Tekes Review 291/2012

Capabilities for innovation activities

Impact study

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Tekes, the Finnish Funding Agency for Technology and Innovation

Tekes is the main public funding organisation for research and development (R&D) in Finland. Tekes funds industrial projects as well as projects in research organisations, and especially promotes innovative, risk-intensive projects. Tekes offers partners from abroad a gateway to the key technology players in Finland.

Tekes programmes – Tekes´ choices for the greatest impact of R&D funding

Tekes uses programmes to allocate its financing, networking and expert services to areas that are important for business and society. Programmes are launched in areas of application and technology that are in line with the focus areas in Tekes' strategy. Tekes programmes have been contributing to changes in the Finnish innovation environment for twenty years.

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Foreword

Tekes, the Finnish Funding Agency for Technology and Innovation, is the most important public financier for research, development and innovation in Finland. Tekes's achievement of its objectives is monitored through impact analyses and studies. This report describes how Tekes has succeeded in building capabilities for innovation activities, which is one of its key objectives. This objective is also strongly linked with those associated with competence base and internationalization of innovation activities.

The given assignment was especially challenging because there are no proven methodologies available to measure the impact of public financed actions in capability building. Capabilities for innovation cannot be easily quantified but have to be observed indirectly. Thus establishing valid causal relationship is difficult and measuring the development of innovation capabilities is prone to misinterpretations.

The study was carried out by doctor Johan Wallin and his team at Synocus Ltd. A great deal of their work, as well as discussions at the steering group, was devoted to developing a conceptual model for understanding the role of development activities in innovation capability building. The evaluation team succeeded in producing a conceptual framework that serves well the evaluation of the Tekes's operations impact. The applied methodology might provide a useful tool for future analyses of innovation policy impact as well.

On behalf of the steering group, I would like to express warm thanks to the Synocus evaluation team for their creative problem solving and rigorous work in producing credible outcome for this impact study.

Helsinki, 29 March 2012

Antti Valle
Head of Division, chairman of the steering group
The Ministry of Employment and the Economy

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Background

Tekes is the most important public organization financing research, development and innovation in Finland. In 2010, it provided more than €600 million in grants and loans. In its strategy Tekes has identified four objectives:

Productivity and renewal

- sustainable growth, which requires increased productivity and renewal of the industrial life

Wellbeing of humans and the environment

- effective specific measures will be implemented to improve the wellbeing of humans and the environment

Capabilities for innovation activities

- more skills that can be utilized and enhanced in research and innovation networks

Tekes of the future

- an inspiring, influential and responsible actor.

The third objective, building innovation capabilities is the focus of this report, which evaluates what impact Tekes has had historically on building innovation capabilities in Finland, and what impact Tekes could have on nurturing innovation capability-building in the future.

Capability building within a company or network cannot be easily quantified. Unlike e.g. productivity, capabilities for innovation cannot be measured as easily as dividing output by the quantity of resources used, but have to be observed indirectly. A great deal of ambiguity is involved, making measuring the development of innovation capabilities prone to misinterpretations and error. Thus, for example, econometric analysis is of little help, as establishing valid causal relationship that can be operationalized is very difficult.

The approach taken in this impact study is to develop a conceptual model for understanding how the capabilities may evolve if the right set of activities is carried out. Using this model it will subsequently be possible to identify some preliminary hypotheses about which innovation support activities are most important, and then look to verify these hypotheses through case studies and surveys among leading actors in the Finnish innovation system.

The Capabilities for Innovation Activities – impact study, will also serve as a tool in evaluating Tekes's productivity/impact, and provide a foundation for successive future assessments of Tekes's operations. As guidance for the study the first steering meeting raised the following questions:

- How does the research community's expertise influence innovation capability building in the long run?
- How to assess the question of "knowledge spill-over effects" to other industries and sectors outside of the original target? Other studies have indicated that half of the benefits of Tekes's activities are in this category.

- If the focus is on the explicit capabilities of enterprises (companies and public organizations), how to account for more general infrastructure impacts due to Tekes interventions? Building human, structural and relational capital can take place in more subtle ways, whereby its impact can only be recognized ex-post. Especially research-based interventions by Tekes aim to create this form of impact. This implies that there is also a need for an assessment of how the preconditions for innovative behavior are created, considering also the geographical perspective; both domestically and internationally.
- The definition of results of innovation cannot be limited to new offerings, but must also include new types of network constellations, business models and alterations to existing networks and business models as these are also evidence of innovation. Especially when considering the public sector these forms of innovations are important. How to take this into account?
- The dynamic capability perspective (Teece et al 1997, Helfat 1997, Eisenhardt, Martin, 2000, Winter, 2003, Helfat et al 2007, Teece, 2009) is biased towards a firm-centric view on innovation, and subsequently the impact study must also employ complementary perspectives.

With these considerations as a basis the next chapter will introduce the conceptual framework for the study.

2

Conceptual foundation

When evaluating Tekes's impact on innovation capabilities, it is necessary to agree upon a set of basic definitions and a conceptual framework on the basis of which it will be possible to discuss Tekes's impact. These definitions will be introduced in this chapter. This chapter will proceed as follows.

In the following section we will use an open-systems approach to operationalize the notion of capabilities for this impact study, resulting in the categorization of capabilities into four operational and three leadership capabilities. We will then use the example of Exel and One Way Sport to illustrate how capability building resulted in a process innovation, which radically altered the market for ski-poles in Europe. This will address the question: What are capabilities? Having thoroughly discussed what capabilities are we will then proceed to address the question: Where do capabilities come from? Here we will use the case of Oulu and its emergence as a leading innovation hub in information and communication technology to explain how capabilities emerge. The remainder of this chapter will use these examples to enrich the presented high-level framework for supporting the building of innovation capabilities.

2.1 An open systems view on innovation

In today's business world most companies and institutions create value through extended networks of organizations that cooperate and compete simultaneously. Such extended networks of firms can also be called ***business ecosystems***, *communities consisting of organizations, institutions and individuals that impact the nodal enterprise and its customers and suppliers* (Teece, 2009, p. 16).

Ecosystems link one firm's competences or resources to those of other firms in order to draw on a broader range of competences, to acquire desired competences more quickly or to extend the reach of current competences into new competitive domains.

For a firm to sustain superior performance in an open economy with rapid innovation and dispersed sources of invention, innovation, and manufacturing capabilities it must shape the 'rules of the game' within the ecosystem. This is the result of co-evolution and complex interaction between the ecosystem participants and involves learning, interpretation, and creative activity. However, the micro-foundations necessary to make this work in practice are difficult to develop and deploy (Teece, 2007).

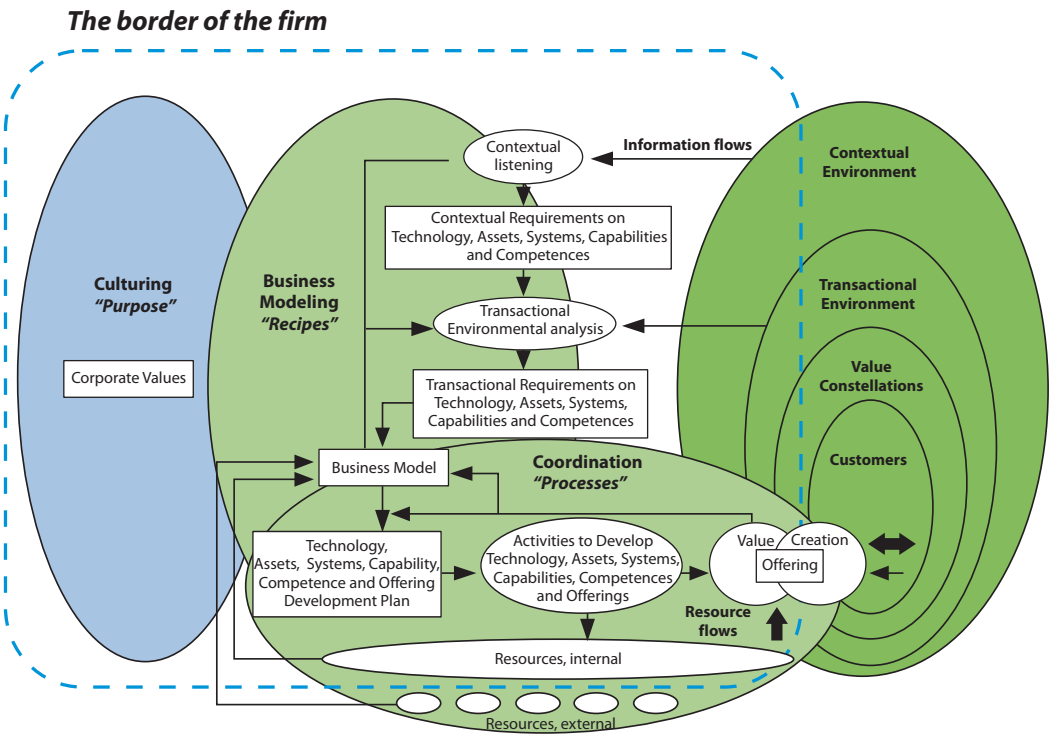
A firm can be characterized as an open system of asset stocks and flows (Dierickx and Cool, 1989).The model of the firm as an open system presented in Figure 1 has its origin in a model, developed by Sanchez and Heene (1996)[1], and was originally presented in Wallin (2000). The model of the firm as an open system can be summarized to consist of three parts: the purpose (values and goals), the recipes (the business model) and the value creating processes.

The origins of the model of the firm as an open system can be located in the value-creating business processes through which the firm-addressable resources and customers are coupled together. To be able to provide value to customers the firm develops and delivers offerings, which require activities to develop technology, assets, systems, capabilities and competences. These activities are planned for according to the priorities set within the business model.

The business model is under constant re-evaluation, as the environment in which the firm exists is dynamic. For the firm, customers represent a very immediate contact with the external environment. Other actors within the val-

[1] Sanchez and Heene (1996) connect their model to earlier works on the systems behavior of firms (Ashby, 1956, Forrester, 1961, 1968, Simon, 1969, Dierickx and Cool, 1989, Teece, Pisano, and Shuen, 1990)

Figure 1. The firm as an open system (Wallin, 2000)



ue constellation, such as co-suppliers (which can also be competitors) also provide the firm with feedback information, based on which the firm will consider a possible redesign of its business model.

A firm must make decisions about which resources to develop, access and deploy. These decisions are influenced by external and internal environmental factors, including the desires or actions of customers and other stakeholders[2]. Therefore, business intelligence activities – getting information about, and feedback from, the firm's transactional and contextual environments – support, and are often key elements in, making the right decisions. Business intelligence activities evaluate the requirements of technology, assets, systems, capabilities and competences imposed on the firm. These business intelligence activities can be categorized into contextual listening and transactional environmental analysis. Business intelligence and decision making together form the business modeling process. The business modeling process is highly influenced by the corporate values, as well as the perceptions of managers, board, and other stakeholders affecting decision making on the business model. Thus the firm's prospects of attaining its goals are critically dependent on its ability to manage the systemic interdependency of its own internal resources and processes, as well as their open-system interfaces, with external resources.

Management controls the processes within the organization it manages and in this sense holds power over internal issues. Management listens to (Crozier, 1989) and influences the transactional environment. This capability of "listening" to contextual environments gains management attention as business becomes more complex and it becomes necessary to an-

2 van der Heijden (1996) and Freeman (1984) have categorized the stakeholders of the firm into five groups: suppliers, employees, competitors, money providers and the government. de Geus (1997) emphasizes the importance of recognizing the firm in itself as a stakeholder.

ticipate discontinuities and to try to act in advance of their full impact (Utterback, 1994, p. 220).

The model of the firm as an open system separates value distribution and value creation. Value distribution is guided by the corporate values, which can be defined as follows:

*Corporate **values** are generalized, but relatively enduring and consistent priorities of what the firm wants to be* (Zetterberg, 1992).

The corporate values address two basic questions:

- who are the main stakeholders of the firm and in which order shall they be served?
- how shall each stakeholder be served according to the corporate values?

The business model in turn defines how value is created by establishing the recipes and organizational routines for the value-creating processes of the firms.

*The **business model** defines the value-creation priorities of the firm in respect to the utilization of both internal and external resources for the purpose of creating value for and with customers. The business model is in itself subject to continual review as a response to actual and possible changes in perceived business conditions.* (Wallin, 2000)

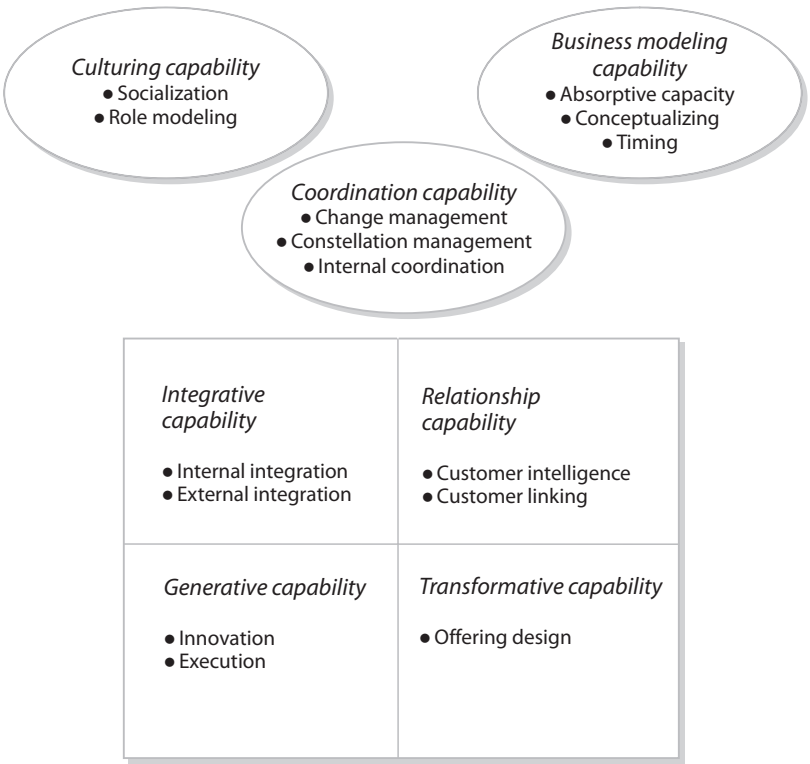
In the here presented model of the firm as an open system corporate values are superimposed on the business model and the business model is superimposed on the value-creating processes. To address how the firm actually mobilizes resources to create value we need to operationalize the notion of capabilities.

An organization's capabilities can be categorized based on whether they relate to the lower-order system elements or the higher-order system elements of the firm as an open system. The notion of higher-order and lower-order control loops (or feedback flows) introduced by Sanchez and Heene (1996) is here adapted to the categorization of capabilities. Higher-order control loops are those monitoring and adjusting asset stocks and flows and governing changes in a firm's managerial cognitions. Lower-order system elements refer to tangible assets, operations and products (ibid.).

The value-creation processes represent the "lower-order elements" of the firm. Viewing customers as "co-producers" helps to identify four capabilities: the firm's capability to develop and maintain relationships with its customers (relationship capability), the firm's capability to design products that deliver value to customers (transformative capability), the capability to create new kinds of product performance (generative capability) and the capability to deploy both firm-specific and firm-addressable resources (integrative capability). These four capabilities are called *operational capabilities*.

The firm also has capabilities that relate to "higher-order system elements". These higher-order systems are culturing, business modeling, and coordination. These capabilities can also be called *leadership capabilities*.

Figure 2. A categorization of capabilities (Wallin, 2000)



The categorization of capabilities suggested here would thus consist of seven categories: relationship, transformative, generative, integrative, culturing, business modeling and coordination capability (see Figure 2).

The innovation capability of the firm can also be approached in a different way based upon what types of resources affect the formation of the capabilities. The intellectual capital perspective takes this perspective, and divides the capabilities into three sub categories:

- human capital, or capabilities associated with persons,
- structural capital, or capabilities contained in systems, structures and operating methods,
- relational capital, or capabilities that are part of interaction, networks and images.

For an innovation agency the ambition is to be able to promote the development of each set of capabilities forming the intellectual capital. This then requires that one examines the mechanisms through which capabilities are developed and, consequently, identifies policy actions that can promote their development.

As an innovation agency primarily is interested in the emergence of radical innovations, this implies that there is a need to simultaneously develop human, structural, and relational capital in successful innovation initiatives. Subsequently the two perspectives on capabilities have to be interlinked: the categorization of capabilities and intellectual capital.

To illustrate how the capabilities view provides new insights into how competition is playing out, the way Exel lost its position as market leader in the ski pole business is an illuminating case.

2.2 Capability-based competition Exel vs. One Way Sport

Companies must increasingly evaluate their innovation possibilities in a global context, considering what resource inputs to mobilize for the value creation in order to be cost competitive. If this perspective is not taken into account, the capabilities that once proved to be superior for innovation may become obsolete in a very short time.

In Finland such a challenge was imposed upon Exel in the ski-pole business. Exel had introduced the first composite based cross-country ski poles in 1973. Its product became the leading ski-pole and entering the 2000s most Olympic medals in skiing were won by athletes using Exel poles.

In 2004 a new company, One Way Sport, entered the ski-pole business. Right from the start One Way Sport used Chinese manufacturing and large international wholesalers for its distribution. This enabled One Way Sport to operate the sales of half a million skiing and trekking poles sold in more than twenty countries with less than twenty people. For each distributer it could offer a customized solution at a very competitive price.

One Way Sport built its business model without any own strong technological basis. Instead its founders, seasoned executives from the sports industry, were well connected both with suppliers in Asia, and with the large distribution chains in Europe. Using these connections they were able to design a business model that was based on networking both up and down stream. From the perspective of the sports retailer, the concept they put together provided exactly the same technical products and delivery conditions that Exel could offer. But thanks to its outsourced production One Way Sport could provide a significantly lower price level.

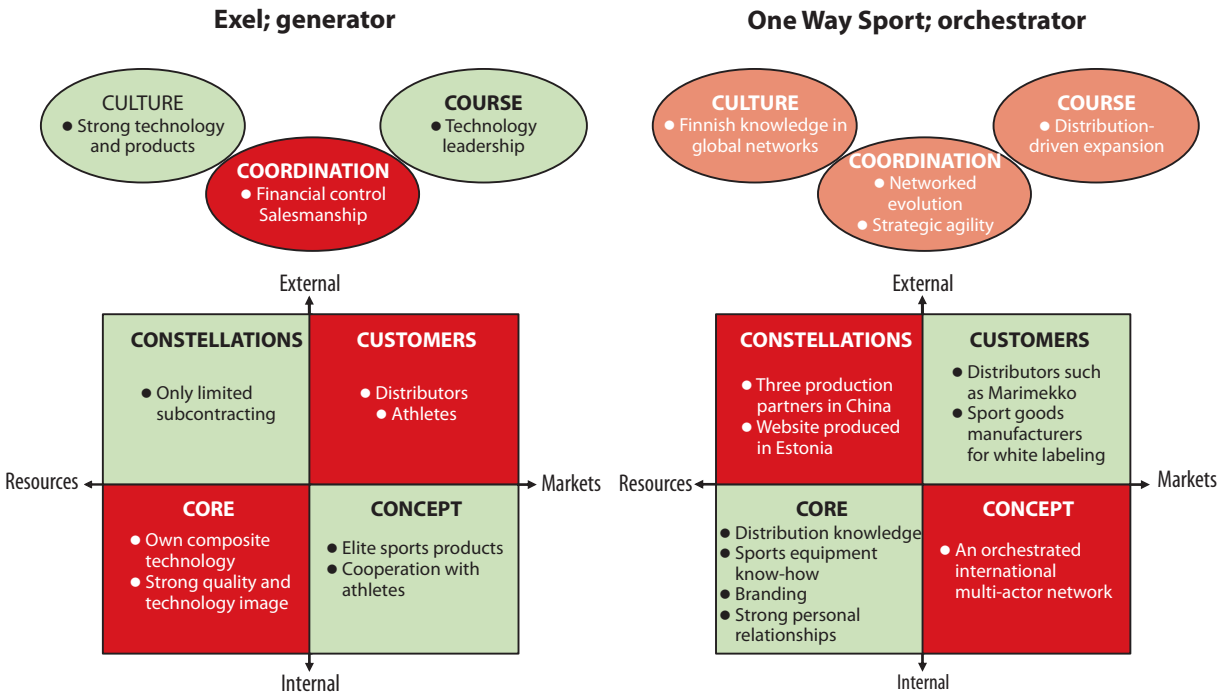
The capabilities of Exel and One Way Sport are depicted in Figure 3. The distinctive capabilities are indicated in red. For One Way Sport the leadership capabilities are in purple to indicate that they are not directly comparable to the coordination capability of Exel, but instead there is a broader scope of leadership within One Way Sport compared to Exel.

As the examples of Exel and One Way Sport show, it is difficult for an incumbent company to adapt to a situation in which its market position is threatened by a business orchestrator able to radically change the rules of the game. The way Exel felt the pain is well illustrated in its 2007 annual report:

- *The development of Exel Sports Brands was highly unsatisfactory in 2007. Sales declined and a continued big loss was recorded. Net sales decreased 29.2%. Exel Sports Brands' operating loss was EUR -10.7 compared with EUR -9.4 million last year. Lower sales and low prices from sales of old inventory had a negative impact on the margins.*

The lesson to be learnt from this is that even during times when the company performs well it should start to prepare for a shift towards a more outwardly directed perspective. When Exel was facing the new form of competition from One Way Sport it could not reconfigure its capability base fast enough to match

Figure 3. Capability portfolios of Exel and One Way Sport



the orchestrated, more cost effective business model offered by One Way Sport. In 2008, Exel completely withdrew from the sports business.

The comparison of One Way Sport and Exel raises the question of what actually forms an innovation. In seeking to define what an innovation is, a distinction between inventions and innovations is often made. For an invention to be called an innovation it has to be commercialized on the market by a business or equivalent (OECD Oslo Manual, 2005). The Oslo Manual categorizes innovations into four types: (i) product and service (offering); (ii) organizational; (iii) process, and (iv) marketing innovations.

The Oslo Manual presents four categories of factors relating to innovations:

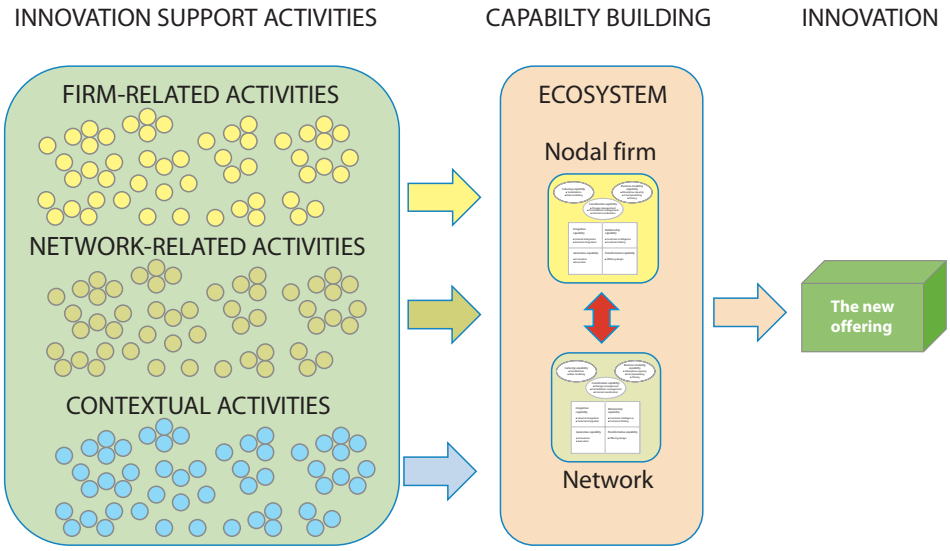
- business enterprises ("firms"),
- science and technology institutions,
- the surrounding environment of institutions, legal arrangements, macroeconomic settings, and other conditions that exist regardless of any considerations of innovation, and
- issues of transfer and absorption of technology, knowledge and skills.

Based on these prerequisites we can identify three sets of activities that support innovations, and subsequently the building of innovation capabilities:

- firm-related activities,
- network-related activities, primarily related to science and technology institutions, and
- contextual activities.

In addition to these three sets of activities, the way that these activities are interlinked is also of importance, i.e. the "issue of transfer and absorption of technology, knowledge and skills". In this chapter, the nodal firm commercializing the innovation will serve as the unit of analysis. The other actors contributing to the capability building and actual commercialization of the innovation constitute the network surrounding and supporting the nodal firm. The firm and the network togeth-

Figure 4. A high-level framework for innovation capability building support



er form a business ecosystem. Capabilities then exist, and can be built, both at the level of the firm, and at the level of the network.

The innovation support activities are provided by a multitude of actors, of which the national innovation agency, in the case of Finland: Tekes, is only one organization supporting the building of capabilities for innovation. It is also important to notice that the innovation support activities may be provided by both public and private actors, and the way that these support activities are provided in different countries may vary quite significantly.

We will use the notion of "offering" to operationalize the innovation. The offering can be a product, a service or a combination of both. The offering can introduce new attributes to the market, but it can also be a copy of an existing offering provided at substantially lower costs. In such a case the innovation has been a process innovation, which has altered the competitive set-up to the advantage of the innovator. Subsequently we can present a high level model for how innovation support, capability building and innovation are interrelated according to Figure 4.

2.3 The emergence of innovation capabilities

This role of national and local innovation agencies as active alliance partners to individual firms has received some recognition in the strategy literature (see e.g. Harwit, 1995, Peng, 2000, Wallin, Su, 2010) raising two questions of particular interest for this study:

- How can national and local innovation agencies support firms creating value through co-specialization and ecosystem orchestration?
- Considering the alternative roles innovation agencies can have for firms in their orchestrated ecosystems, what implications does this have on firm and innovation agency management?

Appendix 1 contains a detailed case analysis of how the Oulu region has benefitted from a fruitful collaboration between public and private actors. The evolution of the Oulu region seems to verify the observation by Porter (1990) that serendipity shapes industry structure and plays an important role in shifting competitive advantage in many industries. In this respect the discovery of valuable strategic opportunity is often a matter of 'serendipity' in the strict sense – not just luck, but effort and luck joined by alertness and flexibility. (Denrell et al. 2003)

Porter also treats the role of entrepreneurs in his description of the "diamond" (Porter, 1990, p. 125) concluding that differences in territorial environments have an impact on the probability that invention and entrepreneurship will occur.

In light of the case of Oulu it is also easy to agree with Porter (ibid.) that one key role of the government is to influence each of the four determinants of the diamond: (i) factor conditions, (ii) firm strategy, structure, and rivalry, (iii) demand conditions, and (iv) related and supporting industries.

In Oulu's case we can see that the government has actively tried to promote the factor conditions by localizing the university and the electronics laboratory of the state owned Technical Research Center in Oulu. In this way, one can say, that the policy of the Finnish government has been successful as it has promoted an industry where the underlying determinants of national advantage were present, and governmental actions reinforced the positive development. These activities have created an advantageous context for the ICT-sector to grow in Finland.

Porter (ibid, p. 581) suggests that it is often "outsiders" to the firms, the industry, and the established social structure that are the catalysts for innovation. The case of Oulu seems to state the opposite. Over a period of more than thirty years a very small society has proven to be able to come up with an astonishing stream of innovations that has created a number of new companies and recognized outputs, both scientifically and in the form of commercially successful products and services. Subsequently collaboration and co-specialization has, for Oulu, provided a basis for success and continuous adaptation as the market conditions have changed.

Similarly, Porter's claim (ibid, p. 635) that there is only a limited role for cooperative research is difficult to support using the findings from Oulu. Porter seems to see collaboration as an impediment to competitiveness. However, the development of the ICT-sector in Oulu suggests that due to mutual collaboration the commercial actors have learned from each other, agreed on roles and responsibilities, and subsequently each actor has become more competitive in his own field. This mutually reinforcing learning process seems to have continued successfully throughout the whole period.

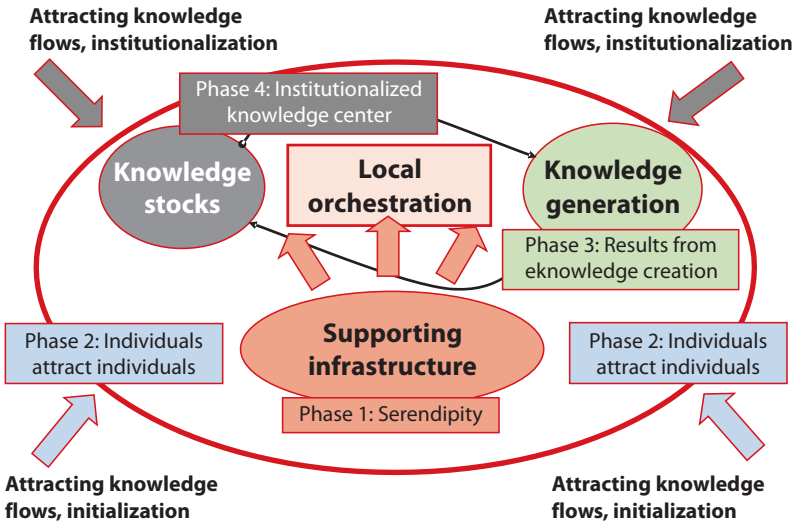
Based on the above observation, we can see that the initiation of a major change in a local commercial sector is, to a high degree, influenced by serendipity. In the case of Oulu very few could have foreseen in the 1950s that the establishing of the university would, in the early 1970s, be an instrumental factor in attracting Nokia, which in turn would mark the beginning of the rapid expansion of the ICT-sector in the Oulu region.

However, the Oulu case also shows that once some minimum critical requirements have been established, the evolution of an industry in a region is dependent on the existence of strong individuals that will provide the means to attract additional individuals sharing the common objective of making the region competitive in the particular cluster.

In the case of Oulu there were individuals who, almost fanatically, drove their case in spite of potential obstacles and resistance. They ensured that the university was established in the region and that the government decided to localize the electronic laboratories in Oulu, in spite of the objections laid out by the officials in Helsinki. All these individuals shared the vision that Oulu should become an important player in electrical engineering. However, it was not enough that these leading actors were bright individuals and shared a common vision. What really made a difference was that they were able to individually and collectively generate concrete results. One such result was the contribution to the decision by Nokia to establish its production of radio equipment in Oulu in 1972. Another was the establishing of the electronics laboratory of VTT in Oulu in 1974. Finally, a third very important factor was Seppo Säynäjäkangas' decision to bring his scientific knowledge into a successful business in the form of Polar Electro.

All these contributions can be seen to have originated from the steadfast actions of a few key individuals. But once these results were achieved the Oulu phenomenon was established; and its dependence on single individuals diminished. Through the knowledge development path (Laamanen, Wallin, 2009) initiated by a few individuals, Oulu evolved into a true knowledge pool or competence center. This evolution positioned Oulu as an institution in the ICT-sector. This institutionalization was further strengthened in the 1990s through the role of Nokia. One could argue that Nokia initially came to Oulu because of the presence of a certain critical mass of knowledge, but over the last twenty years, Nokia has had an im-

Figure 5. The emergence of innovation capabilities in a region



portant role in shaping how the Oulu region has developed. This verifies that once a region's cluster achieves or surpasses a certain threshold of tangible commercial results, the knowledge stocks of the region reach critical mass, where after, the knowledge is institutionalized and its dependence on a few critical individuals diminishes.

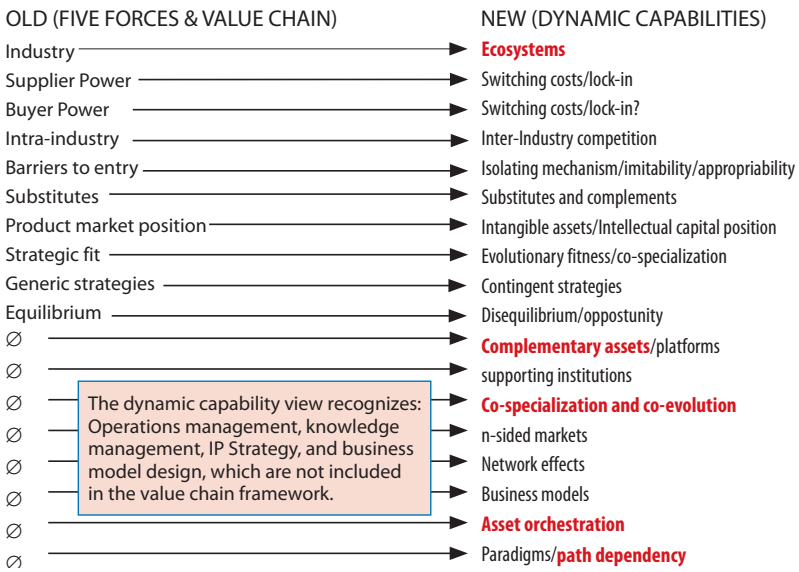
The findings from the Oulu development can be summarized according to Figure 5, which uses the Dierickx and Cool (1989) notion of knowledge stocks to describe how capabilities emerge in a regional context.

2.4 Providing innovation support services

As the example of Oulu shows we need to expand our understanding of competitive strategy and strategic choices beyond the positioning alternatives suggested by the five forces and value chain frameworks (Porter, 1980, 1985). Teece (2008) has presented an illustration of the fundamental elements in strategic thinking which need to be rethought when shifting the perspective towards one of dynamic capabilities (see Figure 6). When considering the relationship between a firm and an innovation agency, five aspects of Figure 6 are of particular interest: ecosystems, complementary assets, co-specialization and co-evolution, asset orchestration, and path dependency.

To address the question of how innovation support services are provided we will use the experiences from Oulu as our starting point, but to broaden the perspective we will first examine another successful case, outside Finland, to complement the observations from Oulu. This second case is well documented in the literature and describes how Volkswagen established its operations in Shanghai (Harwit, 1995, Peng, 2000).

Figure 6. The dynamic capability perspective vs. five forces (Teece, 2008)



CASE: Volkswagen – Shanghai cooperation

The first talks between western car manufacturers and the Chinese government began in the late 1970s. A decision was made to establish joint ventures in three cities, with three different western car manufacturers: American Jeep manufacturer AMC in Beijing, French Peugeot in Guangdong, and German Volkswagen in Shanghai. Retrospectively the most successful of these three initiatives was Volkswagen's. The well documented case study of Volkswagen's entry into Shanghai is therefore a good basis for the generation of some deeper understanding of how the cooperation between local authorities and firms can promote innovation and growth.

Although the Shanghai Volkswagen contract was signed in 1984, preliminary talks had already started in 1978, with Shanghai municipal officials taking an active role in the negotiations. The Chinese pressed the idea of a new model for export, but the Germans insisted on importing completely knocked down (CKD) kits of their existing Santana model for local assembly. Before the contract was signed, Volkswagen proposed a trial operation in Shanghai in order to demonstrate its commitment. It shipped CKD kits to the Shanghai Automotive Industrial Corporation (SAIC), its future partner, and local workers assembled them. In 1983, some 430 vehicles were produced, followed by about 450 in 1984. The trial proved largely successful.

Indeed, finding qualified Chinese suppliers was difficult. After decades of isolation, many suppliers were unfamiliar with Volkswagen's high standards. Furthermore, they balked at the large investments needed to reach German standards as the joint venture initially needed merely a few thousand items - only 8,031 Volkswagen Santanas were produced in 1986. Still the rate of localization at Shanghai Volkswagen was comparable to those of other joint ventures. It more than doubled its local content during 1988–1989. By the end of 1989, the Santana model contained more than 30 percent local components, and after only eight years of operations, Shanghai Volkswagen eventually reached an 85 percent local content level by 1993, thus attaining the highest localization levels among the three Chinese automotive joint-ventures.

Volkswagen was fortunate in that the Shanghai local government often sided with its position. The reason that the local government in Shanghai showed a strong interest in the joint venture was the enterprise's growing importance. Its production crossed the 100,000 mark by 1993. In the mid-1990s, Shanghai Volkswagen was the largest Sino-foreign joint venture in China, and was listed as a "pillar firm" in Shanghai's development plan. Reaching a capacity of 300,000 vehicles in 1997, it contributed up to 17 percent of municipal output, and captured 52 percent of the sedan market in China.

Firm expectations of innovation support services

The first observation from the Volkswagen case, which is also confirmed by the two other cases of AMC and Peugeot, is that the firm and the city basically approached the cooperation with two different agendas. The cities wanted to rapidly get new local business, and insisted that the western partner establish the manufacturing of a totally new car model for the Chinese market in their city. The car companies in turn saw that such a proposal was unrealistic, as the know-how needed to set up the complete local manufacturing was simply not present in the city region, and moving quickly into such large scale local production was not an alternative, as the risks were far too great. This highlights the dilemma of exploitation versus exploration, where public authorities and firms easily diverge in their perspectives.

In his seminal paper March (1991) framed the discussion of exploration and exploitation in the context of a single organization. However, if the unit of analysis is the network some new possibilities open up. As the Volkswagen example illustrates the public sector is very interested in exploration. The firms in turn are reluctant to take risks they cannot manage, and therefore want to be able to get immediate returns as quickly as possible. In the contract between Volkswagen and Shanghai this was also explicitly recognized, as exploring and building new capabilities was the responsibility of the city, whereas Volkswagen was responsible for the manufacturing, i.e. the exploitation part. This suggests that when entering cooperation with a public agency, the firm is primarily interested in exploiting available resources and capabilities in order to rapidly generate profits from the cooperation. The public agency in turn is more interested in explorative activities, which would create unique local capabilities that would increase the attractiveness of the region and create new jobs and regional growth.

But as the Volkswagen case illustrates, in spite of these diverging initial objectives, a common path for-

ward had to be found. A catalyzing element in reconciling the dilemma was the suggestion by Volkswagen to carry out a demonstration initiative, whereby a limited number of CKD Santanas were produced by the local partner in Shanghai, SAIC, in the years 1983 and 1984. These types of trials have been identified as important steps in bridging the gap between exploration and exploitation elements in regional innovation by Cooke et al (2010), who introduce the notion of examination to deal with the stage of experimentation in the innovation process. Examination refers to the important testing and trialing process, which is the bridge between exploration and exploitation. The recent emphasis on demonstration projects, test beds, and living labs is an example of operationalizing the examination phase. In the examination phase, or in the case of Volkswagen, during the demonstration initiative, there is the possibility to test and explore various alternatives, and gradually build trust between the involved parties. A demonstration initiative reconciles the fundamental differences in interest between the public agency and a firm, providing a way for the parties to figure out common interests and simultaneously build mutual trust.

The differences in interest between the two parties cannot be left aside, but must be addressed and reconciled over time. In the case of Volkswagen the fundamental challenge was that the Chinese representatives had unrealistic expectations of how quickly the share of local content in the production of Santanas could be increased. This relates to the notion of knowledge stocks and flows (Dierickx, Cool, 1989, Grant 1996). In general, public agencies would like firms to quickly bring new knowledge flows to the region in order to increase the size of the local stock of knowledge and make it more attractive.

The firm in turn wants the public agency to act as an agent towards other stakeholders, domestically or internationally, in order to promote its own interests and speed up growth. As the Volkswagen case illustrated, the city government of Shanghai often sided with Volkswagen in possible disputes with the national government, which promoted Volkswagen's interests in the larger business context in order to make its business more competitive.

In the case of Volkswagen it was possible within a period of eight years to build a supplier base that provided 85% of the content of the Santana locally. This offered Volkswagen a competitive advantage, as the higher degree of local content meant lower total cost of production, and a more competitive end product. Subsequently Volkswagen became the automotive market leader in China, and has since maintained its position.

Nonetheless, the City of Shanghai also benefited from this relationship. The Jiading district in the northwestern part of Shanghai, where SAIC and Volkswagen established its first factory, has become known as the International Automobile City and is today China's leading automotive center. In addition to Volkswagen, more than 100,000 enterprises have established their businesses in Jiading, many of them related to the auto industry. So the collaboration between Volkswagen and the city of Shanghai has undoubtedly been a success for both parties.

As both the example of Volkswagen in Shanghai and Nokia in Oulu show; firms will not base their decisions solely on history, but, to a great extent, also evaluate what possible contributions the region can bring to them in the future, and strengthen the firm's ecosystem.

However, the public agencies primarily want to develop network capabilities that will attract new entrants and create new jobs. This requires that the region possesses certain "pre-market capabilities" that firms then can assimilate into their own capability portfolio to speed up their development. When developing pre-market capabilities a clear nodal enterprise doesn't necessary exist, and therefore one can use the notion of a value constellation to describe such networks (Normann, Ramírez, 1994, p. 54):

Value constellations *are formed by enterprises coming together to co-produce value and allocate the tasks involved in value creation among themselves and to others, in time and space, explicitly or implicitly.*

The notion of "enterprise" here refers to both private companies and public organizations (e.g. municipalities and educational/research organizations).

The development in Oulu illustrates how the explorative research related to radio technology provided the necessary pre-market capabilities that were exploited by Nokia when setting up its own radio telephony unit in Oulu in the early 1970s. Nokia in turn then established its own ecosystem-related capability building efforts, which further strengthened the overall attractiveness of Oulu as a high-tech center. In this way the explorative activities were primarily handled by the public sector: the city of Oulu, the University of Ou-

lu and the Technical Research Centre of Finland (VTT), and the exploitative activities by the companies (Nokia and its partners).

In a setting where learning and building new capabilities is imperative for the firm the importance of co-specialization increases. Traditionally firms expected regional authorities to be enablers, providing smooth access to land, buildings, skilled labor etc. Firms then compared these production factors to other alternatives, presented by "competing" regions, and the most attractive bundle was selected. If the firm was then established in the region, or expanded its activities in the region, only limited interactions between the firm and the regional agencies were expected to take place.

Shifting from an industrial to a knowledge-based society means that firms must increasingly make their localization decisions based on the innovation potential of respective location. In the ecosystem logic of co-specialization this means that the parties align their respective development efforts on a more granular level, beyond the interfaces, in order to improve the innovation processes. We can thus divide innovation processes into three categories (Wallin, 2007, 2009): *open innovation* (very often used in the exploration stage on ecosystem level), *semi-open innovation* (applicable particularly in demonstrations), and *closed innovation* (traditional in-house innovation, most often leading to incremental innovations through the exploitation of existing knowledge when developing specific new products or services).

Innovation increasingly takes place in open or semi-open contexts with strong international linkages. The question of what role the public authorities can take in the company specific ecosystem then becomes critical when firms compare different locations. This offers new perspectives for public agencies. As the configuration of capabilities within the ecosystem has to be mutually agreed upon, the public agency, as a proactive co-creator, can complement the orchestrating firm with not only operational capabilities but also with leadership capabilities relating to the orchestration of the participants that are important in the ecosystem. This expands the possibility of the public agency to support its most important corporate customers and provide genuine additional value in the joint ecosystem-building efforts. The way the authorities in Shanghai had to nurture the emergence of a local supplier base, capable of raising the local content of the Santanas, is here a case in point.

Innovation support service providers can thus support the firms in various ways. The traditional support in the form of good infrastructures (land, buildings, logistics, skilled labor etc.) is still an important element when building long-term relationships with corporate customers. Establishing an innovation friendly business context is also relevant. This traditional support may include different forms of financial incentives such as tax breaks and subsidies. But, in addition to this, the public sector is increasingly taking the role of the customer within the ecosystem.

Certain industries, such as health care and education, have public institutions as some of the most important customer segments, and the public agencies can serve as important pilot customers in the demonstration phase. The public agency can also be a provider of some central capabilities within the ecosystem. Subsequently, the firm and the public agency can jointly build a long-term win-win relationship. This represents very tangible firm-related innovation support activities.

The more the firm sees the region as an innovation partner, the more it will appreciate the access to well educated professionals with the appropriate skills and the ability of the region to support the firm with complex local orchestration and leadership activities. These are examples of network-related support services that an innovation agency can offer.

Firms will thus have different expectations vis-á-vis the innovation agency depending on how they consider the balancing of exploitation and exploration in their strategy. For individual companies there is a reluctance to invest in explorative efforts that would need a lot of time to develop into concrete commercial opportunities. Innovation support providers therefore have to be able to identify short-term side effects that can quickly create tangible benefits for the involved companies. From this perspective it is useful to think in terms of innovation platforms, which can facilitate the identification of different alternatives for the respective parties to benefit from new opportunities as they emerge. By defining a ***platform*** *as a set of stable components that supports variety and evolvability in a system by constraining the linkages among the other components* (Baldwin, Woodard, 2008) we can identify two types of innovation platforms, which may be partly overlapping.

The constellation platform *provided by a public organization, like e.g. the innovation agency or a participating uni-*

versity, primarily relates to exploration and supports the scanning and search activities.

***The orchestration platform**, operated by the nodal firm, supports exploitation (and exploration) by nurturing communication and engagement among the members of the orchestrated ecosystem.*

Cooke et al (2010) describe constellation platforms as combining many technologies that are adaptable across diverse industrial and technological contexts. Such platforms are the result of what they call 'cumulative' and/or 'combinatory' knowledge flows. They notice that knowledge flows can be seen as distributed widely on the horizontal dimension (across industries and sectors) as well as operating more conventionally on the vertical dimension (within industries or sectors) in a regional context. To distinguish these types of knowledge flow, the terms 'cumulative' (sectoral) and 'combinatory' (cross-sectoral) are introduced. Constellation platforms are often open in their characteristics and by definition they are governed by a public party in order to enable cross-fertilization between industries and actors. A key objective with such platforms is to nurture experiments and trials among actors that normally would not interact, and in this way create 'combinatory knowledge flows' that are innovative interactions that are extra-sectoral, non-systemic and often involve unexpected discoveries.

The ecosystem level or orchestration platform (Wallin, 2006), in turn is a tool to nurture co-specialization and capability building within the orchestrated ecosystem. Such a platform is in its nature semi-open, as part of the content is "for members only" in order to protect the value-creating potential of the ecosystem and support the provision of competitive offerings for customers.

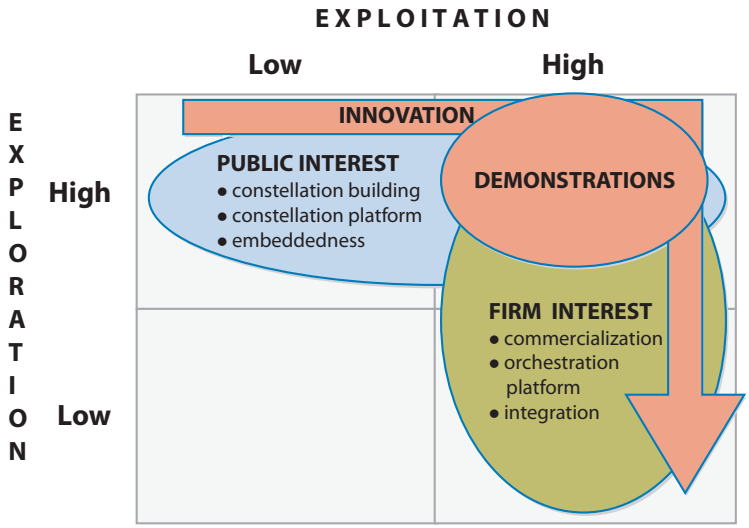
Ecosystem orchestration is a demanding task, and it has been suggested that companies mastering the complex competencies of network orchestration have an opportunity to reap the benefits of network synergies. (Day, Schoemaker, 2011). Three organizational and managerial objectives must be met simultaneously: coordination/integration, learning and reconfiguring. These are the core elements forming the orchestration process, which, proactively: (1) keeps co-specialized assets in value-creating co-alignment, (2) selects new co-specialized assets to be developed through the investment process and (3) divests, or runs down, co-specialized assets that no longer help yield additional value. The orchestration process is entrepreneurial in its nature, and the manager/entrepreneur must also shape the learning processes within the ecosystem (Teece, 2009).

As the Volkswagen case revealed, Volkswagen divided the tasks into different categories, and the building of an ecosystem of capable local suppliers was delegated to the city authorities of Shanghai. This also shows that the role of the regional party can be that of co-orchestrator, which has, thus far, not been commonly discussed within the context of regional innovation.

The collaboration between the firm and the innovation support provider can, on a generic level, be illustrated in accordance with Figure 7.

As Figure 7 indicates, the ambition of the public sector is to support explorative efforts within the broader value constellations, supporting the emergence of as many new innovations as possible during the path forward. The firm's interest is to be able to quickly assimilate some critical parts of the shared development efforts and integrate them with its own existing knowl-

Figure 7. Public-private innovation collaboration



edge in order to exploit this knowledge in the form of new offerings, which can be successfully introduced to the market. Figure 7 also illustrates the interdependence between the two sets of activities. The innovation activity, starting from the explorative efforts, ending in the right down corner and illustrated with the arrow get visually covered by the Demonstrations area. This illustrates the non-linear property of the innovation process, and how bridging the gap between exploration and exploitation demands a complex set of interactions and going back and forth among the various stakeholders, when seeking solutions that would qualify the innovation initiative to truly make a breakthrough and become a commercial success.

This need for properly designed demonstration activities has become particularly emphasized when dealing with societal grand challenges (Pisano, Shih, 2009). These forms of innovation can be characterized as follows (Vinnova, 2011):

- They address essential or critical needs in society and industry. These needs require users/customers whose demand for solutions incentivizes them to engage in developing and testing new solutions. Co-creation is a critical success factor.
- They ask for cross-sector collaborations to find solutions to the needs; solutions to social and societal challenges are rarely found in one traditional sector or in a single research field. New collaboration patterns are emerging between actors in different value chains; for example 'green urban transportation' is being developed at the interface between energy, automotive engineering and ICT.
- They foster systemic approaches which address different social subsystems, framework conditions, political, commercial, technological subsystems, etc.

The notion of challenge-driven innovation emphasizes the broad perspective that a firm needs to take when evaluating how appropriate a particular location will be in the pursuit of addressing a grand challenge. But paradoxically, due to path dependency certain locations are also in advantageous positions to become initiators to address such global challenges. For example nations that, at present, already have a large ageing part of the population have natural potential to become prime movers in developing new innovative solutions for senior citizens. And cities with strong growth supported by extensive greenfield construction become interesting opportunities for developing new low carbon city structures, as illustrated by the rapid expansion of "eco-city" projects in China.

The examples here provide some concrete suggestions for how innovation agencies can better serve customers looking for innovation partners. When they engage with firms in deep collaboration to promote innovation the expectations of the firm suggest that the following issues should be emphasized:

1. By taking the role of customer of the products and/or services provided by the firm the public authorities strengthen their ties with the firm, and also create a stronger negotiation position in other mutually important matters. Another very tangible support service offered by most innovation agencies is funding of research projects, or seed investment in start-up activities. In addition, the innovation agency can contribute capabilities in the orchestrated ecosystem of the firm. Three types of capabilities can be of value:
   a. pre-market capabilities, which will speed up the building of "market" capabilities by the firm,
   b. operational capabilities, e.g. by taking responsibility for the integration of interactions with the individual citizens of the region, when e.g. there are piloting activities going on, or there are marketing or communication efforts directed towards the citizens, and
   c. leadership capabilities provided to strengthen orchestrated ecosystems, e.g. by coordinating the efforts of local SMEs through the provision of local incubators managed by the public sector.
2. The innovation agency can also provide network externalities; e.g. promoting the interests of the firm in a national or international context and establishing a reference case for the firm, in addition to providing access to important stakeholders regionally, nationally and internationally.
3. Additionally, innovation agencies can improve their competitive position by providing cost-efficient production factors for the firms, such as: land, buildings, access to skilled labor, tax breaks etc.

However, it is important to notice that the above mentioned requirements are very demanding, and an innovation agency cannot enter into very many firm relationships with the rela-

tionship depth described above. Therefore agencies must establish Customer Relationship Management practices in order to be able to segment the customers, and they must decide which customers to prioritize in relationship building efforts. When evaluating which firms to prioritize the agency may consider such issues as; the potential for job creation, the fit of the firm into the value constellations nurtured by the agency (Siggelkow, 2002), and the possible spillover effects resulting from the firm's activities in the region.

For the companies in turn they need to take a fairly comprehensive look at how they relate to focal locations in their global footprint. For example the way local cooperation is carried out within the location of the headquarters can provide significant value added to both the firm and the region.

2.5 A process model for innovation capability building

Traditionally innovation policy has been seen in the context of cluster development (Porter, 1990). The transition from an industrial age to a knowledge economy paradigm requires a broader perspective on innovation policy. In the same way as Teece (2008) suggested that the five-forces framework has to be complemented with the dynamic capabilities framework, there is a need to complement the cluster perspective. The belief that "the invisible hand" of self-regulating market forces is the best way to bring the world forward has come under severe doubt.

This need for a broader view has also been raised by Pisano and Shih (2009). They suggest that governments are uniquely positioned to mobilize and coordinate the efforts of the numerous organizations needed to solve "grand challenge problems", like climate change, lack of potable water, our dependence on hydrocarbons, and the ravages of diseases (see also Wallin, Su, 2010). How public-private collaboration should be carried out has become a key issue for debate.

The innovation literature seems to be united in dividing innovation activities into two broad categories: the incremental form of innovation, improving existing technologies and processes, and the disruptive form of innovation, radically changing the competitive conditions in a sector (see e.g. Christensen, 1997). The notion of dynamic capabilities addresses situations where firms have to deal with specific strategic and organizational processes like product development, forming alliances, and strategic decision making that create value for firms within dynamic markets by manipulating resources into new value-creating strategies (Eisenhardt, Martin, 2000).

Cooke (2009) has developed a regional knowledge capabilities model, which highlights issues such as open innovation, related variety, asymmetric knowledge endowments and regional knowledge domains. He observes that regions should not be expected to contain all knowledge interaction possibilities, even if they are strong. Many external-to-the-region interactions will likely occur, with expertise in appropriate other regional domains participating in 'global talent pools'. This is further emphasized in a study by Dahl and Rodríguez-Pose (2011), suggesting that international networking and collaboration is key to innovation in firms. In their study of over 1000 companies from five city-regions in Norway they identified international cooperation as the main source of radical product and process innovation. Additionally, pipeline-type interactions were also identified as being conducive to incremental product innovation. In contrast to most previous studies, domestic interactions did not seem to promote firm-level innovation. There was also little evidence of complementarity between global pipelines and local interaction within Norwegian agglomerations. Firms that develop international partnerships are likely to innovate; firms that rely on local interaction are not, meaning that the transfer mechanisms of knowledge and innovation within close geographical proximity are less prominent than previously thought. Firms can therefore not expect to rely on local interaction for new knowledge. The creation and engagement in pipelines is a must if they are to remain innovative and competitive.

The evaluation of the Finnish innovation system published in 2009 (Veugelers et al 2009) also noticed that the Finnish system is less international than conventionally thought and that there are signs that it is falling further behind. The current ways of addressing the issue are clearly not working. Tapping deeper into the global knowledge pool should become one of the main objectives of innovation policy.

Developing and strengthening international ecosystems calls for business orchestration. Within such ecosystems, while the role of orchestrator is limited to a few actors, all participants must have a clear role in the ecosystem, providing them with the opportunity to leverage upon the knowledge spill-over

effects taking place within that ecosystem.

Subsequently innovation increasingly progresses by means of the evolution of platforms combining several technologies that are, in an increasing number of cases, adaptable across diverse industrial and technological contexts. These platforms can be established and maintained by individual companies, like Apple's orchestration platform, but they can also be organized by a public organization in the form of constellation platforms such as Bayern Innovativ (http://bayern-innovativ.de/).

For an innovation agency like Tekes one key question is to what extent Finland is uniquely positioned to continue to benefit from historical comparative advantages. If this is the case, traditional clusters can still work, and intrasectoral cumulative knowledge flows will strengthen the innovation capacity of the enterprises. In Finland the rapid growth of mining activities is an example of possibilities to be innovative while also creating growth through the traditional industrial logic. Such innovation capability building companies will here be called *generators*, as their core capability is their generative capability.

