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Functional Approach to National Systems of Innovation: The Case of a Small Catching-up Country

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Abstract

Although systems of innovation approach is gaining popularity among researchers and policy-makers, it is still rather difficult to apply this approach to specific policy settings and designs, because the approach is too general and does not provide many direct suggestions for building up an innovation system. It is often pointed out that in catching-up countries the innovation policy is not aligned with the specific circumstances of the innovation systems, but copies similar policies in more developed countries instead. This article finds by analysing the functional side of Estonian national innovation system, that the functions involving the provision of knowledge inputs and constituents of the innovation system, but also support services for innovating firms rather than demand-side activities are recognized by local policy designers. We suggest that by aligning the structure of the innovation system, more coherent logic of public-private co-evolution and better alignment of respective innovation policy measures should be followed. By looking at individual functions, it is clear, that the demand-side activities of innovation policy can be used more to enhance innovation activities in a more targeted way. More generally, we find that the functions that public sector performs in a national innovation system, should be designed and developed carefully in a balanced way, which is especially important for a small catching-up country, where the risk to create misalignments in the system is larger.

Keywords

Innovation system, catching-up countries

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Introduction

It is commonly accepted that innovation is a major road for firms and nations to sustain competitiveness in longer perspective. Many authors have pointed to the growing role of knowledge and learning in the economy (e.g. Drucker, 1993; Nonaka, 1991; Florida, Kenney, 1993). The ability to generate new knowledge requires suitably orchestrated system of innovation. This concept proposed by evolutionary economists is built around the idea of systemic approach to innovation that integrates institutions to create, store, and transfer the knowledge, skills and artefacts (OECD, 1999). Although this approach has been widely accepted, it is proven difficult to apply it in specific policy settings, because the approach is too general (Teubal, 2002) and does not provide many direct suggestions for building up an innovation system (hereinafter IS) (Johnson *et al.,* 2003). This is also among the reasons, why the existing innovation policies are considered to follow linear rather than systemic approach to innovation (see for EU Malas-Gallart and Davies (2006), and for CEE countries specifically Tiits *et al.* (2005)).

The concept has been elaborated more recently by bringing forward specific functions of IS (cf. Högselius, 2006; Jakobsson and Bergek, 2006; Edquist and Hommen, 2008; Johnson, 2008). The discussion of specific functions makes the concept of IS more precise with regard to innovation policy by enabling to link different efforts of public sector towards improving the functioning of IS-s.

Estonian independent innovation policy in 1990s started from „no-policy policy“ (Karo, Kattel, 2010) and followed the developments facilitated by policy-learning from other European countries (most importantly, Finland) rather that specific needs of Estonian economy (Varblane *et al*. 2007). Estonian case possesses the specific features of the extreme smallness of the economy, but also the research system of the country but also the catching-up or latecomer characteristics of respective IS.

This article will offer a contribution by attempting to assess empirically how the functions of an IS specified in the literature are applied for designing and developing Estonian national innovation system (hereinafter NIS). This involves first reviewing the literature of functions of IS-s by connecting these with specific innovation policy measures. Thereafter the (perceived) importance of different functions among Estonian government officials is analysed and the relative proportions of funding different policy measures is assessed by using the financial indicators of EU Structural Funds and Estonian state budget allotments attributable to different functions of IS. The latter analysis has its limitations comprising funding instruments comparable to the amount of total R&D spending of the country (about 1.5% from GDP annually).

1. The functions of innovation systems

The development of the innovation system approach started at the end of 1980. First ones to use this term and conduct research in that area were Chris Freeman followed closely by Bengt-Åke Lundvall. Although the approach is gaining more and more popularity among researchers and policy makers, it has been rather general and not easily applicable. Recently this has started to change due to the introduction of function into the systems approach. (Tamm, 2010)

The main function of the IS according to Edquist and Hommen is "to pursue the innovation process – i.e. to develop and diffuse innovations" (Edquist, Hommen 2008: 8). Carlsson *et al* (2002) state that "*The function of an innovation system is to generate, diffuse, and utilize technology*". These main functions mentioned above are rather general and declaratory, and do not give very useful and precise guidelines for constructing an IS for a country. This supports the existing opinion that IS is more a theoretical approach than a practical tool for designing an innovation policy. That is why a more detailed list of IS functions is needed. (Edquist, Hommen 2008: 460) Such a list was presented by Rametsteiner and Weiss (2006). They brought out three functions of innovation system (Rametsteiner, Weiss 2006: 566):

- reduction of uncertainties through information provision,
- management of conflicts and cooperation,
- provision of incentives.

