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Foreword

The papers presented in this volume are the main results of a strategic institute program organised during 2006-2007 at NIFU STEP on “Innovation processes in an evolutionary perspective”. The objective of the program has been to conduct theoretical studies of innovation processes based on an innovation system approach, partly by addressing rather broad issues relating to our more basic understanding of innovation systems, partly by addressing more specific systems and processes of innovation. Building on previous research activities at NIFU STEP, the program has provided opportunities for working further with issues for which it otherwise would have been difficult to obtain funding.

All papers presented in this volume will be developed further with the intention of publishing in different journals or books. However, we have found it feasible to present the papers in this volume to provide a collection of most of the work organised in the actual institute program. In addition to these papers, there will also be published a separate report in Norwegian on systems of commercialisation organised on university campuses.

The funding of the strategic institute program is provided by the Norwegian Research Council. We are very grateful for having had this opportunity for working with some more basic issues related to innovation systems.

Oslo, January 16, 2008

Per Hetland
Managing Director

Olav R. Spilling
Project Coordinator

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Outsourcing knowledge appropriation

Åge Mariussen

Abstract

Because actions to promote innovation by definition have open-ended outcomes, there is a considerable *uncertainty* connected to calculation of private investments in R&D to promote innovation. Recently, by Malerba and others, attempts have been made to overcome this uncertainty with reference to the predictability provided by technological regimes. The institutionalization of technological regimes, so the story goes, in some sectors create conditions for sector-specific private appropriation of knowledge which results in Schumpeter II type of firms. Here, the uncertainties of innovation is contained by hierarchy. In the current phase of globalization, China successfully applies knowledge accumulation strategies to first copy and secondly through price competition out-compete most Western industrial sectors. In this situation, *strategies* of private knowledge appropriation should not be seen as carved in stone. Instead, the diffusion of technological regimes beyond the borders of firms enables make-or-buy experiments which results in dynamics of *co-evolution, co-specialization and co-optation of different strategies of innovation*. These heterogeneities when it comes to strategies of innovation do not just evolve *between*, as Pavitt pointed out, buy also *inside* sectors. Based on Norwegian data (CIS2000, Creditinform 2002) and with reference to a recent analysis undertaken by MERIT, the paper analyzes this differentiation of strategies of innovation among Norwegian firms. Two basic strategies of coping with actions under uncertainty are identified: *opportunism* and *adaptation*. These strategies must be seen in the context of the long-term dynamics they are involved in, which creates experimental combinations of knowledge appropriation, knowledge outsourcing and knowledge externalization. The analysis highlights the significance of *small* firms *specializing* in innovation and investing heavily in R&D for the rest of the economy.

> "Most firms are unable to make very rational calculations about any one project because of the uncertainty which is inherent in the process, because they lack the information necessary for rational behaviour and because they lack the time and the inclination to get it or to use very complex methods of assessment." (Freeman 1986).

Introduction

Arrow point out that since actions aiming at innovation by definition has unknown outcomes, investments in innovation cannot be based on rational economic calculus. Freeman confirms this empirically (Freeman 1986). Never the less, Malerba provides a theory of *why* rational economic actors *despite* these uncertainties invest their money in innovation (Malerba & al. 2005). Malerba do this by referring to technological regimes, which

> "define broad prescriptions and tradeoffs which identify the basic dynamics and mechanisms and viable firm behaviour" (Malerba and Orseningo 1993:45).

Technological regimes, according to Malerba, may be observed by focusing on sectors. The *sector system of innovation approach* builds on the assumptions that

- First, sectors differ when it comes to conditions for *protecting* the *firm* knowledge base and appropriating new technology (Malerba refers to this as "appropriability").
- This, secondly, is supposed to be motivated by sector-specific opportunities to make a profit. Firms with successful knowledge monopoly strategies may be expected to make money more easily on their investments in innovation in some sectors than in others.
- Third, this is likely to provide varieties between sectors when it comes to incentives of *knowledge accumulation, or private investments in R&D*.

Some sectors are likely to have high *cumulativeness* in terms of learning and knowledge creation and a high level of *appropriability*, in other words the related ability of economic actors of *firms* to protect their knowledge base in different countries, through patenting and /or by accumulation of a unique form of private knowledge *inside a firm*. Other sectors according to Malerba consistently are more open for external intruders. This, he think, reduces the incentive to learn cumulatively. Sectors with high cumulativeness and appropriability are likely to converge towards similar types of well-established and innovative large firms with a high level of technology-specific *internal heterogeneity*, characterized by "creative accumulation" (the Schumpeter II or SII mode of innovation). On the other hand, sectors with low appropriability and low cumulativeness, in other words more open for external intruders, are inside the "creative destruction" mode of innovation (the Schumpeter I or SI mode of innovation).

> "The empirical evidence (Malerba and Orsenigo 1996) suggests the existence of differences across sectoral systems in the pattern of innovative activities, and, for each sectoral system, of broad similarities across countries. This result provides support for the relevance of the technological regimes in determining sectoral invariances across countries in innovation patterns. This is as long as appropriability, cumulativeness and opportunity conditions are quite similar across countries. Empirical analysis has shown that appropriability and cumulativeness conditions are similar across countries." (Malerba 2004:23)

Opportunity, according to Malerba and Orsenigo reflect *the ease of innovating for any given amount of money invested in research* (opt.cit page 48). Science is seen as a major source of opportunities, but during the evolution of industries, opportunity conditions and requirements will change. In this paper, these simplistic notions are challenged by a more nuanced perspective on innovation as actions under uncertainty. Since innovators are unable to calculate their investments in relation to their outcomes, they follow alternative strategies, designed to cope with this uncertainty.

By way of introduction, let us briefly remind ourselves of some of the objections which may be raised against explaining firm organization with reference to technology, as well as the mechanisms which encourage externalization of knowledge.

Society and technology

The *sociological* roots of the various systems of innovation theories and models are leaning in favor of a perspective of *co-evolution* of technology and society, rather than seeing societal forms of organization, such as the organization of firms and the ways in which firms learn through various systems of innovation as *determined by technologies*. These roots go back to the *socio-technical paradigm* (Trist 2001, Cole and Walder 1981), as well as later studies of *the social construction of technology* undertaken by Bijker, Hughes, Latour and others. A common theme in these early studies was the various ways in which *human* forms of societal organization and *technology* are *interrelated*. The sociologists backing the socio-technical paradigm and the historians of technology involved in the social construction of technology school were confronting a common enemy, approaches which saw the organization of work and society as, broadly speaking, *determined by technology*.

Similarly, in the varieties of capitalism research program, founded by Richard Whitley and his allies, there is a line of arguments in favour of the impacts on business or firm organization by certain national level *institutional complementarities*. The roots of these institutional differences between countries, according to Whitley, are nationally specific ways of handling risk and uncertainty, sharing and privatizing knowledge, and relating different forms of knowledge to each other. This results in nationally specific configurations between interest groups in sectors and as well as different knowledge configurations within firms. This, again, results in varieties of firm organization, in the ways in which relations between different types of knowledge are perceived, and knowledge is accumulated and protected (or appropriated) by firms. These things are often discussed with reference two "models", such as the US/UK or entrepreneurial model and the form of organized capitalism usually associated with countries like Germany and Sweden.

These objections should point in the direction of a certain caution when it comes to explaining patterns of innovation only with reference to technological regimes. However, technological regimes may be seen as dynamic in their own right when it comes to innovation.

Co-evolution of strategies of innovation

Rip and Kemp (Rip & Kemp, 1998) define technological regime as "…the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, way of defining problems; all of them embedded in institutions and infrastructures". Institutionalization, generalization and diffusion of the rules and concepts defining technological regimes have enabled what one might call applied forms of transaction cost theories promoted by Coase and Williamson. The problem within transaction cost theory was the question posed by Coase in 1937 of weather an activity should be integrated into the hierarchy of the firm or simply bought in a market (The "make or buy" problem). Coase concludes by saying that the size of the firm is dependent on the costs of using the price mechanism, and on the costs of organization of other entrepreneurs. The problem was that of opportunism in market transactions. Opportunism distorts the price mechanism and creates uncertainty. Efficient market transactions without too complex contracts require clear cut definitions and standards of what is to be supplied. As long as a transaction is open ended, with no clear definition of the product, fiat provided by hierarchy was seen as a guarantee against opportunist behaviour. One would assume that actions to promote future innovations should be integrated inside the firm, and not outsourced. If so, in order to innovate, the firm should accumulate a heterogeneous knowledge base.

On the other hand, in a world where technologies becomes increasingly complex and expanding, even the largest hierarchies becomes too small to appropriate any specialized service integrated in the operation of the technology. In the real world, accordingly, to appropriate highly specialized forms of knowledge by internalizing the specialist inside the hierarchy is likely to create slack or capacity which is not used, thus undermining productivity. Outsourcing of functions, and the related knowledge, means that the demand for appropriation must be relaxed. The nice thing about outsourcing is that it enables price competition, even when it comes to highly specialized services, simply because out there, in the larger cluster, the scale of the market is so large that markets for even the most highly specialized skills may develop.

What is more, according to transaction cost theory, the market may protect you against opportunism if the outsourced product may be *defined clearly, within the framework of the technological regime*.

In this way, the institutionalization, generalization and diffusion beyond the border of the firm of *technological regimes* provided the tool by which outsourcing was possible. The technological regime provides widely distributed and accepted *definitions* which enables *modularization* and hence efficiently working *markets of technologies*. If a clear market standard is possible, competition between several suppliers will ensure a sufficient quality at a low price. In this way, technology is externalized and shared, and specialized producers are subjected to price competition, enhancing productivity. This process also tends to create a differentiation between supplier firms trying to optimize productivity in the production of standardized components, and highly innovative firms further up in the value chain, synthesizing components, creating a variety of new products, based on input from their suppliers. Examples of this are found within sectors with widely different technologies, such as textiles, ship-building, construction, aviation, food industry, and consumer electronics. Outsourcing soon proved to be an important element in globalization, as corporate actors realized the potential to offshore production and in that way cut deeply in terms of costs.

One of the drivers for Chinese success in the global market is the economy of scale and low levels of cost in the huge Chinese domestic market. Another important factor is the Chinese strategy to copy successful forms of western capitalism inside the Chinese economy. This is done by coordinating cumulative Chinese learning processes which results in a copy inside China of a technological regime in USA or Europe (Krug 2006). These processes typically start with the relocation of standardized production (suppliers or sub-suppliers) from USA or Europe to China at the end of the technology which is standardized and outsourced. Once this lower level of the value chain is put in place in China, the Chinese are able to coordinate processes of knowledge accumulation which enables them to copy the *entire* technological regime, including higher-levels of the value chain, and its consumer market products inside China. Once the technological regime is copied, it may turn out low cost global market consumer products. This, it goes without saying, breaks down barriers of appropriability painstakingly constructed in USA and Europe. What *appeared to be* fortifycations of “appropriability” and “cumulativeness” once carved in stone, is now in sector after sector turning into thin air.

These considerations should lead to some caution when it comes to applying simplistic dichotomies like Schumpeter II or Schumpeter I types of innovation. Instead, the long term dynamics of outsourcing leaves a trail behind them, as co-specialization, co-evolution and sometimes also co-optation (Carayannis, 2006) between firms and sectors. Let us, based on these considerations, look at the ways in which different strategies of innovation may be classified, and how the relations between these classifications may be explained, taking a long term perspective on co-evolution and co-optation.

Method

If firms are not able to calculate strategies of innovation in a very rational way, if these strategies are shifting, co-evolving and contextualizing each other, it is not a good idea to start sending informants standardized questions of what their “strategy of innovation” happens to be. This has created a methodological problem in studies of systems of innovation. As Lundvall points out:

> “to find new ways to define the embryonic elements of the innovation process is therefore a challenge.” (Lundvall 2007).

To solve this problem, the paper applies two related methods.

First, a statistical method called factor analysis. This is an inductive approach. The objective of a factor analysis is to generate a classification. A *factor* is an analytic variable, created through calculus, which explains variation in a set of input variables. The strength of the factor is a measure of how much variation in the selected set of input variables the factor explains. The factor, seen as an abstract, analytical variable, is characterized through correlations with input variables. The input variables in this analysis are information on innovation and budgets in Norwegian firms, combined with data on sectors. If all input variables are correlated to each other in a straightforward way, this results in one factor. However, if the *direction* of a relation, say, between R&D investments and profitability is changing, the analysis is likely to generate several factors, which may be seen as indicative of different strategies of innovation. The output of the factor analysis is then interpreted. The question is: what are the embryonic elements of the process of innovation this type of firms are likely to be involved in? Based on the outputs of a factor analysis, it should be possible to make an analytical *conceptualization* of this strategy. These analytical concepts are not taken a priori, but they are derived as empirically based *interpretations* of the factors.

Secondly, since strategies are only expected to be understandable in their context, the study try to connect different types of strategies into a pattern which may be described as a preliminary sketch of the structure of the national system of innovation of Norway. In order to do so, since some of the strategies may only be understood as adaptations to clustering, the study also operates with aggregated statistics of sectors. Through an ecological analysis, the context variables are then introduced together with firm level variables.

Factor analysis can not explain causality, or cause-effect relations. It is usually assumed that cause-effect relations presuppose time series data. The current paper on the contrary aims at drawing a sketch of the Norwegian system of innovation. In terms of method, the paper in this way falls back to a sociological tradition founded by Max Weber. Weber used a statistical mapping of Protestant, Catholic and Calvinist regions and countries, and used that map to develop a theory of the long-term genesis of the system of capitalist production, including the embryonic ways of calculation involved in that process.

Since one of the outcomes of this analysis was the identification of strong relations between sector level and firm level variables, the analysis also includes a causal model, using correlation coefficients. Here, we make the *assumption* that a positive correlation between an independent and a dependent variable is an indication that there is a cause-and-effect relation. The objective of this step is to illustrate the impact of clusters (understood as agglomerations of firms in innovative sectors with high levels of R&D) on firm level strategies of clustering, where certain firms apply exploitation of knowledge externalities as their strategy. In the model, it is also assumed that clusters are again created by *opportunities*, which are measured as *profit differences*, or deviations from "perfect competition". In this way, given the assumptions of this causal model, we estimate indicators for the impact of opportunities on clustering and innovation.

In discussing co-specialization between firms, the paper is interpreting the quantitative material with reference to a theory of long term dynamics, both in terms of firm trajectories, decisions of firm strategies, such as decisions of what to keep externally and what to externalize, and in terms of clustering or exploitation of knowledge externalities. For this purpose, organizational theories of actions under uncertainty, outsourcing and logics of make or buy as outlined in organizational theory come in handy, to explain trajectories of co-evolution. Some of these suggestions are substantiated with reference to results from empirical case-studies, and other available knowledge of specific sectors and firms.

Co-specialization between sectors and firms

The classic analysis of co-specialization was carried out by Pavitt (1984:364). Based on interviews on strategies of innovation with British firms in different sectors, he came out with a model which illustrates technological linkages between firms in different sectors. Certain sectors in the economy were specialized in developing equipment and other technologies applied by other sectors. Other, more scale-intensive sectors, such as for instance chemical industries, depended on science-based knowledge, which was provided by firms in other sectors specializing in commercial applications of science. A fourth type of firms depended on others for their innovations. These firms were supplier dominated. This discussion by Pavitt was carried further by Lundvall, who referred to these kinds or relations as user-producer interaction. Co-specialization between on one hand science based firms and technology providers, on the other hand scale-intensive firms and supplier dominate firms were also discussed by Michael Porter, as clusters (1990).

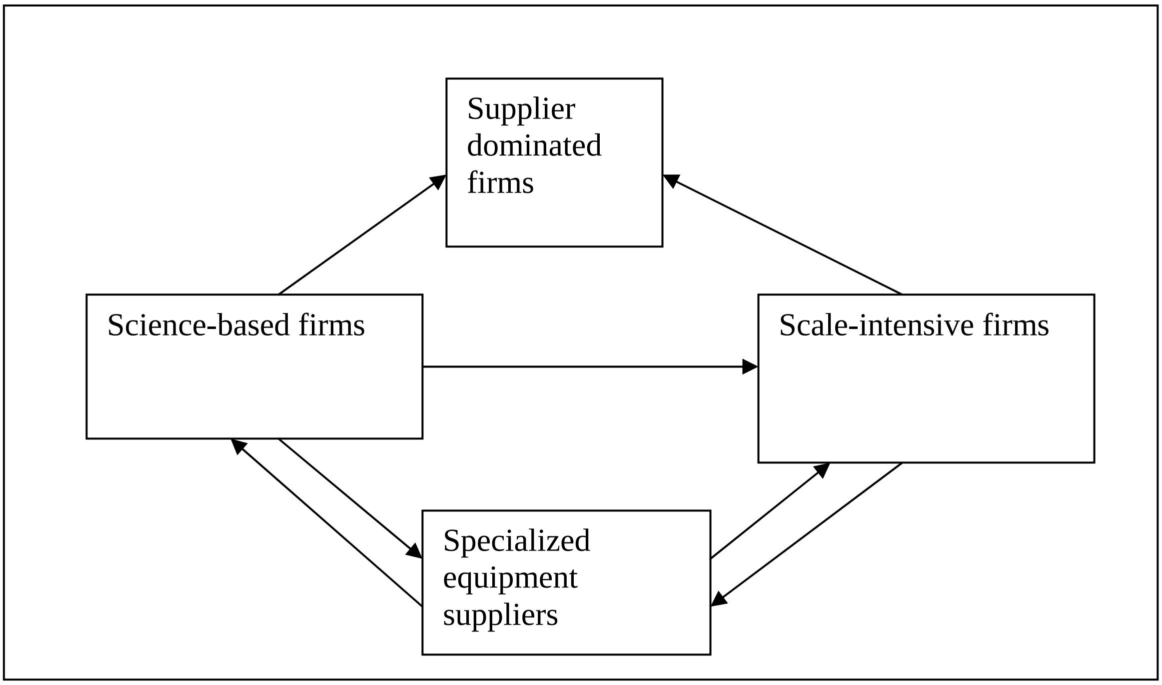

Figure 1: The main technological linkages amongst different categories of firms. K. Pavitt, (1984: 364)

The arrows indicate directions of transfer of technology and innovation. Specialized equipment suppliers are innovating through interaction with scale intensive firms and science based firms. In addition, scale intensive firms get innovations through contacts with science-based firms. Supplier dominated firms are innovating through input from science based and scale-intensive firms. Now, if the Pavitt classification still is valid, co-evolution and co-specialization is taking place *between sectors*. If so, sectors could develop different versions of the Schumpeter II firm, appropriating privatized knowledge.

However, preliminary results from the on-going EU-funded Systematic project (Hollanders, 2007) on the contrary suggest that there is a considerable variation between firms or co-specialization *within the same sectors*. Hollanders outline a *typology of innovation strategies which cut across different sectors*.

- *Strategic innovators* have introduced a product or process innovation that is at least partly developed in-house, they have performed R&D on a continuous basis, they have introduced at least one product which is new to the market and they are active both in national and international markets. These strategic innovators are likely to innovate in a way which is later adopted by other firms inside the sector.
- *Intermittent innovators* develop innovations at least partly in-house, and they have introduced new-to-market innovations.
- *Technology modifiers* have developed an innovation at least partly in-house, but they do not perform R&D

- *Technology adopters* have developed innovations which depend on adaptations of equipment or products made by others.
- The fifth type is non-innovative firms.

In the MERIT study, these types are mapped based on micro-level data for more than 70 000 (N=71477) European firms in all sectors. Now, interestingly, the study reveals that these *types* are found also in sectors with fairly low levels of innovation. Food, energy and textiles have some (3-4%) strategic innovators, and an even higher amount of technology modifiers (10-15%). The relative shares of strategic and intermittent innovators are higher among innovative sectors like aerospace (34 and 13%), ICT (18 and 29%) and chemicals (19 and 27%).

This should indicate that in addition to the Pavitt *differentiation at the sector level*, between on one hand innovating and R&D intensive sectors and on the other hand sectors adopting these innovations there is also, as pointed out by Hollanders, a differentiation between *firms within the same sectors*. Taking these variations between highly innovative and less innovative firms both across and within sectors into consideration, we get the following classification of strategies under uncertainty.

Table 1: Typology of firms and sectors

Firm\ sector	Supplier dominated/ scale intensive sectors	Science based/ equipment supplying sectors
Strategic/ intermittent firms	Adapters (R&D intensive firms) Strategic innovators	Opportunists R&D intensive firms Strategic innovators
Firms modifying/ adopting innovations from others	Adopters	Clusters / externalities

This creates four categories.

- First, *adopters* are firms which are mainly adopting technologies and innovations developed by others. There firms are found in sectors which are supplier dominated or scale intensive.
- Secondly, as demonstrated by MERIT, even inside these sectors they find highly innovative "strategic" and "intermittent" innovators. We will assume that these highly innovative firms which are located in sectors which rely upon others sector to innovate as *adapters*.

The adapter will play the role of strategic innovator through their ability to adapt or apply technologies or science based inputs from the "science based/ equipment supplying" sectors in developing new processing technologies. The new adaptations may then, once they are developed, be adopted by the adopters. A typical role for an adapter is a firm located in a processing industry sector testing (and adapting) new production technologies provided by an equipment supplier, thus innovating a new process. There may be other adapters, such as radical innovators in textile industries, designing new cloths, which are later processed by adopters, their subcontractors.

In the context of science based or equipment supplying sectors, the similar differentiation is likely to be between on one hand the strategic innovators, typically firms who play a leading role in R&D-driven development of new products, or firms developing new technologies, and on the other hand firms within the same sectors who are innovating through copying these technologies, modifying them, and combining them with other technologies. These latter firms are not investing in innovation themselves. Instead, they rely on what in the literature is known as "knowledge externalities", or clustering (Cooke, 2002). Before we return to the issue of clustering below, we will first take a look at the heterogeneities created by variation of innovation strategies both between and inside sectors.

The basic dimension, in line with Pavitt, may be seen as the differentiation between scale-intensive adopters of technology from others, and the small and large firms developing this technology. This differentiation reflects two different types of firm with different institutional complementarities. It boils down to the discussion of the uncertainties created by opportunism, and the need of the hierarchy to control this uncertainty.

Opportunism and clustering

To Coase (1937) and Williamson (1985), opportunism in the market was based on the exploitation of the ignorance of buyers, or information imbalances, by sellers who withdrew information of true production costs to reap a super-profit. From a certain point of departure, making super-profits from product innovation may be seen as a form of opportunism. One example of this is product innovators who exploit privatized knowledge. In sectors characterized by conditions favoring this kind of opportunism, there is likely to be differences in levels of profits between firms. These differences are a signal that the market mechanism has "imperfections" because knowledge appropriation/ information imbalances enable super-profits. If the secret knowledge of the success story had been common knowledge, competitors would intrude and destroy the opportunities created by private knowledge appropriation.

The actor operating in this kind of market is likely to be motivated by a vision of an opportunity. He can see other innovators making lots of money (observable as profit differences in the sector), and he can see a technological possibility for making a new product which may succeed in this market in the future, possibly giving an equally high return. He starts to behave in ways which in organizational theory are referred to as opportunistic. The new product may break the established rules of the game, it may be based on large investments in R&D, and in that way it may recombine elements which have not been combined before.

The term opportunism refers to the fact that these firms rely on the possibility to get super-profits through knowledge privatization, or through the construction of information imbalances, in the discussion of Williamson. These strategies may sometimes be fairly short-term. Successful opportunism is likely to lead the firm into a position where it controls a more complex knowledge base, which enables at least for a while a stronger competitive position. This position may have to be defended through new investments in R&D. Now, however, the firm may also enjoy other strengths, like control of markets, a brand name, and financial resources. These success stories also recreate the conditions which constructed them in the first place, as other entrepreneurs may use the example to be inspired, and risk new adventures with high R&D investments. This is the upper-right end of the table, R&D investing firms in R&D-intensive industrial, where there are large profit variations.

Private investments in R&D also results in knowledge which sooner or later will become externally available. Opportunism creates knowledge externalities. Others may steal or copy ideas and technologies, and innovate through fairly low R&D investments. Firms in sectors with concentration of R&D may be expected to be able to innovate themselves, by playing the role of intermittent innovators and technology modifiers. These are the externalities of opportunism. We will look for these opportunist externalities in particular in sectors and regions characterized by high opportunities and high levels of sector R&D investments. This is observable as clusters. Clustering may be seen as another kind of opportunism, the free-rider, exploiting common knowledge generated by investments made by other. This is the lower-right end of the table, clusters generating externalities *inside sectors*.

What should be emphasized here is that clustering is significant because it links the R&D-investing actors in the system of innovation with forms of innovation which are not R&D – related. It also links the chains of causality between opportunities and innovation, in that way looking upon externalization as opportunity-driven.

Adapters - adopters

Adopters use technologies developed by others in scale-intensive sectors characterrized by processing industries submitted to price competition. In order to be adopted, these technologies have to be adapted. Adapters are innovating and testing new value chains within these sectors, through experimenting with new technology from the outside in innovative and new ways. In order to do so, they may also start to modify technology by themselves, and to work closely with suppliers of technologies and new products in other parts of the cluster. These firms are likely to have high levels of product innovations inside sectors where R&D-levels and levels of product innovations are low. Unlike opportunists, adapters have a more long-term calculus. Profits flowing from their investments are assumed to come through an equally long-term sequence of harvesting the innovation. In other words, they do not need to be inspired by the same kind of profit differences in the sector, which motivates opportunists. Their reward is a successful adoption, within another mode of calculus.

Firms and sectors

The analysis below is based on Norwegian CIS data (N=3027) for 2000, combined with firm budget data for 2002 (Creditinform). Sector statistics is obtained through aggregation. In terms of firm level innovativeness, we construct an indicator (a factor) based on firm rate of product innovation and firm rate of R&D investments. In examining variation across and within sectors, we use two factors. The Firm innovation factor is based on two variables, *innovation*, measured through the Oslo manual standard as share of new or improved products of total turnover, and *firm rate of R&D investments*. The correlation of these two variables with the joint *firm innovation factor* is 0.815. This factor is the vertical axis in the table below.

Similarly, the sector opportunity factor is based on *standard deviation of profits in the sector and the sector R&D rate*. Sector is defined on a NACE level 2 (N=36). Sector with low scores on this indicator are likely to be in the scale-intensive/ supplier dominated category of Pavitt, while firms in the other end are science based firms and suppliers of specialized equipments and services. The plot below illustrates that even though there is a correlation between the meso level variables and firm level R&D investments and innovation, there is a lot of variation within all sectors.

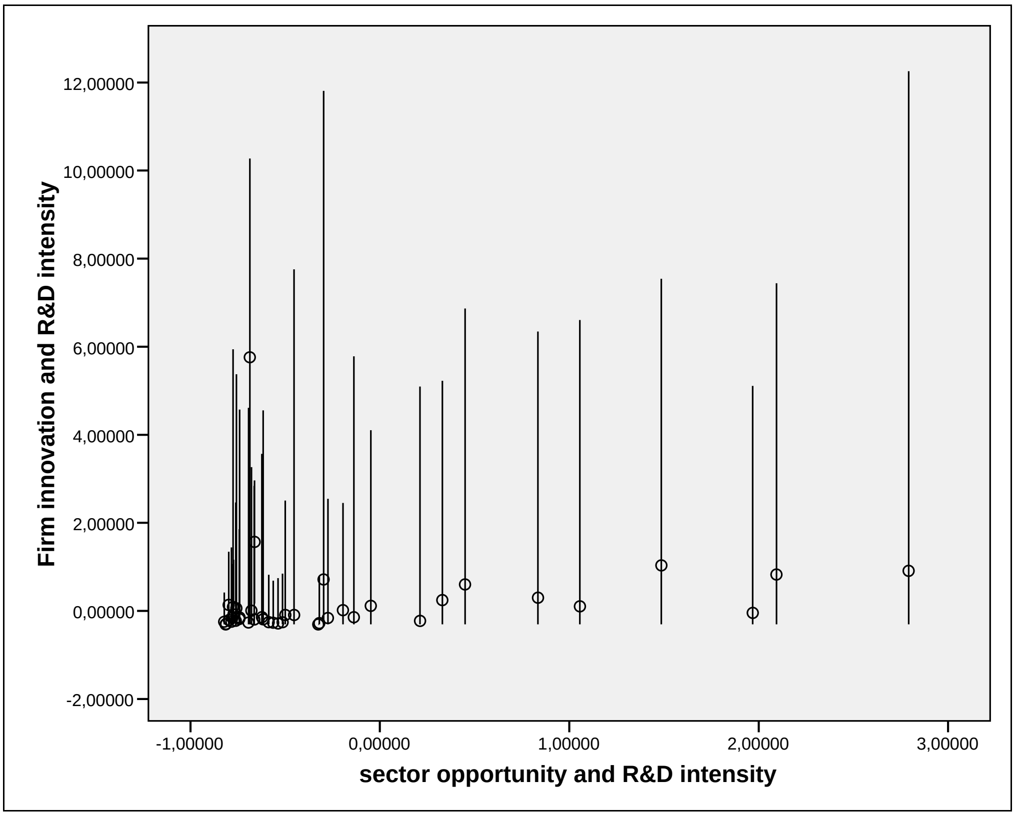

Figure 2: Typology of firms and sectors

Here sector opportunity is the horizontal axis and firm innovation is the vertical.

The columns are variations (maximum and minimum values) within sectors of firm innovation and R&D intensity. Even in sectors characterized by low levels of opportunities, and low sector levels of R&D investments, there are firms with high levels of R&D investments and high levels of product innovation. This basically points in the same direction as the conclusion of the MERIT study. There are highly innovative firms in sectors with low levels of innovation, and there are firms who are not innovative or investing in R&D in sectors characterized by high levels of R&D investment and high opportunities. We will look closer at two examples, in each end of the sector opportunity and R&D axis. On one hand a sector with a relatively low level of R&D investments and opportunities, aquaculture, and on the other hand a sector with high levels of opportunities and R&D, business services.

Adapters and adopters – the case of aquaculture

Aquaculture in Norway is based on domesticated off-shore production of salmon. The industry is experimenting with domestication of new species, such as cod. This activity includes the development of new processing technologies. Here, we will include the following input variables:

- Profits

- Assets
- Size, measured as total turnover 2000
- Innovation, measures as share of new products to the market (the extended Oslo protocol definition)
- Rate of external R&D investments
- Rate of internal R&D investments Export as share of turnover
- Turnover/ employee

In terms of variations of firm strategies in aquaculture, we get the following four factors, which may be interpreted as four distinct strategies.

Table 2 Aquaculture: Rotated Component Matrix

	Component			
	Adapters Labs	Scale intensive adopters	Adapters Testbeds	Strategic innovators
PROFITS	,062	-,029	-,041	,872
ASSETS	-,245	,093	,817	-,136
Total turnover in 2000	-,038	,887	-,060	,253
Share of new or impro-ved products to market	,135	-,157	,817	,210
Rate external R&D	,962	-,041	-,106	-,027
Rate internal R&D	,985	-,089	,025	-,006
Export share	-,136	,747	,009	-,499
Turnover/ employee	-,343	,131	,212	,486

The labels in this table refer to the analytical interpretation of the factor scores on the variables. Here, we find four types of strategies, expressed as four factors.

Scale intensive adopters,

Scale-intensive adopters are firms with high turnover (+0.887), high export shares (+0.747), fairly high productivity or turnover/ employee (+0.131), and low profits (-0.029). These large scale producers of standardized products are fighting for survival in an export market characterized by fierce price competition. In doing so, they are adopting standard technology, available from other sectors in their cluster.

Adopters.

We find two types of adopters, labs and testbeds**.**

- *Labs* (Factor 1) are firms with high levels of R&D investment (+0.962 external R&D and +0.985 in internal R&D), low profits, low turnover, and a moderate level of innovation (+0.135). Labs are externalized research laboratories, or, to be more precise, research projects, organized as firms. They are accordingly highly R&D intensive, but they typically have not yet reached the level where they are able to start to turn out new products. New products in this respect are test products, which typically represents a small part of the total turnover.

- *Testbeds* are firms with a combination of large assets (0.817) and new products (0.817). Typically, these firms are producers trying to launch new species, such as domesticated cod, which used to be the major innovation strategy in the industry. Testbeds are not investing in R&D, they are not profitable, but they have lots of assets. Assets in this context are licenses issued from the regional authorities to produce new types of fish products at certain locations in the sea. The test production itself, it goes without saying, is a part of the development of the new product, and it is not profitable. This unprofitable production is financed through credits which are given by banks, with a guarantee in the license. This is why these firms are flashing the value of the license in their budgets, they need it to get the long term credits which is financing their product development efforts.
- *Opportunists/ strategic innovators: fodder***.** In aquaculture, production of fish fodder is differentiated from production of fish. They are producing fodder for the domestic market of exporters, and hence do not export themselves. Fodder is the key element on the cost side of aquaculture production, and it is crucial to the quality of the consumer market product. For human consumers of salmon, eating a fish which has been fed on a wrong diet could potentially be a health risk. The industry is struggling hard to keep a high health profile in the market. Salmon is good for your heart (and it does not contain too much poisonous components). Fodder is also crucial to texture, color, and taste of the product. Fodder is a key element in this strategy, and it is accordingly the link of the value chain where the profit of the sector ends. In this respect, the fodder industry is a *strategic innovator* in the sector, it supplies the size intensive companies with new products which make it possible to maintain a high quality and at the same time reduce the price. In this relation the size-intensive companies plays the role of adopters: they buy new types of fodder.

Together, this illustrates the highly diversified character of the sector. This diversification is the result of a process of co-evolution, where different strategies of innovation are followed by different types of firms. In this sector, there is also a co-optation between labs and testbeds and the large scale producers. Labs and testbeds are R&D departments and off shore laboratories often owned and financed by owners of large scale producers and profitable fodder companies. This finding is consistent with the idea presented in the introduction, that R&D intensive firms in a low-R&D intensive sector is likely to be innovating new processes, through adoption. In this case, the new process is commercialization of cod. The analysis also show that because of the differentiation between fodder and salmon production, this sector also have a success story which is in the direction of a strategic innovator, not an adapter. This contributed to the heterogeneity within the sector.

If this sector had been characterized by Schumpeter II type of firms, these things would have been integrated within the large scale producers, to secure private appropriation rights. These factors are instead the inventory of a disintegrated value chain, which makes up a wide variety of innovation strategies. We would like to see the existence of this disintegrated value chain as the result of rational decisions made by actors who knows a lot about the things they are doing.

Tentatively, an explanation may be outlined as follows.

To the large scale producers, competing on price and struggling to maximize productivity, there are several advantages in outsourcing experiments with new adaptations of technologies and new processes. When you are specializing in productivity enhancement, you should be extremely conservative in the choice of technology, and only adopt what is well proven and tested. In other words, standard production is not open for experimentation. Another advantage in outsourcing is the uncertainties of experiments. Labs and testbeds are likely to fail. If you are risking money, there are many advantages of isolating this risk to a separate firm, rather that including these losses in the bottom line of the large company.

This is why adaptation and adoption are two different strategies which are followed by different, co-evolving firms.

Opportunity-driven innovation: The case of business services

Another example in the other end of the scale has a high score on opportunity and a high sector based investment rate in R&D is business services

Table 3 Business Services: Rotated Component Matrix(a,b)

	Component		
	Labs	Global, scale intensive	Success stories
PROFITS	-,583	-,015	,542
ASSETS	-,021	-,059	,640
Total turnover in 2000	-,096	,798	-,002
Innovation (Share of new or improved products to market)	,264	,126	,547
Rate external R&D	,664	,001	,332
Rate internal R&D	,869	,000	-,011
Export share	,190	,423	,074
Turnover/ employee	-,078	,781	-,053

The interpretation of this output is the following three factors or main types of firm strategies in this sector

- *Labs* with a high level of R&D investment, a moderate level of innovation, and a dramatically negative rate of profits.
- *Global actors*, fighting in global markets with cost competition and a resulting low level of profits, compensated by a large turnover and low R&D investments.
- *Success stories* have a high level of profits (0.542). They also have a sophisticated internal knowledge base, with a high level of knowledge assets (+0.640), and they have a high level of innovation (+0.547), and fairly high investments in external R&D (+0.332).

The combined existence of labs and success stories explains the high score of this sector on opportunities. There is a substantial variation of profits, and this variation is motivating investments in laboratories, which are highly unprofitable on a short term basis.

In this case, a lab is likely to be a project with innovators, struggling to commercialize a new product, financing their journey through the credit market. On the other hand, there are actors within this sector who are following straight forward strategies of price competition, with low profitability combined with large scale service production.

Again, these heterogeneities of strategies within the same sector confirm our initial hypothesis.

Externalities created by opportunists

In turning to the cause-effect model of clustering (or exploitation based on knowledge externalities), the analysis is based on the following variables:

Opportunities.
At the level of sector, we see the standard deviation of profits within the sector as an operational way of measuring the visible opportunities of making money based on investments in product innovations. A large standard deviation is indicative of the existence of success stories, or firms who have been able to innovate in a successful way, thus creating high profits, combined with firms making deep and long-term R&D investments.

Sector rate of R&D. Regional based knowledge externalities.
Similarly, we assume that the regional R&D rate is indicative of proximity-based knowledge externalities, which enables firms located in the region to innovate with no or limited own R&D investments.

Here, we are referring to the 36 sectors of the Norwegian economy, when we apply a 2-digit level of NACE.

At the firm level we include innovation (New or improved products as share of total turnover) and R&D rate of the firm (R&D investments as share of turnover).

Assuming that causal relations or influences between variables may be empirically observed and measured as coefficients of correlation, we will expect that all these variables are positively correlated. Sectors with high opportunities are likely to have firms with high private investments in R&D. This is likely to result in high sector based R&D-rates, and high levels of innovation in firms. Similarly, we expect highly innovative sectors of be concentrated in highly innovative regions.

The model of causality, including the computed coefficients of correlation, is illustrated below. Actual correlations are illustrated below.

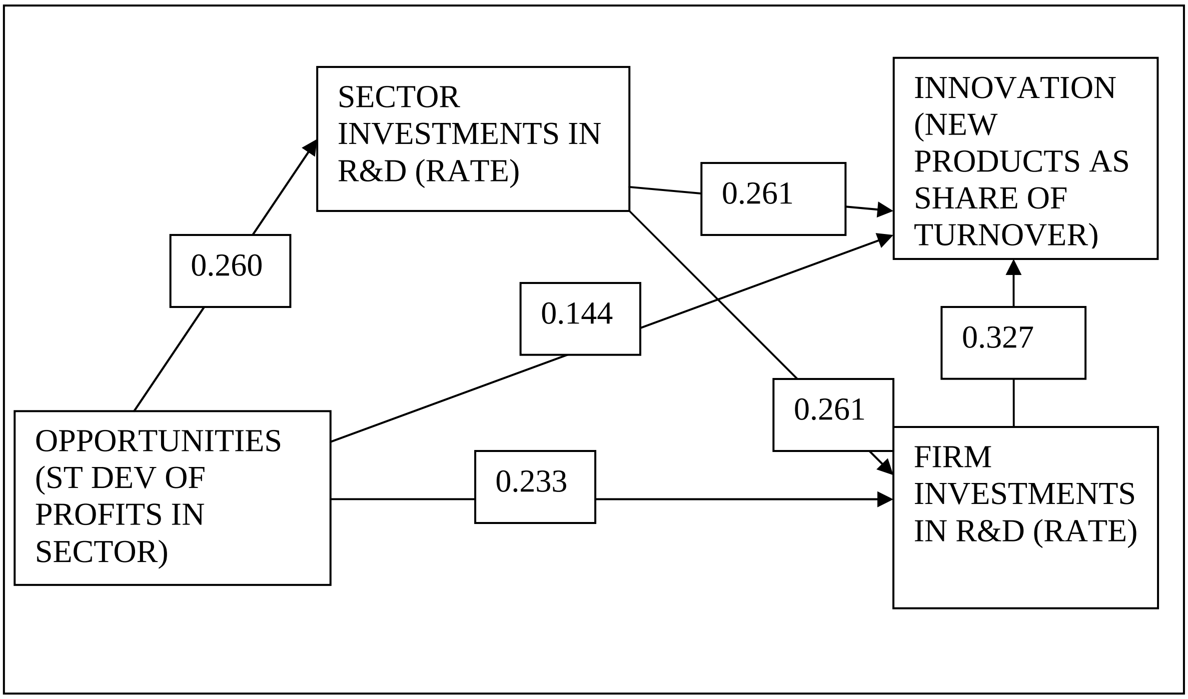

Figure 3: Causal model of the relation between opportunities, clustering and innovation

Impacts of clusters

A proper model with causality is based on time series data. In this example, we are only including data from one point in time (2000). The implication of this is that the analysis can only be seen as indicative of a possible cause-and-effect relationship. In looking at the impacts of sector R&D investment rates on innovation, we have a direct impact, and an indirect, through the firm R&D investment rate.

Table 4: Model of impacts of clusters on innovation.

Variable	Chain of causality	Impact
Sector	Direct effect	0.261
Sector	Indirect, through firm R&D investment (0.261*0.327)	0.085
Total	Cluster	0.346

Again, the coefficient *0.346* should only be seen as indicative of a positive causal relation between clustering and innovation.