The rapid transition of the Finnish economy however suggests that there is also a need to deal with the other type of innovation process: orchestration. This calls for more horizontal activities, integrating different forms of technologies and encouraging combinatory knowledge flows, characterized by interactions that are extrasectoral, non-systemic and often involve unexpected combinations (Cooke et al, 2010). Such ecosystems are then characterized by the need for co-specialization, co-evolution and asset orchestration (Teece, 2008) carried out by business *orchestrators*.

Within orchestrated ecosystems there has to be a willingness and interest to engage in collective learning. This requires lateral absorptive capacity (among industry branches), possibly co-located to some extent, to access the external economies, including knowledge spillovers, from geographic propinquity but open to distant network relations with other firms in other continents (pipelines). Distributed knowledge flows, their identification and capture characterize this socio-technical learning system in which alert firms routinely thrive and survive. For such an ecosystem to flourish in a territorial context it is necessary to establish (i) efficient circulation of knowledge between the region and other areas, (ii) efficient circulation of knowledge between the different knowledge segments; and (iii) a central role for some organizations endowed with knowledge integration capacity (Cooke et al, 2010, p. 341).

How successful a region will be in an ecosystem is dependent not only on its internal relations, but also on the way the region connects itself to larger pipelines through a subset of nodes. This requires a coalition of key actors working in the regional context to co-align their forces based on a grounded and converging vision of the region's strategic identity and mission (Normann, 2001, p. 307). This calls for a high quality strategic process based on horizontal interactivity, future-oriented processes to evolve a vision of strategic identity, the skill and ability to utilize events and various assets and processes to bring people together in creating a new 'social reality' with action implications (Normann, ibid. p. 311).

When considering how Tekes's funding and support translates into project and network level impacts it should be recognized that Tekes already through its funding criteria shapes the industrial mosaic in Finland to some extent. Those companies that apply for funding are aware of "the rules of the game", and subsequently these rules in themselves are important signals for how the innovation landscape in Finland is framed (we will return to this in chapter 3). At those companies approved for funding, the project activities are expected to contribute to the building of innovation capabilities. However, the effect this has on the outcome is not easy to directly measure. However, what is possible to see is how the companies that are funded are performing: some companies will perform better, whereas others will perform worse. For the evaluation of the building of innovation capabilities two particular types of companies are of interest:

- The generators; companies that are growing and display strong generative capabilities. These are the backbone of the industrial, technology-based part of the innovation system.
- The orchestrators; companies that provide the platforms for combinative knowledge to enable new solutions. These companies are very important in the knowledge economy.

The innovation capability building activities in the funded companies may lead to further capability building (in favorable cases) in the larger ecosystem. The result of this capability building should then be some form of materialized innovation. For an innovation

to materialize the following conditions must prevail:

(i) the innovation has to provide value to a set of customers or users,

(ii) the costs for providing this value have to be lower than the value, in order to be able to set a price which is acceptable to the customer or user and generates profits for the provider, and

(iii) the costs must also be lower than those of any potential competitor prepared to offer the same value proposition to the same set of customers or users.

Here the notion of "value" is broader than mere financial or commercial gain as it is based on a consideration of perceived value or benefit. Subsequently an improvement e.g. of the efficiency of the public health care sector, despite a lack of any clear new products, provides value and the activities leading to this (e.g. activities that have increased physical activity among the elderly thus improving their health) is an innovation. Any innovation will have a positive impact on growth for the company/companies/public organization and subsequently contribute to GDP growth in the country.

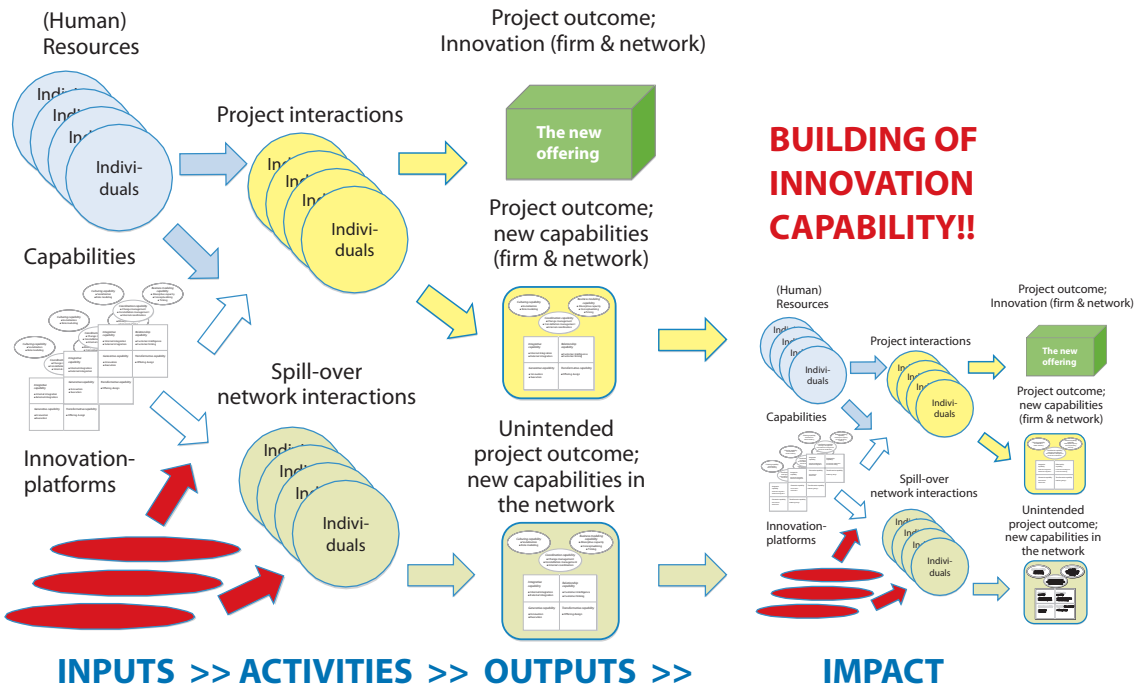
Another note is on the definition of offering; this is not just products and services provided by companies, but also what the public sector offers to the community. The following definition will be used here (Wallin, 2000):

*An **offering** is a limited set of focused human activity which can, and is intended to, generate positive customer value and exchange value.*

With these definitions of innovation and offerings a more detailed description of how the building of innovation capability takes place is presented in Figure 8. This model emphasizes an organization's capacity to create future innovation as this is a central aspect in defining the successful creation of new innovation capabilities. The model is as follows:

This model uses the term Impact to refer solely to the repeated innovation activities, which ultimately confirm the establishing of innovation capability. By employing this model it is possible to start from the end of a successful innovation creating activity and trace its origins back to the root capabilities (pre-market capabilities, leadership capabilities and operational capabilities), the human resources (key indi-

Figure 8. A model for innovation capability building



viduals) and the role of innovation platforms (constellation platforms and orchestration platforms).

What also is important to notice is that the Input Capabilities consist of both the firm's and the network members' capabilities, an important part of which are the so called "pre-market" capabilities. Such capabilities may be present in the network due to prior development, such as the Oulu region's pre-existing capabilities related to radio technology, based upon which Nokia decided to locate is mobile telephony unit there. New insights and inventions originating in universities can take up to fifteen years or more before they become commercial successes.

It has also been shown (Cooke et al, 2010, p. 17) that the way platforms emerge depends on the industrial context. In the biotechnology sector the major platforms have emerged around leading universities, whereas in the ICT sector such platforms have emerged around individual companies. The notion of a 'platform' is thus quite broad and flexible, and less determined by sectoral perspectives, capturing elements of the framing of innovative challenges and opportunities as they emerge through useful knowledge flows and interactions. (Cooke et al, 2010, p. 273)

The notion of *innovation capabilities* must also be considered from a geographical perspective. In this area the role of "white spaces" in the regional innovation landscape, as described by Cooke and Eriksson (2011), provides an important contextual factor impacting the innovation process.

The significance of physical proximity and interaction in the context of a defined geographical region has been proven substantial. Therefore, it is also important to consider to what extent physical proximity and the possibility for physical interaction influence innovations compared to the role of digitally mediated interaction, and also to what extent this differs across sectors and industries when considering innovation activities.

While Tekes operates on a national level, it should be remembered that, as a nation, Finland is, ultimately, e.g. in terms of its GDP comparable to the regional level in a larger country, such as Germany.

2.6 Pre-market capabilities and the role of key individuals

While companies certainly outweigh the public sector as targets of Tekes's funding, the public sector still remains a viable and significant target of Tekes's activities. A key question to be addressed is what metrics should be used to assess the public sector benefits and gains created by innovation activities? Economic gains benefit not only the target enterprise but society as a whole. Evolving and developing the innovation system and creating new capabilities in networks, as opposed to single companies, create future benefits and gains across the entire network.

Assessing the impact of innovation activities on the public sector demands a long-term perspective, as the ultimate benefits of many of the infrastructural improvements are not apparent until many years after the efforts have been made. This perspective is, however, essential when assessing the success of an innovation policy. Such infrastructural and network-wide gains cannot be left in the hands of the free-market, as they are investments which need to be made by the public sector and are often considered unjustifiable by individual companies in the short-term. In many cases the societal benefits will, however, eventually far outweigh these investments. An ecosystem-oriented approach enables the assessment of such cases.

While research institutes play an integral role in innovation processes, these institutes are in addition background influencers which provide the important "pre-market" capability inputs for the building of innovation capabilities at a later stage.

As innovation is about learning, and learning only takes place on the level of the single individual, it is also important to consider the effect of migration of personnel as a source of knowledge and input factor to the innovation process. As perhaps half of the gains will be appropriated outside the Tekes-funded enterprise, a key consideration is tracking the migration of personnel between enterprises funded by Tekes when analyzing Tekes's customers.

The model presented in Figure 8 for assessing the building of innovation capabilities will be used in the innovation analysis which will be covered in chapter 5 of this report. To provide the context for how innovation capabilities have been and can, in future, be built in Finland, the third chapter will, however, first present a brief overview of the Finnish innovation system, followed by a comparison of some other national innovation systems in the fourth chapter.

3

The Finnish innovation system

In chapter 2 the innovation support activities were analyzed from the perspective of the firm in order to be able to identify how innovation agencies can support innovation capability building in a region. In this chapter we will shift the perspective to that of the innovation agency itself, and use the Finnish innovation system, and the specific role that Tekes has within this system, as a means to establish a framework for the way an innovation agency supports innovation-capability building.

Most national innovation agencies are established to finance demanding research and development projects with the goal of promoting the development of companies. When evaluating how well the agency has been able to support the building of innovation capabilities, the first level of analysis should thus focus on how well the supported companies have progressed, as a result of the support from the innovation agency. This then also highlights an important aspect of innovation policy; in addition to simply assessing whether a development has crossed the threshold to be considered an innovation (instead of remaining a promising invention) it is also necessary to look at the further growth induced by the innovation. Subsequently we also need to consider to what extent successful innovations have scaled up, and genuinely contributed to growth and job creation. In this respect the Oulu-Nokia example is a good illustration of genuine innovation support, as the ICT-investments in the region created significant growth within the sector. We will further explore this issue when analyzing the individual innovation cases in chapter 5.

This chapter will, on one hand, provide an overview of the Finnish innovation system, and on the other hand it will also enable us to build up the elements for a framework to be used when comparing the innovation systems across different countries in chapter 4, using Finland as the "base case". This chapter will thus begin with a brief overview of the Finnish economy, highlighting the industrial structure, and the most recent developments. Based on this introduction to the Finnish economic landscape the structure of the Finnish innovation system will be described. Some recent comparisons between Finland and other countries are then presented. This is followed by a more detailed analysis of Tekes, and the way Tekes has lately shifted its priorities from merely supporting technology development to more broadly promoting the overall Finnish innovation agenda. Based on these building blocks the last part of this chapter will then combine the various elements into a framework of how an innovation agency supports capability building, using Tekes as an example.

3.1 A brief overview of the Finnish economy

Finland has a highly industrialized, largely free-market economy, based on abundant forest resources, capital investments, and technology, with a population of 5.4 million and a GDP of €188 billion in 2010. Traditionally, Finland has been a net importer of capital to finance industrial growth.

In the 1980s, Finland's economic growth rate was one of the highest among industrialized countries, and following the recovery from the 1992 depression the economic competitiveness has been rated first in the world for several years. The Finnish depression in 1992 was primarily due to the collapse of the Soviet Union, which at the peak in the early 1980s represented over 25% of the Finnish exports but shrank to less than 5% in 1992. Subsequently, Finnish exports to Russia started to increase again and represented more than 16% of total exports in 2010.

The major Finnish export sectors are telecommunications, electronics, paper and forestry, engineered metal and metal refining, and chemical industries. Except for timber and some minerals, Finland depends on imports of raw materials, energy, and most components for manufactured goods. Because of the climate, agricultural development is limited to maintaining self-

Figure 9. The development of Finnish exports (source: Statistics Finland)

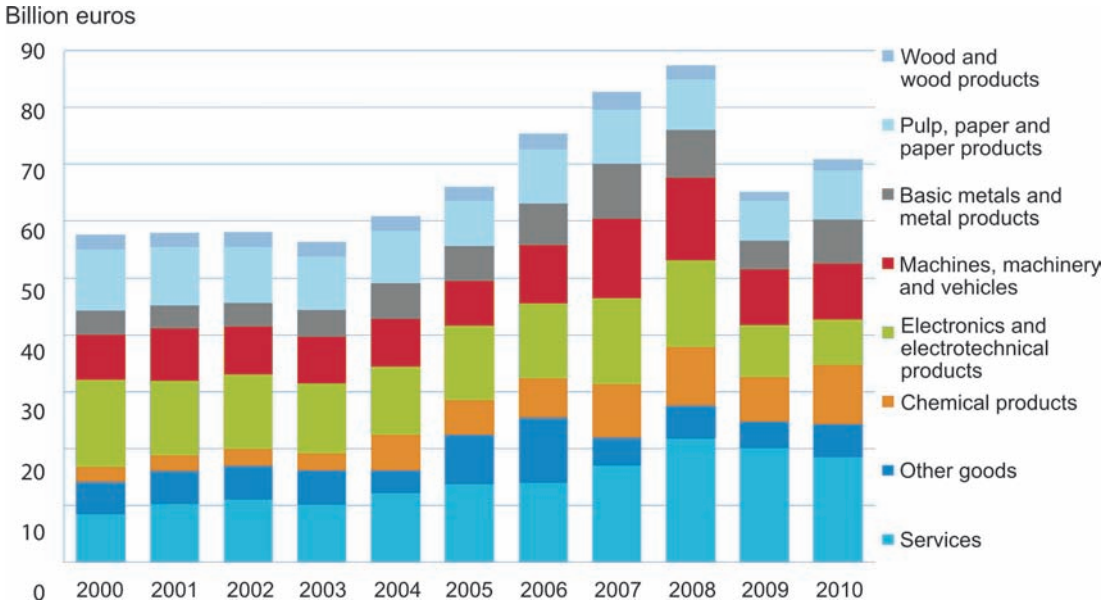


Figure 10. The breakdown of Finnish exports of goods (source: Statistics Finland)

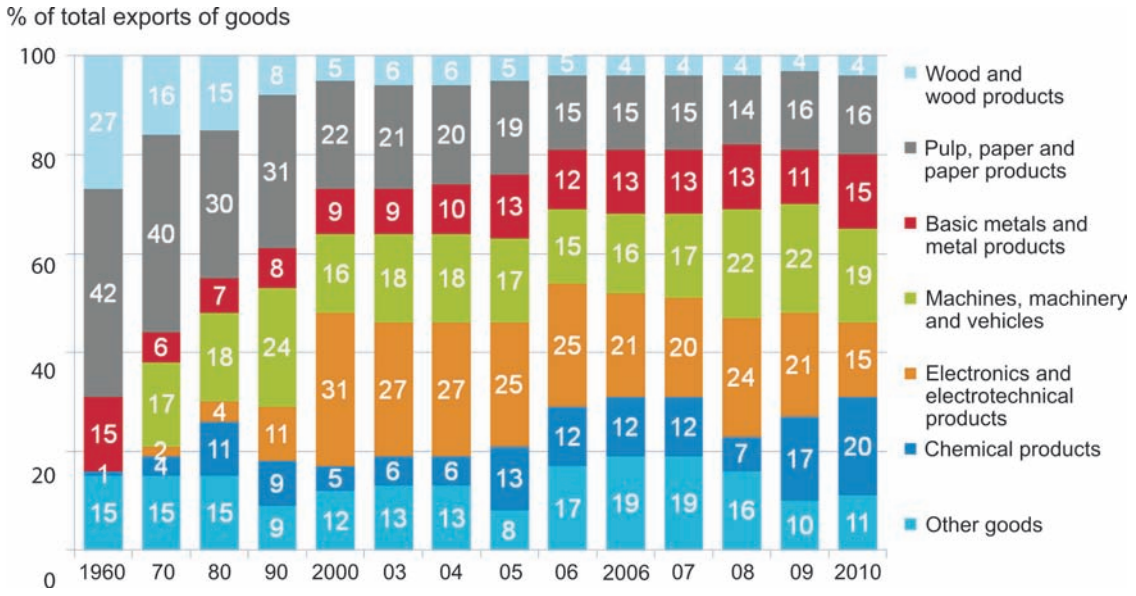
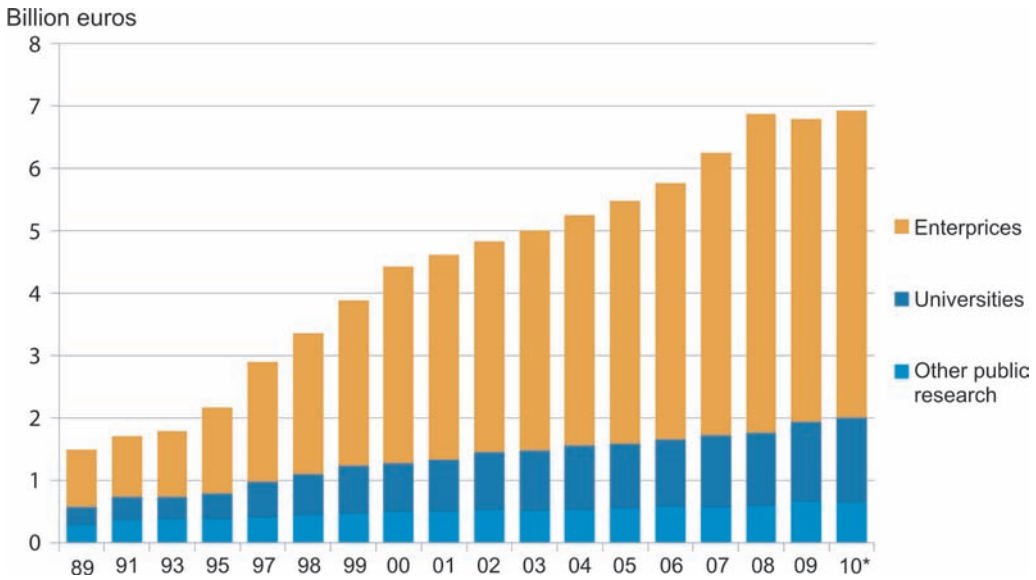


Figure 11. Finnish R&D spending 1989–2010 (source: Statistics Finland)



sufficiency in basic products. Forestry, an important export earner, provides a secondary occupation for the rural population, although its significance has declined in recent years.

The breakdown of Finnish 2010 exports is presented in Figures 9 and 10. Finnish total exports in 2010 stood at €71 billion, of which goods represented €52 billion.

As can be seen from the above figures; forest industry, metals and mechanical engineering, and electronics and electro-technical products are the dominant export sectors. Interestingly enough, chemical products have significantly increased their share in 2009–2010.

Finland had three companies on the 2007 Fortune 500 list: Nokia (telecommunications), StoraEnso (forest and paper products), and Neste Oil (energy). However, in the 2011 list only Nokia remains.

The Finnish innovation system is primarily based on private investments from the corporate sector (see Figure 11). Nokia is the biggest spender in R&D, and 60 per cent of its 21,000 global R&D employees are in Finland.

The challenges in developing the Finnish innovation system relate to the prioritization of activities, international and national positioning of research organizations, and the development of selective, foresight-based decision-making. Finland had set a goal of raising the share of R&D spending to four per cent of GDP by 2010, from 3.5 per cent in 2006, and in 2009 the share of R&D expenditure, of Finland's GDP, was 3.93 per cent, with 2.79% coming from the private sector and 1.11% from the public sector.

3.2 The organizational structure of the Finnish innovation system

In 2010 the governmental budget outlays on research and development amounted to €1.9 billion. Government R&D expenditure as a proportion of overall government spending, excluding debt servicing, stood at 4.5 per cent. In the EU countries, the share of public R&D funding of the gross domestic product was the highest in Finland, 1.0 per cent.

The formulation of national Finnish science, technology and innovation policies has been assigned to an expert body, the Research and Innovation Council, which is chaired by the Prime Minister. Nearly 80 per cent of governmental R&D funding is channeled through two ministries, Ministry of Education and Culture and the Ministry of

Employment and the Economy. These ministries are the foremost organizations responsible for science and technology policies. The Ministry of Education and Culture handles matters relating to education and training, science policy, universities and polytechnics, and the Academy of Finland. The Ministry of Employment and the Economy is in charge of matters pertaining to industrial and technology policies, Tekes, and the VTT Technical Research Center of Finland, a governmental research organization with over 3,100 employees and a 2010 turnover of €292 million, of which 32 per cent was financed by the government. Figure 12 presents the composition of Finland's innovation environment, displaying the various actors active within it.

The two governmental agencies Tekes (The Finnish Funding Agency for Technology and Innovation) and Suomen Akatemia (The Academy of Finland) distribute research funding in Finland with open, competitive schemes.

Tekes is the main government financing and expert organization for research and technological development in Finland. Tekes finances industrial R&D projects as well as projects in universities and research institutes. Tekes especially promotes innovative, risk-intensive projects.

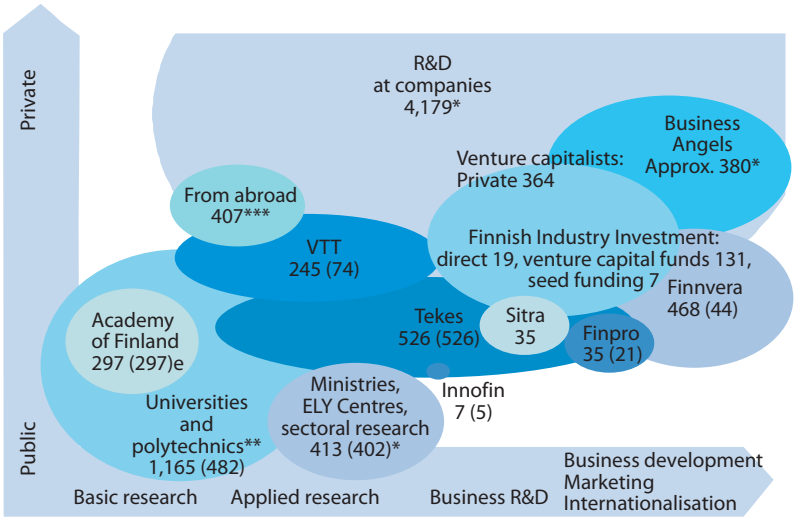
The main focus of the Academy of Finland is in the multifaceted advancement of professional research career options, the establishment of cutting-edge research environments and the utilization of international opportunities. In 2011 the Academy issued funding decisions worth about €340 million, which represented 16 per cent of government R&D spending of about €2 billion in Finland. The Academy has a wide range of funding instruments tailored to different purposes. Each year, Academy-funded research projects account for some 3,000 researcher FTEs at universities and research institutes. The Academy of Finland also functions as the party enabling rotation of experts between academia and industry, and supports and facilitates researcher training and careers in: research; internationalization; and the practical application of research results. The Academy is keen to emphasize the importance of the impact of research and breakthrough research by encouraging researchers to submit boundary-crossing funding plans that involve risks but that also offer promise and potential for scientifically significant breakthroughs.

A third development agency funded by the government is Sitra, the Finnish Innovation Fund. Sitra is an independent public fund which under the supervision of the Finnish Parliament promotes the welfare of Finnish society. Sitra's responsibilities have been stipulated in law. The funding decisions of Sitra in 2008 amounted to €35 million.

The structure of the public Finnish research funding is depicted in Figure 13.

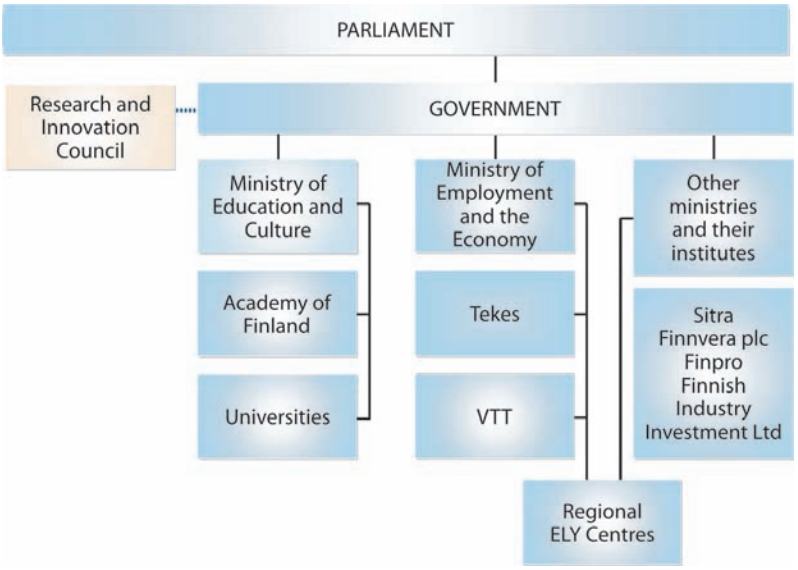
The strategy of the Finnish public innovation policy is to secure sustainable and balanced social and economic development. Achieving this aim entails a high employment rate, high productivity and strong international competitiveness. The Research and Innovation Council of Finland, chaired by the Prime Minister, advises the Government and its Ministries in important matters relating to the direction, follow-up, evaluation and co-ordination of research, technology and innovation policy. The Council also puts forward relevant plans and proposals.

Figure 12. Resources of organizations in the Finnish innovation environment in 2008, m€ (source: Tekes)



The figures represent the total extent of each organisation in million euros in 2008, those marked with star are earlier. In parenthesis the share that is funded from the State budget.
** includes polytechnics ***includes R&D costs of corporations units

Figure 13. The organization of the pubic Finnish research funding



The Research and Innovation Council is continuing the work of the Science and Technology Policy Council of Finland, which operated 1978–2008. The Council's remit involves assisting the Government and its ministries. To that end, the Council carries out the following tasks:

- follows national and international developments in research, technology and innovation;
- reviews the field and developments within it;
- addresses major issues relating to developments in science, technology and innovation policy and the human resources they entail, presenting the related proposals and plans to the Government;
- attends to preparatory work on matters relating to the development and allocation of public research and innovation funding for the Government;
- co-ordinates Government activities in the field of science, technology and innovation policy; and
- undertakes any other duties assigned to it by the Government.

In 2006 the Science and Technology Policy Council of Finland decided to form Strategic Centers for Science, Technology and Innovation, or SHOKs in Finnish, to speed up innovation. Such centers of excellence have been established in the following areas: energy and the environment, metal products and mechanical engineering, the forest cluster, health and well-being, information and communication industry and services, and build environment innovations. This was a further step towards providing cluster based support, continuing on the path set forth when establishing the Center of Expertise program for regional development for the first time in 1994.

In a strategic center, or SHOK, enterprises, universities and research institutes are expected to agree on a joint research agenda, which will fulfill the enterprises' application-orientated needs on a 5–10-year period. In practice this means that the leading companies within their respective industries have to agree on a common research agenda, and then they can heavily influence the decision making on which research projects will be financed by the government in relation to this research agenda. The first SHOK, the Forestcluster Ltd., was established in April 2007 and the remaining five in 2008 and 2009.

The formation of the SHOKs illustrates a strategic shift in the Finnish innovation policy. Until 2005 the official English name of the main funding agency (Tekes) was The National Technology Agency. Then the name was changed to The Finnish Funding Agency for Technology and Innovation. This change was a response to a world where competitiveness and innovation is more and more about services, knowledge and capabilities.

Globalization represents a major challenge for Finland. The development focus of large Finnish companies is shifting from a strong technological focus at home, within Finland, towards more emphasis on services and localized concept development with international partners that are closer to the targeted customer segments abroad. Increased customer orientation and solution focus are goals which apply to leading companies in the ICT-sector, in mechanical engineering, as well as in the forest industry. At the same time orchestrated ecosystems exploiting access to cheaper labor resources e.g. in Asia are disrupting many industries where Finland

has traditionally had a prominent position. Many Finnish companies that have been slow to respond to these changes have already experienced considerable weakening of their market positions. Common to all these is that the leading producers are today located in lower cost countries such as China.

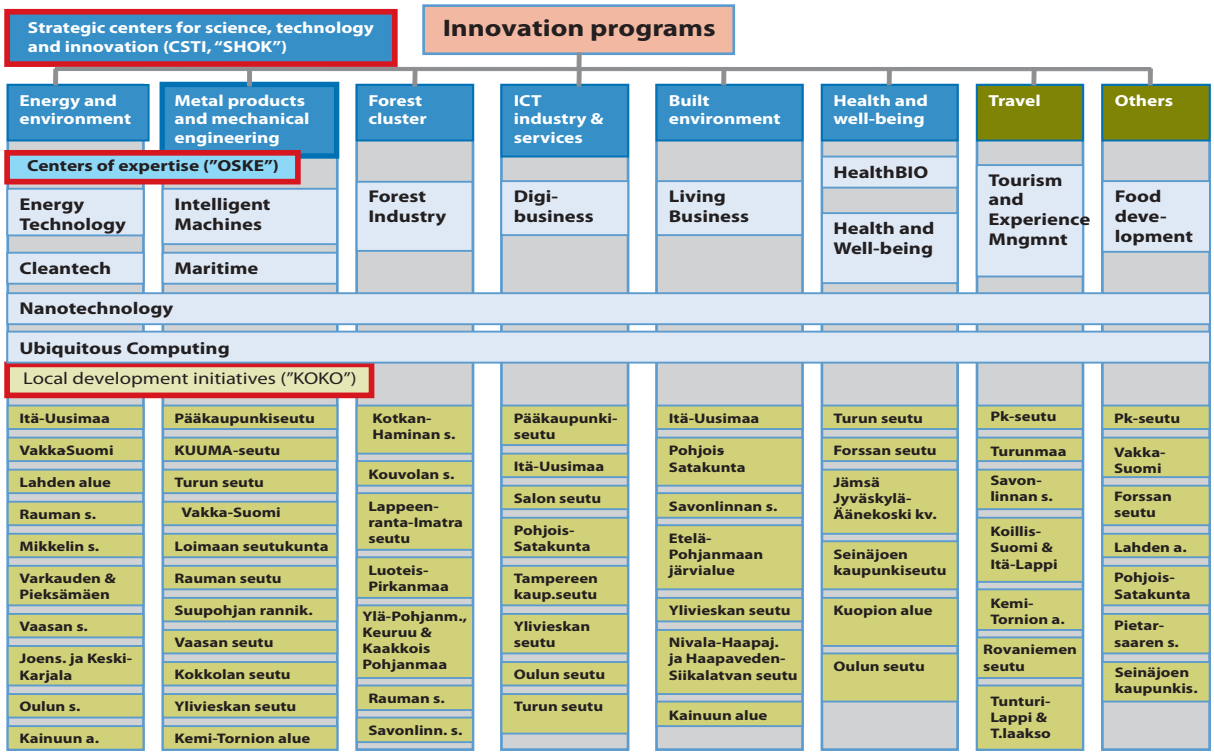
When the Finnish government decided to put more emphasis on its innovation support, the selection of focus areas indicated that the traditional industrial competence areas, such as forest industry, metal products and mechanical engineering, and information and communication industry and services, were seen as the basis for growth also in the future. These industries represent those in which Finnish companies have a global presence such as Nokia and Tieto in the information and telecommunication sector, M-Real, StoraEnso, and UPM in the forest industry, and Cargotec, Kone, Konecranes, Metso, Outokumpu, Rautaruukki, and Wärtsilä in metals and mechanical engineering. All these companies share a need to adapt to a changing competitive landscape requiring increased emphasis on solutions and services. Additionally, there is also a greater need to localize both manufacturing and innovation in areas which show more rapid expansion compared to the mature European markets. So, in considering what the government can do to support these SHOKs certain needs appear to be common among several industries.

The innovation system also encompasses regional development. The network of Finnish universities and polytechnics, technology centers, the Center of Expertise Program, and other operations have developed innovation prerequisites in the regions to the extent that it is now possible to speak of the innovation systems of the regions and their development.

The third Center of Expertise program, or OSKE-program in Finnish, runs from 2007 to 2013 and supports 13 clusters and 21 regional Centers of Expertise. The OSKE- and SHOK-programs bring together research resources in areas important to both enterprises and society.

During spring 2009 the Finnish government initiated a new program called

Figure 14. Overview of the Finnish innovation programs



the regional Cohesion and Competitiveness program (KOKO). The goal of the KOKO- program was to improve the competitiveness of regions in Finland and to balance regional development by supporting interaction and networking between different regions. The KOKO-program started in 2010 and covered all of Finland. In December 2011 it was announced that the KOKO-program would be terminated due to budget cuts.

Based on a thematic analysis of the 56 supplied KOKO-applications in 2009 it was possible to draw a map of the interconnections between the three different innovation programs, the SHOKs, the OSKEs and the KOKOs. This resulted in the structure presented in Figure 14.

As a small country it is important for Finland that the areas that are prioritized are truly evaluated based on their global potential, understanding both the market possibilities but also realistically evaluating the underlying strengths based upon which the commercial activities could be undertaken. In this respect identifying where there are opportunities to build new innovation capabilities is one of the key success factors.

3.3 The Finnish innovation system in international comparison

In general Finland has ranked high in different international comparisons relating to competitiveness and innovation throughout the 2000s. Some recent examples of this are as follows:

- The **OECD Science, Technology and Industry Outlook 2010** noted that Finland's innovation investment and performance was among the strongest in the OECD area.
- The **Innovation Union Scoreboard** 2010 rated Sweden, Denmark, Finland and Germany "Innovation leaders".
- According to the **WEF**, Finland ranked third in innovation and was the seventh most competitive country, overall, in the world in 2010. The most competitive countries were Switzerland, Sweden and Singapore.
- The US based **ITIF** (Information Technology and Innovation Foundation), in a 2011 comparison, ranked Finland as the second most innovative and competitive country out of 44 countries based on R&D input and personnel, venture capital, productivity and trade indicators (Singapore was ranked first).
- In the **Global Innovation Index** rankings, compiled by **INSEAD**, Finland ranked fifth after Switzerland, Sweden, Singapore and Hong Kong.
- **The Global Information Technology Report, by the WEF**, ranked countries by the network readiness index (2010–2011); Finland was third after Sweden and Singapore.

3.4 The role of Tekes in the Finnish innovation system

Tekes's objectives are illustrated in Figure 15.

The main function of Tekes is to finance and support private and public research and development projects. Tekes targets its funding to three types of actors: enterprises, universities and research institutes, and other actors. One third of funding is allocated to universities and research institutes. Enterprises receive about two thirds of funding. Other actors, such as public service providers and third-party actors receive only a minor share of the funding. A breakdown of Tekes funding in 2010 is as follows (€633 million, 1896 projects) illustrated in Figure 16.

Enterprise funding is targeted to (i) young SMEs, (ii) established enter-

Figure 15. Tekes objectives

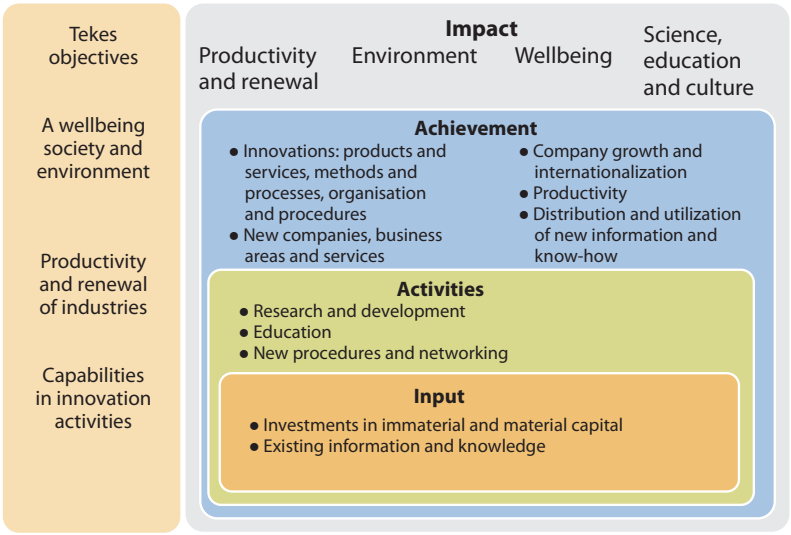
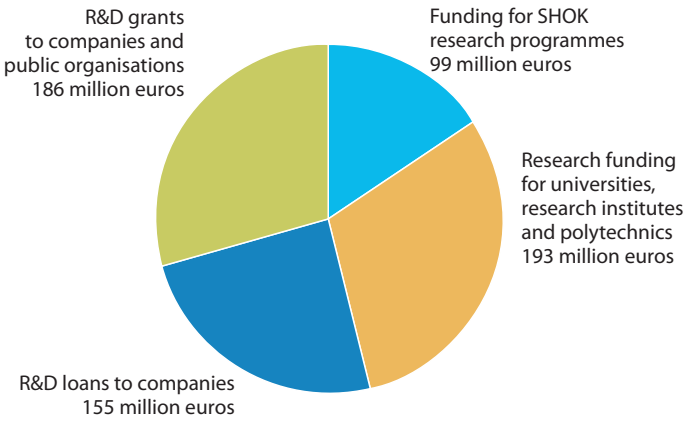


Figure 16. Tekes funding in 2010



The funding for R&D includes 29 million euros from EU Structural Funds. Research programmes of the Strategic Centres for Science, Technology and Innovation (SHOK) are joint programmes for research organisations and companies.

prises with less than 500 employees and (iii) enterprises with more than 500 employees. Large enterprises are only funded, if external impacts on other actors are significant, or if the company is essentially reinventing its business operations. Each target group receives approximately one third of the enterprise funding. All projects funded are based on customer ideas and plans.

Different selection criteria for receiving funding exist depending on e.g. the size of the applicant company and the type of project. The financing instrument also varies based on the needs of the project or company. The funding provided by Tekes should help to leverage the existing capabilities and knowledge within the funded enterprise, thereby enabling more rapid and successful development than would otherwise be possible.

Funding is directed differently depending on the respective size of the enterprise, small or medium sized enterprises receive funding for different purposes and under different conditions than do large companies. The funding directed to small or medium sized enterprises is generally utilized to affect short-term business growth or in-house R&D. Large enterprises are required to partner with public research organizations and SMEs, and direct a majority of the funding they receive towards these partner organizations.

Based on Tekes's criteria, certain types of projects and companies are selected for funding. Tekes funding has many implications on the actors and the projects they take on. The funding allows companies and other organizations; e.g. to increase their R&D investments and resources committed to R&D. Tekes support also enables the actors to undertake riskier projects as well as to increase the scope of the projects. In addition, Tekes funding aims to increase networking in the funded organizations. Three sets of activities are primarily sought for: research and innovation activity, education, and new processes and networking.

Tekes funding eventually translates into concrete activities in the companies or other institutions. These activities include e.g. product R&D, development of organizational processes, business model research or international networking. The activities that companies want to be engaged in vary significantly based on e.g. the industry and size of the company.

The activities funded by Tekes result in different outputs. These can be divided into three distinct categories:

1. Project results (company specific)
2. Development of capabilities (company specific)
3. Network level results (ecosystem effects)

Project results are e.g. innovative products and services, new processes and methods, organizational development, new enterprises, new business areas and services, growth and internationalization, productivity improvements, and the distribution and utilization of new knowledge and skills. Many of these outputs can be quantified. Activities inside the organization also develop the company's capabilities. Ecosystem effects relate to outputs affecting the entire network of stakeholders.

Project results and capability building are primarily company-specific and benefit those parties involved in the project. Network effects, on the other hand, relate to broader benefits to actors not participating in the project directly. These benefits could include e.g. establishment of international network

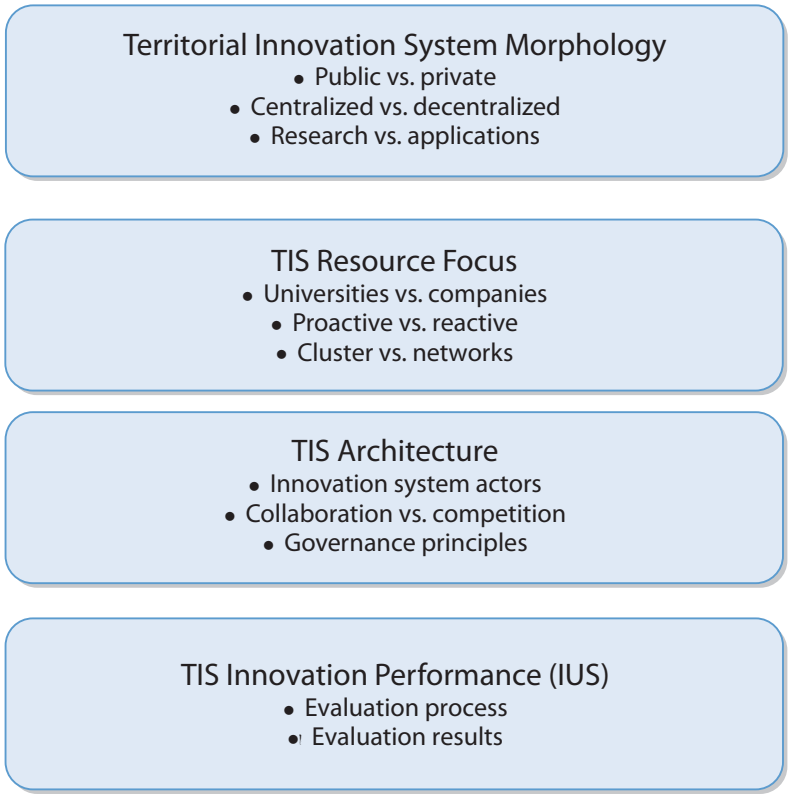
relationships or improved value chain management.

In addition to the capability building effects relating to individual projects and programs, the overall strategic direction of how Tekes allocates funds also has an impact on Finnish innovation activities. Recent examples of how Tekes has reformulated these decisions include: the introduction of the SHOKs; and the decision to further strengthen the support of rapidly growing young companies, through the VIGO accelerator program. These changes in the strategic direction of Tekes funding will be addressed in greater detail in the analysis portion in chapter 5.

3.5 A framework for innovation system anatomy

The analysis of the Finnish innovation system has provided the basic facts about those factors forming the way the Finnish innovation system works. These factors will now be evaluated in the context of a preliminary framework for evaluating the "anatomy" of the innovation system of a particular country. The preliminary framework is depicted in Figure 17. This framework does not attempt to explain why one innovation system would be superior to another, but rather to provide a basis for discussion of why different countries have different forms of innovation systems, and enable a comparison that would also identify possible needs for change in a new context.

Figure 17. A framework for innovation system anatomy



Finnish innovation system morphology

The Finnish innovation system is characterized by strong cooperation between the Finnish government and the corporate sector. There are historical reasons for this cooperation. After WWII, Finland had to pay its debt to the Soviet Union, and the strong ties between the Soviet-planned economy and Finland continued later on in the form of bilateral trade agreements between the two countries. As the quotas stipulated by the bilateral agreements were politically agreed, the companies had to interact closely with the politicians in order to make sure that the commitments could be fulfilled in practice. This also introduced a strong centralized culture into the Finnish innovation system, as the demands arising from the discussions with the Russians were channeled into different types of development initiatives with both public and private participation. Icebreaker ships, machinery and electrical appliances were examples of product areas that were developed and sold to the Soviet Union. These products required the development of new technological know-how that also enabled the companies to compete on a global basis. The cultural underpinnings that had been established during the Soviet area continued to, a large extent, prevail, after the regime change in Russia as well.

Finland continues to have a strong centralized innovation system today, and corporate involvement has been

even more visibly highlighted through the establishing of the SHOKs. Research is carried out with both a focus on applied research as well as on the area of basic research. The research policy is now up for re-evaluation, as the quality of Finnish research results is not considered to be high enough in relation to the allocated resources.

Research focus

A recent innovation assessment (Veuglers, et. al 2009) made the following statement:

It is quite possible that Finland currently has one of the best national innovation systems worldwide. Even that may not be enough in an era, where the global operating environment is rapidly evolving and the whole concept of a national innovation system has rightly been questioned. Companies have been the primary object of the innovation policy but, as they become increasingly footloose and geographically dispersed, the focus may have to shift to nurturing and attracting creative individuals.

These types of tendencies can be identified in the recent developments in the Finnish innovation system. In the interest of supporting creative individuals, the ambition is to have a greater variety of programs, and aim for research areas that have a real possibility of making international breakthroughs. The formation of the Aalto University and the mergers of some other universities are evidence of these ambitions. However, the balance between promoting state of the art academic research and supporting the interests of companies expecting applied research is still evolving.

The SHOKs are seen to be a vehicle that will enable the research agendas to be set in consensus between the various parties. Considering the SHOKs' performance thus far, not all commentators are convinced that this is the final model. However, what is clear is that there is a strong interest to shift the focus more from traditional clusters towards different forms of cross-sectoral initiatives, e.g. by introducing the service (Serve) and the business management (Liito) programs in Tekes.

The recently launched Tekes-program for electric transportation, the EVE-program, is another example of a program that unifies different industries, such as the automotive, energy and information technology industries. These programs, together with stronger emphasis on international networking when evaluating applications for funding, signal a genuine ambition at Tekes to further strengthen the global competitiveness of its funded innovation activities.

TIS architecture

The architecture of the Finnish innovation system was described in Figure 14. The private sector represents the majority of the innovation funding, but as previously mentioned, public spending on R&D amounts to about 1.0% of GDP, representing the highest figure in Europe. The relatively high degree of public R&D spending is also mirrored in the governance structure, in having the Prime Minister serving as the chairman of the Research and Innovation Council.

TIS performance

Finland was, in the 2010 Innovation Union Scoreboard, classified as one of the four countries that were considered to be EU innovation leaders (Sweden, Denmark, and Germany being the three other ones). When expanding the ranking to all European countries, Switzerland emerged as the leading country. However, the evaluation also highlighted the Achilles heel of the Finnish innovation system:

In dynamic terms, in the last decade Finland has outperformed the EU, the United States and other highly knowledge-intensive countries in Europe in terms of private and public R&D investments and the share of new doctoral graduates. However, this rosy picture in terms of increasing input does not find its immediate translation in terms of growth in scientific and technological output, especially in terms of patents, where the country seems to lose ground vis-à-vis these reference countries.

…despite being among the scientific and technological leaders in Europe, Finland's internationalization in science and technology still remains behind the reference group including Sweden, Denmark and Switzerland, notably in terms of technological cooperation. This may signal an untapped potential for progress that could benefit future competitiveness and growth of the country.

The specific activities initiated to address these shortfalls will be addressed further in the analytics part in chapter 5.

The anatomy of the Finnish innovation system is illustrated in Figure 18.

Figure 18. The anatomy of the Finnish innovation system

4

International comparisons

The international comparisons conducted in this study address how other innovation organizations have supported the building of innovation capabilities. For the purpose of this study, the countries to be included in the comparison were chosen from similar small economies, which have been considered to be at the leading edge of innovation or economic growth. This resulted in the selection of the four benchmark countries to be studied: Denmark, Ireland, Sweden, and Switzerland. The analyses of these four countries are presented in Appendix 2.

The comparisons attempted to address the following questions:

- How has Tekes succeeded in achieving its objectives compared to other similar institutions in other countries?
- How well have the objectives been achieved nationally compared to international development?
- How can the achievement of objectives and development of capabilities for innovation activities be measured (company level, network level, societal level)?
- How does Tekes compare with similar organizations internationally?
- How are capabilities for innovation activities developed internationally?

The study's ambition of investigating the support provided for the building of innovation capabilities was made more challenging by the absence of a uniform European framework for this. A further challenge was posed by the varied compositions of the innovation systems in various countries, with none being structured quite like Finland's. As a result, no institution precisely like Tekes exists in other countries. Because of this it is necessary to compare the entire national innovation systems, and draw the relevant conclusions in respect of what can be observed regarding innovation capability building.

As Cooke et al (2010, p. 325) state, it is indisputable that there are an increasing amount of cases where a core regional industry competence is threatened or actually harmed by the globalization processes, notably cheaper production of the core product portfolio at equivalent or better quality, undermining key markets. Such changes are, for example, very visible in most engineering sectors, and hence also of great relevance for Finland.

In such situations more open innovation is expected, and outsourcing in general is seen as a means of coping with the increased cost pressures. At the same time, the possibilities to leverage upon the strongholds by identifying new applications have to be evaluated.

Based on observations gathered from the four comparisons (Denmark, Ireland, Sweden and Switzerland) the questions will be addressed by taking specific perspectives in respect of each of the issues.

The first question regarding how Tekes has achieved its objectives, in comparison with similar institutions, will be addressed from two perspectives: firstly, how the agencies have managed the balance between universities and the corporate sector; and, secondly, how the regional aspects of innovation policy are handled. We will call this *Innovation support strategies*.

Comparing how objectives have been achieved nationally and internationally will be addressed by discussing how the countries have dealt with *Clusters and networks*.

Performance measurement will be assessed using the procedures employed in each respective country; *Performance measurement*.

Innovation-capability building is discussed in more general terms, as none of the other innovation agencies has set building of innovation capabilities as an objective. This discussion also includes the international dimension of how innovation capabilities are built and nurtured.

Finally this section will summarize Tekes's overall performance as compared to its peer organizations in Sweden, Denmark, Switzerland and Ireland; *Summarizing the comparisons*.

4.1 Innovation support strategies

The publicly funded operations of the Danish, Irish, Swedish and Swiss innovation systems are based, in large part, on support channeled through universities. Public funds for R&D in Sweden are usually directed towards Higher Education Institutions through research councils, and in Sweden direct public financial support to big companies is very limited. Worthy of note is also the fact that innovation actors in both Sweden as well as Denmark report primarily to the ministries of education. In Switzerland, with an R&D intensity of 3% of GDP, the role of the public sector is very small, as the private sector and higher education together represent 98%. This means that the Swiss innovation support structure is only well aligned with two major national innovation actors: the Swiss National Science Foundation and the Commission for Technology and Innovation. The Swiss situation is, however, very special, as Switzerland benefits from its geographical location, an attractive tax regime, its close collaboration with Germany, a favorable climate, and a long tradition of strong industrial activity in a multitude of industries, not least of which is the financial services sector.

However, it is also important to note that both Sweden and Switzerland have a high degree of company funded R&D, which has been seen as the engine of the successful innovation systems in these countries. In Sweden there are signs of some decline in innovation activities, which is partly due to some of the leading MNCs relocating their research activities from Sweden to other countries.

As to the balance between centralized and regional aspects: the Danish, Irish, and Swiss innovation agencies have a strong centralized mandate, whereas Sweden has a more fragmented public innovation system, with a multitude of actors, both on national and regional levels. In Sweden, one can see a certain shift in emphasis from the national level to stronger regional centers, particularly around Gothenburg and Malmö/Lund. The regional aspect in Sweden was also emphasized in the highly successful VINNVÄXT program.

Ireland has a very different approach to innovation compared to the other countries in this comparison. Ireland used to rely on a low-tax policy and strong support for FDI into Ireland, and was successful with this approach until the beginning of this century. The economic crisis has radically affected Ireland, and the changes in the innovation system that were announced in 2006 now face significant pressure due to the financial difficulties. Irrespective of this, Ireland remains extremely dependent on international trade, and the success of its innovation policy in the near future will depend on how well Ireland can engage the MNCs in expanding their R&D activities in Ireland.

As the Irish budget for R&D is substantially smaller than the other countries in this comparison, the Irish experiences primarily tend to support the view that innovation capabilities can only be developed over the long term, and require efficient collaboration between the public and private sectors. Temporarily a country may be attractive due to tax policies and structural imbalances, but long-term economic growth requires a solid foundation in the society, whereby the different actors in the innovation system are able to constantly readjust and realign the efforts in keeping the country competitive.

Assessment 1: *The Finnish innovation system has its own historical background and appears to have a good balance of university and corporate support.*

Recommendation 1: *Tekes's role in the future is to remain flexible in adjusting its policies in order to meet the increasingly global requirements facing innovation actors.*

4.2 Clusters and networks

The notion of clusters is actively used in Sweden, with five clusters being identified as areas of specialization: cleantech, automotive, ICT, materials, and life sciences. Ireland has also identified a number of clusters that are afforded special recognition: medical technology, computer hardware and software, and pharmaceuticals. In Switzerland the leading clusters are pharmaceuticals, financial services, machinery, and watches and precision instruments.

Sweden is also the only country in this comparison with a series of programs specifically supporting the R&D activities of foreign actors, for example in the automotive sector. Another specific feature in Sweden is the training of "innovation system developers".

A new initiative in Sweden, Challenge-driven innovation, is a clear indication of a change taking place in Swedish innovation practices. This multidisciplinary call for proposals, announced in 2011, will result in a three-stage innovation program with the most promising ideas gaining financing for up to ten years. The first round

of applications resulted in over 600 proposals, showing that the format introduced by VINNOVA was very attractive. These networks are designed in an international setting from the outset, in this respect they differ from the regional approach employed in the previous large program, VINNVÄXT.

Denmark is also initiating new programs in the area of eco-innovations, and is looking to support large demonstration facilities. This also further underlines the way Denmark emphasizes technology-driven industries and at the same time increases its R&D intensity. In Denmark collaboration between business and research is one of four focus areas of Innovation Denmark. Two types of networks are formed in Denmark to support this: competence and innovation networks, and innovation consortia. The innovation consortia represent a flexible framework for collaboration between enterprises, research institutions and non-profit advisory/knowledge dissemination parties. The budget of an average innovation consortium is approximately between €3 million and €7.5 million. The consortium must consist of a minimum of two enterprises, one research institution and one knowledge dissemination party.

The Swiss innovation system has two strong networks, the National Research Programs and the National Centers of Competence in Research (NCCRs). The key program is the NCCR, which has the objective of promoting "scientific excellence in areas of major strategic importance of the future of Swiss research, economy and society" and a usual funding duration of 12 years. At the moment there are 27 NCCRs, each of them coordinated by one academic unit undertaking formal collaboration with further research teams located throughout the country. At the same time the same academic unit can also participate in another NCCR.

Ireland has largely adopted a network strategy, similar to that of Switzerland, by introducing two forms of networks: Centres for Science, Engineering and Technology; and Strategic Research Clusters.

In Switzerland competition has led to a certain degree of academic specialization, as universities compete for extra funding and industry partners. This collaborative structure enables co-specialization. While a university might have the responsibility for one or two NCCRs in certain areas of expertise, its other academic units can connect themselves to funded research projects conducted at other institutions. The NCCRs therefore are the clearest examples of orchestrated ecosystems found in any of the five countries. The Swedish Challenge-driven Innovation program seems to be going in the same direction, but the Swiss system has already been in operation since 2001, and can, therefore, provide a practical example for how such ecosystems can be nurtured.

