Academic entrepreneurship

a source of competitive advantage

le manageur
Navigating your Strength & Entrepreneurship

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Preface

This research report is the result of the BRIDGE 2003 research project organised by *le manageur,* the students' association for strategy and entrepreneurship of the Erasmus University Rotterdam (EUR). The Bloomington-Rotterdam International Doctoral and Graduate Exchange Program (BRIDGE) provides a trans-atlantic educational and research partnership between the Erasmus University and Indiana University (IU). EIM Business and Policy Research in Zoetermeer actively supports this transatlantic partnership, which brings American and Dutch students together to facilitate research into current topics in entrepreneurship.

BRIDGE builds on the courses 'Dynamics and Entrepreneurship' taught at the EUR by professor Roy Thurik and 'Regional Development' taught at IU by professor David Audretsch. Together these courses provide the backbone for the BRIDGE research projects providing students with the required background on the selected research topic and guiding the students through the research process

BRIDGE 2003 is the latest research project conducted under the BRIDGE program. Under the skilful guidance of professor Roy Thurik a group of 18 highly motivated students started research into the importance of university knowledge transfer through entrepreneurial spin-off. This field of study is highly relevant as universities in the Netherlands are increasingly becoming involved in regional economic development. Encouraged by government reforms, universities and other public research organizations are increasingly setting up facilities to commercialize their knowledge and cooperate with industry.

Conducting both desk-research in the Netherlands and field research at the Indiana University in the United States we have created a comprehensive study of the importance of Public-Private cooperation and innovative entrepreneurship based on university knowledge for economic development within the modern economy. It evaluates university spin-offs in the transfer of technology from universities into society and provides a comparative case study of spin-off stimulation in the United States (Indiana University) and the Netherlands (Erasmus University Rotterdam).

The research presented in the four chapters of this book has strong implications for both university policy and regional economic development. As our research on the Netherlands is supported with a case study of the Erasmus University Rotterdam, the synthesis and conclusion of this book will mainly focus on the actions that should be taken by the Erasmus University Rotterdam and the regional government to assure the competitiveness of the region. Nonetheless this research has clear implications for other regions in the Netherlands with public knowledge institutions.

This achievement would not have been possible without the help of the project comity, the academic staff, Roy Thurik and Ingrid Verheul, and the help, dedication, and hospitality of David Audretsch and Adam Lederer at Indiana University.

Freek Jan Frerichs
Project coordinator
le manageur

Synthese en aanbevelingen

De processen van globalisering en technologische ontwikkeling hebben een significante invloed gehad op de economische prestaties en industriële structuur van moderne nationale economieën. Als gevolg van internationale concurrentie zullen makkelijk te imiteren economische activiteiten zich verplaatsen van OECD landen, zoals Nederland, naar lage lonenlanden. Deze verandering heeft belangrijke sociale en economische gevolgen en vereist een omslag naar economische activiteiten gebaseerd op kennis. Deze economische activiteiten zijn immers moeilijker te imiteren of te verplaatsen.

Omdat concurrentiekracht in de kenniseconomie gebaseerd is op innovatie, zullen economieën sterk moeten zijn in zowel het ontwikkelen van economische kennis als de daarop gebaseerde nieuwe toepassingen. Met deze overgang naar de kenniseconomie wordt onderzoek en ontwikkeling (R&D) steeds belangrijker voor economisch succes. Nu de snelheid waarmee innovaties plaatsvinden steeds verder toeneemt door snelle technologische veranderingen en toegenomen concurrentie, lijken oude economische structuren, met een dominante rol voor grote multinationale ondernemingen, niet meer te voldoen. Grote ondernemingen richten zich immers voornamelijk op het verbeteren van hun bestaande technologieën. Dit leidt tot een incrementeel innovatiepad wat onvoldoende is om competitief te blijven in de moderne economie. Om competitief te blijven heeft een economie zowel incrementele als baanbrekende innovaties nodig. Omdat de economische waarde van zulke baanbrekende innovaties vaak erg onzeker is, is risicodragend ondernemerschap onmisbaar in het innovatiesysteem van een kenniseconomie.

De opkomst van de kenniseconomie leidt dus tot een veranderende verhouding tussen de betrokken partijen (overheid, kennisinstellingen en bedrijfsleven) vooral daar waar het gaat om het ontwikkelen, toepassen en verspreiden van kennis. Het innovatiesysteem van een kenniseconomie vraagt om substantiële overdrachten van kennis tussen kennisinstellingen en private ondernemingen. Wanneer er een grote afstand is tussen publieke kennisinstellingen en private ondernemingen of wanneer kennisinstellingen commercieel inzicht ontberen, kunnen er fricties ontstaan in het innovatiesysteem. Steeds meer wordt ingezien dat wanneer een land een bloeiende kenniseconomie ambieert, de activiteiten van bedrijfsleven en kennisinstellingen beter geïntegreerd moeten worden en dat overheidsbeleid op het gebied van wetenschap en technologie noodzakelijk is.

Overheden die fricties in de transfer van kennis willen aanpakken moeten kennisinstellingen overtuigen en helpen een proactieve houding te ontwikkelen ten aanzien van commercialisering en samenwerking met het bedrijfsleven. Het stimuleren van ondernemerszin en overdracht van kennis is een belangrijke maatregel om deze fricties weg te nemen. Dit onderzoek toont aan dat spin-offs een goede aanvulling zijn op veel gebruikte huidige methoden van kennisoverdracht, als licenties

en contractonderzoek. Spin-offs vormen een goede methode om radicale technologieën hun weg te laten vinden naar de maatschappij. Daarvoor is het echter wel van belang dat er voldoende *entrepreneurial human capital* is binnen de samenleving.

Academisch ondernemerschap in Nederland

Een gezonde economie heeft zowel *entrepreneurial human capital* als *professional human capital* nodig (Iyigun en Owen, 1998). Echter, voldoende *entrepreneurial human capital* is in een economie niet automatisch aanwezig omdat er een inefficiënte verdeling kan bestaan tussen het volgen van onderwijs en het opdoen van praktische ervaring als ondernemer. Deze inefficiëntie kan ontstaan als er een discrepantie bestaat tussen de maatschappelijke en private opbrengsten van onderwijs en ervaring als ondernemer. Dit resulteert in suboptimale economische ontwikkeling. In Nederland, zou de risico-averse houding van de bevolking en de relatief lage sociale status van ondernemers wel eens een dergelijke inefficiënte verdeling kunnen veroorzaken. Deze eigenschappen van de Nederlandse samenleving zijn mede een oorzaak van een gebrek aan ondernemerszin en bijbehorende ondersteunende infrastructuur. Hoewel de rijksoverheid de afgelopen jaren zowel een fysieke als een niet-fysieke infrastructuur heeft ontwikkeld, ontbreekt er op regionaal en universitair niveau nog steeds een goede ondersteunende infrastructuur voor ondernemerschap.

Om deze problemen te boven te komen en een ondernemende samenleving te creeren, moet er dus niet alleen voor een goede infrastructuur voor ondernemers worden gezorgd, maar moet men ook een cultuur van ondernemerschap in de samenleving bewerkstelligen. Het ontwikkelen van een dergelijke cultuur begint met een bewustwordingsproces; iedereen zou zich bewust moeten zijn van het belang van ondernemerschap voor onze maatschappij. De volgende stap is het stimuleren van een positieve houding ten opzichte van ondernemerschap en het ontwikkelen van persoonlijke eigenschappen die bevorderlijk zijn voor ondernemerschap, zoals creativiteit, risico nemen en pro-activiteit. De laatste stap is het trainen van vaardigheden nodig voor ondernemerschap, zoals managementvaardigheden, het schrijven van een bedrijfsplan en het hands-on ervaring in ondernemerschap (Bosma et al., 2002; Iyigun en Owen, 1998).

Voor een optimale economische ontwikkeling is het noodzakelijk dat toekomstige generaties Nederlanders de juiste eigenschappen ontwikkelen en de juiste vaardigheden leren. Waar hogescholen al op de goede weg zitten, lijken universiteiten achter te blijven. Ondanks de gestage daling van het werkgelegenheidsaandeel van grote ondernemingen gedurende de afgelopen decennia (Carlsson 1989, 1999) leiden universiteiten studenten nog steeds op voor een carrière bij een multinational. Resultaat is een marginale rol voor ondernemerschap in het onderwijs op Nederlandse kennisinstellingen. Dit heeft, samen met de Nederlandse terughoudendheid ten aanzien van ondernemerschap, geleid tot relatief lage aantallen spin-offs.

Het Ministerie van Economische Zaken heeft verschillende studies naar de Nederlandse situatie op het gebied van ondernemerschap en spin-offs geïnitieerd. In een van deze studies (Kreijen en Van Tilburg, 2003) wordt een complete set aanbevelingen gegeven aan overheden, kennisinstellingen en beleidsmakers. Deze aanbevelingen zijn opgenomen in de appendix. De aanbevelingen in dit stuk zullen zich concentreren op de Erasmus Universiteit Rotterdam (EUR) en de relevante regionale overheden. Veel van deze aanbevelingen zullen ook van toepassing zijn op andere universiteiten.

De Erasmus Universiteit Rotterdam en regionale overheden

De EUR heeft op dit moment een gebrek aan een integrale benadering van academisch ondernemerschap. De huidige activiteiten op het gebied van ondernemerschap zijn bottom-up ontstaan vanuit docenten en studenten, en hebben vervolgens steun vanuit de organisatie ontvangen. Een gevolg van deze ontwikkeling is dat een overall visie, een volledig aanbod van activiteiten en afstemming ontbreekt. De huidige activiteiten omvatten een aantal belangrijke elementen nodig voor succesvol academisch ondernemerschap, maar lang niet allemaal.

De universiteit ontbeert een top-down benadering. Er zal daarom een visie en masterplan ontwikkeld moeten worden voor een integrale aanpak van academisch ondernemerschap. Dit zou bijvoorbeeld teweeg kunnen worden gebracht door het opzetten van een centrale organisatie voor ondernemerschap en technologie transfer. De huidige activiteiten bereiken slechts een klein percentage van de studentenpopulatie, en vinden buiten het reguliere curriculum plaats. Bovendien worden de effecten van deze activiteiten niet of nauwelijks gemeten waardoor het onduidelijk is of ze dat bereiken wat ze beogen. Het belang van een sterke kenniseconomie voor de samenleving impliceert dat overheden een leidende rol moeten hebben en met krachtige initiatieven moeten komen om actieve kennis transfer en academisch ondernemerschap binnen de kennisinstellingen te stimuleren en bestaande, ongebruikte technologieën met potentiële ondernemers samen te brengen.

Derhalve adviseren wij de belangrijkste spelers in het veld, zoals de universiteit, hogescholen, Ontwikkelingsbedrijf Rotterdam, Provincie Zuid-Holland, Kamer van Koophandel en de relevante studentenorganisaties, samen een visie en een concreet plan van aanpak te ontwikkelen voor het stimuleren van academisch ondernemerschap in de regio.

1.

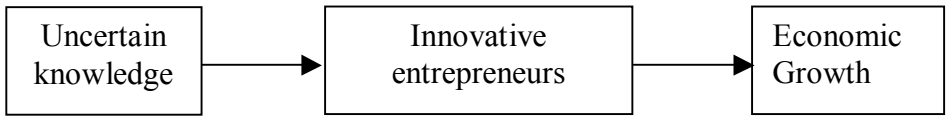
Innovative entrepreneurship in knowledge driven economic growth

1.1. Introduction

Over the last few years knowledge and entrepreneurship have seen increasing interest of the both popular press and the scientific community. Knowledge based economic growth is said to be crucial for the competitive advantages of modern societies. The European Union, for instance, has the ambition to become the most dynamic and competitive knowledge economy in the world by 2010[1]. The Dutch government has the ambition to become one of the leading countries within Europe in this respect[2].

This first chapter will take a look at knowledge, entrepreneurship and growth from a macroeconomic perspective. We will argue that although both knowledge and entrepreneurship influence economic performance in several ways, it is the transformation of uncertain, asymmetric knowledge by innovative entrepreneurs into economic value that might be the most conducive contribution to economic growth, see Figure 1.1

Figure 1.1: The transformation of uncertain knowledge into economic growth



To substantiate this claim we will first take a closer look at the concept of knowledge and its relationships with growth. Secondly, entrepreneurship and its possible effects on growth are explained. Finally, we discuss the most promising area where knowledge and entrepreneurship meet: innovative entrepreneurship.

[1] http://europa.eu.int, January, 14th, 2004
[2] http://www.regering.nl, January, 14th, 2004

1.2 Knowledge

The following quote from the OECD shows the perceived importance of knowledge for economic growth: *"Changing economic and social conditions have given knowledge and skills –human capital- an increasingly central role in the economic success of nations and individuals. Information and communications technology, globalization of economic activity and the trend toward greater personal responsibility and autonomy have all changed the demand for learning. The key role of competence and knowledge has been widely recognized by economists and others"* (OECD, 2001b).

Globalization and technological change have made a significant impact on the economic performance and industrial structure of the world's economies. Falling transportation and communication costs and increased segmentation of production processes have caused a revolution in the geography of production (Dicken, 1998). During the initial stages of globalization labor intensive production was relocated from the high cost economies to locations in Asia, which had a strong labor cost advantage over most western economies. Subsequent waves of globalization have further eroded the west's comparative advantage. Asian countries such as Taiwan, Singapore, and South Korea successfully upgraded their industrial structure and started to attract production with increasing capital intensiveness placing increased pressure on western comparative advantage. Increased low cost competition from relatively well educated and skill intensive countries in Asia and Eastern Europe, has led to a fundamental shift of the source of comparative advantage of the OECD countries (Audretch and Thurik, 2001).

As a result of global competition, economic activities, based on skills readily available to lower cost countries, will eventually shift away from the high cost OECD countries. This shift of production from OECD countries to their lower wage competitors has important socio-economic implications. Moving production from one country to another leads to the destruction of jobs in the source country and can lead to an increase of unemployment. This signifies the need for a shift away from production, which is easily transferred to a low cost location, to production that is not so easily transferable. Economic activity that is based on ideas and knowledge cannot easily be copied or transferred to other regions (Audretch and Thurik, 1998). This implies that economic activity based on knowledge provides a good base for the comparative advantage of high cost economies.

