

**Research on the Knowledge Filter:  
Status and Potential use for Policy  
Analysis**

*To be discussed at ICE meeting, 13 October 2006*

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## **Background**

The most important obligations for universities in the industrial society were education and research. Not much was done to commercialize knowledge. The passing of the Bayh-Dole act in the US in 1980 was a response to support technology transfer in order to increase the return on public investments in research and development (R&D). As a consequence of this law, universities retain ownership to inventions made under federally funded research. In return, universities are expected to file for patent protection and to ensure commercialization upon licensing. The royalties from such ventures are shared with the inventors; a fraction is provided to the University and department/college; and the rest is used to support the technology transfer process. Many countries have followed with similar initiatives. In the aftermath of the Bayh-Dole act research universities established technology transfer offices (TTO's) to manage and protect their intellectual property. These offices are typically biased towards filing for patent protection and licensing. In the knowledge-based economy the focus on the universities and research institutions is intensifying and their role related to create and commercialize knowledge either indirectly or directly. The public research institutions are now seen as potential engines of growth but several studies suggest that the potential might only be realised if the country has a vibrant entrepreneurial environment.

In January 2006, the International Consortium on Entrepreneurship (ICE) had several discussion concerning high-growth and the possible links between innovation and entrepreneurship policy. Based on these discussions ICE agreed to strengthen its understanding of these links, as the links might be crucial for the returns on public R&D spending and thereby future growth.

FORA initiate the work by reviewing the relevant literature and based on the review prepared this paper to be presented at the upcoming consortium meeting on 12-13 October 2006 in Copenhagen. The paper provides policy makers with an overview of the main research in the new emerging literature on knowledge filter and develops an analytical framework for possible future policy studies of this area. The framework will allow for detailed studies of the framework conditions for knowledge transfer from Universities to private firms or entrepreneurs.

The new framework builds on our work on entrepreneurship (Gabr and Hoffmann, 2006) and Phan and Sigels (2006) extensive review of the notable research on university technology transfer and their framework for considering technology transfer from universities. This paper also benefits from Verheul *et al*'s framework of determinants of entrepreneurship including six basic elements (demand side and supply side, individual decision making, actual and equilibrium rates, government invention and the cultural component). Finally it draws on Shane's (2003) notion of different modes of exploration.

In relation to this paper, consortium members should take note of the results from the literature and consider whether they would be interested in applying this framework in a joint ICE project.

### **WHAT IS A KNOWLEDGE FILTER?**

Increased spending on R&D is a common policy response among OECD countries in order to expand their growth and welfare. The EU countries have, for example, specific targets for R&D spending as a share of GDP. Intuitively more input of R&D should

lead to more knowledge, which in turn would lead to better process, products and services or in short to innovation. This linear innovation model has been and is in some cases still a dominant way of thinking in many policy reports.

However, studies often do not find a relation between investments in R&D and economic growth in high-income countries (see figure 1). Japan and Germany are common used examples of this "paradox", as both countries have some of the world's highest R&D spending but have over the last 10 years experienced very little growth. Many reasons exist for the lack of growth in Japan and Germany but most of them are related to structure problems in these economies (OECD, 2005).

**Figure 1: Expenditures on R&D and economic growth in 29 OECD countries 1981-2000**



Source: OECD Statistical Compendium on CD, 2002:2/Acs, Audretsch, Braunerhjelm and Carlsson (2003).

A new strand of literature provides additional reason for the lack of linearity between R&D and growth. A knowledge filter stands between investment in research on the one hand, and its commercialization through innovation, leading ultimately to economic growth, on the other (Audretsch, *et. al* 2006). The density of the knowledge filters

varies among countries and even among universities within countries. Many factors determine the density of the filter. Entrepreneurship seems to be a dominant factor. Studies establish a link between economic growth and the interaction between a country's knowledge (R&D) stock and the level of entrepreneurship (Table 1). Previous studies have established a link between entrepreneurship and both economic growth and employment (Audretsch and Thurik, 2002; Thurik, 1999). In the mean while, recent studies finds that, while there is a relation between economic growth and entrepreneurship, the strongest effect relates to the impact of entrepreneurs in exploiting spillovers originating in a country's knowledge (R&D) stock (Acs, Audretsch, Braunerhjelm and Carlsson, 2003; 2005a; 2005b).