Assessment 2: *The emphasis of innovation support is shifting from clusters to networks, and towards orchestrated ecosystems in particular. The Swiss example of NCCRs and VINNOVA's Challenge-driven Innovation show the tendency to support longer-term development efforts which have a clear, identifiable organization as the orchestrator of the ecosystem.*

Recommendation 2: *Tekes should consider the experiences from these methods of supporting the development of ecosystems when determining how to provide orchestration support e.g. in its Value Networks program.*

4.3 Performance measurement

The leading countries in respect of innovation seem to actively reference international rankings in assessing their success. In addition, the comparisons also show that Denmark has quite a fine grained process of assessing and monitoring of its own innovation activities. The Danish innovation system's rapid improvement suggests that this practice is something other countries could actively consider.

Sweden and Switzerland seem to primarily measure direct outputs of the innovation activities (number of new PhD and master's degrees, scientific publications, granted patents). Qualitative measures have also been collected in Sweden and Switzerland through questionnaires.

The Swedish assessments do emphasize the significance of durable relationships in explaining innovation success. The Swedish experience suggests that trust and confidence, particularly between key members of each organization, are far more important than formal agreements. Long-term and large grants have created opportunities for establishing relatively broad collaborations with other R&D milieus both within and outside their own institutions primarily, but not exclusively, in Sweden. In the Swedish system the university is clearly assigned the role of ecosystem orchestrator, as the Swedish calls for proposals for center grants require that the university itself must be the applicant.

Ireland, as a country which is striving to catch-up, places great emphasis on tracking how its R&D intensity is progressing. In the last decade private R&D intensity grew from 0.8% in 2000 to 1.17% in 2009.

Assessment 3: *There are clear indications that trust and confidence are important factors strengthening the innovation process.*

Recommendation 3: *Tekes could use the experiences from abroad when broadening its assessment process. Increased active monitoring of the innovation activities as they proceed should be emphasized. In networks there is also a need to be able to monitor how relationships and trust are nurtured through Tekes's activities.*

4.4 Innovation capability building

The challenge to operationalize capabilities for the purpose of properly understanding the underlying logic of how certain organizations are able to change and transform is a universal problem. David J. Teece, the leading academic authority on capabilities, admits this:

The microfoundations of dynamic capabilities – the distinct skills, processes, procedures, organizational structures, decision rules, and disciplines – which undergird enterprise-level sensing, seizing, and reconfiguring capacities are difficult to develop and deploy. Enterprises with strong dynamic capabilities are intensely entrepreneurial. They not only adapt to business ecosystems, but also shape them through innovation and through collaboration with other enterprises, entities, and institutions. (Teece, 2007, p. 1319)

Researchers grappling with the issue of national innovation systems have similarly had difficulties in identifying the prerequisites for the success of different types of innovation systems. Professor Beng-Åke Lundvall and his colleagues (2002) have, in various studies, compared different innovation systems and their dynamics. One study was a large-scale project on the Danish system of innovation, mainly carried out in 1996–1999 where they observed that the Danish system was built on specialization in low technology sectors and that most of its innovations had been incremental and experience-based rather than radical and science based. They also noticed that the Danish economy was characterized by intense interaction between firms, while the interaction between firms and universities was weakly developed. These findings from the late 1990s can now be reflected upon in light of the strong emphasis on university–industry collaboration carried out in the 2000s in Denmark, and the significant improvements Denmark lately has had in innovation rankings.

Another observation from the Danish innovation system is that it favors a broad concept based on a wide set of policies including social policy, labor market policy, education policy, industrial policy, energy policy, environmental policy and science and technology policy. Such a national innovation system then calls for national development strategies with co-ordination across these policy areas (Lundvall et al, 2002).

Later, Lundvall and his colleagues (Jensen et al 2007) have developed ideas about two basically different forms of innovation approaches. One mode is based on the production and use of codified scientific and technical knowledge, STI (Science-Technology-Innovation mode), which dominates the innovation discourse in most countries. The other mode of learning is based on Doing, Using and Interacting (DUI mode), which refers to an experience based knowledge policy, or a human resource policy. The vast majority of innovation studies have little to say about the relation of DUI-mode learning to innovative performance.

Empirical data from Denmark has shown that companies that perform well on both these dimensions (STI and DUI) are the most successful ones in respect of innovation. These firms tend to combine informal experience-based learning with activities that indicate a strong capacity to absorb and use codified and scientific knowledge. This would then imply that human resources are key to innovation, and there is a need to build innovation and competence building systems that include labor market institutions, industrial relations, vocational training and educational principles, and that support organizational learning and life-long learning. Practical means of strengthening the DUI mode in organizations and networks include: project teams, problem-solving groups, and job and task rotation (Jensen et al, 2007).

Lundvall has also interpreted the above results in the light of the success of the Nordic countries in respect of innovation (Lundvall, 2008). Here he suggests that in small countries most ideas based in scientific research come from abroad and the capacity to integrate them in the practice of domestic firms will reflect not only R&D-activities but

also the competence and collaborative efforts of scientists, engineers, managers, workers and marketing experts. This would suggest that small countries in general neither can nor should set the same ambitions for domestic innovation as the United States or China. Critical to the performance of small countries is the capability to learn. This requires skilled labor, good labor relationships and good collaboration with customers and among experts with different backgrounds. Having made this basic assumption Lundvall comes to the conclusion that the Finnish innovation strategy is the one that comes closest to combining the DUI and the STI-mode, forming a systemic understanding of what drives innovation and of how innovation is transformed into economic performance (Lundvall, 2008, p. 5). This observation is based on the explicit strategy formulation of the 2008 Proposal for Finland's National Innovation strategy.

Lundvall also appreciates that Denmark, Sweden and Finland are actively taking part in transnational networks and EU programs, and that they aim to attract star scholars from abroad. He also acknowledges the ambitions of the countries to not only focus on direct transfer knowledge from universities to industry, but also to actively promote the presence of academic labor in industry, thereby encouraging indirect knowledge transfer. This has been very explicit in Denmark, through its industrial PhD scheme, where the research student divides his or her time between an enterprise and a university. Also Switzerland has a similar PhD program. In Sweden the transition of PhDs into industry has been considered a positive result of publicly funded innovation projects.

Lundvall also addresses some more fundamental issues which he considers prejudices. So for example he questions to what extent lowering personal taxes attract experts. There is no evidence that low tax economies perform better in terms of innovation than those with high taxes. Here the case of Ireland in comparison with the other countries of this study seems to also raise the question of how efficient a low tax policy is in nurturing innovation.

Another issue raised by Lundvall is that of entrepreneurship. This area also shows no indication that countries with high frequencies of start-ups perform better in terms of innovation and growth than those with low frequencies of start-ups. One reason for this may be the fact that most innovation processes are interactive and take place within or across the borders of existing organizations. – What may be more important than individual entrepreneurship may be 'collective entrepreneurship'.

Despite of Lundvall's skepticism, it seems that most countries are actively trying to encourage an entrepreneurial culture. In Denmark the main challenge is that even if there is a high level of start-ups, there is a low level of high growth firms. Scaling up is therefore a key word used by several of the innovation agencies. To help start-ups and small firms to gain access to innovation support, both Denmark and Switzerland have introduced innovation voucher schemes. In Switzerland the objective of the scheme is to provide support in a fair, user-friendly, and flexible manner. Switzerland has also launched Knowledge and Technology transfer networks in 2005. These networks have assigned advisors to help SMEs to determine exactly what kind of innovation support services they require. Coaching of young entrepreneurs is also provided.

Lundvall welcomes the Finnish model in which innovation is under the Ministry of Employment and the Economy as this may give adequate weight to policies affecting human resources, labor market and work organization (Lundvall, 2008, p. 7). He concludes that social capital and participatory learning could be the hidden and forgotten strengths of the Nordic innovation systems. This could be due to the fact that the egalitarian character of the Nordic innovation systems, with small income and status differences, makes vertical, interactive learning and delegation of responsibility much more frequent and efficient. This would also indicate that national educational systems with the main emphasis on the formal training of scientists and engineers, while neglecting the broader forms of vocational training, may be vulnerable in the context of a learning economy.

From Sweden, Denmark and Switzerland there is very clear evidence that companies' adoption of scientifically based working practices, recruitment of research graduates, competence development and absorption of R&D results are facilitated if companies collaborate with leading R&D milieus and actively participate in joint R&D projects.

Assessment 4: *Innovation capability building requires the convergence of a multitude of factors.*

Recommendation 4: *Tekes should track and evaluate which particular innovation support activities are effective in*

what situations, and to support different innovation needs. On one hand, there is a need for longer term programs, orchestrated by leading organizations, and, on the other hand for fair, user-friendly and flexible instruments for start-ups and SMEs. Tekes should also emphasize the transfer of knowledge through individuals, by e.g. encouraging PhDs to alter between academia and industry.

4.5 Summarizing the comparisons

Both Sweden and Switzerland seem to benefit from the image of being innovation leaders. When assessing one Swedish innovation program it was concluded that becoming internationally known both in the scientific arena and on commercial markets means that Sweden's image as a research and technology nation is further strengthened. Strong R&I systems comprise internationally leading R&D milieus of considerable mass, which maintain close and sustainable collaborations with internationally leading companies.

Also seemingly on the rise is the need to support innovation from exploration to exploitation through different forms of demonstration initiatives. This is the case in the Swedish Challenge-driven innovation program, and is also evident in the Danish Proof-of-Concept program, which particularly emphasizes technology transfer between national and international research institutions and enterprises.

The Swiss innovation system is at the moment, in light of the material provided for this study, the leading system of those compared. This is very much a result of the confluence of several factors, which have allowed the Swiss research and innovation system to establish strong scientific and technological connections with partners in other European systems. 45% of all Swiss patent applications include a co-inventor located abroad, showing the high degree of international networking within the Swiss innovation system.

The results from the country comparisons now enables a return to the conceptual framework introduced in chapter 1 and a reconsideration of the framework from the perspective of the innovation agency, which is illustrated in Figure 19.

Figure 19. Innovation capability building support; the innovation agency perspective

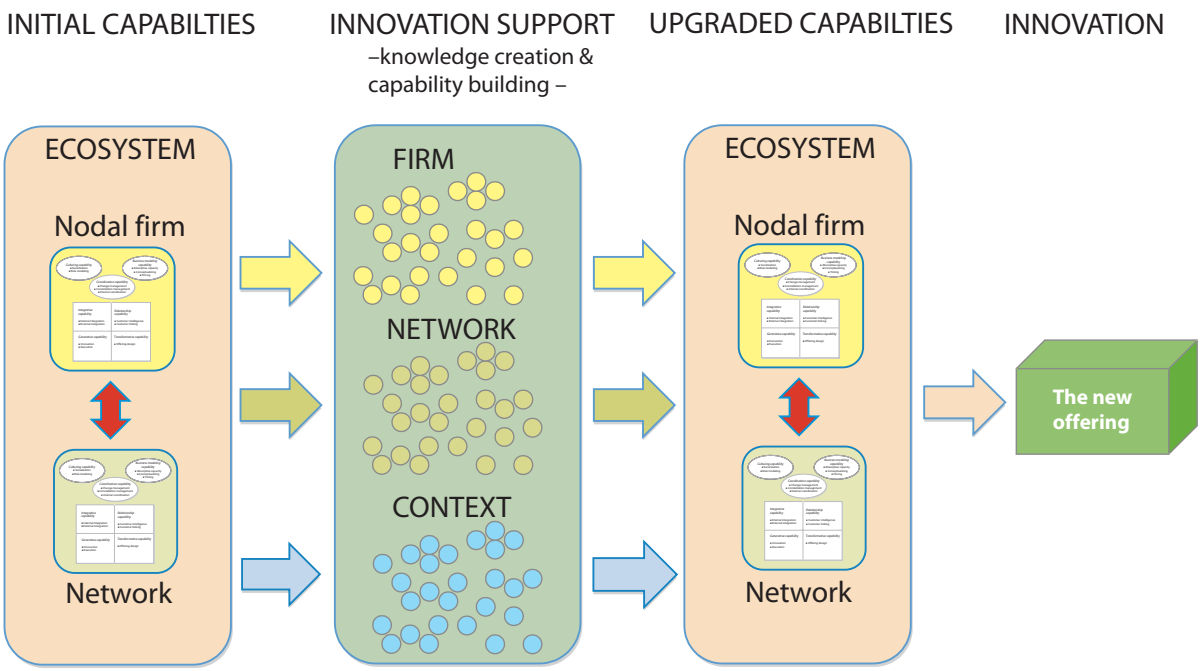


Figure 20. Innovation support activities

FIRM LEVEL ACTIVITIES

- Seed investments for start-ups
- Financing long-term development (incubators, accelerators etc.)
- Financing firm research projects
- Pre-market incentives and demonstrations to support early adopters of new technology
- Public procurement as encouragement for new solutions
- Foresight to support innovation activities
- Coaching of entrepreneurs
- Access to key expertise (technology, marketing etc.)
- Co-orchestration support in ecosystems
- Access to market and distribution channels
- Connections to alliance partners
- Possibilities to gain access to established international pipelines
- Providing political credibility in front of stakeholders (investors etc.)
- Fostering a collaborative spirit in large ecosystems
- Input on the design of new business models

NETWORK LEVEL ACTIVITIES

- Selecting and funding demanding research projects and programs
- Creating complex financing packages for large research projects
- Attracting venture capital
- Nurturing creative individuals
- Investor engagement in early stage research initiatives
- Public procurement and incentives to stimulate research collaboration
- Train innovation system developers
- International researcher exchange to strengthen research quality
- Rotation of researchers between academia and industry
- Venture management to secure market pull in research projects
- Domestic and international research alliances to sharpen research focus
- Market making/positioning as guidance for research priorities
- Providing stewardship and disciplinary diversification in the network
- Constellation platforms bringing together actors from different sectors for open innovation
- Nurturing trust in constellations and ecosystems

CONTEXTUAL ACTIVITIES

- Access to land and premises at competitive prices (e.g. science parks)
- High quality communication networks (transportation, data etc.)
- Health and safety regulations.
- Supportive tax system
- Investment support for innovation efforts
- Laws and regulations guaranteeing smooth business operations
- Technical standards and coordination
- Societal inclusiveness enabling integration of foreign labor
- Welfare system which strengthens workforce motivation
- Public operating procedures which makes dealing with authorities simple
- Access to educated workforce at competitive conditions
- Availability of service workforce to secure basic business operations
- High labor moral including low frequency of strikes and work disputes
- Labor market flexibility
- Support of an entrepreneurial climate

The innovation agency is a co-creator of innovation capabilities. The focus of the innovation support activities is on knowledge creation and capability building. Activities contributing to this are listed in Figure 20:

Assessment 5: *The international comparison of innovation agencies in Sweden, Denmark, Switzerland and Ireland suggests that the leading innovation agencies have broadly similar strategies and objectives. Compared to these other countries Finland is less internationalized, and this has to be taken into consideration by Tekes.*

Recommendation 5: *As international networks are becoming the main form for successful innovations, Tekes should focus on the individuals and the organizational capabilities needed to build and foster international networks.*

5 Innovation analysis

This chapter uses the conceptual framework to evaluate how the activities of Tekes have supported innovation capability building in the Finnish innovation system. The analysis will consist of four parts. First, the overall direction of Tekes's activities, and how these have changed over the years, is analyzed in section 5.1. Second, Tekes's interactions with individual organizations and what the organizations expect from Tekes, is the focus of section 5.2. Third, Tekes's means of assessing its own performance is the subject of section 5.3. Certain new imperatives for innovation agencies, derived from these findings, are presented in section 5.4.

5.1 Innovation capabilities vs. Tekes financing and operating methods

When considering how the activities of Tekes have contributed to the building of innovation capabilities the key questions are:

- How has Tekes considered the objectives and strategic choices associated with capabilities for innovation activities, competence bases, and internationalization and networking in its financing criteria, financing instruments and operating methods?
- How does Tekes operate, target its funding and support, and what are the funding criteria?
- How well are Tekes's strategic choices, relating to the strengthening of innovation capabilities, represented in its financing criteria, financing instruments and operating methods?
- How can the chosen financing criteria, instruments and operating methods be justified in light of stimulating the strengthening of innovation capability?
- How should the criteria, instruments and operating methods be improved?

This section will address policy level issues relating to Tekes's performance in building innovation capabilities. Section 5.2 in turn will address the interactions with customers based on case analyses and additional feedback gathered from Tekes customers and other stakeholders during this study.

Tekes has defined its objectives as follows:

We finance demanding research and development projects and we promote the development of companies. (In Finnish: Rahoitamme haastavia tutkimus- ja kehitysprojekteja ja edistämme yritysten kehittymistä; source www.tekes.fi)

Based on the above definition the focus of Tekes activities is to provide support to companies. This implies that a study of Tekes's impact on innovation capabilities should take its origin in how well Finnish companies have developed, as a result of the support Tekes has provided. This is the reason for this impact study's strong company-centric view.

In considering the historical direction of Tekes's financing, the first question is WHO is being funded by Tekes. This will be dealt with in section 5.1.1. The second question when considering Tekes interventions is WHAT types of activities get funded, and here the way Tekes has organized its own activities in the form of programs is of particular interest, as the programs in themselves are Tekes's means of signaling its content priorities in respect of innovation support. The programs and other funding priorities are discussed in section 5.1.2. The third question of importance regarding the way Tekes supports innovation capability building is HOW the innovation support is carried out. This is the topic of section 5.1.3.

5.1.1 Who is being funded by Tekes?

In Finland there are strong links between the innovation agency, companies and the state funded research institute VTT. During 2010 the funding to VTT was increased, from 50 to 64 million, which makes VTT, by far, the single largest recipient of Tekes funding. Sweden in turn has a very clear focus on universities, whereas SMEs are Den-

mark's primary target group. Switzerland has a much smaller ratio of government financed R&D to GDP compared to Finland, Sweden and Denmark, even if universities play as significant a role in the Swiss innovation system as they do in the Nordic countries.

The conceptual framework of this impact study puts forward some suggestions to explain the reason for Switzerland being on top of the chart, even if the national innovation agency has a very minor role in the development. By taking the company-centric view we can argue that the strong ecosystems around the leading Swiss MNCs as well as the well networked Swiss banking sector provide individual start-up companies with access to both financial and intellectual capital through market mechanisms. In such a case, "innovation support services" are provided by the market, which also seems to be the case in Silicon Valley. Therefore national innovation agencies in countries, with less robust markets, must substitute for those activities that the local, national market fails to provide. This means that in allocating its funds, Tekes cannot directly copy the Swiss success story, as the contextual factors in Switzerland are quite different from Finland. An important conclusion to be drawn from this is, however, that innovation support services can be provided by both private firms as well as public organizations.

In the case of Finland, this means that those innovation support activities that the market cannot provide should constitute the activities provided by the public innovation support providers as a result of market failure. In addition, other forms of support may also be necessary due to system failure. In such a case the institutional framework prohibits certain types of market mechanisms from being established in the first place. One example in Finland is the way in which universities are institutionalized, implying that they cannot be freely financed by the market. As the role of universities is crucial in the innovation system, this mechanism presents certain specific constraints upon how Tekes can perform in the Finnish innovation system.

Another observation concerns the way companies are supported by the public sector; Tekes must take this into consideration when directing its own targeted activities. The ultimate role of an innovation agency is to support growth and generate jobs. The cases of Volkswagen in Shanghai and Nokia in Oulu are examples (see chapter 2) of the mechanisms that have achieved this: supported growth and generated new jobs. Tekes needs to critically evaluate what alternative paths exist for achieving these objectives, and what alternative strategies an innovation agency such as Tekes has for contributing to such development. Particularly in light of the increasing difficulty of mobilizing public funding, as a result of the financial crisis, leveraging upon activities carried out by other actors in the innovation system becomes a key objective.

One important question, which has been raised in the public discussion, is to what extent Tekes should provide financing to the largest companies. Through an analysis of quantitative information from Tekes's customer database and ex-post report data regarding Tekes's customers over the period 2004–2010 it becomes apparent that Tekes's funding of the largest Finnish companies is actually quite small, and that the amount of financing awarded to the largest recipients has decreased over the 2004–2010 period.

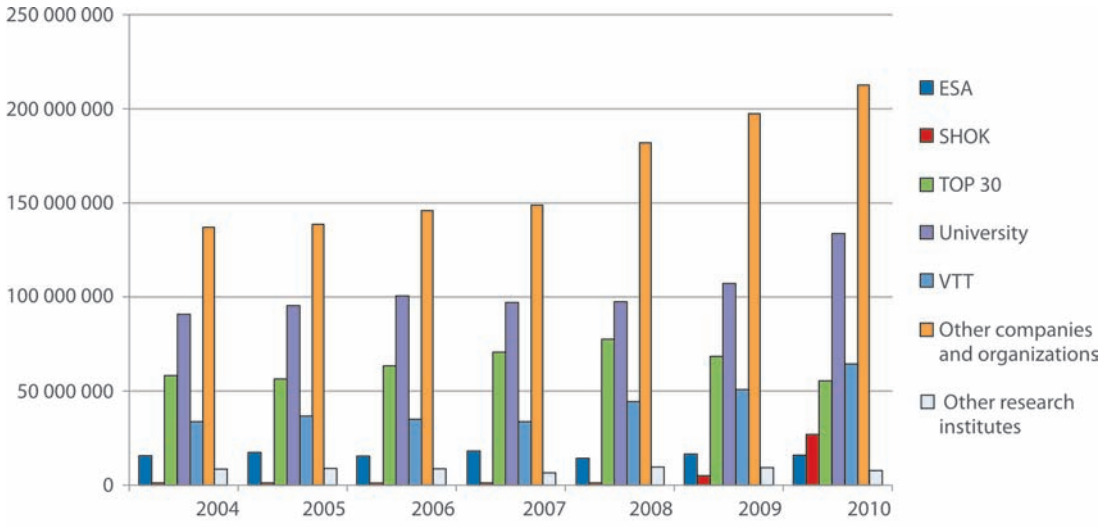
For example, in 2010, only 10.7% of Tekes payments were allocated to the 30 largest recipients, compared to 2004 when 16.9% of Tekes payments were allocated to the 30 largest recipients. Figure 21 presents how Tekes payments have been divided between different organization types.

The share of Tekes payments directed to Finland's largest companies is assessed by comparing the amount of funding with their revenues by using *Talouselämä* magazine's TE 500 list, which ranks the Finnish companies based on revenue. Together, the 50 largest companies represented payments of €291 million during the period 2004–2010, equal to 18.1% of all Tekes payments to companies. Of the *top* 50 TE 500 -companies only 13 were also on Tekes's list of the 50 largest payment recipients for the period 2004–2010 (see Table 1).

The emergence of the SHOKs, and the funding allocated to them, constitute a noteworthy new phenomenon which has surfaced during the period of observation. This funding appears in the figures, until 2010, in two forms, as payments to the SHOKs, but primarily, in the individual figures for each of the respective receiving companies within the SHOKs. This further underscores the fact, that even with the introduction of SHOKs, Tekes financing has systematically been more geared towards SMEs during the period 2004–2010.

When moving from individual companies to industries, the evolution of the overall industrial composition must be explored. During the peri-

Figure 21. Tekes payments to organizations, by organization (source: Tekes data, Synocus analysis)



Values	ESA	SHOK	TOP 30	University	VTT	Other companies and organizations	Other research institutes	Grand Total (€)
2004	15 143 160	0	58 194 328	90 004 891	33 631 241	137 955 325	8 450 661	343 379 606
2005	17 138 654	0	56 214 541	95 012 130	36 700 036	138 853 312	8 959 805	352 878 478
2006	15 661 334	0	63 219 065	100 136 615	34 821 960	146 214 669	8 659 368	368 713 011
2007	18 041 405	463 027	70 581 125	96 561 684	33 519 640	148 982 431	6 532 167	374 681 479
2008	14 262 132	625 096	77 299 301	96 984 883	44 328 189	181 879 946	9 640 599	425 020 146
2009	16 410 449	4 608 333	68 407 566	106 701 176	50 865 035	197 308 568	9 277 159	253 578 286
2010	15 858 245	26 303 129	55 379 626	133 267 494	64 734 029	212 204 603	7 708 293	515 455 419

od 2004–2010 the most significant development has been in the software and data processing industry, where Tekes payments have increased more than 100%, up to almost €60 million in 2010. Although Tekes funding has been increased in the majority of industries, software and data processing is the only industry which experienced significant relative growth from the perspective of Tekes funding. This is illustrated in the Figure 22.

Figure 23 shows how funding awarded to large companies is further allocated to the broader network.

Three trends are identifiable from this analysis. Firstly, the financing has, in general, been directed slightly away from large companies and towards

Table 1. Main recipients of Tekes funding, 2004–2010 (source: Synocus analysis)

Company	Ranking in Tekes payments 2004–2010	Sum of all payments	Revenue 2010	TE 500 list rank
Nokia	1	84917957	42446000000	1
Metso	2	42764365	5552000000	10
UPM-Kymmene	3	23059867	8925400000	5
Tellabs	4	22302619	312690000	162
Neste Oil	5	19591203	11892000000	2
Wärtsilä	6	18862330	4553000000	15
Orion	7	18349516	850000000	67
Elektrobit	8	16175693	162000000	283
Outotec	9	13630417	970000000	60
FIT Biotech	10	13371850	0	-
Kemira	11	13370486	2161000000	25
Biotie Therapies	12	13258397	1711000	-
Stora Enso	13	12861989	10297000000	3

Table 1. continues...

Company	Ranking in Tekes payments 2004–2010	Sum of all payments	Revenue 2010	TE 500 list rank
KONE	14	12633191	4987000000	12
Rautaruukki	15	12374662	2415000000	22
Teleste	16	11585946	46600000	-
Silecs Oy	17	10799919	3900000	-
Hormos Medical Oy	18	8682281	12444000	-
ABB	19	8357094	2161000000	24
Chempolis Oy	20	8315511	1000000	-
Finnzymes Oy	21	6988279	13400000	-
Valio	22	6921823	1822000000	35
TeliaSonera	23	6919097	1713000000	40
NetHawk Oyj	24	6780167	16806000	-
Honeywell Oy	25	6648577	46520000	-
Oy Jurilab Ltd	26	6640605	0	-
Technopolis	27	6597763	82000000	-
Medicel Oy	28	6255977	74000	-
VTI Technologies	29	6247565	75788000	-
KWH	30	5453256	484000000	121
Borealis	31	5450370	315000000	161
Philips	32	5275971	95000000	447
Vaisala	33	5083465	253000000	156
Patria	34	5015016	564000000	101
FibroGen Europe Oy	35	4950000	13000	-
IonPhasE Oy	36	4917352	628000	-
On2 Technologies Finland Oy	37	4888422	598000	-
BBS-Bioactive Bone Substitutes Oy	38	4645832	0	-
Cassidian Finland Oy	39	4632348	150	302
Outokumpu	40	4326134	4229000000	17
Tuotekehitys Oy Tamlink	41	4288653	2800000	-
M-real	42	4231130	5377000000	11
Metsäliitto Osuuskunta	43	4206138		
Fastrax Oy	44	4201703	8429000	-
Beneq Oy	45	4131027	10034000	-
Ipsat Therapies Oy	46	4104672	-	-
Foster Wheeler	47	4075822	154000000	293
Ekahau Oy	48	3834598	3300000	-
Vapo	49	3829931	720000000	77
Winwind	50	3738118	84000000	487

SMEs. Secondly, most industries have maintained their relative share of financing during the observation period, only the ICT-sector has significantly increased its relative share. Thirdly, the financing instruments have been fine-tuned to ensure that funding allocated by Tekes will encourage networks to be formed, to establish closer collaboration between large and small companies, with the support of universities and research institutes.

Considering what groups of organizations Tekes should finance in the future inevitably brings up the debate regarding whether society should finance large companies to begin with. This debate has inspired *The Economist* (December 17th-30th, 2011, p. 122) to argue that today's economy seems to favor big companies over small ones. Three arguments were made in support of this statement (see Mendel, 2011):

- Economic growth is increasingly driven by big ecosystems; these ecosystems need to be managed by a core company that has the scale and skills to provide technological leadership (*i.e. business orchestrators*).
- Globalization attaches a greater premium to size than ever before.
- Many of the most important challenges for innovators involve vast systems, such as education and health care, or giant problems, such as global warming. To make a serious change to a complex system, you usually have to be big (*grand challenge innovation, see Pisano, Shih, 2009, Wallin, Su 2010, Day, Shoemaker, 2011*).

The Economist goes on to suggest that this has profound implications for policymakers. Western governments have been obsessed with promoting small

Figure 22. Tekes funding by industry 2004–2010 (source: Synocus analysis)

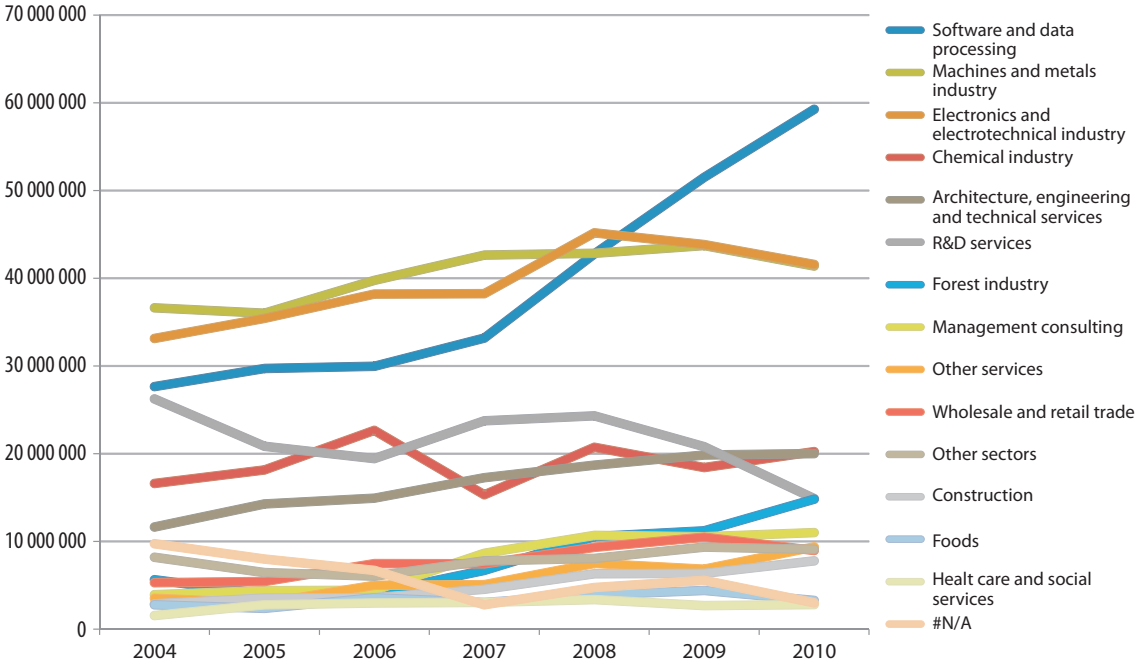
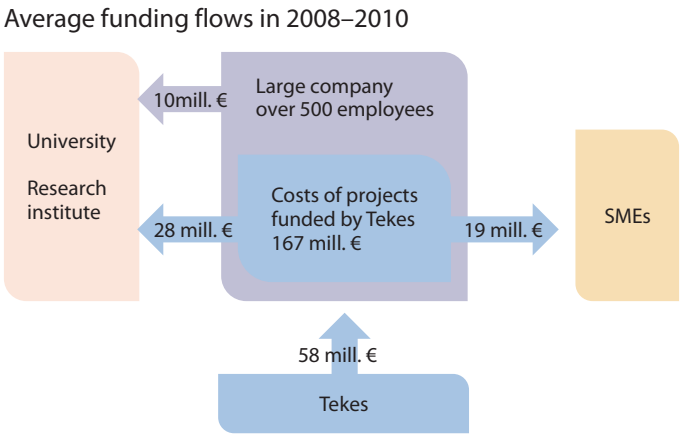


Figure 23. Tekes funding flows to large companies in 2008–2010 (source: Tekes)



Funding flows, million euros	
Tekes funding for large companies	+ 58
Large companies projects buy research services from universities and research institutes	-28
Large companies projects use SMEs as subcontractors	-19
Large companies co-finance public research projects in universities and research institutes	
Net flow	-10
	+ 1

businesses and fostering creative ecosystems. But, if large companies are the key to innovation, there is an increased need to also more strongly integrate the large companies into innovation networks. In this respect, the formation of SHOKs, which integrate all three constituents: large companies; SMEs; and universities/research institutes, is a step in this direction. The key question then is: how well does this organizational construct serve, and support, each of these constituents in practice?

Including large companies in the innovation system is also only part of the solution to the innovation conundrum, as many have acknowledged (and as *The Economist* also points out): large companies often excel at incremental innovation (see e.g. Christensen, 1997), but are less comfortable with disruptive innovation. The other important factor is a firm's ability to grow, which is valuable in itself. Progress tends to come from high-growth companies. The conclusion is that a good innovation system needs both large and SME companies.

Assessment 6: *The distribution of funds by Tekes during 2004-2010 has evolved in a way which encourages collaboration between various actors in the innovation system. This varied composition seems to accurately reflect the larger changes in the business context. Tekes's ambition of being both adaptive and pro-active seems to have proved successful. The correlation of recent successes in the ICT sector and the relative increase in the sector's funding is a positive indicator.*

Recommendation 6: *Tekes should continue its independent evaluation of the larger business context, and balance its funding portfolio for the purpose of long term support of innovation, avoiding becoming focused on short term opportunistic trends affecting the public discussion.*

The invitation to tender for the impact study highlighted the complex dynamics related to the building of innovation capability as follows:

Outcomes of this type result in more extensive societal impacts as new capabilities for innovation activities are created in new fields of research and application. In the next phase, extensive new capabilities for innovation activities of this type will act as an input in enterprising activities aiming at renewal of the economy and productivity growth. In other words, business life networks are a key part of the relational capital, which can help transfer capabilities accumulated through earlier research and development activities as inputs in the networks' own activities.

The above quote illustrates the difficulty of establishing the causal relationships of Tekes intervention versus the formation of innovation capabilities in the business community affected by Tekes's activities. The notion can *help transfer capabilities* underlines the uncertainties related to the assessment of the impact on capability creation of Tekes's interventions.

A key question arising from the conceptual framework (chapter 2) and the comparison of the different countries (chapter 4) is how Tekes supports the formation of international ecosystems. If the innovation is based on a technological invention, the focal company is a Generator. Such a company will primarily look for access to scientific knowledge, which is normally available in universities and research institutes. Subsequently, any arrangement that will facilitate and enable the company to gain good access to such resource pools will provide support in this respect. For example, cities developing technology parks in adjacency to leading universities provide such support, and, for many start-ups, access to the university campus may be what they are looking for in order to pursue their business ambitions. In this respect a substitute for support from Tekes is the provision of physical proximity to the research community provided by a local agency, be it a city, incubator or university organization. For the company, any organization that supports its innovation efforts could be perceived to serve as an "innovation support provider", meaning that, in certain situations, Tekes, the City of Espoo, Technopolis, or Aalto University may all provide "innovation support services" in the Finnish capital region.

If the objective is to create new orchestrated ecosystems, then the nodal organization must be an Orchestrator. Therefore, there are two types of organizations which are critical to the formation of internationally successful ecosystems: Generators and Orchestrators. Generators build their own core resources, and engage in active cooperation with customers within an efficiently managed operational framework. Orchestrators, in turn, develop new concepts and actively build networks that they guide and nurture through their strong leadership capabilities.

There is only a small portion of Finnish companies that, like One Way Sport, aim at being fully-fledged ecosystem orchestrators similar to Apple or IKEA. But there are a considerable number of companies elaborating with business models and service concepts which strengthen the companies in this area, due to the increasing im-

portance of business ecosystems as the environments where important innovations emerge. This implies that companies occupy different roles, in different business contexts and ecosystems. It is therefore relevant for Tekes to support both those companies that build generative capabilities, enabling innovation according to the traditional industrial logic, as well as those that provide orchestration capabilities. Such orchestrating organizations need to develop and/or gain access to the Absorption – Conceptualization – Networking capabilities, which are required to pursue the orchestration strategy. These capabilities are not primarily found in universities or research institutions, but either through access to large companies with whom the orchestrating enterprise can make an alliance, or through access to financers that can provide relevant networks with complementary capabilities.

In the case of Silicon Valley we can see that the venture capital community provides support to build the necessary capabilities for start-up firms, whereas it could be speculated that the large Swiss MNCs together with the strong banking sector in Switzerland provide smaller companies with similar capabilities. Tekes is increasingly developing these types of supporting capabilities for Finnish start-up firms through the Vigo program. Vigo Accelerators form the backbone of the Vigo program. Accelerators are carefully selected independent companies run by internationally proven entrepreneurs and executives. These Accelerators help the start-ups grow faster, smarter, and safer in entering the global market. The Accelerators are co-entrepreneurs, who invest in the companies they work with to guarantee common goals and shared development effort.

In the case of an Orchestrator, the need for Absorption – Conceptualization – Networking capabilities means that the requirements on the "innovation agency" are quite different from what is required for a Generator, and the Vigo Accelerators are one way of establishing such co-orchestration support for start-ups. However, the need for orchestration also exists for established companies, and larger ecosystems. For such purposes Tekes recently launched its funding program for Value Networks. In projects funded within this program special emphasis is placed on developing larger ecosystems that enable the establishment of new and broad international business, which is based on the strength of the engaged network. Financing can be provided to both large companies as well as SMEs. Of special interest in these projects are new business models, concept development, new forms of collaborative processes, and customer-driven, iterative development. The average development cycle is expected to be 2–4 years, and the total investment of each initiative is in the range of €5–10 million. Tekes will, however, not participate in the costs of forming the consortium, the application must, instead, be provided by an existing consortium.

The above examples show that considering the company as a member of an orchestrated ecosystem allows us to see that the national innovation agency, i.e. Tekes in Finland, is only one possible service provider that can support the company in building innovation capabilities. Subsequently, innovation support services can also be provided by large companies as alliance partners, venture capitalists, smaller companies specializing in network orchestration, banks, cities, universities etc.

Thus, the success of building innovation capabilities in general is ultimately determined by the combined effects of the different actors. Regarding Tekes, it is therefore increasingly important to make sure that its resources are leveraged upon in order to engage other parties for the purpose of building innovation capabilities.

Assessment 7: *Tekes supports both the development of new technologies formed by individual companies as well as the orchestration of internationally engaged ecosystems. The Vigo and Value Network initiatives are important new elements in the funding portfolio, which effectively support the new emergent need to enable capability building in ecosystems.*

Recommendation 7: *Tekes should place particular emphasis on ensuring that dynamic and orchestration capabilities are properly built in the ecosystems, and that funding also supports the inclusion of necessary international elements.*

5.1.2 What is being funded by Tekes?

Tekes's allocation of its own funding through different forms of programs is one way of evaluating how the emphasis of Tekes's innovation capability building efforts has evolved. Tekes funding is distributed by a variety of means, both in the form of individually funded business research and development projects or public research projects, as well as through long term research programs. These long term programs, varying in length from 3-8 years with a majority lasting four or five years, include companies, research institutes and universities as well as public sec-

tor organizations participating in joint research projects. The selection of participating firms and individual projects within these programs is conducted separately for research organizations or universities and businesses. The selection process for businesses is an open, year-round application process wherein businesses may apply for funding for an existing, or planned, research and development project which the business believes would fit the program's general goals. Research institutes and universities, however, are selected through public research calls, often conducted annually or biennially.

In 2010 Tekes's programs accounted for an estimated 36% of all Tekes funding and, as such, serve as a reliable indicator of general trends governing the organization's funding strategy. The goals of these programs, as well as their significance as markers of Tekes's evolving priorities, are further underscored by Tekes's description of the targets of these programs as "…strategically important areas of R&D that Tekes has identified together with the business sector and researchers." The overall evolution of the allocation of Tekes funding in the form of programs during the last ten years is depicted in Figures 24–26.

The assessment of the industries or fields of commerce targeted by the programs active between the years 2000–2011 here presented shows the broad trends governing Tekes's funding decisions over this period. The assessment has cataloged the 91 programs, active during the period of 2000–2011, according to three factors: (i) target industry or field of commerce, (ii) total amount of funding awarded by Tekes; and (iii) the program's total duration. The programs were classified using six industries: (1) built environment, (2) energy & the environment, (3) forest, (4) health and wellbeing, (5) ICT, (6) metals and mechanical engineering, and the remaining programs were grouped into the final category (7) others, which includes those projects involving multiple industries or ones which did not represent any of the six "base industries". This data enabled the assessment of developments over the breadth of Tekes's programs as well as those within individual industries, providing a broad perspective on the prevailing trends.

Those industries or sectors with the most programs active over this period are: information and communication technology, and energy and the environment. However, the mere number of active programs does not necessarily reflect the sector's significance in respect of funding. To address this question it is integral to consider the total amount of funding allocated to a given sector. The following table (Table 2), categorizes the programs active within the period in question according to industry and total amount of funding, awarded by Tekes.

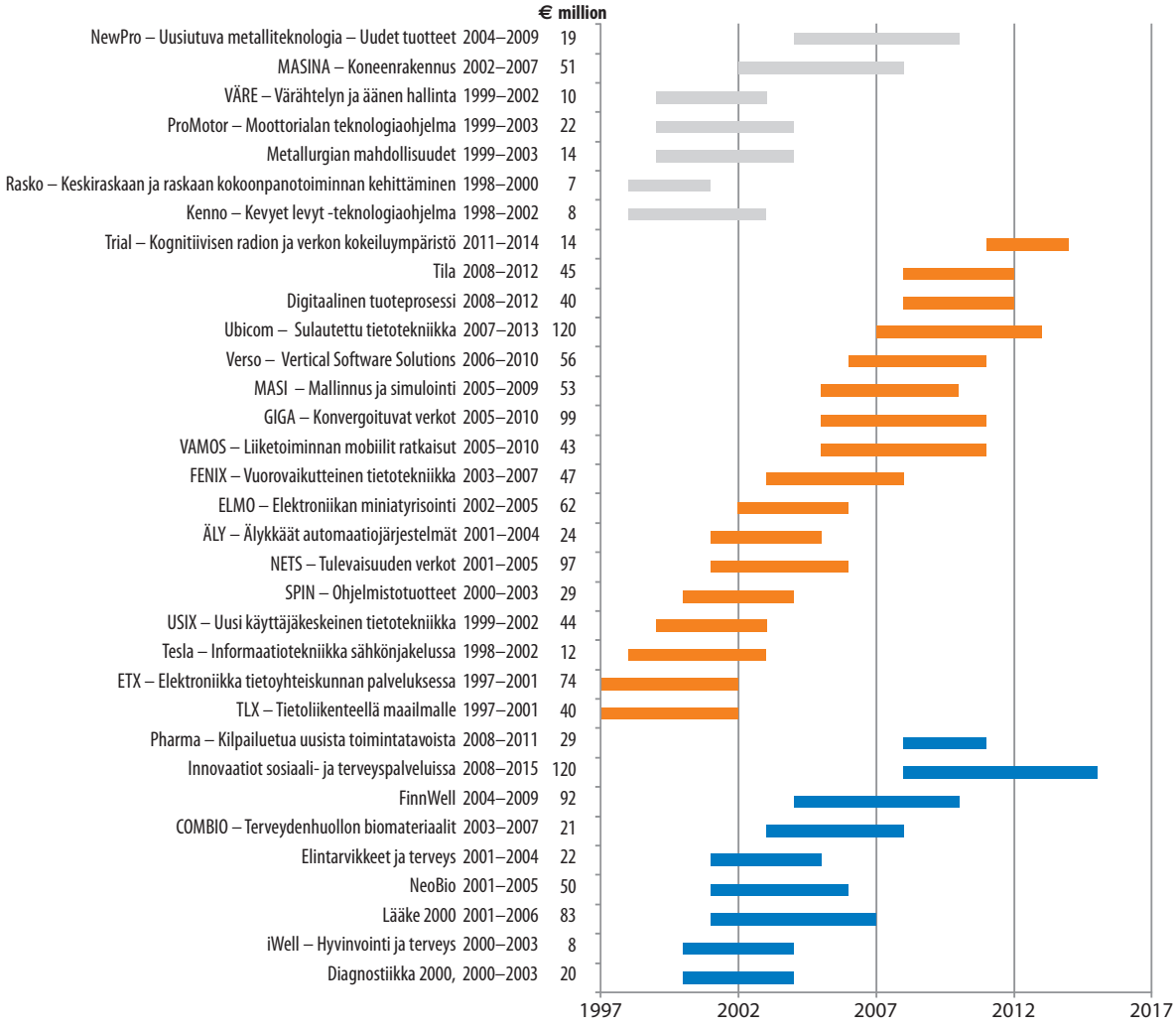
As is evident from the above table, the single largest portion of funding has been directed towards programs relating to the field of information and communication technology, having benefited from a total of €900 million. This funding has been quite evenly spread out over a total of 17 programs throughout the period in question, with the earliest program (TLX Telecommunications – Creating a Global Village) having originated in 1997 and successive programs in the industry continuing throughout the period. (see Figure 24)

The next most significant sectors have been those of health and well-being (€447 million, 9 programs) and energy and the environment (€363 million, 15 programs) (see figures 24–25). While fewer in number, individual programs within the health and well-being sector have consistently been of comparable duration and funding as those within the ICT industry and have proceeded without pause since the beginning of the iWell and Diagnostics 2000 programs in 2000. Programs within the energy and environment sector have been evenly spread out over the period in question but have been limited to more moderately budgeted programs

Table 2. Total funding awarded by Tekes and number of programs for all active programs (2000–2011) by industry
(source: Tekes, Synocus analysis)

	Built environment	Energy & environment	Forest cluster	Health & well-being	Information & communication technology	Metals and mechanical engineering	Multi-industry & other
Number of programs	9	15	5	9	17	7	29
Total funding	€192 million	€363 million	€127 million	€447 million	€900 million	€132 million	€831 million

Figure 24. The allocation of Tekes funds through programs classified as (from top to bottom): Metal products and mechanical engineering; Information and communication industry and services; and Health and well-being



and have not included single programs as sizable as some within the ICT (such as the €97 million NETS or the €99 million GIGA programs) or health and well-being sectors (the €92 million FinnWell or the €83 million Drug 2000 programs).

Total funding for the remaining three sectors: built environment, nine programs; metal products and mechanical engineering, seven programs; and forest industry, five programs, falls below €200 million each.

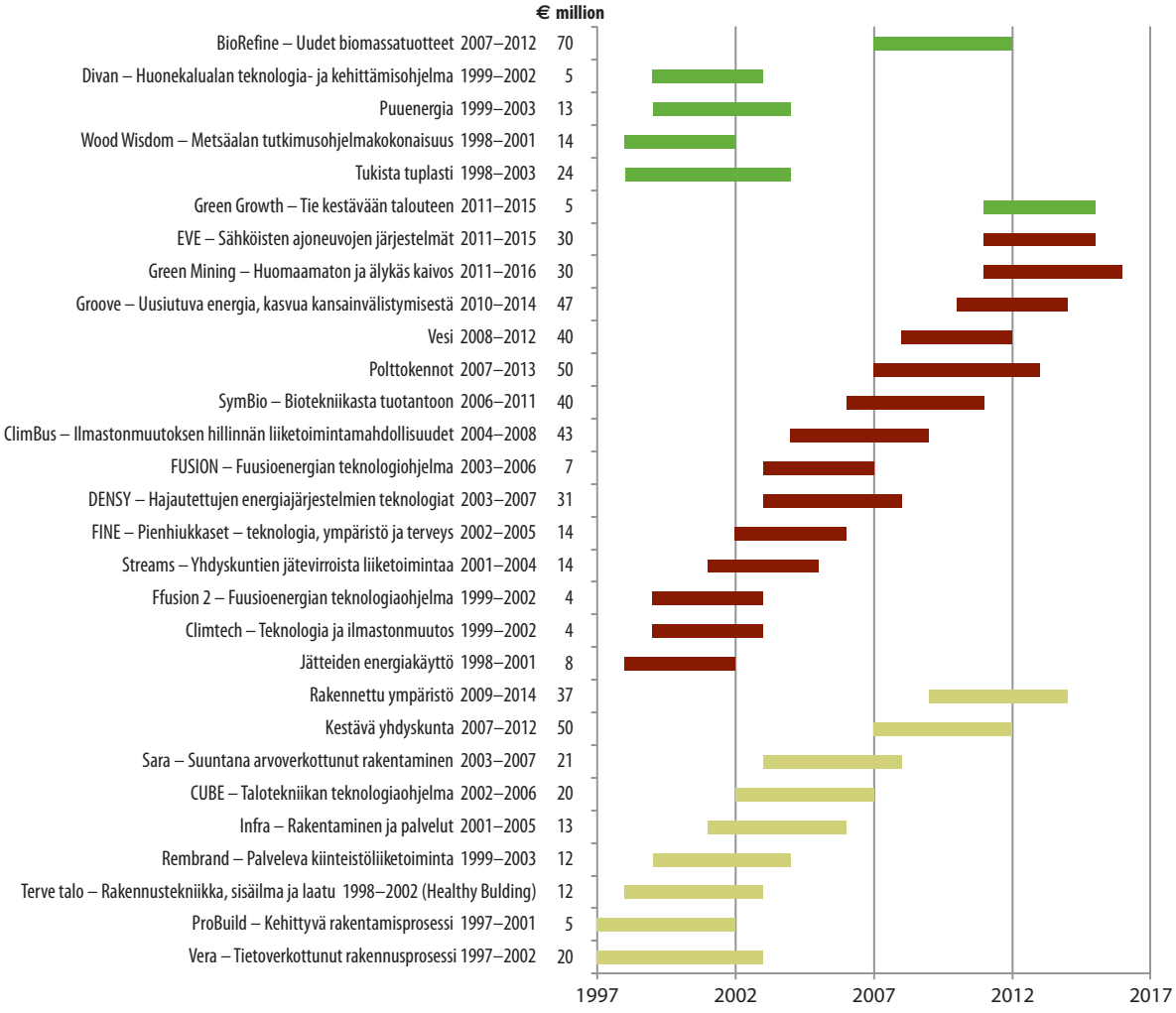
Programs within the built environment sector have generally been more modestly budgeted, with only two of the sector's most recent programs having exceeded €30 million in funding (Sustainable Community, €50 mil-

lion, and Built Environment, €37 million). While programs within this sector have continued throughout the period in question, there was a four-year gap between the initiation of new programs between 2003 and 2007.

Funding of the seven programs active within the metal products and mechanical engineering sector has followed much the same pattern as those in the built environment sector, with only one single program exceeding €30 million (MASINA at €51 million). However, programs within the metals and mechanical engineering sector have been less evenly dispersed than those within other sectors, with five of the seven programs having originated before 2000 and no ongoing programs dedicated solely to the sector in 2012.

The forest sector, traditionally considered one of Finland's legacy clusters, has received not only the least amount of total funding over this period but also the smallest number of dedicated programs. Furthermore, four of the sector's five programs were conducted between 1998 and 2005, all falling under €30 million in total funding. The opening of the BioRefine pro-

Figure 25. The allocation of Tekes funds through programs classified as (from top to bottom): Forestry; Energy and the environment; and Built environment



gram in 2007 constitutes a significant show of faith in the industry's future potential within the field of recyclable biomass, particularly considering its €70 million budget.

The remainder of the program activities between 2000 and 2011 consist of a variety of multi-industry programs (programs such as Functional Materials, €84 million, the application of which concern a variety of industries) and those which do not address any of the traditional industrial sectors (such as the service industry targeted Serve, €112 million, or the security services targeted Safety and Security, €80 million).

The assessment reveals certain broad trends regarding Tekes's funding decisions. Firstly, as already shown by the analysis of funding to individual enterprises, there has recently been a significant rise in the funding of the ICT industry, which, over the course of the preceding decade, has come to represent Tekes's most prioritized industry. The rise of the ICT industry has come at the cost of two of Finland's legacy sectors: forest and metal industries, which have experienced a comparative dearth of programs over the period. However, one also has to remember that the two SHOKs, Forestcluster and FIMECC, were among the first SHOKs to be established, and they in turn have been funded by Tekes without the allocation through Tekes-specific programs. While not directly targeted at the metal products and engineering sector, the Functional Materials program does also indicate a renewed effort on Tekes's behalf to promote the development of new, innovative directions for Finland's flagging industrial sectors.

The energy and environment sector did not attract a great deal of funding at the outset of the period in question. However, during recent years there has been a significant rise in the budgets and frequency of new programs. These new programs have notably been aimed at addressing the challenge of global warming, with programs focusing on issues such as sustainable development (Green Growth, €5 million), electromobility (EVE, €30million), or renewable energy (Groove, €47 million). This development, together with those in the forest (the above mentioned BioRefine program) and built environment (the Sustainable community program aimed at improving the sustainability and energy efficiency of buildings) sectors, seems to indicate a shift towards programs, which address grand challenges through technology.

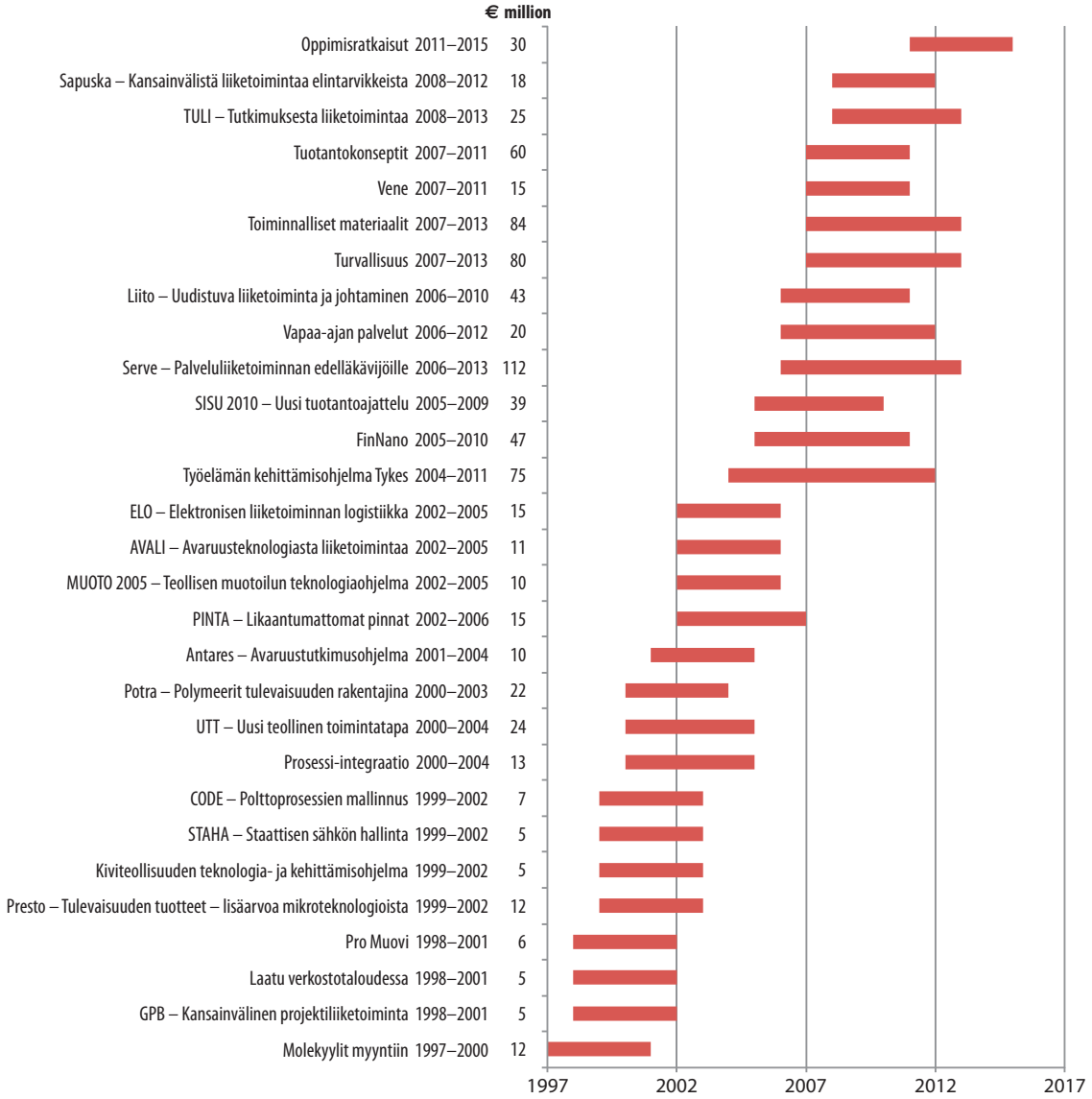
The health and well-being sector's strong presence in Tekes's activities from 2000 onwards can largely be attributed to the pharmacological industry, the development of which has been driven by such programs as the €29 million Pharma or the €83 million Drug 2000. However, recent years have seen a marked shift towards service focused innovation within the health and well-being sector, as exemplified by programs such as Innovations in Social and Healthcare Services (€120 million) or the FinnWell (€92 million) program.