1.2.1 The concept of knowledge

The concept of knowledge must be separated from related concepts such as *data* and *information*. *Data* are observations or facts, and are relatively meaningless until they have been processed or analyzed; the result of this processing or analysis is meaningful *information* (Bocij et al., 2003). Bocij et al. (2003) consider knowledge to be a further level of sophistication of in this process. They state that: "… knowledge can be regarded as the next level of sophistication or business value in the cycle from data through information to knowledge" (Bocij et al., 2003, p.29). Many people consider knowledge to be roughly the same as (technological) ideas, but the concept of knowledge also includes skills (CPB, 2002).

Knowledge is often divided into codified and tacit knowledge. The concept of tacit knowledge originates from the work of Michael Polanyi (1891-1976). For the purpose of this paper we consider codified knowledge roughly the same as

information, and tacit knowledge as knowledge that has not been codified. Knowledge and information are complementary; one usually needs some tacit knowledge to understand information. This implies that, although information can cross boundaries in a split second using Internet technologies, one still needs a less mobile human expert with tacit knowledge to interpret the information (CPB, 2002). Hence, economic activity that is based on ideas and knowledge cannot easily be copied or transferred to other regions (Audretsch and Thurik, 2001). This implies that economic activity based on knowledge provides a good base for the comparative advantage of high cost economies.

1.2.2 Linking knowledge to economic growth

Knowledge can be seen by different people from different perspectives and applied in varying ways indicating that knowledge is characterized by asymmetries (Audretsch and Thurik, 2001). Due to these asymmetries, it is impossible to determine the exact value of specific knowledge. This implies that knowledge has a different value to different people (Audretsch and Thurik, 2001). Moreover, tacit knowledge is difficult to transfer from one individual to another. It takes time, for instance, to study a theory that has a theoretical and empirical base (Audretsch and Thurik, 2001). As knowledge is stored in the human brain it is transient. Hence it is important that knowledge is codified to save this knowledge for future generations. Maybe most importantly, knowledge is a non-rival good, as the use of it by one person does not diminish the ability of others to use it (Arrow, 1962). The adoption of the same knowledge by multiple people or business can create a multiplier effect. These so called spillovers[3] can have a substantial influence on growth on at the macro level.

In the literature linking knowledge to growth three strands can be distinguished. The first strand links research and development (R&D) to output[4]. The argument put forward in this body of literature is that R&D is an important prerequisite for innovation and innovation consequently increases productivity. Donselaar et al. (2003) conclude, based on a literature survey[5], that investments in R&D have a large influence on growth in the Netherlands, with a multiplier between five and ten.

The second strand links human capital to growth[6]. Human capital relates to the quality of labor and can be seen as the tacit knowledge that is created by education and experience. In empirical research human capital is usually proxied by years of education. Investing in human capital increases productivity. Empirical results verify this; the OECD (2001a), for instance, finds a robust positive relation between human capital and output growth.

The third strand links entrepreneurship capital to output. This concept combines human capital elements with entrepreneurship. Entrepreneurship capital is the capacity of economic agents to generate new firms (Audretsch and Keilbach, 2002). Although at first sight one might consider entrepreneurship capital a specific form of human capital, the concept also encompasses cultural, legal and institutional factors since they influence economic agents' capacities to generate new firms as well. Audretsch and Keilbach (2002) argue that entrepreneurship is a mechanism for

[3] Marshall (1920) already describes spillover effects.
[4] See: Romer (1990), Jones (1995) and Young (1998).
[5] Amongst others: Coe and Helpman (1995), Guellec and Van Pottelsberghe de la Potterie (2001) and Jacobs, Nahuis and Tang (2002).
[6] See: Lucas (1988) and Mankiw, Romer and Weil (1992).

knowledge spillovers; it increases competition and provides diversity among firms. The authors use the number of startups in a region relative to population as a proxy for entrepreneurship capital. A more thorough discussion of the relations between entrepreneurship and output will be presented later on in this chapter.

1.3 Entrepreneurship

Like knowledge and growth, definitions of entrepreneurship vary widely (Hébert and Link, 1989). Wennekers & Thurik (1999, p. 47) state that entrepreneurship is a behavioral characteristic of persons. This is quite similar to the concept of entrepreneurial orientation for firms, which refers to the processes, practices, and decision-making activities that lead to new entry (Lumpkin and Dess, 1996). Lumpkin & Dess discern five dimensions of the entrepreneurial orientation of firms: autonomy, innovativeness, risk taking, proactiveness and competitive aggressiveness. Of these facets of entrepreneurial orientation we consider risk-taking, innovative behavior to be the most important aspects of entrepreneurship for the purpose of this chapter.

Business ownership rates are often used as a proxy for entrepreneurship. However, these two concepts are not synonymous. The distinction between entrepreneurship as (small) business ownership and entrepreneurship as an attitude is very important. There are a lot of small businesses that are far from entrepreneurial and people within large firms do sometimes perform entrepreneurial activities. Wennekers and Thurik (1999) identify three types of entrepreneurs: the Schumpeterian entrepreneur, the managerial business owner and the intrapreneur (see Table 1). Of these three types both the Schumpeterian entrepreneur and the intrapreneur poses entrepreneurial attitudes, while the managerial business owner can be taken to be a common shopkeeper. Hence it might seem strange that small business ownership is used as an important proxy for entrepreneurship in academic studies, but new and small firms are a major vehicle in which entrepreneurial behavior thrives (Thurik and Wennekers, 2004).

Table 1.1: Three types of entrepreneurs

	Self-employed	**Employee**
Entrepreneurial attitude	*Schumpeterian entrepreneurs*	*Intrapreneurs*
Managerial attitude	*Managerial business owner*	*Executive managers*

Source: Wennekers and Thurik (1999, p. 47)

1.3.1 Linking entrepreneurship to economic growth

The question if there is a positive influence of the amount of small business on economic growth is an ambiguous one, more small business is not always better. This

depends on the current size distribution of firms[7]. It's a different question if there is a positive influence of an entrepreneurial orientation on economic growth. Audretsch (2002, p.13) provides evidence that the positive relationship between entrepreneurship and performance holds across a broad spectrum of performance measures and across multiple units of observation for different countries in Europe and North America[8]. Hence the answer to these questions is related to the paths through which small business and entrepreneurship can lead to growth. Small businesses can have an effect on the performance of an economy through their smallness, multitude, and entrepreneurial attitude[9].

1.3.2 Smallness

There are three general characteristics of smallness that discern the influence of small businesses on the economy from that of big businesses: the flexibility these firms display, their labor-intensity, and the work mentality of the business owner. First of all, small firms reduce average costs through flexibility instead of reducing average costs through economies of scale like large business (Audretsch and Thurik, 2001). A higher variability in demand requires a higher flexibility from firms and reduces the optimal firm size. Secondly, small firms are more labor-intensive than large firms. Hence, a shift towards a greater share of small business in the economy reduces unemployment (Loveman and Sengerberger, 1991). Although this might have a positive impact on government budgets and GDP, it might just lower overall productivity. Moreover, though total employment may rise, the lower average wages that small firms pay may at least partly offset the welfare effect induced by the employment growth (Audretsch, Carree, Van Stel and Thurik, 2000, p.13). Thirdly, business owners often work harder than ordinary managers do[10] (Carree and Thurik, 2003). However, the effect of this on the economy as a whole might not be very large as majority of the labor force still is on the payroll.

1.3.3 Multitude

The number of small firms in industry can have a positive effect on economic performance in two different ways: through diversity and competition.

Cohen and Klepper (1992) state that there is a trade off associated with changes in the number of firms within an industry. While increasing the number of firms does not necessarily benefit individual firms in an industry, it does promote technical advance. A larger amount of firms benefits society by increasing the number of productive approaches to innovation that are collectively pursued within industry. Some of which would not have been pursued otherwise. Conversely, reducing the number of firms will increase average firm size and the level of innovative effort applied to each approach of innovation that is pursued. However, this comes at the cost of reducing the number of productive approaches to innovation that are collectively pursued in the industry.

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[7] Audretsch, Carree, Van Stel and Thurik (2000) propose the idea that any country has an optimal industry structure, and that deviating from that optimal structure has a negative impact on growth.

[8] In a literature survey for the European Commission (i.e. Konings, 1995; Audretsch, 1995; Acs and Audretsch, 1990; Wagner 1994)

[9] For an overview see also De Clerq and De Sutter (2003)

[10] This argument has its roots in the agency theory since the business owner more easily appropriates the results of extra work than the manager (Carree and Thurik, 2003).

The second argument says that more businesses induce more competition and more competition leads to better corporate performance (Porter, 1990). Glaeser et al. (1992) find evidence that an increase in competition increases the performance of a city. From this perspective, the source of social advantage associated with small firm size is not smallness per se, but the greater number of firms that small size implies given some industry demand. According to Audretsch and Thurik (2001) the optimal number of firms in each industry depends on uncertainty. If the degree of uncertainty is relatively low, concentrating knowledge results may result in greater technological change. However, when the degree of uncertainty increases, a diversity of approaches, represented by a multiplicity of technological trajectories, becomes more important.

1.3.4 Entrepreneurial attitude

Perhaps the strongest effect entrepreneurship has on performance is that of entrepreneurial behavior, which favors innovation. Large incumbent firms are primarily focused on improvement upon their existing technologies leading to an incremental pace of innovation (Kassichieh et al., 2002). Kassichieh et al. (2002) indicate that this process of incremental innovation seems to be insufficient for sustained competitive advantage in the modern economy, requiring instead a combination of both incremental and disruptive innovation. Furthermore, it seems to be small entrepreneurial firms that are best equipped to realize disruptive innovation.

The innovations of the knowledge economy are driven by the creation of new economic knowledge. As mentioned before, knowledge is characterized by high uncertainty, asymmetry across people and high transaction costs. These characteristics often cause differences in the value of new ideas (see also Audretch and Thurik, 2001). Sometimes these new ideas can be implemented within existing firms leading to intrapreneurship; however more often than not individuals find that their idea can only be pursued outside of the organization that employs them, leading to new business creation. These new and small firms are particularly important because they provide the opportunity for people to implement new ideas that otherwise would be rejected or remain unexplored; in doing so these firms serve as agents of change for the economy (Audretch and Thurik, 2001). Hence, an entrepreneurial economy is conducive to a successful knowledge economy.

Schmitz (1989) puts forward a growth model that links entrepreneurial activity and economic growth. In this model not the innovative entrepreneur, but the imitating entrepreneur plays a key role. Since it is not the invention itself that causes growth, only when adopted by many other firms the innovation starts to significantly affect growth. It is imitation that diffuses innovations throughout the economy. This imitation bears close resemblance with the multiplier effect of the previously mentioned spillovers. Another important implication of Schmitz's model is that there might be an optimization problem, i.e. that there might be less people choosing to become an entrepreneur than would needed for a social optimum.

A similar conclusion is drawn by Iyigun and Owen (1998). They state that a healthy economy needs both entrepreneurial and professional human capital. Entrepreneurial human capital is build by working in an entrepreneurial environment; professional human capital is build by schooling. In their model there might be an inefficient allocation between schooling and entrepreneurial experience, resulting in lower economic performance. This because social returns to work and education might differ from the private returns. An important implication of this model is that

entrepreneurship should not merely be facilitated, but be stimulated by governments and the education system, for an optimal economic performance.

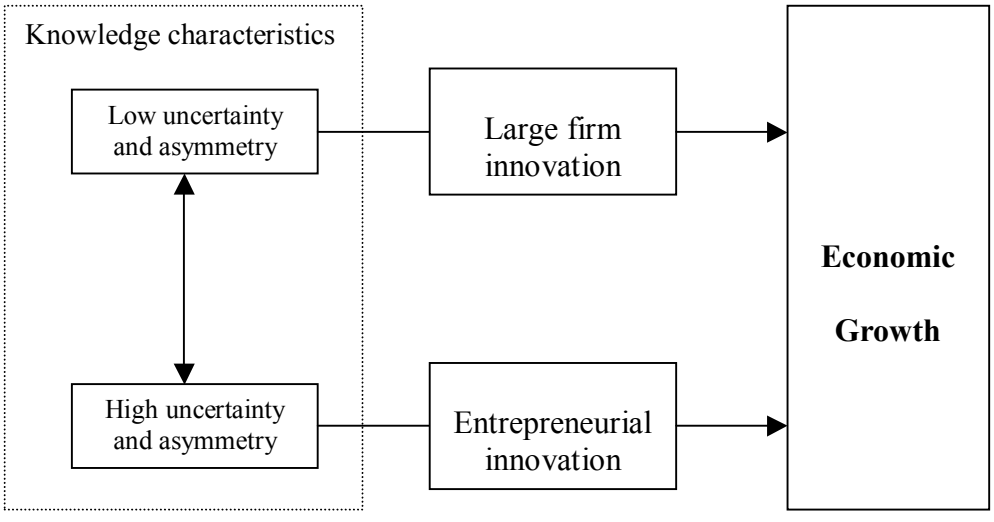
1.4 Synthesis

In the previous paragraphs we have seen how both knowledge and entrepreneurship influence economic performance. Knowledge influences growth through R&D and human capital, and entrepreneurship influences economic performance through small business and innovative entrepreneurial behavior.

To influence growth new economic knowledge needs to be adopted by a substantial amount of firms. For sustained competitive advantage a modern economy requires a combination of both incremental innovation and innovation based on radical ideas (Kassichieh et al., 2002). Small firms seem to be more apt to handle uncertain knowledge and radical ideas. Large firms use knowledge to their benefit as well. However it seems that these large, incumbent firms favor incremental innovation.

"*Because knowledge is inherently uncertain, asymmetric and associated with high costs of transactions, divergences emerge concerning the expected value of new ideas. Economic agents therefore have an incentive to leave an incumbent firm and start a new firm in an attempt to commercialize the perceived value of their knowledge. Entrepreneurship is the vehicle by which (the most radical) ideas are sometimes implemented*" (Audretsch, 2002, p.10). It seems that the higher the degree of uncertainty and asymmetry related to the knowledge, the more likely it is a small firm will commercialize that knowledge. This is supported by empirical research. Audretsch (1995, p.63), for instance, finds that, due to differences in the underlying knowledge structure, new-firm start-ups tend to be more important in industries that can be characterized as having high asymmetry of new knowledge. Thus most important contributing factor to growth of both knowledge and entrepreneurship is radical innovation using both knowledge and an entrepreneurial mindset. Hence, innovative entrepreneurship is a vehicle for transforming uncertain, asymmetric knowledge into growth.