**Table 1: Growth, Employment and Entrepreneurship.**

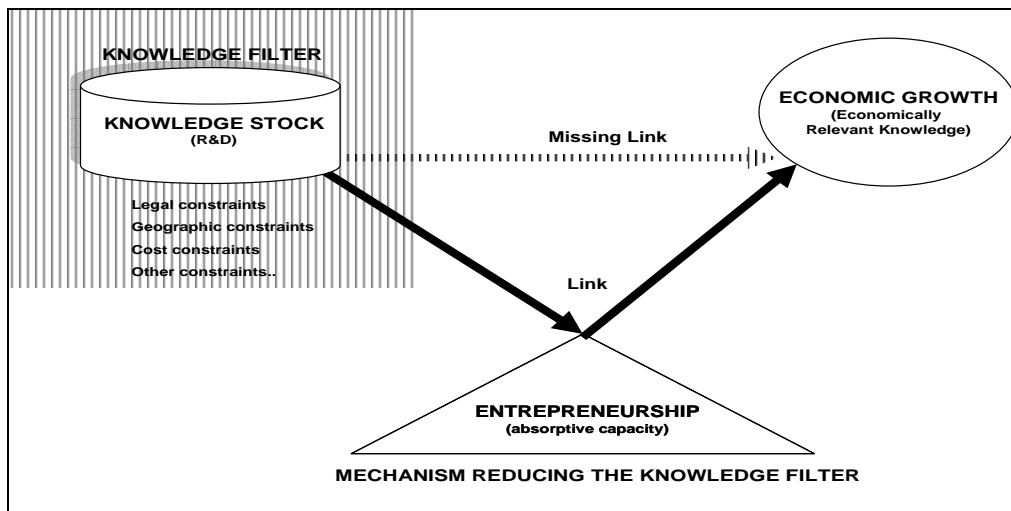
<b>Focus</b>	<b>Findings</b>	<b>Study</b>	<b>Sample frame</b>
Growth	Finds some positive impact of entrepreneurship on growth but the strongest effect relates to the impact of entrepreneurs in exploiting spillovers originating in a country's knowledge (R&D) stock	Acs, Audretsch, Braunerhjelm and Carlsson (2005a)	18 OECD countries (1981-1998)
	Positive impact of entrepreneurship of growth but the strongest growth effects relates to the importance of entrepreneurs in exploiting spillovers originating in a country's knowledge (R&D) stock.	Acs, Audretsch, Braunerhjelm & Carlsson (2003)	20 OECD countries (1981-2000)
	Increases in entrepreneurial activity tends to result to higher subsequent growth rates and a reduction of unemployment	Audretsch and Thurik (2002)	17 European countries/23 OECD countries (1990-1994)/(1974-1998)
Employment	Find that the "entrepreneu-rial" effects are considerably stronger than the "refugee" effects. This paper investigates the dynamic interrelationship between self-employment and unemployment rates. On the one hand, unemployment rates may stimulate start-up activity of self-employed. On the other hand, higher rates of self-employment may indicate increased entrepreneurial activity reducing unemployment in subsequent periods.	Audretsch, Thurik, Stel and Carree (2006)	23 OECD countries (1974-2002)
	Increases in entrepreneurial activity tends to result to higher subsequent growth rates and a reduction of unemployment	Audretsch and Thurik (2002)	17 European countries/23 OECD countries (1990-1994)/(1974-1998)
	Increased entrepreneurship is associated with higher rates of employment at the country level	Thurik (1999)	23 OECD countries (1984-1994)
Entrepreneurship	Finds a strongly positive relationship between entrepreneurship and the stock of knowledge, and that the relationship remains strong when controlling for institutional, market, and individual factors. When restricting the regressions to the 1990s, the knowledge stock variable becomes more significant and the wage variable becomes negative and statistically significant as suggested by the theory.  Find that the personal tax rate is negatively related to entrepreneurship. By contrast the corporate tax rate is positively related to entrepreneurship.	Acs, Audretsch, Braunerhjelm and Carlsson (2005b)	18 OECD countries (1981-1998)

	Find that the extensive knowledge exploitation by incumbents is negatively related to the degree of entrepreneurial activity. By contrast, both expenditures on education (absorptive capacity) and economic growth are positively related to entrepreneurship.		
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Source: Own making

Entrepreneurship reduces the knowledge filter by being the missing link that transfers knowledge into new products, process and services (see figure 2). The importance of knowledge transfer is not a new policy insight. On the contrary, many countries provide support for commercialization of R&D.

**Figure 2: The missing link between R&D and economic growth**



However, these efforts are biased towards filing for patent protection and licensing and do not cover all modes of transfers. It's not just a question about technology transfer. It's a more general question about transfer of new knowledge, either technology or for example through methods and tools to enhance user-driven innovation. This implies that the role of technology transfer offices are to be understood more broad in terms of transferring new knowledge about either technologies, user needs or the compatibility between these extremes (Abell, 1980). Besides this commercialization today does not always go through the TTO office. For example University scientist appear to be more

vigorously involved in entrepreneurial activity, in the form of university spin-offs not going through the TTO office (Audretsch, Aldridge and Oettl, 2006).

Furthermore, the universities and research institutions play a little role among the types of information considered highly important for firms' innovation (Third community innovation survey/CIS3, 2004). To day government or private non-profit research institutions, universities or other higher educations play a little role among firms with innovation activity (see figure 3). This is biased in favour of large firms. It must be kept in mind that increasing this percentage might have profound effects on transforming knowledge into economic relevant knowledge. The picture is similar among service and industry firms with innovation activity considering different sources of information (Third community survey/CIS, 2004).

**Figure 3: Universities and research institutions play a limited role as information sources for firms with innovation capacity.**

	Small	Medium-sized	Large	Total
Within the enterprise	34	41	70	38
Other enterprises within the enterprise group	6	14	31	9
Suppliers	19	18	29	20
Clients or customers	26	30	47	28
Competitors and other enterprises from the same industry	11	13	21	12
Universities or other higher education institutes	<b>4</b>	<b>5</b>	<b>10</b>	<b>5</b>
Government or private non-profit research institute	<b>2</b>	<b>3</b>	<b>6</b>	<b>3</b>
Professional conferences; meetings; journals; all sizes	11	10	16	11
Fairs and exhibitions	16	15	17	16

Source: Eurostat, NewCronos (theme9/innovat/inn\_cis3).

Note: Proportion of enterprises with innovation activity citing selected sources of information considered as highly important for innovation, EU, 1998-2000 (%).

A better understanding of the framework conditions supporting the commercialization of public research is needed. A large amount of literature covers the effectiveness of university technology transfer mechanisms. Whether these findings can be used develop a systematic and coherent policy framework that in the future might serve as a model for identifying policy priorities to better foster commercialization of the public knowledge (R&D) stock is the subject for this paper.

An attempt will be made to underpin what policy areas are important to prioritize between for minimizing the knowledge filter. This is obviously a very complicated issue requiring comprehensive theoretical and empirical research to come up with durable answers. No doubt this will take many years.

The endeavour of this paper is much more limited. Based on a large amount of research, mainly covering the effectiveness of university technology transfer mechanisms, an attempt will be made to illustrate a possible systematic and coherent policy framework and classificatory scheme for policy areas affecting the commercialization of the public knowledge (R&D) stock, that in the future might serve as a model for identifying policy priorities to better foster commercialization of the public knowledge (R&D).

The paper is structured in the following way. First, we infer something about the public's current role for firms with innovation activity. Second, we suggest a five-dimensional classificatory scheme and develop a policy framework of growth drivers for commercialization of the public knowledge stock. Thirdly, we based on a large amount of literature and the classificatory scheme; suggest policy areas related to the five-dimensional classificatory scheme. Fourth, we summarize the major patterns from the literature review. Finally some specific directions for further research and analysis,

hopefully leading to a better understanding of policy areas and commercialization of public research are suggested.