The evolution of service focused innovation programs is also apparent among those programs falling into the multi-purpose, other category. These include such significant programs as the €112 million Serve program, focused on spurring innovation in customer service professions, or the Tourism and Leisure Services program (€20 million), promoting research and development within leisure services providers. This shift away from traditional technology innovation towards more concept driven forms of innovation is in line with Tekes's strategy, which was recently amended to include an emphasis on "…service-related, design, business, and social innovations." In addition to the traditional technological breakthroughs which had served as the organization's central mandate for the majority of its history.

The programs in the other category also indicate Tekes's continued support of emerging industries, a central component of the agency's strategy. Within this category are programs which reflect other non-technology driven forms of innovation emphasized in Tekes's renewed strategy, such as: business model innovation, the €43 million Liito program which developed business management practices; or design, in programs such as the €15 million Boat program, which emphasizes the significance of design in driving consumer demand and customer satisfaction.

As here indicated Tekes's published reports from completed programs provide ample evidence of four main prevailing trends governing Tekes's funding strategy. These trends, are: (i) the rise of the ICT sector, (ii) the decline of traditional industrial sectors as Tekes-targeted programs, which however is compensated for by the financing to SHOKs, (iii) increased funding to address grand challenges, and (iv) a growing support for service-related innovations as well as other less-technology focused forms of innovation. These trends are indicative of Tekes's aim to continually develop its strategy and priorities to keep pace with the fluctuating demands

Figure 26. The allocation of Tekes funds through programs classified as "Other"



placed on innovation agencies by today's increasingly globalized business world.

Assessment 8: *Building innovation capabilities demands a versatile approach, supporting both established and emergent business sectors. Tekes funding seems to provide such versatility and recent efforts have further encouraged collaboration across established industries.*

Recommendation 8: *Tekes should search for innovation opportunities in adjacent fields or "white spaces". Possible solutions include, for example: allocating part of the SHOK-funding to be available for initiatives that explicitly engage two or more SHOKs, or for Tekes to create new multidisciplinary programs.*

5.1.3 How is Tekes funding provided?

When evaluating the impact of Tekes activities relating to innovations there is a need to make a clear distinction between invention and innovation. This implies that one must, therefore, assess how the innovations have performed on the market over the longer term. In an analysis of the Sfinno database seven fields of innovation (VTT, 2012) were investigated through case studies: health promoting food, medical biomaterials, packaging and logistics, energy saving environment, self-care, ICT and computer games, and machinery and equipment. The analysis has described how the individual companies have carried out their innovation activities, and also analyzed what role Tekes has had as a provider of innovation support in each respective case.

The Sfinno database is a longitudinal database of some 4500 individual product innovations of Finnish businesses from across the Finnish economy. These innovations have been commercialized during the years 1945–2005. It is compiled on the basis of different methodologies starting mainly with so-called literature-based innovation tallying. Subsequently, complementary data on the commercializing firms has been collected from secondary sources such as business registers and the patent office. A questionnaire instrument, with coverage from 1985 on, has been used to provide more detailed information related to the innovation and innovation process. Variables include: characteristics of the innovation; the innovation process; and the firm. Information has mainly been gathered by identifying innovations from 15 industrial and professional journals. In addition, the identification process includes the annual reports of the 20 largest Finnish firms and expert interviews. The innovations have been identified by VTT's research team.

The database includes mainly product innovations introduced on the market. On the other hand, the number of identified process and service innovations is increasing due to the fact that several of these innovations are considered to be, from the seller's point of view, product innovations whereas customers perceive them as improved processes.

For an innovation to be included in the Sfinno database, it needs to fulfill four criteria. First, the innovation must have been commercialized on the market, including at least one significant sales activity. Second, the innovation is technologically novel or is a significant improvement to the firm's existing product range. Innovation development includes internal R&D, at least in some part of the development process, in order to exclude pure imitations of foreign innovations. Lastly, the innovation is developed and commercialized by a domestic firm, or a foreign affiliate registered in Finland.

The analysis by VTT attempted to (i) illustrate Tekes's role in the national innovation system, (ii) shed light on Tekes's activities in relation to company innovation processes, and (iii) provide information about the challenges and bottlenecks Tekes faces when aiming to generate impacts. The overall results of the analysis of the Sfinno survey data showed that 62% of the innovations had been supported by Tekes during the development phase, and 83% of the funding recipients evaluated Tekes's support as significant for the inception and progress of the innovation process (VTT, 2012, p. 44). The Sfinno analyses for each particular field of innovation are summarized in the following.

Health promoting food

Within the health promoting food industry the first cases presented go back to the 1970s, with Xylitol, Hyla milk and Benecol as examples of significant Finnish innovations. A characteristic of the health promoting food sector is the need for close cooperation between research and industry, as inventions are often made in universities or research organizations from where they are transferred to industry; by, for example, creating spin-offs or licensing agreements. The role of industry is to get the scientific inventions to be accepted by the market and become significant revenue generators.

In the food sector, Tekes took a proactive position in the 1990s by forcing companies, which had limited experience of collaboration, to join forces in the Renewable Food program. This program concentrated on process measuring, new technologies, and foodstuff and health. This created a positive cooperative atmosphere which led to the successive Food and Wellbeing program, launched in 2001. However, although the programs created a higher degree of cooperation, VTT notes that the programs showed that the difficult process of commercializing foodstuff inventions proved an apparent challenge in the health promoting food sector. It was obvious that both Finnish food firms as well as academia lacked the necessary skills in the internation-

alization of health promoting foodstuff and components.

Medical biomaterials

The biomaterial sector has two strong regional concentrations of firms, spinning off from universities in Turku and Tampere. The first Tekes program aimed directly at the medical biomaterials field was called COMBIO 2003–2007, which targeted small, young firms and included 22 firms and 31 academic units. The VTT report draws similar conclusions regarding this program as those regarding health promoting food: "The evaluation of the COMBIO program indicates that internationalization of the novel start-ups is difficult to achieve, therefore the exact internationalization targets were not reached." Therefore the subsequent program, Functional Materials, concentrates on building capacities by means of creating international competence networks and globally competitive value chains. VTT mentions Bioretec Oy as one example of a company which has been an active participant in many Tekes programs. However, even if this company has been considered to have made several innovations, its sales have remained stagnant over the period 2008–2010, confirming the difficulty of achieving international success in this sector. An important finding from this sector is that future technological development trends in medical biomaterials require even deeper multidisciplinary collaboration. Co-operation, in the form of consortiums, is a key success factor to become internationally competitive requiring seamless cooperation between a variety of different actors. Tekes has in the biomaterial sector established Finnish-Japanese collaboration and also serves as coordinator of the Eurotrans-Bio initiative, which has been set up to support transnational R&D and innovation.

Packaging and logistics

The forest and paper industry, and its transportation needs, have served as important drivers for development of logistics competencies in Finland. In the packaging area Tekes has had, particularly at an earlier stage, an active role in networking and supporting development of co-operation between companies, universities and research institutes. With time, Tekes's role as an active actor facilitating networking has, however, become less visible while its role as funder of R&D has remained more or less stable. One company that has been an active participant in the packaging and logistics sector has been UPM. It has actively developed RFID tags and inlays since the mid-1990s. Not only UPM itself benefitted from the company's early interest in development and application of RFID in the mid-1990s. As a large export oriented company, UPM lent the emerging technology area credibility and its example encouraged many other companies to explore potential applications of RFID in their businesses. This contributed to the growth of the RFID community in Finland over time resulting in the formation of the non-profit association, RFID Lab Finland, which unites the key actors developing RFID technology. Tekes programs have not only provided funding but also a platform for Finnish actors to network domestically and internationally as well as to tap into to international expertise in the RFID field.

Energy saving environment

Since the 1990s Tekes has carried out 33 energy technology programs and 10 environmental programs. The first energy programs were launched as early as the late 1980s by the Ministry of Trade and Industry, and were continued by Tekes beginning in 1995, when the execution of technology programs was moved from the ministry to Tekes. One example of a more comprehensive effort by the Finnish government to promote new innovations in the energy sector was the way the government promoted the development of high environmental-quality engine petrol, carried out by Neste Oy. Due to the regulated market in the late 1990s large global oil companies were unable to make the investments necessary for reformulated products. Additionally, competitors also criticized the protectionism given by tax relief granted to the CityFutura petrol developed by Neste. The tax relief was provided on environmental grounds, and made it possible to introduce the product to the market at an accelerated pace. Focus on environmentally friendly energy also spurred entrepreneurial activities, and St1, founded in the mid-1990s, is now one of the pioneers in bioethanol fuels. St1 is chaired by Mika Anttonen, who started his career at Neste, but left to become an independent oil trader in 1996. He has subsequently developed an energy business, whose vision is to be the leading producer and seller of CO_2-aware energy. The company researches and develops economically viable, environmentally sustainable energy solutions and has seven bioethanol plants in Finland and more than 1000 gasoline stations in Finland, Sweden and Norway.

Self-care

In the field of self-care the first initiative came from abroad as early as 1992: Wagner CCM was the first formulation of a chronic care model which set the center's patients and relatives in the actor network of care. The model identified the essential elements of a health care system encouraging high-quality chronic disease care. Some elements of this model were soon adopted in Finland, but as a whole the model is only currently being introduced to Finnish primary care. Subsequently the Finnish government has adopted several national development plans for social and health care services. Since the early 2000s the plans have also embraced promotion of self-care.

Tekes has systematically supported the creation of self-care services through several consecutive funding programs. Tekes's role has changed gradually. In its first programs, Tekes took an active role in the development of health technology expertise and competence for Finland. Recently, however, Tekes has extended its role to promoting system innovation in health and welfare. But, here too, achieving breakthrough innovations has proven a considerable challenge. For instance: Nokia developed a support system for diabetes self-care (Wellmate), and Polar Electro introduced a support system for hypertension self-care. However, neither of these innovations ultimately proved successful. Achieving commercial success has proven difficult despite a product's technology being reviewed positively. This has also been evident in the case of the Vivago "WristCare" system which was the world's first commercially available security device monitoring the user's well-being 24 hours a day. VTT notices that the markets for self-care products have turned out to be very difficult, and the programs have failed to produce the desired results. The technologies have not been adopted as widely as expected. As a consequence of these results, a recent program, Innovation in Social and Healthcare Services, has been launched. This program focuses on financing innovative consortiums led by public organizations and emphasizing customer orientation and customer needs. This program's scope includes social services and systems. However, this program has also been criticized because of the difficulties in coordinating actions with the other public organizations involved in the social and healthcare services sectors. It is now evident that success will require strong collaboration between a multitude of institutions, and a better clarification of their roles is necessary.

ICT and computer games

One industry in which Finland has achieved international success is computer games. Major international successes have included: Habbo Hotel, Alan Wake, and Angry Birds. The poorly developed private venture capital market in Finland has been seen as one of the weakest links in the Finnish innovation system. The foreign interest in new start-ups in the gaming industry has, however, somewhat improved this situation lately.

Tekes has targeted start-ups in the ICT sectors for quite some time. In 2007, a benchmark study outlined the challenges faced by start-ups and identified: a risk-averse attitude; low level of competences to steer growth businesses; low number of research based start-ups; and too few serial entrepreneurs with global experience, as some of the main reasons for the relatively low portion of rapidly growing new firms in Finland. After the benchmark study, The Ministry of Employment and the Economy (TEM) together with Tekes introduced three new instruments and activities to support high-growth and start-up firms. The funding for young innovative companies (NIY) offers support for those aiming at fast international growth by granting funding in phases based on the growth of the firm. The Vigo Accelerator program is a joint effort by TEM, Tekes and Finnvera to meet the urgent demand for early venture investments for start-ups by establishing venturing cooperation between public and private financers. A third program, Kasvuväylä ("Growth Path"), aiming at giving guidance to find suitable partners during the entirety of a young firm's international growth process, was launched and tested among 21 ICT-companies in 2011. These new instruments are new services to firms, and deviate from Tekes's traditional role, i.e. R&D support, as they focus on supporting the commercialization phase of innovation.

Machinery and equipment

Tekes has been closely involved in the development of mechanical engineering industries and related research fields over the last decades in close cooperation with companies, industry associations and the research community. This has been fertile ground, as Finnish mechanical engineering companies have proved to be flexible and open-minded towards new methods and

technologies. Absence of a 'rigid tradition' has also supported diffusion and utilization of production methods, processes and technologies across companies. Tekes has actively tried to introduce new operational methods, processes, networking models and technologies in mechanical engineering. Companies which have participated actively in these programs include Rocla and Cargotec. Rocla executed almost 30 Tekes co-funded projects between 2001 and 2009. By using both enterprise R&D projects and participating in Tekes programs such as the Masina and Serve programs, Rocla has evolved into one of the most innovative warehouse truck producers in the world. Thanks to its modular service concept Rocla was named Finland's most successful solution provider of 2011 by the Association of Finnish Technical Traders. Cargotec in turn has actively participated in Tekes programs when developing its Kalmar straddle carrier product, which has become a successful concept for effectively bringing containers to and from the ship's side at megaports. The role of Tekes in these cases has been broadened to also contain softer and intangible objectives like service and work life development and business development.

Assessment 9: *Tekes has been a significant contributor to the majority of recent Finnish innovations. Still, there are a number of industries that have experienced challenges in making real commercial breakthroughs. Tekes has recognized this, and a number of recent new instruments have been introduced to more actively support scaling up and fast growth.*

Recommendation 9: *Tekes should be prepared to provide stronger support for those firms that have displayed a clearly identified potential to grow significantly. Working together with other important innovation support providers such as public and private investors should also be prioritized.*

5.2 Tekes's influence on the generation of intellectual capital

Here the key questions are:

- In what ways has Tekes influenced the generation of intellectual capital and the development of intellectual investments in Finland?
- What kind of phenomena and national level indicators can be identified?
- How are intellectual capital and innovation capabilities built and developed?
- What kinds of indicators can be utilized in measuring the influence on a national level?
- What are the effects of Tekes's activities on the generation of innovation capabilities in Finland?
- Where does Tekes stand compared to other similar institutions?

As intellectual capital comprises human, structural and relational capital, and our framework for analysis (chapter 2) creates the link between intellectual capital and the presented seven categories of capabilities we will here approach Tekes's influence on the generation of intellectual capital through the operationalization of capabilities, and use information gathered directly from Tekes's customers as a way to address the above questions. As the comparisons with other countries showed, other innovation agencies do not explicitly address the issue of capability building, and subsequently we have had to develop, in this impact study, the tools for addressing these questions.

When analyzing what particular venues exist for companies to grow and prosper two major logics were identified in chapter 2: technology push and market pull. By using the examples of Exel and One Way Sport we operationalized these two logics in the form of the capability maps, highlighting that technology push emphasizes two key capabilities: generative capabilities and customer relationship capabilities, whereas the market pull company needs three key capabilities: absorptive capacity, offering design or conceptualization, and integrative capabilities or networking. The former logic we call Generator logic, and the latter Orchestrator logic.

In order to evaluate the extent to which the two logics are visible in the Finnish innovation context; a sample of ten Finnish innovation cases were selected for in-depth study. The resulting case descriptions are presented in Appendix 3. These cases were selected, while fairly randomly, to represent different industries, different regions within Finland, and also a combination of old established firms and younger companies.

Given the study's focus on understanding how innovation capabilities are built, the capability development paths of the investigated companies were of particular interest. Among the aspects addressed herein were: the subject companies' entrance into the observed fields of innovation, and the particular outcomes of the innovation

Figure 27. Summarizing the case analyses (source: Synocus analysis)

Company	Technology	Product	Solutions	Ecosystems
CVOPS	1980s–1990s			
Valio	1980s >>	**2001–**		
Nexstim	1990s >>	**2003–**		
Sintrol		**2007–**	<< 1990s	
GreenStream			2001–	
Tekla		**1998–**	<< 1980s	2011–
Normet		1970s >>	**2007–**	2007–
The Switch		2000s >>	**2006–**	2006–
Beneq	2000s >>		2005–	**2005–**
Smartum			1995–	**1995–**

activities. The analyses revealed that the innovation activities could be related to four different development areas within the companies: technology, products, solutions and ecosystems. The focus of the case study subjects' innovation activities in these respective areas, and how this focus has, over time, shifted is illustrated in Figure 27.

Four of the cases have a strong technology foundation. The Virtual Operating System (CVOPS) was developed by VTT to support Nokia and other ICT hardware and software providers. This platform evolved, based on the Finprit program established in 1983, into a national platform. This platform served the Finnish ICT-cluster in a multitude of ways until the early 2000s.

Valio in turn had started to use chromatographic technology for its HY-LA products in the 1980s, and in 1990, this technology was applied to the development of lactose-free milk. The first product was launched in 2001.

Nexstim has become a leader in navigating stimulation of the brain providing a new standard for pre-operative functional brain mapping prior to neurosurgery for tumor resection or epilepsy. The scientific discoveries upon which Nexstim is based were made in the early 1990s. More than €30 million of external capital has been invested in the company to date. Annual sales are now, approximately, €2 million.

Beneq has its roots in Nokia, and was spun off in 2005. Unlike the other technology based cases, Beneq decided to opt for an orchestrated business model, and outsource the actual manufacturing of its thin film manufacturing equipment to third parties from the very outset. In this respect Beneq is also a good example of a successful orchestrator, as the company has experienced rapid growth and in 2010 its turnover passed the €10 million mark.

Industries with strict product regulations require, by definition, a strong product focus within the companies. Food, pharmaceuticals and medical equipment are examples of such industries. Therefore it is quite natural that both Valio's and Nexstim's focus is on the products.

Interestingly enough, Tekla and Sintrol both began as general solution providers, Tekla as a provider of technical calculations for Finnish engineering companies in the 1960s and Sintrol as a technical trader, but both have later shifted to a stronger product focus. In 1998 Tekla decided to focus on software for building information modeling and energy/infrastructure applications. Sintrol, in turn, launched in 2007 its first product, a dust monitor. For both Tekla and Sintrol the gradual narrowing of focus on a specific product has been seen as a means to international expansion, as the broader solution provision strategy has been difficult to expand internationally.

The development paths of Normet and The Switch have been the exact opposite of those of Tekla and Sintrol. As mechanical engineering companies, their roots are firmly in products. However, their internationalization efforts have required a broadening of the offering. They must now provide services and customized offerings in an increasingly solution driven market. Normet has focused on two customer segments, underground mining and tunneling. For these segments the offering has been strengthened both through internal development projects to build new capabilities and through acquisitions. The Switch in turn has aggressively penetrated the rapidly growing market for wind-turbines in China. In its striving to become a viable orchestrator, The Switch attempted a merger with the American AMSC, which however was terminated due to AMSC's difficulties in gaining the required financ-

ing. None the less, The Switch is moving forward with its networked business model, even if the product offering remains narrower as compared to the expanded offering which this deal would have made possible.

As Figure 27 illustrates, the majority of the case companies apply a solutions strategy. Given that GreenStream Network is a relatively young company providing green asset management solutions, it has yet to display any indications of considering adjustment of its solutions strategy. As mentioned earlier, two other service companies, Tekla and Sintrol, have decided to develop a more product driven approach for their internationalization.

The solutions provided by both Normet and The Switch include a strong proprietary product, but also a network of partners, both upstream and downstream. However, both companies are relatively small in a global comparison, and they have to be adaptive and agile to succeed in markets where the main actors are significantly bigger companies. Therefore they must align within those ecosystems that surround their most important customers, and then, if possible, establish some smaller complementary ecosystems of their own.

Two companies, Beneq and Smartum, have both been successful in establishing a strategy based on ecosystem orchestration.

Beneq is a globally recognized supplier of production and research equipment for advanced thin film coatings. This position is supported by active interactions with leading customers, manufacturing companies, and research institutions. Beneq then combines the strengths of its partner network to provide the customer with a unique technological and equipment manufacturing solution.

Smartum, also a successful orchestrator, operates in an entirely separate field. It is a domestic Finnish market leader in offering voucher payment solutions for employee benefits such as sport and cultural activities. This platform knowledge has lately been expanded to serve the public health care sector. Smartum is now also actively involved in the development of voucher-based payment solutions for homecare, child-care, and dental health services.

In light of the analysis of the case companies there seems to be support for the interpretation that the Orchestrator logic is becoming relatively more important compared to the Generator logic. To verify whether this is the case a survey among leading actors in the Finnish innovation community was carried out to identify which innovation support activities they considered most important. A total of 35 individuals were interviewed (the list of interviewees is in Appendix 4). Each respondent was asked to list the ten most important innovation support activities out of the total list of 45 activities. The responses to this survey are summarized in Figure 28.

As can be seen from Figure 28, the top innovation support elements are:

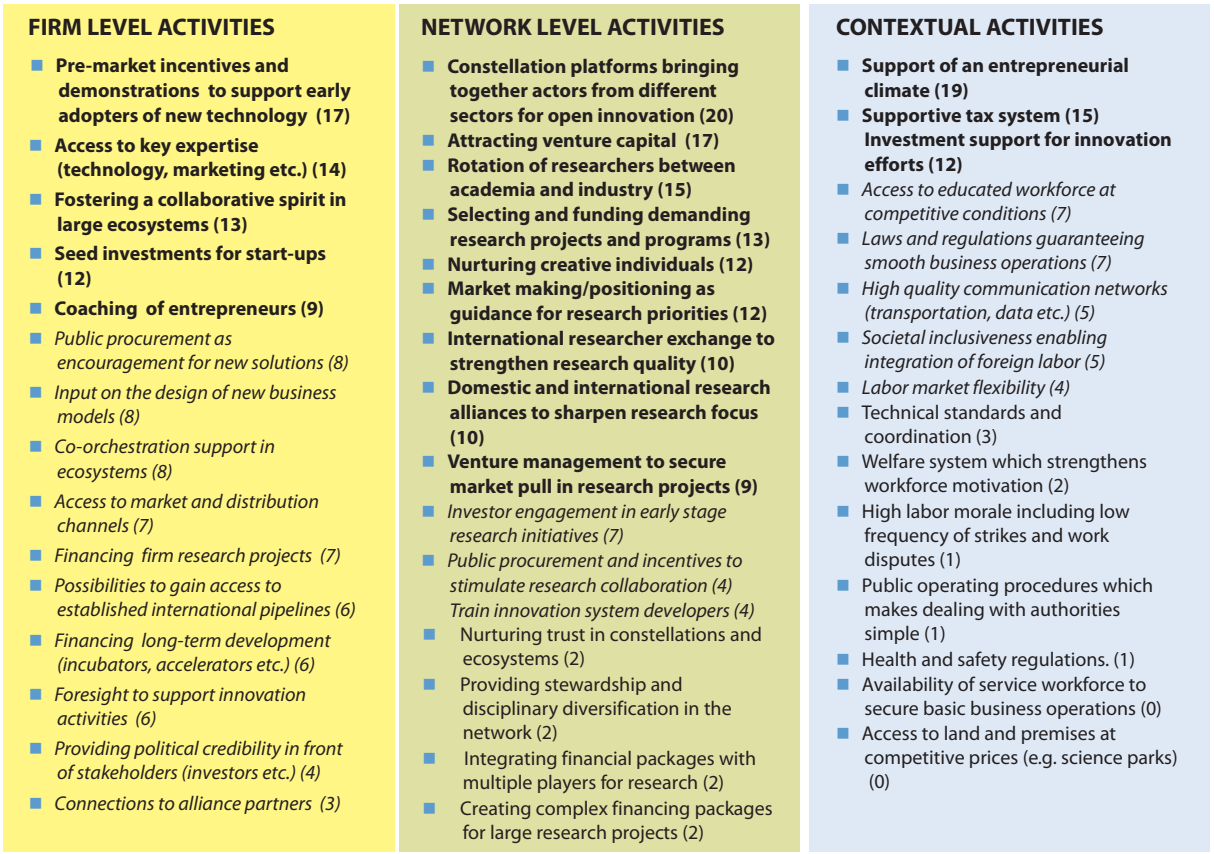
- Constellation platforms bringing together actors from different sectors for open innovation
- Support of an entrepreneurial climate
- Attracting venture capital
- Pre-market incentives and demonstrations to support early adopters of new technology
- Supportive tax system
- Rotation of researchers between academia and industry
- Access to key expertise (technology, marketing, etc.)
- Fostering a collaborative spirit in large ecosystems
- Selecting and funding demanding research projects and programs

The above list indicates that the innovation support activities considered most important involve a multitude of actors within the innovation system. However, it also confirms the utmost significance of establishing entrepreneurial processes that bring together different players to jointly conduct innovation activities (coming in at #1) followed closely by the need to support an entrepreneurial climate.

The focus on both generator companies and orchestrators has subsequently found support both in the case analyses and in the survey conducted among key individuals active in the Finnish innovation system.

Thus, as for the implications on Tekes's operations: two different types of innovation support capabilities are necessary in response: supporting generators and supporting orchestrators. The focus of the generator is on the generative capability, and the achievements of such a company can be measured in the form of tangible outputs. As most Finnish companies still operate according to the industrial logic, measuring how strong their generative capabilities are is the appropriate means of assessing their innovation capacity. In this evaluation, more traditional innovation measures can be used, such as patents, revenue growth, new product introductions etc.

Figure 28. Prioritized innovation support activities (source: Synocus research)



The orchestrators, however, are more difficult to assess. Their success is determined by how successful they are at combining the resources of their partners, but also on how well they can capture the created added-value. As the example of One Way Sport illustrated, it was able to put Exel out of the sports business. However, in light of the financial results of One Way Sport it is doubtful whether the company has created any significant value in the Finnish context, even if its business model was innovative when it was launched (see Table 3). In this respect One Way Sport may, in many ways from a national perspective, be seen as a capability destroying phenomenon.

This problem of game-changing innovations leading to process efficiency also highlights the risk that a disruptive innovation may indeed change the competitive dynamics and permanently shift the resource use into low-cost countries. Subsequently, this has an irreversible effect on the dynamics of the ecosystem once the transformation has taken place. Therefore the most critical capability here is the transforma-

Table 3. One Way Sport; financial development (source: www.finder.fi)

One Way Sport Oy	2005/12	2006/12	2007/12	2008/12	2009/12
Company turnover (1000 EUR)	3285	3028	2905	2771	4013
Operating profit (1000 EUR)	-12	-4	32	-304	40
Number of employees	8	8	11	N/A	10

tive one: how well does the new business model (i) serve the needs of the customers, (ii) appeal to those ecosystem partners involved, and (iii) present the orchestrator with an opportunity to capture a significant amount of the new value created. In the case of One Way Sport the first two criteria seem to have been well met, but it is less evident that proper value capturing has taken place.

Despite the fact that there are still very few pure orchestrating business models active in Finland, both our literature study and the case analyses confirm that orchestration support is an increasingly important form of innovation support that Tekes has to integrate into its repertoire of innovation tools. The examples of Beneq and Smartum also verify that when successfully applied, an ecosystem orchestration strategy can provide the basis for rapid growth and good profitability. These cases also illustrate that there are various ways that Tekes can support this form of development. Smartum has received support for the very traditional development of a software application for the management of the benefits of its voucher program. Beneq has received much more versatile support, and has also cooperated with Tekes in the development of the new Young Innovative Enterprise program. This program, as well as the Vigo program and the Value Networks program show that Tekes is proactively developing new instruments to more forcefully support orchestrators as well.

Analyzes of the orchestrators' development paths also reveals that the orchestrating firms, Beneq, Smartum, but also Tekla and The Switch, persistently upgraded their own capability portfolios, not only in respect of generative capabilities, but also in relation to their conceptualizing, networking and leadership capabilities. Leveraging upon this to strengthen the part of the ecosystem that is active in Finland should become a key objective for Tekes when financing companies that are actively orchestrating ecosystems.

The Beneq and Tekla cases also give light to a pattern of active interaction with universities and research institutes outside Finland. This phenomenon must also be taken into consideration in Tekes's development of support instruments for orchestrators. How can Tekes best extend its support to include international expertise, when this knowledge is crucial for the innovation to become internationally successful?

Beneq illustrates, in many ways, the multi-faceted role Tekes can take in the development of an orchestrator capability set. On one hand Tekes has provided financing and steering in research and partnership development. Hence Beneq has also strengthened its own resource integration capabilities, which in turn has benefitted the larger ecosystem surrounding Beneq both in Finland and internationally. Tekes has also, through its programs, supported the co-development of new offerings/business models and thus helped to strengthen Beneq's generative and transformative capabilities.

Tekla shows how Tekes's support first enabled the development of new basic technologies and offerings that fulfilled a customer need later enabling the development of new managerial capabilities to engage with global ecosystems active in the industry. In the case of Tekla this meant the merger with Trimble Corporation, which should be expected to further strengthen the possibilities for Finnish know-how to find global demand.

Both Smartum and GreenStream have successfully exploited changes taking place in respect of regulation. For GreenStream this meant changes relating to the trade of carbon emission rights, and for Smartum the introduction of tax incentives for companies promoting well-being at work. In these cases, Tekes has provided important stimulus for the renewal of the respective company's business model to actively provide new solutions for the opportunities created through these changes in regulation.

Assessment 10: *In light of conducted case studies and surveys among Finnish companies, ecosystem orchestration is becoming increasingly important for spurring the evolution of innovations. For Finnish companies this entails a need to integrate with international networks, and either look for positions to become orchestrators or become skilled in complementing the leading firms orchestrating the ecosystems. In such situations, Tekes can support the explicit development of those capabilities necessary to ensure a firm's success in its role as a member of an orchestrated ecosystem.*

Recommendation 10: *In its foresight activities, Tekes should continue to identify changes e.g. in regulations making the emergence of new ecosystems more probable, and then proactively support companies leveraging upon these opportunities. As ecosystems are of an increasingly global nature, Tekes should look for further ways to selectively support innovation building activities that take place outside Finland, but, nonetheless, have significant possibilities to strengthen the Finnish companies and researchers active within these ecosystems.*

5.3 Continuous monitoring and measurement of Tekes's performance

Here the key questions are:

- What types of methods for continuous monitoring and measurement can be identified to support Tekes's management in the target areas related to capabilities for innovation activities?
- What are Tekes's needs for continuous monitoring and measurement?
- What methods of monitoring and measurement exist?
- From the different monitoring and measurement methods, which would be best suited to Tekes?

Tekes continually assesses each individual project that has been funded. Based on questionnaires Tekes has developed an assessment model to evaluate the impact of Tekes-funded projects. These assessments have utilized the General Logic Model for Innovation Intermediaries (developed by Professor Margaret Dalziel, Universtiy of Ottawa) to illustrate how Tekes has influenced the creation of new capabilities and added value both within the enterprises, to which it has awarded funding, as well as in the surrounding community or network.

The assessment material is based on an analysis of a series of final reports and multiple-choice, customer surveys conducted over the course of the last ten years. The surveys have been conducted three years after the conclusion of the project in question. The database consists of assessments from more than 1500 respondents from research institutions, nearly 1500 responses from SMEs and over 500 from large companies.

The reasoning behind the statistical analysis is that, through a combination of Tekes's input and the inherent characteristics of the funded enterprise, a set of activities will be undertaken, in the form of the project, but also in related activities that will result in certain outputs. These outputs in turn may lead to a broader impact on the society (spill-over effects). The analysis employed regression analysis in order to identify how these inputs, activities and output and impact effects cluster into aggregated factors.

In the analyses the aggregated factors or clusters have been given names, aimed at illustrating the compound attributes of the respective factors. The aggregated factors are presented in the summarizing figures in order of weight, with the most important factors at the top.

The main role of the analyses presented in the following is to:

1. identify hypotheses relating to the building of innovation capabilities, and
2. compare the results from the assessments with the findings from the case analyses conducted in this impact study.

The following consists of a discussion of the findings from the respective categories of respondents.

Universities and research institutes

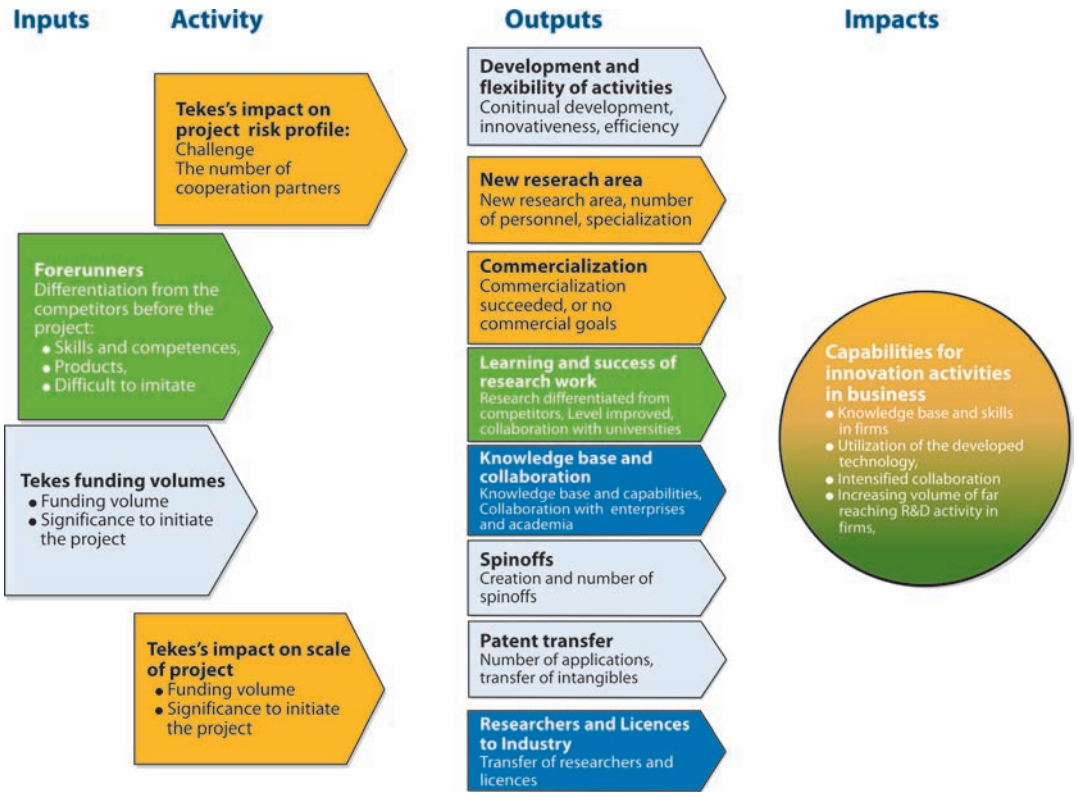
The clustering of factors in assessments made by representatives from universities and research institutes results in three main factors: Entrepreneurship; Competitiveness and regional development; and Capabilities for innovation activities in business. For the purpose of this impact study the third factor is the one of particular interest. The regression analysis has highlighted the underlying factors leading to the establishing of capabilities in business in accordance with the following figure:

As indicated in the above figure there are two main development scenarios.

The first relates to projects initiated by research teams which are already forerunners in their own fields from the outset. Tekes support will enable such teams to learn and progress more effectively. Engaging with the firms further improves this learning process, creating new knowledge and skills within the participating companies as well. This type of scenario corresponds well to the type of research projects carried out by Beneq, which seeks to interact with the leading researchers in the particular field of interest. One could assume that in this type of development the participants are already quite well aware of the potential commercial benefits that the project could bring about, and subsequently the capability building efforts can be aligned with these commercial goals. This approach may be dubbed the "Core Competence path". This path is also successful on an international level, and creates spill-over effects that strengthen the national knowledge base.

The other path illustrates activities which are more explorative in their nature. Here Tekes's role is more proactive, and owing to insights provided by Tekes, the scope and scale of the project may be adjusted, in addition to also introducing new partners to the project. Such more explorative projects may also identify new research areas, or alternatively they will be able to enter commercialization. This seems to support the "white spaces" -idea, by means of

Figure 29. Clustering of impact factors for public research institutions



new insights regarding unforeseen commercialization opportunities introduced by new these new partners. This then also confirms the importance of providing the constellation platforms for open innovation. This path can be called the "White Spaces Path". Furthermore, the conditions for the "White Spaces Path" also proved conducive for establishing an increased degree of entrepreneurship. By increasing the level of challenge experienced by participants, and the number of cooperation partners, Tekes has also been able to foster additional entrepreneurial activity.

When entering a new research area, there are two types of successful cases: the above described "White Spaces Path", and an alternative path where the research is focused solely on addressing some particularly challenging scientific problem. An example of such a research case was the initial phase in the research leading to the formation of Nexstim. While research at the Helsinki University Central Hospital began during the first half of the 1990s, the company was not formed until the year 2000. Also of significance in this early research was a high degree of international cooperation. This in turn resulted in the build-up of a very strong research unit in this particular area, which is now a core area of expertise in the Department of Biomedical Engineering and Computational Science at Aalto University.

It is noteworthy that these early stages of challenge-driven research do not include any commercialization ambitions. In fact, a premature focus on commercialization may imply that the necessary iterative research process, leading to a significant breakthrough in the research field, will not be given enough time and efforts. This is confirmed by the over 1500 responses tracking the development paths of various types of research projects.

A third correlation that emerged from the assessments is that between the combination of: the project-internal knowledge base; and collaboration with the transfer of researchers or licenses to the industry, and the positive impact on

the building of innovation capabilities within the companies. However, this was not systematically connected to any specific instrument or activity organized by Tekes, but was an independent phenomenon identified in those projects that were assessed to successfully have built innovation capabilities in companies.

SMEs

Among SMEs the three main aggregated factors were: Renewal of the economy; Development and organizational activity and productivity in wide enterprise networks; and Growth and internationalization of (adolescent) enterprises.

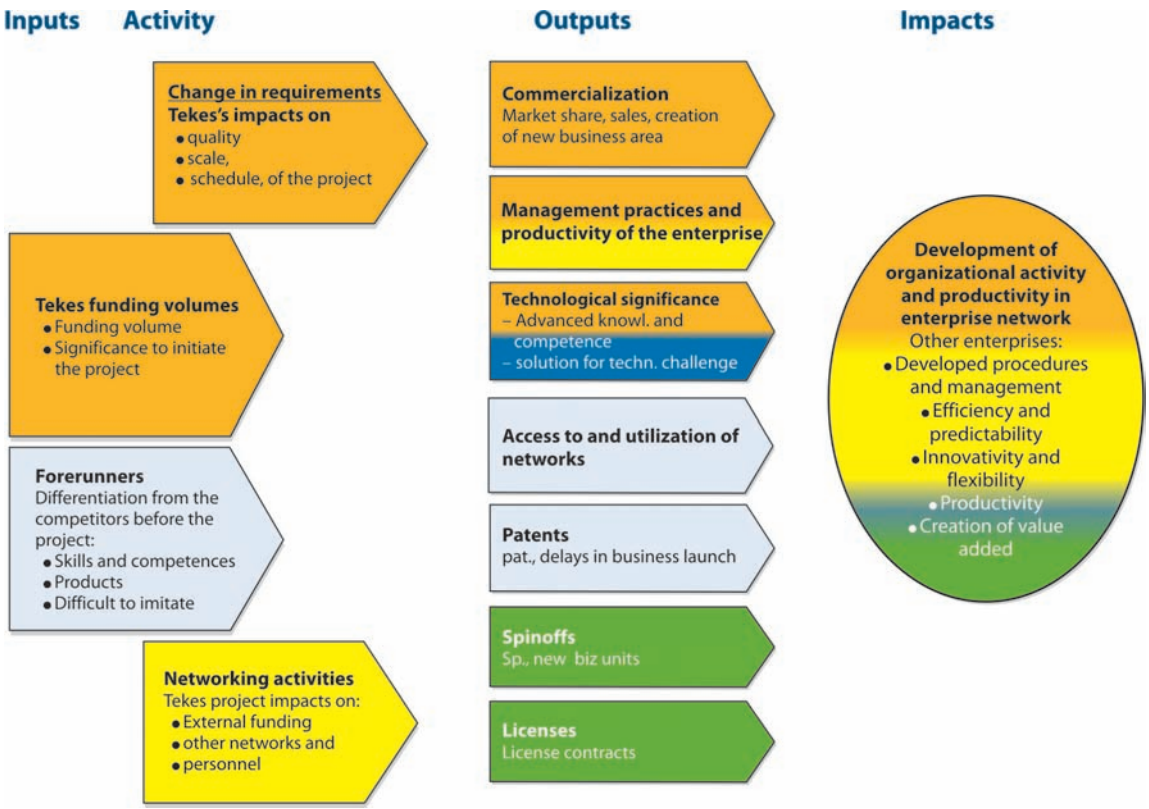
A key development path contributing to the Development and organizational activity and productivity in wide enterprise networks is the volume of Tekes's funding, which in turn makes possible more ambitious requirements as well as improvement of the outcome's quality. Demanding more from the project increases commercialization and leads to growth and internationalization. This in turn also has a positive impact on the management practices within the participating firms. This path is, however, difficult to distinguish as unique, as the funding volume can be assumed to create more activity, but doesn't, as such, reveal what the ultimate financial outcome is.

The other central path emphasizes Tekes's establishing of networking activities, and thus bringing together new sources of expertise, which, in turn, also affects the management practices of the participants. This path we can call the "Network Building Path".

Forerunners are here identified to increase their technological skills and other competences as well. This, in turn, has contributed to the development of organizational activities and productivity in enterprise networks. In the context of an SME this means that the SME has the possibility to interact with forerunners providing access to advanced knowledge and technologies. This path could be called the "Apprenticeship Path".

Additionally, a fourth phenomenon can be identified among SMEs:

Figure 30. Clustering of impact factors for SMEs



spinoffs and license contracts serve as catalysts for additional organizational activity and the formation of new networks. However, this takes place without Tekes's systematic intervention.

Research has found that, in seeking to identify the role which forerunners play, they are rarely identified as drivers for networking. This is an important observation, as the common view of "local anchors" seems to assume that a participating forerunner will, by definition, spur local collaboration. While, here it would appear likely that the leading company, the forerunner, tries, rather, to protect its own interests, and uses the core competence itself in its international activities, and is not particularly interested in promoting such networking.

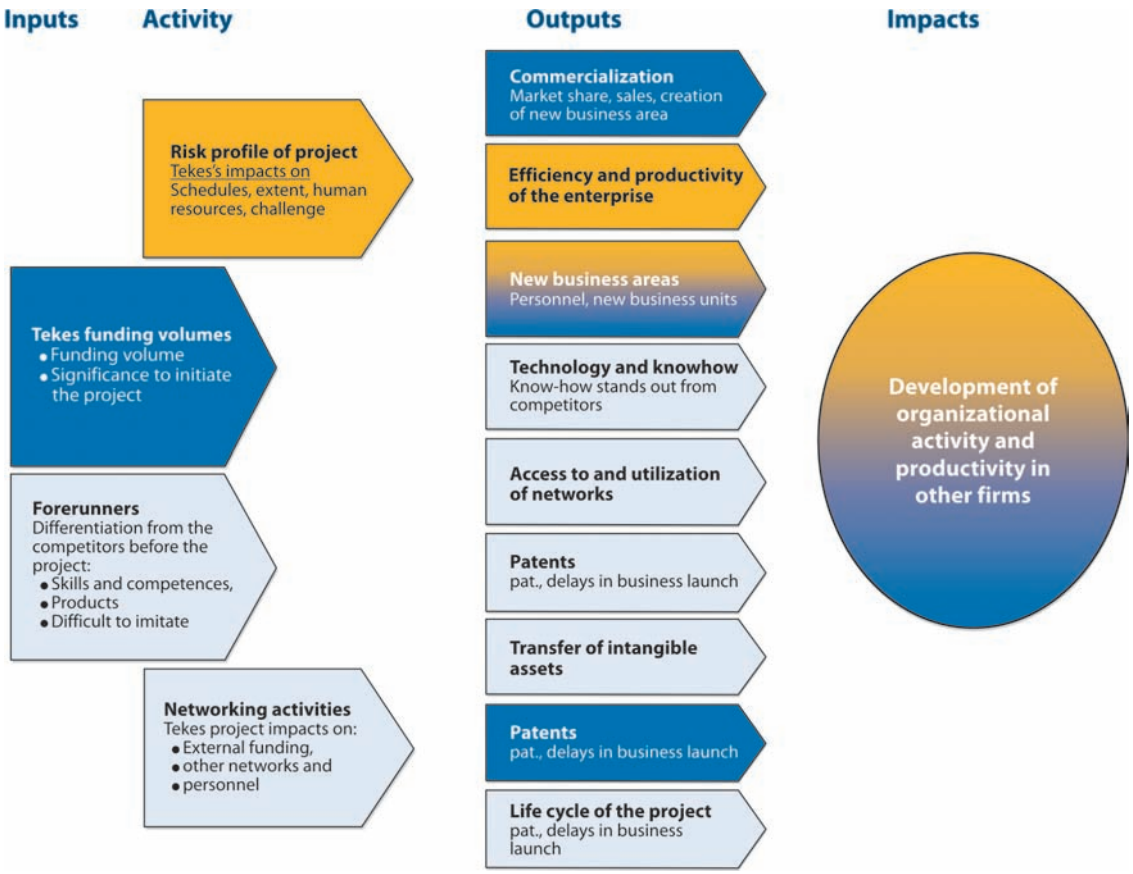
The development paths for SMEs are illustrated in Figure 30.

Large enterprises

Clustering of factors among large enterprises did not explicitly reveal capability building to be a significant outcome in the assessments. Here the key factors are: Development of organizational activity and productivity in other firms; Employment and regional development; and Broad clustering, subcontracting and R&D networks. The main factor, Development of organizational activity, was mainly driven by Tekes increasing the project's level of ambition by influencing project schedules, project scope, and the human resources involved. The ambitious project has generated new processes which have increased the efficiency and productivity of large enterprises. This has had a positive impact on the development of organizational activities and, thus, productivity, coming as a result of other firms adopting the knowledge from their large counterparts. This could be described as the "Challenge-driven Path".

Another means of increasing organizational activity among other firms

Figure 31. Clustering of impact factors for large enterprises



is by increasing funding volumes, which naturally leads to increased activity. This in turn may then also lead to faster commercialization, being linked with efficient intellectual property management, and an increased number of patent applications. This path could be called the "Commercialization Boost Path".

The emergence of the Development of organizational activity -impact factor is illustrated in Figure 31.

Assessment 11: *The analysis of the assessment information shows that this database has great potential to provide additional depth in understanding how successful innovation paths emerge.*

Recommendation 11: *Tekes should expand the assessments to also include background information regarding respondents to use the impact data to develop more detailed explanations for how projects succeed depending on industry, network type, competitive challenge etc.*

Further needs for assessments and monitoring

The assessments conducted by Tekes have identified several paths that show correlation between subjective, ex-post evaluations of the broader impacts of projects carried out. However, these assessments do not reveal possible differences between industries, and between old, established and new companies. The effects of international competition on the companies are also missing from the analysis.

However, in spite of the lack of background information relating to the individual organizations providing the assessments, the findings are well in line with the other empirical results of this impact study. The identified paths can also be identified among the investigated case companies.

As Tekes has to be able to serve a multitude of enterprises, in various industries, and at different stages in their company's evolution, it is of utmost importance for Tekes to continuously gather feedback regarding the impact of its innovation support activities. Therefore it is necessary to complement the present assessment process with more regular feedback regarding ongoing project activities, which should use the same "information architecture" to enable comparisons across different measurements. In such monitoring activities one should look for more fine-tuned measures, so that the industrial and company specific attributes would also be monitored. This would then also enable shorter feedback loops, which would be particularly important in situations where the introduction of new instruments and tools will be necessary to keep up with the fast pace of change in the market place.

This would then also address the question of how the monitoring process and its results may more efficiently impact Tekes's means of evaluating who should receive funding. Another important question regards the requirements dictated for a company's behavior within a project in qualifying for different types of support. For example what incentives should be used to promote a higher degree of international networking, and how will the follow up of this be arranged?

What the assessments have clearly shown is that both competence as such (i.e. generative capabilities) and the networking of a multitude of actors (i.e. orchestration capabilities) have a positive impact on the capability building efforts within the innovation system. How to monitor the success of different types of network arrangements requires more detailed investigation.

Assessment 12: *Tekes needs to complement its existing ex-post assessment system with additional monitoring activities in order to be able to more quickly test and verify the effects of various new instruments and tools, and also be able to abandon those that are not successful.*

Recommendation 12: *Tekes should make efforts to better understand the relative suitability of various instruments and tools in relation to different industries, network types, and firms in different stages of their development cycle. Especially when promoting innovation in networks it is important to recognize that there are various forms of networks, and how well they perform should be evaluated separately for each category.*

5.4 The new imperatives for innovation support

This impact study has addressed the issue of innovation capability building from several different perspectives.

First, a conceptual framework was developed to provide a sound theoretical foundation for the discussion regarding the definition of innovation capabilities, what possible activities can be carried out to support the building of innovation capabilities, and how a national agency like Tekes can successfully take part in these support activities.

Second, a comparative study of the national innovation systems of Denmark, Ireland, Sweden and Switzerland was conducted. The purpose of this study was to collect insights about how these countries have built their innovation systems to secure the necessary innovation capability building.

Third, ten in-depth case studies of successful innovations were carried out, focusing upon understanding how the capability portfolios of the enterprises evolved over time, and what role Tekes has had in this development.

Fourth, a very intensive collaborative relationship with the project and steering groups was secured to provide guidance for the study. Additionally, two half-day workshops with the steering group representatives were carried out in December 2011 and January 2012 to validate preliminary findings, and receive final guidance for the completion of the study.

Fifth, based on feedback from the project and steering groups a survey of 35 key individuals in the Finnish innovation system was conducted in order to identify which specific innovation support activities are particularly important when considering how to build innovation capabilities in Finland to secure a competitive Finnish national innovation system.

Sixth, feedback, gathered by Tekes, on completed Tekes projects, over the period 2005–2010, was evaluated. This included almost 3000 responses to a standardized questionnaire.

All these activities have been carried out simultaneously, with the Synocus team coordinating and distributing intermediate project reports to all the individuals involved in this project, including the external experts Phil Cooke, Arne Eriksson and Tomi Laamanen, who have all read and commented on earlier versions of the project report.

The results of all these activities have shown a high degree of convergence. The first set of observations relate to the overall changes in competition in the markets. The second set of observations relate to the implications of changes in the marketplace have on the innovation processes. The third observation, and the key finding for this report, relate to the implications this has for a national innovation agency, such as Tekes.

Changes in competitive patterns

The Finnish innovation field has undergone a transformation in the period from the 1980s to today. Its roots are in a strong anchoring in domestic technologies, and strong local clusters. This provided Finland with a good position in respect of these technologies. This advantage is evidenced by such examples as those of; CVOPS providing a basis for Nokia's competitiveness, and the scientific work supporting Valio's development of lactose-free milk.

In the late 1990s, the beginnings of a shift, due to globalization and driven by companies, could be identified. Companies that had, hitherto, been successful with their technology–based, domestic innovation strategy had to reconsider these strategies when internationalizing. The large companies already operating internationally also had to reconsider their positions due to the changing international field of competition. To cope with these changes we can observe two major trends. On one hand large product based companies, e.g. in mechanical engineering, have decided to enlarge the scope of their offering and increasingly focus on the development of more versatile service-offerings and solutions. This entails a trend towards increasingly outsourcing part of their manufacturing activities to third parties, thereby increasing their flexibility to better respond to the needs of individual customers. Of the case studies presented in this report, Normet and The Switch provide ample illustration of this development. On the other hand, domestic companies, which have achieved success in Finland with a relatively broad offering, have found it necessary to focus on more narrow products in order to succeed internationally. Tekla and Sintrol represent this category. Thus evidence can now be found to support both those internationalization strategies that broaden the offering as well as those which narrow the offering. The strategy best suited to a given situation depends on the industrial structure, and the strengths of the company in question. Thus, these product and solutions based strategies exist increasingly in parallel.

The 2000s saw the rise of two important new phenomena which have further increased the complexity of global competition: open innovation, and the focus on addressing global grand challenges. These two phenomena, both in combination as well as individually, have increased the significance of ecosystems as the unit of analysis when studying the emergence of innovations. For Finland, Apple's rise to become the leader in mobile communications served as a harsh lesson in how orchestrated ecosystems can radically change the competitive landscape. In addition to restructuring the field of competition in major industries, such as mobile communications, such orchestrated ecosystems can also exist in more narrow niches, as illustrated by the examples of One Way Sport and Smartum. It is also possible to combine a strong technology- and product based foundation with the additional benefit of becoming the orchestrator of the ecosystem, thereby enabling com-

plex and customized solutions, as evidenced by companies such as Beneq.

However, concurrent with the above developments, cost competition has also increased. The Internet has, by providing access to global information in any industry, increased transparency, and driven the rapid growth of Asian companies as viable global competitors has forced large Finnish MNCs to also shift activities to lower-cost locations to cope with the price pressures.

Changes in innovation patterns

The need to, simultaneously, be cost competitive and develop new, more attractive value propositions has forced many companies to open up their innovation processes. Procter & Gamble has been a global trendsetter here, instituting a corporate policy requiring more than half of all new product and technology innovations to come from outside the company.

However, open innovation is not a remedy for all innovation challenges. Apple has been used as an example of a company which has only opened up certain parts of its innovation activities for the outside world, and maintains very tight control of the core architectural elements, which makes it very difficult for competitors to copy Apple's strategy. This, again, illustrates how dependent identification of the type of innovation strategy best suited to a company's needs is on the industry and on the inherent strengths of the company.

Climate change and the financial crisis have forced many organizations, both public and private, to be more selective in setting strategic goals. These conditions have also prompted a renewed consideration of the notion of time in the actions of strategic planners: What do we need to do to survive in the short term? Where should we put our bets regarding longer term opportunities?

When dealing with increased uncertainty, both relating to the competitive context (as described earlier) as well as the impact of various contextual changes regarding concerns of time, an increasingly frequent complaint among enterprises is that the "visibility is poor". For example: Nokia, when announcing its 2011 results, didn't provide any guidance to the market in respect of 2012 earnings. Similar challenges meet political decision makers. They must deal with time-critical challenges relating to the financial crisis, but at the same time they have to bring forward undertakings aiming to improve the efficiency of public sector organizations, and deal with problems such as an ageing population and increased pressure to combat climate change.

Organizations have reacted in three ways when trying to cope with this increased complexity.

The first immediate reaction has been to reduce the funding for innovation. The logic behind this is quite straight forward: as we don't know in what direction the world is moving, undertaking innovation efforts guaranteed to be successful proves to be too difficult.

Secondly, enterprises increasingly frequently prefer to make their innovation bets in a gradual, stage-by-stage fashion, with clear process gates and increasing security that the investment will pay off in pace with increasing the bets. This also explains the growing interest for pilots and demonstrations, as such initiatives have a role of making the intermediate results visible and transparent, thus also making it easier for outside observers to evaluate whether the innovation has a good chance of being successful or not.

