in this paper.

Kirzner's view was that the entrepreneur moves an economy towards equilibrium (contrasting Schumpeter) by taking advantage of arbitrage possibilities: entrepreneurs were "...attracted to notice suboptimalities to the scent of pure profit which accompanies such suboptimalities" (Kirzner 1992, p. 174). More generally, Kirzner claimed that a fruitful way to view entrepreneurship is the notion that entrepreneurs account for the competitive behaviors that drive the market process. This definition, which is based jointly on behavior and outcomes, is succinct and gives a satisfactorily clear delineation of the role of

entrepreneurship in society. It recognizes that micro-level decisions and actions are needed for any change to occur. And it is also clear about changing the market requires an activity that has some direct or indirect success. Mere contemplation over radically new ideas, or vain introduction of fatally flawed ones, does not amount to "entrepreneurship".

If one adopts the view that entrepreneurs are agents that (instantaneously) corrects deviation from an economy being in equilibrium, it also implies an implicit assumption of perfect information. By contrast, imperfect information generates divergences in perceived opportunities across different people. The sources of heterogeneity across individuals then include different access to information, but also cognitive abilities, psychological differences, willingness to incur risk, as well as preferences for autonomy and self-direction. In addition, differential accesses to scarce and expensive resources such as financial capital, human capital and social capital do separate individuals.

Neither Kirzner nor Schumpeter focused on the risks tied to entrepreneurial activities. Doubtlessly, Schumpeter was aware of the fact that new activities do involve elements of risk-taking, even though he did not stress that aspect as a dominating feature of entrepreneurship. Rather, capitalists that provided the finance required to embark on new ventures orchestrated the risk-taking part. Kirzner allotted the role of the arbitrageur to entrepreneurs, which did involve some element of risk, but again was not part of the main argument. It was Knight (1921) who proposed the role of the entrepreneur as someone who had the ability to transform uncertainty into a calculable risk.[7] To some extent he thereby bridged the roles of the entrepreneur and the risk-taker that Schumpeter had claimed were separate. Kihlstrom and Laffont (1979), Brouwer (2000) and Rigotti et al. (2001) present modern versions of this role

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[7] Knight and Schumpeter were more aligned on other aspects of entrepreneurship. For instance, they shared the belief that entrepreneurial talent was a scarce resource. Such scarcity is not so much associated with entrepreneurs' alertness, or with their professionalism, as with their psychology. See also Chen et al. ((1998).

of the entrepreneur while Hébert and Link (2007) outlines the historical view on uncertainty, risks and entrepreneurship.

More contemporary definitions of entrepreneurs are elaboration or slight modifications of these earlier contributions. Williamson (1975) argued that the entrepreneur is an agent that reduces transaction costs, suggesting a link to both Knight and Kirzner. Lazear (2005) defined the entrepreneur as someone who specializes in taking judgmental decisions about the coordination of scarce resources. He also suggests that entrepreneurs have a more balanced talent that spans a number of skills. This could be argued to strengthen their "combinatorial capacity", as compared to the more limited role of specialists. In the perspective of the issue we raise, the entrepreneur could be viewed as being endowed with multi-task talent, while the inventor is more of a specialist.[8]

Specific individual capabilities or more psychological characteristics are emphasized in another strait of the literature (McClelland 1961, Carrol and Hannan 2000, Shane 2000, Casson 2005). Some of the research focuses on the role of personal attitudes and characteristics, such as self-efficacy (the individual's sense of competence), collective efficacy, and social norms.[9]

Taking a more general view on the research field of entrepreneurship, Shane and Venkataraman (2000, p. 218) suggest that it comprise the analyses of "how, by whom and with what effects opportunities to produce future goods and services are discovered, evaluated and exploited". Focusing at "whom", a recent eclectic definition of the entrepreneur is provided by Wennekers and Thurik (1999). The entrepreneur is i) innovative, i.e. perceives and creates new opportunities, ii) operates under uncertainty and introduces products to the market, decides on location, and the form and use of resources, and, iii) manages his business

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[8] See Lindbeck and Snower (2000) on multi-tasking.

[9] Schumpeter also considered individual's psychological capacity as the key in identifying opportunities.

and competes with others for a share of the market.[10] Apparently, this definition can be linked to all three classical contributions referred to above. Note that invention is not explicitly mentioned in this definition, nor excluded from the interpretation of entrepreneurship.

To summarize the dominant strands of entrepreneurship theory, they all evolve around the ability to identify and exploit opportunities but differ as to what defines such opportunities. Note also that they are less clear on the source of opportunities, rather they focuses on the exploitation of opportunities. Thus, basically entrepreneurial opportunities are taken as being exogenous. The question is then where do opportunities stem from?

2.1.2 The sources of entrepreneurial opportunity[11]

Since long the idea that opportunities are objective but the perception of opportunities is subjective has persisted in economic theory. Hence, the realm of opportunities is always present, it is the ability to identify such opportunities that determine whether they are revealed and exploited. From a policy point of view that implies a quite fated attitude towards the possibilities to influence entrepreneurial activity within the economy. It seems self-evident that the institutional framework within a society, how the incentive structure is designed, etc., shapes entrepreneurial opportunities. Obviously, these are factors that largely fall under the control of a society and thus impact the opportunity space for entrepreneurs.

Historically the Austrian tradition is probably closest to making the connection between knowledge, opportunity and entrepreneurial activity. While von Mises (1949) defined the market as being driven by entrepreneurs, Hayek (1937, 1945) did relate opportunities to the acquisition and communication of knowledge, albeit he saw it as a part of an economy's strive to attain equilibrium. The continuous move towards an elusive state of equilibrium would

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[10] We adopt the somewhat modified version as introduced by Bianchi and Henrekson (2004). For a classification of entrepreneurs, see also Karlsson, Friis and Paulsson (2004).

[11] I will not address the issue of necessity-based entrepreneurship since this paper deals with the nexus of knowledge, entrepreneurship and growth. See Reynolds et al. (2002).

involve a continuous process of discovery. These thoughts were elaborated and refined by the more modern Austrian school referred to above.

As noted above, Schumpeter's model of economic development involved separate stages: invention (technical discovery of new things or new ways of doing things), innovation (successful commercialization of a new good or service stemming from technical discoveries or novel combinations of knowledge), and imitation (more general adoption and diffusion of new products or processes). However, the origin of opportunity was not explicitly introduced into his model even though there is a reference made to technical discoveries. This simply mirrors that Schumpeter's attention was focused at the entrepreneurial activity, not where opportunities came from. In his own words:

"It is no part of his function to "find" or to "create" new possibilities. They are always present, abundantly accumulated by all sorts of people. Often they are also generally known and being discussed by scientific or literary writers. In other cases, there is nothing to discover about them, because they are quite obvious" (Schumpeter, 1911, p.88).

Hence, there is little doubt that Schumpeter viewed the creation of opportunity as being outside the domain of the entrepreneur. Rather, the exploitation of such opportunities is what distinguishes entrepreneurs, i.e., innovation. Thus, entrepreneurial activity depends upon the interaction between the characteristics of opportunity and the characteristics of the people who exploit them.

The view taken by the contemporary literature on entrepreneurship is basically no different. It is a virtual consensus that entrepreneurship revolves around the recognition of opportunities and the pursuit of those opportunities (Venkataraman, 1997). But the existence of those opportunities is, by and large, taken as given. Shane (2003) presents a discussion concerning the differences between Schumpeterian and Kirznerian sources of opportunity

where it is claimed that only Schumpeterian type of opportunity requires "creation" by the entrepreneur.

A considerable part of the literature is pre-occupied with the cognitive process by which individuals discover opportunities and take the decision to start a new firm. This has resulted in a methodology focusing on differences across individuals in analyzing the entrepreneurial decision (Stevenson and Jarillo 1990, Vosloo 1994, Shane and Venkataraman 2000, Shane and Eckhardt 2003). Shane (2000) has identified how prior experience and the ability to apply specific skills influence the perception of future opportunities.[12] Krueger (2003) underlines that entrepreneurship is about detecting opportunities.[13] Since discovery is a cognitive process, it can take place only at the individual level.[14] Buenstorf (2007) argues that in case of "higher-order opportunity", the entrepreneur is both the creator and the discoverer of opportunity, while Sanders (2007) makes the link between entrepreneurs and knowledge more explicit (and the link to growth).[15]

As pointed out by Audretsch et al. (2006), there is an interesting contrast between most predominant theories of the firm and the entrepreneurial literature's assumption on opportunity. According to the former, innovative opportunities are the result of systematic and purposeful efforts to create knowledge and new ideas by investing in R&D, which subsequently are appropriated through commercialization of such investments (Griliches 1979, Chandler 1990, Cohen and Levinthal 1989, Warsh 2006), which stands in sharp contrast to the entrepreneurial tradition of a given, exogenous opportunity space.

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[12] For different typologies of opportunity, see Sarasvathy et al. (2003) and Plummer et al. (2007).

[13] Holcombe (1998) argues that opportunities stem from entrepreneurs, while Hülsman (1999) refute the entrepreneur as the main agent of growth, and Minniti (1999) emphasize the network externality that may pertain to entrepreneurship.

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

[15] Berglund (2006) claims that there are considerable overlapping between the creation and the discovery of an opportunity.

Nelson and Winter (1982) developed an alternative model where they suggested that opportunity exploitation was shaped by two distinct knowledge regimes associated by different industry contexts. Large incumbent firms are creators of opportunities through purposeful R&D and other knowledge creating efforts, which are referred to as a routinized technological regime. These are then exploited by the same firms, i.e. this regime corresponded to the assumption implicit in the traditional model. By contrast, the entrepreneur or the small firm is considered to have the capacity of exploiting commercial opportunities without engaging in R&D-investments, i.e. they operate under the entrepreneurial technological regime (Winter, 1984).[16]

To conclude, the predominant view seems to be that the opportunity space is assumed exogenous in relation to entrepreneurship whereas the individual abilities determine how entrepreneurs can exploit the given opportunities. This relates to Arrow's (1962) perception of knowledge, stressing that knowledge differs from other factors of production. The expected value of any new idea is highly uncertain, and as Arrow pointed out, has a much greater variance than would be associated with the deployment of traditional factors of production. Arrow emphasized that when it comes to innovation, there is uncertainty about whether the new product can be produced, how it can be produced, and whether sufficient demand for that visualized new product might actually materialize.