An even more detailed list of functions are presented in Table 1 summarizing functions mentioned in four different studies. These lists are more comprehensive and useful for policy design than the abovementioned functions of IS.

Högselius highlights 12 functions of IS. All of these (except the last) may be influenced by the formulation of public policy (last function) because through it all other functions can be influenced, created and/or supported. Högselius also mentions the formulation of vision as a function of IS. This function does not exist explicitly or implicitly in the other approaches presented in Table 1. The authors of this article support the exclusion of vision as a function because a system as an entity cannot have a vision. A common vision may and should be shared by the actors in a system and through this shared vision actions moving towards that target can be implemented.

Högselius's listing of functions has some additional shortcomings. First, the function that mentions the adaptation of organizations to accommodate innovation does not take into consideration that besides organizations, institutions and society as a whole also have to be ready to accommodate innovations. Second, there is no mention of labour as a necessary resource for innovation activities/policy. Both of these aspects are taken into account in Johnson's approach. Johnson (2008) compared the findings of different researchers of IS-s to compose the list of the functions common across studies. The authors of this chapter take the approach presented in Edquist and Hommen (2008) as a basis for empirical assessment because this list is the most explicit and representative overview of IS functions.

To create and/or support the functions mentioned in Table 1, several policy measures can be designed and implemented. Edquist and Hommen (2008) define innovation policy through the main function of IS. According to them innovation policy is defined as "*Actions by public organizations that influence the development and diffusion of innovations*" (Edquist, Hommen 2008: 9). There are different policy measures designed to support the main and sub-functions of IS. For example, the creation of knowledge may be influenced through education policy, grants for scientists and researchers, financial support for R&D activities executed in enterprises, tax incentives etc. The external and internal context of the firms is more or less influenced by government interventions, and enterprises have to exist in this system of links and interconnections; in other words, innovations and technological changes take place "within a social fabric" (Archibugi, Michie 1997: 1). This describes the situation where firms perform the important role of innovating, but the innovation process taking place in a firm is influenced by many other institutions and organizations surrounding the firm, so the innovation process is influenced by interactions between the firm and its environment (Archibugi, Michie 1997: 1–2; Smith 2000: 73).

There exist differences between firms' environments including institutional contexts across IS-s, and this affects the macroeconomic performance of countries. The differences in systems may arise from capabilities, and governance systems and activities including policy measures to intervene in the economic activities of organizations and institutions. (Smith 2000: 74) Differences also may arise from barriers existing in enterprises' innovation processes.

Table 1. Different approaches to the functions of innovation systems

Högselius (2006)	**Jakobsson and Bergek (2006)**	**Edquist and Hommen (2008)**	**Johnson (2008)**
• formulation of visions; • articulation of demand for new, improved and/or cheaper products; • creation of new knowledge; • competence-building; • formation of new firms and other organisations; • market entry and exit; • adaptation of	• market formation (creation, increase in volumes, and mass marketing); • knowledge development (breadth and depth of the knowledge base) and its diffusion; • support to entrepreneurial spirit and activities; • influencing the search activities and investment behaviour; • resource	• provision of know-ledge inputs to innovation process (provision of R&D, creation of new knowledge, competence building) • demand-side activities (formation of markets, articulation of quality requirements) • provision of constituents of IS (creating and changing	• identification of the bottlenecks in IP; • creation of knowledge to solve the identified bottlenecks; • recognition of the potential of innovation; • creation of incentives to be engaged in IP; • creation of markets for innovation; • decrease resistance to

Högselius (2006)	Jakobsson and Bergek (2006)	Edquist and Hommen (2008)	Johnson (2008)
organizations to accommodate innovation; • networking; • provision of finance; • consultancy, advice and lobbying activities; • creating, changing and abolishing institutions; • formulation of public policy.	availability and mobility; • creation of legal environment suitable for innovation systems; • development of positive externalities.	organisations and institutions, and networking) • support services for innovating firms (incubation, financing, consultancy services)	change; • facilitate knowledge and info exchange; • supply of resources (incl. competencies); • guidance for the search processes (e.g. standards and regulations); • reduction of social uncertainty.