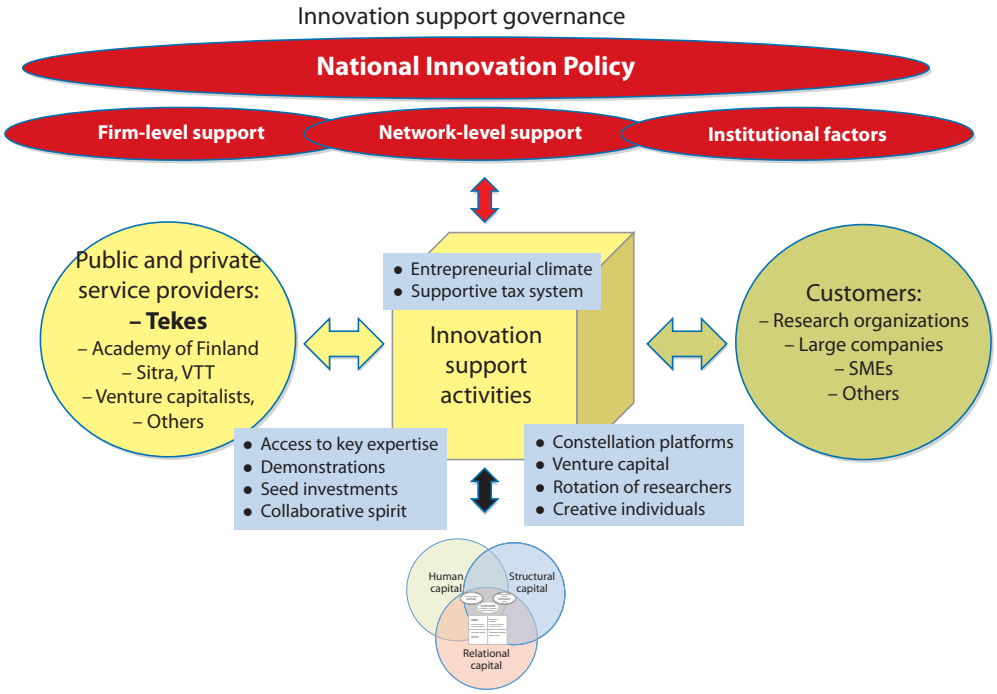
Thirdly, innovations are increasingly undertaken as collaborative projects, either within orchestrated ecosystems, such as those within the mobile telecommunications industry, with three ecosystems competing against each other: Nokia/Microsoft, Apple and Android/Google; or in the form of emergent constellations, such as the different public-private demonstration projects in the field of electric vehicles and urban transport, with the EVE-program financed by Tekes serving as an illustration.

The new role of national innovation agencies

This impact study has verified that at the same time as the scope of factors affecting innovation decisions taken by companies have been expanded; the expectations regarding the role of the public sector have also grown. For public innovation agencies, this poses quite a challenge, as efficiency requirements also tend to reduce the amount of resources that governments are willing to allocate for innovation activities. The key question is then: how to achieve more with less? From the government's perspective the answer has to be through stronger coordination and alignment of various policies that will nurture innovation. This means that there has to be a broad governance perspective on innovation, which is illustrated in Figure 32.

Figure 32 presents a simplified version of the conceptual framework developed at the beginning of the process, and highlights those innovation support activities that this study revealed as most critical during the final survey.

Figure 32. The requirements for the Finnish national innovation system



This is not to argue that these ten activities are exactly the ten most important factors the Finnish innovation system should address, but ones which provide a very strong indication of the aggregate view on what type of innovation system is necessary in Finland today to ensure that the key enterprises feel comfortable in continuing to direct innovation investments into Finland.

As Figure 32 indicates, there are four factors that with a strong appeal to the individual companies: access to expertise when needed, the possibility to benefit from public incentives for demonstrations, seed investments in the start-up phase, and the maintenance of a collaborative spirit in joint innovation initiatives. Four other factors are more visible on the network level: access to constellations platforms that will support open innovation, the general attractiveness of Finland for venture capitalists, the principles for rotation of researchers between academia and industry, and how the innovation system nurtures creative individuals. The two final factors, how an entrepreneurial climate in general is fostered in Finland, and how the tax system can spur innovations are contextual factors that are affected by laws, regulations and political leadership.

The list of requirements resulting from this study shows that the concept of "broad-based innovation" seems to be a suitable fit with the expectations of the Finnish innovation sector. These results have enabled the development of a fine-grained operationalization of what this broad-base innovation approach should actually contain. This in turn reveals that it is quite obvious that those support activities necessary to ensure the success of the Finnish innovation system cannot be delegated to Tekes alone, but must be provided through a strong national collaboration involving different public agencies as well as the private sector. This also, increasingly, demands international support, as the venture capital and expertise requirements are not confined to only resources available within Finnish borders. This poses significant challenges for Tekes. On one hand, Tekes is often expected to take the intellectual

lead when political decisions have to be made for the future direction of Finnish research policy. However, at the same time Tekes should be a neutral financer, following the innovation policy guidelines provided by the government.

To resolve this dilemma, Finland would require a stronger integration of the various public actors in the field of innovation, especially when one considers that the issues of entrepreneurial climate and a supportive tax system also figure heavily on the list of factors necessary to ensure a successful, national innovation policy. Based on this we suggest our first new imperative for the Finnish innovation policy:

Imperative 1: *In an increasingly globalized world a national innovation policy requires coherent integration in order for the country to be internationally attractive for top experts and venture capital. The Finnish government needs to take this into consideration when forming an integrated national innovation and industrial policy. The new innovation policy should simultaneously emphasize firm-level and network-level activities as well as making certain that institutional factors supporting an entrepreneurial climate and forming innovation-friendly tax policies are also taken into consideration.*

Historically, Tekes has proven its capacity to provide the foresight capabilities essential to initiating necessary new initiatives in the Finnish innovation system. Additionally, Tekes could also strongly support the forming of the agenda, define the guidelines for how to bring various actors together, and co-orchestrate the collaboration within the knowledge community building the next generation of the Finnish innovation system.

The single most important innovation support activity raised in the survey was the need to establish constellation platforms bringing together actors from different sectors for open innovation. This implies that besides the need for Tekes to proactively promote a broad innovation policy agenda in Finland, Tekes itself must also increase its support of different forms of networks, and provide platforms that will enable more efficient collaboration.

Innovation collaboration can be carried out in three distinct phases of the innovation process: (i) the exploration phase, (ii) the important phase of testing and experimenting, often supported by demonstration initiatives, and (iii) in the final commercialization or exploitation phase. Each phase is characterized by different forms of collaboration processes. For Tekes this means that there is a need to develop different forms of support for these different phases in the innovation process. Of particular importance is the question of how the knowledge management activities can be supported by an innovation agency like Tekes. The three phases of exploration, demonstration, and exploitation need therefore to receive particular attention when Tekes increases its support of innovation in networks.

Research sponsored by Synocus has shown that leadership and relationships within the network are closely interlinked. In the exploration phase agile and flexible relationships must be encouraged for the innovation process to proceed in an adaptive fashion. During the demonstration phase, collaborative leadership is required to support the necessary self-organization. Once commercialization is at hand, stricter coordination will be necessary to meet deadlines and shift focus towards operational excellence (Wallin, G., 2011).

In ecosystems there is a need to integrate the internal knowledge management activities with those conducted externally. Subsequently, Tekes must not only consider the interests of the individual firms initially committed to joint innovation activities, but should also facilitate the further expansion of the network. Tekes should encourage, in particular, the continuous search for new opportunities, as companies easily become preoccupied by their exploitation activities, whereby they gradually become incapable of renewing themselves. This leads to the second imperative for the innovation policy:

Imperative 2: *Tekes should encourage open innovation and the conducting of an increasing amount of innovation activities within networks and ecosystems. When supporting such activities, Tekes needs to particularly steer the knowledge management activities, as the self-interests of the individual participating companies may be in conflict with the broader national interests represented by Tekes. There is also a need to distinguish between the different phases of collaboration in innovation: exploration, demonstration, and exploitation. Each phase will require its own specific form of knowledge management support process.*

6

Conclusions

The surroundings in which Tekes operates are undergoing significant changes. These changes can be summarized in three points:

- The innovation market is increasingly shifting from technologies and products towards solutions and ecosystems.
- A coherent national innovation policy is necessary to support the formation of the various elements required to ensure the emergence of successful collaborative arrangements.
- Tekes has identified the changes taking place, and has initiated a series of actions required to support innovation capability building in this rapidly changing business environment. Supporting the important knowledge management processes in various forms of innovation networks is a significant opportunity for Tekes to add new value.

Based on general feedback gathered from leading individuals in the Finnish innovation system during the study, the general impression of Tekes was of an institution with a solid understanding of what is required to bring the Finnish innovation system to the next level. There is also strong evidence that the innovation support activities which Tekes has undertaken throughout its history, have kept pace with the changing requirements of the business environment.

This impact study has addressed the issue of how an innovation agency can support innovation capability building on two levels. On the one hand, it has looked at the innovation system on the national level, and made comparisons with other successful nations. On the other hand, it has looked at the innovation support needed from the viewpoint of the individual organization, and the individual decision makers within key organizations.

Much of the contemporary discussion concerning the building of a successful innovation system has been focused on the intermediary level, looking at regional innovation hubs, and analyzing the actors in various geographical locations. The results of this study seem to support the view that the innovation system cannot be designed as one uniform machine, serving all types of industries and all forms of companies and institutions. Instead it is crucial that the overall contextual factors, such as: tax policies; level of education; and the general attitude to entrepreneurship, are competitive. Once these conditions are met, the national innovation agency's support activities must be fine-tuned to the specific needs of individual industries and innovative companies. A common element across all this is that innovations are increasingly emerging in networks. Recent efforts by Tekes to establish new programs such as the Value Networks program show that the same conclusions have already been made within Tekes, and the necessary steps are taken to meet these new demands.

This impact study has provided detailed, concrete suggestions that can be used by Tekes when looking for ways to further improve its performance. What this report has not addressed is the efficiency of the innovation capability building activities. The important question is, of course, could the same results have been achieved with fewer resources? This question was raised especially when comparing the funding of the Swiss innovation system, but it has been outside the scope of this study to try to provide a clear answer to this question.

In the interest of providing a summary of the results, the report will conclude by repeating the assessments and recommendations made throughout this report. The first five assessments and recommendations presented in this report were derived from the country comparison data (see Appendix 2 for the individual country analyses and chapter 4 for the conclusions). The assessments and recommendations based on the international comparisons are as follows:

Assessment 1: *The Finnish innovation system has its own historical background and appears to have a good balance of university and corporate support.*

Recommendation 1: *Tekes's role in the future is to remain flexible in adjusting its policies in order to meet the increasingly global requirements facing innovation actors.*

Assessment 2: *The emphasis of innovation support is shifting from clusters to networks, and towards orchestrated ecosystems in particular. The Swiss example of NCCRs and VINNOVA's Challenge-driven Innovation show the tendency to support longer-term development efforts which have a clear identifiable organization as the orchestrator of the ecosystem.*

Recommendation 2: *Tekes should consider the experiences from these methods of supporting the development of ecosystems when determining how to provide orchestration support e.g. in its Value Networks program.*

Assessment 3: *There are clear indications that trust and confidence are important factors strengthening the innovation process.*

Recommendation 3: *Tekes could use the experiences from abroad when broadening its assessment process. Increased active monitoring of the innovation activities as they proceed should be emphasized. In networks there is also a need to be able to monitor how relationships and trust are nurtured through Tekes's activities.*

Assessment 4: *Innovation capability building requires the convergence of a multitude of factors.*

Recommendation 4: *Tekes should track and evaluate which particular innovation support activities are effective in what situations, and to support different innovation needs. On one hand, there is a need for longer term programs, orchestrated by leading organizations, and, on the other hand for fair, user-friendly and flexible instruments for start-ups and SMEs. Tekes should also emphasize the transfer of knowledge through individuals, by e.g. encouraging PhDs to alter between academia and industry.*

Assessment 5: *The international comparison of innovation agencies in Sweden, Denmark, Switzerland and Ireland suggests that the leading innovation agencies have broadly similar strategies and objectives. Compared to these other countries Finland is less internationalized, and this has to be taken into consideration by Tekes.*

Recommendation 5: *As international networks are becoming the main form for successful innovations, Tekes should focus on the individuals and the organizational capabilities needed to build and foster international networks.*

Having assessed the operations of other innovation agencies, the recipients of Tekes funding were analyzed next. In evaluating the allocation of funding, the study assessed how different types of companies (large and small) have been funded as well as the funding of network activities (see section 5.1.1). This resulted in the following two assessments and recommendations.

Assessment 6: *The distribution of funds by Tekes during 2004-2010 has evolved in a way which encourages collaboration between various actors in the innovation system. This varied composition seems to accurately reflect the larger changes in the business context. Tekes's ambition of being both adaptive and pro-active seems to have proved successful. The correlation of recent successes in the ICT sector and the relative increase in the sector's funding is a positive indicator.*

Recommendation 6: *Tekes should continue its independent evaluation of the larger business context, and balance its funding portfolio for the purpose of long term support of innovation, avoiding becoming focused on short term opportunistic trends affecting the public discussion*

Assessment 7: *Tekes supports both the development of new technologies formed by individual companies as well as the orchestration of internationally engaged ecosystems. The Vigo and Value Network initiatives are important new elements in the funding portfolio, which effectively support the new emergent need to enable capability building in ecosystems.*

Recommendation 7: *Tekes should place particular emphasis on ensuring that dynamic and orchestration capabilities are properly built in the ecosystems, and that funding also supports the inclusion of necessary international elements.*

It is also relevant to consider what has been funded by Tekes. The analysis of this dimension (section 5.1.2) used the findings from the evaluations of programs financed between 2000 and 2011, amounting to a total of 91 research programs. This analysis resulted in the following assessment and recommendation.

Assessment 8: *Building innovation capabilities demands a versatile approach, supporting both established and emergent business sectors. Tekes funding seems to provide such versatility and recent efforts have further encouraged collaboration across established industries.*

Recommendation 8: *Tekes should search for innovation opportunities in adjacent fields or "white spaces". Possible solutions include, for example: allocating part of the SHOK-funding to be available for initiatives that explicitly engage two or more SHOKs, or for Tekes to create new multidisciplinary programs.*

This study then evaluated the recently published VTT analysis of the Sfinno database regarding the building of innovation capabilities. The following conclusion emerged from this analysis:

Assessment 9: *Tekes has been a significant contributor to the majority of recent Finnish innovations. Still, there are a number of industries that have experienced challenges in making real commercial breakthroughs. Tekes has recognized this, and a number of recent new instruments have been introduced to more actively support scaling up and fast growth.*

Recommendation 9: *Tekes should be prepared to provide stronger support for those firms that have displayed a clearly identified potential to grow significantly. Working together with other important innovation support providers such as public and private investors should also be prioritized.*

The majority of the activities carried out in this impact study were related to collecting information from companies and other organizations active in the Finnish innovation field. This information has primarily been gathered by means of two approaches: conducting in-depth case studies of 10 successful innovation projects (see Appendix 3), and interviewing individuals active in the Finnish innovation system (see list of interviewees in Appendix 4). The role of these activities has been to identify more specifically, precisely what is needed to align innovation support activities with present needs. This has led to the following assessment and recommendation based upon the syntheses (presented in section 5.2):

Assessment 10: *In light of conducted case studies and surveys among Finnish companies, ecosystem orchestration is becoming increasingly important for spurring the evolution of innovations. For Finnish companies this entails a need to integrate with international networks, and either look for positions to become orchestrators or become skilled in complementing the leading firms orchestrating the ecosystems. In such situations, Tekes can support the explicit development of those capabilities necessary to ensure a firm's success in its role as a member of an orchestrated ecosystem.*

Recommendation 10: *In its foresight activities, Tekes should continue to identify changes e.g. in regulations making the emergence of new ecosystems more probable, and then proactively support companies leveraging upon these opportunities. As ecosystems are of an increasingly global nature, Tekes should look for further ways to selectively support innovation building activities that take place outside Finland, but, nonetheless, have significant possibilities to strengthen the Finnish companies and researchers active within these ecosystems.*

Tekes also has an extensive internal assessment process, which has generated over 3000 ex-post evaluations of conducted projects. This material has been evaluated and analyzed (section 5.3) resulting in two assessments and recommendations:

Assessment 11: *The analysis of the assessment information shows that this database has great potential to provide additional depth in understanding how successful innovation paths emerge.*

Recommendation 11: *Tekes should expand the assessments to also include background information regarding respondents to use the impact data to develop more detailed explanations for how projects succeed depending on industry, network type, competitive challenge etc.*

Assessment 12: *Tekes needs to complement its existing ex-post assessment system with additional monitoring activities in order to be able to more quickly test and verify the effects of various new instruments and tools, and also be able to abandon those that are not successful.*

Recommendation 12: *Tekes should make efforts to better understand the relative suitability of various instruments and tools in relation to different industries, network types, and firms in different stages of their development cycle. Especially when promoting innovation in networks it is important to recognize that there are various forms of networks, and how well they perform should be evaluated separately for each category.*

Finally we identified two imperatives for ensuring the future success of the Finnish innovation policy. On one hand there are on-going changes in the market place, which require Tekes to be continuously proactive in renewing the Finnish innovation system. On the other hand, Tekes must also reconsider its own position as an increasing amount of innovation takes place in networks, which also opens up new opportunities for Tekes to take a more active role, especially in respect of knowledge management in networks (see section 5.4).

Imperative 1: *In an increasingly globalized world a national innovation policy requires coherent integration in order for the country to be internationally attractive for top experts and venture capital. The Finnish government needs to take this into consideration when forming an integrated national innovation and industrial policy. The new innovation policy should simultaneously emphasize firm-level and network-level activities as well as making*

certain that institutional factors supporting an entrepreneurial climate and forming innovation-friendly tax policies are also taken into consideration.

Historically, Tekes has proven its capacity to provide the foresight capabilities essential to initiating necessary new initiatives in the Finnish innovation system. Additionally, Tekes could also strongly support the forming of the agenda, define the guidelines for how to bring various actors together, and co-orchestrate the collaboration within the knowledge community building the next generation of the Finnish innovation system.

Imperative 2: *Tekes should encourage open innovation and the conducting of an increasing amount of innovation activities within networks and ecosystems. When supporting such activities, Tekes needs to particularly steer the knowledge management activities, as the self-interests of the individual participating companies may be in conflict with the broader national interests represented by Tekes. There is also a need to distinguish between the different phases of collaboration in innovation: exploration, demonstration, and exploitation. Each phase will require its own specific form of knowledge management support process.*

Finally, it is also important to note that innovation capabilities must be perceived of as dynamic entities. What is required from the Finnish innovation system today is different from what was required ten years ago, and will be different from what will be required ten years ahead. However, what is important to note is that a general trend can be identified from all these recommendations: The field of innovation is moving more towards the direction of solutions and ecosystems, with less emphasis placed on technologies and individual products. This doesn't mean that these are not important; indeed they will still be the spearheads through which commercial success will be built. However, the analyses conducted in this study support the view that by more actively promoting innovations which take place in networks, and which encourage the formation of ecosystems, Tekes can once again provide guidance, which will spur the Finnish innovation system towards international success.

References

Ashby, W.R. 1956. An Introduction to Cybernetics. Chapman and Hall.

Baldwin, C. Y., Woodard, C.J. 2008. The architecture of platforms: A unified view. Harvard Business School Working Paper 09-034.

Christensen, C.M. 1997. The Innovators Dilemma: When New Technologies Cause Great Firms to Fail. Harvard Business School Press.

Cooke, P. 2009. The Economic Geography of Knowledge Flow Hierarchies Among Internationally Networked Medical Bioclusters: A Scientometric Analysis. Tijdschrift voor economishce en sociale geografie, 100, 236-249.

Cooke, P., de Laurentis, C., MacNeill, S. and Collinge, C. 2010. Platforms of innovation; dynamics of new industrial knowledge flows. Cheltenham: Edward Elgar.

Cooke, P., Eriksson, A. 2011. White Spaces Innovation in Sweden Innovation policy for exploring the adjacent possible. Vinnova Report 2011:10.

Crozier, M. 1989. L'entreprise à l'écoute. Paris: InterEditions.

Dahl Fitjar, R, Rodríques-Pose A. 2011. When local interaction does not suffice: Sources of firm innovation in urban Norway. Instituto Madrileño de Estudios Avanzados (IMDEA) Ciencias Sociales, Working Paper 2011/05.

Day, G.S. and Schoemaker, P.J.H., 2011. Innovating in uncertain markets: 10 lessons for green technologies. MIT Sloan Management Review, 52(4) pp.37-45.

Denrell, J., Fang, C., Winter, S.G. 2003. The economics of strategic opportunity. Strategic Management Journal 24: 977–990.

Dierickx, I., Cool, K. 1989. Asset stock accumulation and sustainability of competitive advantage. Management Science 35(12): 1504-1511.

Eisenhardt, K. M., Martin, J. A. 2000. Dynamic capabilities: what are they? Strategic Management Journal, 21(10-11), 1105–21.

Forrester, J.W. 1961. Industrial Dynamics. MIT Press.

Forrester, J.W. 1968. Principles of Systems. MIT Press.

Freeman, S. 1984. Strategic Management. Pitman.

de Geus, A. 1997. The Living Company. Harvard Business School Press.

Grant, R.M., 1996. Toward a knowledge-based theory of the firm. Strategic Management Journal, 17 (Winter Special Issue), pp. 109-122.

Harwit, E. 1995. China's Automobile Industry, Armonk, NY: M. E. Sharpe.

van der Heijden, K. 1996. Scenarios: The Art of Strategic Conversation. Wiley.

Helfat, C. E. 1997. 'Know-how and asset complementarity and dynamic capability accumulation'. Strategic Management Journal, 18(5), 339–60.

Helfat, C.E., Finkelstein, S., Mitchell, W., Peteraf, M., Singh, H., Teece, D.J., Winter, S.G. 2007. Dynamic Capabilities: Understanding Strategic Change in Organizations. Blackwell Publishing.

Hultin, H., Kuusela, V., Wallin, J. 2004. Balancing Strategic Regional Development by Emphasizing Both Individual Skills and Organizational Capabilities. Paper presented at the 24th Annual International SMS Conference in San Juan, Puerto Rico, October 31-November 3.

Jensen, M.B., Johnson ,B., Lorenz, E., Lundvall, B.A. 2007. Forms of knowledge and modes of innovation. Research Policy 36(2007): 680-693.

Jensen, J., Tollin, N. (2004) Networks as tools for sustainable urban development. Paper presented at the 'Innovation, Sustainability & Policy' international conference, Munich, 23-25 May.

Laamanen, T., Wallin, J. 2009. Cognitive Dynamics of Capability Development Paths. Journal of Management Studies 46(6):950-981

Lawton, T.C., Innes, P.A. 2003. Institutions and institutional engineering: a study of the Irish software sector. Paper

presented at the 23rd International SMS Conference, Baltimore, MD, November 9-12, 2003.

Lundvall, B-Å. 2008. A note on characteristics of and recent trends in National Innovation: Policy Strategies in Denmark, Finland and Sweden. http://www.kunnskapsdugnad.no/ikbViewer/ Content/746507/081112_Lundvall_Note%20on%20Nordic%20Innovation%20Policy%20Strategies.pdf

Lundvall, B.-Å., Johnson, B., Andersen, E.S., Dalum, B. 2002. National systems of production, innovation and competence building', Research Policy 31(2002): 213-231.

March, J.G., 1991. Exploration and exploitation in organizational learning. Organization Science, 2(1), pp. 71-86.

Mendel, M. 2011. Scale and Innovation in Today's Economy. Progressive Policy Institute. http://progressivepolicy.org/wp-content/uploads/2011/12/12.2011-Mandel_Scale-and-Innovation-in-Todays-Economy.pdf

Normann, R. 2001. Reframing Business: When the Map Changes the Landscape. Wiley.

Normann, R., Ramírez, R. 1994. Designing interactive strategy. Wiley.

OECD. 2005. Oslo Manual. http://www.oecd.org/dataoecd/35/61 /2367580.pdf

Peng, M.W. 2000. Controlling the foreign agent: How governments deal with multinationals in a transition economy. Management International Review 40(2):141-165.

Pisano, G.P., Shih, W.C. 2009. Restoring American Competitiveness. Harvard Business Review 87(7/8): 114-125.

Porter, M.E. 1980. Competitive Strategy. Free Press.

Porter, M.E. 1985. Competitive Advantage. Free Press.

Porter, M.E. 1990. The competitive advantage of nations. The Free Press.

Sanchez, R., Heene, A. 1996. A systems view of the firm in competence-based competition, in Sanchez, R., Heene, A., Thomas, H. (eds.) Dynamics of competence-based competition. Elsevier.

Simon, H.A. 1969. The Science of the Artificial. MIT Press.

Teece, D.J., Pisano, G., Shuen, A. 1990. Firm Capabilities, Resources, and the Concept of Strategy. CCC Working Paper No. 90-8, University of California at Berkeley.

Teece, D.J., Pisano, G., Shuen, A. 1997. Dynamic Capabilities and Strategic Management. Strategic Management Journal 18(7): 509-533.

Teece DJ. 2007. Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. Strategic Management Journal 28(13): 1319-1350.

Teece,D.J. 2008. Intangible (knowledge) assets snd dynamic capabilities - new paradigms for analyzing competitive advantage. Plenary address at the 28th SMS conference in Cologne, 13 October 2008.

Teece , D.J. 2009. Dynamic capabilities & strategic management. Organizing for innovation and growth. New York: Oxford University Press.

Tekes. 2011. Invitation to tender – Capabilities for Innovation Activities – Impact Study

Utterback, J.M. 1994. Mastering the Dynamics of Innovation. Harvard Business School Press.

Veugelers, R. (ed.). 2009. Evaluation of the Finnish National Innovation System – Full Report. www.evaluation.fi.

Vinnova, 2011. Challenge-Driven Innovation. http://www.vinnova.se/upload/EPiStorePDF/vi-11-07.pdf

Wallin, G. 2011. Knowledge management in co-specialized and orchestrated networks. B.Sc. Thesis, Aalto University.

Wallin, J. 2000. Customer Orientation and Competence Building. Acta Polytechnica Scandinvavica. Industrial Management and Business Administration Series No. 6. (Doctoral dissertation, Helsinki University of Technology)

Wallin, J. 2006. Business Orchestration. Wiley.

Wallin, J. 2007. Semi-Open Innovation in Services. Paper presented at the 2007 World Conference on Mass-Customization & Personalization at MIT, Cambridge/Boston, Massachusetts, October 7-10.

Wallin, J. 2009. Liiketoiminnan orkestrointi. WSOYPro.

Wallin, J., Su, J. 2010. Innovation and Collaboration for a Harmonious World. WSOYPro.

Winter SG. 2003. Understanding dynamic capabilities. Strategic Management Journal 24(10): 991-995.

Zetterberg, H. 1992. The study of values. Paper presented at the 87th Annual Meeting of the American Sociological Association, Pittsburgh, Pennsylvania, August 20-24.

Appendix 1. The Oulu region as a high-tech center

In 1965 the department of electrical engineering of the University of Oulu, focusing on radio technology and electronics, started operations. The first professor of the department of electrical engineering, Juhani Oksman, was appointed in 1967[1]. At its beginning the major area of interest of the department was theoretical electrical engineering, but in the early 1970s the emphasis gradually shifted more towards data communications and especially radio communications. The reasons for this were twofold: firstly there was a shortage of telecommunications engineers in northern Finland, and secondly Juhani Oksaman himself was originally trained in radio technology. Dr. Oksman was also a skilled administrator, and during the years 1990-1993 he was the dean of the University of Oulu.

Juhani Oksman was instrumental in recruiting Matti Otala to become the first professor of electronics at the University of Oulu. Otala, having previously worked for Nokia and Helvar, brought with him an industrial background that has since fostered a climate of strong industrial collaboration within the university. Professor Otala was focused on producing functioning electrical equipment, and this has later distinguished the development of the whole Information and Communications Technology sector (ICT-sector) in the Oulu region. In the beginning of the 1970s this meant developing and producing innovative new products in the field of telecommunications, but later this was extended into such areas as manufacturing equipment for telecommunications products and industrial components.

Professor Otala was also actively recruiting new companies to establish operations in the Oulu region. In the 1970s, Matti Otala was employed both as the professor of electronics at the university and as the director of the laboratory of electronics of the Technical Research Centre of Finland (VTT). He could therefore support researchers like Seppo Säynäjäkangas and Seppo Leppävuori to work in close co-operation with the local companies.

In 1969, Seppo Säynäjäkangas became the first M.Sc. in electrical engineering to graduate from the University of Oulu and, in 1973, the first to get a doctorate. Subsequently he was appointed professor of his alma mater. Having developed the first miniature wireless telemetry for heart monitoring, Säynäjäkangas founded Polar Electro in 1977, the company that introduced the heart monitor that would become the first choice for athletes looking for pulse monitoring for aerobic and anaerobic training. In 1983 Polar Electro launched the world's first wireless Heart Rate Monitor. This product was developed by Polar together with the department of electronics at the University of Oulu. In 2011 Polar Electro operated in over 80 countries and had approximately 1 200 employees.

Seppo Leppävuori, whose academic career began at the Helsinki University of Technology, was, in 1975, appointed Associate Professor at the Department of Electrical Engineering at the University of Oulu. In the early 1970s he started the Microelectronics Laboratory at the University, and worked for the University until his retirement in spring 2004. In the early 1970s, Professor Leppävuori had been instrumental in the decision to locate the laboratory of electronics of VTT in Oulu, and he continued, throughout his career, to actively promote a three party collaboration between the University of Oulu, VTT, and the private sector. The research activities of professor Leppävuori and his research team aimed at developing new materials and future manufacturing technologies required for novel information technology products. The group has played an important role in the research for novel electronics materials, high-density electronics packaging and reliability techniques. Precision engineering has a key role in these fields. Professor Leppävuori has published more than 300 scientific and technical papers in internationally refereed journal and conference publications.

The University of Oulu and the electronics laboratory of VTT would probably not have reached the out-

[1] The analysis of Oulu was originally presented by Hultin, Kuusela and Wallin(2004).

standing results during the last thirty years, were it not for Nokia's decision to establish its unit for radio communications in Oulu in 1973. This decision has to be understood in the context of the structure of Nokia at that time. Nokia was then a conglomerate. In 1967, three companies merged: (i) Nokia, then primarily a pulp and paper company, (ii) the Finnish Rubber Works, a galosh and tire manufacturer, and (iii) the Finnish Cable Works, which manufactured phone-cables. The new company was called Nokia Group. This new conglomerate consisted of four industrial groups: pulp and paper, rubber, cables and electronics. Of these, electronics was the smallest, representing only 3% of the total turnover.

The electronics group of Nokia (Nokia Electronics) thus had its origin in the Finnish Cable Works, the oldest Finnish cable company established in 1917. The CEO of the Finnish Cable Works, Björn Westerlund, had already in the 1950s recognized the growing significance of computers, and in 1960 the electronics department was established. The first product the department developed and sold was an analyzer for advanced measurements in nuclear physics. The department also imported and distributed computers, and by the mid-1960s was a licensed distributor for Siemens, Elliot, and Bull computers.

The first Oulu based cable manufacturing company Pohjolan Kaapeli, a subsidiary of Nokia, was established in 1960. The same year another private company, Kaapeliteollisuus, also began manufacturing cables in Oulu. In 1969 Pohjolan Kaapeli started the production of cable harnesses, and cable production was expanded. In 1987 Kaapeliteollisuus was sold to Nokia. As Nokia decided to focus on telecommunications it sold its cable operations in the end of the 1990s to the Dutch company NKF Holding. The company changed its name and has been known as Draka NK Cables since the beginning of 2003.

Based on the strong cable manufacturing knowledge in Oulu, a new company, PK-Cables (later PKC Group), was formed in 1994. This company grew very fast at the end of the 1990s in the areas of telecommunication wiring harnesses and cabling.

Contributing to the decision to choose Oulu as the location for the mobile telephony unit was the fact that Nokia, through the Finnish Cable Works, was already established in Oulu, combined with the possibility of tax breaks and the access to well-educated engineers from the University of Oulu. The young radio engineer that got the responsibility to set up this operation was Lauri Kuokkanen, who immediately after his graduation in 1969 had started to work as a unit manager for Nokia Electronics in Helsinki.

In 1972 Nokia Electronics began to manufacture radio equipment in Oulu for the Finnish defense forces. Oulu was selected as the production site partly because the production had to be located outside the capital region due to political reasons. In 1973 Nokia started the production of radio phones, base stations and relays in Oulu, and two years later the product mix was expanded by modems and PCM equipment. In 1985 Nokia Mobile Phones established a research and development unit in Oulu.

The need for electronics components inspired the formation of a company called Aspo Elektroniikka (later Aspocomp) in 1973. The product development activities of this company greatly benefited from the scientific work (e.g. thick-film hybrid innovation) done by Professor Seppo Leppävuori. The company expanded rapidly. In 1979 a printed wired-boards plant and a hybrid factory were inaugurated and in 1986 a printed circuit-board plant was established. Aspocomp was taking over similar operations from Nokia in 1997. Today, the main business of Aspocomp consists of the production of printed circuit boards.

The third major player in the electronics field in Oulu in the 1970s was Kajaani Elektroniikka. This company, established in 1970, was a subsidiary of a pulp and paper manufacturer that had decided to diversify outside its core business. It was established in Oulu based on close collaboration between the parent company CEO, Mikko Tähtinen, and Matti Otala. The first product of Kajaani Elektroniikka was a pulp bleaching process instrument. In 1982 Kajaani Elektroniikka delivered fare collection devices for public transport. The business became a part of a company called Edacom Oy, which became Buscom Oy through a management-buy-out arrangement in 1986 and became a part of the Norwegian Fara group in a 2007 merger.

Lauri Kuokkanen was more of an entrepreneur than an administrator, and in 1976 he left Nokia to become a partner at a subcontractor making metal parts for industrial clients. Two years later he started his own company, Lauri Kuokkanen Ltd. that made duplex filters for radiotelephones. He sold this company to Nokia in 1985, and the name was transferred to LK Products. Later on Nokia disposed of the company and sold it to Filtronic upon which the name

became Filtronic LK. By 2000 Filtronic LK employed more than 1 000 people. Lauri Kuokkanen moved ahead, and in 1986 he formed a company called Solitra making radio transmitters/ receivers for telemetry applications. This company was sold in 1993, and until 2001 remained part of ADC Telecommunications. Then the unit, employing 600 people, was sold to Remec, a San Diego based designer and manufacturer of high frequency subsystems used in the transmission of voice, video and data traffic over wireless communications networks and in defense electronics applications. Kuokkanen continued his entrepreneurial career and established Ultracom and Ultraprint, making integrated circuits. In the year 2000 he sold Ultraprint to JMC Tools, but continued his relationship with Ultracom. Ultracom specializes in high frequency radio products and system solutions for wireless data communications.

In the 1980s a number of new companies emerged in pace with the increasing demand for subcontracting work for the telecommunications industry. One of these companies was JOT Automation, which made production equipment for the electronics industry. Veikko Lesonen set up the company in 1988. It was in 1995 turned into a group, and Jorma Terentjeff was appointed managing director. Lesonen and Terentjeff made an aggressive growth strategy for the company, and they listed it in September, 1998. Lesonen and Terentjeff sold their shares at the peak of the market in February 2000. Lesonen cashed in over €130M. Lesonen, a technician from Kemi, north of Oulu, remained in Oulu after his exit from the company he founded, and is actively promoting different business activities in the region. One of his activities has been to engage in regional development as a venture capitalist. The vehicle he formed for this activity is Head Group. Today Head Group consists of a network of capital investment and development companies.

In March 2002 it was announced that JOT Automation would merge with Elektrobit, a company founded in 1985 by another entrepreneur from Oulu, Juha Hulkko. The merged group took the name of Elektrobit Group, specializing in mobile technologies, life-cycle testing of electronic products and production automation.

CCC Group, a software company, was founded in 1985 by Timo Korhonen. Prior to forming the company Timo Korhonen had worked for the University of Oulu. Seppo Säynäjäkangas, the founder of Polar Electro, had supported Korhonen in his efforts to form his own company, which today employs almost 200 people.

The evolution of the overall employment in the Oulu region is summarized in Table a.

The evolution of employment in the ICT-sector in the Oulu region is summarized in Table b.

Table b shows how the origin of the ICT-sector in Oulu is to be found in cable manufacturing. Cable manufacturing was still the major employer in the early 1980s. At the same time Table b also shows the overwhelming impact Nokia has had on the development of the ICT-sector in the region. Except from Polar Electro and the two telecommunications operators (long distance operator TeliaSonera and the local telephone company Oulun Puhelin) all other large ICT-sector companies

Table a. The employment structure of the Oulu region.

Facts / Year of Analysis	1960	1970	1980	1990	2000	2003
Population in the city of Oulu	53 000	85 000	94 000	101 000	121 000	126 000
Population in the Oulu region[2]	n/a	120 000	141 000	159 000	189 000	199 000
Share of primary production jobs	1.6%	1.7%	0.8%	1.0%	0.6%	0.6%
Share of construction sector jobs	13.8%	13.6%	9.2%	8.1%	6.9%	6.7%
Share of jobs in industry	25.9%	23.5%	23.2%	17.0%	22.1%	19.1%
Share of service sector jobs	58.1%	61.1%	66.8%	72.3%	69.1%	72.2%
Total jobs in Oulu	n/a	39 000	45 000	58 000	64 000	66 000

2 The Oulu region consists of the municipalities of Hailuoto, Haukipudas, Kempele, Kiiminki, Liminka, Lumijoki, Muhos, Oulu, Oulunsalo, and Tyrnävä.

Table b. The major employers of the ICT-sector in the Oulu region.

Company / Year of Analysis	1983	1990	1/2001	1/2002	1/2003	1/2004
1. Nokia Corporation	567	1 860	4 271	4 134	4 300	4 300
2. Sanmina SCI EMS (ex. Nokia Networks in Haukipudas)	-	-	863	600	730	700
3. PKC Group	-	-	450	450	490	580
4. Filtronic LK (ex. LK products)	50	~350	1 100	970	700	550
5. Elektrobit Group (including JOT Automation)	-	52	400	500	370	470
6. Draka NK Cables (ex. Nokia Kaapeli, Pohjolan Kaapeli, Kaapeliteollisuus)	1 430	1 550	550	550	523	457
7. Oulun Puhelin	132	205	393	432	439	431
8. Remec (ex. Solitra, ADC)	-	~30	648	480	420	350
9. CCC Group	-	60	158	280	300	350
10. VTT electronics laboratory	95	205	325	320	320	305
11. Polar Electro	~20	<100	258	291	~300	~300
12. Aspocomp	150	220	414	379	296	299
13. Scanfil	-	50	270	280	260	240
14. TeliaSonera (ex. Tele)	~600	~600	356	348	232	239
Total	3 044	5 282	10 456	10 014	9 680	9 571

have had some link with Nokia, either as spin-offs from Nokia or major suppliers to Nokia. Scanfil for example, founded by the 30-year old entrepreneur Jorma J. Takanen in 1976, is a contract manufacturer and systems supplier for communication and industrial electronics. Originating in Sievi around 100 miles south of Oulu, Scanfil opened its Oulu factory in 1991. The company is today listed on the Helsinki Stock Exchange as Sievi Capital, and had by the end of September 2011 over 2 000 employees, of which less than 400 were employed in Finland.

However, as earlier stated, the fact that Nokia established its electronics unit in Oulu in the early 1970s was at least partly due to the knowledge base that already existed in the area. This knowledge base had been built up for more than ten years. The first step in this evolution was the decision to establish a university in Oulu. Already in 1949 a professor at the Helsinki University of Technology, Pentti Kaitera, born in Oulu, suggested the establishment of a techno-economic research institute in the north of Finland. In 1952 the Council of State nominated a committee to plan the future university policies of Finland. Pentti Kaitera was a member of this committee. In 1956 the committee suggested establishing a university in north Finland focusing on forest related research. This suggestion was largely opposed in Oulu, due to the very limited scope of the suggested university.

A new committee, chaired by Pentti Kaitera was nominated in 1956. A year later this committee suggested establishing the University of Oulu having faculties of philosophy, technology and medicine. This proposal again mobilized severe opposition in the south of Finland among the established universities, who were afraid that their part of the governmental support would diminish. In spite of this a consensus was reached, and in 1958 the University of Oulu was founded, and Pentti Kaitera was nominated to become the first dean of the university.

Once the University of Oulu was in place the regional decision makers continued to push the national authorities to get more activities localized in Oulu. The second major decision was to have VTT (the state owned Technical Research Centre) to establish its electronics laboratory in Oulu in the early 1970s. In the beginning of the 1970s the governmental policy was to increasingly decentralize governmental institutions. The dean of Oulu University at that time, Markku Mannerkoski, was actively promoting the establishment of an Oulu branch of VTT. Mannerkoski was able to gain support for this idea from the director general of VTT, Pekka Jauho, and the inauguration of the new electronics laboratory took place in 1974. After that Mannerkoski actively built up the co-operation between the university, VTT and the local industry.

The gradually growing ICT-sector was consistently supported by the decision makers of the city of Oulu. One concrete decision to further attract the attention of local and external investors was to establish the Science Park Oulun teknologiakylä ("Technology Village") in 1982. One of the major influencers for the driving of this initiative was Ilmo Paananen, the mayor of Oulu from 1974 to 1990. Once the Technology Village was in place, Oulu also took further responsibilities in supporting technology development. The Oulu Region Centre of Expertise was established in 1994. The center supports the development of telecommunications, electronics, and software engineering businesses in the region.

The University of Oulu established the Center for Wireless Communications (CWC) in 1995 in close collaboration with the local business community. CWC is an independent research institute focusing on next generation mobile communications, beyond 3G, 4G, and Ultra Wideband (UWB) technologies. Table c summarizes the evolution of the ICT-sector in Oulu through five decades.

To conclude one can state that the development of the region of Oulu as a high-tech center has its origin in important decisions made already in the 1950s and 1960s. Thanks to these decisions a foundation for continuous knowledge creation in the information and telecommunications sector was laid.

Table c. The development of the ICT-sector in the Oulu region.

Facts / Decade	1960s	1970s	1980s	1990s	2000s
ICT-sector employees	<100	~1 500	~2 000	~5 500	~13 000
Key events	The department of electrical engineering was established at the University of Oulu	The university focused on data communications / radio communications, New product innovations in the region	Solid and long-term work related to the ICT-sector product innovations, New company set-ups	A huge expansion of the IT and telecommunication employment, Subcontracting expansion / spill-over effects	Internet bubble in Finland, Economic slow-down, Staff-reductions
Institutions	The University of Oulu	The University of Oulu, VTT Oulu	The Science Park / Technopolis Oulu	CWC, The Oulu Region Centre of Expertise	The Oulu Growth Agreement
Leading companies (focusing on the ICT-sector)	Pohjolan Kaapeli, Kaapeliteollisuus	Pohjolan Kaapeli, Kaapeliteollisuus, Nokia Electronics, Aspo Elektroniikka, Kajaani Elektroniikka	Nokia, Polar Electro, LK Products, Aspocomp	Nokia, Polar Electro, Filtronic LK, Elektrobit, JOT Automation, PKC Group, Solitra/ADC	Nokia, CCC Group, PKC Group, Buscom
Technological focus areas	Cable manufacturing / harnesses, Electrotechnical industry	First initiatives in the area of electronics (radio equipment, radio phones, base stations, relays, modems and PCM equipment)	Nokia concentrates its R&D operations in Oulu, Mobile phones volume production	GSM, Local subcontracting for Nokia	3G/4G and Ultra Wideband (UWB) technology R&D
Significant individuals	Pentti Kaitera, Juhani Oksman, Matti Otala	Juhani Oksman, Matti Otala, Lauri Kuokkanen, Seppo Säynäjäkangas, Seppo Leppävuori, Markku Mannerkoski, Ilmo Paananen	Seppo Säynäjäkangas Lauri Kuokkanen, Veikko Lesonen	Lauri Kuokkanen, Veikko Lesonen, Jorma Terentjeff, Juha Hulkko	Juha Hulkko, Timo Korhonen, Jorma J. Takanen
Regional development activities by the authorities	Background work for the VTT localization	Regional work groups	The Science Park, "The Technology Village", was launched	Strategy process and growth targets for the electronics sector employment	The Oulu Growth Agreement strategy process

The country studies presented in this appendix have been carried out by Arne Eriksson (Denmark & Sweden), Phil Cooke (Ireland), and Tomi Laamanen (Switzerland) with support from Synocus's analyst team.

Denmark

Denmark has become well known for its very flexible labor market, with unemployment in Denmark remaining relatively low in spite of the ongoing financial crisis. However, lately Denmark too has witnessed increasing unemployment, exceeding 7 per cent at the beginning of 2011.

With a population of 5.6 million and a 2010 GDP of DKK 1 750 billion (€235 billion) Denmark had the fifth highest nominal GDP per capita in the world in 2010. At the same time Denmark also has the highest tax rates in the world, with a value added tax of 25 % and income tax ranging up to 63%.

Danish innovation system morphology

R&D intensity in Denmark was 3.02% in 2009 (0.99% public + 2.02% private). Over the period 2000–2009, Denmark's R&D intensity increased notably, with an average annual growth rate of 8.84% over the period 2006–2009, one of the highest growth rates among the EU Member States.

In 2009 and 2010, new innovation policy measures were introduced in Denmark targeting private R&D investment, including: increased public procurement of eco-innovations; support for large demonstration facilities; and the launch of the Renewal Fund as well as a risk capital fund. This is evidence of Denmark's strong focus on SMEs and dissemination of knowledge on the one hand and a very clear science focus on the other.

Overall, Denmark's specialization profile is strongly driven both by intangible assets (marketing-driven industries such as games and toys), but at the same time by natural endowments (agricultural products, sea, etc.), explaining its bipolar focus on both innovative and less innovative sectors.

The economic reform program for 2011 identified three fundamental challenges for the Danish economy:

(i) Growth potential has to be strengthened. Without reforms which increase labor supply or a higher productivity growth the growth potential is very limited – around 1 per cent per year – and there is a risk that Denmark will be a low-growth economy. With great challenges for both public finances and growth, it is the conditions for private enterprise growth that must be improved. This requires reforms that strengthen labor supply, productivity and competitiveness.

(ii) Public finances need to be strengthened substantially in order to ensure that the public budget is balanced in the longer term. Without further reforms the room for growth in public consumption over the next decade will be around zero if balance on public finances in 2020 (structurally) is to be ensured.

(iii) It is a fundamental requirement that spending does not continue to increase more than what is planned and agreed. Stricter control mechanisms have been implemented, but it is assessed not to be sufficient. There is a need to introduce a new spending management system based on binding spending ceilings for the central government, municipalities and regions.

Research focus

Denmark is specialized in mainstream manufacturing industries (electric motors, generators and transformers), and in marketing-driven industries (the manufacture of games and toys, meat and fish products). Danish exports are, to a great extent, based on labor-intensive industries such as the manufacture of builders' carpentry and joinery. At the more aggregated sector level, Denmark features value added specialization in sectors with high innovation intensity (machinery), as well as in those with low innovation intensity (water transport).

In terms of change, Denmark has strongly increased its emphasis on technology-driven industries such as medical equipment. Also, sectors with high educational and innovation intensity, such as electrical machinery (e.g. wind turbines), have gained increased attention. At the same time the relative share of sectors with low innovation and education intensity (land and water transport) have decreased. The change

dynamics for exports have been somewhat different, with high education sectors having increased strongly (financial services) but high-innovation sectors (communication equipment) and technology-driven industries (aircraft and spacecraft) having slightly decreased.

Denmark's R&D intensity has risen considerably, while there has been little change in the quality indicators. At the sectoral level, Denmark has gained R&D intensity mainly in services sectors such as distribution, software and research and development, while decreasing R&D intensity in machinery and transport and communications.

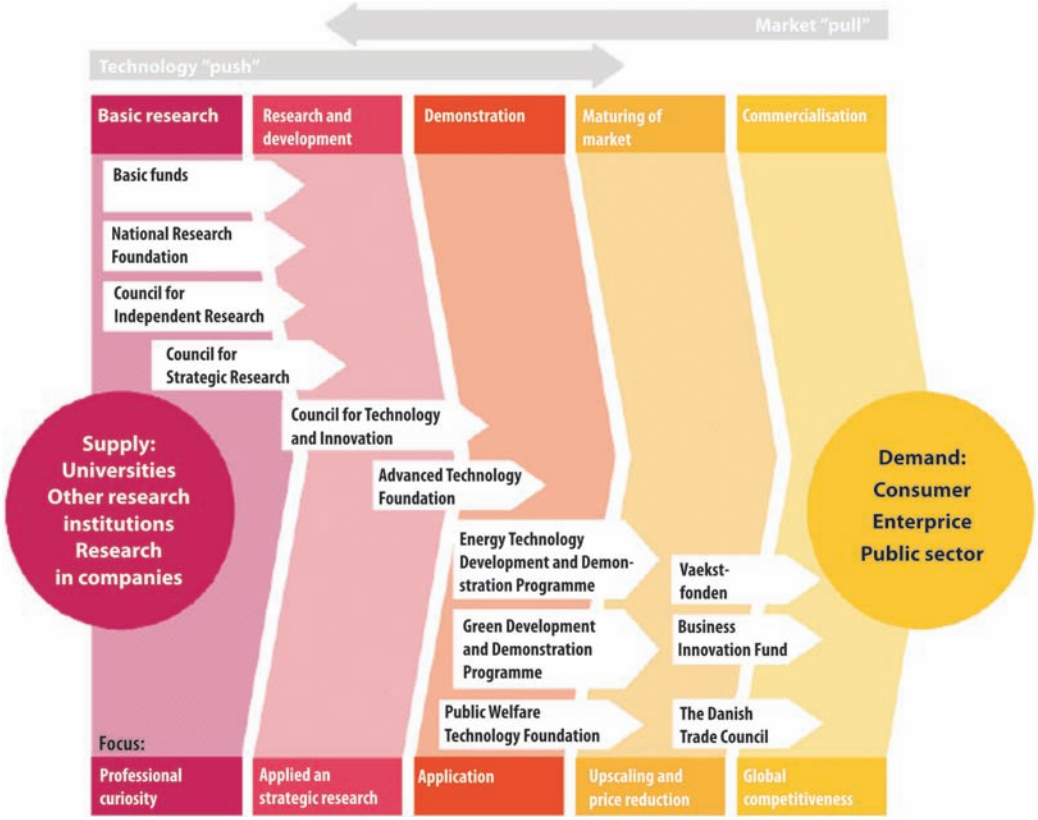
The impact of the financial crisis on Denmark's specialization patterns was limited, with no clear overall direction of change during the crisis years. The impact on total manufacturing production was severe, and its level in April 2011 was still 14 % below its previous cyclical peak.

Start-up rates in Denmark have increased steadily in recent years and are high in international comparison. The overall importance of high growth firms is increasing but remains below the level of some other countries. This has stimulated the Danish government to put forward ambitious objectives for entrepreneurship in general and high growth start-ups specifically. The challenge is the low proportion of high growth firms. This underpins almost all policy measures in the SME area, e.g. the "Erhvervspakken" and the "New firms package" with measures aiming at providing funding and easing financial constraints for start-ups and SMEs.

TIS Architecture

The Ministry of Science, Innovation and Higher Education is responsible for the following policy areas: research; innovation; and higher education, including university education and internationalization of education and training in Denmark. The principles for public Danish funding of innovation activities are illustrated in Figure 1.

Figure 1. The principles of the public Danish funding of innovation activities



The ministry aims to make Denmark a leading entrepreneurial and knowledge based society, offering education that rank among the best in the world, and to create the best possible opportunities for citizens and businesses to realize the vision of Denmark as a network society. The ministry includes the following departments: The Danish Agency for International Education; The Danish Agency for Science, Technology and Innovation; The Danish University and Higher Education Agency which, together with the Permanent Secretary's Department, are referred to as the Ministry of Science, Innovation and Higher Education.

Also within the scope of the ministry are a number of funding bodies for research and innovation, research and advanced technological service institutions and Denmark's eight universities.

Innovation policy is managed by the *Danish Agency for Science, Technology and Innovation* – DASTI. Its main responsibilities are in areas such as: public research and innovation funding; researcher mobility; dialogue on priorities in research and technology initiatives; regionalization of research and innovation; interaction between knowledge institutions and the business community; innovation policy; and international cooperation on research and innovation.

The Danish National Research Foundation was established in 1991, and is an independent foundation, which works at strengthening Danish basic research within all research fields. The Foundation's main working method is to set up and fund research centers of the highest international standing, Centres of Excellence, for 1–2 periods of funding. The Foundation annually distributes up to DKK 400 million (€57 million). This corresponds to approximately 2 percent of the annual public research expenditure. As a supplement to the Centres of Excellence, the Foundation experiments with various other programs, particularly those with a view to strengthening the internationalization of Danish research. Following this strategy the Foundation is active in collaborations with international foundations and organizations on joint programs.

The effect of these investments is clearly visible, e.g. in the exceptional quality of the research output, the high degree of international cooperation, the extensive PhD production, and in the ability to attract external funding from abroad.

The Danish Council for Technology and Innovation was established in 2002, and is an independent council, which works at strengthening Danish private research, development and innovation and economic growth in Denmark. The council distributes up to DKK 1100 million (€150 million) annually. The council's work consists of two parts. One is to advise the Minister of Science, Technology and Innovation about technology and innovation policy. The other is to administer the initiatives given to the council by the Minister.

The objectives of the council are to promote:

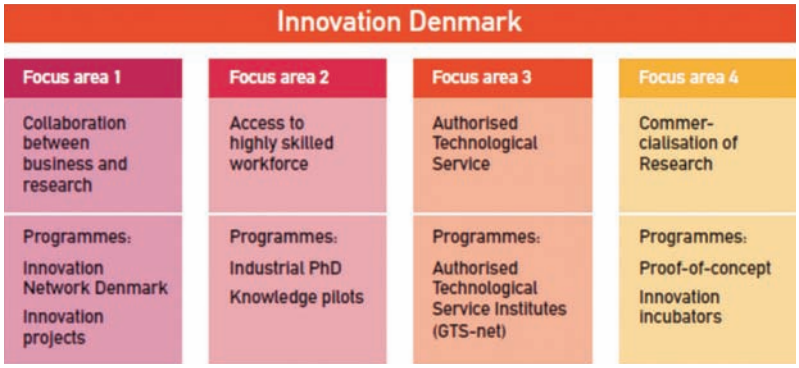
- Collaboration and dissemination of knowledge between researchers, research and educational institutions, advanced technology groups, knowledge institutions and enterprises.
- Innovation, development, diffusion, use and commercialization of new research and technology, and knowledge of organizations and markets.
- Flow and development of knowledge and technology based enterprises.
- Innovation and input of capital and expertise for knowledge and technology based enterprises.
- International collaboration on the utilization of knowledge and technology.