2.2 Knowledge in Economic Theory

> *"…the production of inventions and much other technological knowledge, whether routinized or not, when considered from the standpoint of both the*

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[16] The resource-based view (Cooper et al. 1994, Cooper 1995, Penrose 1995, Cooper and Gimeno-Gascon 1992, Cooper et al. 1994, Woo et al. 1989 and Woo et al. 1991) could be argued to represent an alternative view, where the initial endowments of resources are decisive in turning opportunities into start-ups (an survival). Four types of capital is identifies as particularly important: i) general human capital, that serves to spur productivity and access to network resources, ii) management know-how, which alludes to the entrepreneur's previous experience, iii) industry-specific know-how which is mostly tacit and refers to knowledge about business traditions and culture within a given industry, and, finally, iv) financial capital. Dahlqvist et al. (2000) includes a fifth category, access to market and resources.

objectives and the motives which impel men to produce them, is in most instances
as much an economic activity as is the production of bread." (Schmookler 1966)

As discussed in the previous section, even though not explicitly modeled, knowledge seems to be one critical underlying determinant of the opportunity space. Notwithstanding there are a number of other factors that influences opportunity, e.g. the extent to which the economy is regulated or the amount of social capital possessed by individuals, the discussion here will center around economic knowledge and how that links to the individual possibilities and occupational choice.

The observed surge in knowledge investments – measured as R&D – in the last couple of decades is paralleled by an increased academic interest of various aspects of knowledge, i.e. its definition, its generation, its diffusion, its appropriability, and how it relates to growth.[17] The definitions of knowledge do however vary considerably within the economics literature. This is hardly surprising considering the multi-dimensional character of knowledge. It stretches from basic education to individuals' capacity to upgrade their competence, outlays on R&D, managerial and organizational know-how, etc. The knowledge space is in itself unbounded, implying that decisions will be taken under "bounded rationality" and will always be influenced by subjectivity (Simon 1955).

2.2.1 Knowledge – how to define it?

In principle there is a dividing line in economics where knowledge is defined as either an object or a process. Preceding that discussion is the question how information and knowledge are related to each other. Sometimes information is defined as data that can be easily codified, transmitted, received, transferred and stored. Knowledge, on the other hand, is seen as consisting of structured information that is difficult to codify and interpret due to its

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[17] See also Marshall (1890), Teece (1986, 1988) and von Hippel (1988).

intrinsic indivisibility. Part of knowledge will always remain "tacit" and thus non-codifiable (Polyani, 1966).

In contrast to information that may be interpreted as factual, knowledge may be considered as establishing generalizations and correlations between variables. Knowledge is also cumulative in the sense that the better known a field, the easier it is to assimilate new pieces of knowledge within this field. Generally, knowledge can be described somewhere between the completely tacit and the completely codified. Tacit, sticky or complex knowledge, i.e. highly contextual and uncertain knowledge, is best transferred via face-to-face interactions, since knowledge assets are often inherently difficult to copy (von Hippel 1988). The ability to indulge knowledge relate to human cognitive abilities to absorb and select among available information. Proximity thus matters since knowledge developed for any particular application can easily spill over and find additional applications.

An alternative way of classifying knowledge is to allure to its origin.[18] Three main categories have been defined:

- *Scientific knowledge*, i.e., scientific principles that can form a basis for the development of technological knowledge.

- *Technological knowledge* – implicit and explicit blueprints – in the form of inventions.

- *Entrepreneurial knowledge* that comprises business-relevant knowledge about products, organization, markets, customers, etc.

The first two definitions of knowledge are more associated with incumbents, such as firms or universities. This relates to the characteristics of knowledge described as the degree to which it is rivalrous and excludable (Arrow 1962). A purely rivalrous good has the property that its use by one economic agent precludes its use by another. Excludability relates to both technology and legal systems and thus to the possibilities of inventors to appropriate

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[18] See Karlsson et al. (2004).

the returns of their inventions. A good is excludable if the owner can prevent others from using it. Technological knowledge may be perceived as a non-rivalrous, but partially excludable good due to legislation on intellectual property rights (IPRs), i.e. patenting and copyrights. Its non-rivalrous character stems from that technological knowledge is inherently different from other economic goods. Once the costs of creating it have been incurred, it may be used repeatedly at no additional cost. Romer (1994) elaborates on the differences between generic technological knowledge – wich is a public good – and specific technological goods which can be appropriated by firms.

The third category, "entrepreneurial knowledge", comprises specific knowledge tied to the market and the functioning of an economy. It actually closely connects to what is required in order to introduce an innovation, i.e. a new product, a new process, a new market, a new source of supply or a new organization (Schumpeter 1911). An innovation can be either an application of entrepreneurial knowledge or the combined result of technological and entrepreneurial knowledge. Audretsch et al. (2006) introduce a production factor called *entrepreneurship capital*, arguing that this is related to the more general concept social capital. Entrepreneurship capital reflects a number of different legal, institutional and social factors and forces. Altogether these factors constitute the entrepreneurship capital of an economy, which creates a capacity for entrepreneurial activity.

Taking this institutional aspect one step further, Acs et al. (2004) argue that the exploitation of knowledge depends on the broad spectrum of institutions, rules and regulations, or, in their terminology, an economy's *knowledge filter*. The knowledge filter is the gap between new knowledge and economic knowledge or commercialized knowledge (Arrow 1962). The greater is the knowledge filter, the more pronounced is this gap between new knowledge and new economic – that is commercialized – knowledge.

Hence, there will always be restrictions on the access to knowledge and measuring knowledge will always be partial. Indeed, even if the total stock of knowledge were freely available, knowledge about its existence would not necessarily be. In the tradition of Adam Smith, Hayek (1945) concluded that a key feature of a market economy is the partitioning of knowledge among individuals. Knowledge is thus highly decentralized and therefore partially non-codifiable. Consequently, in contexts where knowledge (particularly new) plays an important role and is associated with a greater degree of uncertainty and asymmetries across economic agents, there will be divergence in the valuation of new ideas across economic agents, or between economic agents and decision-making hierarchies of incumbent enterprises. That constitutes one fundamental source of entrepreneurial opportunity and also implies a market structures dominated by imperfect information and imperfect competition.

2.2.2 Knowledge, individual ability and occupational choice

Retaining the assumption for the moment that opportunity is exogenous, why do individuals choose to become entrepreneurs? The economist's answer is quite straight-forward: ceteris paribus individuals evaluate whether the expected return from remaining an employee is higher as compared to start a new firm. If the gap in the expected return accruing from a potential entry is sufficiently large, and if the cost of starting a new firm is sufficiently low, the employee thus decides to establish a new enterprise.

How does knowledge influence the choice? A growing empirical literature (see section 3.1) suggests that entrepreneurial startups constitutes an important link between knowledge creation and the commercialization of such knowledge, particularly at the early stage when knowledge is still fluid. That is, individuals who possess the ability to detect such opportunities also embark on entrepreneurial activities. Then, where does ability stems from?

As discussed in section 2.1.2, one strand of the literature claim that discovery of entrepreneurial opportunities has to do with cognitive processes. An interesting approach to

heterogeneity in entrepreneurial ability is suggested by Sternberg (1985) in his Triarchic Theory of Human Intelligence which distinguishes between creative, analytical and practical intelligence. Creative intelligence is associated with divergent thinking and generation of new ideas, the ability to deal with new situations and to see opportunities where others do not. Analytical intelligence, on the other hand, is associated with abstract thinking and logical reasoning and the ability to evaluate and solve a given problem. Finally, practical intelligence is associated with the ability to apply knowledge to the real world, e.g. to create a market where one do not exist and to go from an abstract idea to a concrete product. According to Sternberg (2004, p. 196), "One needs the creative intelligence to come up with new ideas, the analytical intelligence to evaluate whether the ideas are good ones, and the practical intelligence to figure out a way to sell these ideas to people who may not want to hear about them". What is important to entrepreneurial success is the combination of the three types of intelligences, which Sternberg (1997) refers to as "successful intelligence".[19]

Combining Sternberg, Hayek, Arrow and the cognitive school, the occupational choice could be illustrated in a simple model where an economy endowed with a population of L individuals that live for two (or more) periods. In the first period incumbents employ all individuals, but between periods they make intertemporal choices between remaining an employee or becoming an entrepreneur. Due to the uneven distribution of entrepreneurial ability $(\overline{e_i})$, i.e. successful intelligence, individuals (i) at the higher end of the distribution will identify more opportunities to commercially exploit as compared to individuals with lower ability. By combining given entrepreneurial capacity with the aggregate knowledge stock (A) in an economy operating at efficiency level σ (which is an efficiency parameter that influences entrepreneurial opportunity), a certain share of the population (L_E) will identify

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[19] Thulin (2007), building on Sternbergs findings, presents an interesting model where occupational choice depend on the individual's relative endowment of the respective type of ability.

profitable opportunities in running their own firms and become entrepreneurs (e_i) in the periods sequencing the first. Thus, at a given point in time,

$$e_i = f(\overline{e_i}, A, \sigma), \quad \sum_{i=1}^{L} e_i \equiv L_E \tag{1}$$

As a share L_E shift from being employees to become entrepreneurs, part of the given aggregate knowledge stock will be exploited in the commercialization process.[20] Simultaneously, L_E could also be interpreted as belonging to the knowledge stock (entrepreneurial knowledge), as well as augmenting the existing knowledge stock through entrepreneurial activity thereby introducing new products, new ways of organizing production or simple by defining a market niche.