Impacts of opportunities on innovation

Opportunities (standard deviations of profits) are positively correlated to sector level of R&D investments and regional level of R&D investments. Opportunities are also directly correlated to innovation in firms. If we look at the direct and indirect impacts of opportunities on innovation, we have the following main linkages

Table 5: Impact of opportunity on innovation

Variable	Chain of causality	Impact
Opportunity	Direct	0.144
Opportunity	Indirect, through Sectors	0.068
Opportunity	Indirect, through firm investments	0.076
Total		0.288

Again, this result should be seen as indicative only, as data are not time series. Given these reservations, the analysis suggests that there are positive causal impacts of opportunities, measured as variations in profitability if we take the intermediate effects of clusters (sectors) into consideration.

Paradoxes of knowledge appropriation

Malerba is right in emphasizing that there are important differences between sectors when it comes to innovation performance and investments in innovation. But both the European level results reported by MERIT as well as the analysis of Norwegian data presented in this paper suggest that there are variations of strategies of innovation *within* sectors as well. In this article, we have discussed innovation from two opposing perspectives of action under uncertainty, as *opportunism* or *adaptation*.

Opportunists are clustering together

The opportunist is sensitive to his environment. He is looking for external possibilities to make more money than others, and at the same time, he wants to reduce the associated uncertainties, and avoid making too large investments in R&D to innovate. Opportunist product innovation strategies aim at accumulating knowledge through R&D investments, and control this knowledge in a way which creates a super-profit.

The analysis confirms that opportunities, in terms of differences in profits in a sector, are positively correlated with the level of innovation. The correlation coefficient is *0.144*. Similarly, the direct impact of opportunities (profit differences) on firm investments in R&D is *0.233*.

At the same time, through his wish to appropriate knowledge, the opportunist is likely to generate knowledge externalities. Knowledge externalities is failed appropriation, in the sense that it consists of opportunities for other actors to steal, copy or in other ways make money on accumulation of knowledge paid by others. In looking *across sectors*, we found that high opportunities, measured as differences in profits, are also strongly positively correlated to high rates of R&D investments at the sector level. We referred to this agglomeration of private investments in R&D as the cluster. The total cluster impact on product innovation is estimated to *0.346***.** This should be compared to the impact of firm level R&D investments in innovation, which is *0.327*. Indeed, in controlling for the cluster impact through firm level R&D investments, the firm level is down to *0.242***.** The result suggests that the cluster of the firm is at least as important to product innovation as R&D investment decisions undertaken by the firm itself.

There are two main types of opportunity-driven innovations.

First, there are success stories or, what the MERIT group refers to as strategic innovators. Firms with well developed knowledge base combined with a high level of product innovation, a high level of R&D investments, a highly values knowledge base, and high profits. These firms are often seen as strategic innovators within their sectors, supplying the rest of the sector with innovations, or they play a similar role within the global networks where they operate. These firms are the long-term outputs of successful strategies of knowledge accumulation and appropriation through R&D investments.

Secondly, however, we have also identified another type of firm, in this paper referred to as laboratories. There firms often represents externalization of knowledge privatization. They may be test-beds or laboratories, innovating new products and processes. Labs are externalized R&D projects organized as firms.

In R&D intensive industries, these firms may be projects organized around radical ideas with a potential to offset and destroy the knowledge base of existing success stories. They correspond to the discussion of Schumpeter I by Malerba, with the difference that this competition occurs within the context of markets protected by high barriers of knowledge accumulation, and sophisticated mechanisms of knowledge appropriation. Their existence documents that knowledge appropriation strategies aiming at creating a single type of strategic innovator in a sector has failed, there still is external technological competition, challenging the existing success stories. In other cases, these firms are also real outsourced laboratories, emerging within the size intensive processing industries, which focus on adopting existing technologies.

Throwing out the opportunists: adaptors and adopters

According to Coase the hierarchy of the firm is set up to control and prevent opportunism. However, it is well known that opportunists may prevail inside organizations. As opportunists are pushing their own projects and ideas, and set aside routines and established rules, they are often regarded as disruptive to organizational efficiency and productivity. It is well known that efficient processing of standardized products often is possible through well-defined routines, adopting well-tested and approved technologies, developed by others. The institutionalized norms and incentive structures inside these organizations are likely to be supportive of efficiency.

Integrating rule-breaking opportunistic experimentation with new processing technologies into these organizations may entail several uncertainties. First, it may be seen as normatively disruptive to the company. Secondly, in processing of natural resources, like fish and petroleum, it is crucial to maintain a continuous flow of production. Experimentation may disrupt this continuity. It would accordingly result in a high level of uncertainty, potentially hurting the core function of the company. One way to solve this problem is to differentiate within processing sectors between adaptors and adopters.

Outsourcing of R&D-based product innovation in the processing sector itself makes it possible to share the extreme uncertainty which characterized these projects with several external investors and owners.

Outsourcing of knowledge appropriation

The analysis indicates that opportunism and adaptation creates a pool of innovative small firms out in the open, busy in accumulating and appropriating new knowledge. Two dynamics of outsourcing and co-evolution *inside sectors* are suggested

- opportunism-externalization and
- adaptation-adoption.

In addition, we have the relations between sectors

- opportunism-adoption
- opportunism-adaptation
- externalization-adoption
- externalization-adaptation

These dynamics suggest a deeper strategy, outsourcing of knowledge appropriation, or adoption - opportunism.

The alternative would be to internalize knowledge appropriation through investments in innovation into the firm. There are several good reasons why this option is selected away. These good reasons have to do with uncertainty management. Since the uncertainty of knowledge appropriation projects is extremely high, only firms enjoying formidable advantages of scale may be expected to turn out a reasonable rate of profit, following a strategy of knowledge accumulation and appropriation. The *externalization of knowledge privatization and new knowledge appropriation* reduces significantly the risks involved in radical innovation from the point of view of the large scale firms. Outsourcing of innovation makes new sources of funding possible. Investors supporting these projects may themselves have advantages of scale. Through investing in several projects, they will sooner or later hit one which may pay for the other losses. This reduces the incalculable risk in investments in innovation.

Outsourcing of innovation is private knowledge appropriation, within a context of ownership which is deliberately kept open for external investors. In this way, importantly, we are far away from the Schumpeter II type of large scale corporate actor innovating through investing in internal R&D. Corporate actors give up on appropriation, and in return they avoid the uncertainties these projects carry. What they instead achieve is a market of success stories they may buy themselves into. Once these entrepreneurial firms succeed, they become valuable targets of large scale investors, wanting to renew their knowledge base.

The paper seems to confirm the idea that there is a specialization of different roles in systems of innovation. Some firms are specializing in innovation whereas other firms are specializing in using innovations made by others. Between these opposite positions, there are various intermediaries. In innovation policy, one often finds the idea of policies promoting more innovation across all firms. This approach is often expressed through ideas of incremental change through "additionality" of policy instruments. If the division of labour in the system of innovation is working well, the focus should instead be on the core actors driving innovation in the system. These core actors are here seen as opportunists and adaptors, characterized as firms with high rates of R&D investments and high rates of innovation. The R&D investments of these firms should be subsidized, for three reasons:

1. These firms create new products and processes diffused to and adopted by others.
2. They also create knowledge externalities exploited by others
3. If they succeed, they are likely to become highly profitable, and accordingly create new opportunities (profit differences), which inspire other entrepreneurs to invest more private money in innovation

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Financial systems, open innovation and technological regimes: A theoretical discussion

Sverre J. Herstad

Abstract

There is an increasing research (Dahlander and Gann 2007, Laursen and Salter 2006, Cassiman and Veuglers 2006, Christensen et al 2005) and policy interest (OECD fortc,) in so-called "open" (Chesbrough 2003, 2005) innovation strategies. The novel contribution of this concept is primarily related to how it extends the notion of innovation systems to include processes of knowledge sourcing and commercialization occurring in the equity market (Chesbrough and Schwartz 2007, Waites and Dies 2007). This paper goes beyond Chesbroughs own analysis by discussing more detailed how growing private equity activity and the spread of the "shareholder value" logic of corporate control combine to produce a distinct institutional landscape which influences not only the possibilities for new enterprises to gain access to finance, but redefines the room for decision making, strategy and structure within large, publicly listed enterprises. This *institutional complementarity* (Milgrom and Roberts 1992) is representing an incentive against the long-term build-up of diverse internal capabilities and competencies, including but not limited to formal R&D, and a similar incentive towards basing corporate business renewal on acquiring new technologies readily available in the market – i.e. in the form of small, technology-based firms. This provides flexibility and responsiveness (Chesbrough and Teece 1996) complementary to high opportunity and high uncertainty Schumpeter Mark I regimes. On the other hand, the institutional foundation underlying this model may very well be constraining firms operating in regimes with lower rates of change and a heavier reliance on long-term development of dedicated knowledge, skills and assets. It also raises serious questions related to a possible, major decrease in outflows of knowledge spill-overs from industry, and its long-term impact on growth.

Introduction

Since the pioneering work of Freeman (1987) and Lundvall (1988), a firm understanding of the interactive and inter-organizational dynamics of innovation has been established. The primary research emphasis of different innovation system approaches has been on interaction within and across value chains, between actors holding knowledge, i.e. on user-producer relationships involving research institutes, suppliers, and customers; and their resulting knowledge diffusion and externalities. They remain limited in their ability to deal with issues such as strategy formulation in general and the link between innovation strategies and business models in particular. The task of including finance, corporate control and strategy in innovation system analysis remains (O'Sullivan 2005).

The "open innovation" concept of Henry Chesbrough (2003) has brought with it a supplementary focus on strategies for a) sourcing and b) commercializing technologies *outside* the realms of innovation system linkages as traditionally defined – i.e. ongoing knowledge-development within and in relationships between industrial actors, research institutes and universities. It introduces knowledge sourcing and commercialization *through equity and patent markets*, and argues – normatively - that firms should not attempt to develop themselves what can readily be acquired in the market for patents or corporate control. In advocating this, it uses corporate business models and organisational principles as its point of departure, and focuses heavily on business strategies maximizing *private* returns on R&D by minimizing of own production of spill-overs, and by utilising involuntary spill-overs and controlled spin-offs originating in the activities of other private or public actors.

The following focuses on what Chesbrough (2005) refer to as outside-in (acquisitions) and inside-out (controlled spin-outs) strategies of open innovation – strategies utilising the market for corporate control to source, commercialise and recombine technologies. Consequently, it leaves issues such as innovation search and collaboration aside, acknowledging that these are far better covered by mainstream innovation studies (see Dahlander and Gann 2007 for a critique of Chesbroughs broader open innovation concept).

Understanding open innovation

The concept of "closed innovation" is tightly linked to US industry and the large-scale in-house R&D labs which grew out from the particular institutional landscape of the 1950s and 1960s (see figure 1 - 3). Much used examples include Fairchild Semiconductors, AT&T and its Bell Laboratories, later to be inherited by Lucent Technologies, Xerox and IBM. Common to what Chesbrough (2003) claim was a distinct paradigm is the emphasis on building and protecting knowledge monopolies through explorative science; with very few and selective interfaces towards the external environment. This in turn rests on specific financial foundations *conducive* to long-term knowledge exploration and privatization, of which the massive public funding of industrial R&D in the US is but one component. First and foremost, it rests on sheltering from short-term financial performance and reporting constraints; and administrative autonomy to allocate corporate earnings towards cumulative and uncertain, internal knowledge development (Lazonick 2005). Closed innovation, i.e. a strong strategic emphasis on internal knowledge development, *'…favor internally generated resources because of their reluctance to reveal valuable information about their investment projects'* (to equity or bond markets); they favor equity financing over debt financing (because dept constrain liquidity independent of earnings), and debt financing through banks (where information is privatized) over open-market bonds (susceptible to the same public information problems as equity) (Bah and Dumontier 2001:675-676, 685, 690, Ruigrok and van Tulder 1995).

Second, it rest on the ability to develop, diffuse and *accumulate* firm specific knowledge and competencies in house. The inherent non-exclusive and often tacit nature of knowledge and competencies entail that such primarily move with the mobility of people; and are lost or gained through the ability to retain or attract personnel. The ability to develop, accumulate and appropriate rents from specialized knowledge development is therefore contingent on the ability of enterprises to develop internal labor markets (Lam 2000) through which excessive external turn-over of personnel (see O'Sullivan 2000) is avoided. According to Morgan (1995:11, in Asheim 1997:161) this *'…process of continuous improvement through interactive learning... presupposes a workforce that feels actively committed to the firm".* This, in turn, presupposes the commitment of the organisation to the individuals working within it (Lazonick 1994 in Asheim 2000:3). Low external mobility of personnel, in turn, for the same reason equals fewer uncontrolled spill-overs of knowledge and technology into the external environment, thus in effect plugging the most important pipeline for technology-based new-firm formation (Bhide 1996, 2000, Franco and Filson 2002, Lindholm-Dahlstrand 2001, Cassiman and Ueada 2004) and potentially leaving many ideas and technologies not commercialized nor in other ways made available for societal experimentation (Carlson and Eliasson 2002).

This model of *cumulative* internal knowledge development nurtured by mutual capital-labor commitment does not fit well with the current regime of rapid technological change and the potential for super profits; within particular ICTs; nor does it fit well with the now high rate of turnover of employees in US enterprises (Farber 2007, Wever 1995). And it fits particularly badly with the modern mode of corporate control developed in the US. Resulting human resource management principles, in turn, appear to contradict modern theories of organizational design and communication quite severely (Tourish and Hargie 2004); highlighting the emphasis put on *recombining* through factor markets rather than developing through organizational learning created by the system as a whole (see O'Sullivan 2000:43-52). Against this background, the strength of the US economy within certain high-tech sector poses key questions concerning the dynamics and limitations of this distinct "societal mode" of organizing industrial innovation (Boyer 2004).

Closed innovation constraints

Business strategies reflect the defined objectives of corporate enterprises; and hence – in the case of large publicly listed enterprises - the systems a) defining what these objectives are, and b) securing that corporate management is pursuing them (Kester 1996, Blair 1997). Understanding strategies in relation to institutional conditions thus imply understanding systems of corporate control. By the early 1970s, the US industrial landscape was dominated by large, diversified conglomerates managed under – and growing from – the principle of “retain and reinvest”. Rather than being distributed to the financial markets as dividends, corporate returns where used to fuel further diversification and growth – controlled by the “visible hand” of a managerial elite which at the time was untouchable from the point of view of stockholders. Returns, on the other hand, had through the 50s and 60s been secured by rapidly expanding consumption markets; and investments in R&D supported by the massive expansion of the role of federal government in industry after World War II (O’Sullivan 2000, Gordon 2003, Porter and Stern 1999)[1]. On top of this came antitrust legislation drawing the “make-or-buy” decision in the direction of either full vertical integration, or buy on a pure market basis. Managers where not only left to follow their own preferences for growth and diversification, but received strong institutional support for it. Within these enterprises the “first generation” (Lam 2000, Roussel et al 1991), or closed (Chesbrough 2005), technology-push R&D organization came to flourish.

During the 1970s this logic was challenged from two sides; the slow general economic growth and high inflation of the period, causing markets to stagnate, and new players, in particular Japan, applying modes of industrial organization deviating significantly from those found in the US (Hollingsworth 1991) and eating a larger and larger piece of the stagnating cake (Fligstein and Shin 2007, Lazonick and O’Sullivan 2000). According to Jensen (1993), the period starting in the early 1970s saw

> “…technological, political, regulatory, and economic forces … changing the worldwide economy in a fashion comparable to the changes experienced during the nineteenth century Industrial Revolution… corporate internal control systems… failed to deal effectively with these changes, especially slow growth and the requirement for exit”.

The first generation – closed – R&D model was challenged.

While managers preferred growth and diversification, shareholders demanded competitive valuation of, and liquidity in, their assets. This lacking alignment of preferences between owners and managers of productive assets was considered the main barrier to necessary structural change, and opened up for the new ideology of corporate management later to be known as the principle of “maximizing shareholder value” (Lazonick and O’Sullivan 2000, Fligstein 2001). Building on agency theory, it claimed that managers are “agents” hired to act on behalf of – and only on behalf of – shareholders. Shareholders, in turn, are in a unique position because they invest in the

[1] For instance, during the 1950s more than half of the revenues of IBMs domestic electronic data processing business stemmed from government programs.

development of productive assets, the returns from which are “residual”, i.e. they cannot by their very nature be contractually defined. To increase investments, and secure the optimal allocation of these investments between different activities, mechanisms must therefore be in place to make sure that corporate management – at any given point in time - act only to for the purpose of maximizing these residual returns. Institutional barriers to this, such as labor market frictions or employee co-determining rights, must consequently be removed[2].

With this the capital allocation function of the economy was taken out of conglomerate hierarchies, and embedded in external capital markets. Returns from invested capital was to be allocated to projects within enterprises only to the extent that the market did not signal, through relative stock appreciation or depreciation; that it *perceived* it could not make better use of it elsewhere. A system of *market co-ordination* was installed; relying heavily on entry-exit signals based on publicly available information and the formation of expectations. The success criteria of individual companies became not long-term survival, but short-term secondary market capitalization gains relative to benchmarks and expectations developed by investors kept at arms length; continuously scanning the market for other investment options. The carrot was management stock options; the stick was the real threats of hostile take-overs or legal action towards managers failing to meet their judicially defined obligations to take care of the short-term interests of minority shareholders.

This, in turn, paved the way for a new understanding of “professional” corporate management, which is still in the process of being spread far beyond the US by likely and unlikely agents ranging form institutional investors to governments. Predictability, transparency and public disclosure of information on the industry side; in itself constraining the information privatization conducive to closed innovation; is linked to portfolio diversification and trading based on market indicators and mathematical modeling at the owner/investor side. The lack of private knowledge exchanges and financial *commitment* between investors and US industrial enterprises is clearly visible in data comparing ownership concentration between the US and continental Europe (Barcha and Becht 2001, Allen and Gale (eds 2000). “Retain and reinvest was during the 1980s replaced by “distribute and downsize” (Lazonick and O’Sullivan 2000, O’Sullivan 2000) – the problem was solved with a knife. As of the early 1980s the large-firm sector share of US investments in research and development has fallen dramatically (figure 3). This occurred while overall intensity of business expenditures on research and development increased, and following from a distinct downturn in intensity during the 1970s (see figure 1).

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[2] The main mechanisms are performance-based management rewards, i.e. stock options, and the threat of a hostile take-over with consequent replacement of the management team if companies are underperforming.

The institutional foundation of US managerial control, and hence the "closed innovation" paradigm, eroded. This effectively eliminated the ability of incumbent enterprises to secure their own revenue streams through activity diversification. The management of risk was to be taken care of not by corporations but by the equity market, through investor portfolio rather than corporate activity diversification. Individual enterprises was to handle weakening markets through downsizing and buying less in the market for inputs, e.g. by adjusting the workforce size according to its contribution to revenues today or equity market expectations of the next quarter. And, according to Chesbrough (2003), they should enter new growth markets by acquiring actors already present in those markets, or holding technologies of knowledge relevant for these, rather than attempt entry based on internal development of new capabilities.

Fixed costs related to operating large R&D labs and accumulating broad, in-house competencies and skills by avoiding employee turnover (see O'Sullivan 2000:124) on IBM) don't fit very well with this (Herstad 2005). Rather, emphasis was put on retaining only "narrow and concentrated skill bases" (Lazonick and O'Sullivan 1998). Consequently, the way work is organized in the United States has undergone radical changes during the last 20 years. Job stability has declined for long-tenured workers, there has been a large increase in the use of contract and temporary workers (Dickens and Posen 2001), long-term employment has become much less common (Farber 2007). Hire-and-fire strategies create porous organizational boundaries; eases knowledge sourcing in the labor market, and provides the flexibility sought to protect short-term earnings. Farber (ibid:23) point out that whereas

> "…both the U.S. and Japan have been faced with similar global competitive pressures…firms in the U.S. have laid off workers, even those in long-term primary jobs. Reassignment to other jobs within firms has not been an important phenomenon".

According to Jensen (1989, 1993) downsize and distribute was necessary to boost structural change, and results where "as intended". Porter and Stern (1999) agree, and praise the willingness of the system to investment in radically new technologies. In Porter (ed) (1992) this understood as a tendency to *over-invest* in "*…discrete, stand-alone investments that generate leaps in position"*, and a preference against "*...complex patterns of complementary investments, whose returns can only be assessed as a group'* (Porter (ed) 1992:64) which translate into under-investments in cumulative learning. Porter and Stern (1999) do express serious concern about shift in corporate R&D away from long-term research projects, and towards short-term development, although they do not link this explicitly to corporate control. Chesbrough (2005:191) similarly points out how *"…industry can no longer be expected to underwrite the bulk of the costs of early-stage research"* and that the shift in strategic orientation means that the future will see *"…less basic research being conducted within corporate research laboratories"*.

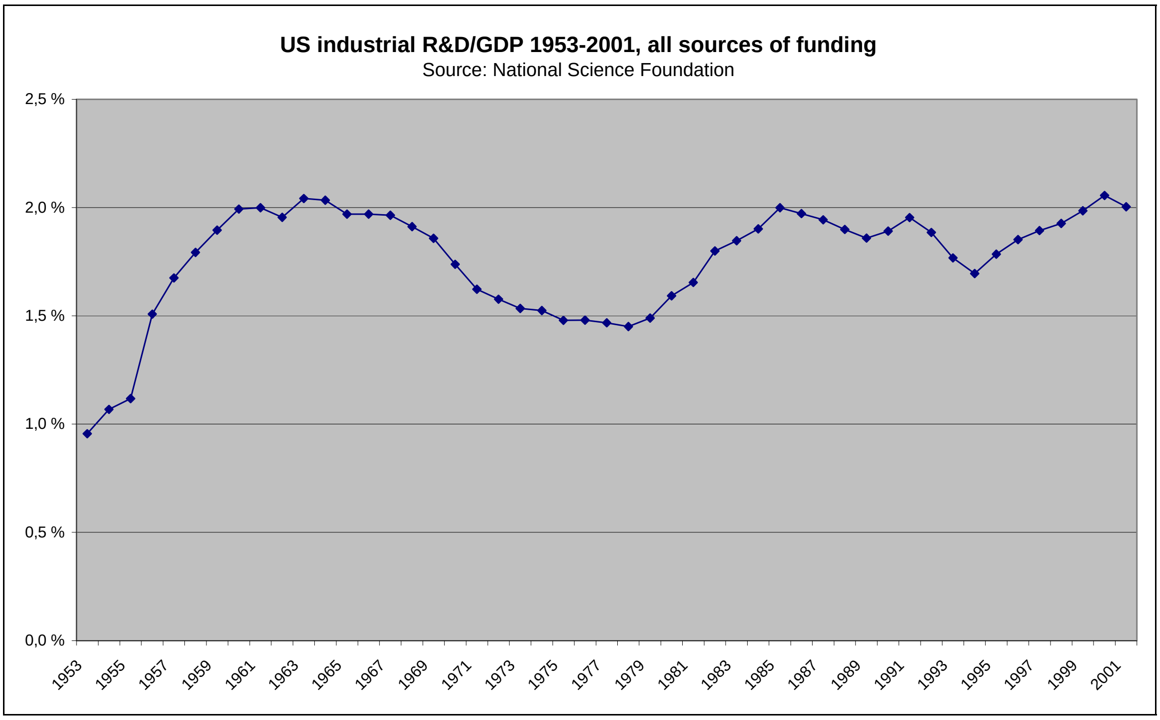

Figure 1: R&D performed by US industrial enterprises as percentage of GDP.

Last but not least, the focus on "shareholder value" is part and parcel of the transformation of corporate stock into a "currency" for the open innovation regime (Carpenter et al 2003). A strong, relative valuation of own stock meant that other enterprises can be acquired without any effect on cash reserves, cash flows or even debt. Combined, this means that the constraints imposed on running diverse long-term development projects within complex conglomerates are supplemented by the emergence of alternatives to such strategies; contingent, or course, on the success of the enterprise in boosting shareholder value to begin with. Focus on transparency, cost-effectiveness and core competencies meant appreciation of own stock; which in turn means increasing purchasing power in the acquisition market. The role of the market for corporate control in combining and recombining component technologies and knowledge becomes apparent.

We have now entered the realm of equity-based open innovation. For course, critical in *enabling* such strategies are vibrant markets of companies-to-be acquired;

i.e. technology and capabilities “held in stock”, awaiting recombination with other technologies or capabilities.

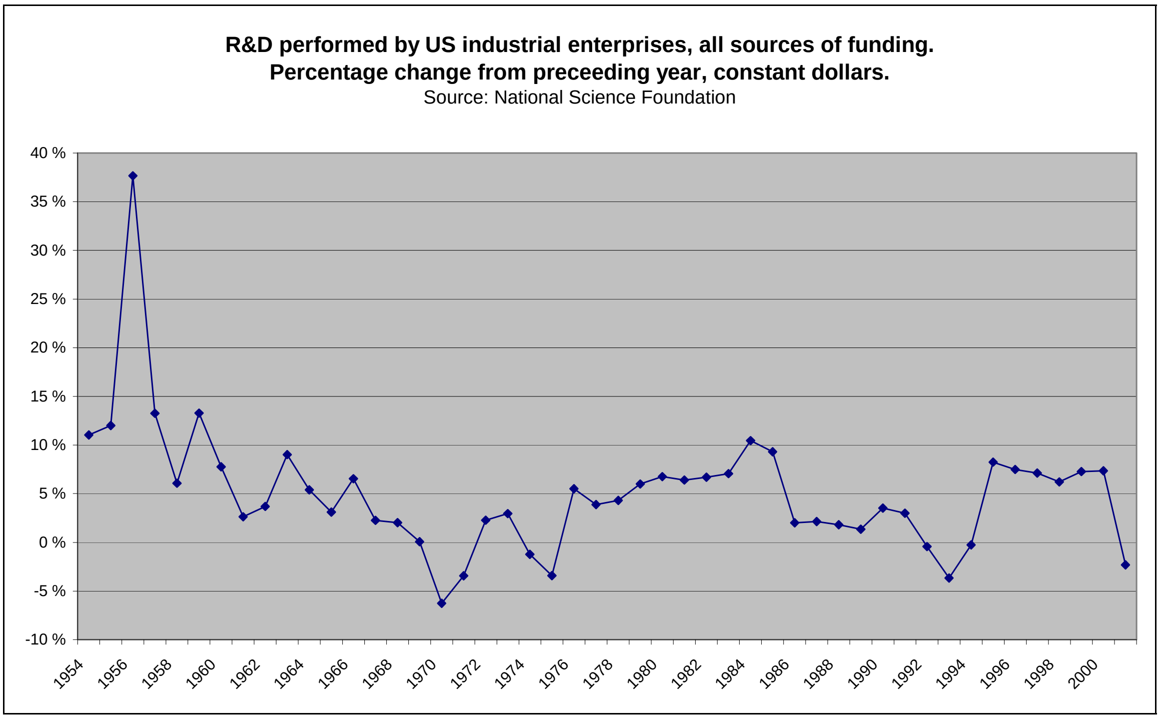

Figure 2: Growth rates, R&D performed by US industrial enterprises.

Open innovation opportunities

New players have entered the innovation funding game, paving the way for new models of innovation (Chesbrough 2003). These include pre-seed and seed investors, investing in the early high-uncertainty phases of a company lifecycle; venture capitalists investing in the border territory between uncertainty and risk, and last but not least expansion phase or buyout actors focusing e.g. on entry into underperforming public enterprises in need of a committed, large owner. These are nurtured by the availability of institutional or private capital seeking alternative high-risk, high-return investment opportunities with only medium-term requirements to commit and still unwilling to abandon the virtues of portfolio diversification. This capital is filtering out of private households in the form of pensions, insurance schemes and other non-realestate investments; and from established industry in the form of earnings not reinvested but distributed to the market for the purpose of seeking the “next big thing” (Perez 2002)[3]. It is also, importantly, comprised of

[3] Perez (2002) introduces the distinction between committed and knowledgeable industrial capital, and financial capital continuously scanning the market for new high-return, high-uncertainty business opportunities.

capital retained by incumbents who are seeking to resolve their need for technological renewal with capital market incentives against reinvesting revenues in intramural R&D. Equity investments in promising new firms offer either this transparency, or the possibility to isolate and conceal ventures on the side of core activities; and the option of returns through exit rather than returns through a revenue flow presupposing long-term commitment. All this stimulated, or course, by the long history of successful exits made by the US venture industry since its infancy in the late 1940s[4]; and resulting in the share of total R&D performed by large, publicly listed enterprises dropping (figure 3). By way of comparison, the Nordic countries developed their first private equity actors as late as during the 70s and early 80s; and saw this market collapse in the wake of the stock-market crash in 1987.

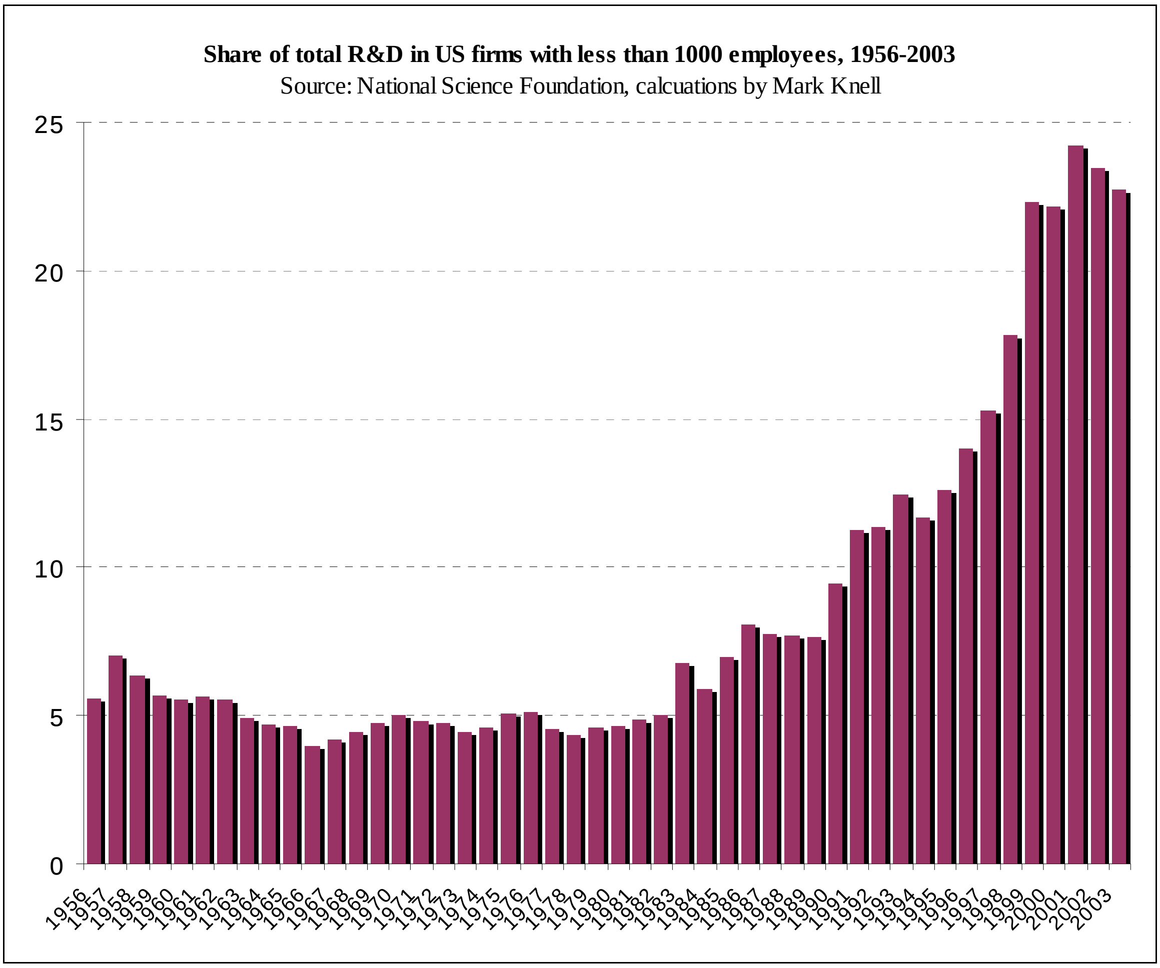

Figure 3: The increasing role of smaller R&D-performing enterprises in the US

[4] The first venture investment fund, American Research and Development, was established in 1946 by employees of Harvard and MIT, and members of the Boston investment community, motivated by the prospects of super profits stemming from government-funded technological development programs (O'Sullivan 2000:130-131).

Private equity capital serve three primary functions: It 1) for limited period of time shelter promising companies from the earnings requirements and reinvestment constraints of the organized capital markets, the funding constraints of individual or family ownership, and the collateral constraints related to bank funding. This enables development (seed capital) and refinement of new technologies (venture capital), and the consequent expansion into large-scale production and distribution (expansion phase capital). It also provides first aid for companies left for too long in the public market cold (buyout capital), and – presumably (Langeland 2003) – ensures a high level of integration (Lazonick 2005) between corporate management and investors with industry-specific competencies and knowledge. Ad-on acquisitions to combine with other technologies or capabilities are a part of this picture. But more importantly, it enable 2) the stable supply of trade-sale or acquisition candidates which is critical to outside-in open innovation strategies at the large-firm side of the equation. These are instrumental in creating a market for discrete, stand-alone technologies. Last but not least their existence 3) supply incumbents with a means to share risk or uncertainty related to (core or non-core) research and development programs, this as such activities can be located in separate companies and private equity invited in to share the risk; and a means of isolating and perhaps even "hiding" ventures on the side of core competencies. Equity investments don't depress operational returns.

Vibrant private equity activity does not emerge out of thin air, but is rather a product of the same capital market characteristics which imposes constraints on the incumbent side of the equation. A key determinant of venture capital investments is the market for exit (Jeng and Wells 2000), and consequently the overall secondary market capitalization and liquidity sought nurtured by "shareholder value" ideology. Black and Gilson (1998:258) argues that the potential for exit through an IPO is critical to the development of an active venture industry even given how exit predominantly occur through the sale of portfolio companies to other industrial companies.

The existence of a vibrant IPO market provides a guarantee for liquidity without assuming the existence of a trade-sale candidate at the desired time of exit. In addition this market enables performance-based compensation of managers and researchers without constraining liquidity, and gives the manager-entrepreneur a call option for regaining control at the time of the IPO. The importance of a viable exit market is confirmed by Jeng and Wells (2000), who find a significant, positive and robust relationship between IPO activity and venture investments even when controlling for the obvious possibility of reverse causality[5]. Highlighting the concept of complementarities these authors also find a significant positive relationship

[5] I.e. IPOs driven by venture activity, rather than driving venture activity.

between civil law legal systems and intensity of IPOs; and a significant *negative* relationship between labor market rigidities and seed capital investments. Controlling for cross-country fixed effects related to investment regulations, these also find that pension fund levels exert a positive influence on new funds raised. The authors also point out that whereas their models have a high explanatory power for later-stage venture investments, their explanatory power is much lower for the early-stage venture activity (Jeng and Wells 2000:285).

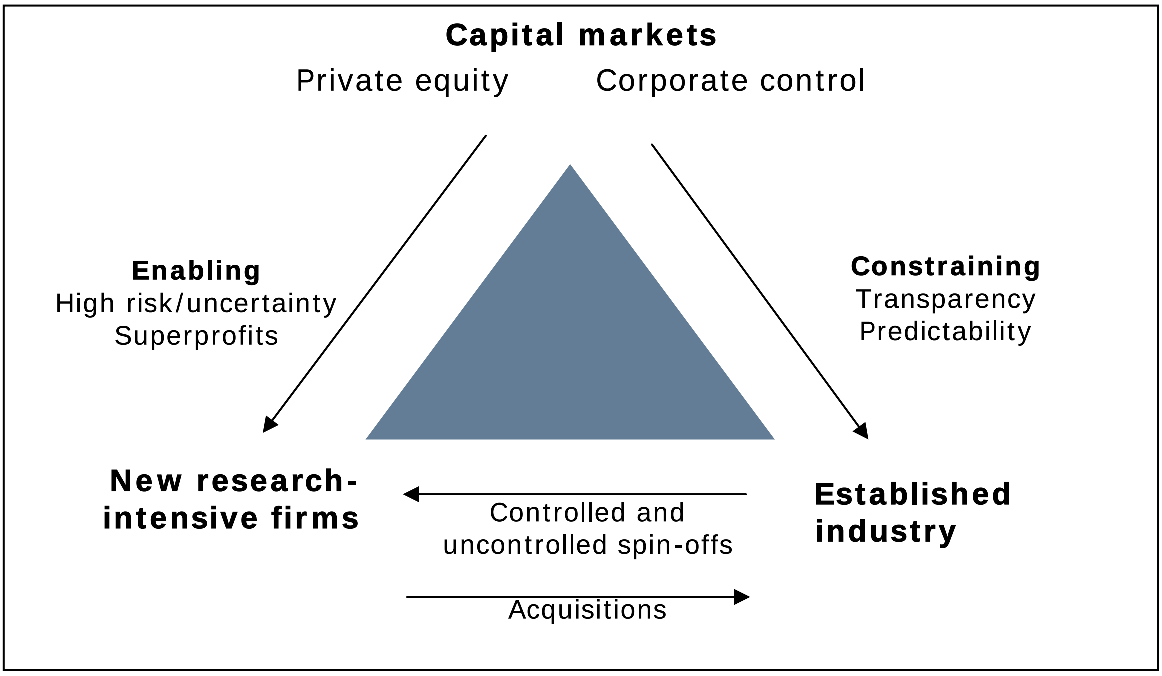

Figure 4: The interdependencies between capital markets, incumbents and new firm formation.

So, by way of concluding (see figure 4) private equity markets *enable* new strategies on the side of incumbents; but their activities *presuppose* a certain general financial set up, which in turn provides incentives (equity-based open innovation) and constraints (long-term cumulative, collective knowledge development) on incumbents; and impose their own set of constraints on portfolio companies. Seed and venture capitalists do not commit to financing the ongoing accumulation of organizational competencies; they finance stand-alone, discrete modular technology development projects for *a limited period of time;* i.e. limited to the predetermined lifespan of the fund, not to the commitment required by involved technologies. Venture-backed IPOs in the US economy are therefore, not surprisingly, highly concentrated around a limited number of sectors (see figure 6 below) with highly specific knowledge and opportunity (Malerba and Orsenigo 1993) conditions.

Divergent national systems

This indicates the importance of diversity in institutional configurations (Boyer 2004), and diversity between economic activities in their requirements for institutional support. The question is the extent to which US institutional preconditions for open innovation strategies are present in other economies. Figure 5 below shows equity market capitalization relative to GDP, a commonly used indicator for equity market size. In the US, this ratio was in 1995 231% of the ratio for EU15; decreasing to 175 % of EU15 in 2005. The largest economy in Europe, Germany, showed a ratio of only 46 % in 2005, compared to the US level of 144% the same year. This reflects the political, judicial and academic emphasis of the US on nurturing vibrant equity markets, of which the shareholder value mode of corporate control is part and parcel.

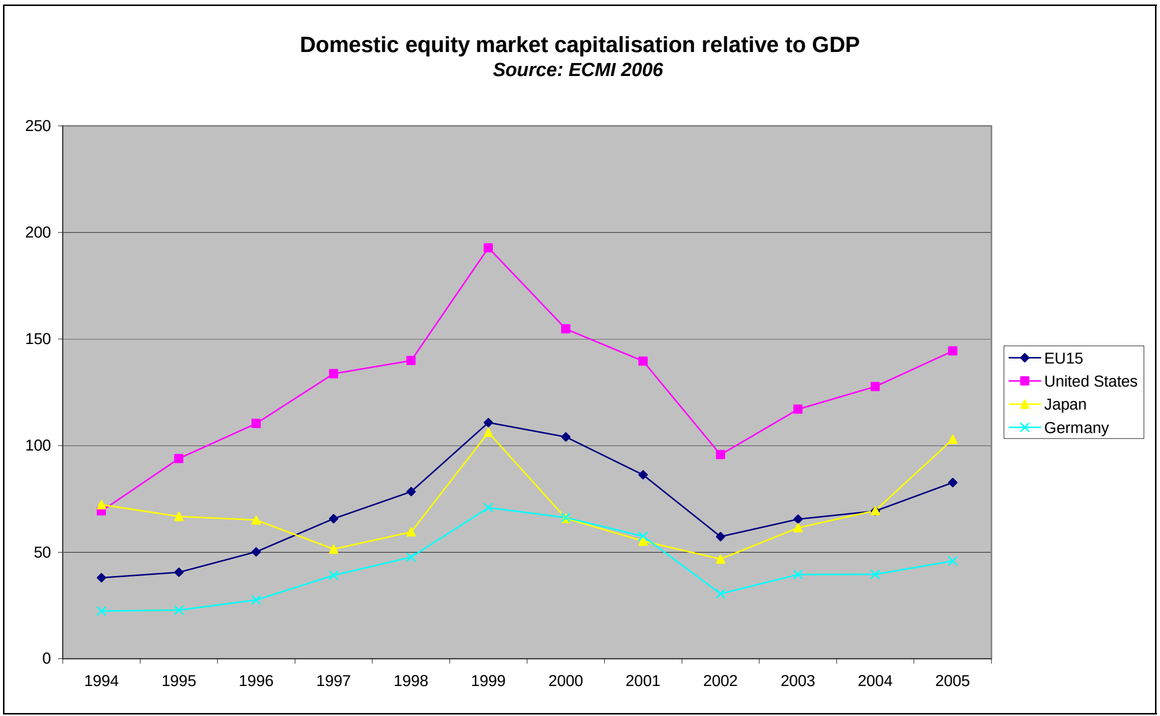

Figure 5: Divergent national equity markets

What it is does not reflect is differences in overall capital market development, but differences in the relative importance of bank, bond or debt financing respectively; and related differences in modes of control. Relatively even scores on (open market) bond financing; which combines certain aspects from equity and bank loan financing respectively; ad to highly divergent scores on bank assets and equity financing respectively and in sum reflect the role of non-market debt financing in the so-called *bank based systems* of continental Europe and Japan, versus the role of capital allocated through open bond or equity markets respectively in the US (see table 1). Bank financing come with privatized communication between funding source and enterprise management. As debt holders are not awarded residual returns, it also means far weaker incentives so seek high uncertainty – high super profit strategies - and it enables long-term cumulative knowledge development as it does not come with a demand for transparency or potential super profits. Last but not least, to the extent that banks are able to directly influence corporate strategies, the preference is strong towards retain and reinvest principles of governance, as this secures the role of specific enterprise, on which banks hold in-depth private information, as future profitable customer for debt.