Figure 1.2: The process from knowledge to economic growth



2.

National innovation systems and knowledge driven economic growth

2.1 Introduction

Globalization and technological change have had a significant impact on the economic performance and industrial structure of many national economies. As a result of global competition economic activities based on skills readily available to lower cost countries, will eventually shift away from the high cost OECD countries. This shift of production from OECD countries to their lower wage competitors has important socio-economic implications. Hence, it signifies the need for a shift away from production, which is easily transferred to a low cost location, to economic activity that is based on ideas and knowledge (see also Audretsch and Thurik, 2001). Economic activity based on knowledge provides a strong base for the comparative advantage of high cost economies as it cannot easily be copied or transferred to other regions. A new source of competitiveness for the OECD countries therefore lies in a knowledge driven economy.

The previous chapter indicated that the ability of countries to reach and maintain economic growth based on technology and knowledge is a fundamental issue in recent approaches to economic growth theory. It mentioned several theoretical approaches towards knowledge based economic growth, and outlined a basic model which shows the importance of innovative entrepreneurship. To elaborate on this model and substantiate the factors that drive the processes through which knowledge is transformed into economic growth, this chapter will discuss the innovation process and factors, which influence the outcome of this process.

The concept of innovation systems provides a functional framework to shed light on these processes. Systems of innovation consist of elements and relationships, which interact in the production, transfer, diffusion and adoption of new and economically useful knowledge (Lundvall, 1992). The outcome of these systems influences the performance of firms and nations within the economy. It is therefore very important to have a thorough understanding of these systems, how they work, and how they can be influenced to promote national success within the modern economy.

There has been some discussion on the level at which these system take place (see also Archibugi and Michie, 1997). These systems are not necessarily confined to one country but national characteristics play an important role in shaping them (OECD, 1999). A country's innovation system therefore influences its ability to maintain economic growth. National systems of innovation comprise of several elements including: the internal organization of firms, inter-firm relationships, the public sector, the institutional set-up of the financial sector, and the R&D intensity

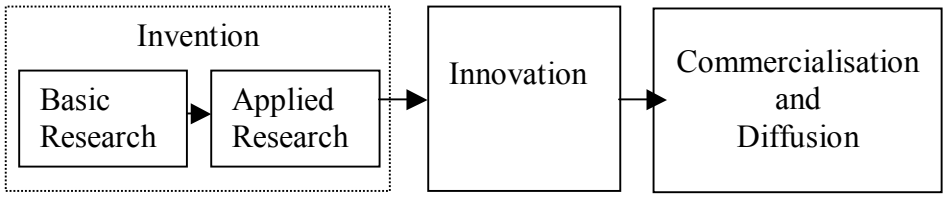
and R&D organization of a nations firm population (Lundvall, 1992). These elements together form the innovation system. They can combine in such a way that they can either reinforce each other, promoting the process of innovation and learning, or combine in a way that obstructs or even blocks the learning and innovation process of a country.

It is not within the scope of this book to develop a model of such a system. However the innovation system concept will be used to highlight and discuss several issues that these systems encounter as countries make a shift toward a knowledge driven economy. To do so in a structured manner, a better understanding of the facets that builds up the basic innovation process is required. This process will be used as a guideline to gain a better understanding of components of the innovation system and the measures that can be taken to improve a country's performance in the modern economy.

2.2 Modeling the innovation process

Traditionally the process of technological change has been characterized as a linear process with three main stages (see Figure 1). These stages are *invention, innovation,* and *commercialization & diffusion*. Invention is defined as the stage where new technological knowledge is produced, innovation is the stage where it is applied to production, and diffusion is defined as the stage in which the innovation becomes widely adopted.

Figure 1 : A Linear model of Innovation



Source: Wessner, 2003

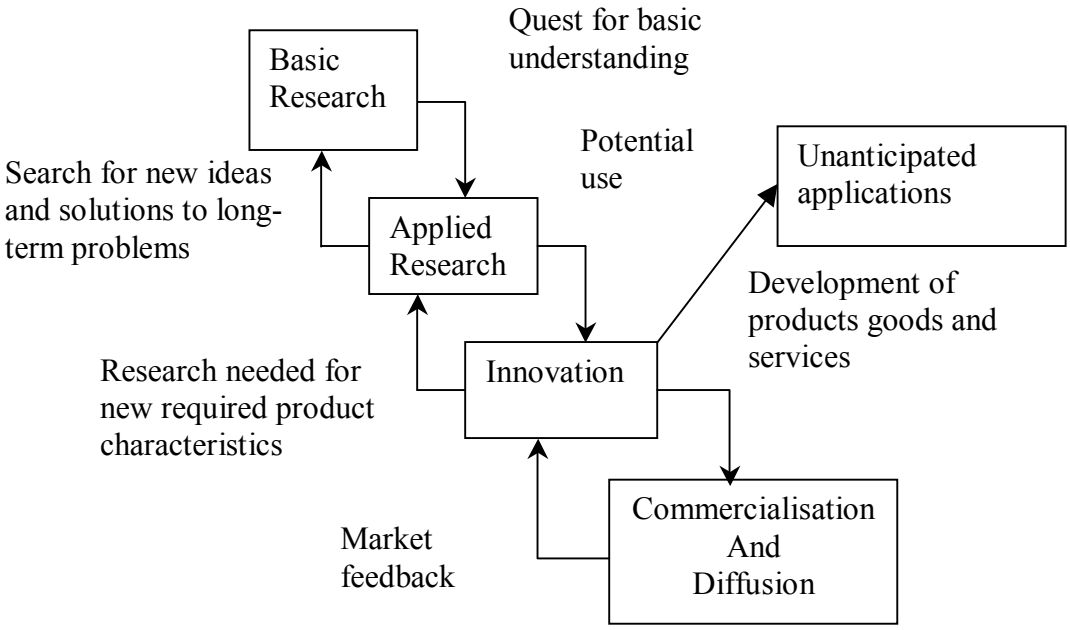
The model presented in Figure 1 shows that investments in basic and applied research are major sources of invention. They will substantially influence the opportunities for technological innovations, which in turn affect the growth rate of the economy and thus employment. This is a useful simplification of the innovation process. However, it seems to fail to capture other important sources of innovation and tends to overestimate the importance of basic research in the innovation process[11]. A more detailed model of innovation is therefore necessary to come to a good understanding of the processes that drive innovation systems. This more detailed model will be introduced shortly.

[11] Wessner, C. (2003), Current trends and challenges in the US innovation system; public policies to create science-based economic growth, presentation at the BRIDGE 2003 seminar, april 24th, Bloomington, Indiana.

There are only a few industries that have strong direct links with basic research (e.g. biotechnology, pharmaceuticals, chemistry and semiconductors). Other industries usually benefit from basic research in more indirect ways such as that embedded in machinery and their employees (OECD, 1999). Moreover, although improvements in scientific knowledge are generally expected to raise the innovation potential of a country, its utilization is not guaranteed. The creation of basic research mainly lies within the public domain while the rest of the innovation process generally is preformed by market driven firms. As a result basic knowledge created within the public sector first has to be transferred to the private sector if it is to be used in the innovation process of the firm. This transfer process is not necessarily free of problems. This implies that although basic research is an important factor underpinning economic growth it is not necessarily a sufficient factor.

Inventions and innovation will not yield value unless successfully commercialized. The uncertainty and complexity of the innovation process often prevent promising inventions from reaching the market. Successful innovations often require strong interaction between the developer and the user (see also Teece, 1992). Scientific research is therefore not the only source of innovation. Innovations can also be sparked by learning processes in production (incremental innovation), new customer demands, or through the application of existing knowledge in new contexts, inducing completely new chains in the innovation process (see also Hämäläinen and Schienstock, 2000). A too narrow focus on research and development as a source of innovation therefore overlooks the importance of other significant sources of innovation (see also OECD, 1999). The innovation process should therefore be viewed as a chain linked process, which has multiple feedback loops (Fig 2).

Figure 2: A chain linked model of Innovation



Source: Wessner, 2003

It is important to recognize that the process through which basic research and applied research are turned into innovations has several bottlenecks, which are associated with the stages depicted in Figure 2. As mentioned before, basic knowledge for instance is only productive if it is effectively transferred to the private sector. Once transferred it must be coupled with applied research to lead to innovations, which only under the right conditions will then become commercial products, driving economic growth. Moreover, there seem to be issues which influence the setting in which the innovation process takes place. Although the creation of technical knowledge through basic and applied research is an important factor in innovation it is by no means a sufficient factor.

The way in which the innovation model functions within a country is determined by factors related to socio-cultural practices that are unique to each country. Hence, innovation systems are influenced by societal factors such as: culture, national institutional setting, and the interests of nations' economic actors (see also, Lundval, 1992, Hämäläinen and Schienstock, 2000). These factors influence the process through which ideas and technology are created, the way in which technology is transferred, and the actor that conducts or induces the innovatory act. These national and regional factors define and shape the innovation process and form an integral part of any evaluation of such systems. The way these factors influence the ability of national innovation systems to cope with the pressures of the modern economy will be described in the next section. More importantly, several potential frictions in the innovation process related to the effective generation and use of knowledge will be discussed. Clearly, when these issues arise they need to be dealt with for successful transition to an economy driven by knowledge and ideas.

2.3 Knowledge creations and the innovation process of the firm

Because competitiveness in the knowledge economy is based on innovation, it is important for countries to stimulate the creation of new economic knowledge and its adoption in new products. Hence, the shift toward a knowledge economy therefore puts an ever-increasing emphasis on knowledge creation and R&D as the base for economic success. It is therefore no surprise that investment in, and the exploitation of knowledge have been identified as key drivers of innovation, economic performance, and social-well-being in OECD countries (OECD, 2002).

Companies achieve competitive advantage through innovation, including both new technologies and new ways of doing things (Porter, 1990). At the base of these forms of innovation lies the creation of new knowledge. Under intensifying global competition and rapid technological change, the pace at which innovation has to occur is increasing. To remain competitive, countries therefore have to ensure that its firms effectively adopt the knowledge available to it. Hence, it becomes increasingly important that the innovation process detailed in Figure 2 functions as smoothly as possible. This however often seems to require changes in the innovation system in the area of inter-firm and public-private cooperation. Moreover, it seems that the economic structure of countries has to change to reach this goal (Audretsch and Thurik, 1998). These processes and their consequences will be explored more in-depth in the subsequent paragraphs.

2.3.1 Competition and cooperation in innovation

Companies can acquire knowledge through different channels: using the knowledge embodied in their employees, hiring external research institutes and cooperating with universities, and by carrying out their own research. This applied research is driven by the necessity of firms to remain competitive through innovation. Competition requires firms to attain cost reductions or quality improvements to remain competitive and is an essential driving factor of the firm's innovation processes (Teece, 1992). Too much competition on the other hand might reduce profits to a point where it becomes impossible for individual firms to conduct research and introduce innovative products. As competition has increased rapidly over the years, firms increasingly seem to require cooperation with other firms and public research institutes to be able to forge ahead with the research and development of new products (OECD, 1999).

Although it may seem contradictory, competition and cooperation have a supplementary role in the knowledge economy (see also Audretsch and Thurik, 2001). The pressures of increased competition force firms to focus on their core business. This process limits the possibility of bringing people with varying knowledge bases together within the structure of the firm. This forces firms to seek complementary knowledge outside their hierarchies in order to remain capable of introducing a broad range of innovations[12]. Knowledge therefore tends to develop through frequent firm interaction within localized production networks embedded in innovative clusters (see also Dicken, 1996; Markussen, 1996). Knowledge intensive industries therefore benefit greatly from the externalities of concentration.

Cooperation among firms is increasingly important because individual companies are no longer capable of financing and managing the risks of new product development. Rapid technological change has made the business environment increasingly complex and difficult to manage. This places extra pressure on firms to collaborate with each other to reduce the risks brought by the modern economy (OECD, 1999). Research by Sakakibara (1997) shows that research alliances can reduce costs and enhance innovativeness. This indicates cooperation can be an important source of competitiveness within the modern economy. Not only does it allow the partnering firms to gain synergies such as risk reduction as a result of pooling their efforts but they also enhance the possibility of breaking out of their research path by bringing together people with more widely varying knowledge bases. It is therefore of no great surprise that cooperation has become an important strategy for firms trying to cope with the shift towards an economy driven by knowledge and innovation.

Cooperation can prevent the rejection of research projects by firms that lack the technological capabilities, or find the project too risky and expensive to pursue the project on its own. Therefore, cooperation may prevent rejection of research projects, which could be potentially beneficial for a society as a whole. However, Feldman and Kelly (2003) indicate that this problem might still occur when a firm considers the costs of cooperation too high. Hence, even in an area of research that is associated with market forces there might be an important role for public intervention to ensure this type of research and product development is conducted by industry.

[12] New knowledge, whether applied or basic, is often created when different types of knowledge are exchanged or combined in a new way. Due to the tacit nature of knowledge, this often requires intensive interpersonal communication and rich knowledge flows amongst people with varying knowledge bases (Hämäläinen and Schienstock, 2000).

2.3.2 Frictions in public private knowledge flows

In addition to intra-firm cooperation, firms are increasingly seeking to take greater advantage of technologies developed by universities and government research labs. The importance of public-private knowledge flows, depicted in Figure 2 by the arrows between basic research and applied research, seems to be increasing. As previously noted, basic scientific research is increasingly important within the knowledge intensive industries that make up the knowledge economy. National innovation processes therefore increasingly rely on the effective interaction between scientists and the business sector (see also OECD, 1999).

Advances in basic scientific research are generally driven by the quest for the advancement of science and the curiosity of researchers. Basic research is a long-term process, which does not necessarily generate productive outcomes. The creation of basic research therefore mainly lies within the public domain and relies for a large part on public funding; a source which seems to be under pressure as governments are increasingly forced to cut budgetary spending. Basic knowledge is predominantly created within public research institutions such as universities and government research laboratories. Often independent from industry, the research that these institutes conduct is not fine-tuned to the wishes of the market. A large difference in the orientation of research institutions and industry and a low degree of commercial orientation on the part of the research institutions can create difficulties in the transfer process (Bartholomew, 1997). It can create problems such as mismatches between the type of basic research required by national industries and the type conducted by national research institutions. Even when such a match does exist, failure to learn about the results of public research often prevents the commercialization of potentially valuable ideas.