Sources: Composed by the authors on the basis of Högselius 2006: 34–36; Jakobsson, Bergek 2006: 691–693; Edquist, Hommen 2008: 10, Johnson 2008: 12

For a long time there has been discussion on whether the government should intervene in market processes and the economic environment or not. It is accepted by different researchers that some intervention is necessary to create the general framework for economic processes through laws, regulations and so on. But how much government should intervene to support innovation processes, in what circumstances and through which measures, is still under discussion.

2. The IS functions and innovation policy measures

Innovation policy measures implemented by the public sector are influenced by two theoretical approaches: neo-classical and evolutionary (Frenkel 2003: 120). According to neo-classical theory, firms are the main element of economic activities and they have to survive in a neoclassical market without any supportive organizations (Teubal 2002: 237). The neo-classical approach is based on the equilibrium and optimization behaviour of economic actors. Although aspects such as strategic interdependence between firms, uncertainty, asymmetry of information etc. are dealt within mainstream neo-classical theory, this approach sometimes fails in explaining some issues, which are present in the systematic approach. (Smith 2000: 75) It may be said that the classical approach emphasizes the economic model with rather isolated profit-maximizing firms with perfect information and almost no risks. It disregards the organizations and institutions interacting with and influencing innovating firm and ignores the fact that not all organizations are profit-maximizing entities. (Edquist, Hommen 1999: 68)

Several innovation policy measures implemented up until now have been influenced by neo-classical production theory. According to this theory, firms have to decide what to produce and how to produce it on the bases of production functions. Firms

have information about current and future input prices, all the techniques and technologies (seen as knowledge) available for production etc. to solve the profit-maximising exercise and find the optimal solution. The knowledge in this theory is generic, codified, accessible without costs, and context-independent. When the external context of the firm changes, it changes its position without any problems and is able to find a new optimal point of production. (Smith 2000: 82–83, 85) Therefore, neo-classical theory does not include any adjustment problems. In this framework the objectives of policies lie in freeing the markets, removing barriers from factor movements, increasing the competitiveness between enterprises, producing knowledge through publicly-funded institutions or providing subsidies to knowledge-producing firms, and solving the problems with a low level of appropriability of knowledge. (Smith 2000: 82–83, 85) The policy makers possess perfect information and their task is to eliminate market failures preventing the system to reach optimality through implementing different incentives in the economy (Hommen, Edquist 2008: 470).

Modern innovation policy on the other hand is based on a systematic approach, and instruments emphasising the importance of learning, knowledge exchange, evolution, and coordination between different alternatives. Systematic instruments cover five functions supporting the functions of the IS presented in the previous sub-chapter (Smits, Kuhlmann 2004: 5):

- management of links and connections between different subsystems and actors;
- creation, deconstruction and governance of IS-s;
- establishing conditions for learning and experimenting;
- provision of infrastructure for creation of strategic knowledge needed by actors;
- encouragement of demand and visions for the discovering and/or creation of new opportunities.

All firms' activities are based on some kind of knowledge base, which can be divided into three parts – firm-specific knowledge, sector-specific knowledge and general knowledge (Smith 2000: 87). These types of knowledge are linked to each other and they evolve over time (Smith 2000: 89). Searching, exploring, and learning are the most important activities for innovation inside IS approach. Therefore policy within the NIS framework has to deal with learning and knowledge originating from learning. (Smith 2000: 81) The management of links and connections between different sub-systems and actors may therefore be considered as one of the most important tasks of public policy support measures. Through interactions, knowledge is exchanged, opportunities identified, and new combinations created. (Edquist, Hommen 1999: 66)