The Danish Council for Technology and Innovation administers a number of initiatives the purposes of which are to promote private research, development, innovation and dissemination of knowledge between knowledge institutions and enterprises. The initiatives are:

- Cooperation and interaction between business and research:
  - Innovation consortia scheme
  - Innovation voucher scheme
  - The scheme for new forms of collaboration
  - The competence and innovation network scheme
- Approved technological service (The Danish GTS-system)
- Industrial PhD scheme
- Knowledge pilot scheme
  - Entrepreneurship and commercialization
  - Technology transfer offices at universities
  - Business incubators (The Danish innovation incubator scheme)
  - The proof-of-concept scheme

The council has, in collaboration with the ministry and after a broad national consultation procedure with: organizations; institutions; and innovation actors, established the second four year action plan called Innovation Denmark 2010–2013 which describes the main innovation policy initiatives under the Ministry of Science, Technology and Innovation. The initiatives are divided across four broad priority areas:

Figure 2. Innovation Denmark



The most important tools of the Danish Council of Technology and Innovation are:

1. Innovation Denmark project program: a) Innovation consortia, b) innovation vouchers and c) new forms of research-business collaboration projects: i.e. large and small national and international innovation and research projects operated in collaboration between academic and research institutions and enterprises
2. Innovation Denmark Network Programme: 22 competence and innovation networks (cluster organizations)
3. Highly educated staff and researchers in enterprises:
   a. The Industrial PhD Programme where the research student divides his or her time between an enterprise and a university
   b. The knowledge pilot scheme (an innovation assistant program) which promotes employment of highly qualified staff in small and medium-sized enterprises.
4. The Danish GTS-net: The approved technological service institutes which are independent knowledge institutions delivering knowledge to enterprises
5. The Danish Innovation Incubator program: 6 business incubators invest public capital in entirely new, high-tech enterprises.
6. The Danish Proof-of-Concept program: Commercial exploitation of public research: In the form of support for maturation of inventions from public research institutions (proof-of-concept) and projects which promote technology transfer between national and international research institutions and enterprises.

The Danish Council for Technology and Innovation also supports ***competence and innovation networks***. A competence and innovation network is a flexible framework for collaboration between enterprises, research institutions and non-profit advisory/knowledge dissemination parties. The annual budget of the ministry's total network program is approximately €10 million. The annual budget of an average network is approximately €0.9 million of which 40 percent is financed by the network program of the DCTI, at least 40 percent is financed by enterprises and the rest is financed by regional sources, universities, technological and research institutes and the European Union. In 2011 there are 22 national networks with support from the DCTI network program.

One of the most important tasks of a competence and innovation network is to ensure that national innovation policy is not simply a matter for large research enterprises; both by ensuring that smaller enterprises participate in network projects, and by ensuring that the networks help this target group to make use of other innovation policy initiatives e.g. innovation consortia, innovation vouchers, the knowledge-pilot scheme and the industrial PhD scheme. The use of other innovation policy programs is three times higher among enterprises that participate in network activities than among similar enterprises not participating in innovation networks.

The DCTI finances national networks for a period of four years with the possibility to add additional 4-year periods after a tender.

There are nine core network services, the majority relate to bridge-building activities and meeting places (themed networks; matchmaking; idea generation; conferences; seminars, etc.; partnership projects; pre-projects; R&D&I projects; and business-to-business partnerships) but two core services relate to knowledge development and communication (consultation and skills development).

An ***innovation consortium*** supported by DCTI is a flexible framework for collaboration between enterprises, research institutions and non-profit advisory/knowledge dissemination parties.

The budget of an average innovation consortium is approximately between €3 million and €7.5 million. The average funding by the DCTI is 40 per cent of a consortium's budget, i.e. between €1 and €3 million. An innovation consortium must consist of at least two enterprises which participate throughout the entire project, one research institution and one advisory and knowledge dissemination party. Additionally, an innovation consortium may involve or attach other types of partners which are considered relevant for the project.

The Danish Council for Independent Research funds specific research activities that are based on the researchers' own initiatives and that improve the quality and internationalization of Danish research. The council annually distributes up to DKK 1400 million (€187 million).

The Danish Council for Strategic Research was established in 2003, and is an independent foundation, which works at strengthening Danish strategic research within all research fields. The council annually distributes up to DKK 1100 million (€150 million). The aim is to ensure Denmark's position as a global frontrunner regarding welfare, wealth and science in both the short and long term.

The Danish National Advanced Technology Foundation was established in 2005, and is an independent foundation. The Foundation annually distributes up to DKK 600 million (€80 million).

The aim of the Danish National Advanced Technology Foundation is to enhance growth and strengthen employment by supporting strategic and advanced technological priorities within the fields of research and innovation. The foundation makes special efforts to promote research and innovation in small and medium-sized enterprises, and supports larger projects which are relevant to advanced technological research and/or innovation. The foundation pays special attention to applications which fall within the areas of nano-, bio-, and/or information and communication technology, including the interface between these areas.

The Danish Council for Research Policy (DCRP) advises the Minister for Science, Technology and Innovation on research policy. The Danish Parliament and any minister can also obtain research-related advice from the Council. This advice is given upon request or upon the initiative of the Council. The council does not distribute funds.

The Council's responsibilities generally include advice on Danish and international research policy for the benefit of society, including advice on: framework conditions for research (funding for research, major national and international research infrastructures, development of national research strategies, Denmark's role and position in international research collaboration, and research training and recruitment of researchers) and impacts/evaluation.

TIS Performance

The Danish approach to innovation policy evaluation utilizes econometric methods more than many other countries. So does e.g. a recent analysis of the return from private R&D investments in Denmark show that those R&D-active enterprises, which collaborate with universities or other research institutions, experience an average 15 per cent higher productivity per employee compared to the average Danish R&D-active enterprises with no cooperation with research institutions. Furthermore, the productivity per employee increases 9 per cent for enterprises initiating collaboration projects with research and technology institutions compared to a control group of similar non-collaborating enterprises found by using the propensity score matching method among 20,000 Danish R&D-active enterprises.

An additional analysis of the Danish innovation consortium program, which supports research business collaboration, shows that an average consortium enterprise's investment of €400,000 in public-private research partnerships yields €2–3 million gross profits.

Moreover, analyses of the return from private R&D investments in Denmark show that R&D-active enterprises have a 15 per cent higher average productivity per employee compared to non R&D-active enterprises. Further, innovative enterprises have 6 per cent higher average labor productivity than non R&D active enterprises. The return of increasing private investments in R&D&I is, on average, between 30 per cent and 66 per cent for Danish enterprises.

OECD analyses show that an effective diffusion of knowledge doubles the economic impact of private investments in research, development and innovation. In other words, it is beneficial to invest in research, development and innovation and to do so in cluster or project collaborations between research and business. The likelihood of enterprises to innovate is 3–4

times higher for enterprises participating in clusters and networks compared to similar enterprises not participating.

In 2011 a separate econometric impact assessment of the Innovation Network Denmark program was conducted. The study showed that participation in innovation networks and clusters increases the likelihood of innovation by more than 4.5 times year 1, after participation. Companies participating in different innovation networks have an increased probability for innovation with the effects on innovation becoming apparent from the first year on. The probability of being innovative is 4.5 times higher for companies participating in innovation networks compared to a control group composite of other similar companies not participating in networks. This means that for every time 10 companies in the control group become innovative, 45 participating companies in innovation networks will become innovative.

The impact study also documents that the probability of R&D collaboration is increased four-fold following participation in a network. Innovation networks assist companies in entering joint R&D and innovation projects by providing the companies with the competencies required for this complex task (competencies which SMEs, in particular, did not possess prior to participation).

Additionally, innovation networks provide a platform within which companies can identify potential collaboration partners. Already within the first year of participation, the probability of entering R&D collaboration increases by 95 per cent, and, thus, nearly doubles the probability of entering R&D collaboration. Thus, for every company in the control group, consisting of other similar companies (found through propensity matching score) not participating in innovation networks, entering into R&D collaboration, two new companies participating in innovation networks enter into R&D collaboration.

Another impact analysis of 220 enterprises which have participated in at least one Innovation Consortium (IC) using national developments assessed success primarily using two parameters: gross profit and employment. The results of the analysis can be summarized as follows: Of the enterprises that participated in the IC scheme, small enterprises have experienced significant increases in the growth of gross profit and employment in association with program participation. These results are robust even when controlling for pre-participation growth and developments in the growth of enterprises in the control group. It is important to note that these potential effects depend on the size of the enterprises under consideration. The analysis finds positive potential gross profit effects (increase in growth) that are significant at a five per cent significance level for enterprises with a gross profit below DKK 150 million (approx. €20 million) the year before the program. The analysis also finds potential employment effects for enterprises with less than 150 employees in the year before the program.

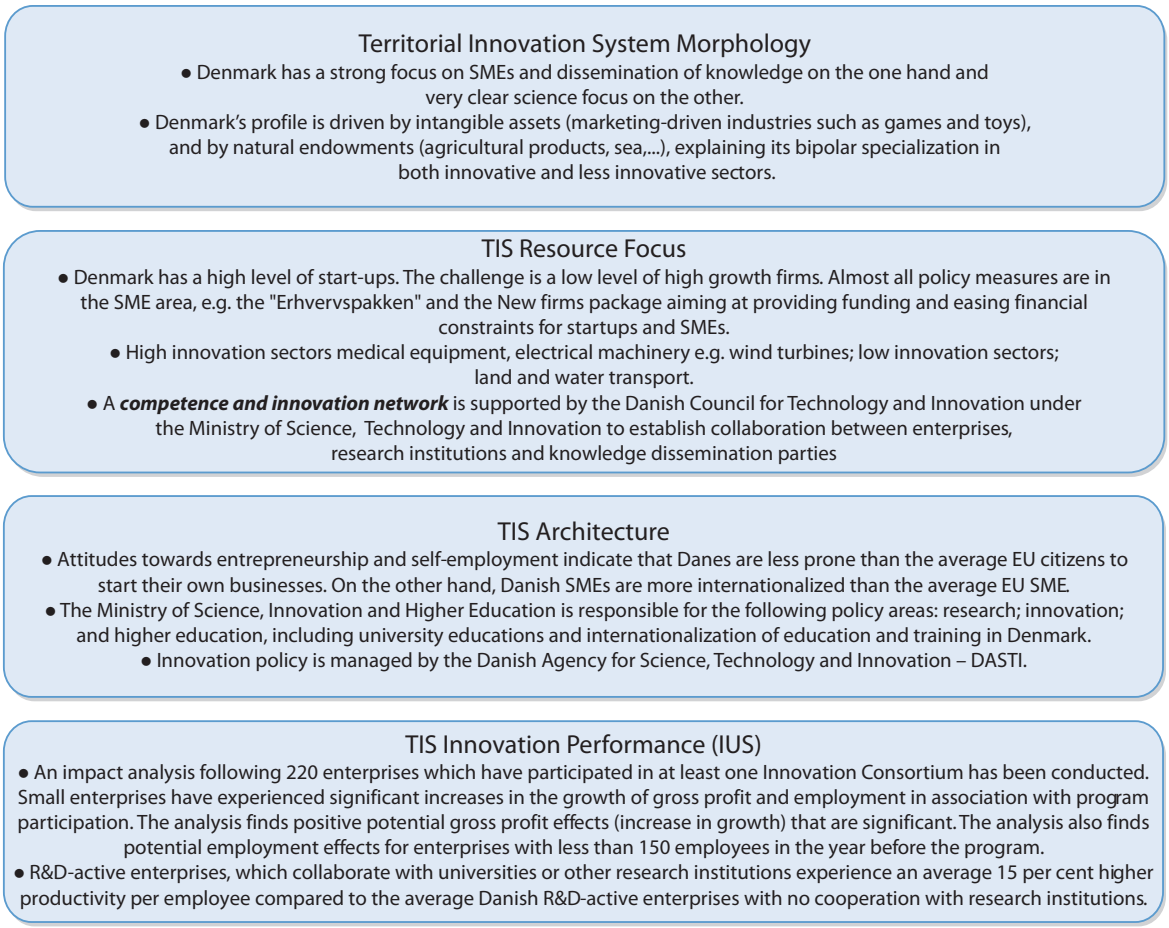
Similar econometric calculations of other programs have also been completed. These include the knowledge pilot scheme, the industrial Ph.D. program, the innovation voucher scheme and the technological service system.

The above findings show that Denmark's research and innovation system benefits from a strong scientific production, building on a high level of funding, human resources and international scientific cooperation. Over the period 2000–2009, the Danish government increased the share of total government expenditures allocated to R&D, leading to an increase of 30% in R&D expenditures financed by government, as % of GDP.

This funding is reflected in one of the world's highest levels of scientific excellence (a ratio of 17.5% of national publications to the 10% most highly-cited in the world). The Danish innovation system also builds on substantial researcher intensity in the labor force and a focus on technologies for societal challenges and future growth areas, well adapted to the Danish industry profile. The weaker points in the Danish innovation system, in relative terms, are the patent intensity and share of new doctoral graduates, which are lower than in similar knowledge-intensive countries such as Sweden, Finland and Switzerland.

Over the period 2000–2009, Denmark increased its performance in all areas where it is lagging behind the other world innovation leaders, particularly in technology production. Denmark has also enhanced the knowledge-intensity of its economy, with a growing share of activities based on highly-skilled employees. Only in public R&D expenditure and international scientific cooperation has Denmark lost ground compared to both the EU average and to other world innovation leaders. – The anatomy of the Danish innovation system is depicted in Figure 3.

Figure 3. The anatomy of the Danish innovation system



CASE: The Danish cleantech cluster

The emergence of Denmark's powerful cleantech cluster in the 2000s came as the result of a combination of factors ranging from national and local governmental policies supporting the renewable energy field to an innovative, policy intervention model employed by local businesses. active local, small-business community. The policies which set the stage for this development can be traced as far back as the 1970s and continue to the present. One such policy is the 2007 'A Visionary Danish Energy Policy 2025', which proposed cost-effective measures to secure energy supply, reduce environmental impact and enhance competitiveness. To promote research into these measures, the government earmarked almost €137 million (annually) for R&D into and demonstration of energy technology from 2010 onwards, effectively doubling the previous sum.

In the absence of any precise, globally controlled, cleantech or eco-innovation instruments driving actions from any specific innovation agency, development has benefited from numerous regulatory frameworks at national level 'framing' general subsidy or incentive schemes that fit in and support what has been occurring at local or regional level where such are deemed necessary or desirable. These frameworks have stimulated the emergence of an efficient business intervention model. The business intervention model is based on lobbying or 'concertation' be-

tween business associations and ministries, often at the behest of business more than government. This often involves taking initiatives upwards in the multi-level governance structure beyond Denmark to the EU and elsewhere to influence supra-national institutions, again with firm or business association-led initiative to the fore.

This collective, entrepreneurship policy-influence model can also operate at the lowest level in the multi-level governance hierarchy without intervention from national government. In Denmark, this has involved municipal commissioning of locally engineered district power stations fuelled by varieties of localized renewable energy. It is internationally respected as an exemplar of enlightened 'green' public procurement. But it is by no means an isolated instance of innovative eco-governance in Denmark. One of the best and most impressive eco-innovation cleantech public procurement initiatives in the world was Copenhagen's leadership of the *Dogma* program, which was completed by 2009. *Dogma* was fundamentally a policy network; that is, an informal or semi-formal organizational mechanism involving public and private individuals, stakeholder groups, organizations and associations interacting around specific multi-level policies and programs. Network stability derived from establishment of trust, reliability, reputation and customary rules to which network members adhered. Network maintenance was secured by the access members had to resources and influence in projects. Network management, brokerage and facilitation were necessary functions taken by different network members in the target group. This is illustrated in the practical sense by Jensen & Tollin (2004) in their disclosure of how networks spread innovative policy knowledge in Copenhagen's *Dogma* sustainable development strategies and actions. The dogma was a set of rules that each member of the network agreed and signed up to. However they also had to 'walk the talk' by fulfilling their commitments, otherwise their membership of the network was terminated in 'punishment'.

Danish implementation of the business intervention model has been extremely successful in penetrating global markets for district cooling as well as district heating schemes. A striking effect of this success has been the 'revolution' in the decentralization of power generation in Denmark where regional and local providers came to dominate the scene after the 1980s. With regional administrations established in Denmark since 2007, an exemplar of new regional initiative has been north Jutland's emergent 'green regional innovation system' a cleantech cluster-platform which grew out of the early lead established by Danish wind turbine eco-innovators.

North Jutland is nowadays specialized in building and developing renewable energy through District Heating innovations and innovative technology mixes. Demanding customers for District Heating in Denmark are the municipalities (the central motivating factor in the shift towards decentralized power generation), most of whom run local energy supply companies and some 60% of Denmark's citizens rely upon it. Municipalities seek a balanced supply and order customized mixes of biomass, biogas, wind, solar and marine energy depending on location and the type of solution required. The Danish National R&D Strategies for Renewable Energy Technologies (2003), Subsidies for Renewable Electricity Generation (2004) and the Danish Energy Strategy 2025 (2005) initiatives set the appropriate framework for Danish heating and cooling engineers to evolve multiple renewable energy systems combining wind, solar, marine, geothermal, biomass and biogas energy to offset variability in supply of single sources. Hence, system variety and adaptiveness became 'emergent' in Danish renewable energy portfolios and the region whose path inter-dependence was able to press home its inherited collective advantage was north Jutland where most companies and clients are based (Cooke 2010).

Together, these regional District Heating firms, municipalities, university laboratories and technology transfer agencies created an association entitled Innovative Region: Flexible District Heating. This consortium, since renamed Flexenergie, for example, successfully bid for a project, valued in the millions, from the Danish 'Demand Driven Innovation Fund', which since 2007 has been managed and implemented through each of Denmark's five regions. This funds a number of future projects on multiple renewable energy combinations. This region serves as an 'environmental foreign policy' lighthouse attracting visits from numerous foreign delegations. Similarly, the Danish government has applied this public procurement model to the development of its electric vehicle and wind energy sectors, as well as several other sustainability initiatives aimed at reducing CO_2 emissions, with the aim of promoting demonstration projects and R&D activities.

Ireland

In 1949 the Industrial Development Authority (IDA) was established with responsibility for attracting foreign investment to Ireland. This began the transition of the Irish economy from a rural to an industrial based economy and set in motion an economy which, towards the end of the century, would move heavily into the tertiary sector. During the 1970s Ireland began to consider science policy through the work of the National Science Council and, subsequently, the National Board for Science and Technology. These efforts had a broad purview at the policy level, encompassing areas such as energy and the marine, as well as policy on technological innovation exemplified by the formation of Ireland's first biotechnology program. However, during this period there was a significant disjunction between the effort put into policy analysis and the funding flowing from that analysis.

A decisive shift in public policy and funding was initiated under the National Development Plan (NDP), 2000–2006. The major initiatives involved the foundation and funding of Science Foundation Ireland (SFI) and the expansion of the Higher Education Authority's Program for Research in Third Level Institutions (PRTLI). Both of these initiatives have been the subject of review by panels of international experts, with positive findings in regard to the rapid progress in building a base of world class research in Ireland.

Forfás, Ireland's national policy and advisory board for enterprise, trade, science, technology and innovation, was one of the first national agencies that had come out with recommendations for stronger emphasis on the knowledge society aspects of national innovation policy by making a series of recommendations in the 2004 report *Ahead of the Curve*. The Forfás 2006 Annual Report described Ireland's position in the globalized knowledge society as follows:

The accelerating pace of globalization continues to present enormous opportunities for countries with small open economies such as Ireland. The countries that will succeed are those that are agile and can respond quickly to emerging opportunities through coherence in policy choices and responses, and those that can forge knowledge-based partnerships with globally competitive enterprises and that create the conditions necessary to support new and emerging enterprises and innovations… Services exports now account for almost 40 % of total Irish exports of goods and services… Success in services also depends on the availability of creative and innovative individuals and on creating a strong research and innovation base across diverse areas from digital media to finance and law. It will also require increasing flexibility in the provision of state supports.

The Irish focus on knowledge-based partnerships, increasingly in services, became a dominant theme in the activities of Forfás. But an increasing interest in environmental issues could also be observed. Martin Cronin, Chief Executive of Forfás, noted in a newsletter in July 2007 that maintaining economic progress was contingent on good environmental practices. Ireland is more dependent on imported oil for its energy requirements than almost any other European country; it has been estimated that it will take up to 10 years to significantly reduce this dependence.

Forfás acknowledges that, compared to most EU member states, Ireland allocates a relatively minimal amount of state aid for the purposes of assisting companies to achieve environmental objectives. Forfás does however emphasize that policy makers and enterprises are becoming more aware of the benefits that enhanced environmental practices can have in strengthening competitiveness in tandem with improving environmental protection.

The present Irish strategy for science, technology and innovation, launched in 2006, aims at making the next leap forward to move Ireland from an impressive latecomer to an acknowledged leader. The success would be marked by demonstrable achievement in a number of critical areas:

- Increased participation in the sciences by young people;
- Significant increase in the numbers of people with advanced qualifications in science and engineering;
- Enhanced contribution of research to economic and social development across all relevant areas of public policy including agriculture, health, environment and the marine and natural resources;
- Transformational change in the quality and quantity of research undertaken by enterprise – both directly and in cooperation with third level institutions;
- Increased output of economically relevant knowledge, know-how and patents from those institutions;
- Increased participation in international S&T cooperation and transnational research activity;
- An established international profile for Ireland as a premier location for

carrying out world class research and development;
- Greater coherence and exploitation of synergies to mutual advantage in the development of STI policy on the island of Ireland.

Irish innovation system morphology

Ireland, with a 2011 population of 4.6 million people, earned the nickname the "Celtic Tiger" as a result of the rapid growth of its economy between 1995 and 2007. From 1995 to 2000 the GDP growth rate ranged between 7.8 and 11.5%. The rate then slowed to between 4.4 to 6.5% from 2001 to 2007. However, the expansion underwent a dramatic reversal from 2008, with GDP contracting by 14 % and unemployment levels rising to 14% by 2010. The 2010 GDP of €156 billion was thus considerably lower than the peak of 2007 of €190 million. One of the major reasons for the rapidly declining growth rate was the impact that the decline of the housing and construction market had on the Irish economy. The construction sector represented 19 % of GDP in 2007.

The rapid decline of the Irish economy was a radical departure from the growth path entered in the 1990s. Ireland had successfully positioned itself as one of the world's "super competitive" locations, earning a share of rapidly expanding cross-border global trade and FDI flows that had been out of proportion to the size of the Irish economy. Fast export growth from MNCs and a growing cohort of successful indigenous exporters had created a rapid increase in Ireland's global market share. Almost uniquely among developed countries, manufacturing's share of output and employment increased in Ireland in the 1990s. Productivity of those at work also improved rapidly, and a huge expansion in the numbers at work was facilitated by a favorable age structure, a high initial stock of unemployed workers, immigration and increasing female workforce participation. The FDI and export boom had a positive knock-on effect across the economy, stimulating increased household and government spending and rapid, broadly-based, economic growth.

Ireland remains very dependent on international trade. Its 2010 exports amounted to €163 billion, with chemicals (32%), computer services (17%), business services (14%) and machinery and transport equipment (7 %) as the most important export categories. UK (17%) and the US (16%) are the main export destinations. 2010 imports amounted to €127 billion, with business services and royalties/licenses representing half of the imports, and USA being the main import partner followed by the UK.

During the growth period, Ireland was transformed from one of Europe's poorer countries into one of its wealthiest. The causes of Ireland's growth are the subject of some debate, but one of the key drivers for the growth was the very low corporate tax rate, which attracted considerable foreign direct investment, particularly from the United States, which used Ireland as a bridgehead to enter the European Union. The infusion of foreign capital in turn stimulated the construction industry, to support the newly established companies, and it also positively affected the Irish financial services sector.

The total outlays on R&D in the Irish budget for 2009 were €941 million, which fell to €872 million in 2010. Due to the sharp drop in GDP due to the economic crisis, the R&D intensity in Ireland increased from 1.12% in 2000, to 1.45% in 2008 and up to 1.77% in 2009.

Research focus

The Irish research and innovation system is characterized by a strong high-quality scientific performance coming as the result of a well-established number of renowned universities, and the significant presence of foreign multinational companies, who account for a large share of the Irish scientific and technological performance and contribute to the positive manufacturing trade balance in high-tech and medium high-tech products.

Approximately two-thirds of innovation funding is undertaken by private industry in Ireland. The higher education sector performs about 30%, while the Government sector spends approximately 4.3% of the total.

The business sectors performing the largest percentage of R&D are the manufacturing sectors (40%), and information and communication services (26%). Total expenditure on R&D performed in the State sector fell to €131 million in 2010 (including R&D performed in hospitals).

One of the outcomes of a highly structured and planned approach to Foreign Direct Investment has been the rise of industrial clusters at a regional level. The main clusters are the medical technology cluster in the West of Ireland, the computer hardware and software in the East, and the pharmaceuticals cluster in the south-east.

Data for 2010–2011 indicate that there has been some scaling back in public R&D expenditure and there is

a fear that further erosion of publicly funded R&D could have an impact on the progress being made in increasing firm level innovation capacity and on export performance, given the traditionally strong relationship between these variables. Ireland's reduced GDP in recent years has, to a large extent, masked this decline given that R&D intensity ratios have improved owing to reduced national income. In particular, Ireland needs to continue the sustained growth trajectory in indigenous R&D spending, especially in manufacturing, if it is to continue to win export markets.

Modern and R&D-performing sectors have sustained output and export growth during the economic recession. The number of firms undertaking R&D and their R&D intensity has increased, towards international sectoral averages, but further progress is needed to bring firm level performance to that of competitors internationally. There has been a marked increase in commercialization activity from higher education institutes.

To strengthen the connections between researchers and industry Science Foundation Ireland (SFI) has established two vehicles: the Centres for Science, Engineering and Technology (CSETs), and the Strategic Research Clusters (SRCs). CSETs and SRCs help link scientists and engineers in partnerships across academia and industry to address crucial research questions, foster the development of new and existing Irish-based technology companies, and grow partnerships with industry that could make an important contribution to Ireland and its economy. SFI currently supports 9 CSETs and 19 SRCs.

A comparison of 2010 figures with year-end figures from 2009 shows an overall increase of 44% in the number of collaborations taking place with companies, 867 collaborations in total versus 601 in 2009. There was a corresponding increase of 37% in the number of companies (534) collaborating with SFI funded researchers. This is the upward trajectory expected as a result of, very significantly, SFI industry focused programs since the CSETs commenced in 2003 and the SRCs in 2007. Virtually all the blue-chip MNCs based in Ireland are connected to SFI funded researchers now and many companies (e.g. IBM, HP, Intel, Roche & Pfizer) have multiple collaborations. Through SFI, and complemented via other research investments, Ireland has seen a transformational change in the relationship between academic and industry in recent years.

Enterprise Ireland (EI) operates a suite of programs to expand research capacity in companies, to increase collaboration between enterprise and the research sector and to maximize the commercialization of the state's research investment. In 2010, Enterprise Ireland invested over €120 million in science, technology and innovation related activities. The main activities of EI are:

Transforming R&D Activity in Enterprise – This initiative supports the significant building-up of a company's in-house R&D capabilities and infrastructure, in the context of a development plan by the company for growing the business, taking into account the economic and market context in which companies operate.

High Potential Start Up Scheme – The provision of strong supports for start-up companies and entrepreneurs, primarily through equity investment instruments, will help to secure a source of future employment and will ensure that Enterprise Ireland's client companies are in a strong position when markets begin to recover. This activity is targeted for priority funding under the current budget projections to increase output to 100 HPSUs per annum by 2013.

Industry Collaboration with the Third Level Sector – Technology Centres & Industry Led Networks – The objective is to achieve competitive advantage for industry in Ireland through world-class collaborative research. The Centres are industry led and carry out market-focused strategic R&D by translating advanced research into technology capable of commercialization. It is planned to expand the number of Technology Centres to 16 by 2015 under the existing budget projections.

Commercialization of Research – The Commercialization Fund activities support academic researchers to undertake commercial, output driven research and to bring that research to a point where it can be transferred into industry.

Technology Transfer System – captures, identifies and protects intellectual property throughout the third level system.

TIS Architecture

In 2004 the Irish government noticed that if Ireland was to make the transition to a market-led economy, knowledge-based businesses would need to develop strengths in two areas which are, with recommendations for action, listed below (source: Enterprise Strategy Group, 2004):

In-depth knowledge of markets and customer needs:

- Establish, within Enterprise Ireland, a dedicated structure, 'Export Ireland', with its own budget and strong, experienced leadership, to develop a more focused approach to export market intelligence and promotional activities. (*Department of Enterprise, Trade and Employment*)
- Incorporate work placements and modules that focus on the practical capabilities required by firms into marketing and sales curricula. These should also be available to students of technical disciplines. (*Higher Education Institutions*)
- Establish a five-year program, to place, on a cost-sharing basis, 1,000 graduates and internationally experienced professionals in Irish firms to augment the stock of national sales and marketing talent. This program should be complementary to existing programs, such as the Export Orientation Program. (*Enterprise Ireland, IDA Ireland*)
- Target sales and marketing and European headquarters projects from both established multinationals and smaller companies at the early stage of internationalization. (*IDA Ireland*)

The ability to develop high-value products and services to satisfy those needs:

- Continue funding for research programs on a multi-annual basis beyond the current National Development Plan (NDP). (*Department of Enterprise, Trade and Employment, Department of Education and Science*)
- Establish, within Enterprise Ireland, a dedicated structure, 'Technology Ireland', with its own budget and strong leadership, to develop a cohesive, strategic and focused approach to market-led applied research and technological development and to leverage increased enterprise investment. (*Department of Enterprise, Trade and Employment*)
- Establish a consultative process to identify technology platforms. These platforms should be used to prioritize state expenditure on research and enterprise development. (*'Technology Ireland'*)
- Public funding for applied research and in-firm R&D should be progressively increased to match that invested by the Department of Enterprise, Trade and Employment in basic research. This includes support for infirm capability development, commercialization, cluster-led academic research and innovation partnerships. (*Department of Enterprise, Trade and Employment*)
- Develop an effective oversight and review mechanism that includes the appointment of a Chief Scientist, to optimize Ireland's national investment in science, technology and innovation. It should provide strategic direction to and co-ordinate national investment and should include structured evaluations of R&D expenditure. (*Department of Enterprise, Trade and Employment*)
- Draw up a national research and innovation strategy statement. An integrated approach to policy formulation and implementation should be undertaken that involves all players (enterprise, research community, state agencies, etc) in the national innovation system. (*Department of Enterprise, Trade and Employment*)
- Allocate a budget of 20 million per annum for five years from existing enterprise development agency resources to support the creation of enterprise-led networks to foster collaboration in defined areas of activity. All-island business networks should be supported where complementary strengths are identified. (*Department of Enterprise, Trade and Employment*)

In addition to the above listed measures the 2004 report argued that it would be important for businesses to recognize the importance of, and assume responsibility for, management capability building. This area should be a major business development priority. Additionally, business networks should articulate the management development needs of their members. These networks could act as a focal point for the delivery of targeted training.

At present, the Department of Enterprise, Trade and Employment (DETE) is committed to working for the Irish Government and people in order to increase the amount of quality employment and enhance national competitiveness. Other Government Departments whose activities hold implications for growth policy include: the Department of Education and Science, the Department of Rural and Gaeltacht Affairs, the Department of Art, Sports, and Tourism, the Department of Justice, Equality and Law Reform, and the Department of Finance. The DETE strategy supports entrepreneurs and innovative companies most extensively through:

- Enterprise Ireland which supports high growth potential start-up enterprises;
- City and County Enterprise Boards which support start-ups and enterprises with fewer than ten employees, and are responsible for the promotion of entrepreneurship at a local level;

- The Community Enterprise Centres (CECs) and Business Innovation Centres (BICs) which provide practical support and assistance to entrepreneurs at local level;
- FAS which provides training to nascent and actual entrepreneurs;
- BASIS which provides online information on State supports;
- An interdepartmental committee facilitates a unified approach by different Government agencies and bodies to the implementation of strategy;
- The Office of Science, Technology and Innovation (OSTI), which is responsible for the development, promotion and co-ordination of Ireland's Science, Technology and Innovation (STI) policy.

Enterprise Ireland (EI) is the main actor in Ireland for encouraging and supporting new high potential start-up businesses. EI provides advice and support to businesses at the pre-incorporation, pre-commercialization phase by incubating project ideas and highlighting available resources. Newly established businesses can also benefit from co-ordination assistance, seminars, workshops, and strategic direction. Businesses in the investment phase, have access to legal assistance, commercial evaluations, investment proposal assistance, and can be assigned legal, equity, and commercial teams.

EI is the government organization responsible for the development and growth of Irish enterprises in world markets. EI works in partnership with Irish enterprises to help them start, grow, innovate and win export sales on global markets. In this way, EI supports sustainable economic growth, regional development and secure employment. The range of services is:

- Funding supports – a range of supports, for start-ups, expansion plans, and R&D business plans.
- Export assistance – including the provision of in-market services, local market information and the facilities of its international office network.
- Supports to develop competitiveness – companies to become leaner to make them more competitive in international markets.
- Incentives to stimulate in-company R&D – new product, service and process development to ensure sustainability, and growth through the evolution of products and services.
- Assistance with R&D collaboration – with research institutions, to develop and bring to market new technologies, products or processes.
- Connections and introductions to customers overseas – providing access to a global network of contacts – from heads of government to end customers.

Enterprise Ireland's main objective is to accelerate the development of world-class Irish companies to achieve strong positions in global markets resulting in increased national and regional prosperity. The focus is on Irish companies, and there are five main areas of activity: achieving export sales; investing in research and innovation; competing through productivity; starting up and scaling up; and driving regional enterprise.

EI has a network of 13 Irish offices supplemented by 33 international offices; and works with entrepreneurs enabling them to compete to grow. EI also provides assistance for international companies who are searching for world-class Irish suppliers and support international companies who want to set up food and drink manufacturing operations in Ireland.

The following criteria are necessary for a business idea to benefit from EI's services:

- Entrepreneur must plan to operate in either the manufacturing sector or in an internationally traded service sector in an export led environment;
- Proposed product or service should be technologically advanced;
- Business must have high potential - likely to achieve significant growth within three years;
- Projected sales must incorporate a heavy export element;
- Business must be Irish owned and be located in Ireland.

Budget wise Ireland invests approximately €250 million annually in attracting foreign direct investment, which is the responsibility of IDA. IDA administers a range of investment incentives: capital grants, employment grants, and grants for training and for research and development; and it provides sites and buildings, often in partnership with private developers. Another highly important financial incentive is the low corporation tax rate: zero on export profits (1956–1980); 10 percent (1980–2003); 12.5 percent (2003–).

The key sectors attracting investment support from IDA are Life Sciences (Pharmaceutical, Biopharmaceutical and Medical Technologies), Information Communications Technology (ICT), Engineering, Professional Services, Digital Media, Consumer Brands and International Services. Emerging areas are Clean Technology, Convergence and Services Innovation.

TIS performance

Ireland was, in the 2010 Innovation Union Scoreboard, classified as an innovation follower, with an average close to that of the EU27, together with countries such as Austria, Estonia, France, the Netherlands, Slovenia and the UK. Ireland's performance was encouraging at an international level, with a high proportion of firms engaged in innovation activity, and a high level of innovation expenditure. At a domestic level, there are notable weaknesses in innovative activity, particularly on the part of small indigenous firms. Ireland's relative strengths on the scoreboard are in: Human resources; Open, excellent and attractive research systems; and Outputs, these areas also show a good level of growth. Especially Ireland is networked in co-publishing science internationally. In its evaluation of Ireland the Innovation Union report makes the following conclusion:

In the last decade, private R&D intensity grew from 0.8% in 2000 to 1.17% in 2009. This relative progress was achieved mainly due to the rise in importance of some medium-high tech and high-tech sectors, such as medical, precision and optical instruments in the overall economy, and the move towards higher research intensive segments in research intensity sectors such as office accounting and computing machinery. The weight and research intensity of the chemicals and chemical products sector are noticeable and constitute strong assets for the country. As a whole, the Irish economy is relatively well diversified and its trend towards a more knowledge and innovation intensive economy is a realistic prospect in spite of the current severe financial constraint. This will largely depend on the ability to maintain fa-

Figure 4. The anatomy of the Irish innovation system

Territorial Innovation System Morphology

- The overall Irish R&D intensity ratio increased to 1,77% in 2009, up from 1,12% in 2006, bringing it to the level of EU average, this development can, however, be largely accredited to the economic crisis. The industry performed 66 % of the total R&D and the higher education sector, 29 %, public sector accounting for 5%.
- The national Irish strategy for science, technology and innovation is becoming more centralized.
- Historically the Irish innovation system focus has been international, integrating attracting FDI and innovation policy.

TIS Resource Focus

- Ireland has a traditional focus on applied research.
- There are some high quality and renowned universities, but in terms of capitalizing this in terms of innovations Ireland needs to integrate better third level institutions into the innovation system. A commitment set in 2008 aims to double the number of PhD graduates in science, engineering and technology to nearly one thousand p.a. by 2013.
- Emergence of clusters relating to medical technology in the west of Ireland, computer hardware and software in the east, and pharmaceuticals in the south-east can be partly attributed to focused FDI strategies.

TIS Architecture

- Low inter-firm co-operation; collaboration promoted through networks, centers for science engineering and technology,
- The ministries and Forfásas advisory organ function as innovation policymakers. Institutions in implementing the policy are Enterprise Ireland and IDA Ireland for indigenous respectively exogenous enterprise innovation/ development, Science Foundation Ireland and Irish Research Council for Science, Engineering & Technology are responsible for research funding.
- In addition to R&D funding, tax exemptions also have an important resource allocation effect for R&D .

TIS Innovation Performance (IUS)

- The 2010 Innovation Union Scoreboard classified Ireland as an innovation follower, with an average close to the EU27.
- At a domestic level, there are notable weaknesses in innovative activity, particularly on the part of small indigenous firms.
- The scoreboard points out relative weaknesses in Finance and support, Linkages & entrepreneurship, Intellectual assets and Innovators.

vourable framework conditions throughout the sectors and to encourage investment in R&I by less intensive sectors such as food products and beverages or publishing and printing.

An innovation taskforce (see www.innovationtaskforce.ie) presented its report in March 2010. The main recommendations from this report were to: place entrepreneurs and enterprises at the center; establish, attract, grow and transform enterprises; ensure the availability of smart capital; develop an education system which fosters independent thinking, creativity and innovation; encourage flagship projects and prioritize the provision of excellent infrastructure; and sharpen the focus of the national research system to target areas of potential strategic and economic advantage for Ireland.

CASE: The Irish software sector

In the early 1980s Ireland emerged as a hotbed of software development activity. Many of the world's leading software companies including Microsoft, Oracle and Symantec, based their European operations centers in and around Dublin. At the beginning of the new millennium, there were more than 800 international and indigenous software companies located in Ireland, employing over 25 000 people. Ireland had attracted one-third of all US electronics investment in the EU.

In 2004 one-third of all personal computers sold in Europe were manufactured in Ireland. Microsoft's Dublin operation alone accounted for four per cent of Irish exports. The indigenous sector employed more than 15 000 people in 2006 and generated revenues of about €1.4 billion. In total, the software sector in Ireland was responsible for about 13 per cent of Irish exports. However, a challenge was posed by multinationals tendency to use Ireland as a base to export software developed elsewhere, resulting in little of the generated value being able to trickle down to local software firms.

The roots of the development of the Irish software sector went back to the educational reforms of the 1960s and the highly educated generations that were produced in the subsequent decades. A further factor in the success of the Irish software sector was the low corporate tax regime, which proved particularly attractive to multinational corporations.

Under the policy constraints of the 1980s, overseas firms in Ireland had to be classified as manufacturing rather than service firms if they wished to obtain support from the Irish government, e.g. Microsoft had to manufacture disks in Ireland in order to qualify for assistance. There were two reasons for this anomaly: first, corporate tax rules that required proof of 'tangible substance' in the output of companies; and second, governmental reluctance to assist service sector companies (arguing that the wealth creation value was intangible).

From 1981, a statutory instrument identified ten service sectors that government could support. Software was one of these sectors. The objective was to identify winners but only in the context of what was already occurring through market selection and forces in international business. Irish policymakers saw software development and data processing as emerging businesses in Ireland with high growth potential. During the years 1981–97 the Irish government pursued a targeted, preferential policy regime. In 1997 a new regime was mooted, and the government policy no longer targeted sectors or provided preferential treatment for any industrial areas.

Irish industrial policy in the 1960s and 1970s was criticized for supporting foreign MNCs and for being less interested in the promotion of indigenous Irish companies. An influential report produced by the National Economic and Social Council in 1982 initiated a series of changes that increased the attention of the government on indigenous companies.

The Irish industrial policy became what could be called 'state interventionist but with a hands-off approach', which encapsulated the apparently contradictory nature of Irish industrial policy. An example of government proactivism: in the late 1990s, Chris Horn, founder of Iona Technologies, one of Ireland's largest software companies, led an inquiry into the state of the labor market in the IT sector. He concluded that the industry was heading for a labor shortage unless large-scale supplies were found. The Irish Government immediately announced that it was quadrupling the number of degree places in computer science from 400 to 1 600 over the seven years to 2004. The rules on immigration were also eased to facilitate the entry of IT engineers from abroad. FAS, the government sponsored training agency began to host overseas job fairs.

The impact of the Internet bubble highlighted the fragile nature of many of Ireland's early-stage software companies, for example during 2002 the sector lost, in the region of, 4,500 jobs. Lawton and Innes (2003) noticed that there was a need for substantial external funding to keep the whole sector alive. Subse-

quently the most promising companies like Baltimore Technologies and Iona Technologies were not able to respond to the expectations they created in the early 2000's. Baltimore was dissolved, and Iona Technologies was acquired by US based Progress Software in 2008 for USD 162 million.

However, even if the software sector, as a stand-alone cluster, has not been able to live up to expectations, the investments in the software industry have had a positive side-effect: the combination of software and medical sciences has led to the emergence of an Irish MedTech cluster. This cluster comprised, in 2011, approximately 120 companies with over 24,000 jobs.

The MedTech cluster is driven by the significant presence of large foreign-owned subsidiaries, whose capabilities lie in manufacturing as well as product and process development activities. Ireland's MedTech cluster seeks to learn about the cluster in Massachusetts, particularly its institutional model, and despite Ireland's economic woes MedTech FDI continues to grow. On Monday January 9th, 2012, IDA Ireland welcomed the announcement by Allergan Pharmaceuticals Ireland that it would invest $350 million in its Westport operation to expand both its development and manufacturing capabilities. The expansion will result in the creation of approximately 200 new jobs at the site over the next four years and an estimated 250 indirect jobs locally, during the construction period. The investment is supported by IDA Ireland.

A crucial influence in the development of the MedTech cluster is the financing directed towards it. State agencies have played important roles in early stage financing through tax incentives but also through direct funding and loans from agencies such as Enterprise Ireland and the Irish Film Board. This funding has in some cases been crucial in allowing firms to develop their projects to the point where they are viable prospects for external investors. Research funding in biotech serves as a very substantial public subsidy of innovation in the industry.

The performance of the MedTech cluster suggests that, the innovation projects of companies in the Dublin area involve very little collaboration with other regional and even national actors. As regards the sources of knowledge during the various stages of the innovation trajectories, as regards the intentionality of the knowledge flow; the most vital knowledge is exchanged intentionally. Unintentional knowledge flow appears to have been of limited relevance for the specific innovation trajectories although it does occur and can play a role, particularly during the first stages when most projects tend to be in the hands of academic research groups.

The government's role in creating and nurturing the right environment and conditions for high-technology and software clusters has been seen as crucial. The software sector was expected to generate revenues, and moving up the value chain was the ambition. Ireland would then be responsible for idea generation, design, management and the marketing of software. The actual production of software would be done elsewhere. However, the software sector was not able to reach these targets. Nonetheless, the rise of the MedTech cluster may at least be seen as a non-intended spillover effect of those efforts.

Sweden

The Swedish economy has performed comparatively well in Europe in recent years. With a population of 9.4 million, a 2010 GDP of SEK 3 300 billion (€365 billion), and a governmental debt of less than 40%, Sweden is in a position to continue its strict fiscal policy aiming at:

- surplus target for the entire government sector,
- central government expenditure ceiling,
- local government balanced budget requirements, and
- strict budget process.

Sweden's strict fiscal policy implies that macroeconomic *stability* is on top of the economic policy agenda. An important feature of the fiscal framework is that it has led to a governing process that focuses, to a very high degree, on budgetary matters and, to a lesser extent, on policy content and differences between sectors and policy areas. This focus may be in conflict with the ongoing dynamism and change that is associated with much needed innovation and transition. In 2009, Sweden's R&D intensity was 3.6 % (1.06 % public + 2.54 % private). This is well below its peak level of 2001 (4.18 % of GDP). The downward variation is mainly due to changes in private sector R&D investments. In view of 2020, Sweden is considering a preliminary national R&D target of 4 % of GDP.

The Swedish economy is open and export oriented. At the moment, the fact that the most important markets are in neighboring countries with relatively low growth rates, while, simultaneously, a large share of exports are products with relatively low market

growth, poses a problem. The lack of transition to other markets would have been a major problem were it not for China.

Swedish innovation system morphology

In Sweden the private sector is the main source of R&D funding. Public funds for R&D are usually directed towards Higher Education Institutions (HEIs) or through research councils, public foundations or sectoral agencies. On the whole, public research institutes play a minor role with the exception of the area of defense.

The Ministry of Research and Education and the Ministry of Industry (in Sweden called Ministry of Enterprise, Energy and Communications) are responsible for most of the public agencies and research councils financing research in Sweden. Swedish innovation policy underwent a major reorganization in the year 2000, with the creation of new agencies and the reorganization of some of the research funding agencies like NUTEK. Among the new agencies created in this reorganization was VINNOVA.

Despite the fact that Sweden, like Finland, ranks high in most country rankings of competitiveness and innovation, recent years have presented structural problems, which need to be addressed. Even though Sweden scores high there are some signs of emerging challenges and/or problems of policy relevance. Observers have indicated that the dynamism of the Swedish economy is declining. One indicator of this process is that the terms of trade have been deteriorating for several years. This structural problem is also addressed in the Innovation Union report:

The slightly lower dynamics of knowledge-intensive firms has contributed to a lack of major structural change in the Swedish knowledge economy over the period 1995–2007. Many of the large research-intensive firms are close to the world technology frontier in their domains and, therefore, have small margins to increase their R&D intensity relative to international competitors. However, the Swedish manufacturing sector is showing signs of diversification, with knowledge and R&D being injected into and invested in medium-and low-tech sectors, both more traditional (such as textiles or basic metals) and newer sectors (in particular recycling and publishing–printing). The Swedish economy has not shifted towards a larger weight of knowledge-intensive manufacturing sectors in the economy. This stable sectoral composition of Sweden shows that the increases in R&D intensity inside sectors have not been enough to compensate some decreases. Sweden needs the emergence of new sectors.

Research focus

The main structure for research funding – the research councils – has gradually evolved. The first research council in Sweden was formed as early as 1945. The reforms undertaken in 2000 were carried out to change NUTEK and other funding agencies into research councils. Today one can observe that even if the Swedish Research Council (Vetenskapsrådet), the major funder of basic research, and VINNOVA are both formally research councils they operate differently, not least in the way the project applications are evaluated. VINNOVA, KK-foundation and the Foundation for Strategic Research all have mixed groups of experts from both academia and industry whereas the Swedish Research Council uses academics only. These different research councils also operate independent of each other, which means that a specific research group may receive funding from several sources over time.

The Swedish economy is relatively strong in engineering industries, telecommunications, and life sciences. This strength also rests upon the competitiveness of about 20 big companies. These companies account for about 80% of industrial R&D. These companies have long been dependent on international markets. Lately, many of them have, however, been taken over by foreign companies in, for example, the automotive and pharmaceutical sectors. This change in ownership has happened in parallel with a change in corporate governance towards a more Anglo-Saxon style. In combination these two processes have made Sweden less of a home base for large multinational companies, and subsequently much discussion in Sweden has surrounded how to keep or attract footloose R&D investment into the country. One part of the policy answer has been to pool private and public R&D and innovation resources in the development of "Innovation milieus" such as competence centers, innovation clusters etc. Direct public financial support to big companies is quite limited in Sweden.

If the prominence of a few large companies is one important feature of the Swedish innovation system, another is that a significant amount of research is concentrated in universities, while the share of research that is performed in research institutes is comparatively small. This model implies that universities can serve as "platforms" for

curiosity driven research as well as issue-driven research. This "double" role for universities has been an important element in policy discussions for a long time. The challenge is how to attain both academic excellence and societal relevance.

During the last decade, all research funding has been channeled through a reduced number of research councils. The "power" over design and coordination has also shifted from the Office of the Prime Minister to the Minister of Research and Higher Education. The Minister of Industry is responsible for Innovation Policy and VINNOVA serves as the national agency. The emphasis on academic excellence in innovation policy continues to be very strong. The structure of the Swedish research funding system is depicted in Figure 5.

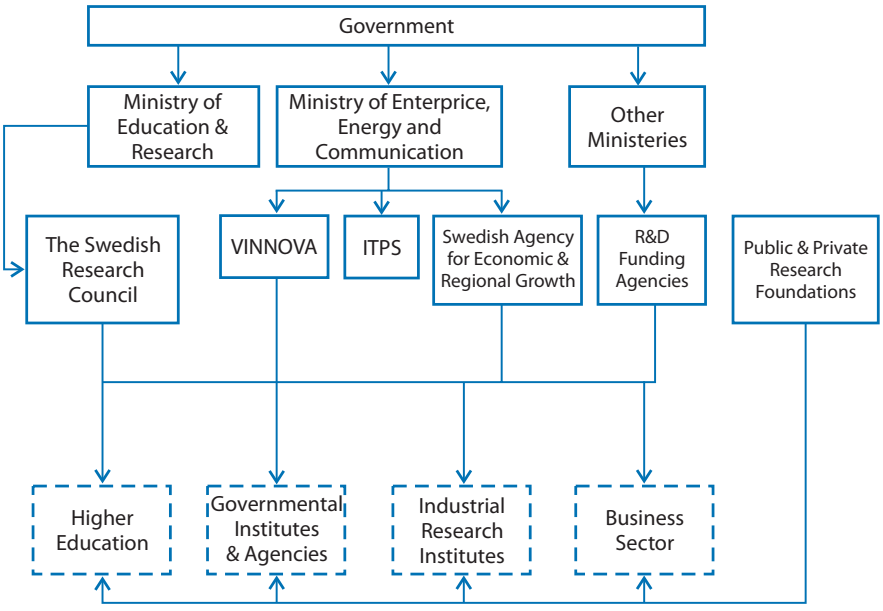
Global innovation and production activities are attracted to certain regions or clusters, which have accumulated competences in a particular industrial area. In the case of Sweden areas of specialization are cleantech, automotive, ICT, materials science and life sciences.

Cleantech: One of the newest clusters in Sweden is comprised of Clean or Green Technologies (Cleantech) and, particularly of biofuels, wind power and solar cell manufacturing. The Swedish cleantech cluster is largely a product of Sweden's accumulated competences in engineering. The cluster is located in the north of Stockholm (including Uppsala).

Automotive: Sweden has a long tradition in automotive innovation which is built on a long specialization in the production of passenger and commercial vehicles. Although the industry is currently undergoing re-structuring (Volvo has been acquired by the Chinese Geely and Saab was forced into bankruptcy), some of the world's most innovative companies in car safety (for example Autoliv) and intelligent transport systems have their headquarters in Sweden. The cluster has attracted production and innovation activities worldwide, including MNCs subsidiaries like Bharat Forge from India. The center of this cluster is Gothenburg.

Information and Communication Technologies (ICT): One of the most important clusters in Sweden is that of ICT, particularly mobile communications, media (IPTV) and computer games. There are three main factors that explain the success in ICT: the presence of

Figure 5. The structure of the Swedish research funding system



Source: Adapted and updated from Roos et al. 2005

world leaders in communication technologies, such as Ericsson; the pool of qualified human resources in related communication technologies; and customer demand. One of the main drivers of innovation in the ICT industries is the proximity to the customer. Swedish customers are among the quickest in the world to adopt new applications and services, which makes Sweden a good test market for new applications. This cluster has attracted a large number of R&D centers from all over the world, like TCS and Infosys from India and ZTE, Huawei and Lenovo from China. The cluster is mainly located in Kista, on the outskirts of Stockholm although there are two emerging clusters in Skåne (for computer games) and Linköping (for web servers and IPTV).

Materials science: The Swedish specialization in materials science can be explained by the combination of research specialization at the universities and the accumulation of industrial know-how in paper and pulp and packaging technologies based on cellulose fiber – like Tetrapak. In the future, Sweden will host Europe's largest research facility for materials research: the European Spallation Source (ESS). In contrast with the previous clusters, the materials science cluster is spread all over the country: e.g. materials research on packaging in Lund and Stockholm and material research related to textiles in Borås (close to Gothenburg).

Life sciences: The specialization in life sciences is based on the combination of world class research (for example The Karolinska Institute in Stockholm) and medical universities and a cluster of large multinational companies in biotechnology (including biomed) and pharmaceuticals like Astra Zeneca, Elektra, Gambro and Pharmacia. There are two main clusters in Life Sciences, one in the South of Sweden – the Medicon Valley – and the other in Stockholm. The life sciences clusters have specialized in biotech tools, diagnostics, medical devices, biomaterials and regenerative medicine.

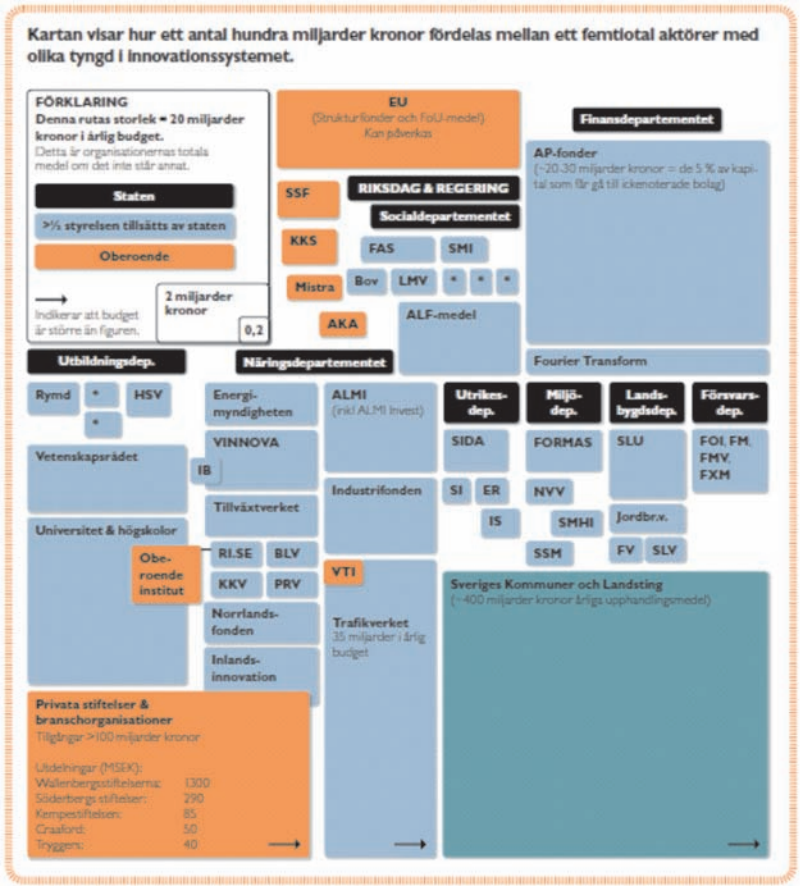
TIS Architecture

The public Swedish innovation system's composition, consisting of various actors, is illustrated in Figure 6.

Figure 6 clearly illustrates the importance of the regional dimension in the Swedish innovation system. Whereas Tekes and the Academy of Finland have a very large portion of the public research funding in Finland, the Swedish funding system is much more fragmented. For instanct, VINNOVA's 2011 budget was about 2.1 billion SEK (about €230 million), which is, relatively, much lower than what the Finnish government has allocated through Tekes. This is also reflected in the slightly different positioning of VINNOVA in the Swedish innovation system compared to Tekes.