The above suggests that frictions and barriers often occur in the transfer to and adoption of basic knowledge by industry (see Figure 2). These frictions clearly need to be overcome if a country wants to benefit from the knowledge it creates. Public policy in this area can be important in preventing these forms of market failure. Government can directly influence the interaction between the parties and in the process help provide public research institutes with an alternative source of funding.

2.3.3 Preventing the loss valuable knowledge: new venture creation

Knowledge is characterized by high uncertainty, asymmetry, and high transaction costs. As a result differences in the perceived value of new ideas often occur within the firms' hierarchies (Audretsch and Thurik, 2001). These differences often prevent the implementation of radically new ideas in the firm's innovation processes. Hierarchies therefore tend to favor incremental knowledge development along locked-in development path. Kassichieh et al. (2002) indicate that this process of incremental innovation seems to be insufficient for sustained competitive advantage in the modern economy that requires a combination of both incremental and radical innovation. This implies that if a country is to maintain rapid rates of innovation it cannot merely rely on cooperative networking interaction between incumbent firms and public knowledge institutions. Governments therefore have to promote the adoption of knowledge by individuals who place higher value on that knowledge than their current employer, preventing its loss in the hierarchies of firms and research institutions. Some times these new ideas can be implemented within existing firms, however these individuals often find that their idea can only be pursued outside of the

organization that employs them, leading to new business creation. These new and small firms are particularly important because their creation provides an opportunity for people to implement new ideas that otherwise would be rejected or remain unexplored, in doing so these firms serve as agents of change for the economy (Audretsch and Thurik, 2001)

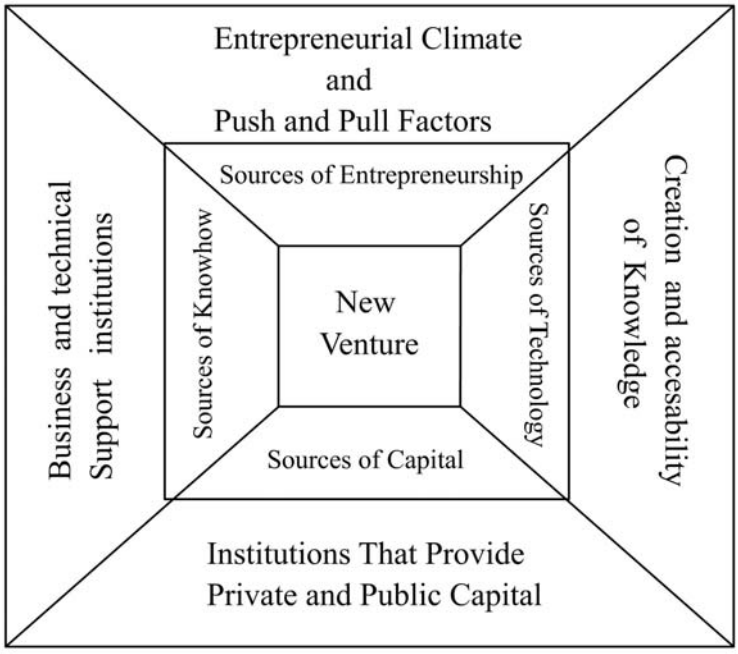
Spin-off or entrepreneurship, based on knowledge and skills aquired within another organization, is an important factor driving the flow and adoption of available knowledge within the economy. It forms one of the most direct ways in which technology and knowledge created in an organization, whether it is a research institution or a market driven firm, can be transferred to and adopted within a new firm (see also Rogers et al., 2001). The greater the number of firms this process creates, the greater the number and diversity of approaches taken to innovation within the country. The pursuit and generation of new ideas is critical to an economy in which innovation is the most important base for comparative advantage. Since entrepreneurship is conducive to innovative activity, the creation of an entrepreneurial economy can be an important prerequisite for a transition to a successful knowledge economy (Audretsch and Thurik, 2001). Therefore it is quite important to evaluate the factors, which drive the entrepreneurial process.

2.4 Innovative entrepreneurship

Successful entrepreneurship is based on variables internal and external to the entrepreneur. The variables that are internal to the entrepreneur relate to the personal traits and experience that allow the entrepreneur to efficiently bring together or tap into sources of new economic ideas, labour and capital. The external variables relate to the entrepreneurial environment. The ideal entrepreneurial environment is a setting where small entrepreneurial firms can take full advantage of agglomeration and proximity, to exploit nearby sources of information, skilled labour, technology, and capital (Malecki, 1997). When such an entrepreneurial environment is developed it can reinforce and sustain entrepreneurial activity within the region. Leading to what Krueger (1995) describes as entrepreneurial vitality, a state where regions with high levels of entrepreneurship stimulates further entrepreneurial development.

Entrepreneurial vitality lies in two important aspects: a society's entrepreneurial climate and regional entrepreneurial infrastructure. These features determine the likelihood of becoming an entrepreneur and the likelihood of entrepreneurial success. Smilor and Feeser (1991) propose a chaos model that represents these factors, which influence entrepreneurial success in technology based entrepreneurship. An adapted version of this model is in depicted in Figure 3. Smilor and Feeser indicate that this type of entrepreneurship requires synergy between talent, technology, capital, and know-how. From a macroeconomic perspective the ability of a nation to support this type of entrepreneurship is determined by initial conditions regarding entrepreneurial climate and the availability and accessibility of knowledge, capital and business support for the small firms it creates.

Figure 3: factors that influence success in technology based entrepreneurship



Source: Adapted from Smilor and Feeser (1991) pp 167

2.4.1 Entrepreneurial climate

The likelihood of a person becoming an entrepreneur is influenced by factors that lie at several different levels of economic analysis (Verheul et al., 2002). At a micro level, entrepreneurship is influenced by an individual's personal traits, which determine the entrepreneur's response to entrepreneurial push- and pull-factors (Smilor and Feeser, 1991). These factors may arise from negative pushes such as: a loss of employment, discontent at work because an idea is rejected or a career path becomes blocked, a desire for independence, or, alternatively, positive pull factors such as: a chance or opportunity to pursue an idea or market opportunity. At a macro level, these traits are determined by a system of a society's values and attitudes towards private enterprise, risk, science, and economic and social change (Piatier, 1984). In a society that places a lot of emphasis on individual performance these push and pull factors will be more likely to result in entrepreneurship, while a risk avoiding society will probably not display a lot of entrepreneurship due to the inherent uncertain outcomes associated with it (see also Malecki, 1997 and Hofstede, 1980).

Societal perceptions towards entrepreneurship can be influenced by government policy. Entrepreneurial spirit can be promoted by creating awareness about the importance of entrepreneurship for society which can be demonstrated through the successes of local entrepreneurial role models (see also Bosma et al., 2002 and Malecki, 1997). The next step is to stimulate a positive attitude towards entrepreneurship and develop entrepreneurial qualities such as risk-taking, creativity, initiative and goal setting. The last step is to train entrepreneurial skills, such as management skills, business plan development, and to experience entrepreneurship hands-on.

2.4.2 Entrepreneurial infrastructure

Entrepreneurial success is strongly influenced by regional and national entrepreneurial infrastructure (i.e. the factors that enable the entrepreneur to set up a successful firm and tap into external sources of technology, capital, and business know-how). Starting entrepreneurs are often inexperienced, the small companies they create are often unable to conduct substantial R&D in multiple aspects related to their base technology, and often have small external networks which limit their ability to draw on external sources of capital and technology, (Malecki, 1997). These disadvantages have a substantial impact on the ability of small firms to reach success. Unable to generate enough capital and technology on its own the small firms must rely on external sources for these inputs to drive its growth and development. As the networks that small firms are able to operate are usually small and typically have little geographical scope, small firms are often forced to rely on networking institutions that bring together these small firms and the resources they require (see also Estimé, Drilhon and Julien, 1993). The availability of these and other institutions that help small firms attain business and technical knowledge, capital and technology is therefore an important variable in the success of these firms.

The problems related to the ability of small innovative firms to acquire capital are well documented. Even in countries that are generally considered to have sufficient sources for capital there seems to be a gap in the availability of capital at the seed and start up stages of firm development. Furthermore there seem to be substantial informational problems, which affect the small firms' ability to tap into the sources of capital technology that are available (see also Cooper, 2003; Audretsch 2003 and Malecki, 1997). Small firms are often unaware of potentially valuable knowledge and technologies available at research institutions and often lack the resources to find suitable partners for cooperative research projects. Countries and regions that lack entrepreneurial culture, sufficient sources of capital and technology or lack the institutions that help small firms access these sources, will therefore not generate a lot of successful technology based entrepreneurial ventures. Even when such infrastructure is available the small firm has to ensure its inventions become innovations, fighting against technological and entrepreneurial risks, before it can successfully commercialize its ideas and become a viable company[13]. Small firms would therefore benefit from external support throughout the stages of their development.

2.5 Policy implications

Governments have to ensure that the country makes the utmost of the knowledge and technologies available, so the national economy can remain competitive and maintain healthy economic growth rates and high wages. In the light of the developments associated with the rise of the modern economy governments are devoting increased attention to the contribution of science and innovation to economic growth (OECD, 2002). The rise of the modern economy has changed the coordination and cooperation between the actors involved in the economy, particularly in relation to diffusing, using and exploiting knowledge. It is increasingly recognized that when a country wants to

[13] Wessner, C. (2003), Current trends and challenges in the US innovation system; public policies to create science-based economic growth, presentation at the BRIDGE 2003 seminar, april 24th, Bloomington, Indiana.

prosper within the knowledge economy tighter integration of the activities of industry, universities, public research facilities, and government policy is required in the areas of science and technology (OECD, 2002).

According to Porter (1990) an important role for the government lies in ensuring there is a good support structure i.e. creating an environment that is conductive to business innovation and ensuring an adequate supply of high-tech professionals on which the knowledge economy is based. Audretsch and Thurik (2001) therefore state that governments should focus on input stimulation raising the country's skill level, stimulating basic and applied technology at universities and lowering other potential barriers to the development of the knowledge economy. To stimulate the development of the modern economy governments therefore have to take away existing barriers that prevent the efficient functioning of their national innovation system (see also OECD, 1999).

In this chapter we have used the innovation process to indicate several of such potential barriers concerning the process of knowledge generation and its adoption by existing and new entrepreneurial firms. The rising importance of entrepreneurship within the innovation systems of countries that are considered forerunners in the modern economy indicates that the factors that influence the entrepreneurial process deserve additional attention. Both a weak entrepreneurial climate and a lack of entrepreneurial infrastructure may limit successful entrepreneurial development. As entrepreneurship seems to be an important feature driving development in the modern economy these issues need to be dealt with when they hinder the performance of the national innovation system.

Market pressures form a sufficiently motivating factor for the business sector to seek a more proactive stance on cooperation amongst each other and with public institutes. Policies aimed at reducing the frictions that occur in the knowledge transfer between firms and public institutions will therefore primarily have to focus on cultural practices and institutional variables present at these institutions. Governments dealing with such problems should help their science system adopt a more proactive stance toward commercialization and cooperation, and help these systems to adjust to entrepreneurial knowledge generation and use, while continuing the pursuit of curiosity driven research within public institutions (OECD, 1999).

Stimulating entrepreneurial spirit and spin-off in public research and educational institutions might be a measure, which can help attain both goals. How these measures can be implemented and compared in effectiveness to the more traditional forms of knowledge transfer at these institutions, will be discussed in more detail in the next chapter.

3.

University knowledge transfer: an introduction to spin-offs

3.1 Introduction

The rise of the modern economy is changing the coordination and cooperation between business, government, and public knowledge institutions. Universities play an important role in this process since they are increasingly involved in incubation and regional development. This is a relatively new development that indicates a shift in the role universities perform in the economy.

Traditionally the primary goal of universities lies in the advancement of scientific research and education. These goals make universities a unique source of basic research that, when adapted by the business community, can function as an important source of knowledge based economic growth. Knowledge tends to develop within innovative clusters (Porter, 1990). Knowledge spill over tends to occur only within limited geographic areas, embedding economic activity based on this knowledge within the region (see also Dicken, 1998 and Markussen, 1996). Hence, universities and other research institution can become important focal points for regional economic developments. This type of development, however, is by no means assured. Research by Castels and Hall (1994) is indicative of this problem as they show that some places with considerable R&D have not been able to generate sustainable economic development or a significant number of new firms.

The previous chapter has indicated two important issues that might explain the failure of several universities to spark of this type of development. First, substantial barriers often occur in the transfer of university knowledge to the business sector and, secondly, a lack of entrepreneurial climate might prevent new business creation based on university knowledge. As indicated by Bartholomew (1997) barriers in public-private knowledge transfer often arise out of large distances between research institutions and industry and a lack of commercial orientation on the part of public institutions. Hence, the rise of the modern economy has sparked considerable debate on the role of the university in economic development. As a result of this debate universities have become more proactive in ensuring the commercialization of their research to help sustain economic growth in the modern economy.

Universities are gradually becoming more involved in economic and social development, and pay more attention to the commercialization of research results, patent and

licensing activities (Branscomb et al., 1999; Etzkowitz, 1998; Etzkowitz, Webster & Healy, 1998). Hence, the role of the university in the modern economy is shifting from a research and education institution towards an institution, which contributes to national economic growth. Looy et al. (2003) even speak of a revolution in this respect adding entrepreneurial objectives as a third component to the mission of the university.

To fulfil this new role, universities need to transfer knowledge and technology to society. This transfer process can take many forms and can take place through a variety of communication channels (Carayannis et al., 1998). A transfer process that is increasingly gaining in attention amongst these processes is the process of spinning-off. A spin-off is most commonly defined as: *an individual or a group of individuals leaving a parent firm to start up a new, independent business on the basis of specific knowledge and competences built op within the parent firm* (Elfring & Foss, 2000). The parent organisation supports the spin-off by allowing the transfer of knowledge, competences, and/or direct means to the new firm (Bernardt, Kerste and Meijaard, 2002).