Note that this simple model has obvious policy implications. A policy that increases the probability of success, e.g. by reducing the regulatory burden or making knowledge more accessible (increasing efficiency), increases the expected return from becoming an entrepreneur. Similarly, policies that increase the expected pay-off even though the probability of success is held constant, such as tax-cuts, tend to encourage more of entrepreneurial activity. But it also suggests that increasing the stock of knowledge (A) has a similar effect on entrepreneurial activities. Moreover, it provides us with an instrument that connects entrepreneurship, knowledge and growth, where entrepreneurship and growth is endogenized through investment in knowledge. Appropriate policies can then set of a virtual cycle characterized by knowledge investments, entrepreneurship and growth.

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[20] Compare Murphy, Schleifer and Vishny (1991).

2.2.3 Entrepreneurship and the knowledge spillover theory

From the section above it can be concluded that entrepreneurs seem to be one crucial vehicle in transforming knowledge into useful goods and services. In other words, spillovers are actually generated through entrepreneurs, simultaneously as commercial opportunities is increasing in a larger stock of knowledge. In fact, the supply of entrepreneurs can (ceteris paribus) be modeled as a function of the societal investments in knowledge. More precisely, from equation 1 entrepreneurship is a function of the i) existing knowledge stock (A) at a given point in time, and ii) how efficient the economy works (σ, e.g low barriers to entrepreneurship increases the efficiency), and iii) given entrepreneurial ability. In addition, culture, traditions and institutions, i.e. more or less non-measurable factors, influence entrepreneurship. Those insights provided the foundations for the The Knowledge Spillover Theory of Entrepreneurship, developed by Acs et al. (2006).

It is indirectly linked to the endogenous growth model since it challenges two of the fundamental assumptions implicitly driving those models. The first is that knowledge is automatically equated with economic knowledge, cf. Arrow's (1962) insight which underlined that knowledge is inherently different from the traditional factors of production. The knowledge that entrepreneurs use as they introduce an innovation to the market is likely to be quite different from the knowledge used in R&D-laboratories or by scientists. Entrepreneurs and researchers employ different subsets of the societal knowledge stock in their activities. The second challenge involves the assumed spillover of knowledge. The existence of the factor of knowledge is equated with its automatic spillover, i.e. knowledge will be used in some commercial application, yielding endogenous growth.

The model has the following basic structure.[21] It consists of a demand side, a supply side, and a financial market. To make the model more transparent, only two types of firms are allowed: incumbents that undertake R&D to improve existing products where they utilize

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[21] For details, see Acs et al (2006).

previous R&D-findings associated with that particular product (a sub-set of the knowledge stock), and entrepreneurial start-ups that exploit the existing stock of knowledge in a broader manner 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. 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 producing final goods (L_F). Perfect mobility across sectors assures that wages are equalized. In the long run, entry implies that profits are zero.

On the demand side consumers maximize standard linear intertemporal utility, where the most recent innovated product or variety, contain the improved quality or the novel features of the product. 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.

Turning to the supply of goods, new products/qualities can either be invented by incumbent firms investing in R&D by hiring labor that undertakes research, where increased employment of R&D-workers enhances the probability of a successful entry. Entrepreneurial start-ups, where existing knowledge is combined in innovative ways, do not require any investment in R&D. Instead, individuals combine their given entrepreneurial ability ($\bar{e}_i$, where higher ability increases the probability of success) with the overall knowledge stock (A) 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 with

novel ways of producing and distributing in traditional businesses, changing business models, new marketing strategies, etc.[22]

Thus, the first type of entry (incumbents) occurs due to increased R&D-expenditures, i.e. a *flow* variable, while the second type of entry – entrepreneurs – draws on the overall *stock* of knowledge and applies it in a novel way. Entry is thus modeled in a way that more closely follows real world behavior. Each type of firm has a certain probability of success, related to R&D-investments, the knowledge stock and entrepreneurial ability in the economy.

All entry implies that some fixed costs are incurred, e.g. R&D or other entry costs such as marketing. Both types of firms are dependent on capital injections to finance entry that is supplied by the financial market, which 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.[23]

It is consistent with evolutionary approaches to economic development, albeit deviates from the traditional view on new firms and SMEs (small and medium sized enterprises).[24] For example, in Jovanovic's (1982) model new firms, or entrepreneurs, face costs that are not only random but also differ across firms. A central feature of the model is that a new firm does not know what its cost function is, that is, its relative efficiency, but rather discovers this through the process of learning from its actual post-entry performance. Hence, they only discover their true ability once their business is established. The evolutionary models suggest that entry and small firms will stimulate and generate economic development and growth.

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[22] Both types of entry are assumed to occur through a Poisson process.

[23] Finally, maximizing intertemporal utility subject to a budget constraint closes the model. It can then be shown that utility is increasing in new and high quality goods.

[24] See also Ericson and Pakes 1995, Audretsch 1995a, Hopenhayn 1992, Lambson 1991 and Klepper 1996.

2.3 The Knowledge-Based (Endogenous) Growth Theory and Entrepreneurship

"...the effect of entry may actually be more profound than just correcting displacement from static equilibria, since entry may also stimulate the growth and development of markets." Geroski (1995, p. 431)

In this section I will go through contemporary explanations of growth, then scrutiny the microeconomic foundations of the knowledge-based growth models and finally present a modified, entrepreneurially driven growth model.[25] But before dwelling into the knowledge-based growth models, let us briefly recapitulate the building blocks of the neoclassical model that constituted the dominant growth paradigm between 1930/40 and 1980/90.

One of the model's most appealing features was transparency and intuitive logic. The building blocks were the supply of labor and capital investments (including human capital in its later versions), together with a "shift" factor. Moreover, the "golden rule" of the neo-classical growth regime held that investments were determined by the increase in labor supply. The mechanism was as follows: to much capital in relation to labor would drive down interest rates below the equilibrium level, and thus halt further investments, whereas to little capital in relation to labor would lead to an upward pressure on interest rates that would spur more investments.[26] Hence, policies to foster growth focused on optimizing the relationship between investments and labor in order to obtain steady state equilibrium growth. Despite its clarity and elegance, the model suffered from a major deficiency: empirical testing showed that little explanatory power could be attributed the capital and labor variables, rather a third, unidentified, factor was driving growth. Even though this factor remained unidentified, it

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[25] As pointed out by Eliasson (1991) in his model on the experimentally organized economy, eeconomic growth can be described at the macro level but never explained at that level. Economic growth is basically a result of experimental project creation and selection in dynamic markets and in hierarchies combined with the capacity of the economic system to separate winners from losers.

[26] The equilibrium rate is related to the rate of time preferences in consumption, i.e. the changes of consumer prices over time that would induce intertemporal shifts in consumption (see Braunerhjelm 2005).

became known as the "technical residual" since it was assumed to pick up new knowledge, both technological and organizational (Solow 1956, 1957, Denison 1968).

The seminal contribution of the knowledge-based (endogenous) growth models that appeared in the mid 1980s was to show that investments in knowledge and human capital were undertaken by profit-maximizing firms in a general equilibrium setting.[27] Whereas firms invested in R&D to get a competitive edge over its competitors, part of that knowledge spilled over to a societal knowledge stock that influenced the production function of all other firms, augmenting their productivity. Hence, growth was disentangled from investments in capital and increases in labor supply: even if those remained constant, increases in knowledge meant that growth would increase.

The first wave of endogenous growth models (Romer 1986, Lucas 1988, Rebelo 1991, and others) emphasized the influence of knowledge spillovers on growth without specifying *how* knowledge spills over. Yet, the critical issue in modeling knowledge-based growth rests on the spillover of knowledge. Hence, while *knowledge production was kept exogenous* in the traditional neoclassical growth model, *knowledge diffusion* – the critical mechanism in generating growth – *is exogenous* in the endogenous growth models. That is, even though an economy invests heavily into R&D, the mechanisms by which this knowledge spills over and is converted into goods and services, is basically unknown (Acs et al. 2004).

This was to some extent remedied in the second generation of endogenous growth models (Schmitz 1989, Segerstrom, Anant and Dinopoulos 1990, Segerstrom 1991, Aghion and Howitt 1992, Cheng and Dinopoulos 1992, Segerstrom 1995). Predominantly the neo-Schumpeterian models design entry as an R&D race where a fraction of R&D will turn into successful innovations. While this implies a step forward, the essence of the Schumpeterian

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[27] As pointed out in a previous section, the difference between this vein of the literature and the entrepreneurship literature is striking. Whereas the latter considers opportunity to exist exogenously, the new economic growth literature opportunities are systematically and endogenously created through the purposeful investment in R&D.

entrepreneur is missed. The innovation process stretches far beyond R&D races that predominantly involve large incumbents and concern quality improvements of existing goods.

In the most recent vein of knowledge-based growth models the focus is narrowed to some well-defined research issues. Most prominent among those are the effects of technology-based entry on the innovativeness and productivity of incumbents, the organization of firms in order to maximize absorptive capacity, and the implications of firm heterogeneity on creative destruction and growth. As regards the first issue, the analysis follows an industrial organization tradition that examines the effects of preemption, entry regulation, strategic interaction, etc. (Gilbert and Newbery 1982, Tirole 1988, Laffont and Tirole 1993, Nickell 1996, Blundell et al. 1999, Berry and Pakes 2003, Aghion et al. 2006). The new element is that these models take into account the effects of competition and innovation of both incumbents and new firms. For instance, Aghion et al. (2006) show that entry – or entry threats – has positive effects on the innovative behavior by incumbents close to the technological frontier, while no such effects could be found for technolological laggards. They coin these effects as "escape-entry" effect and the "discouragement effect" and draw policy conclusions related to the diverse effects across industries.[28]

The second strand is more peripheral to the aim of this paper. It deals with the organization of the firm, this absorptive capacity and builds on the principal-agent literature.[29] The main findings are that firms being closer to the technological frontier, operating in a more heterogeneous environment or recently being established, tend to organize their businesses in a more decentralized way in order to optimize their capacity to absorb knowledge spillovers (Acemoglu et al., 2006).