To fulfil functions of systematic instruments, many different innovation policy measures have been elaborated. In order to group these different measures, several categorizations have been developed. Rolfo and Calabrese (2006) have divided measures of innovation policy into four groups: mission policies, diffusion and technology transfer policies, infrastructural policies, and territorial policies (technological districts, clusters). Mission policies are linked to financial resources for basic and applied research carried out by research institutes and/or firms including the training of human resources, development of new research techniques and tools, and support for general technologies through the cooperation of businesses to

reduce research costs and risks. Diffusion and technology transfer policies cover technical assistance given to firms (financial aid for purchase of new machinery, measures aimed at transferring the knowledge, the promotion of research within the companies, collaboration among companies and with universities, the creation of technology-based firms, support for employing young researchers to companies and the creation of research groups with personnel drawn from industries, universities and research institutes). Infrastructural policies are connected to the creation of technological and scientific infrastructures, educational and research systems including laboratories and equipment, and communication networks (scientific and technology parks, research institutes, incubators, technology transfer centres, technological services and brokerage offering information, consultancy, assistance by themselves and through networks they belong to). (Rolfo, Calabrese 2006: 258–260)

It is also possible to divide policy measures according to a top-down and bottom-up perspective. From a top-down perspective, innovation policy measures are linked with national interest and priorities but they also may be influenced by supra-national institutions and unions. But even in this case policies should take into account the developments and situation inside the country, because policies must be in accordance with its economic environment in order to avoid causing misalignment between designed policy measures and needs of the enterprises. (Howells 2005: 1223–1224)

The other perspective is that of bottom-up policies which are actually based on local situations and needs, but these bottom-up policies still have to be held in accordance with national and supra-national development, to fit into the framework of general policy. By doing this it is easier to get finance for designing and implementing these bottom-up policies. (Howells 2005: 1225) The majority of innovation policies are top-down policies though (Howells 2005: 1227). Top-down approach may cause innovation policies to fail, because policy makers may not be well informed about local situation and needs. The most commonly used grouping of innovation policy measures is to divide them into demand-side and supply-side measures. This grouping also has links with earlier innovation process models. Linear innovation process models advocate supply-side measures or demand-side measures; system-oriented models take into consideration both of them. (Edquist, Hommen 1999: 63–64) Taxonomy developed by Edler and Georghiou (2007) is presented below (see Figure 1).

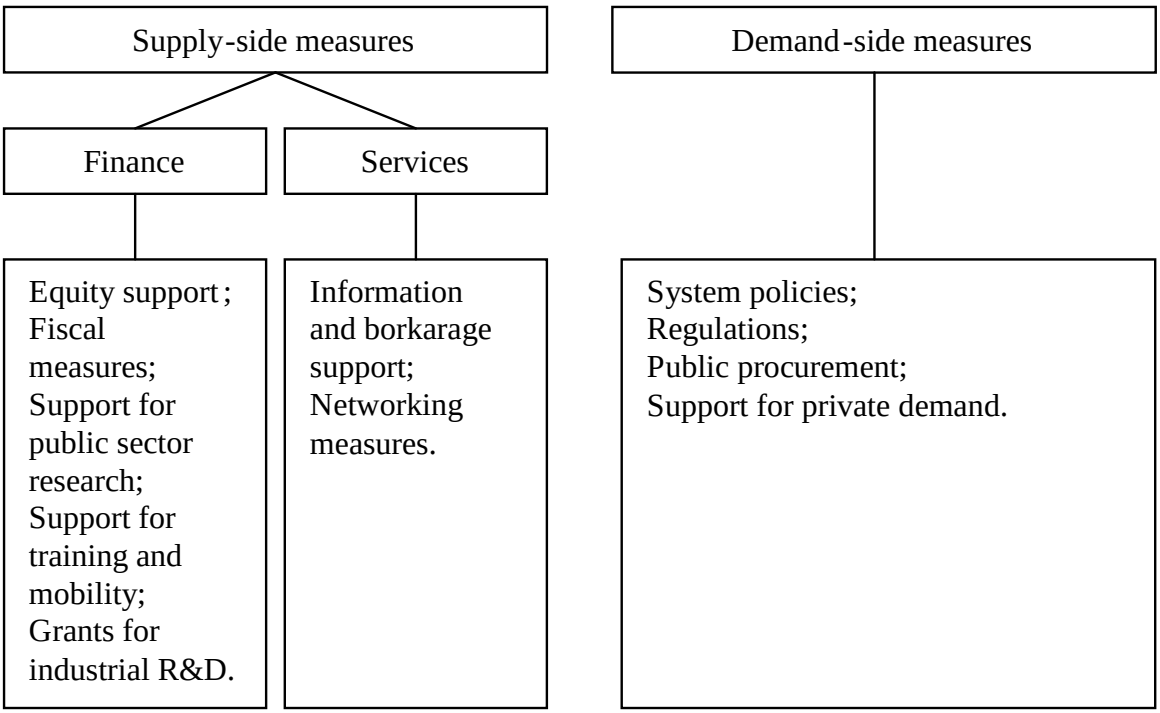

Figure 1. Taxonomy of innovation policy tools (Edler, Georghiou 2007: 953)