## **TOWARDS A CLASSIFICIATORY SCHEME FOR POLICY AREAS AFFTING THE COMMERCIALIZATION OF PUBLIC KNOWLEDGE (R&D) STOCK**

It is fairly evident that the general concept of knowledge filters holds much promise for policy makers, which can be seen in the evidence of entrepreneurship reducing the knowledge filter. The missing link between a country's knowledge (R&D) stock and economic growth is attributed to the filter. However, there is as yet no comprehensive framework covering the policy areas related to reducing the filter. Hence, a useful starting point is to develop a theoretical policy framework of drivers for commercialization of the public knowledge (R&D) stock.

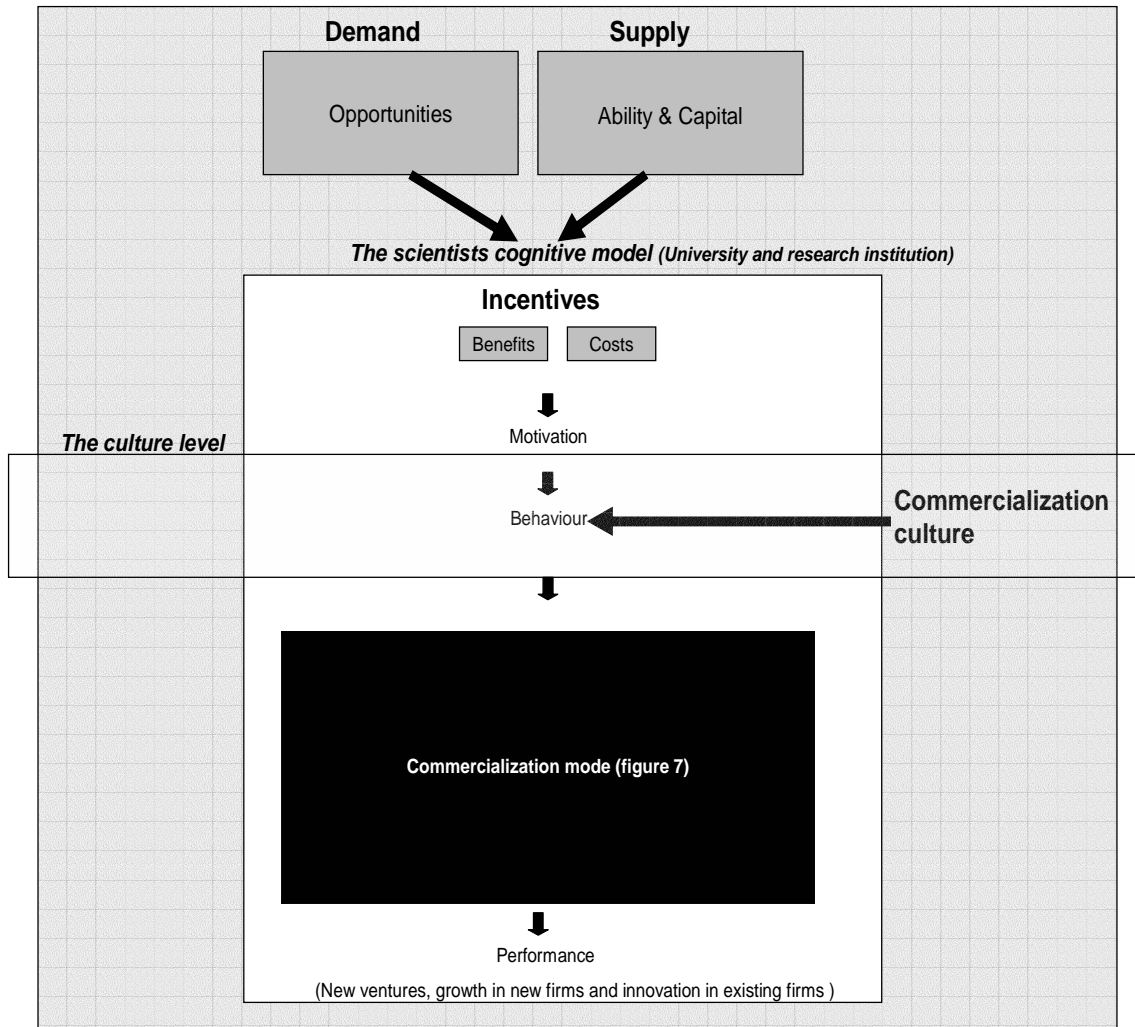
The theoretical policy framework of drivers for commercialization will be seen in relation to those factors, which gives the research scientist (university/research institution) the best possible conditions for transforming knowledge into innovation, competitiveness and ultimately economic growth. A complete theoretical policy framework focusing on the best conditions for transforming knowledge into innovation needs to view the mentioned factors in relation to the researcher/scientist, entrepreneur (Gabr and Hoffmann, 2006), and members of existing firms/incumbent firms (Gabr and Hoffman, *forthcoming*). In this paper we focus on policies affecting the researcher/scientist. Before this we attempt to assess the public's current role for firms with innovation activity. This in order to give an indication of the degree of realized potential of public knowledge.

### *A Five-Dimensional Classificatory Scheme*

The policy areas for enhancing the framework conditions for researchers transforming knowledge into innovation spans a vast number of policy areas. The vast amount of policy areas renders necessary a comprehensive policy framework.

A classificatory scheme for organizing the empirical research on knowledge transfer of public research and for developing a systematic and coherent policy framework that can serve as a model for identifying policy priorities to better foster commercialization of the public knowledge (R&D) stock is needed: We propose a theoretical model of the factors affecting factors affecting commercialization of public knowledge separated into three interacting components: the demand-supply conditions (opportunities, abilities and capital), the research scientist's cognitive model of motivation (incentives) and culture (cultural level) and integrates these components as seen from the policy maker's perspective and the possibly choices to commercialize public knowledge (see figure 4). The rationale for selecting these dimensions is set out below.

**Figure 4: The policy framework of growth drivers for commercialization of public knowledge (stock).**



*Opportunities* are the demand side of the model and represent a demand for knowledge in order to transform it into innovation. Opportunities arise through relations with various actors for example firms and the absorptive capacity of these actors. Opportunities are also affected by the regulation of universities' commercialisation process.