Table 1: Size of bond markets, equity markets and bank assets relative to GPD. 2004. Source: ECMI (2006)

	Bond market	**Equity market**	**Bank assets**
EU15	141,7 %	59,9 %	236,8 %
US	168,8 %	116,1 %	72,7 %
Japan	168,6 %	61,6 %	146,6 %

In Germany, the shareholder value doctrine has, historically, been counteracted by concentrated ownership and large banks, placed in positions where they have been able to exert control over industry and act on their preferences towards securing long-term revenue flow from a stable portfolio of key debt customers (and consequently long-term but conservative investment strategies); in Japan by the dense pattern of cross-ownership within industrial groups providing much of the same function; in Sweden by the Wallenberg and Handelsbanken spheres controlling a large proportion of Swedish publicly listed companies. In this case, roles as equity holders have combined with roles as debt suppliers (i.e. through the Wallenberg-sphere control of Skandinaviska Enskilda Banken, and the Handelsbanken control of equity investor AB Industrivärden). Denmark shows an enduring and highly peculiar pattern of ownership by self-governed foundations, the sole purposes of which are to secure the long-term survival of controlled enterprises. The latter, in essence, is “retain and reinvest” taken to the extreme; and nobody would accuse the Danish economy of lacking industrial competitiveness. In the Nordic economies, the true outlier is Norway. The state and foreign institutional investors are the largest owner groups among listed companies, and the former has – perhaps paradoxically in itself but not against the background of the second largest owning group – been a key proponent of shareholder value ideology.

The link between the equity market in general and venture activity indicates that the strong seed and venture capital markets found in the US cannot readily be duplicated in such bank-based financial systems (see Becker and Hellmann 2003). European countries did develop secondary markets during the early 1980s, allowing pioneering European private equity funds to exit their investments and consequently triggering a wave of new fund raising (Gompers and Lerner 2004:347). These key exit markets collapsed after the 1987 stock market crash, and European private equity investors where unable to exit their investments (ibid: 345). A similar cycle reappeared after the collapse of Neuer Markt and other high-risk organized markets in the wake of the 2001 dotcom bubble collapse. According to Gompers and Lerner (ibid); the problem is related to the exit environment, and therefore to the financial system set-up as a whole.

In addition, many European economies such as the Nordic countries and Germany have employment protection legislation, high degrees of unionization and employee co-determining rights in corporate decision making which provide effective barriers against full-fledged shareholder value governance principles - arguably to the extent that this has slowed down necessary structural change in certain European economies. One should not downplay the role of this system in bringing about the new industrial landscape in the US, but simply keep in mind that the contemporary high-growth industries in the US are limited to a handful characterized by specific knowledge and opportunity conditions (Malerba and Orsenigo 1993), and that US industry as a whole continue to produce trade deficits no small, open economies such as those found in the Nordics would be able to endure.

Following Boyer (2004:25) it is reasonable to assume that “the impact of a given (institutional) characteristic can be unfavorable in one instance, beneficial in another, without this implying the existence of some “outliers”… actually, these “outliers” may well define coherent institutional configurations that remain unnoticed by theoreticians”. In other words, if and only if institutional deviations from the US “mobile capital – mobile labor” model translate into negative effects on long-term, overall economy performance do proponents of shareholder value have a case. Statistical studies of the relationship between long-term macro-economic growth and financial systems appear to reveal no such effects (Demirgüc-Kunt and Maksimovic 2002, Beck and Levine 2001) but rather, in accordance with Boyer (2004), find that ‘…overall financial development boost economic growth…having a bank-based or market-based system per se does not seem to matter much’ (Beck and Levine 2001). Others have found bank-based systems most conducive to long-term growth (Arestis et al 2001), only to later come up with findings in favor of equity-based systems (Arestis et al 2004:4). This has forced them to conclude that '…the apparent failure of large cross-country studies to identify a significant effect of financial structure on economic growth may be due to their failure to account sufficiently for cross-country heterogeneity' (ibid:15-16).

Carlin and Mayer (2003) conducted the first large-scale attempt at empirically dealing with *sectoral* heterogeneity, categorizing industries as debt-dependent, equity-dependent or skill-dependent. They found that *concentrated* equity ownership – rather than the dispersed equity ownership which is the functional outcome of shareholder value ideology – *"…is associated with faster growth of equity and skill-dependent industries and with higher R&D shares of equity-dependent industries'*. Committed equity financing may in part be associated with higher R&D intensity because *'…unlike concentrated shareholders in Sweden, dispersed, anonymous shareholders in the UK may be unable to commit to other stakeholders'* – including employees (Carlin and Mayer (2003:218)). This is, apparently, quite contradictory to the apparent success of the US in fostering high-tech industries. What it does indicate is that the equity-based systems represented by the latter have a superior ability to handle uncertainty, i.e. situations where risk cannot be handled through the commitment of intelligent industrial capital (Perez 2002, O'Sullivan 2005). This all points towards a need for understanding innovation strategies, and their institutional foundations, against the background of different industry characteristics.

Innovation models, financial markets and technological regimes

As knowledge bases and markets diverge significantly within[6] and across sectors; and the sectoral composition diverge across economies, so will required investments in knowledge and modes of innovation diverge across firms and societies. Ongoing experimentation and recombination in the interplay between incumbents, new technology based firms and venture capitalists presupposes distinct knowledge, cumulativeness, and opportunity and appropriablity conditions (Malerba and Orsenigo 1993). There must exist a steady outflow of knowledge which, within the investment horizon constraints of these actors, can be harnessed, recombined and developed into a marketable technology; opportunities to earn super profits from radical innovations must be high enough to defend exposure to high risk or fundamental uncertainty; and cumulativeness and complexity at the firm level must

[6] It is increasingly recognised that sectors defined statistically by their output or main areas of activity show a high degree of heterogeneity in innovation strategies across the actors who constitute them. Coherent groups of firms, defined by similar innovation strategies, are in turn argued by some (see Mariussen, this volume), to be found across sectors.

be low enough rule out that appropriation requires the build-up of broad, collective and specialized organizational competencies related to e.g. marketing, production and multi-disciplinary research (see Aglietta and Breton 2001).

As we have seen above, the existence of fundamental uncertainty, low cumulativeness at the organizational level and broad availability of knowledge externalities from either public or industrial research undermines the rationale for closed innovation models at the incumbent side of the equitation. If cumulativeness on the other hand exists at the industry or regional level; i.e. in the form of externalities, the scene is set for vibrant equity-based open innovation based on the existence of knowledge commons (Foray 2000) sown by externalities, fertilized by venture capitalists and harvested by incumbents. Last but not least, as a result of a low degree of so-called *strategic* protection following from complexity and tacitness (Cassiman and Veuglers 2006), it is a prerequisite that stand-alone technologies can be protected by formal IPR measures, i.e. patents; otherwise venture capitalists would be investing in hot air. A decade before Chesbroughs (2003) main publication, Malerba and Orsenigo referred to this as Schumpeter Mark I technological regimes; driven by entrepreneurs and characterized by "creative destruction".

But Schumpeter himself later discovered that these conditions are not general to industry or to the process of technological development. They are specific to either certain phases of a technology lifecycle or a technological paradigm (Perez 2002), or to certain technological regimes or "fields" of innovation (Mariussen, this volume). As Chesbrough (2003) himself readily admits, there is a vast difference between designing and operating nuclear power plants, and creating consumer software in a basement. When knowledge bases are cross-disciplinary, cross-functional, experience-based and co-specialized (Blair 1997); and development as well as appropriation require access to specialized equipment and complementary capabilities (Teece 2001); cumulativeness at the organizational level may still prevail and *necessitate* a far higher degree of internal, long-term knowledge development. These knowledge conditions (Cassiman and Veuglers 2006) may in turn severely dampens the outflow of externalities from private research, thus weakening those external knowledge commons upon which large-scale venture activity rests. As knowledge bases are specific to commercial activities rather than research disciplines, the outflow of public research knowledge which directly translate into innovations is very limited (Mowery and Sampat 2005), consequently further weakening the external knowledge common. Porters (ed) (1992) "*...complex patterns of complementary investments, whose returns can only be assessed as a group'* prevail; and are weakly complementary to venture capitalist demand for stand-alone, discrete technological development ventures.

In the latter case innovation is not *closed* but patterns and modes of open innovation are different. It may for instance be far tighter linked to interactive collaboration within "..*a more or less integrated structure, in the sense of strict linkages between elements'* (Nooteboom 2001:4) holding specialised, synthetic and analytic knowledge (see Smith 2000), and since there is less new firm formation and less venture capital seeking to invest, the prospects in the equity market is far more limited. The technological dynamism of combining and recombining found in the contemporary version of Schumpeter's Mark I model is replaced by sensitivity towards the closed innovation constraints of the shareholder value mode of control, and its related labor market flexibility. These conditions are referred to by Malerba and Orsenigo as Schumpeter Mark II "creative accumulation".

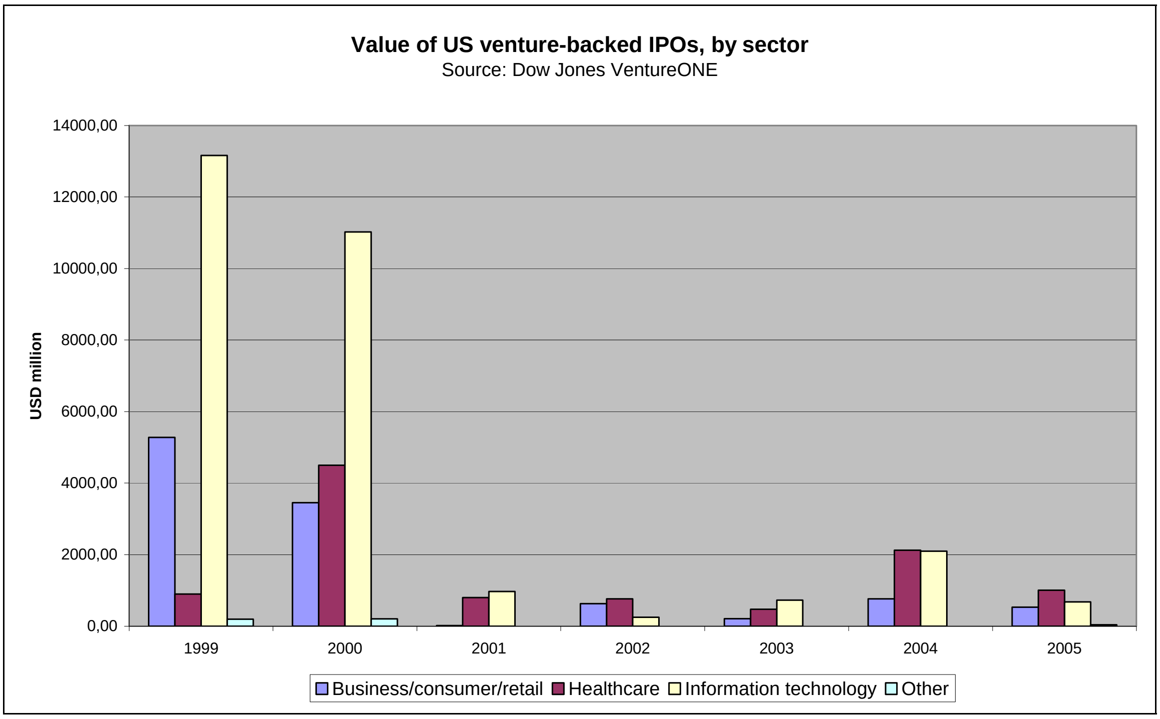

Figure 6: The sectoral composition of US venture-backed initial public offerings (IPO)

So now we see how innovation model goes hand in hand with both institutional contexts (national economies) and technological regime (sectors). A strong focus on technological renewal through outside-in open innovation presupposes a stable supply of technology-based companies available for acquisition. This, on the other hand presupposes first that other companies are applying strategies resulting in new firm formation, i.e. either uncontrolled spill-overs from "closed model" R&D efforts, or controlled spin-offs in the form of inside-out open innovation, then it presupposes the existence of a market within which such activities can be developed further, held in stock, recombined (ad-on acquisitions) and offered as self-sufficient packages to potential bidders. Private equity capital linked to a viable IPO market serves this function, but comes with the constraints of investment lifespan and preferences towards stand-alone, discrete – modular – ventures. Last but not least, it presupposes a final market for these activities, i.e. incumbents seeking external technological renewal. Thus, a context – an industry and/or a place - dominated by large conglomerates who rarely spin off activities and whose employees rarely leave to establish new technology based firms, provides little room for open innovation strategies. This situation is found in e.g. Japan or Germany, in part a result of weaker external labor mobility than found in the US; to a larger extent a result of the capital market mechanisms analyzed above. Similarly, when external mobility of knowledge workers in vibrant labor markets combine with a very strong corporate focus on core competencies, *and consequently* strategies of continuously redefining these by developing new business models and de-merging non-core activities, a larger room for applying open innovation strategies is established, with its own self-sustaining logic.

Discussion

The upside: Knowledge diffusion and experimentation

Outside-in open innovation strategies are powerful tools for business to use when coping with fundamental uncertainty, rapidly adjust to new market demands and act according to opportunities which will – following from specific knowledge conditions- emerge outside the corporate umbrella. Combined with inside-out strategies they are further powerful mechanisms for economies to secure diffusion and consequently experimental recombination of knowledge (Carlsson and Eliasson 2002). They stimulate and enable broad knowledge diffusion from corporate enterprises and research institutes and into the economy, only to then provide the foundation for continuous processes of combining and recombining this knowledge with what is already there. Private equity capitalists competing with each other, based on different experiences and competencies, secure broad and early market-based evaluation of new firms and technologies; whereas established firms focusing on technological renewal through acquiring such activities similarly secure broad evaluation at the last and critical to the economy stage of absorption. This Eliasson and Carlson (2002) refer to as the “experimentally organized economy”.

But according to Chesbrough (2005) these practices go hand in hand with stagnating of declining investments in private sector *research*; and with investment in development *“showing clear signs of becoming more short term”* (Porter 2005:8). This is not surprising, given that the “new innovation funders” of Chesbrough (2003) by their very nature build on harvesting from "knowledge commons" and are reluctant to commit to long-term cumulative and complex learning; and given how incumbents are prohibited by law and constrained by institutional mechanisms from themselves committing to such ventures.

The downside: Cumulative knowledge development and maintenance of knowledge commons

Problems therefore arises if the current regime of tightening corporate control and opportunities stemming from venture activity result in equity-based open innovation practices diffusion throughout industries as *substitutes* for internal knowledge development, as in several of Chesbroughs US (2005) cases (see also Carpenter et al 2003). If the technological renewal of incumbents is to depend on the availability of new technology based firms; and the emergence of such firms is dependent on knowledge development no longer occurring within the population of incumbents as a whole, could such practices be able to sustain industrial dynamics over time? Or rather, will technological and leadership again shift away from the US, as it did during the 70s and 80s, towards economies with institutional and political conditions conducive to other models of industrial innovation – such as e.g. Korea, Japan, Taiwan, China, or even some of the Nordic countries? Since open innovation, in essence is a model focused on short and medium term efficient allocation of existing productive resources, not a model for the long-term build-up of such, it is tempting to answer that the answer to the second question is yes.

When Chesbrough (2003:41) claims that the *"internally oriented, centralized approach to R&D has become obsolete"* as "*useful knowledge has become widespread"*, he may to a certain extent be right from the medium-term perspective of industry and private returns, although he does assume away – or rather neglect[7] - the role of tacit, industry-specific and co-specialization of knowledge (Blair 1997) and stretches his own cases far beyond their external validity. From the perspective of the economy as a whole and its social returns, he is making statements about efficient *allocation* of resources – knowledge – which is out there predominantly as a result of private companies "internally oriented approaches to R&D" (see Mariussen, this volume). The knowledge common (Foray 2000) of Silicon Valley did not materialize out of thin air; nor was it the result of somebody deciding to implement

[7] Chesbrough (2003, 2005) systematically treat "knowledge" as something homogenous; neglecting its wide variety of possible forms and thus varying degrees to which it is easily available externally – and where. Such perspectives were present in earlier work such as Chesbrough and Teece (1996), in which the authors warn against excessive reliance on outsourcing at the expense of the long-term build-up of internal capabilities, points to the role of conditions specific to individual firms and industries – and warn against "blindly following fads". This is the true ironic.

the latest business model in fashion. It was *constructed* in the interplay between public funding and private sector R&D, gaining its dynamics primarily from private sector large-scale production of externalities which then spilled out to be harnessed by the emerging venture capital industry.

Against this background it is not *ironic* (Chesbrough 2003:35) that e.g. Cisco outperformed Lucent Technologies (who had inherited the remains of famous Bell Laboratories after the break-up of AT&T) by substituting investments in R&D with investments in promising start-ups - established in part by former Lucent employees; it simply reveals the importance of knowledge spill-overs and heterogeneity – the co-existence of different actors and strategies - in driving industrial development. So does another example used by Chesbrough (2005), the closed innovation model applied by Fairchild Semiconductors versus the open model initially applied by its spin-off Intel; the former effectively producing research results in the form of patents and publications, the latter becoming a highly profiled commercial success without initially operating any internal R&D.

What is somewhat lost in the Chesbrough (2005) version of the story is how the business model of Intel built on – or presupposed – the existence of a completely different business model applied by Fairchilds. Without the closed innovation of Fairchilds, no open innovation at Intel. The external effects of Fairchilds did not stop with Intel; in fact, *"…so great was the outflow of people and ideas that the majority of semiconductor firms formed in Silicon Valley in the 1960s could trace their origins back to Fairchilds"* (Saxenian 1994:26, cited in O'Sullivan 2000). And where did Fairchilds have its roots? It was a spin-off from Shockley Semiconductor, established by the researcher who led the development of the transistor at Bell Laboratories. By building on externalities from closed innovation efforts, open innovation strategies presuppose the existence of actors operating large, internal R&D labs, consequently producing controlled spin-offs and not least uncontrolled spill-overs (se Mariussen, this volume).

A more specific problem with this model is its sensitivity towards business cycle fluctuations following from its last-instance dependence on equity market capitalization. When overall capitalization drops, markets for IPO dry up, venture funds and their investors find their capital locked up; investors become unwilling to ad additional capital and funds cannot realize capital gains and use these to fund new investments. *Seed* investors then become unable to exit their investments, and the venture cycle grinds to a halt (see figure 7). To this comes, of course, incumbents forced to downsize activities and fire staff to protect own revenues on behalf of shareholders, leading knowledge development in society as a whole to slow significantly down.

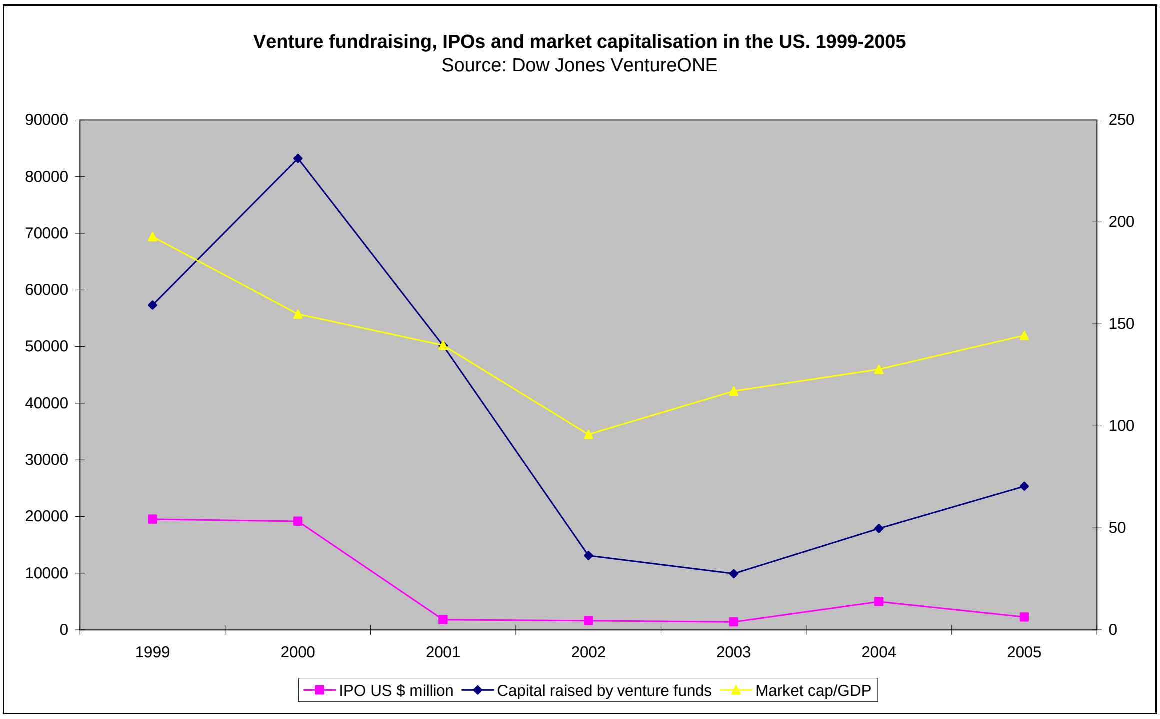

Figure 7: Venture fundraising, IPOs and market capitalization in the US. Source: Dow Jones VentureOne

Policy implications

Everybody cannot live of externalities from everybody else. As Mariussen argues in this volume, it is critical for the innovative performance of industry as a whole that some industrial actors, in each sector and/or region, are willing to sustain investments in intramural R&D. If not, less knowledge will be fed into the system as a whole. A key question which emerge out of this is to what extent university or other forms of public research, linked to systematic commercialization efforts on the spin-off side, and private equity funding on immediate absorption and commercialization side, can substitute corporate R&D. The contemporary role of university or other public research in the private equity deal-flow tends to suggest no (Naas et al 1998, Herstad and Naas 2007, EVCA 2005, EVCA fortc, Cassiman and Ueda 2004), so does the general econometric work on the role of spill-overs from R&D (see Griliches 1998) – and recent empirical work on e.g. the Norwegian (Mariussen, this volume) and Dutch (Frenken et al 2002) economies.

It is also known that the direct sourcing of technologies from university research historically has occurred only within a limited number of sectors, primarily chemicals and pharmaceuticals (Mowery and Sampat 2005) – industries operating based on knowledge bases (see Asheim and Gertler 2005) directly fuelled by scientific progress. Services and creative industries are but two recent examples of sectors growing rapidly based on knowledge bases deviating significantly from those who can be fed directly by knowledge developed through university research. This indicates that there is little reason to believe that future industrial development and growth can be sustained if – as Chesbrough (2005) advices – it is to be based on public research and commercialization efforts *alone*.

In addition to the observed importance of industrial R&D as source of knowledge spill-overs, there are two more specific reasons why public research cannot substitute. First, the idea of large-scale industrial renewal driven mainly by commercialization of university research neglects complexity and heterogeneity in industrial knowledge bases, i.e. the need, created by clients and product markets, to build complex, cross-disciplinary and cross-functional knowledge bases – and it neglects how the existence of such *private sector* knowledge bases, or "competence blocks" in the words of Carlsson and Eliasson 2002, may be a prerequisite for the commercial value of university research results to be harnessed.

Second, it neglects the fact that private sector R&D and broader knowledge development *is embedded within a commercial environment* to begin with; thus substantially increasing the likelihood that key researchers hold the commercial understanding, practical knowledge and willingness necessary to "sell" ideas as commercial projects in-house, or successfully establish new firms. And significantly increasing the likelihood of access to and absorption of knowledge not available from the academic community, e.g. the experience-based knowledge of suppliers, operators or customers. Linkages to such knowledge sources are far more likely to already "be there" or easily established, hence decreasing search, selection and networking costs. To this come the prospects of support from knowledgeable *corporate* venture capital able to commit far longer than independent venture capital is high and increasing. This does not downplay the fundamental role of universities and public research institutions in long-term knowledge exploration and diffusion, but accepts the limitations inherent in such processes being *disciplinary* in nature and occurring de-coupled from the commercial context within which it is to enter and draw additional knowledge. The current emphasis on, and diverse experiences with, the creation of "technology transfer offices" at universities throughout Europe, modeled on US experiences, is symptomatic of this problem.

Overall this points towards a need to embed innovation policy in a true system understanding of industrial dynamics, which is contextualized against the background of specific economies with their respective institutional set-ups (labor and capital markets, industrial relations) and the industrial specializations – with their different regime characteristics – which have developed within them. In the "era of open innovation" (Chesbrough 2003), or rather in economies with well developed open innovation practices, what should be supported massively by public policy is perhaps the industry *intramural* R&D efforts which have been – and from all existing evidence will and should remain – key in sustaining the competitiveness of existing industries and the flow of externalities into society as a basis for new ones (see Mariussen, this volume, for empirical evidence from Norway). Only after this flow is secured may industrial development be driven by private equity capital.

This, in turn, also means that economies where knowledge is excessively contained within corporate R&D labs or universities should consider measures aimed at increasing controlled or uncontrolled spill-overs; and perhaps even increasing the absorptive capacity of the economy as a whole. But this is all context dependent, as the overall objective will have to be to establish the right mix of knowledge exploration and diffusion, in the private as well as public sector. Different corporate strategies presuppose the co-existence of each other, and it is in the interface between complementary strategies of exploration, diffusion and experimentation we find technological dynamics at the level of economies.

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‘Nordic design’ in innovation policy: Embedding Collaborative Social Relations in Developmental Constellations. Lessons from a case study[8]

Finn Ørstavik

Abstract

More than ever before, policy making in modern countries is based on the idea that innovation can provide solutions to major societal challenges, and that science is an essential tool in order to generate useful innovations. The linear model thinking about the relationship between science and industry takes for granted that science is the ultimate source of not only invention, but also of innovation, and that the support for autonomous and unfettered science is the best guarantee for genuine progress. In this paper we point out how a systemic approach differs from linear model thinking, and why systems thinking is more appropriate when we try to develop policies and institutions that effectively can couple scientific efforts and efforts to develop value creation activities (in terms of goods production as well as public and private service provisioning). We argue that the systemic approach was inherent in pioneering years of building a new institutional system of innovation in Norway after World War II, and that this approach was forced on the defensive by a gradual return to linear model ideology. This development may have peaked with the establishment of a singular research council in 1993. The establishment of a new fund for industrial research some years later marked an interesting return to the systems paradigm. Today, in a time when the overall institutional system of innovation in Norway is under debate and is undergoing important changes, it is all the more important to take into consideration the new fund’s logic, the preconditions for its existence, and its effectiveness.

Introduction

With the seemingly infinite potentials of exploiting science and technology in human endeavours, politicians have increasingly come to focus on how progress can be achieved by developing scientific knowledge. After World War II, in the era marked by socialist and democrat political influence in many countries, modernity became associated with a rationalized and knowledge based society. Science and technology was believed to make the fundamental difference, distinguishing present society from primitive societies, and potentially also from societies subjected to the irrationalities of unrestrained capitalism.

Making society in general more science based, poses a dual challenge: First, it is a question how to make non-scientists become more able to access and employ scientific knowledge. Second, the question is what can be done to make men and

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[8] The paper is based on a case study of *Fiskeri- og havbruksnæringens forskningsfond*, undertaken in 2006, and on theoretical work carried out with support from the NIFU STEP strategic institute program on innovation, financed by the Norwegian Research Council in 2006 and 2007. I gratefully acknowledge this support, which gave me the opportunity to further develop theoretical ideas that I have been working with for a long time. I also thank my colleagues Olav Spilling and Sverre Herstad for valuable suggestions and critical comments of earlier versions of this text.

women of science interested in dealing with societal needs by way of their own research efforts. In practice, these issues have often been reduced to the following two imperatives: Improving the absorptive capacity of non-scientists, and providing scientists with adequate resources and autonomy, to enable them to carry out the research they themselves see as pertinent.

This is the essence of what we call the “linear model” thinking about the relationship between science and productive activities in society (be it in business or in public service provision). This way of thinking has been very important also in Norway in the post-World War II period, but it has not ruled the ground alone. The objective of the present paper is to show how “linear thinking” has paved the way for a specific structuring of the Norwegian institutional system of innovation, and furthermore, to direct attention to a quite recent institutional innovation that represents an alternative approach, but also, in a certain sense, a return to the past.

Making our argument, we in the following start out with a brief detour into innovation theory. We deal with some of the complexities of coupling science and research, technology and business activities. The focus is set upon the opposition between a linear conceptualization of the science-technology-industry relationship and another, systemic approach. We pay specific attention to implicit assumptions about social relations, and show how the “linear model” implicitly builds on specific ideas about such relations, in a way that the systemic approach does not.

After this theoretical discussion, we turn our attention towards policy. We characterize the institutional system of innovation as it has been developed in Norway, through the interplay of major policy areas such as national economy, industry, energy, defence, etc. We explain how the innovation system was structured at the outset, with a military research establishment (the Norwegian Defence Research Establishment; NDRE), and a civilian research council (the Royal Norwegian Council for Scientific and Industrial Research; NTNF) as the two main pillars. We point out how systems thinking came to influence this original institutional set-up, and go on to contrast this with later developments. We highlight how the establishment of a singular research council in 1993, the Research Council of Norway (RCN), completed a transformation of the institutional system of innovation, and argue that the new system distributed authority and power among participants in innovation oriented, publically funded research and development efforts in another way than the system had done earlier.

Was there “a baby in the bathwater” that ought not to have been thrown out when the earlier system was dismantled? At the time, there were dire warnings about merging the financing of innovation oriented industrial research activities with the other financing schemes of the more academically oriented research councils into the

RCN. In spite of this, and even though the new research council would develop it's own thematic and strategic programmes, the principle of shaping funding schemes and programmes on the basis of industrial sectors and divisions was abandoned. Moreover, the 'modus operandi' that had been established in the NTNF, in which decisions were taken in a business-like and decentralized manner, could not remain the same in the RCN, where formal procedures, impartiality, and peer review based evaluation of scientific merit formed basic elements of the new order.

More than 50 years after the establishing of the first national research council, the NTNF, and nearly 10 years after the council's demise, another national research financing agency was established that resembled its predecessor NTNF in some significant ways. As will be described in more detail later, the industrial research and development fund that a small group of politicians were instrumental in creating at the turn of the millennium, was set up as a strategic agency specifically for the fisheries and aquaculture industry. Its mission was to create industrial development and growth by way of strategic funding of scientific research and technological development. The fund was meant to achieve this goal by establishing close collaborative relations between businessmen, technologists and scientists. In spite of the heterogeneity of their members, also in terms culture and social status, these developmental constellations were to realize genuine interactive learning.

In a quite peculiar way, then, the Post War approach to funding of collaborative R&D embodied by the NTNF was to survive in the sector of fisheries and aquaculture. The Ministry of fisheries and coastal affairs in this way became the home of an institution which had as its primary focus the promoting of industrial development by way of strategic and applied research and development (R&D). We believe there are important lessons to be learnt from the fund and the reasons for its establishment. Hence, we analyze both the *raison d'être* and the *modus operandi* of the fund.

In the concluding section, we use the results of the earlier theoretical and empirical analysis to draw conclusions concerning Norwegian innovation policy and the overall structuring of the institutional system for innovation in Norway. We point out how the new research fund has been built on an important insight regarding the nature of innovation efforts. We conclude that the interaction of firms and research groups within well defined industry specialties can be said to reflect a 'Nordic design' in innovation policy, as it builds on egalitarian principles and reflects a kind of small-firm industrial organisation that may be specific for Nordic countries.

The non-hierarchical systems approach to innovation

A key point that has been made repeatedly in the literature on innovation is that research and development in itself does neither result in business success, industrial development, nor economic growth. Scientific and technological efforts have to be coupled with specific value creation activities in productive ways (Lundvall 1992; Edquist 1997; Malerba 2004). That is to say, novelty must be developed in a context where scientific interests are balanced with practically oriented strategic and economic interests (Acha, Marsili et al. 2004), and where efforts to change business activities at one point in a value chain are matched by changes along other points in the same value chain.

Kaufmann and Tödtling (2001) argue that innovation systems analysis should exploit a more subtle systems concept and focus on self-organisation. Both Van de Ven's process perspective on innovation (Van de Ven, Angle et al. 1989; Van de Ven, Polley et al. 1999) and social constructivist ideas about innovation as the construction of heterogeneous networks (Rip, Callon et al. 1986; Latour 1987; Bijker, Hughes et al. 1989; Bijker and Law 1992) can be used for this purpose. Also Niklas Luhmann's idea that communication is the constituting element of social systems may be employed, so that innovation systems be defined as

> "that web of communication emanating from and relevant for an emerging developmental constellation of heterogeneous actors making efforts to realize a set of related ideas about a possible future state of affairs." (Orstavik 2008).

As such, innovation systems bridge micro and macro phenomena, constituting arenas for the structuration processes where reflexivity and 'structuration' – in Giddens' sense – are crucial aspects of the dynamics (Giddens 1979; Giddens 1984). In this way, it also becomes obvious that innovation systems are not "clockworks" in which movement of parts are mechanically conditioned, predictable and available for exact measurements.

Innovation happens in developmental constellations in which action to some extent is coordinated, but not programmed in detail (Van de Ven, Angle et al. 1989; Breschi and Malerba 1997; Van de Ven, Polley et al. 1999; Malerba 2002; Acha, Marsili et al. 2004; Malerba 2004). The 'resultant force' of individual efforts will have a certain magnitude and a direction, but will be composed of forces acting in diverse fields and in multiple directions. For example, when we focus on innovation in business, the intended aggregate effect over time is change in value creation processes and their results (product and process innovation). Changes are co-produced along value chains (Hippel 1988; Hippel 2005), and are diverse at different places, but functionally complementary. The set of significant actors is heterogeneous and marked by significant complementarities (Levinthal 2000).

In the literature on innovation systems, whether the focus is set on sectoral systems (Malerba 2004; Breschi and Malerba 2005), regional systems (Cooke 2002; Cooke, Heidenreich et al. 2004) or national systems (Freeman 1987; Lundvall 1992; Nelson 1993; Freeman 1995; Lundvall 1999; Lundvall, Johnson et al. 2002; Nelson and Nelson 2002), authors fundamentally conceive of innovation systems in a structuralist manner; as institutional and organizational structures influencing the actions of individuals and firms. In contrast to this, unless we in this paper explicitly refer to *institutional systems of innovation*, we define innovation systems differently. They are not institutional or organizational structures, nor are they simply aggregates of individual action.[9] Rather, systems of innovation are webs of communication evolving around complexes of actions which are goal directed and reflexively coordinated. Coordination is not in principle hierarchical nor monolithic, but distributed and interactive. Strictly speaking, the innovation systems we are interested in are *self-organized*[10] webs of communication - related to ongoing activities to produce a desired future state of affairs.[11]

A specific issue that deserves closer scrutiny is the balance of power between actors playing their respective roles in innovation systems. How are productive developmental constellations composed? In what way and by what kind of mechanisms can sufficient coordination be achieved? What is the nature of effective use of power in the system of innovation? How is the distribution of power related to the effectiveness of innovation efforts, and in what way is it related to the *direction* and the *content* of the efforts? And of specific interest in this paper: How can and should policies and policy tools reflect social relations and power in their design and their operations?

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[9] In this text, we do not distinguish organizations and institutions, in the way proposed by Edquist. For example, in line with everyday language, we may use the terms *government agencies* and *public institutions* to denote the same *organizations.* We are aware, however, that the term *institutions* also can be used to denote normative structures and conventions.

[10] We here try to use the term self-organisation in the same sense as Luhmann, as Autopoiesis. That the system of communication is self-organized does not imply that there are no structural constraints on what happens, but that the intelligence in this system is distributed, and that no single actor can control the specific outcome of interactions.

[11] We use the term innovation system rather than innovation process, to underline that we are not simply interested in ‘development histories’, or the unfolding of events that are causally and chronologically related. We are concerned with understanding in what way innovation happens under varying conditions, in diverse countries, regions, sectors, etc. How can systemic relations be understood in relation to the specific conditions that an evolving innovation system are faced with? Institutions on the national and sectoral level may be important, as may technological specificities, industry sector conditions, etc. However, the analytical observation point, the ‘unit of analysis’ is the innovation system itself.

In the developmental constellation underlying an innovation system, member organisations may not necessarily belong to the same value chain, and will often encompass other types of entities than commercial firms. They may be firms that are outside the value chain, or other types of organisations, such as research institutes, nongovernmental organisations, government agencies, etc. These actors have resources that make them into useful resources in the innovation effort. However, they usually have widely different overall competences, production activities and missions.

Faced with this kind of heterogeneity, the questions concerning coordination and the nature of social relations in a developmental constellation become critical. Communication across organisational borders of firms in diverse parts of production system (along the value chain) will often be problematic, as firms' 'realities' and immediate goals are different.[12] For actors belonging to entirely difference sectors of society, this challenge is still greater. Even the long term goals of each partner may not be consistent with the goal of promoting the development of valuecreation activities of the commercial firms in the developmental constellation, and may be only loosely related to the strengthening of the value chain that the firms are playing a part in. How, then, should adequate coordination be achieved? Who are to decide on project goals and development strategies? How should relations between actors be constructed, and how should disputes be settled? How can the necessary element self-organization in the innovation system be achieved?

The issue we here touch upon, and which obviously has been subjected to a lot of research since Burns and Stalker in 1961 first published their landmark contribution to the study of management of innovation (Burns and Stalker 1995), is crucial not only for innovators playing a role and investing resources in innovation. It is also of great importance to scientists and research institutions playing their part in such efforts. And it is a very significant issue for policy makers and government agencies endowed with responsibilities to promote science and to foster commercially successful innovation.

The science-bias in the institutional system of innovation in Norway

Our theoretical argument so far has served to substantiate the following claims:

- In order to achieve innovation – or in more general terms, social and economic change – basic science alone is not enough to 'deliver the goods'.

[12] For example, a bakery and a mill may be highly dependant on each other, but may still have completely different production systems and core competencies. Developing a new baked product may presuppose changes in the way flour is produced, and although changes in the bakery and in the flour producer's production systems are needed, change efforts may be very different and may depend on learning in interaction in completely different contexts.

- It is only in the constructive interplay of diverse types of actors and activities that successful innovation can be achieved.
- This interplay, and the necessary coordination and consistency of actions, is not easy to realize, at is depends on communication and matching of ideas and interests of a heterogeneous set of actors.

Scientists in basic research, and in almost all research carried out with the *primary objective* of contributing to the stock of scientific knowledge, are usually quite detached from specific production systems for goods and services. And scientists will be subjected to different framework conditions than people both in commercial firms and in public service provision organisations. Both availability of resources, time horizon in demands for producing tangible results, as well as basic success criteria tend to be different. All this may lead the research institution (or even a specialized corporate research group) to play an auxiliary role with respect to the activities in the commercial operations of firms (or service providing organizations) in a developmental constellation.

For Norwegian policy makers, a most important lesson from the research and development experience of the war was that scientists and engineers – even in a class society such as the British – under the duress of war had been able to work together effectively, coupling practical engineering knowledge of technology with advanced academic science. When Norwegian science was to rise from the ashes of war, this kind of collaboration was considered to be essential (Ørstavik 1994). The question how it could be realized was clearly not approached as a theme for academic research. This was seen as a practical and political problem in which institutionbuilding and technological systembuilding became intertwined aspects. In the defence sector, the Norwegian Defence Research Establishment (NDRE) since its establishment in 1945 came to form a key bridgehead, bringing the US and Norway closer together in military, technological and scientific matters (Ørstavik 1989). In the civilian sphere, the NTNF (*Norges Teknisk Naturvitenskapelige Forskningsråd; the Royal Norwegian Council for Scientific and Industrial Research)* was established in 1946 with the explicit aim of promoting scientific research and "to ensure that the results obtained were used to the benefit of the industries of the country" (Barlaup 1956).