VINNOVA's main task is to "promote sustainable growth and develop-

Figure 6. The key actors in the public Swedish innovation system



ment for the business community, society and individuals by developing effective innovation systems …". This general objective is translated into three main functions:

- Advising the government on innovation policy issues;
- Commissioning and conducting in-house research on innovation related issues;
- Designing and implementing (national, regional and sectoral) policy programs to support and stimulate innovation.

VINNOVA has, very specifically, adopted an innovation approach in policy making. Policy actions deployed by VINNOVA aim at promoting problem solving research and developing *effective* innovation systems. VINNOVA defines *effective innovation systems* "as consisting of actors from science, business and politics, which interact to develop, exchange and apply new technologies and new knowledge in order to promote sustainable growth by means of new products, services and processes". VINNOVA aims to promote the effective interaction of these actors to facilitate the transformation of new knowledge into products, services and processes as well as ensuring effective links with other innovation systems (national, regional and sectoral).

The regional program VINNVÄXT is the best example of how network problems are being addressed by VINNOVA. All initiatives funded at the regional level must involve all relevant actors at that level, including policy-makers. To increase cooperation between the organizations, VINNOVA trains "innovation system developers", that is, facilitators that can "mobilize the level of commitment and resources needed to create efficient groups and processes which will produce concrete results".

The industrial research institutes focus on applied research and are jointly funded by the government and the industry. The institutes were created with the aim of providing some research capabilities to industries that were fundamentally dominated by SMEs. Therefore, the institutes tackle, in principle, two problems related to the Swedish innovation system: the low participation of SMEs in R&D investments and the focus on basic research. However, in contrast to some other countries, the industrial research institutes play a minor role in the Swedish innovation system, with even decreasing budgets over time. Examples of some of the industrial research institutes are: the Institute for Electronic, Optics and Communication Technologies, the Institute for Manufacturing Technology or the Swedish Institute for Food and Bio-Technology.

Sweden has a series of programs supporting R&D in certain strategic areas that are particularly targeted to foreign actors. For example, in the automotive sector, the Swedish government has the *Strategic Vehicle Research and Innovation* Initiative that supports applied research in energy and the environment, transport efficiency, vehicle and traffic safety, vehicle development and sustainable production. Funding is eligible to any foreign company with a subsidiary in Sweden and with an established agreement with a Swedish company or to any university or research institute from abroad that have unique competences not available in Sweden.

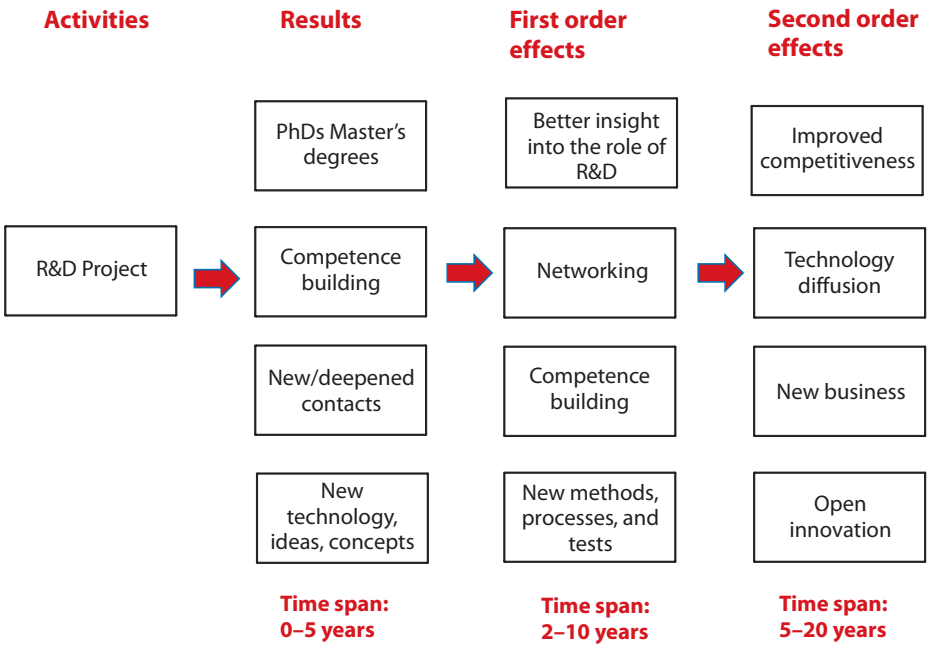
TIS Performance

VINNOVA recently co-funded an assessment of strong Swedish R&I systems (http://www.vinnova.se/upload/EPiStorePDF/va-11-07.pdf). The focus was on the R&I systems as such, not on the funding instruments. It concludes that the strong R&I systems have produced substantial results and impacts across the entire triple helix. The most obvious results were scientific publications, granted patents, PhD degrees, licentiate degrees and master's theses. The analytic framework used in the assessment is shown in Figure 7.

The quantifiable impacts on the companies that this impact assessment was able to validate (there are of course others) were that 96% of the granted patents were issued to Swedish-based companies and that 78% of the PhDs were active in Swedish industry at the time of the assessment. The more difficult-to-define impacts, which the interviewees within the companies nevertheless agree on, are among others:

- New knowledge that has been further developed by the companies themselves, resulting in new, as well as improved and more competitive, materials, processes, products and services reaching the market and thereby resulting in revenue increase
- Bases for decisions on critical technological choices
- Software developed by R&D providers that is being used by companies to speed up and increase the quality of internal processes and development stages, which in turn has resulted in increased competitiveness
- Competence development of existing personnel through participation in R&D projects together with R&D providers and other companies

Figure 7. The impact assessment of R&I systems in Sweden



- Increased competence for the personnel at large through recruitment of PhD graduates (and to some extent, MScs)
- New internal working practices in R&D-related matters
- Access to laboratory facilities and valuable networks

It could also be concluded that the durable relationships that had been established would suggest that the companies had gained something that was of commercial value to them.

For the R&D providers, large, long-term grants have created opportunities to establish relatively broad collaborations with other R&D milieus both within as well as outside their own institutions, primarily but not exclusively in Sweden. This has resulted in a disciplinary diversification that has made the R&D providers more attractive to companies. Recent years' successes with proposals have no doubt facilitated achievement of critical mass for the R&D milieus. The R&D milieus have, over time, developed their working practices and now focus, to a larger extent, on issues of clear industrial relevance.

The main socio-economic impacts are that the country has gained a number of internationally competitive R&I systems, participating companies have become more competitive and a number of PhDs have been added to the Swedish workforce. The R&D providers' contributions to the country's research infrastructure and the increased competitiveness of the companies are both likely to have had substantial positive employment impacts in Sweden. The majority of the PhDs (78%) were employed in Swedish industry.

R&D results and PhDs have also spread to companies and industry sectors that have not directly participated in the R&I systems, including the medical technology industry, pharmaceutical industry, construction, forestry and packaging. Additional opportunities for technology and competence dissemination, particularly for SMEs, arise through participating research institutes. The fact that strong R&I systems, R&D providers as well as participating companies, become internationally known both on the scientific arena and on commercial markets means that Sweden's image as a research and technology nation is further strengthened.

The conclusion of the assessment is that strong R&I systems comprise internationally leading R&D milieus of considerable mass, which maintain close and sustainable collaborations

with internationally leading companies. A strong R&I system has its core in an R&D milieu, but companies and other R&D milieus belonging to the system can be located elsewhere, even abroad. These R&I systems are strong in terms of both development and implementation of new knowledge, and they have a multidisciplinary approach that focuses on industrially relevant R&D.

Apart from necessary conditions in terms of funding and a supportive partnership, which requires an industrial base of relevance for the R&D field, there is no doubt that the most important condition for the establishment and growth of a strong R&I system is competent leadership. Success also requires a shared set of objectives or visions among R&D providers and companies. The durability of these shared objectives or visions requires the presence of challenging R&D problems of industrial relevance. Thus success ultimately demands continuous mutual consideration in order to ensure win-win solutions. Furthermore, trust and confidence, particularly between key members of each organization, are far more important than formal agreements.

A good match between the activities of the R&D milieu and the host university's prioritized R&D profiles is essentially a prerequisite for developing a strong R&I system, since Swedish calls for proposals for center grants in recent years have required that the university itself must be the applicant and also that it must provide co-funding should the proposal be granted. There is, nevertheless, a correlation between the two in that, generally speaking, strong R&I systems constitute an asset for the university, which reasonably defines its prioritized R&D profiles based on existing, strong R&D milieus. This may possibly result in lock-in effects, wherein already strong R&D milieus may be favored at the expense of ones that could develop into new, strong R&I systems.

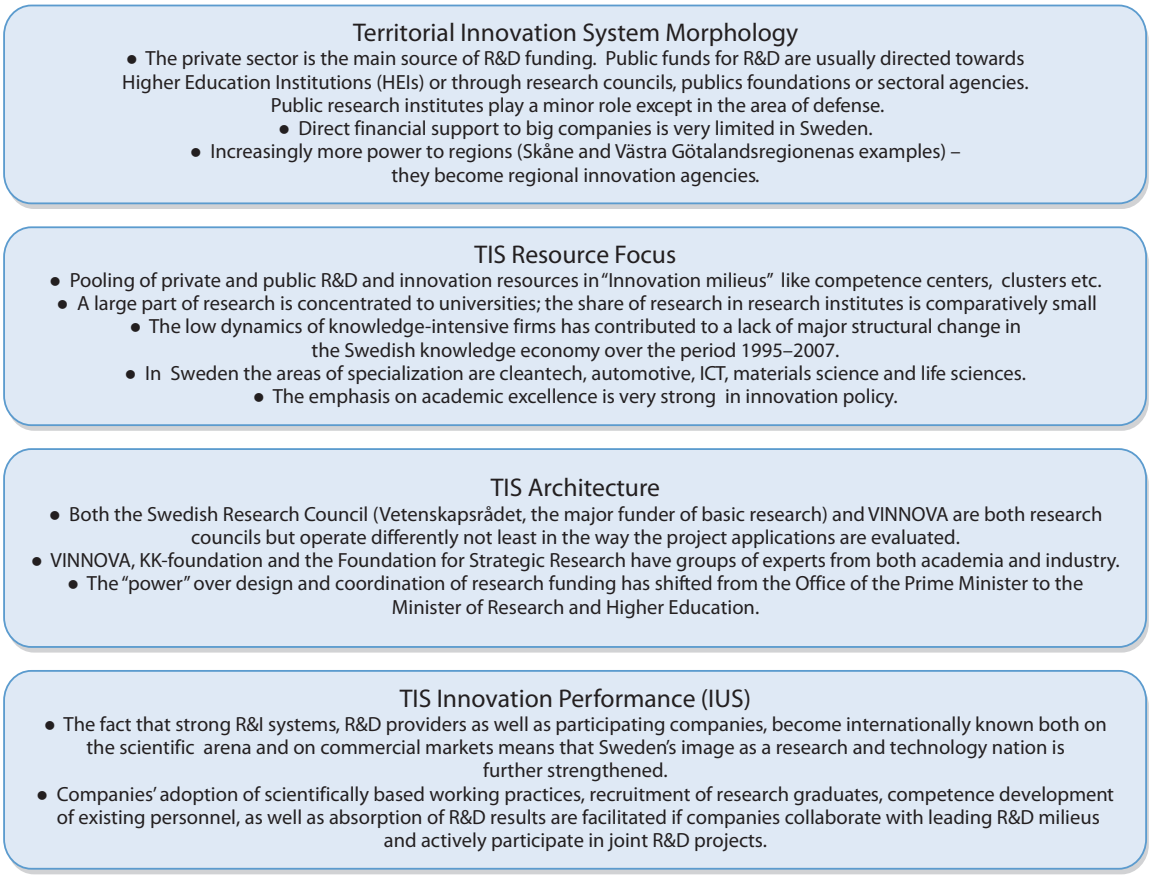
There are relatively few agencies that, like VINNOVA, fund R&D that requires and encourages active industrial participation. Such funding requirements stimulate companies to take part in the activities of R&D milieus, with an obvious expectation of gaining something of commercial value in return. In the absence of such requirements, there are, for most companies, only limited incentives to collaborate with an R&D milieu, partly due to the milieu's R&D activities then becoming more curiosity driven than industrially oriented. Analogously, there are only limited incentives for an R&D milieu to strive to engage companies in R&D collaboration if the funding agency does not explicitly require such collaboration.

Successful R&D milieus have learned to design a portfolio of grants, which complement each other and include funding for both curiosity-driven and industry oriented R&D. The grants portfolio supports the R&D milieu as a whole, and the center grants only constitute a subset. The duration and the stability of long-term grants have nevertheless been crucial for the establishment and evolution of the R&I systems, and the durability has proved far more important than the magnitude of the funding.

This assessment shows that companies' adoption of scientifically based working practices, recruitment of research graduates, competence development of existing personnel, as well as absorption of R&D results are facilitated if companies collaborate with leading R&D milieus and actively participate in joint R&D projects. This assessment also illustrates that the working practices that evolve between R&D providers and companies whet their appetite for more of the same, thus leading to behavioral patterns, additionally; collaboration becomes sustainable and the working practices continue to evolve as long as public funding is available.

The Innovation Union Scoreboard notes that the Swedish research and innovation system is characterized by a dominant private sector combined with a public sector with a very high and expanding research and education investment rate. The leading performer of research in Sweden is the business enterprise sector (accounting for around 74% of the R&D expenditure in the last five years). The second main performer is the higher education sector, with the universities as the main actors (around 20% of total R&D expenditure). Sweden is among the most knowledge-intensive countries in the world, with over 42% of the work force employed in knowledge-intensive activities. It has among the highest R&D intensities, high shares of researchers and skilled human resources in the economy, low unemployment rates for researchers and high levels of new academic-oriented tertiary education degrees. These efforts have resulted in very high and rising quality of scientific production (a ratio of 14% of Swedish scientific publications are among the 10 % most cited in the world) – although here Sweden is below the scientific quality of Denmark, Switzerland and the United States. Sweden has also achieved a high number of patent applications – as well as high-tech patent applications – to the European Patent Office per billion GDP.

Figure 8. The anatomy of the Swedish innovation system



The Swedish national innovation framework conditions show clear strengths in several areas: a stable macroeconomic environment, a highly trained workforce, a handful of R&D-intensive multinational corporations, one of the highest levels of venture capital availability in the world (both for early stage and expansion capital), and a high rate of broadband access by firms. These strengths are reinforced by Sweden's integration into global markets. – The anatomy of the Swedish innovation system is summarized in Figure 8.

CASE: Challenge-driven innovation

In 2011 VINNOVA launched a program called Challenge-driven innovation with an aim to use societal challenges as a driver for innovation. The assumption of VINNOVA is that challenges are drivers of Sweden's innovation and growth in a global context. These challenges should be drivers of need and demand. Starting with a challenge requires broad collaboration between companies, universities, research institutes and government organizations; VINNOVA wants to help link up and catalyze the efforts of various actors.

VINNOVA has identified four societal challenges where Sweden is considered well-placed for internationally leading innovativeness:

- Information Society 3.0
- Sustainable Attractive Cities
- Future Healthcare
- Competitive Production

Some coordination between this program and innovation procurement is to be expected. Together these initiatives

are in line with an international trend of addressing societal challenges, but they also have a special significance in Sweden because of their resemblance to the very successful "innovation model" of the 1950s and 1960s. During this time the Swedish government used public procurement in the energy, transport and communications sectors for innovation and development of early markets. This took the form of "development pairs" between leading Swedish companies like Ericsson, Sandvik, Atlas Copco, Alfa Laval and utility agencies like Vattenfall and Televerket. These collaborations were systematic and long term and took their theoretical inspiration from Erik Dahmén´s work on development blocks.

In April 2011 VINNOVA announced a call for tender for projects that would address grand challenges. The ambition was to attract large constellations of companies, universities, research institutes, public sector, non-governmental organizations or trade organizations. VINNOVA would, in these initiatives, catalyze the collaboration between the various actors to be able to address challenges that identified clear target customers and would produce innovations improving quality of life and economic growth. The structure of the funding procedure is divided into three stages. The first stage focuses on the development of the idea for the project as well as building the research constellation. The second stage involves the actual development and integration of the different elements needed for the systemic innovation to materialize. The third stage focuses on implementation. Through the first call for tender it was possible to apply for funding for the first stage, or if the constellation felt that the idea was at a stage where enabling it to apply directly for stage two, this was also possible. The closing date for the tender was end of September 1st, 2011.

VINNOVA received a total of 635 applications of which 94 were granted funding. The funding decision was communicated to the applicants in the second half of October 2011. Those projects that were granted funding for the first stage would have to prepare the application for second stage funding to be submitted to VINNOVA by the end of March 2012.

Switzerland

Without abundance of natural resources, Switzerland has always relied on the capabilities, ideas, virtues and connections of its inhabitants. As a small, densely populated country with 7.9 million inhabitants in the heart of Europe its individuals and organizations are both intensely interconnected domestically, as well as maintaining widespun connections internationally.

Switzerland counted 15 companies from the 2010 Fortune 500 list. These companies represent a variety of industries such as machinery, precision instruments, watches, chemicals, pharmaceuticals, and financial services.

Swiss innovation system morphology

R&D intensity in Switzerland in 2009 was 3% of GDP. The private sector performed 74% of the total R&D and the higher education sector 24%. Direct government spending on R&D is subsequently low, only 0,02%, which is fairly low in comparison to the OECD average of 0,26%.

While government spending on R&D has been comparably low and stable over the years, the public endeavors to maintain and enhance the national innovativeness in Switzerland are well aligned and are pursued by a small amount of organizational actors with clear responsibilities, strong inter-relations and common priorities. In complementation to R&D spending a strong focus is set on supporting local spillover effects within the existing industrial clusters in pharmaceuticals (Basel area), financial services and machinery (Zurich area) and watches and precision instruments (Jura-Bern area).

Public research funding in Switzerland is based upon two institutions with complementary purposes and responsibilities: the Swiss National Science Foundation (SNF), and the Commission for Technology and Innovation (CTI).

Collaboration on regional as well as national level is intense and ultimately facilitated through population density and physical proximity of key actors. To further foster such inter-linkages, SNF and CTI put emphasis on funding activities conducted jointly by multiple actors. Collaboration on international level is attributed to close cultural and historical ties to its technological links with partners in foreign countries. As a result 45 % of the total Swiss patent applications have been developed with a co-inventor located abroad.

SNF and KTI consider themselves as a funding partnership with a shared overarching strategy but complementary objectives. They conduct joint conferences and public events on national and international level and carefully adjust their funding decisions on local level. The executing actors, the country's 12 universities and 9 universities of

applied sciences collaborate by offering joint Masters- or PhD programs and by conducting joint research projects. The universities of applied sciences throughout the country went through a consolidation process in the past 10 years resulting in regional institutions, with different academic units in different locations.

SNF and CTI also complement each other in respect of their funding. While SNF's goal is to foster the exploration of a wide range of phenomena and ensure a high national absorptive capacity, CTI acts as the central innovation promotion agency with the objective of effective market impact and emphasis on research applications. While universities and federal institutes of technologies receive slightly more funding for basic research, the Universities of Applied Science have a slightly higher activity in industry collaborations and research applications.

Research focus and TIS architecture

The Swiss National Science Foundation is established as a foundation under public law with federal mandate, in order to ensure independence of research funding. Its general objective is the advancement of scientific insight in all possible knowledge areas, ranging from Philosophy and Anthropology to Medicine and Nano Sciences, without consideration of applicability for commercial purposes. It also encourages dialogue between scientists and representatives in society, politics and the economy. A strong focus on education and diversity is realized by a quote of 80% of funding-recipients below the age of 35 and a variety of programs targeted at the advancement of women, which is regarded as a long-term investment in local human capital.

With an annual funding volume of CHF 600–700 million, the SNF is the most important institution for advancing scientific research in Switzerland and supports around 7,200 scientists each year, who are usually associated with one of the 12 universities or 9 universities of applied sciences within the country. Its main activity being the scientific evaluation of the submitted research proposals the SNF distinguishes two categories of funding:

- National Research Programs (NRPs)
- National Centers of Competence in Research (NCCRs)

NRPs are supporting individual problem-orientated, inter- and trans-disciplinary research projects for a usual duration of 4–5 years. On a larger scale, the establishment of NCCRs with the objective to promote "scientific excellence in areas of major strategic importance of the future of Swiss research, economy and society" and a usual funding duration of 12 years, was initiated 10 years ago. The current NCCRs consist of separate, coherently integrated research projects, with the main responsibility upon one research institution and formal collaboration with further research teams located throughout the country. While some teams conduct basic research and explore untrodden lands, others work towards specifically targeted research applications in close interlinkage with business partners.

Since 2001 SNF has created 27 National Centers of Competence in Research, which couple various individual projects conducted by different institutions under the coordination of one academic unit. While research in historically grown industry clusters is augmented through corresponding NCCRs, additional clusters are likely to emerge around interconnected research efforts in nano-scale science, molecular ultrafast technology or multimodal information management. NCCRs economic impact extends the value of its research outputs by the emergence of academic spin-offs and education of highly qualified research personnel. The NCCRs are as follows:

Life Sciences

- NCCR Molecular Oncology – From Basic Research to Therapeutic Approaches
- NCCR Frontiers in Genetics – Genes, Chromosomes and Development
- NCCR Molecular Life Sciences – Three Dimensional Structure, Folding and Interactions
- NCCR Neuro – Neural Plasticity and Repair
- NCCR Kidney.CH – Kidney Control of Homeostasis
- NCCR SYNAPSY – The synaptic bases of mental diseases
- NCCR TransCure – From transport physiology to Identification of therapeutic targets
- NCCR Chemical Biology – Visualisation and Control of Biological Processes Using Chemistry

Environment and Sustainability

- NCCR North-South – Research Partnership for Mitigating Syndromes of Global Change
- NCCR Plant Survival in Natural and Agricultural Ecosystems
- NCCR Climate Variability, Predictability and Climate Risks
- NCCR MaNep – Materials with Novel Electronic Properties

- NCCR Nanoscale Science – Impact on Life Sciences

Sustainability and ICT

- NCCR Quantum Photonics
- NCCR MUST – Molecular Ultrafast Sciences and Technology
- NCCR Robotics – Intelligent Robots for Improving the Quality of Life
- NCCR QSIT – Quantum Science and Technology Information and Communication Technology
- NCCR IM2 – Interactive Multimodal Information Management
- NCCR CO-ME – Computer Aided and Image Guided Medical Interventions
- NCCR MICS – Mobile Information and Communication Systems

Social Sciences and Humanities

- NCCR FINRISK – Financial Valuation and Risk Management
- NCCR Iconic Criticism – The Power and Meaning of Images
- NCCR International Trade Regulation – From Fragmentation to Coherence
- NCCR Mediality – Historical Perspectives
- NCCR Democracy – Challenges to Democracy in the 21st Century
- NCCR Affective Sciences: Emotion in Individual Behavior and Social Processes
- NCCR LIVES – Overcoming vulnerability: life course perspectives

Competition has led to a certain degree of academic specialization within the academic landscape. Universities are competing against each other for extra public funding and industry partners. The clustered and collaborative structure enables co-specialization. While a university might have the responsibility for one or two NCCRs in certain areas of expertise, its other academic units can connect themselves to funded research projects conducted at other institutions.

Complementary to the SNFs goal of fostering exploration of a wide range of phenomena and ensuring a high national absorptive capacity, the Commission of Technology and Innovation (CTI) acts as the central innovation promotion agency with the objective of effective market impact. With a budget of CHF 125 million annually it supports projects with a clear exploitation- and market orientation.

CTI, as the federal administration's decision-making body for the promotion of innovation, aims at creating general conditions that favor innovative capacities and can take targeted support measures. But such measures must be carefully crafted to ensure that they do not undermine competition and personal initiative. The CTIs operating principles have been expressed as follows:

- Reliance on individuals with extensive experience in industry and research.
- Providing support in a fair and user-friendly manner.
- Responding to current needs in a flexible manner.

CTI, focusing on knowledge transfer between universities and companies, regards itself as a facilitator for the Swiss innovation ecosystem and encourages private sector R&D spending. Funding is only granted to projects, which contain of a private industry partner and a public academic partner. By rule, the industry partner covers at least 50% of the project costs, to establish collaborative structures and induce long-term private R&D spending. In 2010 343 such collaborative projects were supported by CTI.

Private sector spending has developed with an impressive average annual growth rate of 22.4% between 2000 and 2004 and 24% between 2004 and 2008.

The activities of the CTI are categorized under three main themes:

- Market-oriented R&D projects
- Knowledge and technology transfer
- Creation and development of start-up companies

Market-oriented R&D projects have the purpose to encourage joint R&D projects between SMEs and higher education institutions. 319 projects received grant funding in 2009, for a total R&D expenditure of CHF 240 million, with nearly 55% (over CHF 133 million) funded by the private sector, as business partners match every Swiss franc invested by CTI with an additional CHF 1.35. This enables SMEs with limited resources to leverage their R&D investments and initiate collaboration with the national higher education institutions. The vast majority of those projects takes place within Micro- and Nanotechnologies, Life Sciences and Engineering Sciences and was conducted by Universities of Applied Sciences. The funding is provided through two main instruments: An innovation cheque à CHF 7,500, which is mainly intended for SMEs which presently do not devote any expenditure to scientific based innovation projects, and the innovation voucher, as a recently introduced pilot instrument, worth CHF 350,000. This funding is provided within a simple, non-bureaucratic procedure and clear admission criteria.

In order to enhance knowledge and technology transfer, the CTI

launched Knowledge and Technology Transfer networks (KTT) in 2005. They are regionally and thematically grouped networks, which provide access to specific expertise in a formalized manner. Every KTT network has an assigned advisor to help SMEs determine exactly what kind of services they require by introducing them to university partners, provide assistance with CTI grant applications and help SMEs introduce their branch or technology in national and international communities. They act as partners of industry and trade to enhance innovation in existing and future markets. Currently, KTTs exist for sustainable engineering, food, timber, tourism, photonics and laser, services, manufacturing, biotech, e-business, micro- and nanotechnology.

CTI also promotes entrepreneurship and entrepreneurship training through the organization of venture challenges as regular university courses, coaching of young entrepreneurs and awarding the CTI startup label. Further, a platform has been established for financing of Swiss high-tech start-up companies and the professionalization of the business angels and venture capitalist scene in Switzerland with a special focus on Life sciences, Biotech, Nano and ICT industries. Conducting matchmaking events, CEO days, investor lunch and innovation roundtables, has resulted in a cumulated financing volume of CHF 300 million since 2003.

The creation and development of start-up companies is fostered by the CTI through three main initiatives which re-emphasize the CTIs approach to foster innovation by acting as a facilitator for collaboration, knowledge-transfer and networking.

Initiative CTI Entrepreneurship

This initiative is executed by venturelab, a CTI sub-organization, which conducts entrepreneurship promotion and entrepreneurship training. They organize venture challenges as regular university courses, train teams for international championships, coach young entrepreneurs and help acquiring venture capital. They maintain an extensive expert network, and act as the "glue" in the Swiss entrepreneurship scene. University members can venture ideas and attend information and motivation events conducted by successful entrepreneurs. Within the semester course venture challenge, which is being offered regularly at most higher education institutions, they can test and develop their business ideas. Ambitious founding teams can attend venture plan, a five-day workshop to tweak their strategies, present in front of experts and investors and receive feedback. Within venture training specific growth- and internationalization-strategies are developed and possible financial sources evaluated. Twenty of the most promising teams travel to Boston each year to participate at the business development program, venture leaders and garner valuable connections to venture capitalists and the international entrepreneurship scene. Since its launch in 2004 venturelab conducted 1,770 teaching days with more than 13,000 participants.

Initiative CTI Start-up

With its network of 40 professional coaches, this initiative provides coaching for existing startups and awards the CTI startup label. Since its foundation in 1996 more than 1,800 projects have been reviewed until today. Of these, around 200 have been distinguished by means of the CTI Start-up label. A study conducted by the University of Basel, analyzing a sample of 886 Swiss startups between 1999 and 2009 came to the conclusion, that companies distinguished with the Start-up label are generally more successful compared to companies without labeling. Five years after foundation, 85 percent of the labeled businesses are still in business, compared to 57,4% without. The labeled companies managed to acquire CHF 1,200 million of funding and created more than 8,000 new highly qualified jobs.

Initiative CTI Invest

CTI Invest is a public-private partnership and the leading platform for financing of Swiss high-tech start-up companies and the professionalization of the business angels and venture capitalist scene in Switzerland. New ventures presented and supported by CTI invest have mostly been active in the Life sciences, Biotech, Nano and ICT industries. With the conduction of matchmaking events, CEO days, investor lunch and innovation roundtables, CTI invest facilitates the interlinkage of entrepreneurs, venture capital firms, corporate investors, business angel clubs and industrial partners and facilitated a cumulated financing volume of CHF 300 million since its establishment in 2003.

TIS Performance

Switzerland issued 112,7 triadic patent families per million inhabitants in 2010, which makes Switzerland the most active patent issuer among all OECD countries. A patent family consists of a set of patents taken in various coun-

tries to protect a single invention. A triad patent family consists of patents issued at the European Patent Office, at Japan Patent Office and the US Patent & Trademark Office.

The coordinating institutions SNF and KTI regularly assess the impact of their instruments:

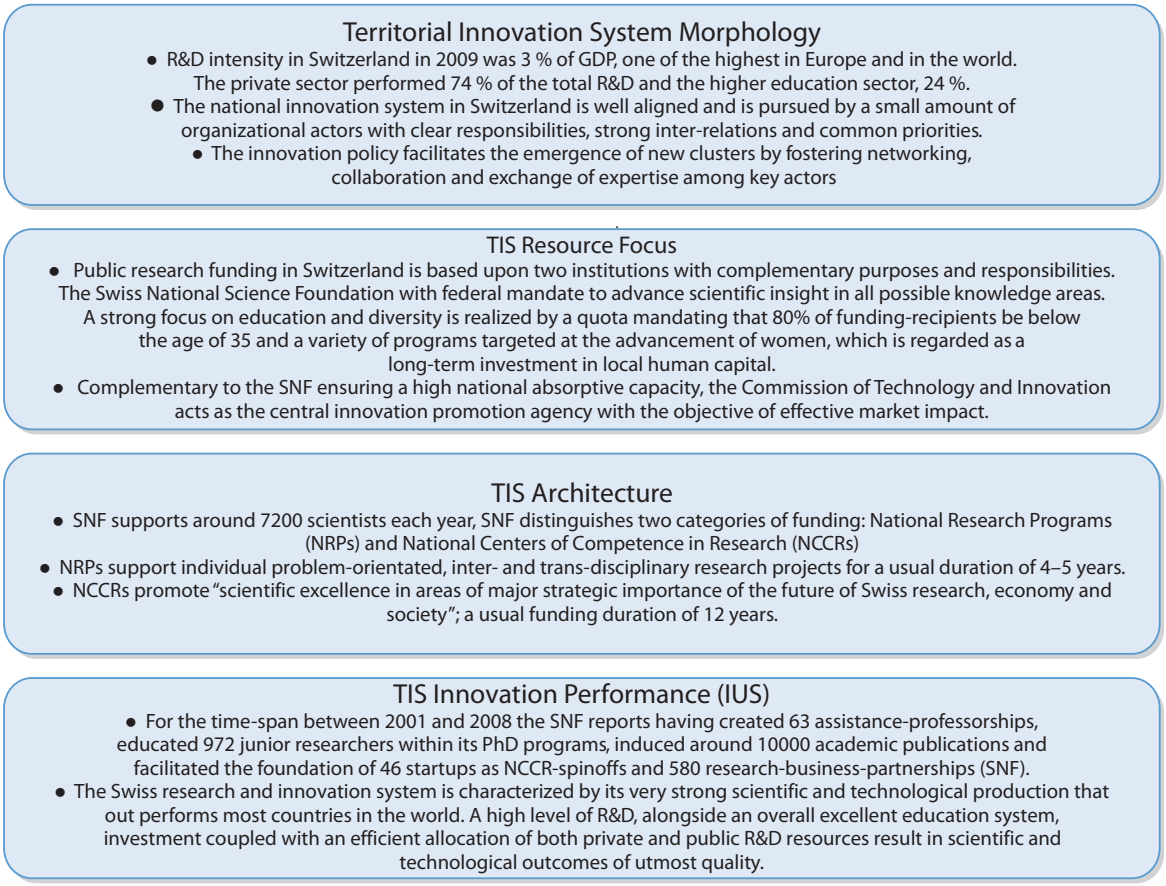
For the time-span between 2001 and 2008 SNF reports to have created 63 assistance-professorships, educated 972 junior researchers within its PhD programs, induced around 10,000 academic publications and facilitated the foundation of 46 startups as NCCR-spinoffs and 580 research-business-partnerships.

In 2010, 343 industry-academic-collaboration projects received grant funding, for a total R&D expenditure of CHF 234 million, with nearly 58% (over CHF 134 million) funded by the private sector. 74% of the participating companies employ 250 employees or less. Between 2004 and 2011 1,770 entrepreneurial teaching days have been conducted with more than 13,000 participants. By facilitating inter-linkage of entrepreneurs, venture capital firms, corporate investors, business angel clubs and industrial partners cumulated financing volume of 300 million CHF into Swiss High Tech startups was enabled between 2003 and 2011.

The Innovation Union country profile highlights the importance of the international networking of Switzerland when evaluating the Swiss performance:

Switzerland is a small country with a very open research and innovation system. The very high quality of its scientific

Figure 9. The anatomy of the Swiss innovation system



and technological production, its superior education system on all levels, coupled with its strategic geographical position and close historical, cultural and linguistic ties have allowed the Swiss research and innovation system to establish strong scientific and technological links with partners in other European systems. As an indication, 45% of the total Swiss patent applications count with a co-inventor located abroad, one of the highest percentages, if not the highest, in the world. Italy, France, the United Kingdom and especially Germany are the main scientific partners, while Germany remains the reference technological partner for Swiss enterprises and research centers. This strong openness is allowing the system to tap into the main global knowledge networks, benefit from strong knowledge spillovers and leverage on their important R&D investments.

CASE: The Swiss Biotech industry

The Swiss Biotech industry has recently played a key role in the Swiss economy. The industry has depicted high levels of innovativeness and consists of both startup and mature companies which employed approximately 19000 people and realized an industry turnover of CHF 9.2 billion in 2010. The recent report of the Swiss Biotech Association is well suited to illustrate how national innovation capabilities are enhanced through various public innovation endeavors. According to the report, several aspects acted as unique fertilizers: first and foremost, the highly skilled local labor pool, which is equipped to conduct high impact research through specific education, such as the M.Sc. in Life Science offered by several Swiss universities. The abundance of expertise, collaboration of public and private actors, and a high degree of geographic proximity enables local spillover effects. Further, agreements of free-movement of persons make it possible to additionally recruit foreign workforce, which is, in turn, attracted by the high living standards. Public recognition of the importance of the Swiss biotech sector has enhanced research spending and led to the establishment of National Centres of Competence in Research, which have become highly connected with private innovation endeavors.

Intense startup support and more than 40 venture capital firms and biotech-specific investment funds are active at all stages of financing in Switzerland and have enabled the emergence of new players in the field. Finally, comparably low taxes and a generally paradigmatic approach to regulatory issues provide favorable conditions for innovative endeavors to prosper.

Appendix 3. Case studies

Tekes – strengthening generative capabilities

CVOPS – The Virtual Operating System

Tekes initiated its first technology program, Finprit, in 1983 and contacted VTT regarding the type of content to be included in the program.

Prior to this opportunity, VTT had conducted a research project with the goal of raising the competence level in protocol standardization and formal description techniques. Additionally, a variety of protocol implementation approaches were compared.

A researcher from VTT, Olli Martikainen, had, in the previous project, developed a prototype of a virtual operating system and suggested the inclusion of a similar type of tool in the Finprit project.

The Finprit-program contained, based on negotiations between VTT and Tekes, development of a protocol tool (VOPS =acronym for Virtual Operating System), development of a router, development of a distributed database and hypertext related development. The analysis here will focus on VOPS – other results of the Finprit-program included:

- a router concept was presented to Nokia management in 1986; but this technology failed to gain support within Nokia (as commonly acknowledged, the development of routers would go on to destroy Nokia's modem business within a few years)
- a distributed database developed during the program formed an integral part of Nokia's digital switches
- the hypertext related development within the program was discontinued

The protocol tool was initially intended to become a platform for developing the program's other parts, but it, ultimately, became a much larger and more crucial part of the development of the Finnish telecommunications sector. The original idea was to simulate future workstations and network architectures with existing minicomputers, LANs and self-built gateways in order to learn to develop network software and to simulate the behavior of such complex systems.

This concept, of building a virtual environment for testing and developing, was novel; and, a mere ten years later, similar types of development environments began to emerge that would eventually displace CVOPS.

Capability development in companies

Olli Martikainen had been recruited by Nokia in 1985. He was able to use his role in the Nokia Research Center to test whether VOPS could be of use. Nokia Research Center and VTT co-developed CVOPS from VOPS and it was taken into use in 1986 (CVOPS was coded in C). CVOPS became a central tool for Nokia during its time of rapid technology related development, as it was a technology platform that could be used for various purposes both within the company but also with key suppliers and partners.

Among CVOPS's important innovations was the use of Ethernet to test the radio communication protocols, which made it possible to test solutions several years before radio system parts were available. CVOPS enabled Nokia to develop and test GSM (and later partially 3G) technologies in advance of the competition and, thereby, gain a forerunner position. For example: Nokia utilized CVOPS as a tool in GSM standardization, by taking the role of software developer in one of the development consortiums. In this role Nokia was able to steer GSM development in a favorable direction – e.g. at one critical junction, Ericsson claimed that certain parts of the specification could not work – but Nokia was able to present simulation results as a proof-of-concept. Nokia developed its solutions virtually at a time when Ericsson still had to develop physical prototypes. After the mid-1990s, Nokia switched from CVOPS to the Swedish Telelogic (now part of IBM) protocol development tools.

After an additional tenure at VTT Olli Martikainen was employed by Sonera and his role included the utilization of CVOPS there. From 1993-1997, Sonera subcontracted the development of SS7, GSM, IN and TMN-related infrastructures to the Moscow People's Friendship University and a company affiliated with the University. This infrastructure was developed utilizing CVOPS. Later, development of the

CVOPS software in Finland was moved to Intellitel Ltd with Sonera as the major shareholder. The CEO of Intellitel was Mårten Mickos until 1999 (he later became the CEO of MySQL) and was succeeded by Pasi Kemppainen.

As an operator, Sonera was uniquely positioned as the sole operator with these types of technological service platforms and used this edge to develop e.g. Zed and SmartTrust. The virtual switch developed using CVOPS was sold to Trio AB in Sweden. Logica (earlier WM-data) recruited Tapani Karttunen, who had led Sonera's offshore development work in Russia.

Finnish universities used CVOPS in training students between 1988 and 1998 and Oulu University continued to use the system until 2003. Altogether, as many as one thousand engineers were trained in this competence in Finland. Moscow People's Friendship University trained more than two thousand engineers in CVOPS during the collaboration with Sonera.

Results

The direct result of the project was the development of a protocol tool for specification, implementation and testing of telecommunication applications. The main result of the investment in CVOPS was that the telecommunications sector's main players were able to outpace their competition at the critical junction of digitalization. As a platform technology it, in turn, enabled the development of several successive innovations.

Nokia, in particular, benefited from this technology as it was able to play an important role in the software development for GSM standardization which would not have been possible without access to CVOPS. Sonera, in turn, was able to develop much of its central infrastructure for services.

Among the investment's indirect consequence has been the rise of several of the CVOPS team members' (e.g. Arto Karila, Jarmo Harju, Kirsi Valtari) to become top researchers in their own fields.

Case synthesis

The CVOPS case shows the potential for technology foresight, when combined with accurately timed investments in a technology platform, to enable an entire cluster to outpace competition. It also illustrates the challenges in transferring a potential innovation from research to business. Only after Olli Martikainen, who had developed the technology during his tenure with VTT, himself began working for Nokia, and later for Sonera, were these companies able to fully utilize CVOPS.

Source: Interviews with Olli Martikainen

Valio – Lactose-free milk

Valio is a company owned by Finnish dairy farmers that secures milk production in Finland as well as the vitality of the nation's countryside by processing milk into products that promote well-being. Quality, expertise and responsibility have served as Valio's guidelines for more than a century. Valio's turnover in 2010 was €1.8 billion. The CEO of the company is Pekka Laaksonen.

Company and capability evolution

Valio has a tradition of developing ground-breaking innovations. In the 1920s, Valio's company laboratory introduced a new field of research to Finland, namely bio-chemical research. This laboratory produced Finland's scientific Nobel Laureate, Artturi Ilmari Virtanen (in 1945), for his research and inventions in agricultural and nutrition chemistry, especially fodder preservation (AIV fodder). The focus on basic research lasted until the 1960s, after which more focused product development was prioritized.

The 1970s saw the development and of hydrolysis technology, to remove lactose from milk, at Valio. The introduction of this product to the market was met with great success. The resulting products were branded HYLA. The awareness of lactose-intolerance grew among the Finnish population as a result of Valio's marketing.

During the 1980s, Valio began selling lactose and acquired chromatographic technology for this aim from Suomen Sokeri. The technology was installed at the Joensuu dairy. Whey was used as raw material, but the process was also tested on milk, to see if it would be possible to produce lactose-free milk (HYLA contains < 1% of lactose). The test was successful and a patent was awarded for the production of lactose-free milk through chromatographic technology. At the end of the 1980s, sales of lactose were discontinued and Valio was left with the unused chromatographic equipment in Joensuu.

Valio initiated a project to commercialize lactose-free milk in 1990 with financial support from Tekes. This project was led by Matti Harju. The process encountered several challenges – the most significant of which were:

- The marketing department's lack of faith in the product was reinforced by a consumer study. Consumers of HYLA-milk were presented with an expensive alternative that tasted like genuine milk, which they turned

down, as HYLA-milk consumers had become fond of the sweeter taste of HYLA-milk. There was another group that, either due to lactose-intolerance-symptoms or dislike of the taste of HYLA-milk, did not consume milk at all. The market research didn't discover that these consumers represented a significant potential for lactose-free milk.

- A standard for lactose-free milk had been set by a Nordic committee. The target of <0,01% lactose content had been lobbied by the margarine industry. The problem was that there was no analysis method to achieve this until Valio developed a method to measure extremely low levels of lactose.
- An additional technology utilized in lactose-free milk was ESL. ESL enabled longer shelf-life, and the increased sales times of lactose-free milk drink that enabled stores to accept the product at its introduction.

The development project was explorative, with its basis strongly in technology. The end result was a lactose-free milk drink, to a large extent ready when the Tekes project ended in 1997.

The lactose-free milk drink was not launched until 2001. The reason was low expectations for product demand - the initial goal was to sell 1 million liters annually. Two million liters were sold in the last four months of 2001 and, at present, 60 million liters are sold annually in Finland and another 20 million are exported. A number of other lactose-free products have been introduced. Competitors have developed their own products as the patent has expired, but Valio still holds market leadership. Despite fears, lactose-free milk has not cannibalized HYLA-sales to any greater extent.

Export sales have required raising awareness of lactose-intolerance in the target countries. The market has been cultivated in Sweden and local competitors are following suit. Sales have also started in Estonia and Russia. Valio had to work hard to introduce these products to international markets, but now demand for Lactose-free milk is spurred through the grapevine and is supported by Valio awareness-building through specialists, magazines and social media.

In its projects, Valio provides the core competence and project leadership. Naturally, external resources are engaged as required in Tekes projects. Presented below are the major actor groups and their roles (Table 1).

Innovation support activities

Together, Tekes and the Ministry of Trade and Industry supported the development of HYLA as well as lactose-free milk. Through the HYLA-project, Valio had already developed capabilities that it could utilize in lactose-free milk. In the case of lactose-free milk, Tekes support was crucial in gaining internal support for the project at Valio; serving as proof of the project's viability.

During 2004–2010 Tekes provided a total of €6,9 million in funding (grants and loans). Valio had both firm-led projects as well as research co-operation – e.g. in the Symbio –program. This period included the undertaking of Valio-led projects as well as two co-operation projects. Valio is also coordinating the SalWe-program (SHOK) Mind and Body. Valio pays its own costs in R&D projects with Tekes and Tekes's support is directed to research institutes and universities. In this way, competences are built in the network and Valio can then access this knowledge when necessary.

Results

Valio was able to develop and commercialize the lactose-free milk drink and other dairy products as well as the related production process and gain the related patents. It also developed the measurement technology necessary to detect low levels of lactose, which was required to verify the lactose-free characteristics of these new products.

As a result of the added value of lactose-free milk Valio now has Europe's highest producer-price for milk. The strengthening of the in-house innovation culture supports the exploration of new opportunities.

Table 1. Valio's major actor groups and their roles

Actor group	Role vis-á-vis Valio	Examples
VTT	Support in research projects	
Universities	Recruitment, testing of novel ideas (masters work), idea & researcher exchange	Aalto University, University of Helsinki
Consumers	Steer product availability & development	New product decisions are derived from sales and consumer-service requests.
Media	Awareness of product benefits (e.g. identifying symptoms of lactose-intolerance)	Specialist appearances, advertisements

Case synthesis

This case shows that Tekes can help to strengthen a company's managerial capability, which can, eventually, lead to new innovations, alongside the build-up of new generative (technological) capabilities.

Sources: Interviews with Matti Harju, www.valio.fi, Touko Perko: Valio ja Suuri Murros, 2005

Nexstim – Leader in navigated stimulation of the brain

Nexstim develops, manufactures and markets Navigated Brain Stimulation (NBS) devices for clinical use and scientific research. Headquartered in Helsinki, Finland, Nexstim employs a staff with high-level expertise in neurophysiology and brain research and extensive knowledge of modern healthcare technology.

Established in 2000, following eight years of extensive technological and scientific research, Nexstim launched its first commercial product in 2003. The company subsequently developed sophisticated tools for neuroscience and clinical research, with sales to leading hospitals and brain research centers throughout the world. The company is still firmly in the development phase with approximately €30 million raised from external investors. The turnover in 2010 was €1.6 million.

Company and capability evolution

The development of Navigated Brain Stimulation (NBS) began with the launch of the TMS (Transcranial magnetic simulation) Imaging Project at the BioMag Laboratory of the Helsinki University Central Hospital in 1994. The key persons were Dr. Risto Ilmoniemi, his student Jarmo Ruohonen and Dr. Jari Karhu, M.D. The technological foundation for the NBS system was laid during various research projects that were carried out at the BioMag Laboratory in 1994–1999. End users (among them Helsinki University Central Hospital, Helsinki University of Technology and the University of Helsinki) were involved in these projects. These projects received financial support from Tekes.

The realization by Ilmoniemi and Karhu, who were also brain researchers themselves, that the end users would benefit from the novel technology led to the founding of Nexstim Oy in 2000 to commercialize the combination of stereotactic TMS and high-resolution EEG monitoring. Additionally, Risto Ilmoniemi agreed to spearhead the further development of Nexstim serving as the first chairman of the board (2000–2003) and functioning as CEO through 2003–2005. Thereafter he has returned to academic work, but remains the largest individual shareholder and technical advisor to the company. Ilmoniemi was supported in the decision to form a company by Markku Lahdenpää, then a professor at the Helsinki School of Economics and one of the coaches for Ilmniemi's team in the TULI project, as well as by his colleague in business consulting, Pekka Puolakka, who became Nexstim's first managing director and was eventually followed by Dr. Jari Karhu 2000–2003.

Although Nexstim launched its first commercial product in 2003, it continues to be, after over ten years, very dependent on external investors. The company has been supported by its founders and investors: HealthCap, Life Sciences Partners, SITRA, Finnish Industry Investment, Lundbeckfond Ventures, Cparicorn Heath-tech Fund NV, and Ilmarinen.

Nexstim has developed a solid understanding of the theoretical and physiological foundations of magnetic stimulation and related aspects. For development of new research equipment, a critical mass of expert engineers, scientists, and clinicians from the relevant areas have been brought together. Today Nexstim has approximately 50 employees and its comprehensive network of various specialists also plays an essential role. The company has recruited a very knowledgeable board, with representatives from investors, customer organizations and developers of globally successful medical equipment.

It takes considerable effort to convert an original idea into a successful product in the market. It has been over 15 years since one of the new concepts, pre-surgical localization of key areas of the cortex, was presented to a surgeon at the Helsinki University Central Hospital. The surgeon, Dr. Juha Jääskeläinen, politely made clear that only reliable products can be used in the actual work of a surgeon. Ten years later, in 2005, the first real life test of the product was conducted, and was a success. Subsequently Jääskeläinen ordered that this method should be used in all similar cases. However, even after making the clinical breakthrough in respect of getting the first customer convinced, generating sufficient sales has taken several additional years. This illustrates the effort required to transfer world class scientific knowledge into a marketable product in such a demanding industry as medical equipment.

Innovation support activities

Financing from Tekes was crucial when Nexstim was still in the basic research phase. During these years, the coaching sevices provided by Tekes's specialist, Simo Luiro, on the development of the innovation was valuable. Also several other key persons, such as Markku Lahdenpää and Pekka Puolakka, functioned as Ilmoniemi's coaches in the initial stages of Nexstim. During 2004-2010 Nexstim has received €2,6 million in Tekes funding (grants and loans) to further develop the technological base.

Results

The NBS System is rapidly becoming the new standard for functional, preoperative brain mapping prior to neurosurgery for tumor resection or epilepsy. The accuracy of the NBS System has been shown to be equivalent to direct cortical stimulation, hitherto considered the "gold standard" method for locating the motor cortex during brain surgery. The NBS System is the only direct, non-invasive cortical mapping device approved for both the USA (FDA approval in 2009) and European markets. Many of Nexstim's innovations are protected by patents.

Case synthesis

Tekes, through its financing, enabled the basic research and partially supported the development of the product after the decision to transfer the commercialization of the innovation to Nexstim. This case shows that the capability base needs to be developed well ahead of large scale commercialization.

Sources: Interview with Risto Ilmomiemi
www.nexstim.com

Sintrol – Quality in process industry measurement

Sintrol was founded in 1975 and specializes in process industry measurements, automation, non-destructive testing and laboratory equipment. The turnover of Sintrol Group, in 2010, was €13 million and the CEO is Karl Ehrström.

Company and capability evolution

Sintrol is an expert in measurements related to process technology and automation. As a solution provider, Sintrol is an importer that provides the customer with the sought for technical solution. In addition to this, Sintrol has also developed its own dust measurement product line, which represents a growing part of Sintrol's business. The dust monitors are exported to countries such as China, India and Germany.

When Karl Ehrström became Sintrol's majority owner in 1988, the company had only five employees. Today, Sintrol has about forty employees in Finland, around ten employees in Russia, two in Kazakhstan, five in China, and one in India. The product portfolio consists of more than 100 different brands (Yxlon, Olympus, Bycotest, Durag, Raytek etc.).

In its development work Sintrol has been looking at ways to further strengthen its service concepts. The challenge for Sintrol has been instigating an internal change among the sales people and the technical experts; from a product perspective to a more customer-oriented way of thinking. To this end Sintrol also participated in Tekes's Liito programs.

Although Sintrol's focus is on processes and developing an understanding of customers' needs, a portion of its business also consists of the pure sales of hardware products. But this business also demands an active approach and an understanding of the changes in the market. You have to understand the bottlenecks of the customers' processes and you must be able to find the right solutions. The role of companies like Sintrol is, on one hand, becoming more and more consultative, but, on the other hand, it requires a constant search for new products, in order to meet the cost and solution requirements of the customers. When Sintrol was established in 1975 the added value offered to the customer was knowhow concerning the import of equipment and logistics; today it must be something else.

Innovation support activities

Sintrol has been supported by Tekes during 2004–2010 through financing of €730 000 (loans and grants). This progress has taken place in both business development as well as product development. Examples of business development driven projects are two firm-led projects within the Liito-program. Sintrol has also participated in the GAP-program. Sintrol has developed its own proprietary technology, such as the dust monitor product, through e.g. a project in the Fine-program.

According to Sintrol's Ehrström some of the changes would have been carried out without Tekes's support, but certainly they would have taken more time as development investments are scarce. Tekes's continued support has been very beneficial to Sintrol. A good example was a market study supported by Tekes. As a result of the study, Sintrol decided not to go into the busi-

ness in question and Ehrström believes this was probably a very wise decision which was made possible by Tekes's support.

Results

Sintrol has been able to change its business model into one which is more customer-oriented and proactive as well as develop a proprietary product (dust monitor).

Case synthesis

The case shows how Tekes financing has made it possible for a company, such as Sintrol, to make changes, it has enabled the company to take incremental steps into new directions.

Sources: Interviews with Karl Ehrström, www.sintrol.com

GreenStream Network – Asset management in green investments

GreenStream Network Plc is a developer and manager of green investment vehicles, basing its excellence on deep market insight and first-class project management skills. GreenStream establishes and manages green investment vehicles by selecting attractive projects and managing these. Northern Europe serves as its home market and China is the key area for growth. GreenStream is also active in Russia and Ukraine. GreenStream operates in the advisory and intermediary businesses in the environmental markets, and its 2010 revenues generated by a staff of 32 people amounted to €6 million. The company has offices in the Baltic Sea region, headquarters in Helsinki, and considerable operations in China. The CEO of the company is Markku Ahponen.

Company and capability evolution

GreenStream was founded in 2001. Most of its founders came from Fortum, with a background in the environmental field and international business. The company started as a green certificate broker, particularly between the Nordic countries and the Netherlands, where taxation was very favorable for green electricity. In 2003/2004 GreenStream began business related to carbon emission markets, the company first served as a broker and consultant in this business. At present, the business is mainly focused on asset management and emission reduction project management. The company is owned by the current and previous management as well as some insurance companies and different investors and banks.

GreenStream's activities have targeted international markets from the very beginning. At its largest, GreenStream had activities in eight different countries, but today business is primarily concentrated in Finland and China. This reduction was a result of the rapid growth of Chinese activities, which required a reallocation of resources.

At the moment GreenStream has contracted about 60 different projects in China related to renewable energy and energy efficiency. Business in China is growing rapidly with over 100 new projects being suggested each year. The company's customers in China consist of the main energy companies and financial institutions. Although growth is taking place in China, the key know-how resides in the Helsinki office.

GreenStream believes in the growth of the environmental business. As the environmental markets are changing fast, they offer a perfect platform for a boutique-type expert organization. Adaptation is especially important for small companies as their ability to compete with the huge players is limited. As soon as larger companies move into the business, smaller organizations must find something new. Thus flexibility and speed are the major competitive edges for the SMEs.

GreenStream's business model is strongly relationship based. In China the most important significant factor is making the right contacts, knowing the right people. This is not easy and it is also a matter of luck and understanding the cultural background. GreenStream presently have 13 employees in China, of these, two are from Finland and the others are Chinese.

The competitive advantage for GreenStream is its know-how and the fact that the company has been in the business much longer than many competitors. The main challenges are how to manage and finance the fast growth of the business.

Innovation support activities

GreenStream has participated in two Tekes programs: Climbus (two projects) and Groove (one project). The total financing by Tekes to GreenStream during 2004–2010 has been around €250 000.

Tekes has supported the development of new service offerings for international markets as well as provided support for relationship building. Tekes has also served as a coaching partner and a strong source of support for GreenStream when internationalizing its business.

Other important networks besides Tekes have included Cleantech Finland and Finnpartnership. Finnpart-

nership has been supportive in GreenStream's Chinese and Ukrainian businesses. However Finnpartnership is basically only active during the build-up period whereas Tekes is a more long-term partner. Another door opener in the Chinese market has been the FECC (the Finnish Environmental Cluster for China).

Results

Based on the internationalization and offering development GreenStream Network has been able to better address the market opportunities in China.

Case synthesis

The GreenStream Network case shows how a firm's capability base enables it to adapt its business model along with the evolution of market opportunities.