The supply side expresses the *capital* and *ability* necessary for the commercialization of the public knowledge stock. *Capital* covers all phases and modes of financing “commercialisation”. *Ability* covers a broad array of factors ranging from the stock of

public knowledge to the human capital and social capital of the scientist in respect to commercialisation and mechanisms supporting coordination of these factors.

The scientist's *incentives* are based on a cognitive model, which reflects the way a scientist reasons. The psychological mechanisms say that the scientist consciously considers the *incentives* including those put forward by the policy makers, before acting. These incentives influence the scientist's *motivation* either through monetary and non-monetary rewards. Cognitive theory offers a framework in which to understand the scientist's motivations, which is influenced by the thought process, and, consequently, the behaviour of the scientist (Ivancevich & Matteson, 1996). The theory builds on five basic human psychological capabilities (Stajkovic & Luthans, 1998), which influence the motivation of the human beings and leads to three main types of motivation (Wood & Bandura, 1989). The first type of motivation is *direct motivation* where people are most likely to engage in a specific action if it is anticipated that the action will produce a valued outcome, rather than unrewarding or punishing consequences. Direct motivation corresponds to the basic economic occupational choice theory, where cost and benefit of becoming an entrepreneur is compared to the alternative (become an employee). In equilibrium, the marginal scientist is indifferent of commercialising knowledge or not commercialising all other things been equal. The second type of motivation is *vicarious motivation* where people are motivated by the success of others, who are similar to themselves, but are also discouraged to engage in behaviour that is known to result in adverse consequences. Successful commercialisation within a department increase all other scientists motivation for commercialisation. The third type of motivation is *self-produced motivation* where

personal standards are the source of motivation. This type of motivate depends on the values embedded in the university and the standards that are told through the education.

Commercialization *culture* expresses the scientist's behaviour, attitudes, and overall effectiveness that are often unnoticed by the scientist (Ivancevich & Matteson, 1996). Recall that a scientist's motivation leads to a given action or behaviour. Culture can be understood in accordance with three layers (Schein, 1985). Layer one includes the *artefacts and creations* that are visible but are often not interpretable. Layer two is the *values* or things that are important to people. Values are conscious and affective the desires or wants that guide behaviour. Layer three is the *basic assumptions* people make that guide their behaviour, including the assumptions that tell individuals how to perceive, think about, and feel about notions, for example commercialization of research and development. For example, observed behaviour could be "I am trying to spin-out", the value could be "its good to be self-employed", and the basic assumption could be that "my employment is "too little" for me to become really rich".

#### *Commercialisation modes*

The commercialization mode expresses the different ways knowledge transfer lead to innovation. The commercialization of public knowledge can be organized in different modes. The underlying process is the same. The process is the identification of opportunities, the reaction upon opportunities, the acquiring of resources, crafting a strategy and finally organizing (Shane, 2003). The displayed types of commercialization activity are independent start-up, licensing/acquisition and corporate venturing. The distinction between the listed modes in the 3\*3 table in figure 5 is whether the individual discovering the opportunity was within or outside the exploiting university or

firm at the time of discovery and whether the entrepreneur exploits the opportunity through a market mechanism or university or firm. All the grey modes have the communality that public knowledge in some form or the other has been involved.

**Figure 5: The modes of commercialization and involvement of public research and development**

	Independent individual	University member	Firm member
Independent individual	Independent Start-up	University Spin-off	Firm Spin-off
University member	Acquisition/ Licensing/ Trademarking	University venture	Acquisition/ Licensing/ Trademarking
Firm member	Acquisition/ Licensing/ Trademarking	Acquisition/ Licensing/ Trademarking	Corporate venture

*Analytical Review Framework/The Proposed Policy Framework and Related Policy Areas*

The literature on technology transfer is rapidly expanding. However, to our knowledge only a few discuss policy frameworks as opposed to specific policies (Phan and Siegel, 2006).

Our policy framework builds on the five drivers (*opportunities, abilities, capital, incentives and culture*) of commercialisation identified above. Each of these five drivers is affected by a comprehensive list of policy instruments. In order to reduce this list to a manageable length, this analysis focuses on policy areas. A policy area is not a well-defined concept but a simple collection of policy instruments with similar objective.

This analysis assumes that it is possible to separate the five main drivers of commercialisation of public research and development into several policy areas. For example, the capital-driver can be separated into the different ways of accessing capital. Policy areas might affect multiple drivers. However, each policy area is placed in relation to the driver it affects the most. The placements are based on a qualitative judgment by the authors.

No correct number of policy areas exists as aggregation and dis-aggregation of the policy areas can decrease or increase the number of policy areas. In this work the number of policy areas is identified by a top-down and a bottom-up analyses. The top-down analysis is based on a review of the theoretical literature (see table 2) connected to each of the five drivers of commercialisation. This review gives us a list of possible policy areas to include (see table 2).

The combined top-down and bottom-up list includes 29 policy areas that have a significant impact on the five drivers of commercialisation (Figure 6). Each of the areas will be described in the following. The focus is only on framework conditions. Not on commercialization modes (performance).

**Figure 6: Policy areas affecting commercialization of public knowledge (stock).**

A total measure of the framework conditions relating to commercialization of public research				
Opportunities	Capital	Ability	Incentives	Culture
Commercialization Regulation	R&D support	Research on universities/ research institutions (stock & flow)	University strategy (research, Education & commercialization)	Social desirability of commercialization
Procurement regulation	Commercialization support	Researcher relations	Credits towards tenure and promotion	Special cultural beliefs (university/ research institution)
Relations with Government	Risk capital	Commercialization education of researchers	IPR (Organisation-researcher))	Communication about heroes, rolemodels/awards
Relations with industry		Commercialization Experience	Knowledge transfer office (compensation practice/ royalty shares)	Introduction of enterprising universities
Test Facilities (proof of concept)		Knowledge transfer office (design, information flows, staffing)	Administrative Burdens Commercialization (pree-start-growth)	
Incubators		Relations with research spin-offs		
Science parks				
Absorptive capacity in firms (stock & flow)				
Special cultural Beliefs demand side				

Source: Own making.