In this way, both the military and the civilian sector received important inputs from people having taken part in the war research effort. The coupling of industrial and scientific concerns was essential, and *organization* and *institution building* were recognized as crucial issues. This was the case for people inside and close to both the NDRE and the NTNF. Both institutions were eager to promote growth, but it was the NTNF that was in a position to devote significant national resources to a systematic expansion of the general research system, as well as to promoting the development of more science based civilian industry. Put in modern terms, NTNF saw it as its key task to contribute to the growth of a *national system of innovation* in Norway. The council became instrumental in promoting the emergence of a sector of publically funded, industrially oriented research institutes. A number of such institutes were established under the auspices of the council, and came to form an 'institute sector' endowed with responsibility for and receiving public funding for undertaking a substantial part of the total industrial R&D performed in Norway (Kaloudis and Koch 2004).

What is of particular interest here is a certain symmetry in the thinking about the domains of science, technology and industry in the two institutions. First, these domains were all seen as important for the overall political effort of rebuilding Norway, and in developing the country as a modern welfare state. Second, the way of thinking about development and change was systems-oriented; it was seen as essential to make the *leading men* from these diverse spheres work actively together, to realize national goals. The leading men of the period were, and to some extent also saw themselves as, strategic builders of a modern Norwegian nationstate (Ørstavik 1990; Slagstad 1998).

The NTNF became an arena where representatives of industrial firms and scientists from research laboratories met and where they obtained support for establishing common research and development projects. Activities were based on industrial realities; industries and emerging technology areas with great potential for industrialization and commercialization provided the basic dividing lines in the structuring of fields of activity. But NTNF found no simple and uncontroversial way to promote innovation by productive coupling of science and business. In fact, the NTNF system over time came to be heavily criticized as being both ineffective and unfair. In the end, the NTNF structure was dismantled, and resources were merged with resources from other research councils, into a new Research Council of Norway (RCN). The family of NTNF institutes had at this point in time already been repositioned institutionally and legally, as independent, non-profit contract research institutes.

Clearly, the RCN establishment could not erase completely the pattern of sector-based organisation in the Norwegian institutional system of innovation as a whole. The organization of the public system for funding R&D based on industries and technological areas survived under the auspices of various ministries, most importantly under the Ministry of Petroleum and Energy (OED) and the Ministry of Defence (FD), but also under the Ministry of agriculture (LD) and the Ministry of Fisheries (FKD). All these ministries maintained their own research financing schemes, and remained sponsors of selected research institutions. These parts of the Norwegian institutional system of innovation were largely shielded from the restructuring going on and could also in a certain degree continue to be shielded for some of the competition that other actors in the research and innovation system increasingly were being exposed to.

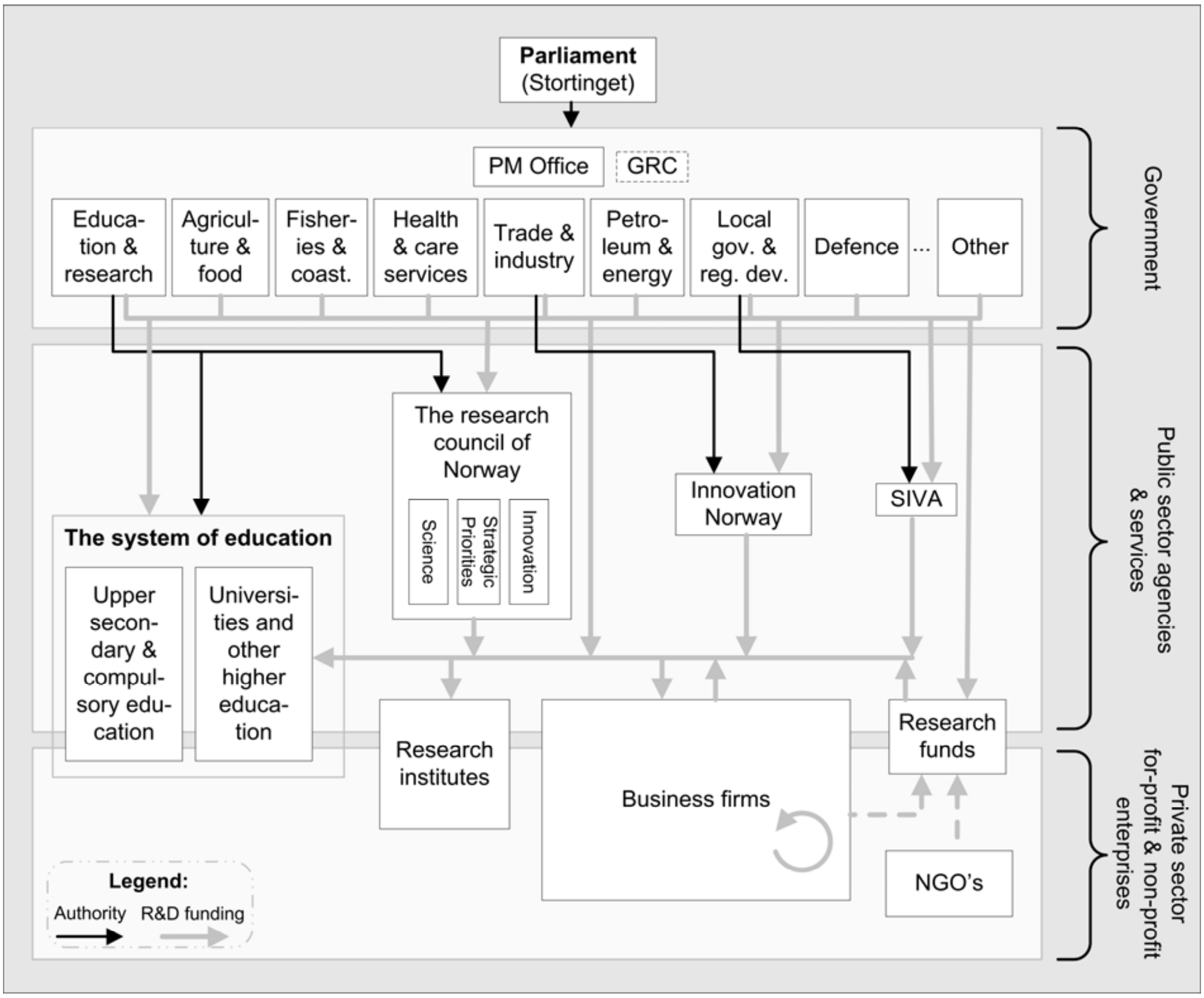

Figure 1: The Norwegian system of education, research and innovation[13]

The institutional system of innovation in Norway is illustrated in figure 1. We here show how government ministries fund and coordinate actions of agencies in the public sector. It is important to note, however, that such agencies often retain considerable autonomy. On the other hand, the *Research Council of Norway* (RCN) which is formally endowed with a central co-ordinating role of research and in

[13] Source: *Norges forskningsråd (2007). Det norske forsknings- og innovasjonssystemet. Statistikk og indikatorer 2007.* Oslo, Norges forskningsråd. The illustration was developed for *Indikatorrapporten 2007* by the author of the present paper.

principle covers all research fields except defence, have a limited ability to act in this role, as ministries insist on keeping part of the research portfolio out of the hands of the council.

The RCN is intended to deal with both basic and more applied research, as well as development and innovation oriented activities in industry and other value creating enterprises, such as in the public system of non-profit service provisioning. In the innovation field, RCN collaborates with *Innovation Norway*, the main public agency set up to promote entrepreneurs, newly-founded and small and medium-sized enterprises, as well as with the Industrial Development Corporation of Norway (*SIVA*). This is a public enterprise set up to *improve the national infrastructure for innovation*, which in practice means that the institution owns and maintains premises that is leased out to newly established firms, entrepreneurial research spin-offs, etc.[14]

As we have seen, the involvement of business interests, government and research institutions was an explicit goal in the first decades after the war, and was obvious both in the case of the NDRE and the NTNF. The preference was to select certain large firms, and to deal with them as *industrial locomotives*. Such firms would usually have at least in part public ownership. However, the years around 1980 stand out as a political turning point. At this time even the leading strategists in Labour found that there was a need for paying increased attention to the dividing lines between business and government. As part of a broad reorientation, the NTNF model in science and R&D policy was phased out, and the new, singular research council was created (Ørstavik 1999; Skoie 2005).

Also in the RCN, as earlier in the NTNF, *relevance for business* is emphasised in the rhetoric. But statistics show that the actual funding of R&D from public sources has been directed overwhelmingly to public and to independent, non-profit research institutions with origins in the public sector. Only 5% of RCN funding went directly to the industrial sector in 2003 (The Research Council of Norway 2006). This raises the question how RCN funding instruments are designed and how effective they are in promoting business relevant effects. The Technopolis evaluation of the RCN (Arnold et al. 2001) argues that evaluation is underutilized in the council, and in general, that the issues concerning design of funding instruments and their effects is an issue that only to a limited extent has been subjected to systematic analysis. However, Hervik and colleagues (2006) have been commissioned to evaluate the impacts of RCN-funded research over so-called user-directed programmes, and have attempted to make quantitative estimations of the effects of such projects. Also, NIFU

[14] SIVA and the other public institutions set up to promote and direct innovation in Norway are described more fully in chapter 4 in Spilling (ed.) (2007).

STEP has produced an overview over innovation policy tools that have been applied in Norway (Norges forskningsråd 2002).

It might be considered self-evident and a consequence of the basic rationale for the RCN, that it is science and the advance of scientific knowledge that is the key priority in the RCN, and not business innovation. The role of the council is to support science, not business. This is why it is the case that even in explicitly innovation oriented programmes, research institutes and academic institutions in most cases are an obligatory point of passage as developmental constellations are set up. What this boils down to is that in settings where science and business are set to produce innovative results together, *it is usually the scientists that are positioned to play the lead role*. We do not disparage this as simply wrong, as there are obviously good reasons to support and protect the capacity for basic science. However, we want to point out that with respect to business innovation, and in particular what regards the very challenging problem of integrating scientific research and value creation efforts in specific production and service provision systems, and where a main challenge is to secure the functioning of self-organized developmental constellations, this way of prioritizing has significant effects. Instead of focusing attention on establishing balanced developmental constellations spanning science and business, scientists are *systematically* put in a position to make the significant decisions about what to do and not to do. Hence, development constellations spanning science and business tend to become small and hierarchical administrative structures, rather than self-organised, evolving constellations of actors.

The establishment of the RCN was contested by some influential observers. From the side of industry, the sectoral interests of fisheries and aquaculture were among the most vocal opponents. The conviction in the industry, as well as in the Ministry of fisheries, was that such a research council would counter the efforts that had already been made in this sector, to couple industry interests and research in a productive way. A specialized, small research council for fisheries and aquaculture had been operative in Trondheim since 1972 (*Norges Fiskeriforskningsråd, NFFR)*, and represented an important area for the close coupling of research and industry interests in the sector. The success of a long lasting efforts to establish an adequate research financing regime, closer to business and with sufficient distance to government, was threatened by the establishment of the RCN in Oslo (Ørstavik 2006).

A specialized R&D fund for fisheries and aquaculture

In the political processes leading up to the establishment of the RCN, the need for consensus led to an internal organization of the council which emphasised continuity and gave room for internal heterogeneity. In spite of such concessions being made to existing practices, the Ministry of fisheries (today the Ministry for fisheries and coastal affairs) could not accept the solution that was found. This was the only ministry remaining opposed to the establishment of the new council (Arnold, Kuhlmann et al. 2001). This ministry and the key organisations of the fisheries and aquaculture sector, and also research performing organisations in the field, were convinced that the disadvantages of dismantling the sector research council in Trondheim in no way could balanced by the potential benefits that the RCN in Oslo could bring (Skoie 2005).

Fisheries and aquaculture is a large and important industry in Norway. It is the biggest export industry after petroleum. During the 1990ies, the industry experienced serious difficulties. Both aquaculture and traditional fisheries were marked by decreasing employment, stagnating markets and mounting losses. There was broad agreement that corrective policy measures ought to be implemented. The level of internal conflict had to be reduced. It would be in the common interest to work together to achieve new growth. The conviction was that technological development and innovation had to be placed centre stage, and that a research and development promoting agency ought to be set up outside of the new, national research council.[15]

The new research fund became fully operative January 1, 2001. The fund was established in spite of resistance from the RCN, and even if the fund stood out as an anomaly in policy terms. After all, this was a period when emphasis had been on reducing the number of funding institutions, and to promote central coordination and consistency in the public funding system for science and innovation. The fund was to be fully financed by way of a small export tax, levied on exporters of fish and seafood.

It is quite obvious how the mission of the fund was associated with the belief in the long term potential of creative synthesis between heterogeneous actors and activities: It was the long term health of the fisheries sector that was at stake, after a period when farming of fish had emerged as an alternative production paradigm, creating multiple and significant strains in the business strategies, organizational setup, and system of governance in the marine sector. The idea was to establish a pool of common resources to establish learning and development activities that could counter tendencies to infighting, and that over time could reintegrate the different parts of the industry. And it is equally obvious that there was no linear model thinking behind the establishment of the new fund: Here, industry would have significant control over priorities and strategies. Scientists would be invited to take part in joint efforts to create progress, but in a contributing rather than in a leading role.

[15] The main reference to the history about the fund is Ørstavik (2006).

In the recent study of the FHF, it's 'raison d'être' was summarized in the following way (Ørstavik 2006, 173ff):

- The FHF was intended as a catalyst for R&D activities that could help develop the industry, by strengthening knowledge bases, increase competence in firms as well as the industry's competitiveness internationally.
- The fund should act strategically and long-term in order to develop the whole industry and the capacity for research and development with relevance for the industry, both in firms and in research institutions.
- The fund should contribute to the initiation of long-term, strategic activities also in new areas and in areas that cut across existing dividing lines (such as between traditional fisheries, aquaculture and processing industry; between farming and supplier industries; between aquaculture and agriculture, etc.)
- The FHF was to be a small, dynamic agency that should collaborate with other institutions funding research and innovation, such as the RCN and Innovation Norway.

The study concluded that during its first five years of operation, the fund fulfilled its role according to the framework that had been set up for it. By integrating the fund closely with the organisations of the industry, one kept research and development as close as possible to business operations, and kept a strong focus on innovation and business development. The FHF remained small relative to the total public expenditures on R&D in Norway. For example in 2003, which was a quite normal year, total R&D funds of nearly 79 millions NOK allocated by FHF amounted to less than 5 percent of total R&D expenditures only in the marine sector that year.

The FHF has a small administration, and a board whose members are proposed by the main industry associations and formally appointed by the Ministry of fisheries and coastal affairs. The major "rival" institutions in the public system for R&D – the Research Council of Norway and Innovation Norway, as well as the Ministry, each have one representative acting as observers in the board.

The most important characteristic of the way the fund operates, is that 'intelligence is distributed'. The fund does not operate in a conventional, top-down manner. For example, the FHF does not receive applications. Rather, it is the fund itself that is responsible for conceiving and establishing projects. Programmes and projects are generated in a dialogue with interested parties. In this context, the aquaculture industry association (*Fiskeri- og havbruksnæringens landsforening; FHL*) has played a particularly important role, as it has been the host of a number of working groups (so-called fora) in specific fields, where representatives of industry and FHL meet to discuss common problems and challenges, and develop plans and activities related to R&D and business development.

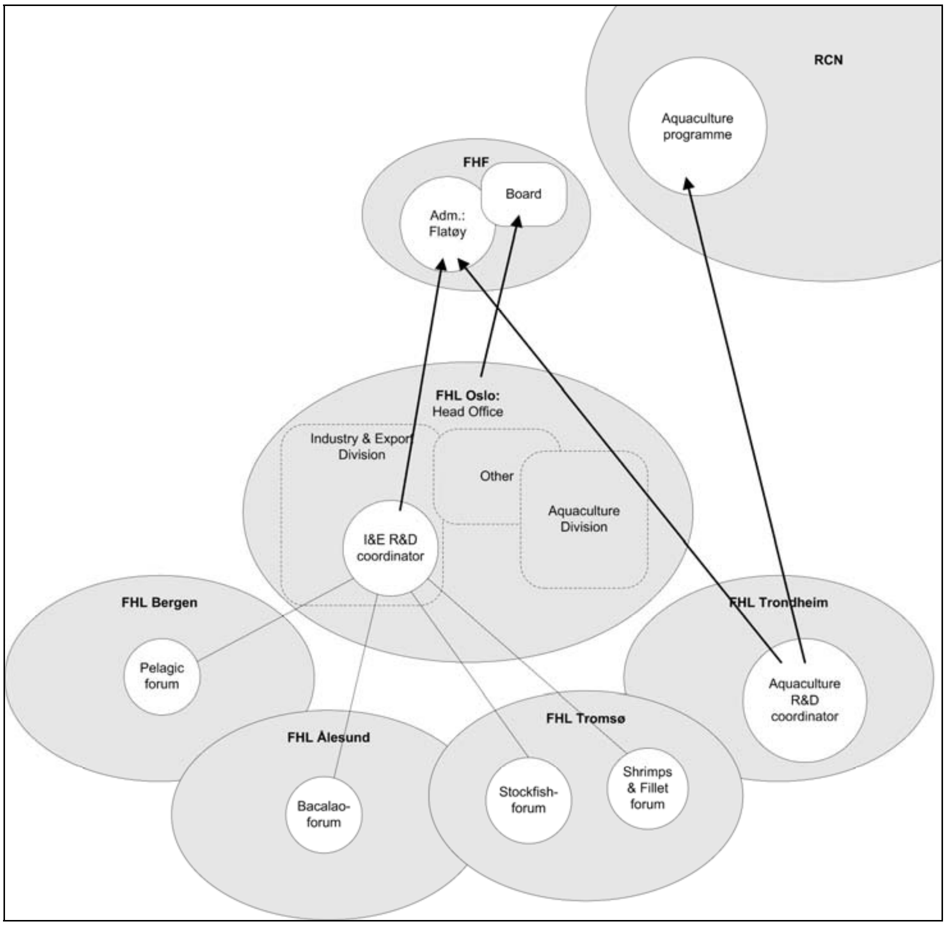

Figure 2: The integration of FHF with FHL

At the outset of the fund's operations, it was important to realize that most firms in fisheries and aquaculture were small, and for the FHF a key priority is to recruit businesses into R&D activities. This mobilization of firms could not routinely be done by the board or administration of FHF, but had to be taken care of by the industry associations *Fiskeri- og havbruksnæringens landsforening, FHL* (aquaculture) and *Norges Fiskarlag* (traditional fisheries). In the case of FHL, some such structures were already in place, and a nearly seamless integration between the fund and the organisations developed, as is illustrated in figure 2. Communication with commercial firms in the different parts of the industry was handled by the regional offices of these organizations.

It has been typical for the sector that activities are both regionally clustered and specific with respect to what species are being taxed, and what kind of processing is taking place.[16] On this basis, an important part of FHF-activities have been handled by specific working groups ("fora"). Such groups form a local arena in which firms

[16] For example, stock-fish is produced by a relatively small number of firms concentrated in Lofoten, while the Ålesund area is the centre for the production of salt cod (clip-fish).

can develop common projects. The working group develops its own strategic development plans, but has to consider also the overall strategic plans of FHF in order to be sure to receive the desired R&D funding. When successful, the forum is an effective arena for inter-firm communication, and also for establishing effective communicative links to academic- and institute researchers that possess relevant knowledge and competence.

In the course of the 2006 study a number of in-depth interviews were undertaken with people from the industry, research institutions, the organizations, and from government. It was found that the opinions were divided on the FHF *modus operandi*. There was disagreement both with respect to the way new projects were established, and concerning the way projects were carried out. A main dividing line was between representatives of science and research, and representatives of industry. Most researchers expressed frustration with what they characterized as *the FHF way*. The crux of their argument was that FHF was overly concerned with short term business issues and not enough concerned with research and long term strategic goals. The fund was seen much more as a development fund than as a fund for scientific research, and lacking in its competence to handle scientific research projects. Furthermore, nearly all of the researchers we talked to complained that decisionmaking lacked in transparency, and that the ability of researchers to compete on scientific merit was extremely limited. In contrast, businesses representatives were expressing satisfaction that the fund was the industry’s own fund, and that the industry could actually influence in a significant way the activities financed by the fund, including the research and development activities undertaken by scientists.

The industry representatives positive feelings towards the fund as being the industry’s own R&D fund was confirmed by empirical data from two surveys that were undertaken in order to gauge with some more accuracy “user perceptions” *in the industry* of the fund itself and of the results obtained in the R&D activities that had been funded. In one survey, respondents that had taken part in innovation oriented FHF-projects were asked about the fund’s operations. Some of the results were the following:

- There was a general and almost unequivocal agreement that the organisational involvement in FHF had been productive and that this involvement ought to be continued.
- There was agreement that the FHF system is able to set up productive development constellations, and that FHF projects are oriented towards the promoting of industry, and not simply the promoting of selected firms.
- Respondents were less certain regarding to what extent project ought to be more practical and hands on than they are.

- Similarly, respondents were less certain about the scientific content of projects, although most were satisfied and very few respondents would claim that scientific content was insufficient.
- Also, few respondents would agree with scientists that projects ought to be more long term and ambitious.

Project participants were furthermore asked what they thought about FHF-projects compared with RCN projects. It was found that very few of the respondents could report on actual involvement both in FHF-financed and in RCN-financed R&D projects, but respondents still thought that FHF projects typically are more relevant for the industry and for participating firms, more oriented towards market needs, and easier for firms to handle administratively.

In line with what has been said earlier, it is not surprising to find that there is a cultural divide between research (academic science) and commercial operations (business). There is an unbalance between the two domains, as people from the regions and from small and medium sized businesses are perceived as less resourceful and in a weaker position, than trained, and in many ways privileged, scientists and researchers. Drawing on the theoretical elements laid out in section 2, we see that the FHF by using fora and by taking control over the development efforts, effectively forces researchers and research institutions to take seriously the need to learn about business and to understand the dynamics and strategies of business development. Interestingly, faced with the demands of business relevance from the FHF system, the crucial "sales argument" we heard from the various research establishments during our in-depth interviews went like this: *No other research institute understands this particular business sector as well as we do.*

What this means, is that research efforts are directed in such a way that they contribute actively to development efforts as these are defined by business, in a language that is understood by business, and with input from other parties playing contributing roles, such as researchers and people and organisations in supplier industries.

In this way, researchers are coupled into innovation systems where the business firms play a decisive role in creating conditions for coordinated action along value chains, and in coupling these efforts to knowledge development efforts in the scientific realm. In this way, a big problem in the academia-business collaboration is moved over from the commercial side to research, namely the task to connect ongoing project efforts into the larger innovation systems that are of strategic significance for the research institution and the researchers themselves. What this means is that researchers have to seek out relevant scientific efforts that they themselves can relate to and contribute to, at the same time as efforts go on to stay connected in a productive way in the innovation system on the commercial side.

But do the developmental constellation constructed in this way become measurably more productive? On this, the 2006 study reported the following:

- Most project participants thought that the project had positive effects on their firm's collaboration with R&D institutions.
- Effects in terms of R&D collaboration with other firms were seen as much weaker, indicating that also in FHF projects, the important learning relationship is between the researchers (which receive the FHF-funding) and the firm, while the relationship to other partners in development constellations are much weaker.
- About two thirds of respondents credited the project with having led to new R&D activity in the firm, while it was almost unequivocally the judgement of participants that project related R&D activities had come in addition to and not instead of other R&D efforts.
- More than half of respondents expected significant positive economic effects in the future, whilst some one third reported significant economic effects so far. Few expected that the project would lead to reduced costs or to increased employment.
- Three out of four of respondents praised the project overall as having had significant positive effect *on the industry*. Technological capacity, collaboration and international position were the more specific aspects that were seen as the areas were the project had its most significant positive effects.

The overall conclusions we wish to highlight are, first, that measuring of effects is difficult, and that conclusive results would presuppose a different and more costly research design than what was feasible in the 2006 study. Second, we will point out that the results that were obtained can be interpreted as confirming how difficult it actually is to establish productive developmental constellations in which the joint efforts of science and business pay off for both parties. Third, we would emphasise that the FHF obtained the best results in terms of innovation in settings were local firms and research groups could work over time to develop more advanced topics for research and further development on the basis of ongoing, commercially viable industrial activities. For instance in the production of stockfish, the improvement of production processes led to considerable economic gains for producers, and at the same time led to pioneering research work and peer review publications in marine biology.

Conclusions and policy implications

We have in this paper considered the significance of social relations in efforts to establish productive coupling of science and business. In directing attention towards heterogeneity and towards the creative potentials in countering the tendency that only *birds of feather flock together*, our theoretical perspective on innovation has made the question about the social relations of the business science interface reappear in a new form.

Throughout the post World War II period, the "linear model" thinking has played an important role in regulating the science – business interface in many countries, and also in Norway. The extensive institutional system of public research and education that is operative in developed countries – constituting the organisational body of modern science – has been seen as an autonomous and exogenous force with respect to business development. Hence, in the general opinion, and apparently in the opinion of many scientists themselves, research and scientific knowledge make up fundamental drivers, of economic development, growth and social change.

The point we have made here is that this thinking is reflected in the structure of the national system of innovation in Norway. We have shown that administrative, hierarchical top-down control is intended to be an important part of the institutional setup, but that the private business system plays a limited role. It has been impossible in this paper to show the subtlety and the complexity of power that exist between different actors in the system, and how important state ownership and ministry control over R&D and business sector development actually is.

What we have concentrated our efforts on, is to show how the structuring of the innovation system in the pioneering post-war period was marked by systems thinking, and how the systemic approach gradually was forced on the defensive. We have argued that the Research Council of Norway in spite of its obvious efforts to promote innovation, fundamentally reflects a concern with promoting science and scientific autonomy, and that the concern with specific innovation initiatives cannot but be considered a secondary concern for the Council's efforts.

We have furthermore contrasted the RCN with the new fund for R&D in the sector of fisheries and aquaculture, the FHF, and have stressed the systemic orientation underlying the efforts of this fund. We have shown how social (and scientific) status has limited significance in the developmental constellations set up by the fund, and why this should be considered an important fact. The learning processes that are established in successful developmental constellations are genuinely interactive and lead to combinations of scientific and business learning that otherwise are hard to obtain.

When successful, the FHF establishes arenas for business – research interaction that at the outset is more in line with business needs than with the immediate needs of researchers. In this way, FHF is contributing effectively to the R&D efforts and innovation in the firms that are involved in FHF-projects. Over time, the fund contributes also to learning in the research institutions, as it forces researchers to take business innovation and development strategies of competitive business firms seriously. Researchers have to learn the language of business, and for this reason, we could claim that FHF actually reverse the concern with absorptive capacity which is otherwise so common in the Norwegian institutional system of innovation. To compete for FHF-funds researchers must not primarily argue their own scientific excellence, but must argue for their own absorptive capacity regarding challenges facing business.

Certainly, the systems approach promoted by the FHF is not without weaknesses and dangers. It is interesting that the successful innovation efforts of the fund tend to involve small firms in local settings. Larger firms and big business seem not to fit easily into the FHF mould, which is based on the active involvement of industry associations and the willingness of firms to consider industry interests as important and legitimate concerns, beside the specific firm's own interests. Also, the particularity of this co-operative orientation of Norwegian business may indicate that the FHF as an innovation policy tool reflects Norwegian, or Nordic, traits, making it of less immediate relevance for policy makers in other countries.

Finally, with its orientation towards industry and industry's strategic needs, the FHF may not be an effective tool for promoting science. In the projects funded by FHF, safeguarding the quality of scientific knowledge production, and making sure scientific efforts are considered relevant in a scientific community, is the sole responsibility of researchers themselves. This certainly is no trivial task, and commercially related research efforts will easily lose scientific attractiveness, as scientists involved perceive the risk of losing standing in their own professional community. The FHF may effectively force researchers into roles as consultants rather than researchers, and may risk ending up at the same time exploiting and undermining the scientific standing of involved scientists and research groups.

In conclusion, the FHF reflects its predecessor NTNF in some important ways, and there certainly was a baby in the bathwater when the NTNF system was dismantled. The industry orientation of FHF and NTNF is important and useful, but working out how this approach should be implemented in a good way remains a challenge. Certainly, the institutional system of innovation as a whole benefits from a strong and vital system of science. Hence, the conclusion can not be that the industrial approach to innovation is the whole answer to the broad challenge of innovation policy, only that it is an important part of the answer.

The overall system of education, science and innovation in Norway is currently under intense debate, and in a process of transformation. In this picture, where amongst other things the dividing lines between universities, university colleges and institutes are being challenged, where the dual role of government in business is again being brought up in the debate, and where Norway's positioning in an ever more globalized world is at stake, moving beyond a simplistic, linear understanding of the role of science is critical.

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The relationship between a university and its technology transfer office: the case of NTNU in Norway

Magnus Gulbrandsen

Abstract

This paper asks how the relationship between a university's central administration and its technology transfer office (TTO) affects the way the TTO operates and performs. The case is the Norwegian University of Science and Technology in Trondheim, which set up a TTO after legislative changes in Norway in 2003 that moved the intellectual property rights from the individual inventors to the higher education institutions. Principal-agent theory is used to guide the analysis, which centres on issues like goal conflicts, adverse selection and moral hazard. It is found that many of the challenges and problems that the TTO has encountered, may be due to how the technology transfer function was set up by the university rather than specific actions and decisions in the TTO. Unrealistic expectations and lack of a university IPR policy has probably created some problems that could have been avoided. However, the legislative changes themselves have been difficult to handle at a university where the old IPR regime was the backbone of a successful policy of entrepreneurship and industry relations.

Introduction[17]

In this paper, the main question is how the relationship between a university and its technology transfer office (TTO) affects the way the TTO operates and performs. Principal-agent theory is used to guide the analysis. The term "university" in the title refers primarily to the central administration and leadership of the university.

The analysis is based on a case study of the technology transfer unit at the Norwegian University of Science and Technology (NTNU). This TTO unit was established in late 2003 following a legislative change concerning intellectual property rights and the missions of universities in Norway. NTNU – with long traditions for commercialisation – had high expectations to the TTO despite some sceptics among the academic staff. However, after a few years of operation, it was clear that the expected number of commercialisation would not be met; neither would the hope that the unit would generate enough income to support itself. The TTO had furthermore entered into some well-publicised conflicts with leading professors at the university, and concerns were raised about the unit's activities and competences. An evaluation was called for in mid-2006, and this paper is based on empirical evidence collected during this evaluation (see Spilling et al. 2006 for the full report). Since the unit had only been in active operation for a little over two years, the evaluation

[17] I would like to thank Olav Spilling, Helge Godø, Tor Borgar Hansen and Åge Mariussen for constructive comments, all the informants and respondents for their time and valuable insights, and NTNU for initiating and funding the study of its TTO.

emphasised organisational and developmental aspects rather than productivity and results, just as this paper does.

Technology transfer offices – a short overview

The literature on technology transfer offices has grown somewhat in recent years, reflecting an increase in the number of such units following changed Bayh-Dole like legislations in Europe and elsewhere and increased academic interest in them (EU 2004; also Rothaermel 2007). There is probably a great variety in what these units do and how they are organised, which is also seen in varying names like Technology Licensing Office/Unit/Organisation and Industrial Liaison Office. Behind the names are national differences in university structure and policies, IPR legislation etc. Most of the units are fairly young, although there are examples of transfer offices that date back many decades (e.g. van Hoorebeek 2004; Mowery & Sampat 2001), showing that the tasks and challenges are not new.

A technology transfer office's core mission may be defined as moving research results and other ideas and technologies, most often originating at a certain higher education institution or public laboratory, into use (Guston 1999). Sometimes an outreach or liaison function is included in the unit (Jones-Evans et al. 1999) and there is disagreement in the literature about the role of the TTO in this respect (Rothaermel et al. 2007). The transfer process usually has several phases (see Hoppe & Ozdenoren 2002), starting with disclosure of an invention to the TTO by the researcher or possibly an active idea search phase by the transfer unit. This is followed by an evaluation of the idea, where external consultants often are used. Subsequent steps may involve patenting, further development of the idea/invention, establishment of a spin-off company and/or negotiation of a license agreement.

The TTO most often has a monopoly on commercialising ideas and technology from its host institution, although it has been found that faculty members are able to circumvent the formal TTO process in many cases or choose not to disclose their ideas (Jensen et al. 2003; Siegel et al. 2003). This could result in the transfer unit getting stuck with mediocre ideas as the best ones are commercialised through direct interaction between researchers and partners in industry and elsewhere (Jensen et al. 2003). Some faculty members may think that the costs of interacting with the TTO are too high or are otherwise reluctant to disclose their ideas/inventions (Chapple et al. 2005; Owen-Smith & Powell 2001). Problematic initial experiences may lead to a bad reputation for the TTO, sending it into a negative spiral of reduced resources, staffing problems and delays as in one of Owen-Smith & Powell's cases. Colyvas and colleagues (2002) found that technology transfer units' activities may have the greatest importance in areas where existing university-industry linkages are weak. Of course, a large number of investigations show how many commercialisation activities take place without the involvement of a TTO (see Mowery et al. 2004).

A European survey of more than 1400 TTO-like organisations revealed three main types (EU 2004): 1) technology transfer units that are integrated as an administrative office in the host institution (53 percent of the cases), 2) units that have multiple hosts and are often part of a regional (public) infrastructure for commercialisation support (33 percent), and 3) units that are organised by a university as an independent for-profit venture (14 percent). There is a lot of variation in age, size, tasks and other aspects. Other studies have furthermore found large variations between the TTOs of a single country (e.g. Canada, see Fisher & Atkinson-Grosjean 2002). Bercovitz et al. (2001) furthermore defined four different organisational structures of internal department TTOs, and find evidence (based on three U.S. cases) that structure is influenced by university history and related to TTO performance.

Siegel et al. (2003) distinguish between three stakeholders in university-industry technology transfer – scientists, TTOs and firms – and they show that there are clear differences in the motives, incentives and organisational cultures of these groups. To some extent it is the TTO’s role to bridge the gap between the stakeholders (see Guston 1999), and Siegel and colleagues (2003:44) emphasise reward systems for faculty involvement, compensation and staffing practices in the TTOs and various actions to overcome informational and cultural barriers. The authors furthermore find that the three stakeholder groups are also quite heterogeneous – and that they all defend open and autonomous basic research. It may be added that there are major differences between entrepreneurial academics in how they work (Etzkowitz 1998; Meyer 2003).

Most empirical investigations of TTOs look at issues like results, efficiency and productivity (Rothaermel et al. 2007). This also includes the speed of commercialisation (Jensen & Thursby 2001) and the volume of licenses and patents (e.g. Coupé 2003). Often the aim is to discuss some possible determinants of outputs like aspects of the TTO itself and its environment. A lot of explanations for variations in efficiency and results have been found. These are not easily comparable because of the large variations in national and institutional context between the transfer units that have been investigated. In general, the investigations find that many TTOs are not very efficient and/or do not create much income and other desired results (e.g. Chapple et al. 2005).

Many investigations emphasise the competences and experience of the TTO staff (e.g. Friedman & Silberman 2003; Markman et al. 2005; Lockett & Wright 2005; Siegel et al. 2003). TTO staff should ideally have both academic and business skills, with the demands possibly varying with technology area. Trust and good personal and informal relations between TTO staff and faculty members is an important part of universities succeeding in commercialisation (Owen-Smith & Powell 2001; Siegel et al. 2003), as is good linkages to industry and venture/seed capital (e.g. Agrawal 2006; Dill 1995; Thursby & Thursby 2004). UK and European studies have found that TTOs generally have a severe lack of both scientific expertise and business skills and capabilities (Geuna & Nesta 2003; Chapple et al. 2005). The effects of the size and age of the transfer unit are not clear but technological specialisation may be important (Chapple et al. 2005; Thursby et al. 2001; Siegel et al. 2003 and 2004). Incentives and organisational structure are probably also important, although the data are not unanimous (e.g. Debackere & Veugelers 2005; Markman et al. 2004; Siegel et al. 2003 and 2004; see also Rothaermel et al. 2007). Several authors also point at external factors as explanations for variations in TTO performance, e.g. national or institutional incentive structures, IPR policies, R&D profile and intensity, and the dependency/organisational relationship between the TTO and the university (e.g. Bercovitz et al. 2001; Feldman et al. 2002; Jones-Evans et al. 1999, Siegel et al. 2003). A fundamental issue seems to be a clear university mission in support of technology transfer and a clear internal patent/IPR regulation (Baldini et al. 2006; Debackere & Veugelers 2005; Dill 1995; Di Gregorio & Shane 2003; Fisher & Atkinson-Grosjean 2002; Friedman & Silberman 2003). Optional disclosure and unclear IPR policies can lead to conflicts over ownership and poor TTO performance (Fisher & Atkinson-Grosjean 2002).

Guston (1999) does not emphasise economic performance and efficiency but rather how TTOs continuously try to demarcate science from other activities, but at the same time try to build bridges across the same demarcation. In this way, the TTO becomes a “boundary organisation” between public policy and the researchers. TTOs here constitute a legitimacy vehicle for the universities as well as a practical tool for defending basic science in a time when the demands for external relevance and industrial orientation may be higher than ever. A good TTO in this framework is one that is able to create a stable demarcation between research and commercialisation that pleases both researchers and policy-makers. Also other authors have emphasised the boundary-spanning role of TTOs (e.g. Siegel et al. 2003).

Thus, technology transfer offices are complex organisations dealing with very complicated processes. Although their existence may make a difference for a university wanting to encourage commercialisation, few of them make a profit and they have been met with unrealistic expectations in many cases (cf. Lerner 2005). Some authors have predicted that many TTOs might be reoriented as broader service units or be closed down in the future (Mowery & Sampat 2001). However, the literature studying economic performance and efficiency may have underestimated the role of TTOs in creating legitimacy for the universities as being “entrepreneurial” and “proactive”, or simply as a reflection on the outsiders view of what a modern university organisation should look like.

Principal-agent theory and TTOs

Principal-agent theory depict situations where one actor – the principal – hands over resources, often in a contractual relationship, to other actors – the agents – in order to reach goals that the principal cannot reach alone. A TTO can be viewed as a principal in the relationship with the university staff, but it can also be seen as an agent of the university central administration and thus as an “intermediary” (Jensen et al. 2003) or a “boundary organisation” doing “boundary work” (Guston 1999; also Debackere & Veugelers 2005). Guston (1999) states that boundary organisations “exist on the frontier of two relatively distinct social worlds” (p. 93) and help stabilise the boundary between them through various principal-agent relationships. Firms, venture capitalists, patent attorneys and other actors may also be viewed as agents of the TTO, or the technology transfer unit can be portrayed as a principal that signals the quality of inventions to potential licensees (Hoppe & Ozdenoren 2002). TTOs usually have a contract with the university administration where the rights and obligations of each party are specified, as well as contracts with the faculty members who disclose ideas. With internal type TTOs it is the university administration/leadership that selects contract terms for both the TTO and faculty (Jensen et al. 2003).

The dual role is complex; the TTO must “balance the ojectives of the university, which owns the inventions, and the faculty, who create them” (Jensen et al. 2003:1272). In addition, TTO staff need to be knowledgeable about how research-based ideas and inventions get utilised in industry, and therefore both academic/technological, commercial and industrial competences are required. TTOs measure their own success with respect to the views of both faculty and university central administration (*ibid.* p. 1273). Or in Guston’s (1999) perspective, the stability of the boundary between the TTO and its principal/agents rests upon the transfer unit carrying out its task to the satisfaction of both principals and agents. It may be difficult for a principal to operate unless it becomes accepted by the agents, not least when it relies on the agents for submission/disclosure, evaluation and later involvement (Braun 1993). For a TTO, a key legitimisation process could be to generate sufficiently high revenues to demonstrate how this benefits basic research at the university (e.g. Guston 1999).

Three sets of problems for a TTO can be discussed with a principal-agent framework as the starting point, drawing on Guston (1996 and 1999) and van der Meulen (1998):

- Goal conflicts: the principal and the agents can have conflicting or only partly overlapping goals. The TTO aims for commercialisation and sale of licenses and it wants to involve faculty in entrepreneurial projects, while they on the other hand often desire autonomy and a level of research funding that allows them to pursue the most interesting scientific problems. Universities also often work for autonomy and a high share of basic funding rather than a reliance on more uncertain sources.
- Adverse selection: as a result of information asymmetry, the principal does not have full information about the agents. This often requires the principal to rely on the agents' own judgement or actions – like disclosure in the TTO case – when selecting the appropriate agent. A delegation and review process is necessary, in which the agents are encouraged to disclose and the principal makes an evaluation of the ideas that have been submitted. This process does not come without costs, however, and it can sometimes be difficult to find evaluators without a close relationship to the agent.
- Moral hazard: the delegation gives the agent an incentive not only to carry out the required task, but also to act in unacceptable ways. Blind trust is rarely an option, so monitoring activities, incentives and sanctioning opportunities often become central. Of course, these carry costs as well.