Sources: Interview with Jussi Nykänen, www.greenstream.net

Tekes – nurturing ecosystems

Tekla – Modeling built structures

Tekla aims to drive the evolution of digital information models with its software, providing a growing competitive advantage to its customers in the construction, infrastructure and energy industries.

Tekla's net sales for 2010 were €58 million and operating result approximately €10 million. International operations accounted for approximately 80% of net sales. Tekla has customers in 100 countries, offices in 15 countries and a worldwide partner network. Tekla Group currently employs more than 500 persons, of whom, approximately, 200 work outside of the headquarters in Finland. Tekla was established in 1966, and is one of the longest-operating Finnish software companies. Tekla Corporation became part of US-based Trimble corporation in July 2011. The CEO of Tekla is Ari Kohonen.

Company and capability evolution

Tekla's evolution can be divided into two phases: the technology development phase, 1966–1997, and the internationalization phase, beginning from 1998. Tekla's original role was to support the technical calculation needs of Finnish engineering companies. Software applications were developed to satisfy customer needs. Co-development with its customers led to new solutions in a wide range of fields, with building information modeling (steel construction) and energy/infrastructure as spearheads.

In 1998 the company made a decision to change its strategy. The new strategy was that Tekla should become an international service/product firm, which would base its competitiveness on strong in-house development of software. This gradually led to a wide range of changes:

- an (hands-off) international distributor relationship with CSC was replaced by a mixed (own + partners) international distribution model

Figure 1. Tekla capabilities in 1997

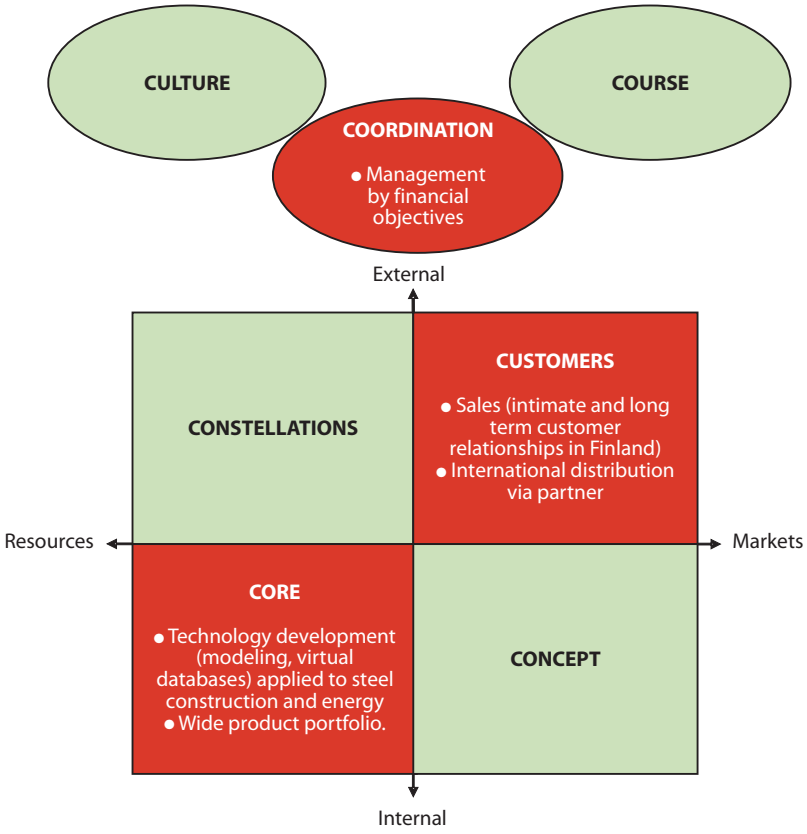


Table 2. Tekla's key stakeholders and their respective roles vis-á-vis Tekla

Actor group	Role vis-á-vis Tekla	Examples
Product development partners	Specific technological expertise	Software company in same field supporting Tekla with information exchange
Key customers	Co-specialization between customers and Tekla - enabling the evolution of Tekla's products and capabilities and providing references	Granlund, Bechtel
Industrial associations	Support in building networks	
Universities and research institutes	Used for developing Tekla's own competence or joint research/ concepts, prototypes	Frauenhofer, VTT
Standardization bodies	Support in promoting Open BIM in practice	

- a decision was taken to concentrate on two core products: building information modeling (BIM) and solutions for infrastructure and energy industries.

But in spite of changing its strategic focus and becoming more international Tekla continued its strong customer focus. Subsequently Tekla's key stakeholders and their respective roles vis-á-vis Tekla are shown in Table 2.

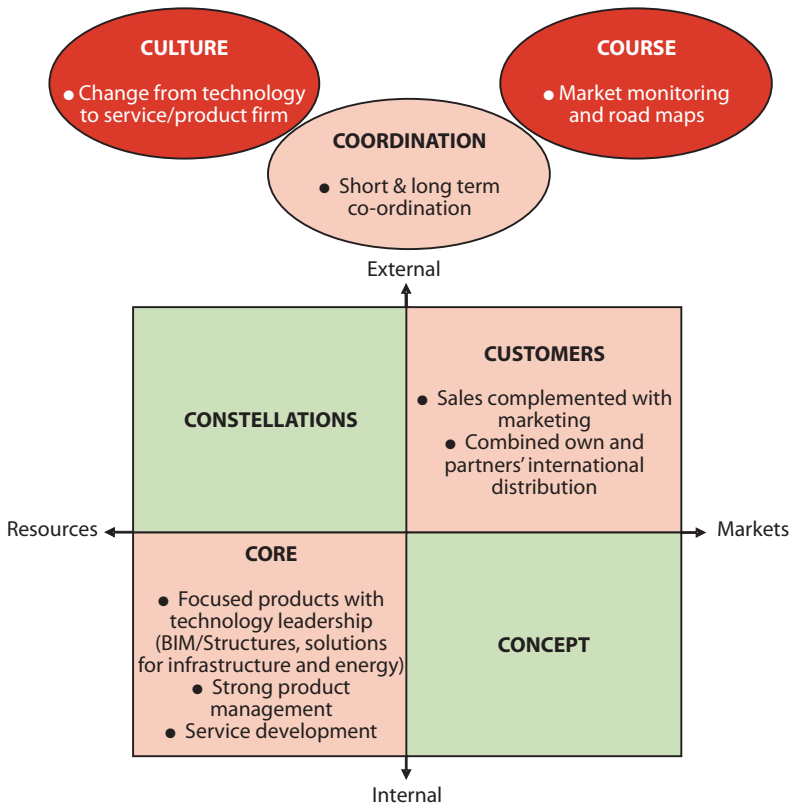
Tekla's initial capabilities, relating to technology and sales/customer relationships, have been expanded to reflect the broadening of the service scope to also include product management and service development, and the sales capabilities have been complemented by Tekla's marketing and distribution capabilities. The co-ordination capabilities have been complemented by foresight and a related systematic road mapping of its future products.

Innovation support activities

Tekla has continuously applied for funding support for its development from Tekes. During 2004–2010 Tekla received a total of €2.8 million in grants and loans. Tekla has, during the period 2004–2010, had four firm-led projects funded by Tekes and it has also participated in one research institute project. Tekla is presently leading one work package in the Pre-program (a SHOK-program).

As Tekla has emerged into a technology leader, Tekes's role has changed from supporting technology development to also supporting the target market's overall development (so that Tekla can better co-evolve with its customers). Program evaluations and Tekla's own reflections point out that Tekes's support has, in later years, also enabled new product functionalities, service development and research of methodologies (that can potentially later be integrated into Tekla's offerings).

Figure 2. Tekla capabilities in 2011



Results

Tekla has been able to integrate its software platforms into its customer processes by developing integrated offering packages. This has enabled Tekla to become a world leader in building information modeling. Tekla has also been highly profitable. This created interest regarding the acquisition of Tekla among numerous potential acquirers. In summer 2011, Tekla's board accepted Trimble Navigation's acquisition bid of €337million. In the press release, the rationale of the transaction was described as follows:

The integration of Tekla's BIM software solutions with Trimble's building construction estimating, project management and BIM-to-field solutions will enable a compelling set of productivity solutions for contractors around the world... Clients around the world will benefit from dedicated workflows and productivity solutions that are unmatched in the construction industry today. Additionally, Trimble's significant global customer base will immediately extend Tekla's customer reach, while Tekla's global presence in the building and construction market will bolster Trimble's own customer reach… Tekla and Trimble's combined solutions will enable us to provide our customers with the broadest and most sophisticated BIM capability available today.

Case synthesis

The Tekla case shows how Tekes's support enables the development of new basic technologies and offerings that fulfill a customer need. These types of needs were complemented by developing further managerial capabilities (e.g. supporting business model innovations) and support of the company's overall industry as Tekla increasingly focused on its core expertise.

Sources: Interviews with Ritva Keinonen, www.tekla.com, Tekla history: From punch cards to product modeling

Normet – For tough jobs in mining and tunneling

The Normet Group is a fast growing Finnish technology company operating globally in 28 locations on 6 continents. Normet is focusing on advanced solutions for selected customer processes in underground mining, tunnel construction and underground space projects. These solutions include: development and manufacturing of specialized machinery and equipment; life time care services; construction chemicals; and customer process optimization. Highly mechanized concrete spraying and explosive charging are examples of these customer processes. Today, the Normet Group is a global market leader in its chosen market segments. The Group generated turnover of more than €160 million in 2011 and employs 700 professionals around the world. The company's Chairman of the Board and main shareholder is Aaro Cantell. Normet received the 2011 Internationalization Award of the President of the Republic of Finland.

Company and capability evolution

Normet began targeting the mining industry in the early 1970s. Revenues from mining equipment did not surpass forest machinery until the 1980s.

Normet was a subsidiary of Orion until 1999, at which time Aaro Cantell first became involved with the company through the Fenno Fund, one of Normet's owners at the time (Eqviteq and Capman were the other owners 1999–2005). In 2005 Cantell became the main owner of the company (70%), with an aim of revitalizing it. Normet's capability set at the end of the 1990s was typical for an OEM manufacturer at that time, strong generative capabilities in production and development of technology and global sales via dealers.

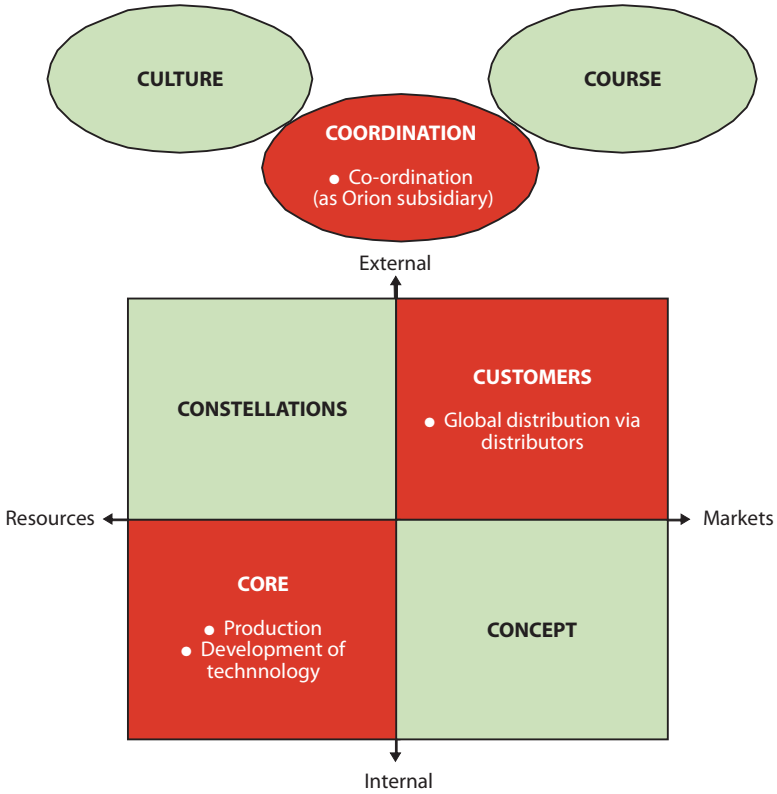
Normet's sights had been set on global markets from the very inception of its forest machinery operations. When Normet began its mining operations, it benefitted from Tekes's foresight, Tekes had developed this foresight as a result of the Intelligent Mine program, launched in the 1990s, which developed automation processes and wireless technologies for new types of mining operations.

When the new ownership evaluated alternative strategic options in the early 2000s, they set out to utilize the international growth opportunity inherent in Normet. This meant changes in business and production models as well as distribution and management.

Normet started to develop its service business and initiated a Tekes-financed project called Norse. In this project it quickly became evident that the change towards services was impossible without changing the distribution structure. This resulted in the 2007 decision to change the sales organization from a distributor driven one to one driven by its own sales force and complemented by select distribution partners.

Simultaneously Normet decided to outsource everything but frame structures and assembly, which it kept at its factory in Iisalmi. This enabled a doubling of production capacity between 2006 and 2010. This change was also

Figure 3. Normet capability base at the end of 1990's



evident in the setup and personnel, as Normet today has 28 sites globally in 19 countries, and more than half of its approximately 700 employees are located outside of Finland.

Normet's more comprehensive offering and the changes in production have led to the following relationships with key stakeholders (Table 3).

Table 3. Normet's relationships with key stakeholders

Actor group	Role vis-á-vis Normet	Examples
Technology partners	Recruitment base to support strategy change	Exertus
Suppliers	Flexible production, freeing up resources for growth	In 2010, Normet was named the Main Supplier of the year
Customers	Development partners of products and services	Finnish mines and tunneling contractors
Research partners	R & D & I support	VTT and Universities

Increased customer contact has influenced Normet's innovation processes. While technical innovation has always been conducted in close cooperation with the customer, customers are now also increasingly involved in the development of new service concepts and total solutions for customers as well. Due to Normet's dedication to maintaining a close-knit, international communication network, its innovation processes are easily expanded to also include close cooperation with external partners within its business network.

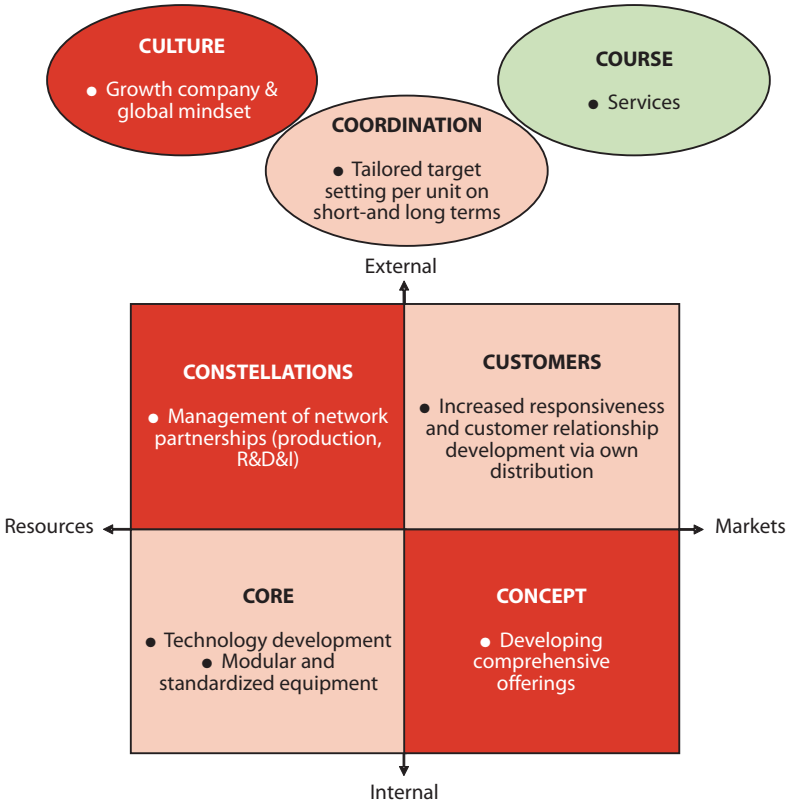
Normet has been able to supplement a traditional OEM capability profile with complementary transformative and resource integration capabilities. It has also considerably strengthened its managerial capabilities.

Innovation support activities

Tekes financing to Normet between 2004 and 2010 was, in total, €1,5 million (grants and loans). Normet has had projects in both the Production concepts and Serve programs, reflecting its dual development challenge: both production processes and the business model. The results have included:

- The development of the production concept has enabled subcontractors to move forward in the value chain and participate in product and service development; more effectively leveraging upon their own core competence.
- Participating in Tekes's programs with research institutes and universities particularly in relation to digital modeling and automation processes has provided significant added-value. The application of the results of research has led to concrete ben-

Figure 4. Normet capability base in 2011



efits. Without Tekes's support, utilizing these competences would have been financially unfeasible.

- The most significant impacts of Tekes's innovation activities have been in the development of new technologies and the evolution of Normet's services. The creation of Normet Services, in particular, led to a complete renewal of the company's strategy in 2005.

Results

Normet has been able to expand its offering significantly, serving more customer-critical processes. With new service solutions, in particular, being introduced (e.g. Life Time Care). To support this development, and address the growth opportunities it presents, Normet has changed its production and business model. Normet has also made a number of acquisitions to support this development.

Case synthesis

Normet exemplifies the capability development from a manufacturing focused OEM to a global service firm with complementing orchestration capabilities, with successful Tekes support provided at different phases.

Sources: Interview with Janne Lehto, www.normet.fi, presentation by CEO Aaro Cantell at Tekes Concepts of Operations programme 17.2.2011

The Switch – Renewable energy transformation

The Switch is a leading supplier of megawatt-class permanent magnet generator and full-power converter packages for wind power and other emerging businesses, including solar power and fuel cell applications, variable speed gensets and industrial applications. The Switch evolved in 2006 from the joint forces of three innovative companies – Rotatek Finland, Verteco and Youtility.

Net sales of The Switch in 2010 were €134 million and the operating profit was €16,6 million. The Switch is headquartered in Vantaa, Finland and has two other locations in Finland (Lappeenranta and Vaasa), three locations in China and offices in Denmark, Germany, Spain, India, Korea and the US. The CEO is Jukka-Pekka Mäkinen.

Company and capability evolution

The Switch was born as a result of the merger of three companies Rotatek Finland, Verteco and Youtility (US). These three companies had mutually complementary technological bases (Rotatek – Generators, Verteco – Converters and Youtility – Fuel Cells). Customer needs had converged and these companies were already forming consortium agreements prior to the merger. The three companies also partly had the same ownership structure.

The Switch's initial strategic decisions were:

- to go international, target the area with the most rapid growth; i.e. China
- utilize a technology new to the segment (proven elsewhere) – permanent magnet generators and full power converters

- customer orientation, which entails a flexible way of working with customers and a flexible offering
- flexible production model, i.e. the Model Factory concept (The Switch provides R&D services, prototypes, and 0-series)

The key founding persons of The Switch were: Veijo Karppinen (CEO of Venture Capital Firm VNT Management), J-P Mäkinen (CEO of The Switch), and Dag Sandås (CFO of The Switch). They all shared a background at Vacon. Their Vacon background had the following benefits:

- a well-established network and trust between the key individuals
- Vacon became a minority shareholder and a component supplier
- Vacon could focus and divest their partial ownership in Rotatek

The founders' initial vision, in 2006, was to serve all segments; wind, solar, fuel cells, industry. However, shortly it became evident that this was not possible and wind was chosen as the first focus, as it was the most mature market. Due to the market's relative youth, The Switch's business model relied on tailor made products.

In 2007-2008, the company was in a phase of high growth which necessitated further development of the production model. Retrospectively, unusually large orders of converters proved very significant for the company. In 2008, operations in China began to grow rapidly and continued throughout the next year.

In 2010-2011, the focus shifted to the generator business, as the effects of the economic downturn, especially notable in the wind power sector, had a significant impact on the company. The flexible strategy has however supported the adaptation.

The market for wind turbines is on its way towards consolidation, and the offering is now packaged in a variety of ways; from standard and adapted products to tailor made products, licensing agreements and component sales. The Switch has twenty wind-energy customers and a few solar-energy customers.

The main partners in converter production are Scanfil (both in Finland and in China) and YIT (only in Finland). In generators the main partners are Holming Works in Finland and Dongfang in China. These partners need to be aligned with The Switch's business model in order for the co-operation to operate efficiently, some earlier partners have not been able to achieve this goal. In total, the partners and The Switch have invested €90 million in The Switch and its production facilities. The Switch has been able to flexibly scale its production capacity based on demand. In Finland, production companies are accustomed to rapid fluctuations, this behavior has been adopted as a result of lessons learned from Nokia. Overall, the Switch has a networked mode of operations, utilizing the best competence available. The key actor groups and roles within The Switch network are shown in Table 4.

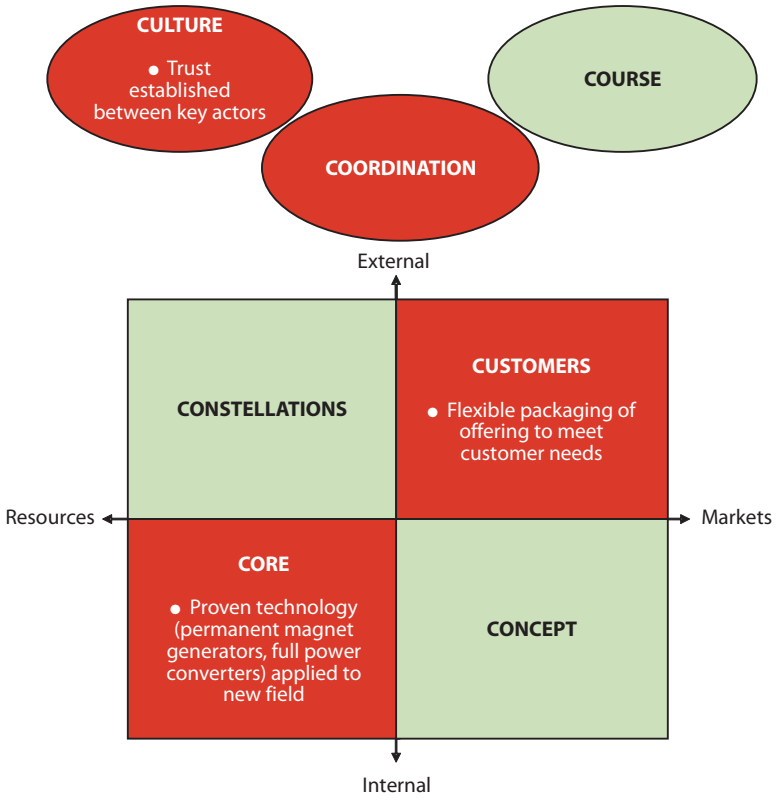
The Switch's growth has been very fast, from 22 employees and a turnover of €10 million in 2006 to 270 employees and a turnover of €135 million in 2010.

The owners and financers have been central to the company's success. Over its first three years, the company made significant losses, after which it has been profitable. The Switch has received investments from Vacon, Semikron, VNT Power Fund and Finnish Industry Investments as well as its personnel. Tekes has supported The Switch with a total of €251 000 (grant and loans), not accounting for pre-merger financing to Rotatek Finland and Verteco.

Table 4. The key actor groups and roles within The Switch network

Actor group	Role vis-á-vis The Switch	Examples
Customers	Support in tailoring solutions	In total, approx. 20 customers in wind power
Production partners	Flexible production capacity based on demand	Scanfil, YIT, Holming Works, Dongfang
Engineering partners	Flexible engineering capacity on demand, or best possible competence	
Other producers of similar technologies	Capabilities in Universities through their work with similar firms.	ABB, Vacon
Locations (and Universities)	Capability bases that can be utilized	Vaasa –energy cluster, Lappeenranta – product development & technology, Vantaa –managerial capabilities

Figure 5. The Switch capability set in 2011



Innovation support activities

Tekes has been valuable in supporting growth ambitions both in terms of technology (broadening the offering) and business model (the networked model was necessary due to the rapid growth). The Switch projects have been Switch-driven within programs such as Production concepts (2 projects), Climbus (1 project). In Groove The Switch has had one firm-driven project and participated in one project with VTT. Prior to the merger, Rotatek Finland and Verteco had several projects in e.g. Densy.

The support from Finnvera was very important in the company's relationships with banks.

The Switch is also an active member in Cleen Oy (SHOK).

Results

The Switch was able to apply an existing technology, permanent magnet generators and full power converters, to a new field. This enabled The Switch to develop the broadest and most flexible offering portfolio in its field (tailored, standard, adapted products, component sales and licensing). This has also been noticed internationally, and in March 2011 it was announced that the American company AMSC would acquire The Switch at the price of €190 million. The rationale behind the acquisition was described as follows:

With highly complementary engineering capabilities and product offerings, the combination of The Switch and AMSC will provide significant additional value for our customers, partners and investor. Both AMSC and The Switch are well positioned in Asia, which is now the world's largest and fastest growing wind power market. Our combined company is expected to be serving China's three largest wind turbine manufacturers – Sinovel, Goldwind and Dongfang – in various capacities. The Switch will also significantly strengthen AMSC's presence in Western wind markets with customers such as GE and create a new channel to market for AMSC. In short, this combination will create a global wind powerhouse.

However, due to a rapid decline of the Chinese wind turbine market, the deal was terminated as AMSC failed to receive the external financing required to fund the acquisition. However, despite the mutual termination of the acquisition agreement, both parties expressed a willingness to continue to seek synergies between the two companies and expected to continue to work collaboratively on drivetrain solutions that increase wind turbine reliability and lower the cost of energy.

Case synthesis

The Switch has developed a business model in which a networked model is applied to enable effective leveraging of its strong generative capabilities in the renewable energy industry in order to gain the flexibility to grow and adapt to market changes. Tekes has been able to support this evolution.

Sources: Interview with Dag Sandås, www.theswitch.com

Beneq – Advanced knowledge in thin film manufacturing

Beneq is a supplier of production and research equipment for advanced thin film coatings. Beneq serves the cleantech and renewable energy fields and is at the forefront of applications development in solar power technology, energy conservation and flexible electronics.

Applications and target industries include transparent conductive oxides, barriers and passivation layers especially for solar industry, LED and OLED and glass strengthening. Beneq also offers complete coating and development services to its customers. The business is built on two nano-based technology platforms: atomic layer deposition (ALD) and aerosol coating.

The company turnover in 2010 was over €10 million and the firm had a total of over 60 employees at its headquarters in Vantaa and subsidiaries in Germany, China and the US. The CEO of the company is Sampo Ahonen.

Company and capability evolution

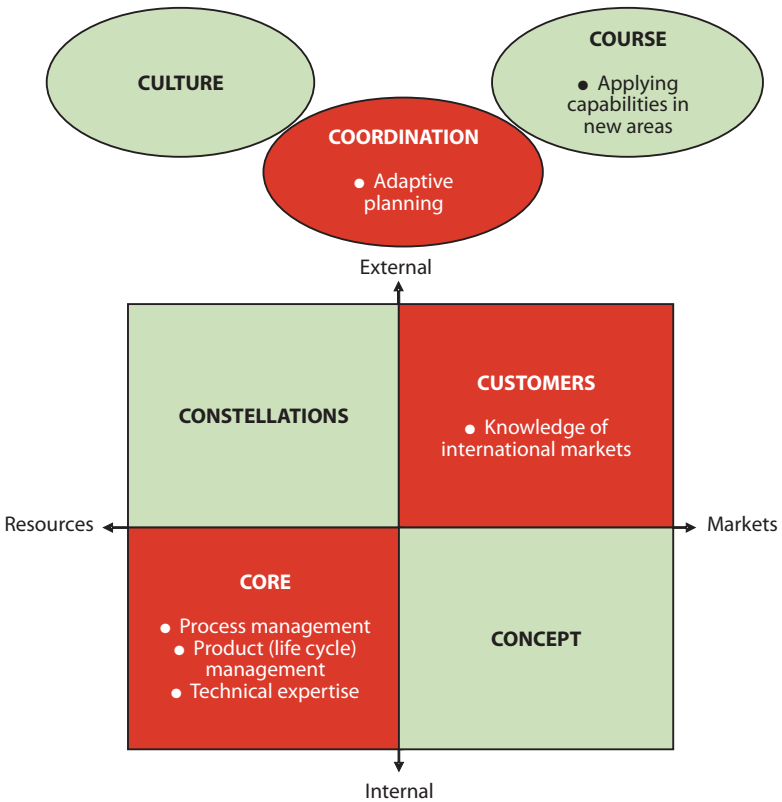
Beneq is a spin-off from Nextrom, a company specializing in fiber optics machinery, and was originally a subsidiary of Nokia. A study was undertaken by Nextrom on where it could successfully apply its capabilities. The key capabilities were identified as: technical expertise in machine manufacturing; knowledge of international markets; process management; product (life cycle) management; and adaptive planning. Following Knill Gruppe's (an Austrian competitor) 2005 acquisition of Nextrom, the diversification plan was halted. As a result, persons involved in the diversification study founded Beneq.

Beneq's initial ten person team represented the competence required to begin operations. The business idea was to design new industrial equipment and machinery using new innovative technologies. The selection of application areas fell on atomic layer deposition and aerosol coating. Co-operation with companies specialized in the technologies, Planar and ABR Innova, was initiated, resulting, a year later, in these technologies being acquired by Beneq. Beneq began developing the first customer solutions based on these technologies, also utilizing competences of leading university researchers. As part of company strategy, Beneq has also developed production and design partnerships to carry out the equipment manufacturing. The first commercial product, an ALD Coating machine, was finished in 2005.

The application areas have later been narrowed down to cleantech/renewable energy and related coating equipment. Beneq is differentiated from its competitors through its continued focus, present from the outset, on both research and industrial scale equipment as well as on developing applications supported by IPR portfolio, whereas competitors have, at least initially, primarily targeted research equipment.

Beneq has developed a business model with the following elements: (i)

Figure 6. Initial capability set of Beneq (2005, at time of spin-off from Nextrom)



finding a relevant technical idea and a globally leading firm as a pilot customer, (ii) providing a joint development process, (iii) linking in additional complementary research for the technological and equipment manufacturing solutions, (iv) building the prototype, and, finally, the production equipment.

By orchestrating its own ecosystem, Beneq manages these collaborative projects and owns the IPR related to the technologies. Beneq wants to ensure the customer's success through the new developed technology. Beneq also searches for alternative paths for commercializing its IPR. The development of Beneq has resulted in a broad network including over 200 organizations in total. Working with the best competence, irrespective of whether the competence is internal or external, has been a guiding principle. Table 5 below presents some key actor groups, roles and examples of organizations.

Beneq's growth strategy has been supported by its founders, private individuals and venture capital firms (Inventure, 2006 & 2007, Via Venture Partners, 2007 & 2011, Finnish Industry Investments, 2011). In the period between 2006-2010, Beneq has received a total of €4,1 million in from Tekes (loans and grants) to support its development.

Throughout its history, Beneq has strengthened its resource integration, business modeling and transformative capabilities. In its innovation and commercialization processes it looks for resources far beyond its own organizational borders. This strong development focus has also refined its technology-related generative capabilities.

Figure 7. Beneq capability profile 2011

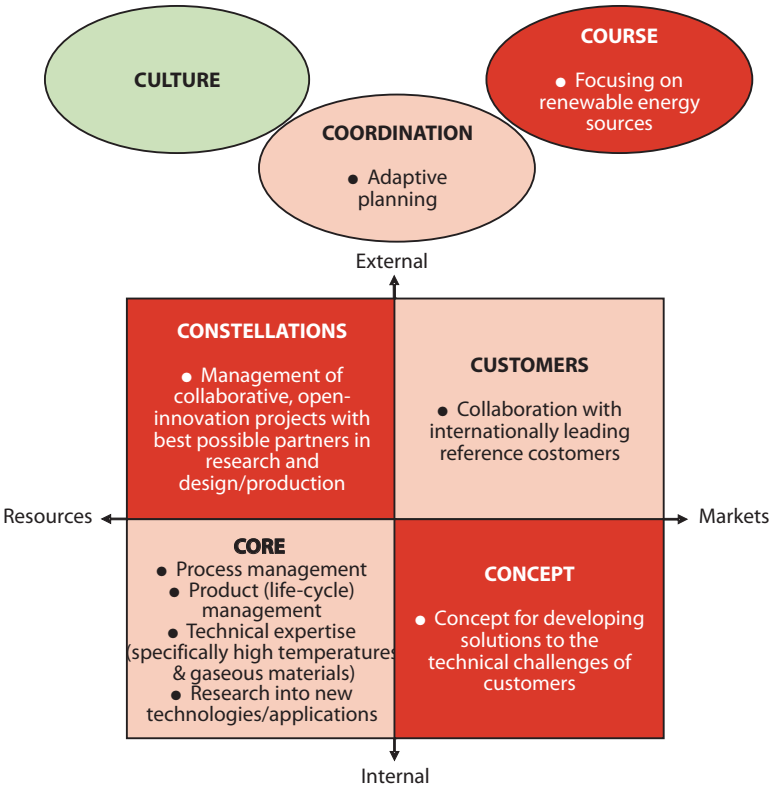


Table 5. Beneq's key actor groups, roles and examples of organizations

Actor group	Role vis-á-vis Beneq	Examples
Leading global companies	Co-developing solutions and business cases	Asahi Glass Limited
Business partners	Co-development of opportunities	Glaston, ALD Nanosolutions
Distributors	Seeking customer & market potential	
Research institutions	Expertise, resources for R&D&I	University of Helsinki (inorganic chemistry), Aalto University (Micronova), Tampere University of Technology (aerosol physics), NREL, NASA, Chinese Academy of Science, Frauenhofer Institute, Helmoltz Zentrum Berlin
Design partners	Complementing design competence	Finnsampo, Etteplan
Manufacturing	Producing the equipment after 0-series	Mechania, KTS Mekano, Turun Tekotekniikka, Partnertech – + 20 other manufacturing partners

Innovation support activities

Among the first activities undertaken by Beneq was the utilization of internationally leading incubators to find innovative application areas for their capabilities. These activities resulted in Beneq's receiving a very large number of suggestions.

Beneq has had a total of six firm-led Tekes projects in the FinNano and Functional Materials programs. It has participated in nine research projects and in one project lead by another company. Program evaluations and Beneq's own reflections express the benefits of Tekes's support in building partnerships in business and research as well as the building of human capital.

Beneq was a pilot company in the NIY –program (Young Innovative Enterprise) and thus has also gained experience of Tekes's new strategy towards growth enterprises. Beneq perceived this as a positive development, this despite Beneq's having to co-develop many parts of the content of the program with Tekes.

Results

Beneq has broadened and refined Nextrom's initial innovation capabilities and applied these capabilities to new applications and technology areas. Beneq's model of supporting the industrial equipment development and production concept with complementary technological expertise from universities has emerged gradually. The co-operation has resulted in the awarding of over 100 patent families to Beneq.

The company's growth has been rapid, and the company has yet to make a profit due to the aggressive growth strategy, but the continued support of the venture capital firms indicates that there is a strong belief in Beneq's potential.

Case synthesis

Beneq exemplifies how a company possessing a generator capability set can build orchestrator capabilities by purposefully co-evolving with a broader network as well as the various possible roles which Tekes can occupy in such a process. The rapid growth has been enabled both by venture capital and support from Tekes. As a result of Tekes's support, Beneq has been able to address a bigger number of technical challenges. Tekes has also helped to steer the research and partnership development as well as the co-development of new offerings/business models.

Sources: Interviews with CEO Sampo Ahonen and CTO Tommi Vainio, www.beneq.com

Smartum – Pioneering service vouchers

Smartum Oy is a service company that produces targeted employment benefits in the form of means of payment. The company was established in 1995. Smartum's targeted payment instruments provide the employer with a versatile, easy, and cost-effective means of supporting an employee's spontaneous development. 100% of the decision-makers in the personnel administration of Smartum's customer companies would recommend Smartum to their colleagues.

Smartum's turnover in 2010 was €50 million. The CEO of the company is Maarit Hannula.

Company and capability evolution

Smartum was born out of the desire to provide greater flexibility in how and where employees use employer-subsidized fitness/sports benefits. The Hyökyvaara founders operated popular gyms, but received customer feedback that their gyms were not approved by the employers for company use. Thus, the brothers decided to develop a service (voucher and support process) to facilitate the optimized management of these benefits for both employers and employees. Smartum was founded and it utilized the lunch vouchers (Lounasseteli) as a model for running the payment system. Perseverant sales activities and being receptive to the suggestions of service providers and employers, created the basis for the success. A new wave of growth came with legislation, introduced in 2004, which made a portion of the employer-provided sports benefits tax-free income for the employee, a development which came as the result of Smartum's active promotion to members of parliament over several years. In a similar manner, Smartum introduced, in 2005, the culture voucher, which again became partially tax-free for the employee later.

The core element of the Smartum offerings is assisting employers in providing benefits to employees and simultaneously opening up a market for service providers. This not only expands employees' freedom of choice but also improves their wellbeing. The wellbeing factor is important as this explains why the state has supported this with a favorable tax code.

The Smartum network now contains 4 000 sites where the benefits can be used and 11 000 employers utilize

the service, which means that 25 % of the Finnish workforce are Smartum customers. Smartum is home-market oriented and family owned.

Smartum basically fulfills two critical roles, firstly, it needs to be a skillful orchestrator to link together the interests of different partners in order to open up a new market (develop a concept, link different resources and evolve the business model). Secondly, Smartum has to serve the established system by providing an efficient system for managing benefits, and developing the support services based on continuous feedback.

Smartum's whole business model is thus based on establishing added value between the various actors in its network and reinforcing their connections to each other (Table 6).

The emergence of Smartum's third, and latest, product range followed a different route. Smartum was introduced to the possibility of operating in a new field: supporting social and health services with their competences.

The ministry of Social Affairs and Health communicated, in 2004, that use of service vouchers could be expanded in the future. This motivated Jykes (a development firm owned by the City of Jyväskylä) to further research this potential market in order to enhance well-being entrepreneurship. In this study it was shown that if vouchers are provided by the public sector there has to be a cost efficient voucher firm to manage the process if benefits are to be gained.

A pilot project was undertaken to test the voucher in select social services. Jykes became the lead organization as the service providers needed to become involved and Jykes was believed to have the skills to work with them. The key person from Jykes succeeded, as a result of persistent encouragement, in convincing Smartum to support the pilot.

The pilot proved that customer choice was a good way to steer the resources, but it presented the city with the challenge of developing a method for managing these services as a whole. Through the pilot, however, Jykes was able to communicate to national legislators that the planned maximum value of €20 per voucher would not suffice if the application area was expanded and, consequently, the legislation does not stipulate a maximum value.

Table 6. Smartum's network and connections to each other

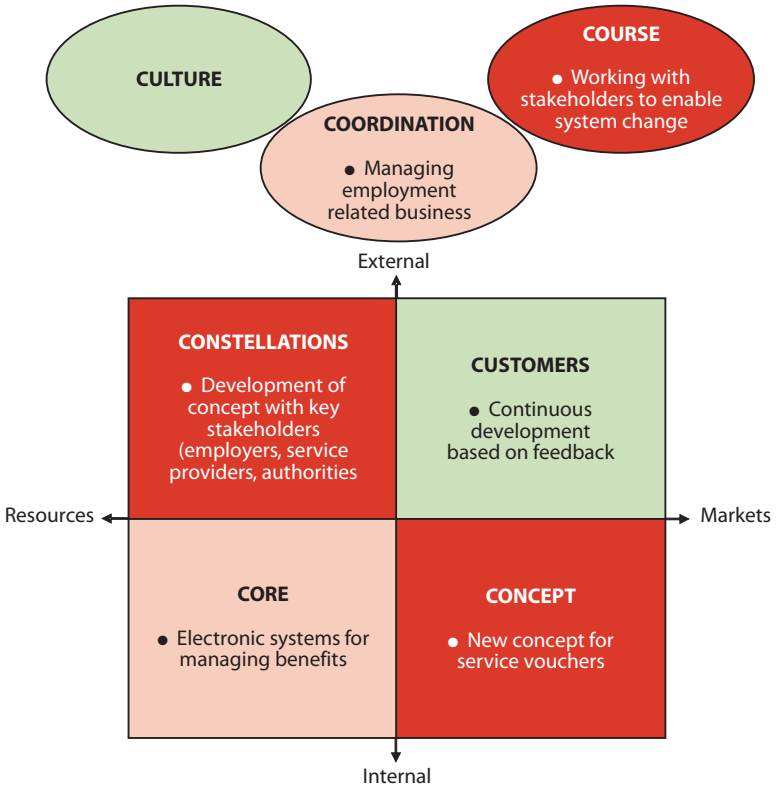
Actor group	Role vis-á-vis Smartum	Examples
End customers	Recipients of vouchers, utilize and provide feedback on and ideas for services	Individuals of all ages
Service providers	New application areas for Smartum's offering	Gyms, museums, dentists
Employers / benefit providers	Paying customer for Smartum's services	
Key customers	Co-development of offering, reference customers	City of Jyväskylä
Professional service firms	Complementing competences	Lobbyists, ICT developers
National authorities	Regulation of market	Parliament, Tax Authorities

The next logical step for Jykes was to apply for funding for the next stage of development in Tekes's Customer – Provider model - project. Tekes's initial response to the application was negative. A refined application received Tekes's support, but the city had then rejected the idea. After some modifications of the project plan the project was undertaken as a co-operation between the city and Jykes, and supported by Smartum.

The project did not proceed smoothly at the beginning. For instance, the merger of several municipalities with Jyväskylä delayed the engagement of the city officials. Gradually, however, the city leadership started to recognize the potential benefits of the concept. A voucher system would improve customer choice and this would, at the same time, imply savings for the city. This would transform the city's health care and social services systems significantly, requiring a customer service desk providing customers with 24/7 support for the vouchers. This implied a cultural change as city officials could now have an impact on how the customer, through his or her own behavior, could reduce expenses for the city.

The key person at Jykes, Mareena Löfgrén, had, prior to the final Tekes decision, joined Smartum and begun development of the voucher related business in the public sector. She was able to utilize the electronic management system for the vouchers (from a Tekes project) as input for designing the health care and social voucher process. The support system was further developed in dialogue with the customer care personnel. Development work has continued and the supported ser-

Figure 8. Smartum capability set in 2011



vice forms have been expanded; beginning with temporary at- home-care and filial care, and later to child family care, therapies and dental health services. The system is provided as a service to the cities, in order to make their decision making easier. The objectives of the Jyväskylä demonstration project have, to a large extent, been achieved. Smartum's capability set at present is depicted in Figure 8.

Innovation support activities

In the case of service vouchers, several systems have been established (Smartum has about thirty cities as customers), whereas the other benefits have only a single national system, this implies that the service voucher systems demand stronger orchestrator capabilities. The first service voucher pilot projects were financed within AKO-program. Smartum has subsequently received financing of €360 000 from Tekes during 2004-2010 by participating in a Serve-project to build the electronic system for benefit management. Smartum also participated in a City of Jyväskylä project funded by Tekes, which enabled the development of its service voucher offering. The Tekes funding enabled a safe environment for development for the city and a reference to Smartum.

Due to its role as an intermediary between parties, Smartum is itself often approached by parties seeking to enter the market, among these are: small firms with new, Tekes-supported offerings. Thus Smartum can, at best, provide innovation support activities itself.

Results

Smartum has become a market leader in service vouchers and has developed a system that is used by over thirty cities and municipalities.

Case synthesis

The Smartum case provides a view of how the actual development of a system level innovation, demanding the establishing of a new orchestrated ecosystem, requires a different capability set than the later phase of actually orchestrating this ecosystem. It also shows that this type of orchestration platform development potentially transforms the roles of the participating parties during the process of the ecosystem's gradual maturation. Tekes's role has, thus far, been primarily to support the development of some technical component of Smartum's ecosystem. But it can be envisaged that the systemic efforts to build such ecosystems are a new important innovation field that also is becoming increasingly important for Tekes.

Sources: Interviews with Mareena Löfgren, www.smartum.fi

Appendix 4. List of interviewees

Nokia, Esko Aho
RYM, Ari Ahonen
Beneq, Sampo Ahonen
Kone, Matti Alahuhta
Sintrol, Karl Ehrström
Forestcluster, Christine Hagström-Näsi
Tieto, Bo Harald
Valio, Matti Harju
SalWe, Saara Hassinen
Elektrobit, Hannu Huttunen
Nexstim, Risto Ilmoniemi
CLEEN, Tommy Jacobson
Tekla, Ritva Keinonen
Kemira, Harri Kerminen
StoraEnso, Jukka Kilpeläinen
Tampere University of Technology, Markku Kivikoski
Lifeline Ventures, Petteri Koponen
Sitra, Mikko Kosonen
FIMECC, Harri Kulmala
Ministry of Employment and the Economy (Centre of Expertise Programme), Pirjo Kutinlahti
VTT, Erkki Leppävuori
Neste Oil, Lars Peter Lindfors
Smartum, Mareena Löfgren
GreenStream Network, Jussi Nykänen
TIVIT, Reijo Paananen
University of Oulu, Taina Pihlajaniemi
Rautaruukki, Arto Ranta-Eskola
FIT Biotech, Kalevi Reijonen
Teleste, Ilkka Ritakallio
Orion, Reijo Salonen
The Switch, Dag Sandås
Tellabs, Risto Soila
Cargotec, Matti Sommarberg
Aalto University, Tuula Teeri
Biotie Therapies, Timo Veromaa

Tekesin toimenpiteet innovaatiokyvykkyyden kehittämiseksi Suomessa

Johdanto

Strategiassaan Tekes on määritellyt erääksi keskeiseksi tavoitteekseen kehittää sellaisia kyvykkyyksiä, joita tarvitaan innovaatioiden aikaansaamiseen. Menestyvän innovaatiotoiminnan edellytyksiin kuuluu osaamisten ja verkostojen vahvistaminen.

Syksyllä 2011 käynnistettiin hanke, jonka tarkoituksena oli selvittää miten Tekesin toimenpiteet ovat edesauttaneet innovaatiokyvykkyyksien rakentumista suomalaisessa innovaatiojärjestelmässä. Tässä raportissa on esitetty tämän selvityksen tuloksia.

Innovaatiokyvykkyys ei ole yksiselitteisesti määritelty käsite. Esimerkiksi Tekesiä vastaavat organisaatiot muissa Euroopan maissa eivät ole määritelleet tavoitteekseen innovaatiokyvykkyyden kehittämistä. Siksi selvityksen ensimmäinen tehtävä oli suorittaa kirjallisuustutkimus, jonka kautta määriteltiin keskeiset käsitteet. Niiden avulla pystyttiin sekä analysoimaan Tekesin tehtyjä toimenpiteitä että suorittamaan täydentäviä yritysanalyysejä ja asiantuntijahaastatteluja innovaatiokyvykkyyksien tunnistamiseksi ja Tekesin toimenpiteiden tulosten arvioimiseksi.

Selvityksen päävastuullisena toteutusorganisaationa toimi Synocus. Raportin koostamisesta on vastannut Johan Wallin. Patrik Laxell suoritti yritys-haastattelut ja -analyysit. Jussi Hulkkonen ja Aleksi Kärkkäinen tukivat analyysityötä koko hankkeen aikana. Tämän lisäksi asiantuntijoina olivat mukana Professorit Philip Cooke, Cardiff University ja Tomi Laamanen, University of St. Gallen sekä Arne Eriksson, joka on tehnyt lukuisia innovaatioselvityksiä Vinnovalle Ruotsissa. Kaikki tässä mainitut henkilöt ovat antaneet kommenttejaan raportin eri versioihin, ja näin ollen raportti edustaa koko ryhmän yhteistä näkemystä.

Raportin rakenne

Raportti koostuu kuudesta luvusta. Johdannossa todetaan Tekesin tavoitteet, ja määritellään ne puitteet, missä innovaatiokyvykkyyden rakentamisen arviointi toteutettiin.

Toisessa luvussa esitetään kirjallisuuskatsaus, jonka avulla määriteltiin tutkimuksen keskeiset käsitteet. Lähestymistavaksi otettiin systeeminäkökulma ja asiakaskeskeisyys. Kyvykkyystarkastelussa nojauduttiin ns. dynaamisten kyvykkyyksien koulukuntaan (ks. esim. Teece, 2009) ja käytettiin Wallinin kyvykkyysmallia, jossa organisaation kyvykkyydet jaetaan neljään operatiiviseen kyvykkyyteen ja kolmeen johtamiskyvykkyyteen (ks. Wallin, 2000). Innovaatioiden määritelmäksi valittiin OECD:n käyttämä tapa. Näiden peruskäsitteiden avulla mallinnettiin innovaatiokyvykkyyksien kehittämistyötä. Mallin avulla voitiin arvioida, mitä toimenpiteitä tarvitaan innovaatiokyvykkyyksien rakentamiseksi.

Luvussa kolme on lyhyt katsaus suomalaiseen innovaatiojärjestelmään. Sen perusteella on myös rakennettu viitekehys, jonka avulla voidaan arvioida kansallisen innovaationjärjestelmän luonnetta. Suomen innovaatiojärjestelmää kuvataan myös tätä viitekehystä käyttäen.

Luotua viitekehystä käytetään luvussa neljä arvioimaan neljää muuta kansallista innovaatiojärjestelmää: Tanskan, Irlannin, Ruotsin ja Sveitsin. Maa-analyysien tärkein tehtävä on ollut tunnistaa sellaisia innovaatiokyvykkyyden rakentamiseen tähtääviä toimenpiteitä, joita on menestyksekkäästi otettu käyttöön muualla, jotta pystyttäisiin arvioimaan kuinka vastaavat toimenpiteet ovat Suomessa onnistuneet. Luvun neljän lopuksi yhdistetään kirjallisuuskatsauksen löydökset ja maa-analyyseissa esiin tulleet havainnot, jolloin pystytään identifioimaan 45 aktiviteettilajia, jotka voivat vaikuttaa suotuisasti innovaatiokyvykkyyden muodostumiseen.

Viidennessä luvussa esitetään varsinainen arviointi Tekesin toimenpiteistä. Ensimmäisessä osassa arvioidaan Tekesin omaan sisäiseen informaatioon perustuen keitä, mitä ja miten Tekes on rahoittanut ja tukenut ja miten nämä toimenpiteet ovat tukeneet innovaatiokyvykkyyksien rakentumista. Toisessa osassa arvioidaan miten asiakkaat, Tekesin rahoittamat yritykset, ovat arvioineet Tekesin toimenpiteiden edesauttaneen innovaatiokyvykkyyksien muodostumista. Kolmannessa osassa on analysoitu, miten Tekesin saama projektipalautteen mukaan on arvioitu innovaatiokyvykkyyksien syntymistä

hankkeissa. Lopuksi neljännessä osassa esitetään muutamia havaintoja siitä, miten suomalaisen innovaatiojärjestelmän tulee huomioida meneillään olevat muutokset kansainvälisessä innovaatiotoiminnassa.

Kuudes luku esittää yhteenvetona kaikki ne arvioinnit ja suositukset, joita on aiemmin esitetty luvuissa neljä ja viisi. Raportissa on esitetty yhteensä kaksitoista arviointi-/suositusparia. Sen lisäksi tuotiin esille kaksi yleisempää tavoitetta suomalaiselle innovaatiojärjestelmälle.

Arvioinnin tulokset

Tekesin toimintaympäristö on voimakkaiden muutosten kohteena. Innovaatiotoiminnassa painopiste on siirtymässä teknologioista ja tuotteista ratkaisuihin ja ekosysteemeihin. Tämä vaatii kansallisilta innovaatiojärjestelmiltä kykyä muuntua ja sopeutua tilanteisiin. Niiltä edellytetään voimakkaampaa osallistumista uudentyyppisten yhteistyörakenteiden luomiseen ja tukemiseen.

Tekes on hyvin tiedostanut meneillään olevat muutokset, ja on myös käynnistänyt toimenpiteitä, jotka vastaavat uusiin haasteisiin. Kun Tekesiä verrataan vastaaviin innovaatiotoimijoihin muissa maissa, Tekesiä voidaan yhä vielä pitää eräänä johtavana innovaatiotoimijana maailmassa.

Lyhyellä tähtäyksellä Tekesin tärkein haaste on luoda toimintamallit, jotka mahdollistavat kansainvälisten arvoverkkojen ja ekosysteemien täysimääräisen hyödyntämisen suomalaisille innovaatiotoimijoille. Tällaisissa hankkeissa korostuu monitieteellisyys ja monialaisuus. Tekesin pitää tässä olla aloitteentekijänä uudenlaisten yhteistyömuotojen ja liittoumien muodostamisessa. Haasteellisuutta lisää se, että toimintamallit ja -tavat ovat toimialakohtaisia. Näin kyky arvioida, mitä tulee mihinkin tilanteeseen soveltaa, nousee ensiarvoisen tärkeäksi. Suomelle ja Tekesille proaktiivinen kansainvälinen toiminta on tässä avainasemassa, ja kansainvälisessä toiminnassa Suomi on jonkin verran jäljessä parhaista kilpailijoista.

Tekesin vuosien 2004–2010 aikana tehdyt toimenpiteet ovat vastanneet hyvin uusiin haasteisiin. Pk-sektorille on lisätty rahoitusta. Suurten yritysten rahoitusosuutta ei voida mitenkään pitää ylisuurena, kun erityisesti viime aikoina on alkanut vahvistua se käsitys, että suurten yritysten merkitys menestyksekkäissä ekosysteemi-innovaatioissa on hyvinkin keskeinen. Myös rahoitettavien alojen valinnoissa Tekes on hyvin tasapainottanut vanhaa ja uutta. On tärkeää, että Tekes jatkossakin pitää omasta linjastaan kiinni, koska Tekes on kiistattomasti Suomen innovaatiokentän keskeisin toimija.

Innovaatiologiikan muutoksista on seurannut kaksi merkittävää haastetta. Toinen on tarve yhdistää erilaisia teknologioita ja osaamisia vaativien ratkaisujen aikaansaamiseksi ja toinen on kasvun tukeminen. Tekes on vastannut molempiin haasteisiin lisäämällä uusia instrumentteja keinovalikoimaansa. Nyt on erityisen tärkeää, että näillä toimenpiteillä saadaan aikaiseksi myös kansainvälisesti menestyviä kasvuyrityksiä.

Yritysanalyysit ja haastattelut toivat esille sen, että menestyksekäs toiminta kansainvälisissä ekosysteemeissä on avain innovaatioiden onnistumiselle. Tekesin tulee tuoda kehitys- ja orkestrointialustoja asiakkaidensa käyttöön ja samanaikaisesti huolehtia siitä, että tiedonhallintaprosessit toimivat siten, että aito itseään ruokkiva yhteistyö lähtee vahvistumaan.

Tekesillä on säännöllinen arviointiprosessi. Sen tuottamaa tietokantaa pystytään tulevaisuudessa hyödyntämään vielä aktiivisemmin ja tehokkaammin. Tulee myös harkita, voisiko väliraportoinneissa käyttää samanlaista informaatiorakennetta kuin loppuarvioinneissa. Tämä toisi vielä tehokkaamman seurantavälineen Tekesin johdon käyttöön.

Arvioinnin yhteenvetona voidaan todeta, että Tekes on varsin hyvin omilla toimenpiteillään onnistunut vahvistamaan innovaatiokyvykkyyttä suomalaisessa talouselämässä. Kolme asiaa vaatii jatkossa Tekesin johdolta erityistä huomiota:

- uusien toimintatapojen juurruttaminen, jotta voidaan pärjätä kansainvälisissä orkestroiduissa ekosysteemeissä
- potentiaalisten kasvuyritysten identifiointi ja niiden tukeminen siihen asti, että ne ovat tukevasti päässeet kasvuurilleen
- kokonaisvaltaisesta innovaatiojärjestelmän kehittämisestä huolehtiminen mukaan lukien verotus ja yrittäjyysasiat.

Tekes' Reviews in English

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