*Policy areas affecting demand opportunities.* The opportunities for commercialization are given by government regulation as for example the organisations form that is possible to create (commercialization regulation), the buying of services or products were public knowledge is a part (procurement regulation), relations where research institutions are one of the parts (university/research institutions – government relations, university/research institutions – industry relations, university/research institutions – incubator relations and university/research institutions – science park relations), proof of concept opportunities (test facilities), people’s prior stock of knowledge facilitating

the acquisition of additional information about markets, technologies and production processes (absorptive capacity), and cultural factors affecting the firms (special cultural beliefs/demand side).

*Policy areas affecting supply of capital.* Access to capital is a necessary condition for potential commercializers. Capital can come from various sources and is needed in various amounts depending on the stages and objectives of the mode of commercialization (R&D support, Commercialization support and Risk capital in the pre-seed, seed and expansion stage).

*Policy areas affecting supply of ability.* The ability includes the stock of knowledge (Research on universities/research institutions), social capital (researcher relations), the researchers skills (commercialization education of researchers and commercialization experience), the design of knowledge transfer, information flow between researcher and mode of knowledge transfer and the staff transferring knowledge (Knowledge transfer office), after spin-off researchers may be dependent upon public research (relations with research spin-offs).

*Policy areas affecting the researcher's incentives.* The University's choice between research, education and commercialization (University strategy and credits towards tenure and promotion), the property rights for the researcher and university (IPR), and the way the knowledge transfer office is rewarded (Knowledge transfer office), administrative burdens. Each policy aimed at creating incentives for entrepreneurship should be seen as corresponding to the motivation that it incites either direct motivation, vicarious motivation, and self-produced motivation, and in relation to the type of reward it offers monetary and non-monetary rewards.

*Policy areas affecting commercialization culture.* Artificially imposing a culture is difficult and often met with resistance. Moreover, the basic underlying assumptions can function as a cognitive defence mechanism making culture change complicated and time consuming (Schein, 1985). Culture is deep rooted in individuals; it can be extremely difficult to bring the assumptions to the surface. Added to this complication, culture evolves over time making it difficult to recreate core values (Ivancevish & Matteson, 1996). In the meanwhile in order to attempting fostering a supportive culture, governments can undertake several things: a sense of history can be developed, a sense of identification can be created, a *sense of membership* can be promoted, and an increased exchange among members can be encouraged (Gross & Shichman, 1987).

## A LITTERATURE REVIEW

The review of the literature based on the above dimensions, and organized around the five factors identified in figure 4 and the policy areas identified (figure 6), is summarized in table 2. The review also includes a discussion of the sample (a single county, across multiple countries, a single country or across multiple countries) used in the reviewed study. Conclusions based on a single country could be idiosyncratic to that county, while a multi-county or multinational study requires the use of more general dimension of policy areas to uncover a generalizable pattern of framework conditions.

We summarize the major patterns below in six main observations, while urging readers to derive additional trends and insights by further analysing table 2.

*Observation One: Policy Matters!*

Policy matters are an interesting hypothesis that seems to appear, when comparing the most studies reviewed here. Most studies reviewed here appear to focus on only a single policy area. In the mean while the studies shows that there are variations in the success of knowledge transfers and the way the different policy areas have been addressed.

*Observation Two: All Five Drivers of Commercialization Matters!*

All five drivers of commercialization matters (opportunity, capital, ability, incentives and culture) are another hypothesis that appears when comparing the most studies reviewed here. Studies attempting to address all the factors are needed. The studies here mainly focus on only a single policy area and the sample frames are different. Hence, the strength of the evidence differs. Studies attempting to address all factors can help to find out what policy areas are critical and which are to be prioritized. Furthermore, the vision of policy makers, Public research institutions, knowledge transfer organizations, and researchers should be matched is another point deriving from the review. Strategic choice and implementation should be matched at all levels.

*Observation Three: Implicit acceptance of a technology focus*

The third observation pertains to the bias towards knowledge transfer of “technology”. Knowledge transfer policies and research have in general defined their sample frame or policies in terms of knowledge that can be patented, largely limited to “technology” industries. While this may have been acceptable in the past, it is now becoming increasingly evident that a broader perspective on knowledge transfer would enrich the policy formulations and research studies. Non-technology university department can also provide knowledge that eventually can be commercialized either directly or indirectly (e.g. university venture or corporate venture). Furthermore, independent

individuals, members of research institutions and members of firms can besides patents appropriate benefits from innovation through patents, lead-time, secrecy, trademarks, registration of design patterns and copyrights. Firms generally do not regard patenting as the most important way to protect their knowledge (CIS3).

*Observation Four: Optimal composition of absorptive capacity?*

We need to know more about the optimal composition of absorptive capacity. The studies to day establish a relation between entrepreneurship, absorptive capacity and growth. In the mean while absorptive capacity is in general operationalized in the form of expenditures on education.

*Observation Five: Composition of performance?*

There does not appear to be any studies that relate growth to commercialization performance of public research. There is established a link between growth and the interaction between knowledge (R&D) stock and entrepreneurship. It could also be beneficial to know the composition of final commercialization where public knowledge is involved (se the 3\*3 table in figure 5).

*Observation six: The links between performance and framework conditions?*

There is no study linking the different modes of commercialization where the public knowledge (R&D) stock is involved with the general framework conditions for commercialization of public knowledge. To day the studies reviewed here either only focus on the link between a few commercialization modes were public knowledge (R&D) stock is involved and a single policy area or simply focuses on the level for a few or a single policy areas.