University spin-offs differ from normal business spin-offs in a very important aspect: the university spin-off transfers knowledge created in a public environment to the private sector. Hence, university spin-offs form a mechanism for the transfer of science, technology and business knowledge (Moncada et al., 2000). In the case of the university spin-off the founder is often a faculty member, staff member, or student who left the university to start a company based on knowledge or technology developed within the university (Smilor, Gibson & Dietrich, 1990). The university, which can be considered the parent organisation, has an important supportive role in the creation of university spin-offs. They can stimulate the creation of these small firms through a formal spin-off program and further aid these young companies in their first years of their existence by providing an incubation program.

The small innovative and dynamic new businesses formed through this process can form an important driver in economic growth, industrial renovation and employment generation (see also Thurik, 2001). As a result, both public policy makers and researchers alike are devoting a lot of attention and effort to the study of this phenomenon and its possible benefits. This chapter aims to give more insight into the spin-off process and evaluate the effectiveness of the spin-off process compared to other forms of technology transfer. Moreover this chapter will serve as an introductory chapter for chapter 4, which highlights the importance of university spin-offs for the life science sector and provides a comparative study of the spin-off programs of Indiana University (USA) and Erasmus University Rotterdam (the Netherlands).

3.2 Knowledge transfer through university spin-off

Universities that actively stimulate technology transfer and partnering with businesses can derive several benefits from this. First of all, additional income can be generated from licensing activities, sponsored research, and donations. Secondly, relationships between university and business can be used to attract and retain star scientists. Moreover, there may be in-kind benefits from these partnerships, such as an increase in the desire of companies to employ students and the creation of additional sponsored research. According to Stephan (2001), these partnerships may also have a positive effect on the curriculum at universities, as faculty members draw on their experiences within firms to provide instruction that is more relevant and more closely aligned with the needs of high-technology firms and business.

The process of knowledge transfer can take many forms and can take place through a variety of communication channels (Carayannis et al, 1998). Transfer can occur through various methods such as: publications, consulting, informal meetings, recruitment of university graduates, cooperative research agreements, contract research, the licensing of

intellectual property rights, and entrepreneurial spin-off (Agrawall, 2001; Rogers et al., 2001). These methods range from informal contact to formalised agreements specifically designed to aide transfer. We will first discuss publication and licensing, as they form the university's most important communication channel and the most commonly used transfer method respectively (Rogers et al., 2001; Siegel et al., 1999).

In the evaluation of these transfer processes it is important to recognise that university knowledge often represents early stage tacit technology, indicating that a lot of these inventions will require further involvement of the academic researcher (Goldfarb and Henrekson, 2003). Moreover, as entrepreneurial development is becoming increasingly important in economic growth it is important to assess the effectiveness of these ways of transfer to both large corporations and small innovative ventures (see also Shane, 2002).

3.2.1 Publication

The publication of articles in academic journals forms the most important way in which research discoveries conducted at universities are made public and it is the most frequently cited technology transfer activity by university research centres (Rogers et al., 2001). Publication in prestigious journals brings status to the researcher and the university. Moreover it forms an important method to assess the quality of the academic research and has an important role in the remuneration of the researcher. Although very important in this respect, publications do not provide an effective means of technology transfer (Rogers et al., 2001). Journal articles are usually written for fellow scientists rather than the potential users of the technology. Moreover, early publication in an academic race may even reduce or prevent revenues from other transfer methods if intellectual property rights have not been arranged properly. In addition to these problems, the access for small firms to this type of knowledge is often limited. Although some large firms might be able to employ people dedicated to the search for new emerging technologies, the scope of these types of activities is limited for small entrepreneurial firms (see also Malecki, 1997).

3.2.2 Licensing

The formal transfer of knowledge from universities to the commercial sector has historically been dominated by the practice of licensing (Siegel et al., 1999). The advantage of the licensing system over most other transfer methods described above is that both the scientist and the university are able to profit from the technology. Furthermore, unlike several other ways of transferring knowledge, the academic researcher is able to pursue his or her research without having to split his time between academic research and commercial matters (Locket et al., 2003).

There are several general disadvantages to licensing for both the licenser and the licensee. The new technology may not be easily patented or managed under a license agreement. Licensing a technology only transfers codified knowledge to the licensee. Moreover the commercial value of this knowledge is not known upfront so that the university may not be able to capture the full value of its technology through a licensing agreement (Locket et al., 2003). Even though licensing is a process that is adaptable to both large and small firms, large firms can more easily bare the costs of such agreements. Moreover, there seems to be a difference in the type of technology licensed between large and small firms (see also Kassichieh et al., 2002; Shane, 2002): large companies tend to licence knowledge which supplements the technologies they have developed internally and often have little incentive to develop ideas that might cannibalise existing investments, leaving more radical inventions unused if they are not applied in (new) small entrepreneurial companies. Hence, the university

may want more direct involvement in the commercialisation of their technology (Franklin et al., 2001).

3.2.3 University spin-off

University spin-offs can be divided into direct spin-offs and indirect spin-offs (Yencken, Cole & Gillin, 2002). Direct spin-offs are companies that are created in order to commercialize a university's intellectual property. It usually involves licensing and a staff transfer to the young start-up. Indirect spin-offs are companies set up by university staff and/or former students drawing on their experience acquired during their time at the university, but have no formal IP licensing or similar relationships (see also Thorburn, 1997 and Upstill & Symington, 1999). Our main focus here will be on direct spin-offs.

As stated in the previous chapter entrepreneurial spin-off forms one of the most direct ways in which technology and knowledge created in an organization, whether it is a public research institution or a market driven firm, can be transferred to, and adopted within, a new firm. Spin-offs are therefore an important method to bring innovations, technologies and products to the market and make use of opportunities that otherwise would have been left unexploited or undeveloped. Hence, university spin-off form an important vessel for the transfer of radical technologies (see also Kassichieh et al., 2002; Shane, 2002).

The innovative small firms created through the spin-off process can be a source of new jobs, accelerate regional economical growth, create a new, or renovate an existing industrial base, and increase a region's competitiveness (see also Thurik, 2001). In addition to these benefits the spin-off process provides an additional option in the careers of scientist, enabling them to actively develop the technical application of their research (Corman et al., 1988 and Doutriaux & Peterman, 1982). Equity participation in the profitability of venture will provide the scientist with enough incentive to put a lot of effort into this commercialization. The promotion of these spin-offs will thus help create an entrepreneurial climate within the academic setting of the university. Moreover, a successful spin-off program can positively add to the status of a university (see also Branscomb et al., 1999 and Bruyland, 2001).

A major shortcoming of the spin-off approach is the fact that it is often difficult to induce the entrepreneurial act amongst academics that are accustomed to working in a non-commercial environment. An additional problem that arises is that the academic entrepreneurs often lack business knowledge and entrepreneurial experience. Daniels and Hofer (1993) find that new business ventures in universities are more successful when the entrepreneur has previous entrepreneurial experience. The lack of such experience on the part of the academic entrepreneur can therefore limit the successful commercialisation of university intellectual property. Moreover, the entrepreneurial process can interfere with the scientist's regular work at the university and create conflicts of interest between the university and the academic (Samson and Gurdon, 1993).

It seems however that most of the shortcomings of university spin-offs can be overcome through the creation of a thorough spin-off program by the university (see also Locket et al., 2003 and Samson and Gurdon, 1993). Universities can stimulate spin-off through the design of a spin-off program that selects potential spin-off technologies and adds elements that circumvent potential conflicts of interest between the university and the scientist. This makes university spin-offs a valuable addition to the normal licensing process.

3.3 The spin-off process

Significant differences exist in the amount of spin-offs generated by universities. These differences do not only occur amongst universities in different countries but also occur within countries. This indicates that, beside national aspects such as entrepreneurial culture and infrastructure, university specific factors influence this process. Studies show that universities that want to stimulate entrepreneurial spin-off can initiate spin-off programs to support the creation and success of these new ventures (see also Locket et al., 2003 and Gregorio and Shane, 2003) These programs determine the importance given to spinning-off as a form of knowledge transfer and contain guidelines how to transfer knowledge to university spin-offs. Spin-off programs can further include incubation facilities. Although the availability of university incubation centers is not necessarily[14] a significantly beneficial factor in the amount of start-ups, they do benefit the success of the spin-offs generated.

The way a spin-off program is set up can significantly influence the success of the university in generating spin-off firms. Locket et al. (2003), for instance, indicate that universities with more explicit and proactive policies towards the development of university spin-offs are more successful in generating them. They further indicate that universities that stimulate the use of surrogate entrepreneurs tend to generate more startups (Locket et al., 2003). Gregorio and Shane (2003) further show several specific areas in which university technology transfer policies can have a significant effect on new venture creation. They indicate that universities that take up equity investments in spin-offs instead of high royalties for their property rights increase the formation of these firms. To gain a better understanding of the factors that influence the quantity and quality of spin-offs we therefore have to examine the spin-off process in more detail

New ventures such as university spin-offs go through a number of critical phases in their development. Several authors have described this process and divided it into stages of firm development. Churchill and Lewis (1983) constructed a suitable model for small business development. Building on the model of Greiner (1972) they developed a framework for small firm growth that defines five stages: existence, survival, success, take-off, and resource maturity. In a similar, general stage-based approach to new business development Van der Sijde and Van Tilburg (2000) divide the process in five phases: awareness, feasibility, start-up, growth, and maturity. Although most of these models can be applied to the spin-off process we will focus on the work of Vohora et al. (2002) as they identify several important junctions in growth and development of university spin-offs: opportunity recognition, entrepreneurial commitment, the credibility threshold, and the critical juncture of sustainability.

3.3.1 Opportunity recognition

In the corporate world, a spin-off company can be created both through technology push and business pull (Roberts and Malone, 1996). Although there might be some room for business pull at universities, the independence of scientists is expected to limit the success of business pull for spin-offs. Hence, it can be expected that universities mostly rely on the process of technology push for creating spin-offs. A straight forward, but essential prerequisite for spinning off knowledge from university is that the parties involved in the research and technology transfer recognize the commercial value of the scientist's research and see an entrepreneurial opportunity to exploit this knowledge. Moreover, one or more individuals

[14] Incubation facilities were not found to have an influence on the amount of university spin-offs in an American study by Gregorio and Shane (2003). This finding might however not generalise to other countries that lack in entrepreneurial climate.

need to be willing and capable to exploit these commercial opportunities and make the start-up a success.

University incubation programs and technology transfer offices can help in this respect by promoting the commercialization of university ideas and stimulating and rewarding entrepreneurship within the university and amongst staff. This process can create so-called entrepreneurial universities (Branscomb et al., 1999), where commercialization of university knowledge becomes a viable and valued option in the career trajectories of academics.

University's commercial or technology transfer offices play an important role in the spin-off process. The university needs to decide whether the technology needs to be protected through patents, industrial copyright, trademarks, registered design, or trade secrets. As this intellectual property will be the core around which university spin-offs create their business, it is crucial that the technology in question is sufficiently protected. As soon as the university has been able to disclose the invention, it is necessary to evaluate the new technology (Roberts and Malone, 1996). Created for the transfer of university technology to the private sector, technology transfer offices aid the process of invention disclosure and evaluate the patent applications for university technologies. Often better equipped than the academic scientist to detect commercial potential, they play an important part in the opportunity recognition for university spin-offs (Siegel et al., 2003 and Locket et al., 2003).

3.3.2 Entrepreneurial commitment

There are two approaches to entrepreneurship associated with the formation of spin-off companies from publicly funded recourses (Radosevich, 1995): the inventor-entrepreneur approach (i.e. the academic entrepreneur), and an approach that uses surrogate entrepreneurs to commercialise university knowledge. Academic entrepreneurship ensures a fundamental understanding of the company's core technology within the management of the start up. As the scientist is often also the originator of the knowledge, academic entrepreneurs often have a strong commitment to the technology, even when they face setbacks during the commercialisation process (Franklin et al., 2001). Moreover, the direct involvement of the scientist may create greater technical capacity and increases the scope of potential benefits arising from continued relationships with the university and the scientist's network (Radosevich, 1995; Scholten et al., 2002).

However, the characteristics and capabilities of a successful faculty researcher with an opportunity to start a spin-off from his research do not necessarily match those of an entrepreneur[15]. Even if academics are (made) aware of the commercial opportunity that has arisen from their research, this is by no means a guarantee that they will pursue it. According to Milton-Smith (1999) researchers often lack the incentive to start a spin-off, as doing so can be inhibitive to their academic career[16]. These, and other problems associated with the lack of experience of academic entrepreneurs mentioned earlier, indicate that a strategy focused on academic entrepreneurship might require substantial support infrastructure from technology transfer offices and incubation centres to aide the start-up and progress of these entrepreneurial companies (see also Radosevich, 1995).

If the academic inventor does not posses the right entrepreneurial skills, so called surrogate entrepreneurs need to be attained (Franklin et al., 2001). The young university spin-off needs an entrepreneurial champion to successfully commercialize its technology (Roberts

[15] Some parallels can be drawn between the academic and the entrepreneur; both need creativity, persistence and need revolutionary approach (O'Boyle, 1984). However in most other aspects entrepreneurs and academics are very different.

[16] Pursuing a business opportunity will most likely come at the expense of the creation of reputation-enhancing knowledge, or worse might lead to the loss of reputation amongst peers (Goldfarb and Henrekson, 2002).

and Malone, 1996). Vohora et al. (2002) recognize the importance of entrepreneurship and believe it is one of the critical junctures in the development of a spin-off. Without *entrepreneurial commitment*, a spin-off will not be successful. The technology originator might not possess the characteristics to become a good entrepreneurial champion (Venkataraman et al., 1992). If this is the case, an external entrepreneur, or surrogate entrepreneur, needs to be acquired.

Surrogate entrepreneurship involves an external individual or organization assuming the role of entrepreneur while the academic originator maintains a position in the university (Radosevich 1995, Franklin, et al., 2001). With skills gained from previous entrepreneurial experience, surrogate entrepreneurs often possess the business skills and business network that the academic entrepreneur lacks. The use of a surrogate entrepreneur can compensate for the lack of business skills on the part of the academic and drive the entrepreneurial development of the spin-off. The benefits of active participation of the scientist who invented the technology can be reached by involving him in an advisory role within the company. Such a division of tasks helps to reduce conflicts of interest (Samson and Gurdon, 1993). Moreover, the active involvement of outside entrepreneurs can help universities discover spin-off opportunities (Locket et al., 2003). Universities can stimulate this type of development by providing links to their business schools, creating science parks and stimulating external contact trough incubation programs.