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[28] For a survey on this vein of the literature, see Aghion and Griffith (2005).

[29] See Sah and Stiglitz 1986, Radner 1992, Geanakoplos and Milgrom 1991, Aghion and Tirole 1997 and Hart and More 2005.

Finally, and more interesting for the purpose of this paper, is the analysis of firm heterogeneity, entry, and productivity. The basic reasoning is that elevated firm specificity in performance (stock evaluation, profits, etc.) is associated with a growing number of smaller and new firms (Pastor and Veronesi 2005, Fink et al., 2005). Moreover, firm specificity is seen as reflecting creative destruction, enhanced efficiency and higher productivity and growth (Durnev et al. 2004, Aghion et al. 2004, 2005, Acemoglu et al. 2003, 2006 and Chun et al., 2007). An increased influence of small firms and start-ups is associated with deregulation, increased competition, etc., but also because new and young firms are more prone to exploit new technologies or knowledge (Jovanovic and Rousseau 2005).

Thus, notwithstanding that knowledge-based growth models implied a huge step forward in understanding growth, there is only a dim understanding of the working of these growth mechanisms.[30] As apparent from a number of empirical studies, the support for knowledge variables as explanations of growth is, to say the least, ambiguous (Jones 1995a, 1995b, 2006). The exact operations of these mechanisms – i.e. knowledge spillovers – have important bearings on the effective evolution of economies and on policy conclusions. Below I intend to highlight how the introduction of the "pure" Schumpeterian entrepreneur influences knowledge spillover and how knowledge thereby can be more or less smoothly filtered and substantiated into business activity. This theory provides some reconciliation between the two different views by providing the *missing link* between opportunity and economic growth (Acs et al. 2004). But before the modified growth model is described, let us go back to the microeconomic foundations of contemporary growth models.

2.3.1 The microeconomic foundation of contemporary growth models

Scrutinizing the knowledge-based growth models reveals that it rests on three cornerstones: knowledge externalities, increasing returns in the production of goods, and

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[30] See also Antonelli (2007) on his "economics of complexity".

decreasing returns in the production of knowledge. These are considered to provide a microeconomic foundation for explaining the mechanisms that promote growth at the macro level.[31] I will argue that present knowledge-based growth theories need to be redefined in order to include the "genuine" entrepreneur, i.e. the individual as described in section 2.1 who recognizes an opportunity but does not necessarily gets involved in R&D-investments.

As a first criticism I will consider the capabilities of incumbents to absorb knowledge spillovers. If we take the view proposed by Cohen and Levinthal (1990) that at any given point in time absorption capacity depends on the knowledge accumulated in prior periods, absorption and transformation of knowledge into useful knowledge becomes path dependent. The potential advantages in knowledge sourcing are often impeded by the inherit incentive structures within the firm. As argued by Christensen (1997), the intertemporal dynamics within large enterprises to attain established growth targets tend to make incumbents less adapt to change a system that may affect the usefulness or value of an existing production structure. Similarly, Aldrich and Auster (1990) make the simpler argument that the larger and older the firm, the less receptive to change the organization becomes. As a result, incumbents have an inherent tendency to develop and introduce less-risky, incremental innovations into the market.

Contrast that with new ventures. These are more prone to develop, use, and introduce radical, market-making products that give the firm a competitive edge over incumbents (Casson 2002a, 2002b, Baumol 2007). Thus, new firms are not constrained by path dependencies and partial lock-in effects, rather they compete through innovation and Schumpeterian manners of creative destruction. That also suggests that radical innovations

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[31] Undisputedly an evolution characterized by innovations, commercialization, entry of new firms and dynamism, depends on the presence of a wide set of factors, ranging from a proper design of the legal framework and institutions (property rights, taxes, etc.), access to venture capital, relevant networks to complementary competencies, to culture, etc. (North and Thomas 1973, Nelson 1994, 2002, Nelson and Winter 1982, Feldman 1999, Acs and Audretsch 2003, Shane 2003). In this section we will narrow the analysis to the entrepreneur, assuming that these other prerequisites are already in place.

will more likely stem from new ventures (Scherer 1980, Baumol 2004), in particular if new firms have access to knowledge spillovers from the available *stock* of knowledge. Therefore they are likely to play a distinct and decisive role in the transformation of knowledge-based economies.

To complement and extend existing growth models, new and small firms that are central to the transformation of knowledge into economic applications, must be inserted to contemporary growth models. Thus, both the individuals and the contexts in which agents operate have to be integrated in the model. In other words, the individual-opportunity nexus has to be operationalized.

2.3.2 A simple model involving genuine entrepreneurs and growth

To illustrate the role of entrepreneurs in growth I take the model of Romer (1990) as the departure point.[32] I will outline the basic structure of the knowledge-based growth model and then introduce the "genuine" entrepreneur into this model. First, assume that there are two methods of developing new products, just as outlined in the knowledge spillover theory of entrepreneurship (section 2.2.3); research labs in incumbent firms and entrepreneurs. There exist three factors of production: labor, capital goods, and entrepreneurship. Markets are characterized by monopolistic competition (due to heterogenity imposed by different valuation of knowledge), i.e. firms compete with diversified products that are exposed to economies of scale in production. Some individuals are inherently better at performing entrepreneurial activities.

Second, just as in the traditional growth model, researchers develop new varieties of new goods or way of organizing business activities by investing in R&D. The novelty is that I will add the entrepreneur as a factor of production who introduces new goods or business models, but will not be involved in R&D-activities. Rather, entrepreneurial activity is the sum

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[32] For the full model, see Braunerhjelm et al (2007).

of inherited and different abilities across individuals (section 2.2.2.), the knowledge stock and how conducive the economy is to entrepreneurial activities.[33] In addition, which also is consistent with the original growth model, entrepreneurs also contributes with new knowledge as they undertake an entrepreneurial act.[34]

An economy's laborforce can then be distributed across three sectors: R&D-staff, final goods production and those engaged in entrepreneurial activities. The economy is endowed with a stock of knowledge (A) at a given point in time. Due to the assumption of decreasing returns to scale ($\gamma < 1$) in entrepreneurial activities – doubling the number of people engaged in entrepreneurial activities will not double the output of new knowledge and varieties - the aggregate production function (Z) for entrepreneurs can be written as,

$$Z_E(L_E) = \sigma_E L_E^\gamma A, \quad \gamma < 1 \tag{2}$$

where σ_E represents efficiencies in an economy that impacts entrepreneurship. Similarly, in its simplest form, the aggregate production function for research activities can be written as,

$$Z_R(L_R) = \sigma_R L_R A \tag{3}$$

where research production is positively influenced by a larger knowledge stock and higher efficiency.

As a side effect of their efforts, researchers and entrepreneurs produce new knowledge that will be publicly available for future use, positively influencing coming generations of

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[33] To some extent this links to the recombinant growth literature (Weitzman 1998, Olsson and Frey 2002).

[34] Where failure contain the same valuable information as success (which is the same as for researchers).

research and entrepreneurial activities. Equation 4 describes the production of new knowledge, i.e. the evolution of the stock of knowledge, in relation to the amount of labor channeled into R&D (L_R) and entrepreneurial activity (L_E),

$$\dot{A} = Z_R(L_R) + Z_E(L_E) \qquad (4)$$

where $\dot{A}$ represents the time derivative. Substituting from equation 2 and 3,

$$\dot{A}/A = \sigma_R L_R + \sigma_E L_E^{\gamma} \qquad (5)$$

The rate of technological progress is thus an increasing function in R&D, entrepreneurship and the efficiency of these two activities.

Implementing the same theoretical modeling devices as in the standard growth model, it can be shown that an equilibrium steady-state growth rate (g) is attained for a certain distribution of employment between entrepreneurs and R&D-staff,

$$g = \frac{\dot{A}}{A} = \sigma_R L_R + \sigma_E L_E^{\gamma}, \qquad (6)$$

and that equilibrium steady state growth is characterized by

$$\frac{\dot{Y}}{Y} = \frac{\dot{C}}{C} = \frac{\dot{K}}{K} = \frac{\dot{A}}{A}, \qquad (7)$$

implying that output, consumption, investments and knowledge, all grow at the same rate. Moreover, the model implies that a sub-optimal distribution between entrepreneurs and R&D-employees will lower growth below its optimal, long run steady state level. Consequently, this simple model of knowledge-based growth includes "genuine" entrepreneurs and incumbents, providing a more realistic microeconomic foundation for growth that can be exposed to empirical testing.

2.4 The Spatial Dimension: Entrepreneurs and the New Economic Geography Theory

"...the play of the forces in the market normally tends to increase, rather then to decrease, the inequalities between regions." (Myrdal 1957, p. 26)

I have concluded that knowledge, together with individual ability, defines opportunity. In addition, it was shown how entrepreneurship is endogenized in the stock of knowledge and how it contributes to growth. Related to that is the discussion regarding geographical proximity in order to access knowledge where previous studies confer that face-to-face interactions may be important. Hence, this suggests that there is a spatial dimension to opportunity, entrepreneurship and growth.

The spatial dimension of economic activities has pre-occupied an increasing number of researchers and politicians since long; however, a new wave of research in this field took off the 1980s. The starting point of the new economic geography theory (irrespective of the fact that many of these insights were also advanced in the "old economic geography", albeit not modeled in the same rigorous way) is the observation that for a number of countries economic activities are not evenly distributed across space.[35] The existence of scale economies is central, since without them economic activities would be evenly dispersed (there would be no trade-off between proximity and trade costs). Thus, these models feature cumulative causation

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[35] See Braunerhjelm et al (2000) for a survey of the economic geography literature.