**Table 2: A review of the empirical research on commercialization of public research.**

Factors	Policy areas	Finding	Study	Sample frame	
Opportunity	Commercialization regulation	There are clearly defined institutional factors to be considered when trying to understand why technology transfer works or does not work	Phan & Siegel (2006)	Literature review	
		The legal environment of German universities does not give them sufficient incentives to exploit the potential of academic-industry technology transfer	Gill, Minshall and Rigby (2003)	Germany. 40 interviews (August 2002 – January 2003) A range of research-intensive locations across Germany with a cross section of individuals active in the commercialisation of Germany's science base	
		The institutional framework for knowledge transfer favours organisations outside the university context.			
			Key Determinants of Start-up Formation: the Ability of the University and Inventor(s) to Take Equity in a Start-up, in Lieu of Licensing Royalty Fees; A Royalty Distribution Formula that is More Favorable to Faculty Members Reduces Start-up Formation.	Di Gregorio and Shane (2003)	U.S. 101 universities out of 116. (1994-1998)
	Procurement regulation	N/A			
	Government relations	N/A			
	Industry relations		This paper provides strong evidence that, after controlling for firm size and other factors, the openness of firms to the external environment (and therefore their willingness to interact with it in different ways) is very important in explaining their patterns of collaboration With public research organizations. Larger firms are much more likely to collaborate. They also find that the chances of firms with intense R&D activities to cooperate are much higher, as is the likelihood of concluding agreements with public research organization: firms with small absorptive capacities had lower probabilities on both counts	Fontana, Geuna and Matt (2006)	Seven EU countries: Denmark, France, Germany, Greece, Italy, the Netherlands and the UK. Focus is on 558 innovator firms.
			University-industry relations (the amount of grants given from firms in the private sector to universities) have a positive impact on economic growth	Mueller (2005)	West German districts (1992-2000)
	Test facilities (proof of concept)	N/A			
	Incubator relations		U.S. Universities Are More Efficient than U.K. Universities; TTOs Exhibit Decreasing or Constant Returns to Scale. Universities With Medical Schools And Incubators Are Closer to Frontier	Chapple, Lockett, Siegel, and Wright (2006)	US. And UK.
		They focus on two types of university linkages: a license obtained from the university by the incubator firm and their links to faculty. The authors propose that a university link to the sponsoring institution reduces the probability of new venture failure and, at the same time, retards timely graduation. Furthermore, they suggest that these effects are more pronounced the stronger the university-incubator link.	Rothaermel and Thursby (2005)	Their empirical analysis is based on detailed longitudinal data from 79 start-up firms incubated in the Advanced Technology Development Center at the Georgia Institute of Technology over the six-year period between 1998 and 2003.	
Science park relations		The Following Factors Are Associated With Science Park Growth: Proximity to the	Link and Scott (2006)	U.S. (1997/2002)	

	University, Whether the Park is Managed by a Private Organization, Whether the Park Has a Focus on Information Technology		
	There is a Positive Association Between the % of University-Based Start-ups and the Age of the Park, the Quality of the Research Environment at the University, Proximity to the University, and Whether the Parks Has a Biotechnology Focus	Link and Scott (2004a)	U.S.
	Proximity to a University and the Availability of Venture Capital Have a Positive Impact on Growth; Science Park Enables Universities to Generate More Publications and Patents, More Easily Place Graduates, and Hire Preeminent Scholars	Link and Scott (2003)	U.S.
	Science Park firms are More efficient Than Non-Science Park Firms in Research (i.e., Generating New Products and Services and Patents)	Siegel, Westhead, and Wright (2003)	U.K. Random sample of 177 firms. 89 science park firms and 88 non-science park firms. (1992)
	No difference in employment growth rates of firms located on university science parks and similar firms not located on university science parks	Westhead and Cowling (1995)	U.K. 277 independent firms. (1986-1992)
	Sponsored Science parks environment did not significantly increase the probability of firm survival	Westhead, Storey and Cowling (1995)	U.K.
	No difference in the survival rates of firms located on University Science Parks and similar firms not located on university science parks	Westhead and Storey (1994)	U.K.
Absorptive capacity (stock and flow)	Supports that investment in education are an important source of economic growth.	Acs, Audretsch, Braunerhjelm and Carlsson (2005a)	17 OECD countries (1981-1998 vs. 1990-1998)
	Supports that the higher the level of absorptive capacity (the share of researchers in private industries (>= a university degree in natural science or engineering) and the share of researchers and scientists in universities) the higher economic growth.	Mueller (2005)	West German districts (1992-2000)
Special cultural Beliefs demand side	The most important external sources of information for innovation that were considered as highly important for enterprises of all size-classes were clients and customers or suppliers. It would appear that relationships with business partners, both upstream (procurement) and downstream (distribution) are an important issue in innovation. The average size of an enterprise did not have any significant influence on this observation. In contrast, important size-class effects were reported, as regards the information source of 'other enterprises within the group'. This was more often a highly important source of information for innovation among large enterprises, which are in effect more likely to be part of an enterprise group than SMEs. Government and other non-profit research institutes were also cited more often as a source of information for innovation by large enterprises with innovation activity. In a similar way, large enterprises with innovation activity also showed a greater propensity to collaborate with universities or other higher education institutes than SMEs, suggesting that economies of scale could be an important factor in determining whether or not an enterprise has the	Third community innovation survey/CIS3 (2004)	EU, Iceland and Norway [Stratified sample survey] (Data 1998-2001)