There are more supply-side measures implemented by governments of different countries than demand-side measures. At the same time, supply side policy measures cannot eliminate and/or create enough incentives to facilitate the innovation process of companies. Demand-side policies are defined as being measures linked to the increase and/or creation of demand for innovations; determining new requirements for new products, services; and a better articulation of demand (Edler, Georghiou 2007: 952). One of these kinds of policy measures consists of the tools implemented with the aim to shift the culture towards the celebration of innovation. Measures such as harmonised regulatory environment, the use of standards and public procurement can be used to achieve this. (Aho *et al.* 2006: 6–7) Demand-side policies also encompass systematic policies, because these policy measures are designed to bring together users and providers of innovations (Edler, Georghiou 2007: 953). Demand-side policies can therefore be divided into four groups (Georghiou 2006: 12, Edler, Georghiou 2007: 953):

- systematic policies providing an environment for actors involved in innovation process (e.g. cluster policies),
- regulations for markets,
- public procurement,
- support of private demand.

The third group of demand-side policies, namely public procurement, is currently starting to gain in popularity amongst policy makers. Public procurement is defined as being procurement inside which innovation is an important condition. Through public procurement, private R&D activities can be increased, demand subsidies introduced,

public services and infrastructure improved, and cooperation supported. (Edler, Georghiou 2007: 950, 952–953, 956) The precise effect of public procurement depends on the composition of the call. Public procurement usually has a broader influence on region than a direct influence on the tender-winning companies. First, it forms an important part of local demand. Second, it may remove the market and system failures linked to problems in the translation of needs into marked demand. Third, it also creates the possibility of upgrading the public infrastructure and/or public services. (Edler, Georghiou 2007: 954) But public procurement can also introduce additional failures into the system. For example, it can "pick-the-winners" through preferring one solution to another without letting markets and private demand to decide. Public procurement measures can also undermine the principles of free market and trade if the conditions of procurement are favourable only to local companies. All these problems can be removed through the skilful and impartial drafting of the procurement call. (Edler, Georghiou 2007: 961) The latter is very difficult to achieve under political pressure from different interest groups.

Although demand-side policies are not yet widely used, the political pressure to design and implement them is rather high. But the implementation of demand-side policies may bring with it many problems. Implementation of demand-side policy measures frequently requires setting targets and determining the direction of technology development via public sector bodies. At the same time, these bodies only possess secondary information about technology and market trends. (Watanabe, Tokumasu 2003: 70) But even so, the recent trend in the EU is to move away from public funding of enterprises towards increasing demand for innovations (European Innovation… 2008: 9).

3. Functions of innovation system from the perspective of government officials

For the innovation system to be effective it has to be active and fulfil its functions. So, besides the components of the IS shown in Figure 2, system functions are also important. According to Edquist and Hommen (2008: 7), the main function of the innovation system is "to develop and diffuse innovations". To fulfil this main function, the following sub-functions and/or actions have to exist within the system (Edquist, Hommen, 2008: 10):

- provision of knowledge inputs for the innovation process:
- provision of R&D and through that create new knowledge,
- competence building in innovation and R&D activities through educating the labour force,
- functions focused on the demand-side:
- formation of new markets,
- development of demand side quality requirements,
- provision of the components of the innovation system:

- creation and change of organizations important for innovations,
- creation and change to the rules of the game linked to innovative organizations and innovation processes,
- creation and effective networks,
- creation and implementation of innovation support measures:
- provision of facilities and administrative support for innovations,
- provision of finances facilitating the commercialization of knowledge,
- provision of consultancy.

Edquist and Hommen did not focus so much on basic research in their list of sub-functions. They focused more on R&D and competencies as necessary for the innovation process to be beneficial, and the demand side of innovation. Also, not all functions of the IS have to be established by the public sector. Some of the sub-functions mentioned above can be provided by private sector organisations. But even if they are provided by private sector organisations, the public sector has to create the conditions for the private sector to participate (e.g. special legislative and economic environment, and/or conditions needed for venture capital associations to exist etc.).