(Myrdal 1957) through positive and negative feedbacks.[36] Such feedbacks – or linkages – are of two types: Pecuniary, which refers to demand and supply linkages which influence costs and prices, and non-pecuniary, which refers to knowledge spillovers.[37] The latter is of prime interest here.

Contemporary research has quite recently elaborated the link between growth and spatial concentration. Theoretically it can be shown that when knowledge-abundant locations have reached a certain level, they tend to attract location of other entrepreneurs and firms, and a self-perpetuating growth mechanism is induced into the system.[38] Related studies that excavate somewhat deeper into the agglomeration mechanisms indicate that mobility in skill is the main candidate that induces agglomeration. Also economic historians have investigated the role of agglomerations for growth. For instance, Hohenberg and Lees (1985) claimed that cities are social institutions where innovations are fostered complex through market and non-market interactions.[39]

More precisely, geographical proximity is needed to transmit knowledge. Technological and entrepreneurial knowledge and innovations emerge uniquely out of regions not simply because one or the other was endowed with a certain initial stock of factors of production, but because many of the assets necessary to compete are created as industries and clusters develop. Consequently, innovation processes are to a high extent localized processes, since innovation concerns the exchange of complex knowledge, which mainly takes place within

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[36] At some point the negative feedbacks will deter further relocation into a region. If most production factors are immobile, an inflow of mobile factors of production will in a relatively short period induce price increases on the immobile factors such that other regions will appear attractive in terms of cost levels.

[37] A different approach is pursued by Porter (1990), who launched the term cluster, where the success of firms depend on the vertical and horizontal links that firms develop in a system composed of certain key actors ("the diamond"). Porter (1998) also underlines the productivity effects related to clusters.

[38] See Waltz (1996), Baldwin (1999), Baldwin and Forslid (2000), Black and Henderson (1999), Fujita et al. (1999), Martin and Ottaviano (1999, 2001), Baldwin, Martin and Ottaviano (2001), Fuijta and Thisse (2002) and Hendersson and Thisse (2004).

[39] In the urban economics vein of the literature, the forces of agglomeration are attributed higher learning, division of labour (economies of scale) and sharing effects (Jacobs 1969, Black and Henderson 1999, Henderson and Thisse 2004).

the borders of a region.[40] Innovation processes are thus governed by interdependencies, complementarities and networking between the different actors. The innovation capabilities stem from the interplay between generic knowledge and learning processes highly "localized" and embedded in the knowledge and market environment of each region.

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[40] This links to the regional innovation systems (RIS) approach, see Lundvall (1992) and Antonelli (1995, 1997).

3. The Empirical Evidence

"The errors which arise from the absence of facts are far more numerous and more durable than those which result from unsound reasoning respecting true data" (C. Babbage, quoted in Rosenberg, 1994, p. 27)

What empirical evidence can be provided on the asserted mechanisms and links between entrepreneurship, knowledge and growth in the previous sections? Albeit still scattered, evidence has indeed begun to pile up suggesting that knowledge exploitation, industrial dynamics and growth is associated with the presence of entrepreneurial activities.

The objective of this section is to provide an overview of some of the more recent empirical contributions, emphasizing the role of the entrepreneurial firm in knowledge sourcing, knowledge exploitation and the ensuing effects on growth at the regional and national level.

3.1. Empirical findings at the micro-level

3.1.1 Entrepreneurs, innovation and firm growth

Starting at a disaggregated level, the question is whether entrepreneurs and small firms contribute with innovations and which firms exhibit growth? A series of articles by Hall (1987), Geroski (1995), Sutton (1998) and Caves (1998) summarize the empirical literature on the relationship between firm size and growth within the North American context. According to this literature a stylized fact is that, when a broad spectrum of firm sizes is included in samples of U.S. enterprises, smaller firms exhibit systematically higher growth rates than their larger counterparts. Audretsch (1995a) reach similar conclusions, but stresses that the growth advantage of small and new firms vis-à-vis large enterprises are even greater in high technology industries.

There are numerous studies using European data that corroborates the U.S. results, i.e. small and new firms tend to exhibit higher growth, thus rejecting "Gibrat's Law".[41] These findings are summarized by Audretsch et al. (2006). Of particular interest here is Almus's and Nerlinger's (2000) analysis, using a large panel database to examine how the post-entry performance of new firms varies across sectors. They find that the growth rates of new firms generally tends to be higher, but particularly so in the most high-tech industries. Similar results are presented by Heshmati (2001) who has examined the relationship between firm size, age and growth for a large sample of small firms in Sweden between 1993-1998.

As classified by Audretsch et al. (2006), even though there is some ambiguity in the studies linking growth and survival to firm size and growth, the results for Europe generally mirror the results found within the North American context. That is:

1. Growth rates are higher for smaller enterprises

2. Growth rates are higher for younger enterprises

3. Growth rates are even higher for small and young enterprises in knowledge-intensive industries

4. The likelihood of survival is lower for smaller enterprises

5. The likelihood of survival diminishes for small and recently established firms in knowledge-intensive enterprises

As regards employment growth, numerous analyses have shown that new jobs primarily originate in a large number of small firms (Brown et al. 1990, Loveman and Sengenberger 1991, Davidsson et al., 1994, 1996). Even though there seems to be an emerging consensus that SMEs are the main contributors of net job creation, this effect has been debated. Davies et al. (1996). Kirchoff and Greene (1998) and Bednarzik (2000), implementing U.S. data,

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[41] A wave of studies has confirmed these findings for different European countries, including Portugal (Mata, Portugal and Guimaraes, 1995 and Mata, 1994), Germany (Wagner, 1992), Tveteras and Edide (2000) and Klette and Mathiassen (1996) for Norway, and Italy (Audretsch and Vivarelli, 1996).

claim that expansion of large firm primarily contributes to new employment. The results have been criticized by Carre and Klomp (1996), arguing that small firms relatively have a much stronger impact. Davidsson et al (1998) refute the Davies et al criticism in an econometric analysis, while Baldwin and Picot (1995) confirm that small firms are more volatile with regard to employment effects, but on average do provide more new jobs then larger firms.[42]

The patterns seem however to differ between the U.S. and Europe. While in Europe the main effect accrues to firms employing one or two new persons (Wiklund 1998, Andersson and Delmar 2000), growth in the U.S. is claimed to be dominated by a small number of new entrepreneurial firms exhibiting extraordinary growth ("gazelles"). Of course, gazelle effects also exist in other countries (Wiklund and Shepherd 2004). They can also be found in all types of industries – examples include Amazon, Apple, Cisco, IKEA and Starbuck – even though they seem to emerge more frequently from exploiting new knowledge (at least in the U.S.). The alleged reasons to these differences may be the institutional set-up as argued by Storey (1994) and Davies and Henrekson (1997).

Apart from creating employment, new and growing firms introduce products, processes, and business model innovations, develop new markets and change the rules of the game of their industries (Bhide 2000). In those processes knowledge is exploited and innovations introduced, which is likely to render substantial knowledge spillovers. Still, the most frequently used measure of invention is patents, suggesting a certain knowledge content and sophistication in a new good or service. But the implication is that only a subset of innovations are taken into account in those measures.

The influx of firms also impacts industrial dynamics, knowledge transformation and economic growth, increasing the "adjustment pressure" by intensifying competition and

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[42] See also Acs, Armington and Robb (1999) and Heshmati (2001) for a discussion of the methodological problems in estimating the effects on the supply of jobs. Braunerhjelm (1996) and Kwoka and White (2001) find that there are huge differences across firms and industries, which they explain by differences in sunk costs of entering a market or an industry.

exploiting opportunities. However, these dynamic effects have largely been ignored according to Kirzner (1973), Geroski (1995), and Nickell (1996). Similarly, exits are the other critical component of dynamics, not least because it releases the resources needed in expanding other parts of the economy. This part of the creative destruction process is however even less researched.

3.1.2 Knowledge sourcing, innovation and entrepreneurs

Despite modest R&D investments, small and entrepreneurial firms contribute substantially to aggregate innovation (Audretsch 1995b; Feldman and Audretsch 1999). Micro studies suggest that entrepreneurs/small firms have their knowledge producing activities spread across a number of different functional areas apart from formal R&D activities (Freel 2003) and that these firms draw on many knowledge sources other than R&D in their innovation (Shane 2000). Thus, many entrepreneurs and small firms exploit existing knowledge – through their network and links to other knowledge producers – to satisfy their specific needs in the production of goods and services. Thereby they also produce new knowledge, even if it does not show up in the R&D-statistics. Almeida and Kogut (1997), and Almeida (1999), show that small firms innovate in relatively unexplored fields of technology. Before that, Rothwell and Zegveld (1982) claimed that smaller firms more frequently introduced radical innovations. Baumol (2004) makes the same argument.

In a couple of papers Acs and Audretsch (1988, 1990) provide interesting results for the U.S. Notwithstanding that the large corporations account for most of the country's private R&D investments, there are substantial differences across industries and large firms did not account for the greatest amount of innovative activity in all industries. For example, in the pharmaceutical and aircraft industries the large firms were much more innovative, while in computers and process control instruments small firms contributed the bulk of innovations. More precisely, their results indicate a small-firm innovation rate in manufacturing of 0.309,

compared to a large-firm innovation rate of 0.202. Their findings links to the suggested restraints on innovation capacities in large firms discussed in section 2.3. Similar results are obtained by Baldwin and Johnson (1999), who confer a particular important role to small firm innovations in the electronics, instruments, medical equipment and biotechnology industry. Baldwin (1995) suggests that more successful firms adopt more innovative strategies.