Adverse selection may be discussed both with respect to the technology transfer office's struggle to develop the right inventions and/or get in touch with the right professors in an idea search phase, and with respect to the university leadership choosing a TTO model. As seen above, there are many TTO models to choose from varying e.g. in degree of independency and centralisation.

Two important types of moral hazard can be discussed, and the first is frequently mentioned in the TTO literature. This is the problem of getting faculty to disclose. As mentioned in the previous section, lack of disclosure is found to be a major problem in several studies, and authors have recommended proper incentive mechanisms to reduce the problem (Jensen et al. 2003; also Fisher & Atkinson-Grosjean 2002). Royalties for the researchers may be one option (Jensen & Thursby 2001) even though this reduces the possible surplus available for unrestricted use (Guston 1999). Second, there may be a danger that faculty who receive financial support for commercialisation to spend this as a normal research grant. This tendency has been referred to as "bootstrapping" (*ibid.* p. 96).

One should recall that adverse selection and moral hazard are not problems with a simple solution – they will always be present as tensions and challenges in principal-agent relationships, but there are ways of balancing and stabilising these tensions in more or less costly and efficient ways. In addition, the creation of income that can be spent on basic research is central when it comes to creating good linkages to the research community.

The aim in this paper is to expand on the literature reviewed here within a principal-agent framework to further explore how the relationship between the TTO and the university administration offers constraints and opportunities for the transfer unit. Although a somewhat similar approach has been followed before, there is a need to expand on the literature with data from outside of North America and with cases where technology transfer units are organised as independent organisations.

The next section presents the case university NTNU and the national setting, followed by an account of the establishment of the university's TTO. Three subsequent sections analyse goal conflicts/information asymmetry, adverse selection problems and moral hazard problems, and a short discussion/conclusion is found at the end.

The case of NTNU and Norway's legislative changes

The Norwegian University of Science and Technology (NTNU) in Trondheim is the country's second largest university with around 20000 students, half of them in natural science and engineering programmes. There are around 4300 full time staff equivalents, encompassing more than 2000 scientific staff of which 800 are full professors. NTNU was created in 1996 through a merger between the Norwegian Institute of Technology (the country's major technical university established in 1910) and the University of Trondheim (a comprehensive university formally started in 1968 but based on older institutions). It is still a major centre for technological education in Norway – 80 percent of all chartered engineers (master's degree) are trained at NTNU, and almost all doctorate engineers. NTNU's goal is to be ranked among the top 10 technical universities in Europe within 2020, and to be the leading institution nationally when it comes to technology transfer and commercialisation.

NTNU's total budget was around 3.8 billion NOK (approximately 480 million EUR) in 2007. The R&D statistics of 2005 show that the R&D expenditures at the university were around 1.7 billion NOK (approximately 210 million EUR). The share of R&D expenditures funded by industry has historically varied between 16 and 20 percent, and the volume of industrial funding is much higher than at any other major higher education institution in Norway. In R&D activities, the most important partner is the research institute SINTEF, located close to the NTNU campus with 1800 employees. SINTEF was created by the technical university in 1950 as a means of technology transfer, and grew quickly to become one of Northern Europe's largest technological contract research organisations.

The university thus has a long prehistory of technology transfer and commercialisation. Staff and students at NTNU have established close to 200 companies the last three decades, some of which have become fairly large multinationals like Fast Search and Transfer (purchased by Microsoft January 2008), GE Vingmed Ultrasound, Q-Free and Nordic VLSI. Inventions and research at the university have been behind important innovations in strong Norwegian industries like oil and gas, shipbuilding, marine harvesting and metals production.

NTNU faculty have traditionally been able to choose many different ways of commercialising their ideas and research results: through direct collaboration with companies, through SINTEF and other applied research institutes, or through patenting/licensing and spin-off companies supported by a structure of incubators and science parks. All of these ways, given a successful commercialisation process, would result in financial gain for the entrepreneurs, not least the SINTEF way which could yield a stable extra income for the professors. Although there have been and still are few formal incentives for commercialisation in the Norwegian university system – promotions are e.g. based on academic criteria – entrepreneurship has been an element of NTNU culture for decades and a prestigious activity for the faculty members. To some extent, it has been "unmanaged and cost-free" for the university (see Guston 1999:93).

Norway's first research-oriented incubator was started close to NTNU's main campus in Trondheim in 1984, with the university and its rector as the main protagonist. The incubator was later transformed into a regional science park/TTO-like organisation called LEN (Leif Eiriksson Nyfotek) which has served as a partner for many NTNU professors. In 1997, the first Norwegian seed capital fund was set up in Trondheim, and it was later merged with LEN. Furthermore, SINTEF has had its own technology transfer unit, SINVENT, since the late 1980s. SINVENT was hibernating for some years but was revitalised a few years into the new millennium. Following a successful exit from spin-off companies and licensing income the unit has established two seed capital funds to support its activities. Finally, several student organisations related to entrepreneurship and commercialisation have been established, and the university has carried out entrepreneurship training and research since the mid-1980s.

In 2003, the legislation concerning intellectual property rights (IPR) and the legislation concerning the mission of higher education institutions were changed. The so-called "professor's privilege" or "teacher exemption clause" was removed, and the ownership of research results was transferred from the individual scientific employees to the higher education institutions. At the same time, the institutions were given more formal obligations to ensure that research results find their way into practice. The legislative changes were partly inspired by the U.S. Bayh-Dole Act and followed the example of many other countries. Norwegian policy-makers were in particular influenced by similar changes in Denmark (2001) and Germany (2000). An important motive for the changes was, naturally, to increase the commercialisation of research results and to “change the culture” in the academic community. Having uniform IPR policies in the whole research sector – for example, there was no teacher exemption clause for the research institutes and the university hospitals – was another important motive. It can be argued that the legislative changes *make* the university a principal because it switches the ownership to research results and introduces a disclosure requirement. It furthermore delegates monitoring and review to the higher education institutions. In the old system, faculty approached other principals for funding and commercialisation support than their own university.

As this section has indicated, NTNU and its “daughter institute” SINTEF had a remarkable history of commercialisation before the legislative changes. Not only did they have long traditions for working with industry, including systematic commercialisation activities. They were also the first institutions to set up incubators, seed capital, formalised entrepreneurship training and technology transfer support. A new TTO did not come to an unfulfilled need but rather to a strong existing support structure.

Establishment of the NTNU TTO

This section and the analysis in the rest of the paper is based on interviews, document analysis (reports, strategies and plans), and a web survey. 27 interviews were carried out: nine with NTNU TTO personnel, five with staff at other technology transfer organisations, four with university leaders and nine with NTNU professors. The web survey was carried out among all the scientific staff at the university (including PhD students, post.doc. scholars and senior technical support staff) with a response rate of 41 percent (1280 people completed the whole questionnaire). One-fourth of the respondents had previous experience with entrepreneurship defined as patenting, creating a spin-off firm, product development for a company and/or licensing. 20 percent of these (59 individuals, mostly full professors) had been involved in more than 10 such entrepreneurial projects.

As a response to the legislative changes in 2003, all the Norwegian universities established technology transfer offices, with NTNU Technology Transfer AS (ltd.) as the first one, started in October 2003 and in full operation from mid-2004. It was created as a limited company with a clear profit motive. Unlike the other TTOs in Norway, NTNU's owns the relevant research results. At the other universities, the TTOs administer IPR on behalf of the university. The initial expectations from the university leadership were high, for example that NTNU and SINTEF should be the source of 30 spin-offs annually.

There were several reasons behind NTNU establishing its own TTO rather than to collaborate with the two TTO-like organisations already in place in Trondheim. Many professors had expressed dissatisfaction with LEN (the regional TTO organisation) which was seen as "greedy" and not offering services that were sufficiently tailored to commercialisation of advanced research results and ideas. These voices were represented in the working group set up by NTNU to assess alternatives for the technology transfer function. SINTEF wanted to retain its own technology transfer unit rather than share it with NTNU. Although the collaboration is still significant, SINTEF and NTNU had grown apart since the late 1970s, with the former acting more and more as an independent research institute rather than a support organisation for the university. This led to NTNU establishing its own separate TTO as a service unit for the whole university with a monopoly on university ideas. The working group suggested that the new unit could collaborate with the existing technology transfer organisations in Trondheim, but this was not followed up in practice.

The NTNU working group emphasised many tasks for the unit:

- Advice about commercialisation to staff and students
- Accept disclosures/register new ideas
- Maintain a system that shows the status, history, decisions, actions and costs for each project
- Decide about patentability and actual patenting, organise the patenting process, manage the patent portfolio and make sure that as many patents as possible are commercialised
- Market NTNU's technology to potential buyers nationally and internationally
- Generate income through sale of licences and property rights
- Divide the income between various involved parties
- Promote success cases

These were made into a more detailed list of 14 tasks, which were changed into a phase model after the unit was established. None of the tasks included changing employment contract for academic staff or creating an IPR policy for the university, however. In addition, the working group suggested that the competences of the TTO should be available for all scientific staff at NTNU, and that the technology transfer unit should operate in a way that strengthens research, teaching and value creation at the university. No concrete goals were set up for income and self-sufficiency, but the group's report emphasised that the TTO could get direct financial support from the university "in a build-up phase".

NTNU TTO established four sub-units corresponding to the university's own chief areas: "science and technology", "industry solutions", "ICT & Arts" and "life sciences". It grew quickly and in 2005 the unit had 17 people and 16 million NOK in turnover (about 2 million EUR). 5 millions were from the university "for services provided", while 10 millions were from the Research Council of Norway, in particular the FORNY commercialisation support programme (the TTO budget has in 2008 increased by a further 60 percent). Since the TTO is organised as a limited company, the university is not allowed to subsidise its activities in any way – it therefore pays for services like informing the faculty members about the legislative changes and arranging courses in patenting and entrepreneurship. The FORNY programme with its incentives and funding criteria has been a central influence on the TTOs in Norway.

In 2005, salaries were the most important cost category (6.7 MNOK), followed by consultancy costs (4.25 MNOK) and patent costs (1.75 MNOK). In mid-2006 the TTO has a portfolio of a little more than 30 patents, which of course generates a lot of costs. Few of them have led to commercial activity, but two license agreements were signed in the first half of 2006 and three more agreements were expected the rest of the year. The TTO had helped create seven spin-off companies (by mid-2006) where it owns a share. Due to a lack of funds, the TTO staff said it was difficult to get further involved in new firms.

From the start, it was clear both from the university's expectations and the TTO leader's background (as an ICT researcher founding a fast-growing firm) that spin-offs would be a major output of the unit. 6-7 staff members were hired directly from the entrepreneurship master's course at NTNU. It was expected that they would work on projects in the TTO and then follow spin-out firms as employees. These trainees, as they were called, were met with a lot of scepticism in the scientific departments due to their lack of scientific competences and industry experience. The trainee programme was therefore later terminated, with some of the people remaining as junior assistants. Contact with firms and venture capital companies furthermore convinced the TTO staff about the importance of patent protection, and new staff members were hired with expertise in this area. However, only the TTO director has a PhD degree, and in the survey, some of the respondents remarked this critically.

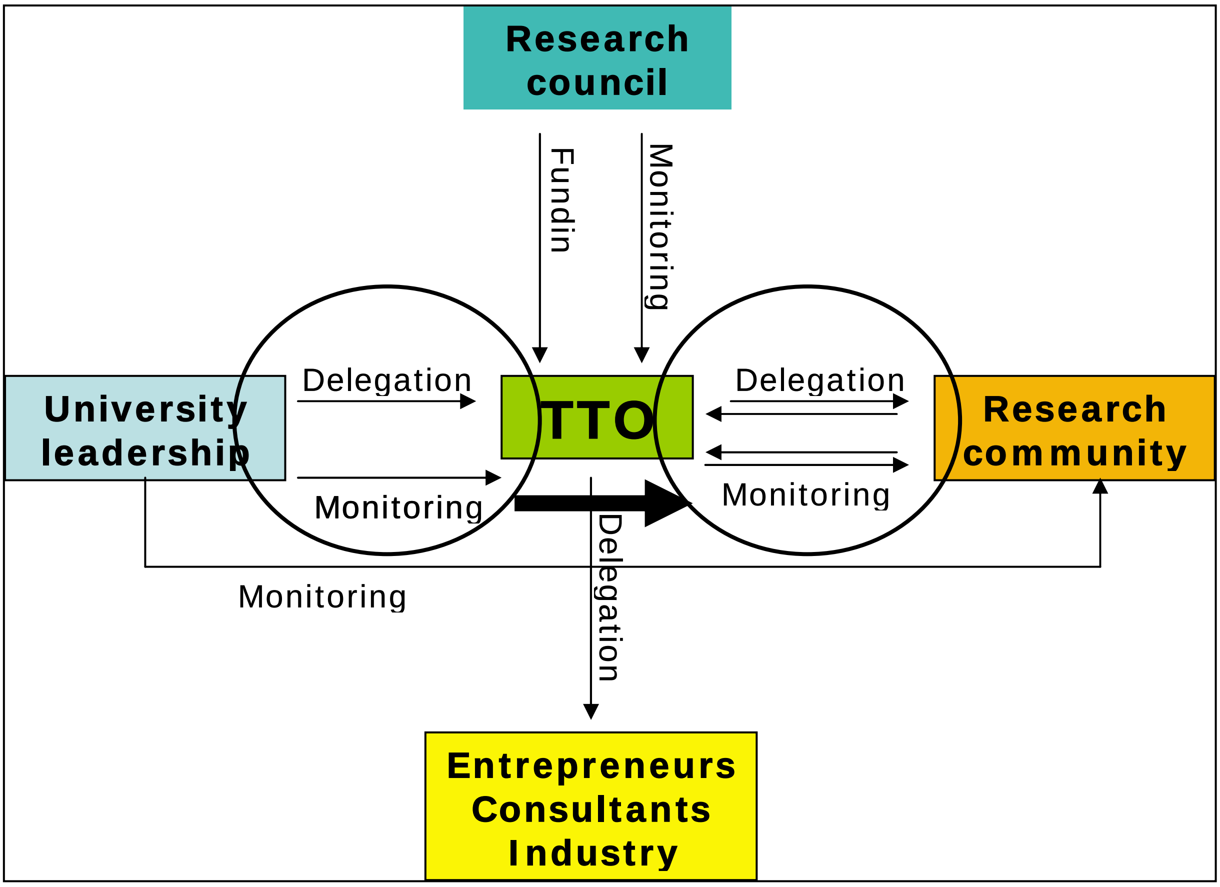

Figure 1: The NTNU TTO in a principal-agent framework.

Figure 1 depicts NTNU TTO in a principal-agent framework, and the circles denote the relationships that are of particular interest in this paper. Put a bit simply, delegation is based on goals and involves problems of adverse selection, while monitoring (including sanctions and incentives) could be necessary to avoid problems of moral hazard. Although not part of the analysis, the central role of the Research Council through its FORNY commercialisation support programme is emphasised in Figure 1. NTNU TTO prepares an annual application to FORNY together with similar organisations in the region. Quantitative targets for next year are set as well as reports made for previous years. The TTOs furthermore get a financial reward from FORNY based on certain quantitative and qualitative indicators. This is a type of monitoring that is more thorough than the formal monitoring of the TTO by the university administration, which is a key theme in the next section.

The university-TTO relationship, goal conflicts and information asymmetry

Despite its history and the general goal of NTNU of becoming a leading entrepreneurial university, commercialisation and entrepreneurship have not been mentioned very much in its strategic plans. Its previous strategic plan from 1998 only included a minor point towards the end concerning “motivating students and employees to innovation and entrepreneurship”. A separate plan for entrepreneurship was therefore made in 2001, stating that this should be an integrated part of all three missions of the university (teaching, research, public service/dissemination). This plan formulated the goal to establish at least 30 spin-off firms based on research at NTNU and its Trondheim partners per year. But even though the legislative changes were in the coming at this point, the plan does not mention a technology transfer unit. High expectations were also found in the university’s TTO working group in 2003 which assumed that the primary source of income for the unit would be sale of IPR to firms and in a longer perspective sale of shares in spin-off companies. No concrete expectations about the level of income were put forward in their documents, however.

When a new strategic planning process was started at the university in 2003 with a final approval in the university board in 2006, entrepreneurship was mentioned as an equally important activity as teaching, research and dissemination. Instead of 30 spin-offs, this plan stated that the university and its partners should be the source of 20 commercialisations (spin-offs and licensing deals) annually by the year 2010. Informants stated that new knowledge and the first experiences with the TTO were factors behind the new and probably more realistic level of expectations. In addition, NTNU should be among the 10 leading European universities when it comes to science-based entrepreneurship by the year 2020. However, in the background documents to the strategic planning process, entrepreneurship was treated very superficially compared to the other activity areas of the university. For those involved in the process, the message was still that entrepreneurship does not have the top management support as the traditional academic missions. Although the university has moderated its expectations, the TTO director is nevertheless very optimistic about the future and has goals about creating a financially self-sufficient unit some time in the future.

Turning to delegation of authority and contractual arrangement, the tasks of NTNU TTO are regulated through a *general collaboration agreement* with the university as well as an *annual specific agreement* about which services the unit should provide. In addition, the university has developed “Guidelines for innovation” in which some principles for IPR management are defined. An important part the 1/3 rule: in most cases, income should be split equally between the inventor(s), the academic unit and the TTO (for small amounts, the inventor gets more).

In the current *general collaboration agreement*, two main areas are described. The first states that the TTO is NTNU’s primary tool for ensuring, managing, enlarging, marketing and selling the right to use and own NTNU’s ideas, inventions, research results and other immaterial rights. Secondly, the agreement states that the

TTO should work actively towards increasing research-based commercialisation, including offering courses, advice and other professional services to students and faculty.

The first *annual agreement* for 2004 defined three services that the TTO should offer to the university in return for funding: 1) training, advice and consultancy, 2) idea generation, idea development and project development and 3) Administration of the university's IPR portfolio. Each of these areas contained a highly specified list of tasks which were related to different phases of commercialisation processes. However, the 2005 agreement was radically changed. Here, the detailed description of tasks was removed, but three new tasks were included: promotion of the university, general encouragement of entrepreneurship in the Mid-Norway region, and a strategic role related to "implementing NTNU's plans" and giving feedback to faculty so that "the research activities become as tailored as possible to market opportunities and the needs of society".

This short overview points at goal conflicts, inconsistencies and uncertainties in the university-TTO relationship. A major inconsistency is related to the key mission of the TTO; it was asked to search for the best ideas in the technological departments but at the same required to be a service unit for the whole university, including the "soft sciences". There are large variations in the degree to which these academic units have relevant ideas and results for commercialisation. A very wide set of tasks was set for the unit, and several interviewees could not easily answer the question about the core tasks for the TTO (or they gave different answers). Another problem was the initial emphasis on spin-off companies rather than IPR protection.

Some tensions were also created when the new unit was set up outside of the existing support structure, even though there was no systematic analysis of strong and weak points about the previous support structure for commercialisation. Regional TTO-like organisation LEN lost most of its idea source overnight, even while the university maintained ownership in LEN. It took two years for the university and SINTEF to reduce their ownership and create a situation with fewer personal conflicts. One explanation might be that the university had many other things to think about during this period, not least a new indicator-based funding system which cost NTNU 40 millions NOK of reduced basic funding. The university also wanted to set up a TTO unit fast to preserve its image as a proactive and entrepreneurial institution.

Still, a discussion about whether the legislative changes required some more fundamental changes in the university's approach, did not emerge. It was unclear who would inform the faculty about the changes in property rights and about the new disclosure regime, and there was no systematic analysis of how NTNU should handle contracts and property rights generally in the strategy or commercialisation committees. This meant that a uniform regulatory regime did not appear and disclosure may have been unknown or seemed optional. With this unclear mandate, the TTO felt a need to justify its existence through emphasising "high profile commercialization projects" and it spent much effort looking for the one idea with a large potential income. This situation is very comparable to the public university case in Owen-Smith & Powell (2001).

Adverse selection problems

Two adverse selection problems may be discussed: the university's selection of TTO model or type and the TTO's selection of ideas/inventions for further commercialisation. It has already been shown that the organisation of the TTO as an independent for-profit limited company was based on previous experience with external support units, high commercial expectations and a somewhat lacking analysis of the implications of the legislative changes. In addition, the university wanted an "arm's length" relationship free of possible liability questions, and other options to the external for-profit unit were not really considered. Although the university director is chairman of the TTO's board, no detailed attempts at monitoring the performance of the transfer unit have been made. Even the readily available database at the Research Council was left unused. TTO staff themselves emphasised that they wanted to be monitored, "with the right criteria", but they did not develop a transparent and well-maintained project database.

Because no system for disclosure was in place when the legislative changes took effect, the TTO decided to do an active "idea search" in the university departments, particularly in the ones well-known for entrepreneurship and scientific excellence. To some extent this was a frustrating experience for the TTO staff, as it revealed many accidental and "unconscious" attitudes among faculty about signing contracts with industry. The web survey showed that in more than half of the cases of university-industry relationships, the university partner had given away the rights to future results. The search still resulted in a list of more than 200 ideas which was sorted down to 139 formal "disclosures" – too many for the young unit to handle which meant that a lot of ideas were put on hold. Some professors were unhappy about this.

To avoid this situation where ideas are put on hold without any review or evaluation, as well as to fulfil legislative demands that a decision is reached within four months of disclosure, the TTO then adopted what the personnel referred to as the "Top 10 strategy". The main intention is to focus on a few projects with an assumed particularly great potential and then spend as little resources as possible on the rest of the projects. What "Top 10" really implies is not really clear from the interviews apart from a slight concentration of resources compared to the first years of operation.

Senior TTO staff also stressed that very successful examples ("listing on NASDAQ!") could create a good reputation and legitimacy in the academic units.

The new strategy affects both the idea search/disclosure phase and the selection phase. It does imply a somewhat stronger concentration on ideas from technology, natural science and medicine. This was criticised by a number of respondents in the survey, arguing that "I thought this was to be a service unit for the whole university" and "why is it only *technology* they want to transfer". Again, this shows how tensions in the goals affect the operation of the TTO. Its solution seems to be to increase its internal diversification. Some of its sub-units are looking actively for few high potential ideas, while others – most clearly the "ICT and arts" unit – seem to build up a broader portfolio.

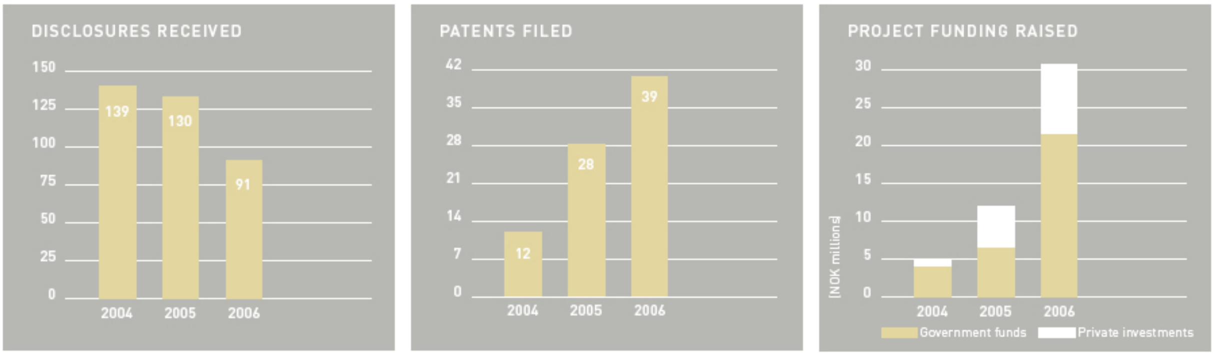

Figure 1: Key data from the first three years of TTO operation. Source: www.tto.ntnu.no.

Figure 2 shows how the number of disclosures has gone down yet the number of filed patents and the volume of project funding raised has increased considerably. The figure indicates that despite certain problems, the TTO has done an impressive job the first two years in acquiring funding and building up a patent portfolio. Interviewees told how selection criteria have developed gradually and bottom-up, resulting in fewer ideas being handled but more of them pass the first selection stages. The gradual expansion of the patent portfolio could indicate that the TTO does not really follow a highly selective "Top 10" strategy after all.

Moral hazard problems

As mentioned, there are two main moral hazard problems surrounding a TTO: lack of disclosure and commercialisation support becoming just a research support mechanism. Most of the Norwegian university TTOs use a "Disclosure of Invention" form to communicate with faculty. NTNU TTO has chosen to have regular meetings with academic leaders to discuss possible ideas and inventions and has downplayed the role of the disclosure form.

This may be a reasonable choice; the survey showed that most of the experienced entrepreneurial academics expressed that the legislative changes “took away one of their most important rights”. Half of the faculty members were not even aware of the legislative changes two years after they took effect, and many research projects involve, as mentioned, industry funding where IPR is given to the external funding partner. This is discussed in the university’s “Guidelines for innovation” although a uniform contract regime has not been developed. TTO staff reported that they often had to spend a lot of time untangling IPR issues in each single case. The moral hazard problem of no disclosure therefore seems highly relevant in the NTNU case.

The legislative change did give the universities the right to all “patentable inventions”, so the universities may be entitled to ensuring that disclosure actually takes place and not least that it takes place through the TTO rather than through faculty’s own firms etc. However, the TTO refused to play the role of “patent police”, as they referred to it, because they needed to establish a good relationship with the academic community. The university administration did not play the police role either, and in practice this could be taken as an indication that disclosure has become optional for the researchers. Unless the researchers actively break the law by commercialising something on their own, the TTO has few sanctioning possibilities for dealing with this type of moral hazard. Many of the interviewees and respondents were quite content with this, praising the lack of a patent police. Some of them also advocated that the best ideas should be commercialised in direct partnership between researchers and industry, while the TTO deals with projects that “require a bit more work”. In other words, one is to some extent stuck with the old model from before the legislative changes but with a new commercialisation unit.

The fear that commercialisation support, e.g. funds for “proof of concept” and “verification” phases, should become just another research support mechanism, seems much less as the volume of these funds is small. In addition, the TTO staff emphasised in interviews how “good scientists make bad entrepreneurs”, and stated that they look for “surrogate entrepreneurs” in many of the most promising commercialisation projects. In this sense they carry out boundary work by attempting a division of labour which keeps the researchers in the laboratory (see Guston 1999:104).

In the interviews and the comments in the survey, there is a fairly strong opposition to the legislative changes and some opposition to the TTO, both significantly stronger from the experienced entrepreneurs. The survey nevertheless shows that there is a high degree of loyalty to the university, and “because the university says it is important" is the third most important motive for commercialisation after "societal and industrial needs". There may be an element of political correctness in the responses, but even the ones fervently against the changed IPR regime deny that they would "circumvent the system". There is, perhaps, at least when looking at the history of the Norwegian universities, a stronger sense of loyalty and institutional belonging at the technical and professional universities like NTNU than at the comprehensive traditional universities.

The incentives and rewards called for in much of the literature may be difficult to introduce in the NTNU case. Although faculty would get one-third of the future income from sale of licenses and other forms of commercialisation, most of them remember a time when "we would get all the income". Their incentives were reduced by the legislative changes in 2003. The TTO's main challenge is to demonstrate added value to the inventions and ideas so that the researcher's share is still considerable. Although the respondents deny that personal financial gain is an important motive for commercialisation, many still admit that commercialisation under the old IPR regime provided some of them with a stable addition to the university salary, which is generally regarded as "far too low".

Concluding remarks

A technology transfer office, even when established at an entrepreneurial university with a strong tradition for commercialisation, may run into problems. As the cases from the TTO literature shows, problems of mistrust, disclosure, selection and monitoring are not unique to the case of NTNU in Norway. Some of these problems may be an effect of the relationship between the university and the TTO rather than organisational and management choices within the TTO unit itself. Principal-agent theory has guided the analysis which has centred on issues like goal conflicts, adverse selection (selecting the wrong agent) and moral hazard (the agent behaves unacceptably). Technology transfer offices have an intermediary or dual position: they are agents of the universities but principals in the relationship to the faculty members.

The university central administration or leadership fundamentally affects TTO performance by selecting an organisational model for it: internal administrative unit, external for-profit/non-profit and external and independent or in partnership with others. In the NTNU case, the choice of model was strongly influenced by some specific historical experiences and high expectations rather than a systematic review of different alternatives.

Furthermore, the university leadership may affect TTO operation by setting certain goals and creating procedures both for this intermediary agency and for the wider population of scientific staff members. One challenge was that the initial expectations to the TTO were unrealistically high and formulated as a certain target number of spin-off companies annually. Another challenge was that the contracts kept being changed and expanded. Over time, the unit was been given other and broader tasks related to regional development and services for the whole university. A third problem was the lack of clear top management support for commercialisation in strategic plans. Unclear and wide goals may increase problems of adverse selection and moral hazard and provide little ground for efficient monitoring. In fact, the university left monitoring of the TTO mainly to the Research Council programme FORNY, which was the transfer unit's most important source of funding.

Another important problem in the NTNU case was that the university did not have a strategy for dealing with the new IPR regime after the teacher exemption clause was removed in 2003. Uniform contract and IPR policies were not developed, and information to the researchers about changes and requirements of disclosure was lacking. This is again problematic with respect to the adverse selection issue and can lead to a situation characterised by "optional disclosure". Many highly profiled faculty members – some with an impressive number of entrepreneurial projects behind them – were strongly opposed to the legislative changes. The TTO was blamed for a lot of things that it could do nothing about, and to some extent it functioned as a scapegoat for the university administration. Although this was probably not intended, it created a boundary between the TTO and the faculty that made technology transfer particularly challenging. Many of the critical comments to the TTO in the empirical material were really critical comments about the legislative changes and other macro developments.

Organising the TTO as an external unit probably has many trade-offs, not least with "optional disclosure" and unclear or unknown rules of ownership. Moral hazard and adverse selection problems may be very high in this model. As other studies have shown, however, an external model might lead to fewer conflicts over ownership than when technology transfer is organised in the academic units.

Finally, the legislative changes – specifically the removal of the teacher exemption clause – can create problems in a system where technology transfer is based on other mechanisms than formal transfer of knowledge through IPR. Efficient transfer used to happen directly between the inventors and potential licensees without the need for an intermediary (see Hoppe & Ozdenoren 2002). A successful follow-up of the new legislation may depend upon the universities becoming more active in monitoring and sanctioning, e.g. somebody taking on the role as "patent police" and warning researchers against circumventing the system. However, the wisdom of the changes may also be questioned as there were only weak indications that a lack of commercialisation of public research was a major problem in Norway. A support structure furthermore existed, although it did not formally bear the name of "technology transfer" units and was located outside of the universities. Instead, the changes has for many researchers constituted a reduction in the incentives for getting involved in commercialisation. The financial incentive is smaller, and the process may seem more bureaucratic with a "disclosure of invention" form and a new and to some extent inexperienced support structure.

Despite all the problems and challenges discussed in this paper, the case TTO seems to be alive and well. It has maintained a bottom-up approach to problem solving and conflicts handling, and it has strived to slowly build up trust and good relations to faculty with a support system that is fairly researcher-friendly. The aim seems to be to avoid the non-disclosure moral hazard problem by making disclosure part of an informal networking process based on an active TTO with strong personal linkages to faculty. Removing the teacher exemption clause has created a difficult learning process, increasingly also involving the university leadership who has recently initiated a process for creating a common IPR policy for all Norwegian universities.

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Barriers to commercialization of knowledge in emerging technological regimes – a comparison of marine biotechnology and mobile commerce

Olav R Spilling and Helge Godø

Abstract

This article presents and compares two case studies on barriers to entrepreneurship and commercialization of research-based knowledge in Norway. The first is on marine biotechnology; the second on m-commerce. The marine biotechnology was developed by academic entrepreneurs. Being oriented towards product innovation, this type of commercialization process has been given recognition and public support. In contrast, m-commerce, which aims at creating innovations in digital mobile communications, has so far not been developed because of structural barriers that block the ICT-convergence that is required for m-commerce development. At present, powerful actors and institutions, having strong interests in existing systems, block the m-commerce development. Furthermore, neither academia (universities) nor public research institutions and public innovation policy supporting mechanisms are helpful for entrepreneurship and innovations in m-commerce. These are more compatible with entrepreneurship and innovation activities that are oriented towards product and process innovation, as demonstrated by the marine biotechnology case.

Introduction

The point of departure for this article[18] is a research project focusing on barriers to commercialization of research-based knowledge where factors hampering and facilitating processes of commercialization are being analysed. The project combines two different approaches. First, commercialization processes are analysed in an entrepreneurial perspective, i.e. the entrepreneurial processes *per se*, and actors involved in these processes. However, the processes are heavily influenced by various contextual and systemic conditions. Thus, this entrepreneurship approach is combined with a systemic approach based on perspectives from the literature on innovation systems and technological regimes. By combining these two perspectives, the objective of our research is to develop a comprehensive understanding of processes of commercialization and factors crucial to their outcome.

Our main focus will be on processes of commercialization in two different systems in order to identify the extent to which barriers to commercialization are system specific or of a more general nature. We analyse two systems which are very different in nature. The first is a regionally confined system of businesses based on marine biotechnology which, to a significant extent, has developed in the area around a specific university located on the coast of northern Norway. A typical feature of this industry

[18] This article is based on the research project "Barriers towards commercialization of knowledge" funded by the Norwegian Research Council, which was finalized in the spring of 2007.

is its high research intensity and long lead times from the initial ideas to the commercial activity primarily aimed at creating product innovation. The second system is an emerging sector related to developing commercial activities based on mobile communication technology, i.e. the use of mobile phones for payment services, denoted here as m-commerce. A typical feature of this system is that innovation is more related to modifying and the application of existing technology in new fields, and lead times for developing new technological solutions may be short. However, the innovation potential of m-commerce may be radical and disruptive because this may create an entirely new economic sector making existing sectors obsolete or redundant. Thus, the technological regimes characterising the two systems are very different.

Commercialization processes

Commercialization may be defined as the process of transferring and transforming theoretical knowledge (Chiesa and Piccaluga, 1998) such as existing in an academic research institution, into some kind of commercial activity. Jolly (1997) defines commercialization as:

> "… the process that starts with the techno-market insight and ends with the sustaining functions of the market-competent product. The problems of commercialization include links between technological discoveries and opportunities, demonstration of technology to opinion leaders, incubation of technology, resources for successful demonstration, market acceptance and transfer of benefits, and selection of proper business tools."

This definition suggests a conception of the processes of commercialization as a stage model in a diffusion of innovation process. Such models generally start with the technology-driven basic development of new knowledge discoveries and inventions, followed by an incubation process in which the business opportunities and business concepts are more systematically explored and developed, culminating with the establishment of a business activity positioned in the market.

In the literature, a number of different approaches to describe stage models may be found (Andreasen and Hein 1986; Cooper 1996; Eeckles and Roozenburg 1999; McAloone and Robotham 1999). For instance, in their discussion of commercialization strategies, Virtanen and Laukkanen (2002) distinguished between the following stages: 1) invention/discovery, 2) proof of principle, 3) demonstration unit/model, 4) working prototype, 5) marketable product, 6) product palette, and 7) established market position.

An important aspect of the commercialization process is that it will often undergo a change from a mainly technology-driven process to a process which is mainly market-driven. In the early stages, it is the opportunities identified and based on technological knowledge that are the main driving forces, and which motivate the actors in their work. During the process, a shift towards increased emphasis on market opportunities will gradually emerge, making apparent how these may be exploited by developing products or services in order to meet anticipated needs in the market. In the final stages, the main emphasis will be on market opportunities and how the business concept and the business strategy may be designed in order to fully exploit these opportunities.

By depicting the commercialization process in terms of stage models, this implies linearity, i.e. where the process goes smoothly through each successive stage. This may be taken as a support for the traditional linear model of innovation, which has mostly been rejected by the development of the interactive innovation model (Lundvall 1992). The point here is not to advocate the revitalisation of the linear model, but rather to point at a way of structuring and provide a basis for analysis. By this we identify stages in the process which may differ from others regarding what kind of knowledge, skills and activities that are important, and which may help identifying important bottlenecks in the process. At each stage issues of specific importance may be identified, and this may in turn provide a basis for developing a framework for analysis (Ndonzuau, Pirnay and Surlemont 2002).

This is not to neglect the fact that processes are generally complex, and do not necessarily follow the 'linear' pattern indicated by the stage model, which explains why some theorists (van de Ven et al.1999) use terms such as 'chaotic' and characterize this as an 'innovation journey'. Hence, actors may go back and forth between the stages, where they may partly combine elements from different stages simultaneously, or important elements from different stages may come in a different order. Furthermore, the actors will also depend on interaction and communication with a number of other actors belonging to the business community as well as the research community. Interaction across our analytical constructs of stages and organisational boundaries are subsequently important for the process, providing the rationale for analysing processes of commercialization in a systemic context.

Innovation systems and technological regimes

The concept of 'innovation system' was introduced during the early 1990s. A basic assumption in this is that innovation is an interactive process and that an innovation system may be defined as the set of actors and other factors that influence the innovation process (Lundvall 1992; Edquist 1997). In our context, the conceptual framework of a sectorial innovation system (Breschi and Malerba 1997; Malerba 2004) is of particular relevance as it focuses on providing an explanation of the distinct differrences between sectors in terms of their innovation capabilities and other characteristics related to innovation dynamics and patterns, such as entrepreneurship and commercialization of new knowledge. In contrast to the conceptual framework of national systems of innovation, the sectorial approach permits a more global and general perspective, explaining why and how sectors evolve by analysing the technological regimes that constitute a sector.

In the analytical framework of sectorial system of innovation, the concept of technological regime (TR) is important. A technological regime may be viewed as a set of important determining factors for dynamic processes within the innovation system. This is inspired by Schumpeter's works on economic development and entrepreneurship, and may explain why the level of entrepreneurship and innovation vary significantly between sectors (see for instance Breschi and Malerba 1997; Audretsch 1997). In the literature two types of regimes are distinguished – the entrepreneurial and the routinized regimes. This distinction explains why the dominant mode of innovation may vary significantly due to characteristics of the technology as well as the organisation of firms in the sector. As an elaboration of this, we will introduce the closely related concept of innovation regime as principles, norms and rules which form actors' expectations and actions (Godoe 2000), and which may be a basis for analysing and explaining differences in innovative behaviour between different sectors.

The aim of this article is to explore and indicate identify factors and dynamics within two different sectors that inhibit entrepreneurs and commercialization of new knowledge. The relevance of this issue becomes particularly apparent in entrepreneurship in various sectors, because the opportunities and constraints on entrepreneurship may be seen as indicators of barriers to innovation. Recently, analysts have suggested that "..the difference between entrepreneurship in biotechnology and other industries is not in the essential ingredients (which are largely the same), but in their proportions (which will vary)". (Hine and Kapeleris 2006, p. 26).

In the research we have undertaken in Norway in marine biotechnology and ICT, a comparison of the two cases suggests that there are qualitative differences between these sectors, both in terms of structural factors and framework conditions for commercialization of knowledge that are significant, and which may plausibly explain why sectoral systems of innovation differ.

Empirical approach

The main approach in this article is to compare two systems that are different in nature, i.e. marine biotechnology and mobile commerce, and to conduct extensive studies of processes of evolution and commercialization in these two systems.

The sector of marine biotechnology is a part of the larger sector of biotechnology, and is characterised in terms of its source material rather than the markets it serves (Biobridge Ltd 2005). The sector is strongly related to fishing and fish farming, partly by being based on raw materials obtained from the sea or by-products from the fishing industry, and partly by providing food ingredients and health related products to these industries. The industry is also an important provider of health-related and dietary products for human use.

Although knowledge of fish farming and the genetics involved in breeding fish has existed for thousands of years, marine biotechnology has a history that commenced with the breakthrough created by the discovery of DNA early in the 1950s, and the subsequent growth of molecular biology as an academic discipline. Since then, biotechnology has rapidly evolved into a large knowledge area with many sub-disciplines and specialized technological domains. Marine biotechnology is one of these. As such, marine biotechnology has the potential to contribute to every industry sector, from healthcare to bioremediation, from cosmetics to nutraceuticals, suggesting that marine biotechnology can contribute to marine as well as non-marine sectors. However, developing and exploiting discoveries in these sectors is difficult without a coherent strategy for investing in research and in proof of principle, an effective technology and knowledge transfer system, and a sensitivity to existing and emerging markets (Biobridge Ltd 2005). Funding these processes can be extremely costly.

In our studies of marine biotechnology, we have focused on a specific regionally based system developed around, and in close interaction with, the University of Tromsø, in northern Norway. It is widely recognized that the university and its research activities have been an important driver in developing the actual cluster of firms engaged in biotechnology in the Tromsø area.