		resources to follow-up on potential sources of information for innovation.		
		The results suggest that firms who adopt “open” search strategies and invest in R&D are more likely than other firms to draw from universities, indicating that managerial choice matters in shaping the propensity of firms to draw from universities.	Laursen and Salter (2004)	UK. Sample of firms from the entire UK manufacturing industry. (the UK innovation survey 2001 based on CIS)
Capital	R&D support	Entrepreneurial activity tends to be greater in those countries where knowledge is more prevalent. The results show that there is a strongly positive relationship between entrepreneurship and the stock of knowledge, and that the relationship remains strong when we control for institutional, market, and individual factors. When they restrict the regressions to the 1990s, the knowledge stock variable becomes more significant and the wage variable becomes negative and statistically significant as suggested by the theory. These results are consistent with the increasing importance of entrepreneurship, knowledge creation, and knowledge spillovers in the 1990s.	Acs., Audretsch, Braunerhjelm and Carlsson (2005b)	17 OECD countries (1981-1998 vs. 1990-1998)
		Supports that investment in knowledge (R&D) are important sources of economic growth. However, those countries with a greater degree of entrepreneurial activity exhibit systematically higher rates of economic growth.	Acs, Audretsch, Braunerhjelm and Carlsson (2005b)	18 OECD countries (1981-1998)
		University Financial Resources Are Significant Predictors of the Rate of Start-up Formation and the Number of Initial Public Offering (IPO) Based on a University Technology License.	Powers, and McDougall. (2005a)	U.K. 120 institutions classified as “research extensive” and research intensive” universities. (1996-2000)
		Positive impact of entrepreneurship of growth but the strongest growth effects relates to the importance of entrepreneurs in exploiting spillovers originating in a country’s knowledge (R&D) stock.	Acs, Audretsch, Braunerhjelm & Carlsson (2003)	20 OECD countries (1981-2001)
	Commercialization support	N/A		
Risk capital	N/A			
Ability	Research on Universities/research institutions	University spillovers (distance alone shows no effect, an effect is found when further considering the spending for the respective university as well as the academic papers published in the natural sciences and the social sciences)	Audretsch and Lehman (2005)	Germnay (1997-2002)
		University Human Capital and Organizational Resources Are Significant Predictors of the Rate of Start-up Formation and the Number of Initial Public Offering (IPO) Based on a University Technology License.	Powers, and McDougall. (2005a)	U.K. 120 institutions classified as “research extensive” and research intensive” universities. (1996-2000)
	Research relations	Social capital enhances (co-publication, co-patenting and severing on a company board of directors or scientific advisory board) the propensity for scientists to commercialize their research (particular high for entrepreneurship).	Audretsch, T. Aldridge and Oetl (2006)	U.S. The top twenty percent of university scientists funded by grants from the National Cancer Institute (Between 1998-2002)
		Collaboration Between Star Scientists and Firm Scientists Enhances Research Performance of Japanese Biotech Firms, As Measured Using Three Proxies: Number of Patents Granted, Number of Products in Development, and Number of Products on the Market	Zucker and Darby (2001)	Japan. Japanese firms using biotechnology (-1990)
	Commercialization education of	A University’s Rate of Start-up Formation is Positively Associated the Business Development	Lockett and Wright (2005)	U.K. 98 Universities.

researchers	Capabilities		(2001/2002)
Commercialization experience	A University's Previous Success in Technology Transfer is a Key Determinant of Its Rate of Start-up Formation.	O'Shea, Allen, Chevalier and Roche (2005)	U.S. 141 Universities. (1995-2001)
	University Entrepreneurs Tend to Be Older, More Scientifically Experienced.	Audretsch (2000)	
Knowledge transfer office (design, information flow and staffing)	Highlights the extent to which additional commercialization of university research takes place, suggesting that the contribution of universities to U.S. innovation and ultimately economic growth may be higher than had previously believed. Scientist entrepreneurship is the sleeping giant of commercializing university research. More than one in four patenting NCI scientists have started a new firm. (Previous research focusing on TTO's supports that the typical TTO does not generate significant commercialization of university research. This study focused on the scientists).	Audretsch, T. Aldridge and Oetl (2006)	U.S. The top twenty percent of university scientists funded by grants from the National Cancer Institute (Between 1998-2002)
	"Gray Market" Activity is Reduced when TTOs are Professionalized, but Such Activity is Associated With More Valuable Discoveries and Heightened Entrepreneurial Activities.	Markman, Gianiodis and Phan (2006)	
	U.S. Universities are more efficient than U.K. Universities.	Chapple, Lockett, Siegel and Wright (2006)	U.S. and U.K.
	U.K. TTO's exhibit decreasing returns to scale and low levels of effectiveness	Chapple, Lockett, Siegel, and Wright (2005)	U.K. 122 Universities. (2002)
	Land Grant Universities are more efficient in University Technology licensing; higher levels of effectiveness	Link and Siegel (2005)	U.S. 80 out of 89 Research One Universities, or those that award 50 or more doctoral degrees and receive at least \$40 million annually in federal research grants. (1991-1998)
	Technology transfer activities remain marginal and under-resourced in most universities	Gill, Minshall and Rigby (2003)	Germany. 40 interviews (August 2002 – January 2003) A range of research-intensive locations across Germany with a cross section of individuals active in the commercialisation of Germany's science base
	Faculty quality and quality of TTO staff has a positive impact on licensing	Thursby and Kemp (2002)	U.S. U.S. universities. (1991-1996)
	Universities That Wish to Launch Successful Technology Transfer Startups Should Employ a Combination of Academic and Surrogate Entrepreneurship	Franklin, Wright, and Lockett (2001)	U.K. 57 Universities out of 116. (1994-1998)
	Research entrepreneur – University/research institution relations	Find that a dominant trend of the cases and the literature on the subject is that founders tend to retain their positions in academe, either part time or full time. This suggests that some of the vital forms of exchange, e.g. transfer of research and personnel are dependent on boundary spanning individuals who have a 'right to belong' in the two different worlds One particular arrangement that seems to fulfill	Johannsson, Jacob and Helleström (2005)