3.3.3 Passing the credibility threshold

Financial capital is crucial to a new business, when attempting to start up. Where normal start-ups initially would have to ask "family, friends, and fools" for financial resources to begin their company, spin-offs can benefit from the relationship with its parent. The university has a broad network and different resources to draw from and is able to reduce the financial strain on the young start up by taking equity instead of royalty fees for their intellectual property rights (Gregorio and Shane, 2003). However, the ability of the management of the spin-off to acquire sufficient funding will still greatly influence the company's potential.

Spin-off companies will have to pass an important *credibility threshold* to reach this goal (Vohora et al., 2002). The university spin-offs need to have a credible business model in order to attract investors and customers. Vohora et al. (2002) mention four specific tasks that are essential to pass this threshold. In its pre-organization phase the spin-off needs to clearly and precisely define the opportunity in terms of a viable business model, develop an explicit strategy that identifies the goals and milestones necessary to realize the opportunity, identify necessary resources/capabilities needed in order to implement the business model, and identify and gain the commitment of key individuals who will form the venture's entrepreneurial team.

The new venture needs to fine-tune product features to make the product or application a success (Roberts and Malone, 1996 and Vohora et al., 2002). To fuel this development it is essential for the new venture to attract first stage finance. This phase therefore demands a lot of the perseverance from the entrepreneurial team, as well as from their ability to attract the necessary resources. This business development phase is very turbulent and the business models will need to be adjusted on a regular basis (Roberts and Malone, 1996). Facing a lot of uncertainty on a wide range of business aspects it is important for the firm to develop a substantial external network to aide the firm's development (see also Scholten et al., 2002). For a spin-off most initial social capital will mainly come from the university, and relationships that have been established while the entrepreneur was still

working at or affiliated with the university. Hence the business network of the spin-off has to be expanded.

As indicated in Chapter 2, successful entrepreneurial companies require a synergy between: entrepreneurial talent, technology, capital, and business know-how (see also Smilor and Feeser, 1991). Lack of business skills, management problems, and under-capitalization are often cited as reasons for small business failure. To help the spin-offs trough their first years of existence it is therefore important that universities provide an incubation program.

3.3.4 Business incubation in the spin-off process

Business incubation programs provide a controlled environment, which help the hatching and development of new businesses. They can be seen as a launching platform that encourages faster growth and higher survival rates for start-ups. The physical space and specialist services offered help young business overcome the problems that so often lead to their failure. Sharing resources in the business incubator's nurturing environment provides start-ups with facilities, tools, and expertise that otherwise may be financially or logistically out of reach. Moreover, the business incubator provides an entrepreneurial setting and an important learning environment (Merrifield, 1987). Start-ups and entrepreneurs within the incubator can share experiences and knowledge. Another advantage is that start-ups in business incubators are more visible in the market place.

Business incubators generally aid companies to become more successful. This aspect is shown in the significantly higher survival rates of start-ups with incubation support. About 87 % of all North-American firms that graduate from their business incubator remain in business, compared to a survival rate of 53% nationally most failing within the first five years[17]. Similar studies in the UK show that these start-ups had an average success rate of 80%, as opposed to a national average below 50%[18].

Business incubation takes place in many forms, first and foremost are incubator centres, but also business centres, science and research parks and innovation centres are a means of creating and growing new businesses. Research and science parks for instance play an important role in promoting research and development by the university in partnership with industry, assisting in the growth of new ventures, and promoting economic development[19]. However, where business incubators provide entrepreneurs with a rather complete start up package, science parks and business centres mainly offer managed workspace. Incubation programs have a mission to provide business assistance to start-ups and lead these companies to self-sufficiency. A business incubator is therefore not merely a building with multiple tenants, a receptionist service, and a shared copy machine.

3.3.5 Sustainability

Reaching a more stable stage of development, companies leave the incubation centre. At this stage the university can see the spin-off process as a success. The university has successfully transferred its knowledge to a viable business and in the process jobs have been created for the regional economy. At this stage of sustainable growth the spin-off should no longer be seen as a spin-off, but as an independent new technology based firm. Even in this stage of the firm's development the relationship with the university should be maintained so that the spin-off can stay at the edge of new developments. Eventually the venture will not be able to

[17] www.nbia.org, May 11th , 2003
[18] www.ukbi.co.uk, May 11th 2003
[19] see also IASP International Board, 2002 and www.aurpnet.org

continue under its old ownership structure. Companies will usually be sold to a larger industry player, or go public through an initial public offering (IPO), which provides the necessary funding for future growth (Roberts and Malone, 1996).

3.4 Synthesis

This chapter aims to evaluate the process of university spin-off as a form of technology transfer and give more insight into the spin-off process. We have shown that spinning-off forms a good supplement to existing transfer mechanisms such as the process of licensing. It forms a good way in which radical technologies can be transferred to society and it allows the university to take a flexible approach to the transfer process to small entrepreneurial firms (see also Kassichieh et al., 2002 and Shane, 2002). The study of the literature on the university spin-off process indicated several important junctions that appear in the generation of these entrepreneurial firms (see also Vohora et al., 2002)

The success factors for technology based entrepreneurship given by Smilor and Feeser (1991) (i.e. talent, technology, capital, and business and technical knowledge) can aid us in describing the factors, which determine spin-off success. As indicated in chapter 2, both technology and business know-how are required for successful businesses (see also Smilor and Feeser, 1991). University staff, students or faculty members often found university spin-offs based on their experience and knowledge, in a particular research field or a specific technology, acquired at the university. However this knowledge is not sufficient, when it comes to creating a successful business. This is illustrated by the fact that spin-offs with a management team that lack these entrepreneurial skills have substantially lower survival rates than those who do not (Daniels and Hofer, 1993).

The presence of both an entrepreneurial champion, experienced in this high technology sector, and people with a thorough understanding of the base technology within the company's management, is a factor critical to the success of the firm. Hence, several of the success factors are closely linked to the skills of the entrepreneur and the management team of the organization. The social capital these people provide is an important asset during business startup as these networks can help businesses to develop faster and more efficient (Scholten et al., 2002).

In the spin-off process both the organizational capital within the spin-off itself, and that of the parent firm, in this case the university, is important. The spin-off needs a well defined business plan with clear objectives and plans, to hasten progress and utilize scarce resources efficiently. The university needs to give start ups a boost by creating a clear spin-off policy, creating an organization that promotes entrepreneurship, and a thorough spin-off program. Although it does not necessarily increase the amount of spin-offs, business incubation is an important element in the services that need to be provided in the spin-off process.

These programs play an important role in providing the spin-off with a useful network in which it can thrive. The access to an incubation program provides spin-off entrepreneurs with training to acquire business skills. Moreover, it provides the spin-off access to the incubator's network through which, guidance and support from experts, business planning services and capital can be obtained. Incubation significantly improves the survival rates of young entrepreneurial firms by aiding them to attain the synergy required in the four factors of entrepreneurial success described by Smilor and Feeser (1991).

4.

University spin-off in the life sciences: a comparative study

4.1 Introduction

The life science industry is an industry with close direct ties to basic research (OECD, 2002). Universities perform basic research, which is fundamental for the life science industry, and produces the breakthrough discoveries on which the industry thrives (Zucker et al., 1998). Hence, university research and research centers play an important role in providing the intellectual base and discoveries that drive this industry. Most life science companies are built on discoveries originating in universities, research hospitals and government laboratories. Moreover, universities train the highly skilled people required by these industries.

The knowledge created by breakthrough discoveries in the life science sector is often highly tacit in nature. This type of knowledge cannot diffuse rapidly and requires continued involvement of the originator of the discovery. Hence, we would expect that the commercialization of university knowledge through university spin-offs could make an important contribution to the life science industry's development. Research shows that star scientists in the biotechnology field have central roles in both the development of the science and its successful commercialization, and, additionally, university spin-offs have played an important role in the industry's development in the U.S. (Zucker and Darby, 1998).

The U.S. is generally considered to be the leading country in the biotechnology field. US technology policy is one of the most influential factors spurring the development of the sector. National agencies focusing on healthcare and technology have created an important scientific base in the nation's universities. And policy focusing on the intellectual property has led to the creation of a proactive entrepreneurial orientation towards technology transfer on the part of American universities (see also Branscomb et al., 1999). The emergence of small direct spin-offs from these universities has provided an efficient technology transfer process for the radical innovations of the life science industry. Moreover, cooperation between universities, university spin-offs and larger existing firms in the industry has created an efficient innovation system in this area (see also Bartholomew, 1997).

The commercialization of biotechnology knowledge out of public institutes in Europe lags behind that of the U.S.. We can even speak of a European and Dutch paradox in this respect (see also European commission, 1996). Even though Dutch and European scientific

performance is considered to be excellent, their technological and commercial performance in high tech industries such as biotechnology lags behind that of other economies such as the U.S. The lack of commercial orientation on the part of European and Dutch research institutions and a lack of entrepreneurial spin-off from these institutions could be important variables in explaining this gap.

This chapter will describe several features of biotechnology and the factors that have benefited the development of the biotech sector in the United States. To substantiate the role of American universities in this process we have conducted a case study at the Indiana University. This study will go into Indiana University's participation in the stimulation program for the biotech cluster within the state of Indiana and discuss the structured approach Indiana takes to business contacts and technology transfer. We will then turn to the development of the biotech sector in Europe and the Netherlands, which seems to lag behind the U.S. A case study is presented of the Erasmus University, which is considered to be one of the more entrepreneurial universities in the Netherlands but has only recently become involved with the stimulation of technology transfer trough incubation.

4.2 The life sciences

The new technologies associated with the life sciences are considered to be ladder technologies that have broad applications in a number of industries (see also Bartholomew, 1997). Life science is a term that is used for the sciences that study and work with living organisms. These are sciences such as agro technology, bio-engineering, cell biology, environmental sciences, food sciences, genetics and genomics, molecular biology, plant science and tissue engineering. These sciences are also often, although not entirely correct, summarized as biotechnology. Biotechnology can be defined as a set of powerful tools, techniques and processes that employ living organisms (or part of organisms) to make or modify products, improve plants or animals, or develop microorganisms for specific uses.

Since the discovery of the structure of DNA, huge leaps have been made in understanding the mechanisms of cell function, metabolism, replication and product formation. Scientific advances in genetic engineering and molecular biology continue at a rapid pace. These advances develop opportunities for creating new industrial production systems based on living cells and cell components, and new medical treatments using novel bio molecules.[20] The key reason why biotechnology is important to modern society is because it can improve the quality of life. It enables cheaper and cleaner production, creates solutions for diseases and allows us to develop new products that can have a positive impact on the environment, our health and our food.

The life science industry is an industry with close direct ties to basic research (OECD, 2002). Universities perform basic research that is fundamental for the life science industry and produces the breakthrough discoveries on which the industry thrives (Zucker et al, 1998). Hence, university research and research centers play an important role in providing the intellectual base and discoveries that drive this industry. Most life science companies are built on discoveries originating in universities, research hospitals and government laboratories. Moreover, universities train the highly skilled people required by these industries.

The knowledge created by breakthrough discoveries in the biotechnology sector is often highly tacit in nature. This type of knowledge cannot diffuse rapidly and requires continued involvement of the originator of the discovery. Hence, we would expect that the commercialization of university knowledge through university spin-offs forms can make an important contribution to the life science industry's development. Research shows that star

[20] http://www.biotech.unsw.edu.au/what.htm

scientists in the biotechnology field have central roles in both the development of the science and its successful commercialization, and university spin-off has played a pivotal role in the industry's development in the US (Zucker and Darby, 1998).

4.3 Biotechnology in the US[21]

Biotechnology's extraordinary evolution in the U.S. can be attributed to supportive federal policy and the resulting infrastructure, which provides incentives for academic-industry research alliances, thereby increasing the research capabilities and the responsiveness to industrial demands of the U.S. university system (Nelson, 1995). Other important aspects of the American system are the presence of a strong venture capital market and government policies stimulating small firm development in the U.S., which have led to the creation of an entrepreneurial orientation of university professors and scientists.

The most influential factor spurring the development of the biotech sector has been the U.S. technology policy. Government spending through the budget for national institutes of health and the national science agency has created a sound base of basic research for the sector (see also Sharp, 1987). The Bayh-Dole act[22] and related policies focusing on intellectual property rights have induced universities to rapidly increase the patenting and transfer of their technologies (Mowery et al., 2001). Branscomb et al. (1999) even speak of the emergence of entrepreneurial universities in this respect. Moreover, additional policy focusing on the stimulation of small innovative firms, such as the Small Business Innovation Research (SBIR)[23], gave entrepreneurial firms an important role in this knowledge transfer process (see also Audretsch, 2003).

The U.S. university system does not shy away from commercial orientation; with its mix of both public and private institutions, it has long played a significant role in conducting research that contributes to technological development and industrial performance (Geiger, 1988; Rosenberg and Nelson, 1994). Scientific advances induced consequent collaboration between university and industry enhancing the flow of knowledge between the two and creating a strong stock of shared knowledge (Bartholomew, 1997).

An important factor in the development of the U.S. life science industry was the emergence of new small firms, founded by entrepreneurial scientists, and financed by readily available venture capital. These science-based startup firms have been the cornerstone of the commercial field of biotechnology. The emergence of small direct spin-offs from universities has provided an efficient technology transfer process for the radical innovations of the biotech industry. Established pharmaceutical firms quickly recognized their value, forming relationships with these university spin-offs to gain access to new scientific advances. The resulting collaborations between universities, university spin-offs and larger existing firms in the industry have created an efficient innovation system in this area (see also Bartholomew, 1997).

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[21] information on Indiana University in this section is based on the following presentations:
Coyne,L. (2003), The role of the university in technology transfer and entrepreneurship, presentation at the BRIDGE 2003 seminar, April 22th, Bloomington, Indiana.
Lange, W. (2003) The role of the Health/Life Science industry in state economies, presentation at the BRIDGE 2003 seminar, April 24th, Bloomington, Indiana.
Johncox, J C. (2003), The Advanced Research & Technology Institute, ARTI's role at IU, presentation at the BRIDGE 2003 seminar, April 24th, Bloomington, Indiana.