The results are extended later by Acs et al. (1994), Acs (1996) and Audretsch and Vivarelli (1996), where the importance of proximity to knowledge nodes such as universities is investigated. It is shown that the innovativeness is substantial and increasing in the presence of universities. The effect is attributed knowledge spillovers. Audretsch (1995b) addresses the same problem from a somewhat different angle, showing that start-ups are more likely in industries in which small firms account for a greater percentage of innovations. This could be interpreted as if firms do exploit knowledge that originates from sources outside the industry leaders.[43]

Thus, public research and universities may constitute an important source for knowledge that is used in commercialization. It is frequently told that the U.S. system – where the IPRs belong to the universities (the Bayh-Dole Act of 1980) – perform much better than the European system, which to a larger extent is based on the individual researcher having the IPRs. However, this is presently widely debated and studies point in different directions. Some studies provide evidence to show that the extent of the commercialization effects of European public research is underestimated. A study on Belgium, Finland, France, Germany and Italy (Balconi et al., 2004) claims that university initiated patents (although not owned by the universities) are considerably more numerous than measurements of university linked patents reveal. Similar results are reported by Meyer (2003), Sargossi and von Pottelsbergh de

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[43] See also Castells (1989), Bleaney et al. (1992) and Mansfield (1995) who report findings that the cost of sourcing knowledge seems to be lower closer to the source, i.e. close to the universities. They emphasize the instrumental role of universities in producing localized knowledge.

la Potterie (2003), and Azagra and Llerena (2003). Still, one would suspect that the same situation prevails in the U.S., i.e. parts of university-based research are commercialized through different channels outside the universities. Hence, the view that the impact stretches beyond patents owned by universities is valid. However it is less obvious that this would explain the difference between Europe and the U.S., nor whether the present European system is working satisfactorily. Surveying this strand of the literature, Genua and Nesta (2004) conclude that there is no evidence of university owned IPRs being an efficient device to transfer technologies and know-how to the commercial sector.[44]

Obviously there are numerous pitfalls in the measurement of innovations. The most frequently used output measure of knowledge exploitation and innovative activities is R&D-expenditures or patents. R&D-expenditures suffer from the apparent drawback of applying input measures in order to approximate innovative output. Patent is a better performance variable but does also suffer from serious limitations. Patent offices do rarely know whether patents have been commercialized, nor do they know whether commercialization was successful, or the size of the inventing firm. Previous studies using such databases have focused on estimating the profits from patenting, or the market value of patents (Sanders, 1962, 1964, Schmookler, 1966, Cutler, 1984, Griliches et al., 1987, Hall 1993). The main conclusions of these studies are that the mean value of patents is positive, but the median value is zero or negative, thus indicating a very large dispersion in economic value. Another strand of the patent literature has analyzed the renewal of patents (see e.g. Pakes 1986, Schankerman and Pakes 1986 and Griliches 1990). These studies show that most patents have a low value and that it depreciates fast, and only a few have a significant high value. In other words, the value distribution of patents is severely skewed.

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[44] Positive effects are reported for the U.S. (Link 1996, Hall et al. 2002, Caloghirou et al. 2001) and for Norway (Gulbrandsen and Smeby 2005) and Belgium (Ranga 2003) in Europe. Other studies claim that the transfer of IPRs had little to do with the increase in commercialization (Mowery et al. 2001, Mowery and Sampat 2001, Nelson 2002 and Mowery and Ziedonis 2001, 2002). For an excellent survey of the universities and technology transfers, see Phan and Siegel (2006).

Patent data have also been used to examine differences in commercialization performance between new firms and existing incumbents. Braunerhjelm and Svensson (2007), using a Swedish data-set, show that commercialization performance is superior when a patent is sold or licensed, or when the inventor is employed in an already existing firm, as compared to the alternative when the inventor commercializes in his own existing or new firm. In the former case, the probability of a successful commercialization is 23 percentage points higher than in the latter case. This is in line with Schumpeter's view that invention and innovation should be separate stages. However, another result is that the activity of inventors during the commercialization is important for the performance. One interpretation is that the inventor is crucial for further adaptation (custom specific, etc.) of the innovation, but also in order to reduce uncertainty about the firm's capacity. In this sense, the results contradict Schumpeter's view that invention and innovation are separate stages. Still, inventors seem to be more successful as transmitters of knowledge than as entrepreneurs.[45]

3.2 Evidence at the aggregate level

"…..the engine of growth is entrepreneurship." Holcombe (1998, p. 60)

3.2.1 Entrepreneurship, knowledge and regional growth

Apparently there is ample empirical evidence of the importance of geographical proximity for knowledge spillovers in innovativeness. There are also numerous studies that examine the determinants and extent of spatially concentrated production (Krugman 1991a, 1991b, Glaeser et al. 1992, Ellison and Glaeser 1997, Feldman and Audretsch 1999, Maurel and Sedillot 1999, Acs, FitzRoy and Smith 2002, Braunerhjelm and Johansson 2003 and Braunerhjelm and Borgman 2004). That contrasts the more limited achievements when it

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[45] Another explanation for the poor performance of inventors when they attempt to commercialize a new product may be lack of experience and over-optimistic behaviour (de Meza and Southey 1996, Arabsheibani et al. 2000, Fraser and Greene 2006).

comes to estimating regional growth – or productivity effects – taking the degree of concentrated or agglomerated knowledge structures into account.

Ciccone and Hall (1996) is one important exception. They undertook a cross sectional study, based on U.S. data from 1988, on labor productivity and concentration at the county level. Controlling for knowledge (as measured by education levels) and capital-intensity, they found that the major explanatory power could be attributed regional employment density. In fact, according to their estimations, doubling the employment density at the county level increased labor productivity by six percent. Still, the issues addressed focused on density and knowledge while the impact of entrepreneurs was not included in the analysis.

Within the last decade there have been several attempts to pin down the relationship between entrepreneurship and regional growth. Reynold's (1999) study indicated a positive relationship for the United States, as did Holtz-Eakin and Kao (2003) analysis of the impact of entrepreneurship on productivity change over time. It is shown that variations in the birth rate and the death rate for firms are related to positive changes in productivity. Corresponding analyses on European data covering roughly the same time period report more ambiguous results. For instance, Audretsch and Fritsch (1996) and Fritsch (1997), implemented data on Germany from the 1980s and beginning of the 1990s, failed to detect any signs of entrepreneurship augmenting growth. However, rerunning their estimations for a later time period, Audretsch and Fritsch (2002) found that regions with a higher startup rate exhibited higher growth rates. Their interpretation was that Germany had changed over time, implying that the engine of growth was shifting towards entrepreneurship.

Callejon and Segarra (1999) used a data set of Spanish manufacturing industries between 1980-1992 to link new-firm birth rates and death rates, which taken together constitute a measure of turbulence, to total factor productivity growth in industries and regions. They adopt a model based on a vintage capital framework in which new entrants

embody the edge technologies available and exiting businesses represent marginal obsolete plants. They find that both new-firm startup rates and exit rates contribute positively to the growth of total factor productivity in regions as well as industries.

The positive relationship between entrepreneurship and growth at the regional level has also been concluded to prevail in Sweden. For example, Fölster (2000) and Braunerhjelm and Borgman (2004), find similar effects using Swedish data. Fölster examines not just the employment impact within new and small firms but the overall link between increases in self-employment and total employment in Sweden between 1976-1995. By using a Layard-Nickell framework, he provides a link between micro behavior and macroeconomic performance, and shows that increased self-employment shares have had a positive impact on regional employment rates in Sweden. Braunerhjelm and Borgman established a positive impact of entrepreneurs on regional growth measured as labor productivity. They also found that the effect was most pronounced for knowledge-intensive industries.

Regional performance may also be affected by the composition of industries (Klepper 2002 Rosenthal and Strange 2003). It has been shown how innovative activities and growth seem to be higher in more diversified regions (Glaeser et al. 1992, Feldman and Audretsch 1999, Henderson and Thisse 2004). The issue of diversity versus specialization in regional composition of industries has been examined by pooling regional data with information on innovative activities.

The issue of regional growth is approached from a somewhat different angle in the literature investigating the role of universities and higher education. A large number of studies contend that regional growth is closely associated with the presence of universities and higher education establishments (Feller 1990, Bleaney et al. 1992, Felsenstein 1996, Phelps 1998, Caniels 2000, Boucher et al. 2003, Andersson et al. 2004, Chesire and Malecki 2004, Venkataraman 2004). Looking at four leading universities in Sweden, Braunerhjelm (2007)

presents evidence that the environment in which the universities are embedded in is more important than the age or research specialization of universities, as regards their impact on regional development. Anselin et al. (1997) stress the differences across industries. Thus, distance indeed seems to be a barrier in accessing knowledge diffusion and spillovers.[46]

But knowledge as such does not suffice. Romanelli and Feldman (2006) looking at biotechnology clusters in the U.S. conclude that three ingredients are particularly decisive for regional development. First, their study reveals that about two thirds of the clusters were founded by local entrepreneurs and investors. Second, regions that exhibited sustained growth revealed a higher degree of spin-offs from local, i.e. first generation, firms. Third, a quite sizeable share (one third) of the entrepreneurs relocated from one metropolitan region to another to found new firms. The conclusion is that entrepreneurs are scanning attractive locations to which they relocate. These results corroborate the findings of Klepper (1996, 2002).

To conclude, a larger number of studies confirm that entrepreneurship, agglomerated knowledge structures and regional growth are interconnected in a complex and still vaguely defined way.