		<p>this to a large extent, and which was preferred by all firms in our study, was the joint supervision of PhD-students. The development of such relations may also be facilitated if the founders retain a position in academia, thereby being able to act as boundary spanning individuals between the two worlds.</p>		(between 8-24 years and from 13-50 employees)
Incentives	University/Research institution strategy	Institutional Policies, Such as Royalty Distribution Formulas, Are an Important Determinant of Entrepreneurial Behavior.	Renault (2006)	U.S. 98 Faculty members/12 universities. (2003)
		Universities That Have More Supportive Licensing and Entrepreneurial Policies Have Better Technology Transfer Performance	Powers, and McDougall. (2005b)	U.S. 134 research extensive and research intensive universities. 92 public and 42 private institutions. (1996-2000)
		The Most Attractive Combinations of Technology Stage and Licensing Strategy for New Venture Creation-Early Stage Technology and Licensing for Equity-Are Least Likely to Favored by the University (Due to Risk Aversion and a Focus on Short-Run Revenue Maximization)	Markman, Phan, Balkin, and Gianiodis (2005)	US. 91 UTTO directors from a sample of 138 universities. (2000/2002)
		The Lambert Review had highlighted the concern that there may be an over emphasis on creating spin-outs rather than seeking to licence a technology to an established business. Successful spin-outs consume a significant amount of staff time from the university commercialisation office. Continuing resources are also needed to ensure that the university's investment stakes in spin-outs are appropriately managed. Such management requires specific expertise, which may need to be drawn in from beyond the commercialisation offices. However, this should not be taken to imply that licensing is an 'easier route' - it was also noted that considerable amounts of staff time and effort are needed to develop and manage a good licensing agreement with an established business.	Minshall and Wicksteed (2005)	UK University Spin-outs. 10 universities. The four universities with the largest research budgets. Three other large universities in major cities. Three universities with significantly smaller research budgets, reflecting in part their lack of medial research activities, but each with a high proportion of research funds from UK industry (1998-2002)
		Universities That Generate the Most Startups Have Clear, Well-Defined Spinout Strategies, Strong Expertise in Entrepreneurship, and Vast Social Networks.	Lockett, Wright, and Franklin, (2003)	U.K. 57 Universities out of 116. (1994-1998)
	Credits towards tenure and promotion	N/A		
IPR	A University's Rate of Start-up Formation is Positively Associated with Its Expenditure on Intellectual Property Protection, the Business Development Capabilities of TTOs, and the Extent to Which its Royalty Distribution Formula Favors Faculty Members.	Lockett and Wright (2005)	U.K. 98 Universities. (2001/2002)	
Knowledge transfer	Universities allocating a higher percentage of	Debackere and	12 European	

office (compensation practice)	royalty payments to faculty members tend to be more effective in technology transfer.	Veuglers (2005)	universities. K.U. Leuven (Belgium), Karolinska Institute in Sweden, the Universities of Oxford, Cambridge and Edinburgh in the UK, the University of Leiden in the Netherlands, the University of Geneva in Switzerland and Universit e Louis Pasteur in Strasbourg, University of Heidelberg and Munich in Germany, University of Helsinki in Finland and University of Milan in Italy. (1990-2001)
	Land Grant Universities are more efficient in University Technology licensing; higher royalty shares for faculty members.	Link and Siegel (2005)	U.S. 80 out of 89 Research One Universities, or those that award 50 or more doctoral degrees and receive at least \$40 million annually in federal research grants. (1991-1998)
	A University's Rate of Start-up Formation is Positively Associated with the Extent to Which its Royalty Distribution Formula Favors Faculty Members.	Lockett and Wright (2005)	U.K. 98 Universities. (2001/2002)
	Equity Licensing and Startup Formation Are Positively Correlated With TTO Wages; Uncorrelated or Even Negatively Correlated With Royalty Payments to Faculty Members.	Markman, Phan, Balkin, and Gianiodis (2004)	U.S. 128 universities. (2003)
	Higher royalty shares for faculty members are associated with higher licensing income.	Lach and Schankerman (2004)	U.S. 102 universities. (1991-1999)
	Higher royalty shares for faculty members are associated with greater licensing income.	Friedman and Silberman (2002)	U.S. Science parks. (2002)
	Administrative burdens (pre – start - growth)	The fact that in Sweden, researchers generally have the legal right to any intellectual property accruing from their research findings explains this situation to a certain extent. Incentives for individual researchers to commercialize their findings are high for would-be innovator-entrepreneurs because of the potential financial gains compared to for instance a smaller percentage of the possible income of a patent or license held by the university should increase the likelihood of university spin-outs. However, in the Swedish case this advantage is somewhat attenuated by the costs of patenting and eventual commercialization. Thus despite the high incentives, Swedish researchers are comparably behind in rates of commercialization. Recent developments suggest a shift in position to a view that fits more closely with the above, i.e. that the low rate of spin-outs may be more of a reflection of the costs of commercialization	Johannsson, Jacob and Helleström (2005)

		rather than who owns the intellectual property.		
Culture	Social desirability of commercialization	Mythos Humboldt and technology transfer do not sit well together in German universities And the status of TTO within universities remains low and this causes problems with recruitment of skilled technology transfer professionals.	Gill, Minshall and Rigby (2003)	Germany. 40 interviews (August 2002 – January 2003) A range of research-intensive locations across Germany with a cross section of individuals active in the commercialisation of Germany's science base
	Special cultural beliefs (university/ research institution)	The Most Significant Determinant of Entrepreneurial Behavior Is a Professor's Belief About the Proper Role of Universities in the Dissemination of Knowledge.	Renault (2006)	U.S. 98 Faculty members/12 universities. (2003)
		Key Determinant of Faculty-Based Entrepreneurship: Local Group Norms; University Policies and Structures Have Little Effect	Louis, Blumenthal, Gluck, and Stoto (1989)	U.S. 40 universities out of 50. The 50 universities that receive the most federal research funds. (1985)
	Communication about heroes, rolemodels/awards	N/A		
	Introduction of enterprising universities	N/A		

Source: Own making.

## SUGGESTED POLICY RESEARCH DIRECTIONS/NEXT STEP?

What is the next step in the consortium? Should we continue the work? Yes? Maybe?, Or definitely not?

If we decide to continue we need to decide on the extent of the analysis. The extent will determine the possible benefits and cost.

The need for new data will require a larger effort compared to the need for existing data. The extent will in terms of coverage span over possibilities concerning identification, collection and analysis. For example identification of data coverage, designing surveys in order to collect new data, collecting data in several countries will be rather expensive.

FORA could initiate the work by identifying whether policy areas are covered by existing data or not. Further, developing frameworks for surveys for collecting the areas not covered. Finally to match the analysis design for collecting the areas not covered to the perceptions of carefully selected stakeholders (researchers, incubators, science parks and researchers with previous experience on this topic).

We estimate that this will require one research analyst working full time for two months and a project leader working full time for one month. This will require 25000 Euro. 17000 for working hours and 8000 for travel expenses, external experts, and stay connected with interviewing stakeholders.

What is the next step in the consortium? Should we continue the work? Yes? Maybe?, Or definitely not?

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**Appendix 1 figure from Phan and Siegel (2006)**

Figure 1  
The Institutional, Organizational and Individual Contexts of Technology Transfer Effectiveness