[22] The Bayh-Dole act provided blanket permission to research institutions to file for patents on the results of federally funded research and allowed these institutions to grant licenses for these patents.

[23] SBIR provides funding to small firms for innovative projects. SBIR has a budget of $1.4 billion annually.

4.3.1 Life science in Indiana

Indiana's traditional manufacturing base is in decline and the state is loosing more jobs to globalization then any other state in America. This has given the state a strong incentive to stimulate the growth of small innovative business to stimulate the development of the local economy. Indiana is focusing on becoming a high technology hub for young companies in the biotechnology, life sciences, and advanced manufacturing sectors. Building on local university research and technology transfer, state and regional government and knowledge institutions are actively promoting these new knowledge-intensive industries. However, Indiana is not alone in this aim as nearly 83% of local and state governments report the development of the biotechnology industry as their number one or two development priority. Still, the state of Indiana stands a good chance of reaching its goals as it has a well-coordinated emerging cluster.

Indiana's biotechnology initiative, BioCrossroads[24], works to attract and create jobs, companies and entrepreneurial opportunities in the life sciences industry. To make central Indiana a center of innovation in the business of enhancing health, it builds on an existing base of both corporate and public research capabilities[26]. Indiana State hosts a significant life sciences industry with a varied industrial base. The cluster is significant because of its size and versatility. With nearly 900 companies and 82,000 employees the Indiana life sciences cluster is well represented with at least 30 companies and 1,000 employees in every major industry sector[26]. The BioCrossroads initiative was formed to capitalize on this strong foundation by attracting new business opportunities, intellectual property and capital. The initiative is working with corporate players, government, economic development agencies and the state's public academic institutes, Indiana University and Purdue University, to make central Indiana a national and international life sciences centre.

4.3.2 Case study of Indiana University

Indiana University (I.U.) recognizes the importance of the university and its knowledge for the regional economy. The I.U. works in close cooperation with regional development clubs, local government, and businesses to stimulate the regional economy. Strong ties with the local business community and technology transfer through licensing and entrepreneurial spin-off form an important element in the institutions development philosophy.

The university considers providing its researchers with an opportunity to commercialize their knowledge an important asset for the university. It allows them to maintain skilled professors and faculty members, which might otherwise pursue opportunities elsewhere. Moreover I.U. considers the industry experience gained in this way to be beneficial to the university as it raises the quality of education for its students, and the companies created provide job opportunities for its graduates.

To ensure that the knowledge created at the university benefits the regional economy, the university is focusing on creating leading research facilities to attract top scientists and top research, and on creating facilities such as incubators to stimulate local economic growth through entrepreneurship. The university actively stimulates the creation of an entrepreneurial environment. Entrepreneurship forms an important element in the education at the university. Moreover, special institutions, such as the *Johnson Centre for entrepreneurship and innovation*, promote entrepreneurial spirit and keep close ties with successful regional entrepreneurs.

[24] www.biocrossroads.com, January 18th, 2004

Although Indiana University started relatively late with a structured approach to technology transfer (in 1991) it is gaining ground on other universities. With the inception of the Indiana University Advanced Research Technology Institute (ARTI) in 1996 Indiana University refocused its activities in this area and brought together I.U.'s existing organizations within the university focusing on technology transfer and industry. Forming a centralized institution for technology protection and technology transfer to both large companies and entrepreneurs, ARTI can be considered one of the strong points of the I.U. system.

4.3.3 ARTI

ARTI, manages and protects technology and intellectual property for the university, it takes care of licensing and trademarks, technology transfer and business development. Since its inception, ARTI's organizational structure has been dynamic and took on its most profound changes when in 1998 most of its operations moved to Indianapolis (Jackson and Audretsch, forthcoming). This move brought ARTI closer to the core of Indiana University's source of patentable knowledge as approximately 80 percent of the inventions declared and transferred by the university arise from researchers at the Indianapolis campus, (IUPUI), a collaboration between Indiana University and Purdue University. Moreover, the move has permitted ARTI to be directly involved with state initiatives in central Indiana like the before mentioned BioCrossroads initiative which stimulates biotechnology in the state of Indiana.

ARTI is aided in fulfilling this mission by several alliance initiatives, which have been created through substantial business participation and support (i.e. - The Indiana Proteomics Consortium[25] the Indiana Genomics Initiative and the Pervasive Technology Labs at Indiana University). Most of these initiatives focus on enabling world-class research in Indiana and are expected to contribute to the regional economy through initial job creation and entrepreneurial opportunity. The university expects these initiatives to spin off new companies that will interact with existing companies in Indiana and contribute to the industrial base of the state. As a private organization ARTI can operate more flexible than I.U.. As ARTI is not subject to many of the rules and regulations that apply state universities, ARTI can hold equity in the companies it helps form, and can be a partner in 'for profit business'.

ARTI performs a scouting function for university technologies, which might have potential value. It actively searches for these technologies and takes a lot of the hassle away related to patenting and technology transfer. ARTI functions as a one-stop-shop for outside firms, displaying technologies for license on its website and offering a host of services which can aid their business development. ARTI is a break-even operation, which gives it more incentives to take risks and be aggressive in technology transfer than other "within budget" technology transfer organizations (see also Jackson and Audretsch, forthcoming).

Once technology is evaluated and thought to be able to support a company, a decision will be made to commercialize it through spin-off. Spin-off is preferred, as failure of the spin-off company does not prevent the technology's further commercialization through normal licensing. So far, ARTI has created 9 spin-off companies and aided the start-up of 15 additional companies created by outside firms. ARTI helps the small spin-off firms to apply for government grants and technology programs such as the Small Business Innovation Research program (SBIR) and related programs, created by government policy initiatives.

To aide its technology spin-offs in the area of life sciences the Indiana University has created the Emerging Technology Center incubator (ETC). Opened in August of 2003, the

[25] A combined initiative between IU, Purdue and the Eli Lilly working on bottlenecks and gaps in current technologies and analytical methods (see also www.Inproteo.com)

ETC is considered the crown jewel of the ARTI organization, (see also Jackson and Audretsch, forthcoming). The life and health science oriented business incubator will provide: subsidized rent for a combination of ancillary services, common office space, "dry" lab, "wet" lab and small scale manufacturing facilities and equipment, help with business plans, management services, client networking, access to venture capital and university graduate students and faculty.

4.4 Biotech in the EU and the Netherlands

Although the biotechnology sector in Europe has developed rapidly over the past few years, the sector as a whole still lags behind the United States. The European biotechnology sector is dwarfed by that of the U.S. as the total market capitalization of the European sector is only slightly bigger than that of the U.S. largest biotech company Amgen (Ernst&Young, 2001). We can speak of a European paradox in this respect (European Commission, 1996). Even though European scientific performance is considered to be excellent, the technological and commercial performance of the European biotech sector lags behind that of other economies. This gap can at least in part be attributed to the lack of commercialization of biotechnology knowledge from public research institutes in Europe.

The Dutch scientific infrastructure in the various subsystems of biotech is considered to be well developed although somewhat fragmented (Janszen and Degenaars, 1998). Biotech related research takes place in 24 percent of Dutch research schools, the Netherlands participates in 37,5% of European research programs, and the number of scientific publications by Dutch academics is relatively high (OECD, 2001c). Moreover, there is considerable biotech activity with 290 companies within the life sciences industry. This makes The Netherlands one of the main centers for the life sciences in Europe. Even so, the life science sector in the Netherlands faces substantial barriers in its development. One of the main explanations in this respect can well be that entrepreneurial activity is low, resulting in insufficient commercialization of available biotech knowledge and expertise form public knowledge institutions.

4.4.1 Lack of innovative entrepreneurship and innovative spin-off

The Dutch Ministry of Economic Affairs has indicated five general causes why the Netherlands has lower rates on innovative entrepreneurship (Donselaar et al., 2003). First of all, the administrative burdens for entrepreneurs are considered to be high; second of all, Dutch bankruptcy law and societal perception to bankruptcy prevents entrepreneurs to start over after business failure (see also Waasdorp, 2002); thirdly the Netherlands lacks a entrepreneurial culture, a factor which is linked to the socio-cultural perception mentioned before and the fact that entrepreneurship receives to little attention the Dutch education system[26] (see also Bosma, Stichter, and Wennekers, 2002). Fourth, there is a substantial financing gap for young techno starters[27]. Even though the venture capital market has developed rapidly of the last few years the availability of early stage seed capital is limited; a feature that substantially affects the ability of entrepreneurs to start up companies in innovative industries such as biotechnology (see also, Janszen and Degenaars, 1998). Fifth, the patenting process is considered to be expensive and time consuming, and European efforts to come to a European patenting system have been sluggish (see also Ernst&Young, 2001).

[26] Even though large multinational corporations are structurally reducing employment Dutch universities still train students for careers in these large corporations.

[27] Several authors have indicated a gap in the capital provision to small entrepreneurial firms during the early stages of firm development for more detailed information about this subject see Cooper (2003).

Another study indicates five barriers in the spin-off process at Dutch research institutions: research institutions lack finance to support spin-offs, a lack of clear guidelines concerning knowledge commercialization, a lack of entrepreneurial culture, lack of expertise concerning spin-off support, and, finally, a lack of supportive facilities (Kreijen and Van Tilburg, 2003). Even so Kreijen and Van Tilburg estimate that the 29 Dutch research institutions produce 107 spin-offs per year. However, the spin-off results (see appendix 1) of the various research institutions found by the ministry are difficult to compare. Some of the Dutch universities are mainly technical universities while others are strongly oriented towards the social sciences. Due to the technical nature of research we would expect the opportunity for direct spin-off to be far greater at technical universities than at universities focussed on the social sciences where opportunities for spin-off might occur less often and will likely have a more indirect nature[28].

One conclusion however can be drawn: the university of Twente is performing significantly better than all other Dutch research institutions spinning off substantially more spin-offs than it technical peers the TU Delft and the TU Eindhoven. Twente University's acclaimed spin-off program TOP[29] has been in place since 1984 and is widely seen as a best practice for other Dutch research institutions.

4.4.2 Biotech specific barriers

The preceding paragraph indicates that there are several general issues preventing entrepreneurial venturing in innovative sectors such as biotechnology. But there are more sector specific issues that prevent these activities in some areas of the biotech sector. Janszen and Degenaars (1998) indicate that public acceptance of biotech innovation low in the food sector. Negative consumer attitudes to biotech innovation in this sector in the Dutch domestic market and major European export markets such as Germany create a substantial barrier to the development of the market. Moreover, the Dutch government has not issued central guidelines for the transfer and commercialization of publicly funded research in the way that the U.S has via the Bayh-Dole act and related policy initiatives. As a result Dutch universities and scientists have not developed the commercial and entrepreneurial orientations displayed by universities in the United States. Hence they have not generated a lot of university spin-offs in the field of biotechnology.

Realizing these weaknesses, the Dutch government has become very active in stimulating the development of the life science industry. Funding the Biopartner initiative to stimulate the start up of biotech companies and a more entrepreneurial orientation at universities and stimulating the creation of additional incubation facilities at universities under the Technopartner initiative. These recent policy initiatives have been quite successful in stimulating the development of the biotechnology sector. Several universities are taking a more entrepreneurial stance towards knowledge transfer, which indicates that the government is surely but slowly realizing a change in culture in the academic world[30]. To indicate some of these successes of the Dutch government we will discuss a case study of the initiatives of the Erasmus University Rotterdam (EUR) concerning entrepreneurship and incubation in both general policy and the life sciences.

[28] For the differences in the definition of direct spin-offs and indirect spin-offs please turn to Chapter 3
[29] TOP provides temporary entrepreneurial positions including financing, office and lab space, mentors and training.
[30] Biopartner, periodiek, www.biopartner.nl, December 2003

4.4.3 The Erasmus University Rotterdam

The Erasmus University Rotterdam has several organizations that deal with facilitating knowledge transfer: it hosts a transfer point, which should put research and or industrial organizations in contact with the various departments of the Erasmus University and it has several research institutions that provide contract research. The initiatives in this area include research organizations such as CASBEC[31], which is an initiative to support academic research in the area of small business and entrepreneurship.

The EUR lacks a central organization, which functions as a one-stop-shop for university knowledge and technology. The EUR's transfer point focuses mainly on technology transfer and licensing in the field of life sciences, and its activities remain largely invisible to the public. The need for an institution such as ARTI, which deals with business needs, was highlighted at a symposium related to this research[32]. It became apparent that local entrepreneurs do not know how to come into contact with the university and miss a one-stop shop where they can turn to for university knowledge.

A lot of recent initiatives are springing up in the area of entrepreneurship, technology and knowledge transfer. The Rotterdam Programme on Entrepreneurship (ROPE) is a combined program, which holds the activities undertaken by both the Economics faculty and the Business Administration faculty in the area of entrepreneurship. It organizes entrepreneurial master classes for local entrepreneurs, conducts small business research and it includes education and exchange programs on entrepreneurial topics for students of the Economics and Business Administration faculties.

Since 1986, students' association *le manageur* is actively providing its student members with activities in the field of strategy and entrepreneurship. Nowadays they host the yearly Ondernemersdag, a conference on entrepreneurship, giving students the opportunity to take workshops in entrepreneurship en get in contact with investors as well as to experience the stories of successful entrepreneurs first hand. Another of their activities is their yearly 24-hour business contest in which students are challenged to start a business within 24 hours. More importantly, the Erasmus University itself has become actively involved in stimulating innovative entrepreneurship through business incubation via its Area 010 and medical incubator facilities, which will be described shortly.

4.4.4 Area 010[33]

Erasmus University started its incubation initiatives in collaboration with two Rotterdam based colleges and local and regional government. With the creation of Area 010, they initiated an incubator for innovative young start-ups with links to these institutions. However, most of the ventures created there do not use technology created at the university, indicating that we are dealing with indirect spin-offs (see also Kleverlaan, 2002).