3.2.2 Entrepreneurship, knowledge and national growth

Turning to a higher level of aggregation, empirical analyses become more intricate as endogenity and causality issues make the interpretation of the results considerably harder. Still, a number of recent empirical studies suggest that entrepreneurship – measured as startup rates, the relative share of SMEs, self-employment rates, etc. – is instrumental in converting knowledge into products, thereby propelling growth. Similarly, different growth variables

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[46] The impact of distance on knowledge spillovers and innovativeness is also analyzed by Kline and Rosenberg (1987), Jaffe (1989), Jovanovic and Rob (1989), Acs, Audretsch and Feldman (1992, 1994), Jaffe, Trajtenberg and Henderson (1993), Anselin et al. (1997, 2000), Acs and Armington (2002), Keller (2002), Henderson (2003), Rosenthal and Strange (2003) and Arundel and Genua (2004).

have also been implemented even though the most common are GDP-growth and growth in employment.

For example, Thurik (1999) provided empirical evidence from a 1984-1994 cross-sectional study of the 23 countries that are part of the Organization for Economic Co-operation and Development (OECD), that increased entrepreneurship, as measured by business ownership rates, was associated with higher rates of employment growth at the country level. Similarly, Audretsch et al. (2002) and Carree and Thurik (1999) find that OECD countries exhibiting higher increases in entrepreneurship also have experienced greater rates of growth and lower levels of unemployment. See also Wennekers and Thurik (1999).

In a study for the OECD, Audretsch and Thurik (2002) undertook two separate empirical analyses to identify the impact of changes in entrepreneurship on growth. Each one uses a different measure of entrepreneurship, sample of countries and specification. This provides some sense of robustness across different measures of entrepreneurship, data sets, time periods and specifications. The first analysis measures entrepreneurship in terms of the relative share of economic activity accounted for by small firms. It links changes in entrepreneurship to growth rates for a panel of 18 OECD countries spanning five years to test the hypothesis that higher rates of entrepreneurship lead to greater subsequent growth rates. The second analysis uses a measure of self-employment as an index of entrepreneurship and links changes in entrepreneurship to unemployment at the country level between 1974 and 1998. The different samples including OECD countries over different time periods reach consistent results – increases in entrepreneurial activity tends to result in higher subsequent growth rates and a reduction of unemployment.

Acs et al. (2004) and Braunerhjelm et al. (2007) find a positive relationship between entrepreneurship and growth at the country level examining 20 OECD-countries for the

period 1981-2002. The impact is considerably stronger in the 1990s than in the 1980s, while the importance of R&D seems to diminish in the latter time period.[47]

The results in the studies undertaken by the Global Entrepreneurship Monitor (GEM) Study (Reynolds et al., 2002) are more ambiguous. There seem to be an empirically established link between the degree of entrepreneurial activity and economic growth, as measured by employment, at the country level. However, when it comes to the relationship between entrepreneurship and growth, the results are more ambivalent and the methodological problems escalate. Thus, there are not only theoretical arguments but also empirical evidence suggesting that the growth of countries is positively associated with an entrepreneurial advantage. Countries exhibiting a greater increase in entrepreneurship rates correspond with decreases in unemployment rates. This would suggest a negative relationship between entrepreneurial activity and subsequent unemployment.[48]

Acs and Armington (2002) asked the question what the relative contribution of new firms is in terms of new jobs? They conclude that new firm start-ups play a far more important role in the economy than has previously been recognized. For the U.S. economy as a whole they show that for the first half of the 1990s new establishments accounted for a considerably larger share of job creation than already existing establishments. As discussed in a previous section, at more disaggregated spatial units – i.e. a city, region or state – the empirical evidence corroborates the results at the national level. They also find that new firms are more important than the stock of firms in a region, but the manufacturing sector appears to be an exception. This is consistent with prior research on manufacturing.

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[47] Levine and Renelt (1992) and Beck et al. (2005) conclude that there is a positive relationship between the share of small firms and growth, applying cross-country analysis. See also Michelacci (2003).

[48] See also Audretsch, Keilbach and Lehmann (2006).

4. Policy Implications

"The factors we have listed (innovation, economies of scale, education, capital accumulation, etc.) are not causes of growth; they are growth. …Growth will simply not occur unless the existing economic organization is efficient. Individuals must be lured by incentives to undertake the socially desirable activities." (North and Thomas 1973, p.2)

The lack of dynamism and the absence of deep structural transformation in most European countries stand in stark contrast to the last decade's developments in many other regions, particularly the United States and parts of Asia. The forces of change and renewal within the American economy can be seen clearly in its dominance with respect to new industries (information technology, biotechnology/ biomedicine etc.), entrepreneurship and an influx of new and growing firms, the diversity of product supply, and the links between universities and the commercial sector. Industrial renewal in Europe, on the other hand, has been largely confined to already established firms, with only a limited influx of new, innovative and technology-based firms during most of the post-war era. European leaders are aware about these differences and the challenges they imply, as became evident during the EU top summit meeting in Lisbon 2000. It was then declared that EU was to become the leading knowledge-based and entrepreneurial area in the world within a 10-year period. The outmost objective is of course to pave the way for sustainable future growth and high welfare levels through more micro-oriented policies.

As business cycles tend to become more correlated and macroeconomic movements (and policy responses) more synchronized in an increasingly integrated global economy, differences in microeconomic policies and the microeconomic setting will to a larger extent than previously influence growth and economic development across regions and nations. The regional dimension is likely to become a much more relevant entity in determining economic

performance. It is therefore of vital importance to gain a better understanding of the driving forces that propel these regions, how sustainable they are, and identify potential threats.

The question is what guidance can be derived from economic theory with regard to these issues discussed above? When policies at the macro-level are increasingly sterilized due to the ongoing globalization and integration, policy-makers obviously have to resort to microeconomic measures in order to propel and sustain growth. Or, more accurately, appropriate policies at the macro-level have to be complemented by microeconomic policies to retain and expand production, reinforce the prerequisites for the development of growth-enhancing factors of production, and strengthen the conditions for sustainable growth. Still, knowledge concerning such microeconomic processes and the ensuing policy implications is scarce.

The decisive role of an appropriate design of the institutional set-up is well known in order to generate economic prosperity, opportunities and social progress (North and Thomas 1973, Olson 1982, Davis and Henrekson 1999, Henrekson 2005, Nelson 2002). According to Baumol (1990), even though he is not questioning Schumpeter's contributions to economic theory, the main shortcoming of Schumpeter's model is that no role is assigned the government in fostering an entrepreneurial society. The government has, however, the ultimate responsibility for the design of the regulatory framework, incentives structures and institutional framework. Knowledge creation and diffusion, innovation and entrepreneurship, are long-term processes, and the design of policies will influence the rate of growth and development at regional/national level. Hence, methods must be developed to systematically analyse the effects of different policies, and to suggest quantifiable indicators of such policies.

A critical aspect is to understand the relationship between policies that support and stimulate accumulation of knowledge on the one hand, and microeconomic incentives at the individual and firm level that encourage exploitation of knowledge through markets at the

other. The latter refers to experiments (start-ups), the risk-reward ratio, the returns to investment in education and knowledge, and why existing firms would adopt expansion strategies.[49] As suggested in recent studies on the commercialization of new knowledge, an appropriate environment for entrepreneurs is important in order to exploit opportunities within new ventures (Reynolds et al. 1994, Feldman 1999, Acs and Audretsch 2003, Shane and Venkataraman 2003). Baumol (2002) suggests that implementation of new technologies, as well as innovation, is stimulated by immigration of individuals with key knowledge. Thus, policies should embrace a wide set of instruments, including the support of knowledge flows (immigration, promote overseas education in countries strong in new technologies, etc.), but also deregulated labor markets, tax-systems that not disfavor SMEs, and deregulation of public monopolies. Financial networks seem to play a pivotal role for successful commercialization, but the mix and organization of private and governmental actors is badly understood.

To achieve a better understanding of these issues I would argue that insights from several disciplines into present models of knowledge accumulation and exploitation, as well as dynamics and growth, must be combined. Economists are skilled in developing and applying transparent methods that allow generalization of results and normative conclusions. However, clarity is obtained by a far too mechanistic view on the processes that foster growth at the micro-level, making insights from other disciplines necessary. Opportunities that can be economically exploited originate in complex interactions between entrepreneurs, firms and institutions (universities, governmental bodies), and the environment in which these agents operate. Yet, as shown above, contemporary macro growth models largely disregard the dynamics at the micro-level that constitute much of the base for growth at the aggregate level.

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[49] Lundström amd Stevenson (2002) make the point that entrepreneurship policies and small business policies should be treated separately.

In particular, the uncertainty, asymmetries and high transaction costs inherent in knowledge generate a divergence in the assessment and evaluation of the expected value of new ideas.

To conclude this section I will list a couple of policy areas where findings from recent research do suggest policies that emanate from a distinct microeconomic setting which should be conducive for entrepreneurial and knowledge driven growth. First, successful regional development seems to be based on local initiatives implemented in a creative and adaptive way (Braunerhjelm and Feldman, 2006). Solutions that appeared to work are diffused, repeated, and fine-tuned, gradually evolving into accepted routines and operating procedures. These routines are adopted by institutions to define common practices. Over time, a repertoire of actions develops, orchestrated by a common vision of the industry. This encourages further experimentation and adaptation. Knowledge of what does not work, what approaches have previously been tried and led to dead ends are part of this local knowledge. The local uniqueness of successful development is in general hard to copy. Adaptability and flexibility at the regional level is one important ingredient.

Second, a prominent feature of regional growth is that the level of entrepreneurship seems to critically interact with the emergence of regional growth. Also, as shown by e.g. Klepper (1996), Buenstorf and Klepper (2005) and Romanelli and Feldman (2006), only those regions that exhibit a secondary, or second-generation growth based on spin-offs, are better equipped to enter virtuous circles of sustainable growth. Regional growth is thus a process relying on the co-evolution of technology, business models, and flexible local supporting institutions that encourage entrepreneurship and experimentation at markets. Serendipity is often a conspicuous feature in the early stage of such processes. However, the outcome is dependent on economic policies. A general conclusion is that policy interventions exaggerate the system characteristics at the expense of incentives on the level of individuals (Carlsson 2006, Maggioni 2006).