The empirical analysis is based on a holistic approach in which a first step has been to map the development of the whole system by analysing secondary data, partly obtained through open data bases and also through the firms' own web pages. We have also been in direct contact (via e-mail) with most of the firms and collected brief information about their start-up processes and their relations to the university. This has been supplemented with information obtained from all relevant public support agencies located in the area. Furthermore, four in-depth case studies have been conducted based on interviews with the entrepreneurs and managers of the firms, where we analysed the respective processes of entrepreneurship and commercialization.[19]

In total, the empirical data provide a good overview of how the regionally-based system of marine biotechnology related to the university city has emerged, what have been the main driving forces in the processes of evolution, and who have been the

[19] An analysis of the four entrepreneurship stories is presented in Spilling, in this volume.

main actors in the processes. Within this framework, we have also explored how the system functions what characterises processes of commercialization.

The research on m-commerce is based on case studies of companies in Norway that are involved in electronic funds transfer (EFT) and related ICT services and product development, in particular for mobile communications services. These were undertaken in 1998–2002 (covering the 'dotcom-period') and during periods between 2005 and 2007. Some of these are multinational corporations; however, most of the firms are SMEs.

In the research carried out 2005–2007, focus was set on four companies, all having an interest in developing and providing services for mobile communications, however, these ambitions were hampered by problems associated with m-commerce. Apart from this, they were very different. The smallest firm had only two employees and had existed for less than two years, doing a shoestring operation. The largest is a multinational corporation with more than 10,000 employees worldwide, and a long history. The third company is five years old and has approximately 40 employees. The fourth company has about 200 employees and has existed for approximately fifteen years.

The largest company may be characterized as a system owner and operator, the next largest as a sub-system owner and operator, while the two smallest could be characterized as companies attempting to commercialize niche innovations. In this endeavour, they have had some success, but these also are hampered by the problems encountered by the m-commerce development.

Although all the firms in the m-commerce study use and develop technological solutions that require a high level of technological and business competence and knowledge, this type of knowledge is not prominent on the curricula and research agendas of universities. Mostly, the knowledge is developed within the firms, but they also rely on knowledge from specialized public R&D institutes and R&D intensive supplier companies. The typical entrepreneur is an ICT engineer with some MBA-type of management education. A few entrepreneurs did not have an engineering background; however, all the entrepreneurs were highly educated, i.e. having university degrees at MA and BA levels. Another common trait was that all the companies in some way or another had business model plans related to m-commerce, and that these were contingent on systems and institutions outside their control and command – an aspect that represented a barrier for commercialization for these firms. This aspect will be elaborated further in a later section in this article.

Although there is an underlying basic conceptual framework that has been guiding our investigations of the two sectors, we also take a 'grounded' approach in the sense that the first stage analysis of each sector focus on defining who the main actors are, what characterizes the evolution of the sector, and the first description of each system will be based on these characteristics. This means that the first models we are coming up with, are very different for the two systems. In the next stage of our analysis, however, we compare the two systems and then analyse them based on a common framework.

The marine biotech system

The history of the marine biotech cluster in Tromsø may be traced back to the early 1970s when the University of Tromsø and the closely related Norwegian College of Fishery Science were established.20 This was followed up by the establishment of the Institute for Fishery Research one year later. Being parts of a targeted regional development strategy, the institutions were developed in order to serve and interact with the local community and regional industries through a focus on biotechnology and marine biotechnology research and other disciplines relevant to the fishing and fish-related industries. These three institutions have provided an important scientific base for the later development of the marine biotech cluster.

While the first decade of operations was mostly characterised by interaction with the existing industries, a new development gradually emerged in the mid-1980s when several new firms based on marine biotechnology knowledge were established. Some of the new firms were spin-offs from the Department of Biotechnology and other departments – the first pioneer to start a new business was actually a professor in biotechnology (Arbo 1999). Other new firms were started by more independent actors, but in many cases these entrepreneurs also had their background from the university. Although the industrial cluster is not large, there has been a steady growth. Generally, there have been 1 or2 new ventures annually but not all have succeeded, and among those which have survived, some have been integrated in larger corporations. By now (2007), the entire cluster accounts for between fifteen and twenty companies, employing between 200 and 300 employees. Most of them are fairly small: only four have more than 40 to 50 employees.

In parallel with the development of this industrial cluster, a differentiated structure of supporting, intermediary organisations from the mid-1990s was also developed, including a science park and an innovation centre, an incubator and technology transfer organisation. Various programs have been organised and more informal arenas been involved in order to strengthen networking activities between the actors. In particular, two organisations should be mentioned as particularly important (Figure

[20] The institutions were originally established as independent organisations. Later, the College of Fishery Science has later been integrated in the University and now serves as a separate university department.

1). One of these is Norinnova which organises the science park and the local incubator and innovation centre, and which also manages a local seed capital fund. Norinnova has been especially important in taking various local initiatives to facilitate knowledge-based industrial development in the region. Among these initiatives was the organisation of a regionally-based research program – MABIT (marine biotechnology in Tromsø). This program has been important for stimulating and coordinating research activities of the marine biotech firms in the region.

An overview of the marine biotech system is provided in Figure 1 and gives an indication of what we regard as the main actors and the main structure of the system.

Naturally, the core part of the system is constituted by the marine biotech firms themselves and other relevant actors in adjacent industrial sectors as well as financial actors and industrialists. However, in this case the university and related institutions have been very important for providing the knowledge basis for the new industry, while the intermediary and supportive actors have been important for facilitating development, particularly since the mid-1990s.

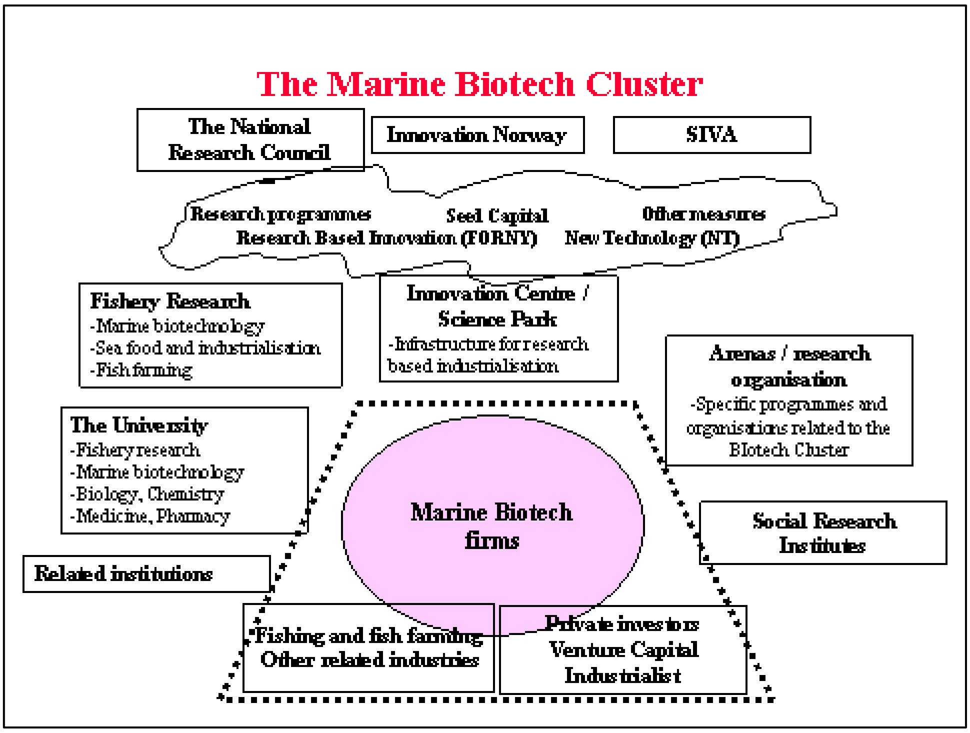

Figure 1: The Marine Biotech System

Typically, the new firms have developed in interaction between a number of actors, and the process of entrepreneurship may occur in many ways (Birley 2002; Carayannis et al 1998). Based on our mapping three types of start-up process may be distinguished:

1. The classical spin-off in which an academic, or a team of academics, start their new venture directly based on their research results, such as professors or PhD candidates.
2. The hybrid variant, in which an alliance between academics and external industrial actors is established, and the new firm is founded on the research-based knowledge of the academics and the economic, industrial and other resources which the industrial actor has access to.
3. The industrial variant, in which an independent industrial actor is the main driving force and initiates the new venture in collaboration with personnel with relevant background.

Within the cluster, each type has almost similar number for firms. Additionally, there also may be identified case of complementary start-ups in which the firms' knowledge base may be in completely different areas, for instance mechanical engineering, to provide services of great importance to the cluster.

There are many factors that influence the opportunities for start-up, and to what extent opportunities actually are recognised and exploited. One important factor is the prevailing culture of entrepreneurship in the region, and to what extent academic staff and their surrounding community are oriented toward entrepreneurial activities. While the University of Tromsø has a background as the 'red' (socialist) university with rather negative attitudes towards involving academia in commercial activities, this culture has changed significantly in recent years. Another important factor is the structure of the academic disciplines and the organised interface with industries and to what extent there is focus on industrial applications and the identification and exploitation of commercial opportunities. From this perspective, there has been a long tradition of regarding the university and the related research institutes as an important basis for regional development.

Another important factor that heavily influences opportunities of commercialization is the structure of the relevant innovation system, how this is made up with different actors and resources, and the relationships within the system. There must be a critical mass of actors, resources and relationships to provide a high number of potential combinations. Generally, the system may be characterised as fairly small, and in spite of relationships to actors outside the system, and a number of efforts to build local arenas and relationships, there are still probably important bottlenecks to the evolution of the system related to the small size of the system.

This is confirmed by some of the firms in the system which point at the fairly weak industrial and financial environment that makes it difficult to establish adequate alliances and acquire long term and 'patient' risk capital (Arbo and Isaksen 2002). Most start-ups we have examined have, in one way or another, been based on alliances with one or more partners in order to get access to resources crucial for the new venture, like financial means, production facilities, laboratory facilities, marketing resources, market access, etc. However, building relationships through alliances is a demanding task, and in several of the cases, for various reasons, significant problems have developed in their relationship with their partners. Generally, the development of the new ventures is often characterized by a high level of turbulence. Hence, the entrepreneurs' capability to redefine their business concepts and develop new constellations of resources is important for the survival of their ventures.

Thus, barriers to commercialization and the development of new ventures may be related to many different factors. This is followed up in the final part of the article.

Mobile communications and the m-commerce system

In an international comparison, Norway is very advanced in terms of ICT proliferation, specifically in the sophistication and scope of digital mobile communications, of which the GSM-system is most renowned. According to recent statistics, there were 5 million mobile telephone subscriptions in Norway, i.e. a penetration rate of 106 subscriptions pr 100 inhabitants.

Other Nordic countries have similar figures for the distribution of mobile telephones in their population. Similar to Denmark, Norway does not have any large and successful ICT equipment manufacturing companies such as Nokia in Finland and Ericsson in Sweden, but it is still part of a Nordic ICT-development community focused on mobile communications. The co-development of broader bandwidths for mobile communications has given rise to increased use of mobile phones for various Internet services, in addition to voice and SMS-services.

M-commerce may be defined as the use of mobile phones for the transaction of either physical goods using mobile handsets as wallets or credit cards (merchandising), or mobile services such as ringing tones, games or any other service that may be mediated by a mobile telephone (Nielsen 2006). In general, the technological potential of digital mobile communications has opened up numerous commercial opportunities in the new systems. Many entrepreneurs, seeing business opportunities, have swarmed into these fields; these new services are also perceived as highly attractive business potentials in the telecom sector, specifically to mobile communication operators. Contrary to SMS, m-commerce has not enjoyed much success, raising the question of why.

In the research on m-commerce, we pursued this question, first by asking entrepreneurial firms that we knew to have some type of plans for m-commerce, asking them their opinion and explanation for why m-commerce so far has failed to materialize. They did not provide a coherent answer. However, two factors emerge from their explanations: banks and the financial sector do not want to loose their grip on the present system of EFT (electronic funds transfer) based on the use of magnetic stripe cards at points of sale in shops, etc. Apart from providing banks with a lucrative, steady supply of income through service charges, this is important for their lock-in strategy which until now has provided them with a *de facto* monopoly in EFT. Banks will probably promote m-commerce in the future; however, they will do this gradually in order to preserve their hegemony in EFT, which implies promotion of its present system based on scriptural money. The other factor, which reflects this, is that firms outside the banking community have been able to develop informal, proprietary quasi-monetary systems that to some extent bypass the EFT system controlled by the banks. These systems have enjoyed some limited success. However, m-commerce that uses the technological potential of mobile communications has so far failed to materialize in Europe and USA: only in Japan and Korea is there evidence of some success with m-commerce for reasons that are not relevant in Europe and USA.

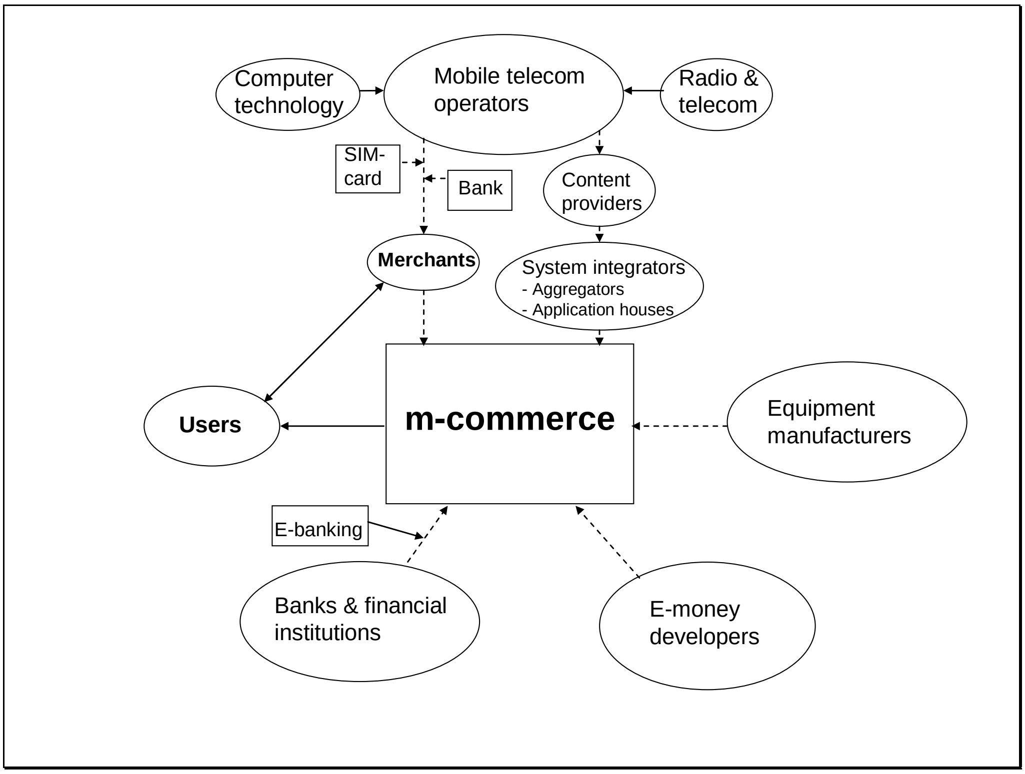

Figure 2: The 'landscape' of a potential m-commerce system

As shown in Figure 2, the landscape from which m-commerce will emerge is complex, being composed of a number of different sectors in command of their own systems, value chains and technological regimes. One may suggest that in this landscape the sectors and institutions have conflicting interests, to such an extent that the interest of one represents a barrier to the other, thereby obstructing initiation of convergence dynamics needed for m-commerce. Some of the most important of these dynamics are:

- Banks and financial institutions
- Mobile communications operators
- ICT equipment manufacturers
- Institutions related to money and trust.

Banks and financial institutions now enjoy a *de facto* monopoly on EFT – Electronic Funds Transfer. Although they are technologically advanced in many ICT areas, their main strategy is to maintain their hegemony over EFT, which is most conveniently carried out by having control of their own infrastructures and ICT systems. They do not want to let other actors into this – and they are able to justify this in terms of security and the trust-factor. This may possibly explain why they have not taken strong initiatives in m-commerce whereby they basically maintain a reactive, defensive strategy.

Mobile communications operators perceive EFT and m-commerce as a business opportunity with a considerable growth potential. However, this requires that they are able to take care of payment functions, i.e. functions that banks now control. Although some mobile communication operators have petty cash banking licenses, the leap towards becoming ‘real’ banks seems difficult to them for many reasons. One is the fear of provoking the banking system, which is politically powerful and may harm them. Secondly, banks and financial institutions are important customers of communication services; the risk of loosing them as customers is considered high. Thirdly, they lack the expertise for banking and EFT.

ICT equipment manufacturers would like to enter into the business domain of mobile communications operators; they think that they could enhance their business opportunities by by-passing operators. One strategy is to make handsets without SIM-cards, a technological solution that enables mobile operators to exert control over their customers. However, in addition to lacking expertise in banking and EFT, they also lack a customer base.

Institutions related to money and trust are essential because m-commerce represents a novel mechanism for economic transactions. Banks and financial institutions base their EFT on *scriptural money*, that is transfer of figures between accounts in their systems, either in internal systems or by means of clearing houses (Ingham, 2002). So far, electronic *fiduciary money* has not had any success, which explains why the use of physical cash still exists. Regardless of type of money, trust is very basic to diffusion of m-commerce. All actors involved, specifically users and 'merchants',[21] need to feel that engaging in m-commerce is absolutely trustworthy.

The picture that emerges is a landscape characterized by fragmentation, i.e. conflicts, tensions and divergent sectoral interests and institutional incoherence. In this landscape, there is apparently no overarching innovation regime that has the strength to create solutions, e.g. business models, which would promote m-commerce to the benefit of most stakeholders. Because of the complex interdependencies and complementarities involved, no single actor or sector seems capable of imposing its own solutions. Furthermore, it lacks a selection environment or a 'market for standards' that would initiate an innovation dynamic.

Comparison of the two systems

As demonstrated in the previous sections, there are significant differences between the two systems in terms of the composition of the systems as well as how commercialization processes evolve. Thus, there will also be significant differences in how barriers to commercialization work in the two systems. To facilitate the discussion, a framework is suggested as outlined in Table 1.

System and technology characteristics

The marine biotech system is characterised as having a strong focus on industry building processes. The interaction between a number of firms, the university and research institutions, and various support organisations, is well organized. Apparently, the systems have developed a dedicated interest in building the industry. The main challenges of the system are related to the composition of the system, availability of various actors and resources, and to building competencies and capacities for industrial exploitation.

In m-commerce, on the other hand, there is a main problem related to conflicting interests between different dominant actors primarily embedded in systems other than m-commerce (e.g. banking, communication operators), and with a strategic focus on other industrial core areas than developing m-commerce. While the marine biotech system is consolidated around a commonly accepted industry building strategy, the m-commerce system is still not established. Thus, barriers to commercialization are manifested in very different forms in the two systems.

[21] 'Merchant' is a common term for the role of anyone who is recipient in an electronic transaction in a point of sale setting.

Table 1: System specific characteristics of relevance to barriers towards commercialization

	The Marine Biotech System	**The M-Commerce System**
System and technology		
System characteristics	Small system with 15-20 core businesses and a generally weak industrial environment, complicated and fragmented support structure	As yet non-existent in Europe and USA, only limited systems in Japan and Korea. Convergence of complex institutional and technological infrastructure required.
Science and technology – general characteristics	High R&D investments in companies, generally long lead times from research to industrial applications	Will require some application and system integration development, but these are not complex.
Science–industry relationships	Close relationship between science and industry, strong emphasis on industrial applications in research departments	In 1990s, close relationship in some areas, e.g. development of cryptographic solutions, but less important now.
Barriers to entry – system specific	Weak industrial environment; limited access to potential industrial partners	Institutional and political – banks and financial institutions guard their present position.
Entrepreneurship and commercialization		
Culture for entrepreneurship	Originally negative to commercialization, significant change towards more entrepreneurial and opportunity oriented culture	Basically positive, but institutional barriers and vested interests in status quo has discouraged entrepreneurship.
Entrepreneurs	Often academic staff who start based on their own research activities or people with background from the University who have later obtained industrial experience.	Highly educated, usually engineers and business school graduates, but their entrepreneurship not based on ideas obtained during education or research.
Barriers to entry – technology and product specific	Mainly inherent qualities in the product and process technologies	Few, barriers are mainly related to systemic factors.
Industrial structure and dominant actors	Mostly small and partly marginal companies, a few larger actors. Fragmented and weak structure.	Strong sectoral power and institutional interests, e.g. banks, equipment manufacturers, operators, etc.
The role of universities and research institutes	Partly close interaction with industries, strong focus on industrial applications and commercialization. Serve as an important and active knowledge base for industrial development	Not so relevant, apart from some very specialized areas, e.g. cryptography, etc.
Policy measures		
Support structure for commercialization	Differentiated and cluster specific structure which plays an active role; however tendencies of overorganisation and too many small actors	Not so strong, apart from some directed at specific product development projects.
Risk capital	Has traditionally been an important barrier, but the situation has improved due to public seed capital and inflow of private investors	Not relevant at present; availability of risk capital will not remove barriers for entrepreneurship in m-commerce.

Commercialization in m-commerce involves the development of service concepts embedded in long and complex value chains, technological interdependencies and infrastructures, which in turn have strong institutional alignments (banks, telecom operators, software, etc.), i.e. complex systemic innovation and commercialization processes. As a potential innovation, m-commerce may be viewed as a systemic innovation, i.e. composed of technological elements that are highly complementary and interworking by means of complex network structures.

Although this requires each interconnected element to have high compatibility and hence clear interfaces, the heterogeneity of various elements could also provide opportunity for creativity and entrepreneurship, and, ultimately, provide opportunities for creativity for the development of new products and services. The technological or knowledge barriers for this are not substantial, but because of the institutional barriers, entrepreneurs have used their creativity to construct technological solutions that will bypass these obstacles.

In contrast, commercialization in marine biotechnology is more related to autonomous product development, aimed at substituting or supplementing existing products. Generally, industrial activity in marine biotechnology is based on high investment in R&D, and the lead time from research to industrial applications is generally long.

In the case of marine biotechnology, because close relationships and interactions between science and industry have been developed, the institutions address challenges related to industrial development through basic research as well as applied research.

In contrast to this, the m-commerce system is characterised by less interaction with universities and research institutes, and the specific issues related to developing this system is on the agenda of the institutions to a lesser extent. The type of R&D and innovation-oriented activities are often ICT-application oriented, directed to making a service embedded in a product (e.g. terminal) function within a system. This requires a type of implementation-oriented knowledge and skills which are generally not well-known at universities, even if these require a high theoretical understanding and competence.

Entrepreneurship and commercialization

While the culture for entrepreneurship at the Tromsø university campus was originally negative and even hostile to commercialization and to active interaction with industry, this has changed significantly during the last two decades. The institutions are now much more oriented towards commercialization and the industrial application of their research activities. However, entrepreneurial activities are still hampered by a weak industrial environment which provides few opportunities for establishing adequate alliances for new industrial ventures.

In the ICT sector, the culture for entrepreneurship has generally been much more positive, and there are fairly long traditions for strong entrepreneurial cultures related to this. In the case of m-commerce, however, entrepreneurial activity is hampered by institutional barriers and vested interests in the status quo.

Entrepreneurs in marine biotechnology are often research scientists who have made inventions or created ideas based on results of their scientific work. In m-commerce, entrepreneurs have engineering and business school education, but are less academically-oriented compared to marine biotechnologists. One reason for this is that until recently, there were few, if any academics at universities who were interested in m-commerce, just as no strong interest has existed for other ICT innovations that have had a profound impact on society. This, of course, may be explained by the institutional bias of academic institutions, because of their orientation towards disciplines and agendas set by these. The type of academic entrepreneurship found in biotechnology also exists in ICT, however. These are seen in the development of components, materials, limited parts of software development and techniques (e.g. croptography) etc., in the type of knowledge that may easily be transferred and developed into product and process innovations.

Due to the systemic and complex structure in m-commerce, entrepreneurs in this field pursue commercialization strategies that are symbiotic with the system, i.e. they attempt to develop new niches compatible to the systems involved because the barriers, which are formidable, are structural and institutional. Yet, because of the success of mobile communications, stakeholders who defend the status quo now seem to realize that they need to develop complementary services and value chains involving partners outside their traditional control. This may represent new opportunities for entrepreneurs and, as a result, contribute towards the type of convergence that evolution towards m-commerce as a new sector will require.

In marine biotechnology, the main barriers to entry are partly related to the weak industrial community, and limited opportunities to organised adequate combinations of actors and resources. Partly, they are related to inherent qualities of the product and process technologies, and the frequent huge investments in R&D required to develop industrial activity.

The success of m-commerce depends on the systemic process of convergence in ICT. This entails intertwining of vested interests of powerful economic sectors that are now comparatively autonomous. Hence, commercialization depends on institutional and political factors in addition to technological factors. This may require some type of political entrepreneurship or agency for restraining the power of strong industrial players and actors. This type of entrepreneurship has so far not emerged, possibly because of low public awareness of the political and economic issues involved.

In marine biotechnology, the system is consolidated around its industrial development. However, the system is fairly weak with a small number for firms which actively contribute to the system. The industrial structure is more fragmented where

SMEs constitute the majority of firms, and so far there are no more than three or four firms of any significance.

Although commercialization and entrepreneurship in m-commerce and marine biotechnology is different, this is not reflected in the organisation of knowledge production in universities and research institutes. During the 1990s, most universities expanded their ICT departments and curricula, typically under the label of ‘computer science’ parallel to giving high priority to biotechnology. As academic institutions, they focus on disciplines and research has become highly specialized.

In the case of marine biotechnology, the structure of university departments and related research institutes and other infrastructure which specifically addresses the needs of the region has been developed. In many fields, these have a strong focus on industrial applications and commercialization, and the institutions have developed a significant knowledge base for industrial development within the system of marine biotechnology. In many respects, the university is the most important factor behind the recent development of the industry.

In contrast to this, the organisation of universities is of less relevance to the specific development in m-commerce, mainly because this is systemic and, in an academic context, transdisciplinary, which is problematic in any academic setting. This may be paradoxical, because if m-commerce becomes an innovation, this could become radical and highly disruptive for the economic system, and hence should be of great concern for a university. In history, many radical innovations have emerged without involvement of universities, but at present, this lack of interest is difficult to understand. This point, which may have policy implications, will be discussed further below.

Policy measures

In the case of marine biotech, a differentiated structure of support agencies and intermediaries for commercialization has emerged, and to a significant extent this structure is developed in order to address the specific challenges of the marine biotech system. For instance, a specific research program in marine biotechnology has been organised, and a number of analyses over the years have been conducted to investigate the future potential for industrial development.

In contrast, m-commerce does not have a public support structure. The specific reason for this is that m-commerce does not involve development of tangible products or processes because of it systemic nature. Generally, public industrial policy supporting organizations does not support development of system innovations if these are outside public responsibility, although there are notable (and highly successful) exceptions, such as the US military agency DARPA's role in the development of Internet in the 1980s and early 1990s (Simcoe and Mowery 2002).

Access to risk capital has traditionally been perceived as a significant barrier to innovation and entrepreneurship in Norway, and in particular this may have represented a significant barrier to commercialization in areas located far away from the Oslo region. However, the situation improved significantly during the last decade, partly due to a number of policy measures to provide traditional venture capital as well as seed capital, and partly due to a vitalisation of the private risk capital sector.

Lack of risk capital has probably been a greater barrier in marine biotech than in the ICT sector, while there are currently few indications that this represents a barrier to development in marine biotech. In the case of m-commerce, the issue of risk capital is not relevant at the present due to the other and more significant systemic barriers to commercialization.

Policy implications

As illustrated by the analyses of the two systems, processes of commercialization may be very complex, and there is no simple recipe for how a policy may be designed in order to facilitate the development of emerging systems. On the contrary, one conclusion might be that policy makers should pay respect to the complexity of the processes and acknowledge that there are limited opportunities for designing policy measures which may have a significant impact on the development. The primary drivers of evolution are the entrepreneurs and the incumbent firms, not the policy-makers. However, the role of policy may be to develop adequate framework conditions and stimulate the development in areas where important bottlenecks or barriers are identified.

In an innovation policy perspective, the comparison of marine biotechnology with m-commerce highlights a fundamental difference between activities that are oriented towards making product and process innovations, and those that have a systemic goal. As shown, universities and public research institutes are much more compatible with the development of product and process innovations than with systemic innovations. This also explains the type of academic entrepreneurship observed in marine biotechnology. With m-commerce, the situation is different because its systemic character requires a much more transdisciplinary approach in academia, and strong political commitment for making a systemic innovation in a policy perspective. Although 'everyone' acknowledges that transdisciplinarity is beneficial for creativity and innovation, the bottom-line is that academia and research funding organizations do not encourage transdisciplinarity. In order to solve this structural and political paradox, a different type of innovation policy approach needs to be developed.

Below, a few aspects of innovation policy related implications of this study will be discussed.

In the case of *m-commerce,* the previous analysis illustrates that the most important policy issue may be to influence framework conditions in order to prevent dominant actors from blocking the evolution of the emerging system. In particular, two aspects are important, i.e.:

- the de facto monopoly of the banks in electronic funds transfer, which blocks for the development of new forms of electronic transfer required for m-commerce,
- the absence of an innovation regime for m-commerce which could facilitate the development of new standards required for the new system.

The implications of these factors are that innovation policy should be coordinated with other policy fields like economic policy. Moreover, an adequate innovation regime for the new system should be established in collaboration between governmental authorities and agencies, and other relevant industry actors. Cross-sectoral approaches are required, and parallels may be drawn to the previous development of the Internet, GSM and other radical innovations that were promoted by new innovation regimes.

Following up on this, a more general issue may be raised regarding how a policy regime may be developed on the one hand, to monitor the current innovation system and identify its strengths and weaknesses, and on the other, to develop routines for searching and identifying fields of potential policy intervention.

In the case of *marine biotechnology*, our analysis illustrates how the evolution of a regional system may go on for several decades. The new system has developed gradually, one event following the other. To a significant extent, the current system may be recognized as being the result of a long-term strategy for regional development in which a number of policy fields have been coordinated, like university policy, R&D policy, industrial policy etc., and more recently the national innovation policy has also been of importance.

On the one hand, this case illustrates how it is possible to build a 'complete' system in terms of various institutions which facilitate the new development. On the other hand, however, the case also illustrates the importance of the local context, and the limitations of policy to facilitate the evolution of new clusters beyond the local industrial base. In spite of the long term and coordinated efforts between various authorities and agencies, the actual cluster is still in a fairly marginal position; one of the main problems being the weak industrial structure of the area and the limited opportunities for new businesses to develop adequate alliances or partnerships with other regionally based actors. Still, this shows that a targeted policy, i.e. ‘picking winners’ has its merits.

The material presented and analyzed in this article accords well with other studies that portray commercialization as generally a complex process. The uniqueness of each case – each case being more or less idiosyncratic – amplifies this aspect. This makes prescription of policies and strategies aimed at increasing commercialization challenging. Still, there may be unexplored potentials for making some adjustments of policy measures and initiatives that could boost innovation and commercialization activities. This may be in the field of system innovations, as illustrated by the case of m-commerce in this article, or the introduction of new procedures in policy measures that are more clear and simple, as supported by the findings from the case of marine biotechnology.

One key issue related to emerging systems and processes of commercialization is finding a realistic annual rate of new commercializations. As indicated by the regional system of marine biotechnology, the annual number of new spin-offs is fairly low, and may stand in contrast to general expectations in this field. In Norway, at least, there have been tendencies of a hype related to the organisation of technology transfer offices at the universities, abolishing teacher’s privilege, and the transfer of IPR to the universities.

One approach to this question is a comparison of the achievements with other, comparable public programs designed to promote innovation and commercialization. In reports from the major program in Norway for commercialization of university research, statistics indicate that the average number of commercializations per university is fairly low (Bolkesjø and Vareide 2004). Although comparable international data are difficult to obtain, at least some data indicate that Norway in no way seems to perform worse than other countries (Rasmussen et al 2007, EU 2004). However, it will be an important task in the future to develop better comparative statistics in the field of commercialization in order to improve understanding of what should be reasonable expectations to university spin-offs and commercialization.

Based on this, we will summarise this article by pointing at the following challenges in developing an adequate innovation policy:

Challenge 1: Create more realism in expectations as to the potential for commercialization by improving the knowledge base.

Policy needs to develop a more realistic sense of what potential exist in various academic groups for commercial developments.. In this, analyses should be sensitive to the fact that academic groups are highly heterogeneous and that these play many different roles. Commercialization may be one of these. However, many academics are not interested in working with commercialization. In addition, there is an inherent competition, possibly a conflict, between commercialization and research; many academics feel that commercialization may be detrimental to research. For this reason, policy should balance these interests and other obligations that academics are expected to fulfil (e.g. teaching). Still, these types of considerations need not be seen as giving commercialization lower priority; what is needed is more knowledge on the relationship and interdependencies of various roles that university people have.

Challenge 2: Develop realistic, long-term strategies.
As shown with the marine biotechnology case from Tromsø, development of this community has evolved over a long period. This accords well with findings from other commercialization efforts. The pace of development is usually incremental and slow, i.e. gradual and not governed by political fiat.

Policy should recognize that commercial development needs a patient, long-term perspective – and that policy instruments need to adjust to the developmental pace of commercialization. A number of policy initiatives have set time-limits that are too short, creating discontinuity and disruption in the support that nurtures development of fledgling firms and spin-offs. For this reason, the time horizons of policy measures should be extended considerably. However, within such long-term perspectives, policy should simultaneously develop mechanisms that undertake systematic evaluation of how various projects develop, and adjust their portfolio of support accordingly.

Challenge 3: Developing system-related innovation competences and capabilities.
Commercialization of novel products and services related to large systems should become a topic in policy and in R&D strategies. Although system approach often is stated as a goal in innovation policy statements, this is not reflected in policy measures and instruments and which more often than not are fragmented. Furthermore, innovation policy has a low awareness of issues and challenges related to development of innovations in systems. The implication of this aspect was demonstrated in the case of m-commerce commercialization. As seen, this type of development depends on factors and dynamics on a national or even international scale. However, this is also relevant in a regional perspective, as seen in the case of marine biotechnology in the Tromsø area and affiliated clusters of projects.

Innovation policy should place greater focus on how systems work as systems – and development of innovations in systems. This should also encompass analyses in evaluations, i.e. become criteria in evaluations. Current evaluations are too focused on individual projects. By this, the systemic perspective tends to become weak or absent, and insights into the totality of policy measures at a system level are not developed. In these types of overall system analyses, evaluation should attempt to identify bottlenecks and other specific barriers that are detrimental to commercialization, as shown in the case of m-commerce in this article. Hence research agendas and programs should be organized to accommodate strategies that are related to systems development. Although many policy measures and programs are designed for promotion of commercialization in specific industries or technological fields, these nevertheless seem to ignore how innovation systems work because system perspectives are not taken into consideration.

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On the role of academic staff as entrepreneurs in university spin-offs – case studies of biotechnology firms in Norway

Olav R Spilling

Abstract

The purpose of this paper is to discuss the role of academic staff in processes of commercialisation. Taking the recent literature on commercialisation processes as its point of departure, the paper summarises contributions to describing commercialisation processes, various types of spin-off processes and the roles that may be taken by academic staff in such processes. The paper takes an explorative approach, and analyses the stories of four spin-off companies which all belong to the biotechnology sector, all part of an emerging cluster of firms developing in the local and regional area around one specific university.

In the paper, various aspects of the commercialisation process and the role of academic staff are discussed. The entrepreneurial approaches are very diverse, from the professor who in collaboration with his students initiates the whole process and continues his research tasks in the new venture and combines it with his position as professor at the university, to the academics who leave the university and gain various sorts of experiences and then start their new venture based on minor contacts with the university. The results are discussed in view of the theory, and a classification of the cases based on the role of the academics and their links to the university is suggested. Based on the two dimensions of research commitment and entrepreneurial commitment, a typology with four categories are suggested: the entrepreneurial professor, the industrial entrepreneur, the research oriented entrepreneur and the production manager.

Introduction

Over the last decades, an increasing interest has developed in the field of technology transfer from academic institutions, and as part of this a growing awareness of the importance of university spin-offs and academic entrepreneurship has evolved. The purpose of this paper is to focus on university spin-offs and analyse the role of academic staff in the processes of developing new firms spinning out from universities. While the concept of academic entrepreneurship may be perceived as a fairly wide concept including all types of entrepreneurial activity conducted by academic people, the concept of university spin-off focus more narrowly on the businesses starting up based on new knowledge developed in a university department or a related research institute (Shane 2004). In this paper, focus is on the fairly complicated processes that may follow in the attempts of developing a new business based on research results, and in particular focus is on the role of academic staff in such processes and how academic staff may contribute as entrepreneurs in the formation of new spin-off businesses.

The literature on academic entrepreneurship, commercialization of research based knowledge and university spin-offs is fairly rich. However, much of the literature is based on a simple stage model approach for analysing processes of commercialization, and there are tendencies of overlooking how complicated such processes may be. Furthermore, although there are some important contributions to the discussion of the various roles academic staff may take as entrepreneurs, there are tendencies of providing a very simple picture of what the role of academic staff may be.

The reason for this may be that much research in the field is based on surveys and cross-sectional approaches, which do not provide opportunities for following how the processes of commercialization evolve over time and to go into details about the complexity of such processes. Neither will these approaches provide good opportunities for discussing the variety of how academic staff may contribute to the commercialization process.

In this paper the analysis is based on a longitudinal case study approach. Four spin-off firms have been selected for study; all four cases belong to the biotechnology sector and they are part of an emerging cluster of firms developing in the area around one specific university located in a city on the Norwegian coast. Based on the examination of the story of these four spin-offs and the entrepreneurs starting and developing the firms, the purpose of the paper is to develop more qualitative insights in processes of commercialization and the role of academic staff in such processes.

Although the main focus is on the entrepreneurial processes per se, it is important to analyse entrepreneurship as a contextualised phenomenon which is under influence of a number of factors (Spilling 2007). Generally, a number of institutions exist which are of importance in order to support the formation of university spin-offs. Particularly during the later years a number of new institutions have been developed in order to stimulate the creation of technology based firms and firms spinning out from universities. Although these institutions may be of some importance for the processes we are studying in this paper, they will not be our primary focus. Our main emphasis will be on the entrepreneurial processes per se, and the role of various support mechanisms will only be briefly commented to the extent they are reflected through the stories of the case entrepreneurs.

Commercialization

The main purpose of any spin-off process and technology transfer process is that of commercial exploitation of the new knowledge. As outlined by Spilling and Godø (this volume) the concept of commercialization may be identified as the process of transferring and transforming theoretical knowledge as existing in an academic institution into some kind of commercial activity (Chiesa and Piccaluga 1998).

In the literature, one will find a number of different approaches for analysing commercialization processes, and generally these approaches are based on a stage model approach (Jolly 1997, Virtanen and Laukkanen 2002). For instance, Ndonzuau, Pirnay and Surlemont (2002) distinguish between the following four stages:

1. Generate business ideas from research
2. Finalise new venture projects out of ideas
3. Launch spin-off firms from projects
4. Strengthen the creation of economic value by spin-off firms.

As discussed by Spilling and Godø (this volume), an important aspect of the commercialization process it that the process will undergo a shift from a mainly technology-driven process to a process which is mainly market-driven. This implies that scientific concepts and principles are turned into viable technologies and products or services, which means that knowledge is transformed from one mode to another (Chisa and Piccaluga 1998; Fontes 2003, 2005).

Furthermore, the stage model approach invites to think in terms of linearity, i.e. the process goes smoothly through the various stages one by one. However, the point here is not to advocate a simplistic understanding of innovation processes as 'linear'. As will be shown by the case studies of this paper, the processes may be very complex. Thus, the purpose by referring to the stage model approach, is rather to point at a way of structuring and provide a basis for analysis (Ndonzuau, Pirnay and Surlemont 2002).

During the commercialization process, actors may go back and forth between the stages, partly they may combine elements from different stages simultaneously, or important elements from different stages may come in a different order. The actors will also depend on interaction and communication with a number of other actors belonging to the business community as well as the research community. So, interaction across stages and organisational boundaries are most important for the process. On this background, the innovation process may be termed as 'chaotic' and as an 'innovation journey' (Van de Ven et al 1999).

However, a basic feature of commercialization of R&D is that it implies some kind of 'linearity' in the sense that the process necessarily will take the existing knowledge base as its point of departure, and the new project will start out based on the existing knowledge base.

Academic spin-offs

The main focus of this paper is on spin-offs from universities or research institutions, and our concern is about the entrepreneurial processes related to spin-offs and the role of academic staff in these processes. A commonly applied definition of a spin-off is a company that is created based on knowledge resources in a parent organisation, and which is organised independent, or at least partially independent, of the parent organisation (Birley 2002; Carayannis et al 1998; Dahlstrand 1999, 2000; Nicolaou and Birley 2003, Shane 2004, Steffensen et al 2004). Different concepts may be applied, like academic spin-offs, university spin-offs or R&D spin-offs, and also the concept of ‘spinout’ is applied synonymously with spin-off. The spin-off is originated in an academic institution, and the entrepreneurs generally have their background as scientists in this organisation. The new venture is based on the intellectual assets of the parent organisation (Birley 2002), and the process is typically characterised by an employee leaving this organisation in order to start the new company based on these assets (Carayannis et al 1998, Steffensen et al 2004). To qualify for a spin-off, the new business must be based on a business idea which originated in the previous organisation (Dahlstrand 2000); the new business is based on intellectual property developed in the parent organisation (Birley 2002; Carayannis et al 1998) and may include the transfer of rights (IPR) related to this.