The goal of Area 010 is to help these young innovative companies to survive the early stages of their existence and giving them a competitive advantage by offering office facilities and business support. Area 010 is involved in: scouting and selecting people with a commercial idea, a loan scheme that enables the entrepreneur to focus on the new venture, business plan assistance, providing flexible, furnished workplaces, and providing social

[31] Center for Advanced Small Business Economics
[32] *ICT ondernemerschap in onze kenniseconomie,* Rotterdam, 20 November, 2003
[33] Post, D. (2003) Area 010, interview, May 23th, Rotterdam, the Netherlands.

capital (being an intermediary between entrepreneurs and internal and external experts within its network).

Since its move to the World Trade Centre in the hart of Rotterdam Area 010 has aided the start-up of 12 indirect spin-offs, two of which successfully graduated from the incubator. In doing so, Area 010 provides an important exemplary role creating extra attention for entrepreneurship and aiding the creation of potential entrepreneurial role models for the students at the participating institutions. As mentioned earlier in chapter 2 this can provide an important boost to regional entrepreneurial climate.

4.4.5 Medical incubator[34]

Working closely together with the local municipal development organization OBR, the EUR initiated a medical incubator to facilitate the commercialization of its medical knowledge and technologies. Established on the 8th of January 2003, the medical incubator is the result of a considerable shift in university policy since the EUR has always taken a quite conservative approach to commercializing its medical ideas.

The university does not consider patenting to be a goal for a knowledge institution. However, patents were, and are, still seen as means in knowledge exploitation, but the university normally leaves patenting to external parties interested in the research due to the high costs associated with the patenting process. Even so, the university does see that it needs knowledge in the areas of intellectual property protection. The university is expanding scouting activities for potentially valuable knowledge and technologies. Moreover, it shares its intellectual property with entrepreneurial companies on a base of both royalty payments and equity, providing a way to reduce the financial burden of these young companies (see also Gregorio and Shane, 2003).

Still a relatively young facility, the incubator is currently fine-tuning the services it offers, but it is expected to professionalize over the coming years. The facilities for young spin-off companies at the medical incubator include: scouting and selection of the entrepreneurs, a special entrepreneurship training program, internal and external expert advice, networks and social capital[35], and it offers office and lab space (850 m² has been made available so far). The incubator expects to help create 19 spin-offs over the next three years. Eleven potential spin-offs have been identified so far since 2002, of which four are registered and use the office and lab facilities available to them, while the others are in an early stage, which does not require office support.

4.5 Conclusion

The U.S. is generally considered to be the leading country in the biotechnology field. U.S. technology policy is one of the most influential factors spurring the development of the sector. National agencies focusing on healthcare and technology have created an important scientific base in the nation's universities. Policy focusing on the intellectual property has led to the creation of a proactive entrepreneurial orientation towards technology transfer on the part of American universities (see also Branscomb et al., 1999). The emergence of small direct spin-offs from these universities has provided an efficient technology transfer process for the radical innovations of the life science industry. Moreover, inter-firm cooperation between universities, university spin-offs and larger existing firms in the industry has created an efficient innovation system in this area (see also Bartholomew, 1997).

[34] Tjabbes, H. (2003), Medical incubator, interview, May 23th, Rotterdam, the Netherlands.

[35] Providing contacts with institutes such as the Chamber of Commerce, government programs such as Syntens and Biopartner, and venture capitalists in the field of biotechnology

The commercialization of biotechnology knowledge out of public institutes in Europe lags behind that of the United States. We can even speak of a European and Dutch paradox in this respect (see also European Commission, 1996 and Janszen and Degenaars, 1998). Even though Dutch and European scientific performance is considered to be excellent, their technological and commercial performance in high tech industries such as biotechnology lags behind that of other economies such as the United States. The lack of commercial orientation on the part of European and Dutch research institutions and a lack of entrepreneurial spin-off from these institutions are important variables in explaining this gap.

The Dutch government has clearly recognized the importance of innovative entrepreneurship for the biotechnology sector. New government initiatives such as Technopartner and Biopartner have initiated a shift toward a more entrepreneurial orientation at Dutch universities and research organizations. The rising importance of entrepreneurship in the education of students and the creation of incubation facilities at institutes like the Erasmus University clearly show this shift.

Indiana University is relatively new in the field of knowledge transfer, but is catching up with universities that have been active in the field much longer. Only recently gaining a more commercial and entrepreneurial orientation, Dutch universities can learn a lot of the policies implemented at Indiana University. There are several similarities between the Indiana University and Erasmus University. Both are actively involved in the stimulation of regional economic development and cooperate with local government to reach these goals. Moreover, both universities have recently created biotechnology incubators to aid the start up of firms in this area and support the development of local clusters.

The comparative study also shows important differences. Indiana University has chosen for a one-stop-shop approach to its industry contacts and technology transfer, a feature that the Erasmus University currently lacks and should consider adopting to benefit the transfer of its knowledge. Moreover, the Indiana University has been very active in creating unique research facilities with the support of local biotechnology industry players. These institutes form an important source for groundbreaking research that will probably lead to extra spin-offs in the area. Dutch universities and regional governments can learn from these initiatives and implement them with the aid of the large industry players within the Dutch life science industry.

5.

Synthesis and recommendations

Globalization and technological change have had a significant impact on the economic performance and industrial structure of many nations. As a result of global competition, economic activity based on skills readily available to countries with lower labor costs will eventually shift away from higher cost OECD countries such as the Netherlands. This shift of production has important socio-economic implications. It indicates a need to shift away from production, which can easily be transferred to a low cost location, to economic activity based on ideas and knowledge. Economic activity based on knowledge provides a strong base for the comparative advantage of high cost economies as it cannot easily be copied or transferred to other regions.

As competitiveness in the knowledge economy is based on innovation it is important for countries to remain an important player in the creation of new knowledge and product development. The shift toward the knowledge economy therefore puts an ever-increasing emphasis on R&D as the base for economic success. As the pace at which innovation has to occur is rapidly increasing due to rapid technological change and intensified competition it seems the old structure of the economy in which large multinationals dominated the economy no longer suffices. Large firms are primarily focused on improving their existing technologies leading to an incremental pace of innovation, which is insufficient to sustain a competitive advantage in the modern economy. To be able to sustain competitive advantage countries require a combination of both incremental and disruptive innovation. The economic value of this type of innovation is highly uncertain turning risk taking entrepreneurial firms into important players in the innovation processes of the modern economy.

As a result the rise of the knowledge economy is changing the coordination and cooperation between the actors involved in the economy (government, knowledge institutions, and the business community), particularly in relation to diffusing, using and exploiting knowledge. The innovation processes of the knowledge economy often require substantial knowledge flows between public knowledge institutions and private firms. When there is a large difference in the orientation of research institutions and industry or these public knowledge institutions lack commercial orientation, knowledge flows between public and private sectors can be impeded. It is therefore increasingly recognized that when a country wants to prosper within the knowledge economy tighter integration of the activities of industry, universities, public research facilities, and government policy is needed in the areas of science and technology.

Governments dealing with problems that occur in the knowledge transfer between firms and public institutions should encourage their science system adopt a more proactive stance toward commercialization and cooperation. Stimulating entrepreneurial spirit and knowledge spin-off in public research and educational institutions is an approach which can help overcome these problems. This research shows that spinning-off forms a good supplement to existing transfer mechanisms such as the process of licensing. Spin-off forms a good way in which radical technologies can be transferred to society. However this form of technology transfer requires a strong supportive infrastructure and sufficient entrepreneurial human capital.

Academic entrepreneurship in the Netherlands

A healthy economy needs both entrepreneurial and professional human capital (Iyigun and Owen, 1998). However, the availability of sufficient entrepreneurial human capital is by no means guaranteed as inefficiencies might occur in the allocation between formal educational and entrepreneurial experience. These allocation inefficiencies can arise when differences occur in the social and private returns to work and education; resulting in lower economic performance. In the Netherlands, the risk-averse nature of society and the relatively low social status of entrepreneurs may account for such an inefficient allocation. These features of the Dutch society have contributed to the lack of both entrepreneurial culture and entrepreneurial infrastructure. Although Dutch government has developed a solid physical and non-physical infrastructure the past few years, the support structure at the regional and institutional level needs additional attention.

To overcome these obstacles to modern economic development, it is therefore not only important that entrepreneurship is encouraged through the stimulation of Dutch entrepreneurial infrastructure, but policy also needs to stimulate entrepreneurial culture. Developing an entrepreneurial culture should start with developing awareness. Everyone should know the importance of entrepreneurs for society. The next step is to stimulate a positive attitude towards entrepreneurship and develop entrepreneurial qualities such as risk-taking, creativity, initiative and goal setting. The last step is to teach entrepreneurial skills, such as management skills, business plan development, and to experience entrepreneurship hands-on (Bosma et al., 2002; Iyigun and Owen, 1998).

To achieve optimal economic performance it is therefore important that future generations of Dutch citizens develop entrepreneurial qualities and are taught entrepreneurial skills. While Dutch colleges ("*hogescholen*") have made a lot of progress in this area, Dutch universities seem to lag behind. Even though employment in large multinational corporations is structurally declining (Carlsson 1989, 1999), Dutch universities still educate students for careers in large corporations. As a result entrepreneurship plays a marginal role in most universities' education. This combined with the Dutch attitude towards entrepreneurship has resulted in relatively low spin-off rates.

The Dutch Ministry of Economic Affairs has initiated several studies into the Dutch policies toward entrepreneurship and spin-offs. In one of these studies Kreijen and Van Tilburg (2003) give a complete set of recommendations for Dutch governments, universities and policy makers. These recommendations are listed in the appendix. The recommendation given here will therefore focus on the Erasmus University Rotterdam (EUR) and the relevant regional governments. Several of these recommendations will hold for other Dutch universities as well.

Erasmus University Rotterdam and regional governments

The EUR currently lacks an integrated approach to the stimulation of entrepreneurship. Current activities in the field of entrepreneurship have mostly surfaced bottom-up, from professors and students, gaining university support as they developed. As a consequence of this type of development, the current approach to entrepreneurship has not developed a lot of breadth. There is no overall vision and coordination. Activities dealing with entrepreneurship currently encompass several important elements in the provision of entrepreneurial infrastructure and culture but fail to address other important elements.

The university lacks a top-down approach, which provides the university with a central vision and masterplan for its activities in this area. Current activities promoting entrepreneurship only reach a small percentage of the student population. Most activities initiated remain largely extracurricular for university students. More importantly the effects of these activities are not measured, making it difficult to ascertain if these activities achieve their goals. We would therefore urge the university to develop a central organization for entrepreneurship and technology transfer, enabling it to face these problems head-on.

The importance of knowledge based economic development for Dutch society implies that regional governments should provide increased incentives for the universities within its borders to actively pursue knowledge transfer and entrepreneurial development. Moreover, regional government and economic development institutions, such as the Province and the OBR, should take leading roles in matching shelf technologies with potential entrepreneurs; bridging a current inefficiency in the Dutch innovation system. Therefore we advise the main players in the field, such as EUR, Hogescholen, OBR, Provincie Zuid-Holland, Chamber of Commerce, relevant student organizations, and AREA 010, to come together and jointly develop an encompassing plan for the stimulation of academic entrepreneurship in the region.

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Appendix 1: Spin-offs from Dutch research institutions

****Scan van een tabel****

Source: Kreijen, M. and Van Tilburg, J.J. (2003), Researchers op ondernemerspad: internationale benchmarkstudie naar spin-offs uit kennisinstellingen, Den Haag: Ministerie van Economische Zaken

Appendix 2: Policy recommendations

Focus in het beleid.

Aanbeveling 1. De tijd is rijp! Het is goed om nu de ondersteuning van spin-offs uit kennisinstellingen te bevorderen vanuit een substantiële integrale aanpak door de centrale overheid via een bottom-up benadering
Aanbeveling 2. Volg een tweesporenbeleid! Maak onderscheid tussen ondernemer gerichte en instituutgerichte stimulering
Aanbeveling 3. Wees gereserveerd t.a.v. een focus op bepaalde technologiegebieden

Taakstelling, wet- en regelgeving.

Aanbeveling 4. Het ministerie van OC&W zal zich duidelijk uit moeten spreken over de taak en aansturing van universiteiten m.b.t. het commercialiseren van kennis en met name t.a.v. spin-offs
Aanbeveling 5. Neem spin-off bevordering op bij programmafi nanciering

Financiering.

Aanbeveling 6. Leningen voor spin-offs
Aanbeveling 7. Verlaging financieringsdrempel door nationaal fonds voor seed- en preseed financiering
Aanbeveling 8. Financiering voor de continuïteit spin-off programma's

Professionalisering spin-off ondersteuning.

Aanbeveling 9. Bevorder professionalisering van spin-off ondersteuning

Infrastructuur

Aanbeveling 10. Ontwikkeling managementdiensten in incubators
Aanbeveling 11. Science park management ontwikkelen
Aanbeveling 12. SIT regeling aanpassen

Informatie, communicatie en netwerken

Aanbeveling 13. Zorg voor afstemming met collega ministeries
Aanbeveling 14. Leer de praktijk kennen: mensen en aanpak
Aanbeveling 15. Maak spin-off praktijk zichtbaar

De aanbevelingen aan de kennisinstellingen

Spin-off beleid

Aanbeveling 16. Veranker spin-off beleid
Aanbeveling 17. Breng spin-offs in kaart
Aanbeveling 18. Stimuleer ondernemerschap bij medewerkers
Aanbeveling 19 Bevorder ondernemerschap in het onderwijs

Ondersteuning van spin-offs

Aanbeveling 20. Professionalisering van spin-off ondersteuning
Aanbeveling 21. Professionalisering van beleid m.b.t. intellectueel eigendom
Aanbeveling 22. Verbeter constructies voor participaties
Aanbeveling 23. Stimuleer ondernemersnetwerken

Omgeving

Aanbeveling 24. Participeer in infrastructurele ondersteuning
Aanbeveling 25. Inzet externe professionaliteit
Aanbeveling 26. Koppel het technologisch spin-off potentieel van bedrijven en kennisinstellingen
Aanbeveling 27 Decentraal spin-off beleid

Source: Kreijen, M. and Van Tilburg, J.J. (2003), Researchers op ondernemerspad: internationale benchmarkstudie naar spin-offs uit kennisinstellingen, Den Haag: Ministerie van Economische Zaken.

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