Third, and of particular concern, is of course policies geared at accumulating and diffusing knowledge. The traditional European link between research and its commercial applications has primarily been through the "open science model", i.e. externalities created by public research at universities.[50] As evidence has piled up as regards the positive impact of public research on innovations, the role of universities has partly been redefined in the 1990s, especially in Europe. Besides the traditional tasks of teaching and conducting research, universities were expected to carry out a more active role in the transformation of academic knowledge into economic knowledge. This calls for a major overhaul of the ways universities traditionally operate and are organized. Altering existing routines and norms that has prevailed since long, is a difficult and time-consuming task (Berkovic and Feldman 2004, Owen-Smith and Powell, 2004, 2006). Individuals tend to be shaped by the economic and social context in which they have been trained and currently are active in. The degree of such social imprinting, the intellectual openness and learning capabilities, together with the incentive structure that faces researchers, determine the potential for new norms to be established.

Fourth, the level and structure of taxes is of course a core policy variable in designing incentives that stimulate knowledge accumulation, entrepreneurship and growth. As argued by Gordon and Cullen (2002) and Cullen and Gordon (2006), in comparison with Europe the U.S. allows for organizational forms that provide a valuable opportunity to reduce risks associated with becoming an entrepreneur through arbitrage possibilities between tax bases. Deductibility of non-corporate losses under the personal tax implies that start-up firms are much less constrained by no-loss-offset provisions under the corporate tax than are larger firms that inevitably remain corporate. Similarly, the design of the tax system affects the

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[50] See Rosenberg and Nelson (1994), Abramson et al. (1997), Hall et al. (2002), Beise and Stahl (1999), Caloghirou et al. (2001) and Miner et al. (2001). See Braunerhjelm (2007) for a survey.

attractiveness of risky vs. less-risky projects, which is important in the commercialization of new knowledge areas or technologies (Fölster 2002).

Hence, taxes influence the exploitation and accumulation of knowledge. Surveys of the R&D tax incentive mechanisms in OECD countries indicates – even though evidence are patchy – that they seem to be relatively efficient in encouraging R&D. Empirical analyses suggest that a dollar in R&D tax incentives stimulates one to two per cent additional R&D above the "tax dollar" spent (Valkonen 2006). There is also some evidence that tax incentives should be based on incremental annual R&D spending. Kanniainen (2006) propose that tax policies must take into account that taxes are not necessarily neutral with respect to the entry decisions of start-up firms. Finally, well-designed taxes could also improve the supply of risk capital needed in growth oriented young innovative companies, i.e. they are important for the venture capital market and for domestic ownership (Maula 2007).

The transformation from a "managed economy" to an "entrepreneurial economy" (Acs and Audretsch 2001) regime thus requires a different approach to economic policy.

5. Knowledge Gaps in the Current State-of-the-Art Research

"…that even when scholars agree on the end – discussing the nature and source
of entrepreneurial opportunity - the means of how best to achieve this goal may
still diverge significantly" (McMullen et al. 2007, p. 282)

Summarizing the current state of the art approaches to analyze knowledge creation, innovation, entrepreneurship and growth at the regional and national levels, new insights have obviously been gained in the last two decades. However, a comprehensive understanding is still lacking concerning many important issues in the field. In particular, the link between micro and macro is too rudimentary modeled.

Economics-based theories and models all fall short of addressing the influence of the independent innovator or entrepreneur to important economic outcomes. The accumulation of factors of production, i.e., knowledge, human or physical capital, cannot alone explain economic development. Human innovation and entrepreneurship are needed to transform these inputs in profitable ways. Several calls have been made in the literature for integrating the entrepreneur into economic theory, but so far progress has been modest.

Similarly, studies of entrepreneurs and firms assume that micro level activities, such as the launching of a new company or the performance of a new venture, automatically translate into societal benefits. However, this is an oversimplification; entrepreneurship may under certain conditions reduce rather than enhance economic progress. This would be the case for illegal enterprising, but also when entrepreneurial talent is spent on rent seeking activities such as litigation. Further, one venture's failure may be the result of competitors' reactions. Business stealing effects, i.e. innovations that erode someone else's economic rents will influence the overall welfare the society extract from innovative entry (Aghion and Howitt 1992).

If increased competition enhances the industry's overall performance, then economic progress will be achieved at the societal level. In other words, it is fully conceivable for successful new enterprise at the micro level to translate into economic regress at the societal level and for a failed entrepreneurship at the micro level to contribute to economic development. Because the societal implications of the actions of individual entrepreneurs have not been considered, little is currently known.

In connecting knowledge, innovation and entrepreneurship, it is essential to emphasize the non-routine innovations that are crucial to economic development. Knowledge for innovation is often thought of, as coming from activities labeled R&D but it is obvious that other processes, such as learning-by doing, generate much market and entrepreneurial

knowledge. Despite making small investments in R&D and other formal knowledge generating activities, entrepreneurs and new and small firms contribute substantially to aggregate innovation thanks to their entrepreneurial activities (Feldman and Audretsch 1999, Bhide 2004). The knowledge generating activities of these economic agents are spread across a number of different functional areas and they draw their innovative processes from many more knowledge resources than their own formal R&D. In spite of this, studies interested in the consequences of knowledge creation mainly rely on measures related to R&D expenditure or patenting activity. In doing so, a substantial share of the knowledge creation relevant to innovation and economic growth is overlooked. Recognizing this problem, start-up rats of new firms have been used as a proxy for addressing alternative ways of commercializing knowledge. However, this line of research does not address the type of knowledge that entrepreneurs use or how it is being applied.

The dynamic component is also largely ignored. Knowledge creation is often a time-consuming process while entrepreneurial actions need to be taken fast, because windows of opportunity are open for a limited time only. This leads to a fundamental conflict in the pacing of entrepreneurial efforts. Knowledge content and entrepreneurial activity is largest within new and developing industries, which are characterized by rapidly changing technology and customer preferences. Therefore, knowledge intensive entrepreneurial possibilities develop slowly but are launched in markets that change rapidly, inserting a stochastic element in the formation of new firms that originates in the individual ability/knowledge opportunity nexus.

This means that firms and entrepreneurs have to develop strategies to balance slow knowledge development processes with fleeting windows of opportunity and find ways of speeding up knowledge generation and exploitation. There is no guarantee that new knowledge with commercial potential is immediately transformed into entrepreneurial

initiatives. Because entrepreneurship entails the actions and activities of individuals working within firms or for themselves, incentives that encourage the risky endeavor of entrepreneurial activity are essential, as is infrastructure allowing the transfer of knowledge from knowledge generating actors to knowledge exploiting entrepreneurs.

A limitation of much of the research in this field is that it disregards the fact that knowledge generation, innovation and entrepreneurship processes are localized processes. Despite the progress in regional economics and economic geography in recent decades, there are still serious gaps in the understanding of how the regional economic milieu influences the generation and the success of these processes. Empirical results seem to support the view that knowledge flows are bounded in space but at the same time, it is possible to observe how knowledge, innovations and entrepreneurial initiatives flow between functional urban regions and countries. At the same time as regions are characterized by their varying internal economic and infrastructure networks, they are also connected by a multitude of such networks. It is obvious that there is an important interplay between localized processes of knowledge generation, innovation and entrepreneurship, but current insights are lacking concerning the relative importance for different types of regional economic milieu, and the embeddedness in interregional and international networks (Thorton and Flynne, 2003).

It is a well-established result that market economies normally do not generate a socially optimal volume of knowledge creation, innovation and entrepreneurship. However, there is no consensus concerning what institutional frameworks and policy measures that might generate such a social optimum given the imperfections in both the economic and the political markets. This has not stopped politicians from launching a large number of institutional changes and policy measures to stimulate knowledge creation, innovation and entrepreneurship. Nevertheless, the number of carefully carried through policy evaluations is rather limited,

which implies that there is a huge knowledge gap concerning which policies actually work and whether they are worth their costs.

6. Conclusions

The gaps in understanding the creation of knowledge, its diffusion and commercialization, means that the predictions and policy implications that can be derived from current knowledge-based growth models must be interpreted cautiously. As noted above, the contributions to knowledge-based growth models in the 1990s have re-introduced the notion of the entrepreneur, however, stripped of its most typical characteristics. The major weakness is associated with the assumption that commercialization of knowledge either occurs through automatic and unexplained (exogenous) knowledge spillovers, or through firm-level investments in R&D-races. Hence, the crucial mechanism in promoting growth, i.e. knowledge diffusion, is not specified in existing models, even though novel research examining the impact of entry on innovation efforts by imcumbents looks promising.

Still, an important objective of future research is to extend the analysis of growth to explicitly introduce entrepreneurship and small business as one important mechanism that connects knowledge and economic growth. Some of the issues that has to be discarded before we can better comprehend the microeconomic foundations for growth are the following: First, the transmission of knowledge between different sectors in the economy, the role taken by entrepreneurs and small firms in those processes and the extent to which other mechanisms are important for knowledge diffusion, e.g. labor mobility? Moreover, how do entrepreneurs and small firm source and upgrade their knowledge base, what role do pecuniary (customers and suppliers) and non-pecunary links play? How do they relate to each other and to what extent are entrepreneurs and small firms actively engaging in knowledge sourcing and knowledge upgrading?

Second, what spark individuals to become entrepreneurs and how are inherit abilities and cognitive processes on the one hand, and an appropriate institutional environment on the

other, interlinked? Obviously, the distribution between these two forces also sets the scope for the role of economic policies. Is it the case that entrepreneurial activities are relatively constant across different institutional environment, but institutions determine whether such entrpreneutial activities are used in productive or non-productive activities? This is related to the question of the origin of opportunities.

Finally, empirical observations along the lines discussed above should form the basis for more theoretically rigourous models linking micro dynamics to outcomes at the macro level.

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