Pirnay et al (2002) state that any phenomenon can be qualified as a spin-off when it fulfils the following three conditions:

- It takes place within an existing organization, generally known as the ‘parent organization’
- It involves one or several individuals, whatever their status and function are within the ‘parent organization’
- These individuals leave the ‘parent organization’ to create a new one.

While much of the literature is focused on spin-offs resulting in wholly new firms, the concept may also include cases in which the new business activity is developed in an existing firm by way of selling licenses for obtaining the rights to exploit commercially the new technology (Shane 2002; Hill 1995). This also is a common way of organising technology transfer. The main point is not whether the spin-off ends up in a new firm, but that the result of the process is the creation of a new *business* activity, and independent of it is organised as a new legal business unit or it is adopted by an incumbent firm which organise the new business activity internally. However, in this paper we only focus on cases which involve the start-up of wholly new ventures.

The literature on spin-offs provides many aspects of these processes. According to Roberts and Malone (1996) and Carayannis et al (1998), it may be distinguished between four types of actors that all will play important roles in the process, i.e. the parent organisation, the technology originator, the entrepreneur and the venture investtor, cf. summary in Table 1. Carayannis et al apply the concept of role rather than actor, but here we prefer to use the concept of actor as this gives a better identification than the concept of role.

The classical way of organising a spin-off, is that one or more of the scientists who have contributed to developing the technological innovation, organise the new business and leave the parent organisation when the new venture is started. This is what Birley (2002) characterises as an ‘orthodox’ spin-off, which is characterized by a ‘clean break’, that is the scientists previously employed by the parent organisation, leave to start the new business. This implies, referring to the types of actors summarised in Table 1, that the scientist initially has the role as technology originator, and then follows up by taking the role as entrepreneur.

Table 1: Main actors and their primary roles in the spin-off process

Actor	Examples	Primary role
Parent organisation	University department, Research laboratory	Host and organise R&D activities to create technological innovations. May also serve as a facilitator for spin-off processes
Technology originator	Individual or group of engineers or scientists	Bring the technological innovation through the innovation-development process; bring the process to the point where technology transfer is possible
Entrepreneur	Engineers, scientists; ‘external’ person with business knowledge	Identify the business idea and develop the new business venture based on the technological innovation; take the technology to create a new venture from it
The venture investor	Venture capital organization, business angles, informal investors	Provide the financial resources to develop the new venture, may also provide needed business management expertise

Source: Based on Roberts and Malone 1996 and Carayannis et al 1998

In addition to the orthodox spinout, Birley (2002) has introduced two other categories of spinouts (she applies the concept of spinout rather than spin-off); the technology spinout and the hybrid spinout. In the case of the technology spinout an outside actor (investor, manager or company) buys or leases the rights of exploiting commercially the technological innovation. The academic staff continue in their roles as scientists and technology originators, while the entrepreneurial function of developing the new business activity is taken care of by external actors. Here, there is no overlap of personnel, the scientists remain as employees in the parent organisation, although they may contribute to the new venture development on a minor basis, for instance as consultants and equity holders. The third category, the hybrid spinout, represents a combination of the two previous categories; the new venture is based on a joint organisation of external and internal actors.

A number of other authors have contributed to the discussion of spin-offs and academic entrepreneurship and focused on different aspects of such processes (Dickson, Coles and Smith 1998; Fontes 2003; Jones Evans 1997; Radosevitch 1995), and some typologies are summarised in Table 2.

The typology suggested by Fontes (2003) is quite similar to that of Birley (2003). While Birley has distinguished between orthodox, technology and hybrid spin-offs, Fontes has distinguished between insider and outsider conducted commercialization and intermediary conducted process as the third category. The insider conducted process corresponds to the orthodox spin-off as it is the scientific staff – the insiders – who conduct the process, while the technology spin-offs corresponds to the outsider conducted process. However, while the orthodox spin-off as defined by Birley implies that the scientific staff involved in the process leave the university – it is a 'clean break' - this is not the primary focus in the typology of Fontes; her emphasis is on who conducts the process, whether they maintain their relationships with the research organisation or not. Furthermore, there is also a difference in the way the third category is defined. While Birley regard the hybrid type as a mixture of the orthodox and the technology spin-off, the third category in the case of Fontes focus explicitly on intermediary organisations as potential actors in the process of commercialization.

Table 2: Spin-offs and entrepreneurial roles

Author	Typology of spin-offs/ entrepreneurial roles	Definitions/comments
Birley 2002	Orthodox spinout	Scientist(s) leave to form the new company – 'clean break'
	Technology spinout	Outside actor organizes the commercial exploitation
	Hybrid spinout	Combination of inside and outside actors
Fontes 2003	Insider conducted commercialization	Insiders of the research organisation (RO) exploring knowledge originating from RO
	Outsider conducted commercialization	Outsiders who establish relationships to gain access to an RO to assist development of business ideas
	Intermediary conducted commercialization	Outsiders or (more rarely) insiders who operate as intermediaries in technology transfer as a business
Radosevitch 1995	Inventor entrepreneur model	Scientist(s)/inventor(s) organise the new venture
	Surrogate entrepreneur model	External actor with entrepreneurial experience organises the new venture
Dickson, Coles and Smith 1998	Academic entrepreneur	Scientist who engages in entrepreneurial endeavours, but maintain their identity as academic scientists.
	Entrepreneurial scientist	Scientist operating full-time in the new business essentially dedicated to scientific interests.
	Scientific entrepreneur	Integration of scientific and business interests, utilising a high level of scientific intelligence to identify new business opportunities
Jones Evans 1997	Research technical entrepreneur Producer technical entrepreneur User technical entrepreneur Opportunist entrepreneur	Terminology based on the background of the entrepreneur

A similar typology is also suggested by Radosevitch (1995) who has distinguished between two models for commercialization of public sector technology; the inventor entrepreneur model in which the scientist takes the role as entrepreneur and organises the new venture, and the surrogate entrepreneur model in which an external actor takes the role as entrepreneur. The advantage of the first model is that the technology originators organise the entrepreneurial process, and in this way provide greater technical capacity and have commitment to the technology and good relationships with the technology source. On the other hand this model implies disadvantages in terms of less experience from entrepreneurial activities and less business knowledge (Radosevitch 1995). The champion of the business idea is seldom the best to manage (Clarysse and Morey 2004). The advantages and disadvantages of the second model, the surrogate entrepreneur model, go in the opposite direction. Advantages are related to entrepreneurial experience and good contacts with the business community, while relationships with the technology originators will be less developed.

A somewhat different framework is suggested by Jones-Evans (1997) who in his studies of technology-based entrepreneurs has distinguished between types of entrepreneurs based on their background; that is in research or as producer, user or opportunist. The first category will coincide with the inventor entrepreneur model, while the other three relates to the surrogate entrepreneur model in which the process is organised by external actors with backgrounds from different positions in the business community.

The role of academic staff

It follows from the previous discussion that the role of academic staff may represent a great variety, both in terms of what functions they are taking care of in the new venture, to what extent they get involved in the new venture, and to what extent they combine activity in the new firm with continued activity in the university or research organisation.

One of the main issues is to what extent academic staff are involved in the role as entrepreneur or not. In the case of the orthodox spin-off, academic staff play the role as entrepreneurs, and obviously, they have to combine this role with their roles as researchers devoted to further development of the technology. The same is the situation in the cases of insider conducted commercialization and the inventor entrepreneur model In the other models – the technology spin-off, outsider conducted commercialization or surrogate model – there are other actors recruited from outside that take care of the entrepreneurial role, and which means that the academic staff involved in the business may concentrate on the R&D related part of the venture development.

Another issue is to what extent academic staff combine their role in the new venture with a role in the university or research organisation, and in what ways their academic position and activities are maintained. In most of the categories of spin-offs referred in Table 2, this is not clear. An exception is the category ‘orthodox spin-off’ which per definition implies that the academic staff leave the academic institution and work fulltime in the new venture.

Furthermore, the typology suggested by Dickson et al (1998) is interesting in this respect as it distinguishes between academic entrepreneur, entrepreneurial scientist and scientific entrepreneur. The ‘academic entrepreneur’ is the scientist who engages in entrepreneurial endeavours, but maintains his or her identity as academic scientist by maintaining the affiliation with the university or research organisation. In contrast to this, the ‘entrepreneurial scientist’ operates full-time in the new venture, but is essentially dedicated to scientific interests. The third category, the ‘scientific entrepreneur’ is somewhat more unclear, but the point made by the authors is that this type of actor integrate ‘scientific and business interests’ and make important decisions related to the future development of the business based on ‘scientific intelligence to identify new business opportunities’ (Dickson et al 1998:36). Although their use of concepts are not intuitively fully clear, and it also is in conflict with the normally much broader concept of academic entrepreneurship, the distinctions inherent in the typology is interesting for the further discussion of the role of academic staff in processes of commercialization.

The issue of to what extent academic staff combine their role in the new venture with a role in the university or research organisation, has been investigated by Samson and Gurdon (1993). Their conclusion is that in a significant majority of the cases they studied, the academics worked full time in the new ventures and maintained no relationships with the university. A smaller share of the academic staff combined part time affiliation with the new venture with full time activity in the university, and in just one case the academic remained in the university without maintaining any contact with the new venture.

The variety of the roles of academic staff in the new venture is illustrated by a case described by Birley (2002), in which the roles of the different academics participating in the team varied from fulltime participators as entrepreneurs to part time or temporary involvements as consultants, board members, members of advisory board and so on. An alternative may also be that the scientist work with the new venture for some time, for instance during the incubation phase, and then returns to his or her original position in the parent organisation.

The institutional and systemic context for spin-offs

As a result of the growing awareness of the importance of university spin-offs, it over the last decades has been developed a number of institutions and programs in order to facilitate processes of commercializing academic knowledge in most European countries, like science parks, innovation centres and incubators (Albert et al 2002, Dahlstrand 1999, Dahlstrand and Klofsten 2003, Stankiewicz 1998). Typically, these institutions are located in the vicinity of universities and R&D institutions, often on the university campus. Furthermore, the role of universities and other institutions for higher education has been addressed in many ways by for instance by organising industrial liaison offices (ILO) and technology transfer offices (TTO), and by launching specific programs in order to facilitate commercialization processes (Rasmussen 2006; Rasmussen et al 2007).

The spin-off process takes place in the interface between the university or research organisation and industry, and the process will to a significant extent depend on specific features of the university environment and milieu as well as the more general industrial and socio-cultural environment (Virtanen and Laukkanen 2002, Spilling 2008). The ability to identify and develop business opportunities will depend on a number of factors in this environment, including the entrepreneurial culture of the academic milieu, and so will the further processes of commercialization.[22] The key driving force, however, is the entrepreneurs and their ability to identify and develop business opportunities, and as part of this to exploit resources available in the environment and organise partnerships or develop other forms of networks with important actors. The institutional set-up may facilitate these processes, and in our analyses we will briefly comment on these aspects. Our main focus, however, will be on how the process of commercialization evolves and the role of academic staff in these processes.

Method and data

This study is based on a qualitative case study approach in which four cases, all belonging to the biotechnology industry in the same geographical area, have been selected for study. All cases are regarded as being part of an emerging cluster formed around a university located in a city on the Norwegian coast.

The research has been organised in two steps; first the development of the whole cluster has been mapped, mostly based on analysis of secondary data, including data available in public data sources. Also, some key data about the firms and their entrepreneurship stories have been collected from the individual firms by e-mail contact. Furthermore, as the actual cluster is fairly small with some 15-20 companies, and is organised with a secretariat which organises a web site with an overview of the participating firms, it has been fairly easy to collect information about the evolution of the whole cluster.

The second step was to select four cases which seemed of interest to illustrate different roles of academic staff. The main criteria for selecting cases was that they should belong to the biotechnology cluster, they should be regarded as spin-offs from the university or a related research organisation located on campus, and they should represent variety. However, as there were problems in establishing contacts with

[22] For a systematic account of how different system related factors may influence on the commercialization process, see Spilling and Godø in this volume.

some of the firms, we also had to be pragmatic and select among the firms with which we obtained contact.

The four case companies have all been visited, and the main entrepreneur or actor in the process has been interviewed. In three cases the interview lasted for an hour, while in the fourth case, we had two interviews with a total duration of four hours. Data collected through the interviews have been supplemented with other available data of the firms, like accounting data and annual reports. For two of the cases, we tried to organise follow up interviews, but without success.

The interviews were conducted as open and unstructured; the only structuring element was the process of commercialization and the entrepreneurship story related to this, and different events of importance to the development of the firms. However, entrepreneurial processes are often very complicated, and it takes a lot of time to map all details and to understand the story and the role of different actors. Given the short time available for most of the interviews, many details may be missing, and our main emphasis has been on illustrating the most important events of the entrepreneurship stories.

Cases

In the following sections we give a descriptive presentation of the four case firms and their entrepreneurs, here called BioX (the professor entrepreneur), BioLab (the laboratory manager), BioPhD (the research based entrepreneurs), and BioGroup (the industrial entrepreneur). As outlined above, all firms belong to the biotechnology sector and are part of an emerging cluster formed around a university. Three of the firms started with basis in the field of marine biotechnology, the part of biotechnology related to life in the sea, while the third company started up in pharmaceuticals. All four firms have evolved in the local area around the University, two of them even in the science park located on campus. To a significant extent, the cluster has developed in close interaction with the academic milieu of the University, and the University may be regarded as the main provider of the scientific knowledge base of the cluster.

While the first company, BioX, started already in the mid 1980s and may be regarded as one of the pioneering firms of the cluster, the other firms are of later origin with start-ups during the 1990s and around the turn of the century. From one point of view the cases may be regarded as fairly homogenous, as they belong to the same sector, are based on the same type of knowledge and even are located in the same geographical area. On the other hand, as will be shown by the descriptions that follow, the four cases also represen significant variety, both in terms of patterns of development and the ways academics have been involved.

Case A: The Professor Entrepreneur
This is the story of one of the most successful university spin-offs within the field of biotechnology in Norway. The company, here called BioX, was established in 1984 in collaboration between a university professor and four of his students. The company was reorganised in 1990, and experienced a steady growth during the 1990s. The company was listed on the Oslo Stock Exchange during the autumn 2005, and reported 56 employees and a turnover of 73 million NOK in 2006.

However, in order to understand this story, it is necessary to go back to 1972 when the main person, the Professor, was employed at the University as professor at the Department of Biotechnology. From the very beginning, he was concerned about the industrial exploitation of biotechnology based knowledge, in particular related to fish farming and the health of fish. He was a pioneer in developing fish vaccines; he also contributed to the development of other technologies which successfully was exploited in the fish industry. When BioX started in 1984, the business idea was to develop technologies, including vaccines, for the fish farming and fish processing industry. The Professor was the main entrepreneur of the company and 'orchestrated' the whole business. However, he did not take the role as manager. This role was left to one of the participating students – Candidate A – while he himself took the position as board chairman and research director. He also maintained his position as professor, the first years in full position, later in an adjunct position.

BioX had a good start and was profitable from the very beginning. However, the development was fairly unpredictable. The market for one of their business activities collapsed after a few years, while other markets developed very well. In particular, the team successfully developed a nutrition ingredient which turned out to be very favourable to the fish farming industry, and this triggered an interesting development partly based on research collaboration with an international company.

Towards the end of the 1980s, a new owner took over the majority share of the company. After some time, however, the new owner went bankrupt, and the Professor and his team had to buy back the full ownership of BioX. After a short period of collaboration with another local firm, an exchange of business areas was organised in 1990, and from now on BioX has focused on pharmaceutical products and developed its business activities within this field. During the 1990s, the company's development was characterized by steady growth, one VC company was involved during the mid 90ies, another VC was involved towards the end of the 1990s when BioX became a public company and prepared for the stock exchange, but due to the recession and the development in the capital market during the early 2000s, the listing on the stock exchange was postponed until 2005.

During almost the whole lifetime of BioX, the Professor has held the role as chairman of the board and worked as research director of the company. He has also, until recently, held his position as adjunct professor at the university. His students have also been involved. Candidate A had the role as managers for the first years of the company, then candidate B took over the role as manager after some years. In the mid 1990s B left the company and is now the managing director of another company. Candidate C, who has followed BioX all the time, took then over as managing director, and has been in this position until recently (2006) when he moved to another company in the biotechnology sector. Both the Professor and Candidates B and C are still shareholders of BioX.

An interesting aspect of the role of the Professor is his role as serial entrepreneur, as he has been involved in some other start-ups. However, this will not be discussed further here.[23]

Case B: The research based entrepreneurs

The story of this company, which we call BioPhD, may be traced back to 1992 when two doctoral students started a research project to test a protein with a very high level of anti-bacteria activity, and identified a field with great potential for further development and potentials for commercialization. Contacts were established with a national pharmaceutical company, joint research activities were organised with the company as lead partner, and up to 2001 about 50 million NOK were spent on these research activities which resulted in five patents.

However, the pharmaceutical company restructured and changed strategy, and left the project. BioPhD was then established in 2003 with the two previous doctoral students as cofounders, and the rights to the developed IPR were transferred to their company.

The company is organised with a small staff of four people, including the two cofounders who are combining their work in BioPhD with half time positions as professor and assistant professor respectively, at the University. The company is still (2007) in its early stage stage of development; their main activity includes further testing of their products, and this is estimated to continue for another 2-3 years. The basic funding of their activity has been provided by private placements, first in two rounds in 2004-2005, then a follow up round in 2006 of NOK 20 millions which was heavily oversubscribed.

An option for the future may be to look for an industrial partner in order to organise a joint venture, but licensing may also be an alternative.

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[23] For a discussion of the whole story related to BioX and the Professor Entrepreneur, see Spilling 2007.

Case C: The laboratory manager

The story of this company, which we call BioLab, started in 1993 when a research institute, which we call RI, located on campus of the actual university was visited by a Japanese person interested in kitosan which is an important ingredient in cosmetics. The contact revealed that RI had capacity for producing kitosan of very good quality. However, due to various reasons, the contact with the Japanese did not lead to any form of collaboration.

In 1994, RI started collaboration with a German company, and a joint research project was organised. In 1995 a new company, which we call Company C, was started jointly by the two parties in order to exploit the commercial opportunities which were expected to develop based on the research activities. A patent was obtained, it was owned 50-50 by RI and the German company - and was licensed to Company C.

In 1998 BioLab was established. It was owned jointly by the German company and Company C. BioLab was originally manned with a manager with background from the UK, and with two of the staff from RI in charge of the research activities and operation of laboratory facilities. A new production plant was set up not far away from campus, and all its produced kitosan was delivered to the German company which sold it to their customers. However, the Germans faced market problems, only parts of the production capacity of BioLab were exploited, and a very complicated story followed. Eventually, Company C gave up their involvement in BioLab, the German company started a process of restructuring, it sold out all their business activities related to ingredients which were taken over by another company which we call "Int-C Scandinavia", which is the Scandinavian branch of a European company.

Since then, Int-C Scandinavia has hired RI to manage the production activity of BioLab, which is still operating in 2007 on a modest scale, two people are employed in the production facilities, and the role as production manager is contracted to RI with one of their research directors in charge.

Case D: The industrial entrepreneurs

This company, which started as BioNutra and later was restructured into BioGroup, was established in 2000 by two founders with various backgrounds in biotechnology related research and industrial experience. One of the founders was originally an economist and has his background in industrial activity and also research activities at a centre for fishery research; the other has his background in marine biotechnology and has also previous experience as an entrepreneur.

Based on their industrial experience, they developed a very ambitious strategy for starting a new company in the consumer and animal food ingredients industry. The first development was based on collaboration with an American company which had a product BioNutra obtained licence to sell world wide. They started planning a production facility in Norway, and the American company acquired the majority of the shares of BioNutra. However, the relationship between the American company and the Norwegian founders did not work very well. A very complicated story followed, the end of which was that the founders acquired back the full ownership of their company.

A period of reconsidering their strategy followed, they reorganised their business activities into the new company BioGroup. A private placement was successfully organised in 2004, and a rapid development has followed with the integration of other companies, among them a production facility located in the region. BioGroup was by 2007 probably the fastest growing biotech company in the region, and planned to be listed on the Oslo Stock exchange during 2007.

The reported sales in 2006 were more than 70 million NOK, and the company employed around 55 people.

Processes of commercialization and firm development

The four cases illustrate that processes of commercialization may be complicated and turbulent, and they may last for many years, even some decades. This is in contrast to the simple pictures provided by most stage models. To illustrate this, we have summarised some characteristics of the evolution of the cases in Table 3.

To the extent these cases are representative, there is no simple way from research to a successful, viable company. In the case of BioX (Case A), which so far seems to be the most successful company, it took more than twenty years from the initial start until the full fledging company was listed on the stock exchange; the company is still in its early stages of development, it is still investing heavily in R&D and have reported significant deficits the last years. Furthermore, the initial years of the development of BioX were characterised by a high level of turbulence, with the need for reorganising the business activities several times before finding a sustainable structure of the company.

In the case of BioPhD (Case B), the initial research period lasted for more than ten years, and the company has so far not earned money and have yet a long way to go to complete the process of commercialization. Thus, the way from research based knowledge to an operative business may be very long.

In case C (BioLab), the time horizon has been shorter, as the actual product basically was developed when contact was established with the industrial partner. However, in spite of this, the start-up of the new production facility was based on five years' collaborative research activities.

In case D, the pattern of development is quite different. The main focus of the new company, BioNutra, was to organise production of ingredients that were fairly well developed and more ready for the market than in the other cases. R&D activity was less important in this case, and the company was profitable after a few years in business.

What really seems to complicate the process of commercialization, are the relations between the emerging new businesses and their industrial partners. In the case of BioX, alliances with another company were important in the early stages in order to get access to capital, and also to technology and markets. However, when their partner faced economic problems, it threatened the whole development of the company which had to restructure its activities. In the case of BioPhD, the initial strategy was to develop the new business in collaboration with of one of the leading, national pharmaceutical companies, and extensive research activities were organised. A potential outcome of this process might be that the new pharmaceuticals were included in the company's product portfolio. However, the company changed strategy and defined its core business in other fields. The development of the new business activity was threatened, and this necessitated the start-up of the new company, BioPhD.

In the cases C and D, the evolution has been even more turbulent. The industrial partners have faced very significant economic problems related to the market. In the case of BioLab, their partner reorganised, and a new partner has been involved. In the case of BioNutra, the relationship between the entrepreneurs and their partner turned out as very problematic, the relationship was ended, and the entrepreneurs redefined their strategy which led to a new start and the reorganisation of their business activity into BioGroup.

Table3: Stages in the processes of commercialization of case companies

	Case A The Professor Entrepreneur Company: BioX	**Case B** The Research Based Entrepreneurs Company: BioPhD	**Case C** The Laboratory Manager Company: BioLab	**Case D** The Industrial Entrepreneurs Company: BioNutra/BioGroup
Pre start-up development	1972-1980 Various research activities at the Department of Biotechnology at the University in collaboration with various companies; developing and implementing new technologies	1992-2001 Extensive research activities over several years organized in collaboration between the University and a leading national pharmaceutical company (NPC), with the company was the lead partner. E	1993- Research activities in the field of marine biotechnology, organised at a research institute (RI) located on campus. Research collaboration with a German company on applying kitosan in cosmetics.	1990s The two entrepreneurs have various backgrounds from research activity at the University and larger companies in Norway and abroad, one of them also with background as the entrepreneur in a regionally based biotech firm
Entrepreneur(s)	Professor at the Department of Biotechnology in collaboration with some of his students.	Two PhD candidates from the University (Department of Medicine and Department of Chemistry)	German company in collaboration with RI and a local company.	Two co-founders; a) a candidate from the University and b) an economist educated abroad
Triggering factor for start-up	The Professor and some of his students identified new opportunities for commercialization	NPC restructured their business activity and focused on other fields	RI contacts with industry representatives interested in their kitosan.	Ambitions to start a fast growth biotech company
Start-up year/firm	1984: BioX	2003: BioPhD	1998: BioLab	2000: BioNutra / 2003: BioGroup
Field of business	Fish vaccines Fish food ingredients Enzyme technology	Development of pharmaceutical products – anti-cancer drugs	Production of kitosan. All production sold to the German company.	Consumer and animal food ingredients
Early development	1984-1900 Developed and launched various products, turbulent market development: • BioX was acquired by another company which experienced economic problems • BioX was acquired back by the entrepreneurs • Collaboration with a local company, exchange of business areas • Research collaboration with a leading international company	2003 – The company is heavily involved in developing anti-cancer drugs, and is still in the stage of testing out various molecules. Funding of activity by private investors – two private placements organised in 2003-2004, and a new placement in 2006. Additional funding by public research programs.	1998-2004 Market problems, only a smaller part of the production capacity was utilised. Turbulent development; was taken over by the Scandinavian branch of an international company in 2004.	2000-2003 Collaboration with an American partner, obtained licence for producing one of their products, majority ownership taken over by the partner. Production facility opened in 2002. Turbulent development, partnership cancelled, the founders got back full ownership of their company..
Later development	1990 – BioX was restructured and established in its current form in 1990 with focus on pharmaceutical products • Steady growth, two emission during the 1990s • Organised as public company in 2000 • Listed on Oslo Stock Exchange in 2005	The company is still in its early development.	2004- The company is operated on a low level activity; app. one third of the production capacity is exploited. The production facility is managed by the staff of RI..	2003- Reorganising of company, steady growth in own business activities and expansion through investments in other companies, building a company group. Plans to be listed on Oslo Stock Exchange during 2007.
Status 2006 (million NOK)	No of employees: 56 Turnover: 73 Profit: - 40 R&D activity: 35	Employees: 4 Turnover: 2,8 Profit: - 4.2	Two people employed in production, two academic staff sharing the role as manager	Employees; 55 Turnover: about. 72 Profit: 5,2

Although the cases are not necessarily representative for the whole cluster, impressions based on summary information about the other companies of the cluster may indicate that the four stories are not unique. A common feature of the evolution of this type of biotechnology firms seems to be the long time horizon of their development and that the outcomes of the processes are less predictable. There is a long way to go from the initial research results and to the new, commercially viable business is established (Hine and Kapeleris 2006). Thus, the cases support our earlier comments that simple stage models may be less adequate to describe the complexity and turbulence of the processes. It seems to be a quite common phenomenon that projects have to be redefined and reorganised, and support the view that such processes often may be chaotic (Van de Ven et al 1999).

The spin-off processes

To facilitate our further discussion, we have summarised some characteristics of the spin-off processes in Table 4. Our point of departure is that all four cases may be classified as university spin-offs as they have developed in close relationship with the university or related research institutes. However, the form of this relationship varies between the four cases.

Case A and B are similar in the sense that the point of departure for the development was research activities conducted at the university. In case A, the new firm was initiated by the Professor in collaboration with some of his students, and the new start-up was directly based on knowledge developed in the university department. Thus, the University Department may be regarded as the parent organisation, the professor and his students were the technology originators, and the spin-off process may be classified as an insider conducted process; insiders were in charge of the process of commercialization in the early stages of development.

Similarly in case B, the development of the new venture was triggered by the research activities of the two PhD candidates. However, their original research was only a point of departure for extensive further research which was organised over several years in a national pharmaceutical company, and when the new company eventually was started by the two PhD candidates, the spin-off may be said to originate from the national company rather than the university. However, the link back to the university is quite clear as the initial research activities started there, and the follow up research was organised in collaboration between the company and the university. So this may also be classified as an insider conducted university spin-off, although the links are more indirect than in the previous case.

Table 4: Characteristics of the spin-off processes

	A. BioX	B. BioPhD	C. BioLab	D. BioGroup
Parent organisation	University Department (Department of Biotechnology)	University Department in collaboration with a national pharmaceutical company (NPC)	Research Institute (RI) located on University campus	No specific parent organisation.
Technology originator	The professor and some of his students	Two PhD candidates in collaboration with the R&D department and NPC	The Research Institute	No specific technology originator; based on already developed technology
Entrepreneur(s)	The Professor and some of his students	The two PhD candidates	Industrial partner (German company)	Two academic candidates with supplementary industrial and entrepreneurial background; also some background in research
Type of spin-off	Insider conducted	Insider conducted	Outsider conducted	Indirect spin-off Outsider conducted
Role of academic staff	Entrepreneurial, with combined focus on R&D and business development	Entrepreneurial, but with main focus on R&D	Production management	Entrepreneurial from an outsider position
Location of company	Headquarter and laboratories located in the city close to campus; also an office in Oslo	In the science park on campus	Production facilities located a few kilometres outside campus	Headquarter located in science park on campus, production facilities located elsewhere in the region
Venture investors	Start-up: The Entrepreneurs Next stages: • Industrial partners • National Venture Capital firms • IPO (Listed on Oslo stock exchange 2005)	Start-up: The entrepreneurs Next stages: • Private placements	Industrial partner	Start-up: The entrepreneurs Next stages: • Private placements • Planned IPO (Oslo Stock Exchange) in 2007
Public research funding?	Yes, extensively	Yes, extensively	No	Yes, moderate
Support from Innovation Norway?	No	Yes, start-up grant	No	No
Public seed capital?	No	Yes, regional seed capital fund	No	Yes, regional seed capital fund

The third case, BioLab, is different in the sense that the main entrepreneurial actor in the commercialization process was an international company, and the spin-off may be regarded as an outsider conducted spin-off. However, the scientific knowledge was developed on campus.

The fourth case, BioGroup, comes in a different category in terms of how the specific knowledge for commercialization has been originated, and what role the academic staff have taken in the process. First, it is not possible to identify a specific parent organisation of the research the company is based on. The basis for developing the company has mostly been already developed or semi-developed nutrition products, and the company has to a significant extent evolved through acquisition and expansion of existing production processes. Second, the founders of the firm have started from a position as outsiders; based on their previous industrial and entrepreneurial experiences they developed their new business idea and so far succeeded in developing a fast growing company.

Although their links to the university are not as clear as in the other cases, the links seem strong enough to classify the company as a university spin-off. The two founders have significant relationships with the university; one of them as a graduate (master candidate) from the university, while the other was employed as research fellow at one of the research institutes. Furthermore, the company headquarter is located in the science park on campus, and the company is now conducting R&D in part funded by a R&D program organised in order to stimulate the development of the biotech cluster around the university. It seems quite obvious that BioGroup would never have been established in the area, if it had not been for the local knowledge base and the emerging cluster formed around the University. However, it may be adequate to classify this case as an indirect university spin-off.

The role of institutions

The four cases belong to an emerging industrial cluster located in a fairly marginal region facing some significant problems related to industrial development. For several decades, the region has pursued a systematic strategy for regional development. One of the main elements in their strategy has been the development of the university and to provide education and develop research activities in areas with a high potential for industrial development. As a part of this strategy, a diversified structure for faciletating technology transfer and university spin-offs has been developed; research centres have been established in order to specialise in areas like fishery and marine biotechnology, a science park and related incubator facilities was established in the mid 1990s, a specific research program focusing on marine biotechnology has been organised to stimulate commercialization and interaction between the academic institutions and industry. Furthermore, regionally based seed capital funds have been organised, the University has organised its technology transfer office, and a process for developing forum and network to support the cluster development has been organised in collaboration between many parties during the last years.

In Table 4 we have briefly summarised to what extent the case companies has taken advantage of the various support mechanisms. This may be summarised in the following points:

- The most important factor is the research activities organised at the university, and the quality and entrepreneurial orientation of the research staff. This has been an important basis for establishing all four companies.
- Two cases are located in the science park on campus.

- Three cases have obtained funding from national and regional R&D programs
- Mostly, the four cases have been based on private risk capital obtained through private placements and public offerings. Local seed capital is involved in two of the cases, and as a part of this, representatives for the seed capital fund are on the boards of these companies.
- Start-up grant is obtained from the national innovation agency in one case.

On this background it may be concluded that there are some working support mechanisms that may be of importance for the evolution of the cluster. However, when talking with the actors involved in the new ventures, their main concern is about all the challenges related to the organising and strategic development of their company. Various support mechanisms may facilitate this; however, the main driving force is the entrepreneurs themselves.

The role of academic staff

The role of the academic staff varies between the four cases, and will now discuss in some details their roles in developing the new venture, in particular how they have been involved as entrepreneur, and how they have conbined their role in the new venture with their role at the university or the research institute.

BioX (Case A): The Professor was the main entrepreneur and took the role of "orchestrating" the whole business while combining the position of research director with the position as chairman of the board, a position he has held continuously until recently. During the whole period, he has also maintained close contacts with the university. During the first years he kept his position at the university in combination with part time involvement in the company, later he was working full time in the company as research director and combined this with a part time position as adjunct professor at the University, a position he held until the turn of the century. And as part of this he has also been the supervisor for PhD students.

With his main focus on 'orchestrating' the development of the new venture, the Professor may be characterised as very entrepreneurial. Based on the framework suggested by Dickson et al (1998), he may be characterised as a 'scientific entrepreneur'. He has been 'utilising a high level of scientific intelligence to identify new business opportunities' (Dickson et al 1998:35), and during most of his life long career, he has been able to combine his role as entrepreneur with his position as professor at the university.[24]

BioPhD (Case B) has to some extent followed the same pattern of development as BioX. The main focus of the two entrepreneurs has been on R&D. They were

[24] The Professor is widely recognised as a pioneer in developing industrial applications based on marine biotechnology, and he was in 2005 appointed Doctor of Honour by the University

involved in research projects at the university, identified interesting opportunities for commercialization, established collaboration with a national company which organised more research in the field. When the company changed strategy, the IPR was transferred to the research fellows who started their new business in which they continued their R&D activities related to developing new anti-cancer drugs. Both founders combine their activities in the company with half time positions at the University. However, what distinguishes this approach from that of BioX, is that they still have a long way to go to develop the commercial potential, and they have not yet clarified what will be the future commercial model of the company. They also seem to have a stronger focus on R&D and disciplinary matters than on the commercial issues which they leave to other members of the team.

BioLab (Case C) represents a very different story as the academic staff have not taken the lead role in the entrepreneurial process, but rather have had a supportive function to the external partner that has organised the new business. The main focus of the research institute and the two research fellows involved in the process, has been that of supporting their industrial partner in developing the production facilities, while they have not been involved in other functions related to the new business. When the new business eventually was operating, their main task has been that of managing the production process on a contract basis.

BioGroup (Case D) represents another and quite different story. The two entrepreneurs have both backgrounds as academics – one as a business economist who graduated at a university in the US, the other as a biologist who graduated at the University – and both have some academic experience in research related to fishing and the marine sector. However, their main background is industrial as they have worked with larger industrial companies for some years. One of the entrepreneurs also has previous experience as an entrepreneur as he during the 1990s was one of two cofounders of a biotechnology firm in the region.

The approach of the two founders of has been very entrepreneurial. Their business idea was to organise commercial production of consumer and animal food ingredients that basically were developed, and their main focus has been on exploiting business opportunities in this field, and they are pursuing a very ambitious growth strategy. Based on the previous framework, they are operating as actors who are external to the university and the research institutes, they are the 'surrogate entrepreneurs' (Radosevitch 1995), and with their strong emphasis of industrialisation, it may be adequate to characterise them as 'industrial entrepreneurs'.

The four cases illustrate that the approaches in the entrepreneurial processes may be rather diverse. To some extent, this diversity may be explained due to differences in types of knowledge that are exploited in the process of commercialization, and thus the role of R&D is very different. In case A and B, continued R&D activity is a basic precondition for the commercialization process, and actually the R&D activity is the most important part of the business, at least in the early stages. Naturally, then, the academic staff may take a leading role in organising the new venture.

In case C, R&D activities were important in the early stages, and it was related to testing out the use of a specific ingredient for a cosmetic product controlled by their industrial partner. The role of the research institute was basically that of testing out the product and developing the production facilities, while knowledge related to the final consumer product and marketing was controlled by the partner. In this case it was a natural solution to hire the research institute and their staff for managing the production process.

In case D, the products mostly were developed prior to start-up. The start-up was based on a licence agreement, and an important task was to set up production facilities. It has also been an important part of the company's strategy to integrate other businesses in the group. Thus, their primary activities have been less research based, it is the entrepreneurial process and knowledge related to this that has been most essential when organising this venture.

When processes of development are in the early stages of development and a high level of R&D activity still is required, this will naturally give much more opportunities for academic staff than commercialization processes focusing on more developed areas. Both Case A and B are examples of early stage processes in which it is a long way to go to be in the market with their products. Case D represents the opposite situation, the commercialization process is close to the market, other types of competences are more essential, and this gives room for the 'surrogate' entrepreneurs.

In order to structure our understanding of the roles of academics in spin-out processes, we have set up a matrix based on two dimensions, research commitment and entrepreneurial commitment, and the typology derived from this, is displayed in Table 5.

Table 5: Typology of the role of academic staff in spin-off ventures

		Research Commitment	
		High	**Low**
Entrepreneurial Commitment	**High**	**The entrepreneurial professor** Continued focus on developing new commercial activities based on a high level of scientific commitment (BioX)	**The industrial entrepreneur** Main task to organise and develop the new business, strong focus on market opportunities and industrialisation (BioGroup)
	Low	**The research oriented entrepreneur** Main focus on research and disciplinary activities in the new firm, involvement in business activities is balanced with the academic career **(BioPhD)**	**The production manager** The role in the company mainly devoted to manage routine tasks, no R&D activity involved. Keeps the main position in the university or research institute **(BioLab)**

‘The entrepreneurial professor’ has the main focus on the over all development of the business and works continually with developing the commercial activity. He combines a high level of entrepreneurial commitment with a high level of commitment in research. The basis for this is his or her scientific merits, and in order to maintain the high level of scientific quality, it is important to combine the role in the company with a continued position at the university. In the specific case of BioX, the Professor has maintained such close relationships through out his whole career, although he during the last decade worked full time in the company.

‘The industrial entrepreneur’ is highly committed to entrepreneurial activities, and is less committed to research and disciplinary activities. This also means that links to the university are weaker, although the background as an academic with knowledge in the specific field is important and may be a key precondition for conducting the role as entrepreneur in an adequate way. In the case of BioGroup, the entrepreneurs have important industrial and entrepreneurial backgrounds, which provided a platform for starting up one of the most dynamic and fast growing biotech companies in the actual cluster.

The next category is ‘the research based entrepreneur’ who starts a new business to develop commercial activity based on own research. Although this type of entrepreneur contributes to start new businesses which may have a high potential, the main focus of the academic is on research and disciplinary matters. This category is close to what Dickson et al (1998) denote as ‘entrepreneurial scientist’ with main focus on scientific issues, while other aspects of the entrepreneurial function is left to other members of the team. In the case of BioPhD, the company is organised with a small team, and important functions related to the commercial development are delegated to the other team members, while the two founders dedicate much of their time for their work in the University.

The fourth category is called ‘the production manager’, and point to a situation in which the academic staff who have contributed to the start-up of the new venture, have a rather limited role in new business in terms of R&D. Their main role is confined to routine management activities. In the case of BioLab, the staff have continued in their ordinary positions in the parent organisation (the Research Institute) and serve as manager for the new production facility on a part time basis.

Conclusion

This study has provided some important insights regarding processes of commercialization and the role of academic staff in commercialization processes.

First, it is important to recognise that processes of commercialization may be characterised by complexity, turbulence and a high level of uncertainty. While the literature to a significant is based on simple stage model approaches, evidence presented here indicate that processes may be very complex, sometimes chaotic, and there may often be a need for redefining and reorganisation of the project. Processes of commercialization are often less predictable, and when planning such processes – to the extent planning is possible – it is important to have an open and flexible approach and be prepared to redefine and start the project in a new way. It may be of the great importance that academics involved in such acknowledge these aspects of processes of commercialization.

Second, academic staff may take different roles in processes of commercialization, and there may be different routes from the academic position in the university to the new venture where the academics may be involved in various ways. Based on the two dimensions of academic and entrepreneurial commitment, we have developed the following typology of roles of academics in processes of commercialization:

- The entrepreneurial professor with a high commitment in entrepreneurial tasks as well as research
- The industrial entrepreneur with a high commitment in entrepreneurial tasks while less commitment in research
- The research oriented entrepreneur with a high commitment in research activities and less in entrepreneurial tasks
- The production manager, who has low commitment in research as well as in the entrepreneurial tasks of the firm, but who still has an important role in managing the production of the new company.

The typology may provide a framework for a more differentiated discussion of the role of academic staff in spin-offs. While much of the literature do not discuss the various roles that academics may take in such processes – this framework may provide a basis for a more differentiated discussion, and for further development of knowledge in the field.

In academic milieus there are often perceived conflicts between academic and commercial activities, and there may be significant barriers to develop a more entrepreneurial culture. And pointing at 'the entrepreneurial professor' as the ideal role, may even increase the barriers, as this role will be unrealistic to most academic staff. Probably, there are few academics that are able to take this role, as it requires a very unique combination of scientific and entrepreneurial skills. In this context, the suggested framework may be of importance to point at different ways that academic staff may contribute to develop new ventures and to contribute to the development of a more entrepreneurial university.

The suggested typology is the result explorative research, and as the empirical evidence so far is limited, it would be interesting with follow up studies to test out the typology, and possibly develop it further.

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Innovation in the public sector – identifying the concept and the systems of innovations

Rannveig Røste

Abstract

The innovation literature has established a thorough understanding of the main processes underlying the development of new products and production processes in the private sector. On the other hand, the public sector has been largely ignored. Recently though, there has been a growing interest in studying innovation in this sector. But what is innovation in the public sector? It has been a tendency to consider the public sector as something uniformly different from the private sector – as rigid and bureaucratic in contrast to competitive and innovative. This paper questions this dualistic view, and aims at identifying the genuine understanding of innovation in the public sector. The paper reviews the literature that addresses the phenomenon and reveals the definitions and discussions of the concept. Moreover, the paper discusses how the System of Innovation approach might contribute to identify the systems of innovation in the public sector.

Introduction

Innovation might be defined as "(…) new creations of economic significance. They may be brand new but are more often new combinations of existing elements" (Edquist 1997, p. 1). Despite this relatively broad definition of innovation, the innovation literature is dominated by studies of new products and production processes in the traditional manufacturing industry (e.g. Drejer 2003). Moreover, the literature has almost totally neglected what is a major aspect of all European economies: the public sector activities. Recently though, there has been a growing interest in innovation in the public sector (e.g. Osborne 1998a; Borins 2001; Albury 2005). But what is actually innovation in the public sector? Is innovation in the public sector the same as in private companies? The studies mentioned do not answer these questions fully. Thus, the aim of this paper is to develop the understanding of the concept of innovation in the public sector.

Generally, it is a tendency to consider the public sector as something uniformly different from the private sector – as bureaucratic, inactive and constant in contrast to the productive, competitive and innovative private sector. The difference is thought to be in the lack of the mechanism of the market. The market mechanism is understood to be the overall mechanism for the success in the private sector, pushing the firms to develop new products and production processes in order to be competitive and survive in the market. The productivity in the public sector, on the other hand, is thought to be held back by monopolistic production systems and bureaucratic structures. This is the foundation for the New Public Management (NPM), a set of fairly similar administrative doctrines that have dominated the bureaucratic reform agenda in the OECD countries from the late 1970s until today. What unites many of these reforms is the use of private sector management principles for improving efficiency in the public sector. The debate around these principles has been one of the most striking international trends in the public administrative literature in the last decades, and is undoubtedly central for the understanding of innovation in the public sector. However, this paper will not follow the debate of NPM, but questions a basic premise for the debate, namely that the public sector is something uniformly different from the private sector. This paper then, aims at exploring what are the main mechanisms for innovation in the public sector, and how these are different from and similar to innovation in the private sector.

The conceptual framework of the classic System of Innovation approach (e.g. Freeman 1987; Lundvall 1992; Nelson 1993; Edquist 1997) emphasises that innovation emerges within systems, where all the actors and the relations and dynamics between the actors, must be studied to understand the cumulative accumulation of knowledge and competence in a company. That is, how the company undergoes a learning process when the expertise and experiences in the system are absorbed and transferred into own skills and know-how. Malerba (2004a, p. 9) claims that: "(…) innovation takes place in quite different sectoral environments", and it is only by studying the systems of these sectors, i.e. their technology, the actors and networks and the institutions that we can understand the systems and dynamics of the different sectors. Hence, in order to understand innovation in the public sector, the systems of innovation relevant to the sector must be identified.

This paper starts with discussing the concept of innovation in the public sector, by pointing at classic public policy and administration literature that has discussed the theme and how the dominance of NPM has created new perspectives on the public sector. Section 3 identifies different definitions of innovation and discusses the literature that addresses the phenomenon of innovation in the public sector. Section 4 debates the dualistic postulate that depicts the public and the private sector as something fundamentally different. Section 5 introduces the System of Innovation approach to the discussion, and section 6 identifies and discusses systems of innovation in the public sector. Section 7 concludes on how the paper can contribute to the further discussion of the concept and systems of innovation in the public sector.

Demystifying the innovation concept

The innovation concept in the public sector may stand out as modern catch-phrase, but the phenomenon is not new. It might for example be traced back to articles on public entrepreneurship in the 1960s (e.g. Ostrom 1964; Wagner 1966). The role of public entrepreneurs, the organisation of institutional goals and the reform processes is also found in the classic organisation perspectives (e.g. Gulick and Urwick 1937; Simon 1945; Selznick 1948) and in the new-institutional perspective of March and Olsen (e.g. March and Olsen 1976, 1989). It may also be recognized in classics on power as a relational phenomenon (e.g. Dahl 1961), on decision-making as incremental steps (Lindblom 1959) and in the perspective of bureaucrats as budget-maximizers (Niskanen 1971). Besides, it is found in the still dominant paradigm of NPM (e.g. Hood 1991; Boston 1996; Minouge 1998) and the Reinventing Government tradition on the need for improving the efficiency in the public sector (e.g. Peters and Waterman 1982; Osborne and Gaebler 1992). However, the innovation concept as a term is very seldom used in the classic literature on public policy and administration. In general, the focus seems to be more on the democratic consequences of change than on how changes happen per se. Still, it is highly interesting how the classic perspectives might contribute to and elaborate the understanding of innovation in the public sector[25].

This article is limited to the literature that applies the concept innovation in the public sector. The innovation concept is found in literature that focuses on various aspects in the public sector, but in spite of this diversity very few discusses what the concept actually covers in the various settings. Moreover, the concept is further mystified by being used in literature that does not focus on innovation per se. The literature is very broad in scope and covers several related phenomena, among others: political and bureaucratic entrepreneurship (Zerbinati and Souitaris 2005; Shockley et al. 2006), innovative leaders (Altshuler and Zegan 1990; Golden 1990) and barriers to innovation in the public sector (Drucker 1985; Borins 2001; Albury 2005). Furthermore, the innovation concept is also used in literature that focuses on how to enhance creativity in organisations (e.g. Frost and Egri 1991; Glor 1998), in the literature on NPM (Grote 2000; Eshima et al. 2001) and in the Reinventing Government tradition (e.g. Bellone and Goerl 1992; Moon 1999). Especially, the understanding of the innovation phenomenon is twisted when the concept is brought up in the NPM and the Reinventing Government literature, where the focus is on efficiency improvement rather than on innovation. On the other hand, as Bartlett and Dibben (2002, p. 108) emphasizes, NPM might also be studied as an innovation: "(…) the role of performance management can be viewed not as a driver of change, but as a tool at the disposal of the public sector entrepreneur which can be used to embed and institutionalize the innovative changes."

[25] see Roste (2005) for discussions of how the classic organisation theory, studies of public policy and the NPM literature might contribute to understanding innovation in the public sector.

Some of the literature on innovation in the public sector holds that the dominance of the NPM paradigm seems to have resulted in so strong a call for change in the public sector that the character and the consequences of change are not regarded as necessary to discuss. Glor (1997, p. 1) states for example that "(…) innovation is portrayed as something desirable in the current public administration and business management literature: public administrators want to be innovative". Moreover, Osborne (1998b, p. 1134-1135) claims that:

> "(…) innovation in the public sector "has become a policy and research buzzword which has apparently risen above the need to define it". Innovation has been acknowledged in the formulation and implementation of social policy as "the promotion of the idea of 'innovation' as normative good (…) This is a crucial flaw. By having the ability to be 'all things to all people', innovation has invariably resisted all attempts to evaluate its achievement" (ibid.).

Furthermore, Hartley (2005, p. 30-31) emphasises that "(…) innovation and improvement need to be seen as conceptually distinct and not blurred into one policy phrase. Unfortunately, this is not always the case". The public sector "(…) feels almost obliged to provide evidence and arguments that they are 'modernizing' and 'improving'." Osborne (1998b, p. 1134-1135) states that innovation has reached such a status in the public sector because of two trends. The first is the increasing demand for efficiency related to the pressure and constrain on social services to meet the needs of a growing population. Second there is the effectiveness need, caused by growing consumer pressure and the individualisation of citizen's needs in the meeting with public social services. "While in part this emphasis can be seen as a reaction against the standardized and universalistic services of the post-war welfare state, it also has its roots in the growth of managerialism, and of the NPM, as the dominant paradigm for managing public services in the late twentieth century" (ibid).

Hartley (2005; Benington and Hartley 2001) suggests that the ideological conceptions, or paradigms, of governance and public management have changed through three epochs. The epochs may be linked to a particular ideology and historical period or as coexisting realities that calls forth behaviours and decisions related to one of the three paradigms.

The first paradigm is *the public administration approach* that might be dated from the post-war period and up to the early 1980s. The paradigm "(…) is largely based on a legislative, bureaucratic and rule-based approach to public service provision". The paradigm is characterised by top-down implementation, where the "(…) role of policy-makers is to act as commanders, creating legislation and then support for whole-scale changes, while assuming that the detailed work of implementation will be carried out by officials" (Hartley 2005, p. 29).

The second paradigm is *NPM* that developed from the 1980s. The paradigm is underpinned by neo-liberal economics and a particular form of management theory. "The innovations arising through this approach focus particularly on organisational forms and processes such as executive agencies in central government, the purchaser-provider splits seen in health, education and local government, and a 'customer' focus" (Hartley 2005, p.30).

The third period is the "(…) move toward *networked governance*, the role of the state is to steer action within complex social systems rather than control solely through hierarchy or market mechanisms. Innovation under networked governance revitalizes the leadership role of policy-makers in translating new ideas into new forms of action". Although this might be regarded as linked to a particular ideology and historical period, it might also be seen as coexisting as "(…) layered realities for politicians and managers, with particular circumstances or contexts calling forth behaviours and decisions related to one or the other conception of governance and service delivery" (ibid). Hence, it is not only efficiency and effectiveness needs for innovation in the public sector, but also legislative, bureaucratic and governance needs.

What is innovation in the public sector?

The classic understanding of innovation goes back to Joseph Schumpeter (1934) seminal work *The Theory of Economic Development*[26]. Schumpeter challenged the classic economic model of the profit-maximizing firm and defined economic development as discontinuous changes of new combinations in the circular flow of economic life.The new combinations might occur in five different types: (1) a new *good* or a new quality of a good, (2) a new method of *production,* (3) the opening of a new *market*, (4) a new *source* of supply of raw materials or half-manufactured goods, and (5) a new *organisation* (Schumpeter 1934, p. 66).

However, when is discontinuous change innovation and not just a customary change or regular production? Schumpeter focused on the introduction of radical and revolutionary new technology. On the other hand, the modern innovation literature has held that continuous improvement, characterized as incremental innovation, is of equal importance (e.g. Lundvall 1992; Fagerberg 2005). Moreover, radical innovations in most cases require several incremental improvements to reap economic benefits. Furthermore, a company may be innovative in two different ways; it may develop brand new technology or introduce an existing innovation from another company (e.g. OECD 1997, Oslo Manual p.52). In contrast, one may argue that

[26] Original version in German in 1911, translated to English in 1934

introducing an innovation into a new context is imitation and not innovation. Yet, introducing it into a new context implies considerable adaptation and might as well lead to new innovations and increased productivity (e.g. Kline and Rosenberg 1986; Godinho and Fagerberg 2005).

The literature on innovation in the public sector focuses on the same problem. Albury (2005, p. 52) underlines that although innovations might be radical, incremental or systemic, the majority of innovations are incremental changes. Incremental changes are "(…) relatively minor changes and adaptations to existing services or processes - brought about by public service professionals to improve performance and the lives of service users". Radical innovations, on the other hand are "(…) development of new services or a fundamentally new way of organising and delivering a service", whereas systemic innovations "(…) require fundamental changes in organisational, social and cultural arrangements to have full impact". Though, the editor of the internet-based *The public sector innovation journal*[27] Eleanor Glor (1997), on her side, claims that improving existing processes, e.g. redesigning something that already exist and "the dissemination of new activities or ideas" can never manage to challenge the existing regime. Then again, it is held in a report on innovation in the public sector that: "Note that the measure employed for 'newness' is newness to the organisation, not necessarily newness to a region or the world. Nearly all of the innovation examples referred to in the literature involve the adoption of best practise and new technology evident elsewhere" (Manley 2001, p. 10). This is also underlined by others. Sanger and Levin (1992, p. 97) hold that "Innovation in the public sector typically is evolutionary (…) it is often simply the use of old stuff in new ways". Newman et al. (2001, p.61) also define innovations as "(…) discontinuous or step change, as something which was completely new to a particular local authority, though which may have previously been applied elsewhere". The central point seems to be as Moore et al. (1997, p. 276) emphasises: "Those changes worth recognising as innovation should be new to the organisation, be large enough and durable enough to appreciably affect the operations or character of the organisation".

Osborne (1998b) has developed a typology of innovation in the public sector that illustrates both the dimension of radical and incremental innovation and the contextual dimension of innovators and imitators. As he puts it, the typology "(…) allows the exploration of the relationship between the staff of an agency (the producers) and the end-users of a service (its market)". Innovation is categorized as (1) total change, (2) expansionary change, (3) evolutionary change and (4)

[27] http://www.innovation.cc/, an internet-based journal aiming at sharing ideas and discussing public sector innovation.

developmental change. Total change implies radical newness, while expansionary change is when methods developed elsewhere is used to meet the needs of a new group of end users. Evolutionary change is new methods developed over time for a defined client group, and developmental change is to refine and modify the methods in order to meet the goals more efficiently. Osborne emphasises that the typology is useful for studying social policy and change because it differentiates innovation from incremental organisational development. The three first types "(…) all involve discontinuity for the organization, in terms of its services and/or its end-user group, but the fourth type, developmental change does not (Osborne 1998b, p. 1142).

The literature on innovation in the public sector points at definitions of innovation "(…) such as 'novelty in action' (Altschuler and Zegans 1990) and 'new ideas that work'. These definitions emphasise that innovation is not just about new ideas, but also about new practices. Altshuler and Zegans (1997, p 20) underlines that: "An innovation has at least two elements: a fresh idea and its expression in a practical course of action. The idea may be an invention (if it is a product of creativity) or a discovery (if it has been found in nature or in some wider human environment)". Albury (2005, p. 51) defines innovation as: "Successful innovation is the creation and implementation of new processes, products, services and methods of delivery which result in significant improvements in outcomes efficiency, effectiveness or quality". Moreover, Hartley (2005, p. 28) points at that some writers (e.g. Damanpour 1993; Moore et al. 1997) have tried to develop typologies of innovation, and finds that these might at least distinguish between product, service, process, position, strategic, governance and rhetorical innovation. Other types are also defined in the literature on innovation in the public sector: service concept, a new way of putting elements together, new goals, new approaches to organising and introducing new decision rules (Nice 1999, p. 5; Altshuler and Zegans 1990). Sanger and Levin (1992, p. 102) also hold that "(…) new ways can also involve public-sector use of techniques that are typically associated with the private sector", e.g. NPM related changes.

Although Schumpeter's (1934) five types might be said to have been recognized in the literature – as well as other types that appear as specific for the public sector – it is not much discussed what this implies for the understanding of innovation in the public sector. In general, there seem to be an over-focus in the literature on innovation in the public sector on Schumpeter's first innovation type, the emergence of new material goods. The discussion is often based on the fact that the public sector does not produce material goods at the same level as in the private sector. From this it is then inferred that not much innovation takes place in the public sector. The over-focus on material goods innovation may be due to the fact that the innovation literature in general is dominated by studies of new products and production processes (e.g. Drejer 2003; Fagerberg 2005).

On the difference between innovation in the public and private sector

Are the main processes underlying innovation in the public sector different from the private sector? The main difference is thought to be the lack of the mechanisms of the market that is understood as the overall mechanism for success in the private sector. Drucker (1985) claims for example that public-service institutions have three main hindrances for innovation, and that this results in maximizing rather than optimizing of the activity in public service institutions. First, public sector activity is based on budgets and not on results, and "(…) any attempt to slough off activities and efforts therefore diminishes the public-service institution. It causes it to lose stature and prestige." Second, the public-service institution has to satisfy everyone. The private enterprises, on the other hand can make alliances and abandon upon others and have success as long as they sell to consumers in a small part of the market. Third, "(…) public-service institutions exist after all to 'do good'. This means that they tend to see their mission as a moral absolute rather than as economic and subject to a cost-benefit calculus. (…) If one is 'doing good' then there is no 'better'" (Drucker 1985, p. 179).

Borins (2001) points at the lack of success mechanisms in the public sector, and claims that the public sector has *asymmetric incentives* for innovation. The public sector does not reward successful innovations, while unsuccessful innovations have grave consequences. There are no bonuses, pay rise or share ownership to motivate the employees. Besides, innovation failures are often denounced in the media and by the political opposition, and might ruin the careers of the public servants involved. On the other hand, Kalu questions whether market mechanisms can be transferred to the innovation dynamic in the public sector. Do "(…) rational individuals acting in a self-interested manner, within a competitively driven market, achieve the maximum social good for all?" (Kalu 2003, p. 542) According to Kalu these key assumptions serve different and even conflicting value orientations, as "(…) self-interest serves an individual end, competition creates value for the market, and social good stands for the public interest". Other mechanisms are also pointed at, and Borins (2001, p. 310) states that: "(…) despite this inhospitable environment, frontline public servants and middle managers are responsible for many innovations". Such innovations can be linked theoretically to the "Total quality management (TQM) movement, which believes that ensuring quality is the responsibility of everyone in a company, regardless of their position or level of formal education" (Borins 2001, p. 313).

Unfortunately, Borins (2001b) does not say much about how TQM and relevant motivating factors lead to innovation in the public sector. In general, there seems to be a lack of empirical studies in the literature on innovation in the public sector (e.g. Hartley 2005). Kalu (2003, p. 540) for example calls for attention to the need for studying practical policy implementation in order to bridge the ideological rhetorical gap between the reinventing government movement (Bellone and Goerl 1992; Osborne and Gaebler 1992; Peters and Waterman 1982) and the democratic governance tradition (e.g. Diver 1982; Moe 1994; Reich 1990). It is a philosophical duel between the two as to "(…) whether administrative leaders and bureaucrats in the public sector should operate as private sector entrepreneurs or should be seen as the conservators of our constitutional values". Kalu emphasises that "(…) whereas the idea of bureaucrats as public entrepreneurs is philosophically problematic, the idea of bureaucrats as conservators, though partly relevant, is insufficient". He emphasises among other things that: "As every ordinary person, bureaucrats are rational actors driven by self-interest. Altruism and the moral obligation to do good cannot be adjudged as the primary factor that drives bureaucrats to become effective public servants." (Kalu (2003, p. 556).

As indicated above, the literature also emphasises that there is a fundamental difference between the private and the public sector. Kalu (2003, p. 544) puts it this way:

> "The market system pursues one goal above all others, the goal of efficiency. But the government, as the repository of the public interest, pursues multiple goals inclusive of efficiency. Whereas efficiency in the private sector is achieved through reductions in the cost of operation and in the generation of profits, efficiency in the public sector is secured through marginal cost reduction through gauging clientele satisfaction as well as procedural adherence to the rule of law, due process and obedience to legislative mandates".

Moreover, as Drucker (1985) pointed at the public service institutions have to satisfy everyone. It should benefit the public good (Manley 2001). Hence, given these essential dimensions of multiple goals that are complexly linked together and the need for satisfying the public good – how then can innovation happen at all in the public sector? This bring us back to where the discussion in this section started, pointing at the lack of the market mechanism and the hindrances for innovation in the public sector. However, the literature on innovation in the public sector also points out that innovation in the private sector does not always lead to success. Though, as Hartley (2005, p. 31) highlights: "In the private sector, innovation based on increasing choice is valuable in its own right as this may give market advantage. Yet, in public services if the extra choices are not wanted or needed, or only give wider but not better services, then innovation has not led to improvement". At the same time, the literature also underlines that being an entrepreneur – and risk taker – is not directly connected with the economic rewards or penalties in the market. The issue of risk is rather an outcome of behaviour and other more or less accidental circumstances, as for example: government policies, economic climate, competitor's actions, the weather, and other factors that may intervene to cause variations in outcomes (Eisenhardt 1988, p. 490).

Furthermore, the literature also recognizes that multiple goals in the public sector can and is divided into relatively manageable policy goals. Albury (2005, p. 51) suggests for example that for the public sector the most "(…) important critical success factor is an effective set of linkages and relations between the innovators and the end-users, and between elements of the 'supply chain'". The adoption of terms such as *customer* instead of *citizen* to describe the users of public services is one of the main features of NPM and the characterising of the public sector in terms of the market. The term *customer* indicates freedom of choice, and an effective market relationship between the public sector as a seller of public services and the citizens as buyers and users. The choices of the customers are seen to act as feedback-processes, in the same way as in the private sector.

On the other hand, it might be argued that the use of such terms is mainly symbolic as a type of euphemism. The customer concept is for example inappropriate regarding receivers of unemployment benefits. These users do not have a number of different funding systems to choose between. On the other hand, there are groups such as the elderly that often have a range of choice opportunities regarding for example home helpers, nurse on call, elderly houses and nursing homes. Though, how free is actually the choice for the public customer? The choices of elderly houses and nursing homes are highly rationed by long waiting lists and are only offered to the elderly in need of full medical treatment. Although these elements are recognized, the literature neither focuses much on how innovation processes progress through success and failure in the public sector, on how the various parts or sectors of the public domain have defined relatively manageable policy goals, or on how the role of citizen as customer can function as a basis for feedback to the service providers.

One possible conclusion of this discussion is that the market dynamic seems to be somewhat overstated as the demarcation criterion between the private and the public sector. The main processes underlying innovation in the private sector is also highly dependent on other mechanisms, e.g. to entrepreneurs and dominating companies in the market. Schumpeter (1934) underlined the role of the entrepreneur for the new combinations to be carried into effect. Entrepreneurs are individuals that see possibilities for *creative destructions* and that are strongly motivated – more often by the joy of creating than the quest for profit. They are the driving-force in convincing others to support and contribute to the development. However, in his later contribution: *Capitalism, Socialism and Democracy*, Schumpeter (1942) underlined the role of the *creative accumulation* taking place in big firms' research and development departments, and that these firms are a barrier to the entrepreneurial start-up activity he had focused on earlier.

These two perspectives on innovation dynamics are referred to as Schumpeter Mark I and Schumpeter Mark II in the classic innovation literature. Remarkably, the literature on innovation in the public sector does not refer much to the Schumpeterian literature at all. In general, the literature refers little to the classic innovation literature and to the literature on innovation in the private sector. Given this, it is quite amazing that the literature on innovation in the public sector focuses on the role of market mechanisms for innovation. Innovation in the public sector seems to be a rather separate theoretical tradition. Thus, the literature seems to be in an un-clarified parallel position. This may be due to the fact that the literature that addresses the phenomenon of innovation in the public sector is quite new, and the fact that innovation theory is not a formal and established theoretical tradition but an amalgam of various disciplines: economics, management, organisational psychology, cognitive theory and system theory, dealing with various aspects of innovation.

The System of Innovation Approach

The classic System of Innovation approach (e.g. Freeman 1987; Lundvall 1992; Nelson 1993; Edquist 1997) claims that companies do not innovate in isolation, but interact with other companies, suppliers, competitors, customers, financial institutions, universities, government agencies and others to "(…) gain, develop and exchange various kinds of knowledge, information, and other resources" (Edquist 1997, p.1-2). In order to understand and explain innovations, a *holistic* perspective is needed, taking in all relevant actors, their relations and the complicated feedback mechanisms of the system. Still, innovation is in the classic approach strictly a *micro-level* phenomenon, starting within companies trying to solve certain problems. The actors and the relations in the system represent various sources to knowledge and competence. Moreover, the company undergoes a learning process, a *cumulative accumulation* of the knowledge and skills in the system that is needed for the innovation to take place. Hence, the *absorptive capacity* (Cohen and Levinthal 1990) is essential, as "(…) this reflects the cumulative and embedded character of firm-specific knowledge" (Fagerberg 2005).

The perspective revitalized Schumpeter's (1934, 1942) ideas. Although several studies during the 1960s and 1970s challenged the neoclassic perspective on economic development, the breakthrough of Schumpeter's ideas of innovation came first with Nelson and Winter's book: *An Evolutionary Theory of Economic Change* in

1982, "(…) that represented the catalyst for the creation of a new, general approach" (Saviotti 1997, p. 181). Nelson and Winter (1982; Nelson 1987, 1995b) claims that economic development is driven by mechanisms similar to Darwin's natural selection. Technology never reaches a state of equilibrium, because the development is never optimal in an absolute sense, only "(…) superior to those earlier in existence and adjustment forces work slowly (Nelson 1987, p. 16)". The evolutionary dimension was brought further by Dosi (1988) who claimed that the innovation opportunities are defined in the *technological trajectories* of the existing technological paradigm. That is, "(…) firms seek to improve and to diversify their technology by searching in zones that enable them to use and to build upon their existing technological base. In other words, technological and organisational changes in each firm are cumulative processes too" (Dosi 1988).

The System of Innovation approach is not a formal and established theory, but rather a conceptual framework underlining the systemic aspects of innovation. Actually, the various perspectives that make up the framework focus and define the system of innovation in various ways, geographically and functionally. The *National System of Innovation* (e.g. Freeman 1987; Lundvall 1992; Nelson 1993) defines whole nation states as innovation systems and focus on national differences in innovation. This perspective has been criticised for being too broad and too all-embracing and especially for taking the geographical boundaries of the nation state as given. Alternative boundaries for the innovation system have been developed in the *Regional Systems* approach, defining the innovation systems by geographical regions or clusters within a country (e.g. Saxenian 1994), in the *Technological Systems* perspective (e.g. Carlsson and Stankiewicz 1991) defining the system in specific technology fields and in the *Sectoral Systems of Innovation approach* (e.g. Breschi and Malerba 1997, Malerba 2004a; 2004b) defining the system in various sectors as "(…) unified by some related product groups for a given or emerging demand and that share some basic knowledge (Malerba 2004a, p.9.)".

The Sectoral System of innovation approach (Malerba 2004a, p. 9) claims that "(…) innovation takes place in quite different sectoral environments", and it is only by studying the systems of these sectors, i.e. their technology, the actors and networks and the institutions that we can understand the systems and dynamics of the different production arenas. However, as Tether and Metcalfe (2004, p. 317) have highlighted: "(…) whilst the 'sectoral systems' approach has tended to be more specific than the 'national systems' literature the sectors still tend to be defined by using conventional 'industries' as points of reference". Their perspective, the Sectoral Innovation Systems in Services does not "(…) attempt to study entire 'sectors' of service provision, but have instead focused on particular problems, innovations and wider transformations arising within the production of specific services”.

In general, the System of Innovation approach underlines the need for defining the actors, the relations between the actors and the feedback mechanisms, and how these represent various sources to knowledge and competence. It is important to study the learning processes, the absorptive capacity and the cumulative accumulation of knowledge and skills in the public sector. Moreover, it is essential to understand these systems as coexisting systems at national, regional and sectoral level, also including the technological systems in the production of specific public services.

Systems of innovation in the public sector

The literature on innovation in the public sector generally regards the public and private sectors as two separate innovation systems at the national level. In this regard the literature largely follows the National system of Innovation approach. However, what is the public sector? In fact very few discuss what innovation is in the various settings of the public sector. This is somewhat surprising given that the literature draws attention to very different parts of the sector, as for example the conservator role of democratic values (e.g. Reich 1990; Moe 1994), the rigidness of the hierarchic and bureaucratic organisation of the state (e.g. Peters and Waterman 1982; Bellone and Goerl 1992; Osborne and Gaebler 1992) and the lack of incentives to motivate the employees in the public service organisations (Drucker 1985; Borins 2001).

However, this paper argues that the public sector might be divided into similar “industries” as in the private sector, and that these sectors must be identified to understand the main processes underlying innovation. Moreover, innovations happen in organisations and institutions within these public sectors. Are the main processes underlying innovation in for example the bureaucracy, the ministries and the local policy institutions the same? This problem is little addressed in the literature on innovation in the public sector. This becomes a problem if we agree with Moore (2005, p. 48) who states that innovation must be studied at the “(…) organisational level rather than sector or industry level variables”.

To remedy this it is first necessary to identify the industries or sectors in the public sector. The public sector consists of numerous specialized fields that are parts of more overall policy areas, as for example the areas of health, defence and education. These areas may be studied with basis in the sectoral system of innovation approach (e.g. Breschi and Malerba 1997; Malerba 2004a, 2004b). The policy areas or policy sectors differ according to their technology, what actors and networks are involved, and the institutions that are relevant. The knowledge base and scientific fields differ clearly from health to education and defence, and in how the technology is applied to produce sectoral results.

Malerba (2004a, p. 24) suggests that "(…) firms are the key actors in a sectoral system. (…) characterized by specific beliefs, expectations, competencies and organisation, and are engaged in processes of learning and knowledge accumulation". Although, the actors in the public sector can not be defined as firms, the "production" also here takes place within similar small or large organisations, as for example hospitals, schools, public job centres and the armed forces. Furthermore, the organisations in the various sectors are connected in formal and informal networks and framed by institutions as in Malerba's sectoral systems of innovation. Malerba (2004a, p. 26) points at the "(…) norms, routines, common habits, established practises, rules, laws, standards and so on, all of which shapes agent cognition and action and affect interaction among agents". Hence, one should also expect that the policy areas in the public sector might vary according to the technology characterizing the sector and the various possibilities for learning processes and cumulative accumulation of knowledge and skills. Moreover, one should also expect that these processes vary according to who are the actors, the relations between the actors and the feedback mechanisms of the sectoral system. The armed forces is perhaps the most archetypical example of a closed sectoral innovation system. The armed forces and the defence industry have a clear mutual existence relationship. The defence industry had hardly existed without the addressed needs of the defence and the tasks and the military-technological level of the national defence is clearly shaped by the weapon production industry. President Dwight D. Eisenhower named this mutual existence relationship the "military-industrial complex" in his last speech as US president in 1961[28].

Moreover, as Moore (2005) points out, there is a need for studying the innovating organisation. Moore describes two different models for the main processes of innovation in the public sector. The first model focuses on "(…) break-through technologies that are large, robust, and can solve the performance problems of whole industries. The other model focuses on learning organisations that seem to have a continuing capacity to improve their operations and do so through the daily accumulation of a large number of small innovations that results in an important change in overall organisational performance" (Moore 2005, p. 44).

Whereas the first model might be regarded as having clear similarities to Schumpeter Mark II, the learning organisation model is also stressed by others. The 'groping along' literature (Behn 1988; Golden 1990) emphasises the need for trying out ideas in action and learning from experiences to innovate. Learning organisations

[28] see for example: http://coursesa.matrix.msu.edu/~hst306/documents/indust.html

“(…) should evaluate its implementation of these policies, not against prospectively stated objectives alone, but in light of discoveries made during implementation” (Browne and Wildavsky 1984, p. 255). Sanger and Levin (1992, p. 104) highlights the learning aspect: ”We found that public sector innovations generally did not spring anew as if from blueprints, but evolved through and adaptive process. Their novelty more often was in their assemblage – often of familiar parts. Like natural selection, the evolutionary tinkering that ultimately produces innovation is messy. Organisms change and adapt; their ultimate fate is tested in the field. Evolutionary tinkering – using bits and pieces of what is around in new ways to meet changing circumstances – is iterative, incremental and disorderly. Failure – error – becomes the basis for evolutionary learning. Analysis occurs at the implementation stage, after a process that is begun to ‘do the doable’”. This seems to have clearly resemblance to the Evolutionary Theory of Economic Change (e.g. Nelson and Winter 1982).

Moreover, given that the public sector consists of very varied organisations, with varied institutional settings, tasks and technology, one should also expect to find that there are different mechanisms, as for example these two models, underlying innovation in the various organisations. The health sector is for example partly developed through huge technological break-throughs as for example the x-ray technology, but also continually learning is probably essential for these and other innovations in the health sector. The mechanisms in the democratic and the political organisations, on the other hand, as for example the Government and the political parties might be described by these processes but perhaps also by “political entrepreneurship” (e.g. Zerbinati and Souitaris 2005). That is, as a special type of entrepreneurship attached to the role of being a politician driven by ideological ideas. It might be argued that this type is driven by the joy of creating emphasised by Schumpeter (Roste 2006). Whereas innovation in the public services in still other situations may be driven by customer feedback as there is a demand for some services and not others.

Thus, it should now stand out as relatively clear that innovation in the public sector is not something uniformly different from the private sector. Innovation in the public sector happens in very heterogeneous sectors and organisations. Figure 1 illustrates the systems of innovation in the public sector, as happening in highly different organisations in several systems at the same time, in national, regional, sectoral and technological systems.

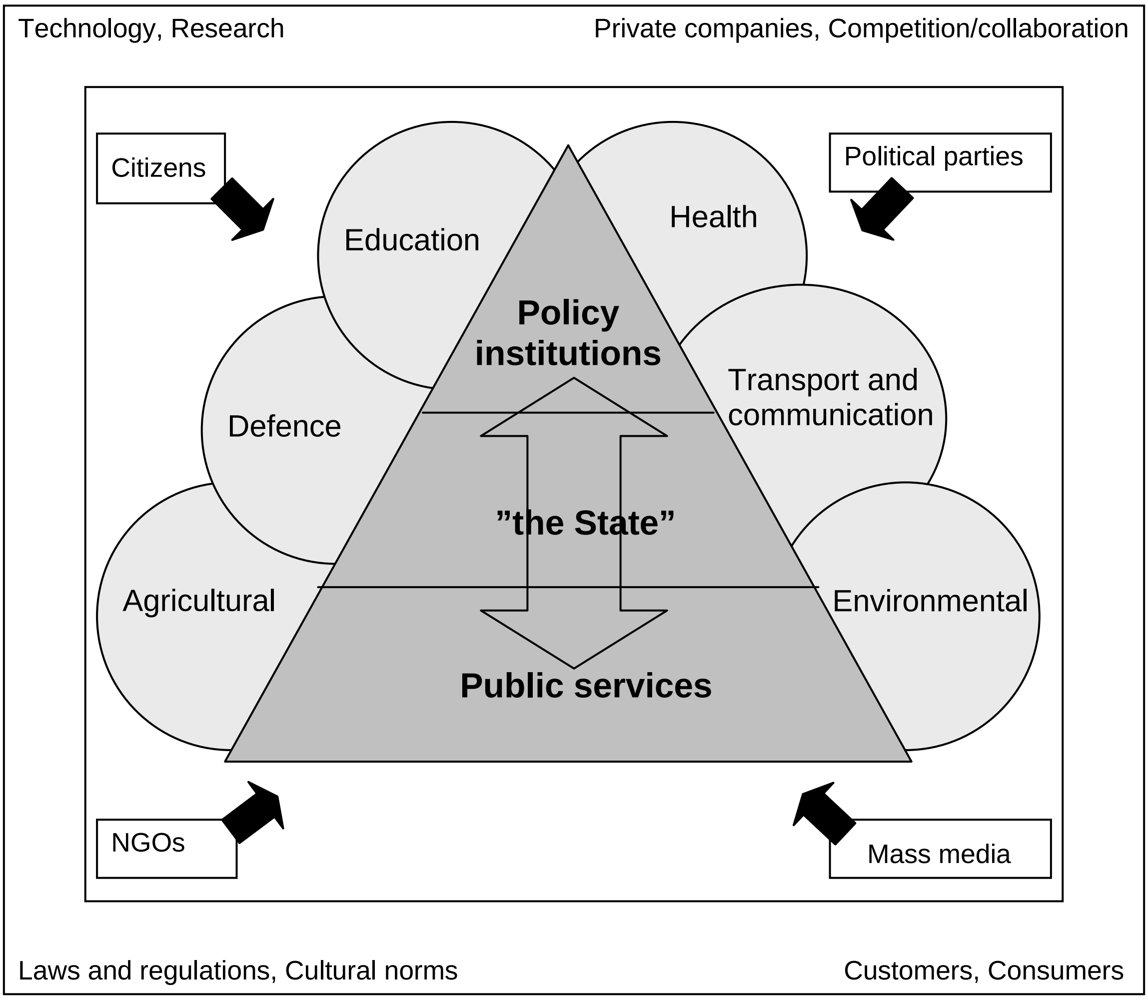

Figure 1: The system of innovation in the public sector

The system of innovation in the public sector consists of several systems at the national, regional and sectoral level. Each of these systems consists of the policy institutions at national, regional and local level, the "state" and the public agencies implementing the policy, and the public services providing practical services to the citizens and the customers. The service providers are not necessarily limited to public organisations, but might also be provided by private companies and non-governmental organisations. The services are here defined as public as long as the public sector is responsible for the service produced.

In principle, the systems may be understood as based on the traditional top-down image of the public sector; with the national policy institutions on the top framing the activity in the policy goals and in "the State" and the public service providers as the implementers of the policy goals. This traditional idea is very embedded in the literature of innovation in the public sector. For example, Altshuler and Zegans (1990, p. 17-18) state the following: "Business innovation is driven mainly by competition (…) competition in the public sphere is by contrast, electoral. This does inspire many politicians to welcome new ideas. (…) Public agencies on the other hand, are typically monopolists within their specified jurisdictions, with management systems that provide few stimuli for innovation". However, as Albury (2005, p. 51) underlines, innovation might also happen as bottom-up processes where the initiative comes from below. As in the private sector, innovation is often happening as parallel developments that have impact over time, where the innovation processes are dependent on entrepreneurs to survive through tuff times. The sources for ideas for future innovations should be several, given the many and various political actors, as for example the citizens, the non-governmental organisations and the mass media that tries to influence on the outcomes of the public sector. Moreover, technology and research in society in general probably also influences on idea generation, and that these vary according to different sectors. The innovation potential in the public sector is probably also dependent on the laws and regulations in the sector, and the demands of potentially customers in the market.

Concluding remarks

The public sector is often thought of as homogeneous, as something uniform that differs from the private sector. At the same time, the private sector is not thought of at the same scale of uniformity, but more of as various industries. This paper argues that the public sector might be divided into similar "industries", and that these sectors must be identified to understand the main processes underlying innovation in the public sector. Moreover, innovation happens within organisations (e.g. Moore 2005; Newman et al. 2005). The public sector consists of a large number of organisations, of for example Governmental agencies, the ministries and public service institutions. These various organisations are quite different from each other when it comes to the actors, their relations to other organisations, their technology and their institutional setting. Hence, the underlying mechanisms for innovation must vary between these organisations. Figure 1 illustrates how innovation in the public sector happens within various organisations in several systems of innovation at the same time, in national, regional, sectoral and technological systems.

This paper has attempted to clarify the concept of innovation in the public sector by questioning the dualistic view of the private and public sector that has dominated the social sciences in the last decades. However, this view seems also to dominate the literature on innovation in the public sector. Still innovation happen. Hence, innovation appears almost as a mystery that happens more as an in spite of phenomenon than because of identifiable underlying processes in the public sector. Though, it might be due to an ideological shift in the public sector that the literature has not yet taken in. Hartley (2005) points at that it has been an historical shift from the paradigm of NPM to the networked governance, but that these paradigms also coexists.

In general, it seems to be a tendency to regard innovation in the public sector as something good in principle that does not need to be defined. Yet, in reviewing the literature, discussions and definitions are found. The phenomenon is here discussed and defined in similar ways as in the classic innovation literature, which is along the radical-incremental dimension of change and of various types of innovation. However, very few discuss what innovation actually means in the various settings of the public sector. Besides, it is also very few empirical studies illustrating the phenomenon. This might be due to the fact that the public sector has been ignored until recently in the innovation literature and that the phenomenon is still quite new and unexplored.

Moreover, the literature seems to focus more on the differences between the private and the public sector, and how to foster innovation in the public sector than on identifying the genuine understanding of innovation. The problem for the public sector is thought to lie in the market as the overall mechanism in the private sector, pressing the firms to develop new products and production processes in order to be competitive and survive in the market. The public sector, on the other hand, is thought to lack the mechanisms of the market and to be held back by budget based production-systems, the lack of motivating rewards of the employees, multiple policy goals and the demand for the public good. However it is not referred to literature that shows that this is the underlying dynamic of innovation in the private sector.

Schumpeter (1934, 1942) emphasised in his early contributions the role of entrepreneurs seeing the possibilities for creative destruction, and in his later contributions the role of creative accumulation in large established firms. The System of Innovation approach (e.g. Freeman 1987; Carlsson and Stankiewicz 1991; Lundvall 1992; Nelson 1993; Saxenian 1994; Edquist 1997; Breschi and Malerba 1997, Malerba 2004a; 2004b) revitalized Schumpeter’s ideas. The approach points at the fact that companies do not innovate in isolation, but they interact with other companies, financial institutions, universities and research institutions and public policy etc. All these actors, their relations and the feedback mechanisms of the system must be studied to understand innovation. Moreover, the production dynamic and systemic interaction do not happen within one clearly defined innovation system, but within several systems at the national, regional, sectoral and technological level. These systems are also complexly linked to each other. This paper is a first attempt to show how the System of Innovation approach might contribute to understand innovation in the public sector by identifying the systems of innovations in the public sector.

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