To investigate what functions of the innovation system are considered important by Estonian public sector representatives and policy makers, an interview plan was constructed and 9 interviews conducted with public sector representatives. An overview of interviewees is presented in Table 2. The people presented in Table 2 were chosen because of their knowledge about the design and implementation of innovation support measures in Estonia. From the public sector perspective, all the most important organisations responsible for designing or implementing innovation support measures in Estonia or linked to these were included. Interviewees from those organisations are heads of departments and/or divisions or deal with issues linked to innovation policy on a daily basis.

Table 2. Overview of interviewee occupation, organization and time of interview

Name	**Occupation**	**Organization**	**Time of the interview**
Harry Faiman	Coordinator of Technological Development Centre Support Programme	Enterprise Estonia	14th of October 2008
Allar Korjas	Director of Export Division	Enterprise Estonia	13th of Jan 2009
Kitty Kubo	Head of Foresight Division	Estonian Development Fund	10th of Oct 2008
Ilmar Pralla	Director of Innovation Division	Enterprise Estonia	8th of Oct 2008

Name	Occupation	Organization	Time of the interview
Mihkel Randrüüt	Head of Technology and Innovation Division	Ministry of Economic Affairs and Communications (MEAC)	8th of Oct 2008
Lauri Tammiste	Head of Economic Development Dept	MEAC	15th of Oct 2008
Marek Tiits	Chief Analyst of Monitoring and Analysis Group	Estonian Academy of Sciences	14th of Oct 2008
Piret Treiberg	Head of Enterprise Division	MEAC	21st of Oct 2008
Oliver Väärtnõu	Adviser of the Strategy Office	State Chancellery	10th of Oct 2008

Source: Composed by the authors

The question about the IS's functions in the interview was not focused on functions existing inside the Estonian NIS, but on a hypothetical system; that is, what functions an IS should have. Six interviewees from the public sector answered this question. Table 3 presents important functions of the IS mentioned by the interviewees. The table only presents the thematic categories of the sub-functions brought out by Edquist and Hommen.

The interviewees most frequently mentioned the existence of innovation support measures and services designed for enterprises as a function that the IS should have. Two of the interviewees stated that this function is the most important, and four interviewees mentioned support measures as being one of several important IS functions. Therefore, no interviewee questioned the need to support innovations taking place in enterprises. But many interviewees emphasised that the IS and its functions including innovation support measures have to be flexible and able to adapt to the changing environment conditions. As one of the interviewees said: "*The innovation system cannot exfoliate from the economy and changes in society. It cannot start to live an independent life. The innovation system has to be embedded in its surroundings."* (Interviewee E).

Table 3. Important functions of the innovation system

	Provision of knowledge inputs	Functions focused on demand-side	Provision of innovation system's components	Support services for innovating firms
Interviewee A			□	□
Interviewee B	□			□
Interviewee C				□
Interviewee D			□	□
Interviewee E			□	□
Interviewee F	□		□	□

Source: Composed by the authors

This explains why the interviewees consider the creation of the components of the innovation system and changes to them almost as important as the innovation support measures themselves. It is important that the system is flexible and able to adjust to changes in the environment. If necessary, changes have to take place in all components of the IS. Otherwise the system can lock-in on its successes or failures – a lock-in failure may emerge. The system also has to be able to look to the future: "*Structural changes taking place in the economy are important. /…/ It is important to have an idea about what you have (in terms of the structure of industry – authors' comment) today. /…/ You also have to know where you want to go."* (Interviewee D).

Changes also have to be introduced to the complex of innovation support measures in response to changes taking place in the environment and/or when organisations foresee such changes. As interviewee H stated about innovation support measures, that it is important for the government to address failures in the environment, it is also important to move out when the failure does not exist anymore. Direct innovation support measures should transform into indirect measures and then into consultation services or disappear altogether when conditions make this possible.

The provision of knowledge inputs is the third most important function of an IS according to the interviewees. Knowledge inputs have been considered an important part of the innovation process since the beginning of 2000. This had been taken into account from the start of the process of designing the innovation policy measures. Currently, during the new programming period new measures are being elaborated in addition to or replacing the existing measures. Those changes cover other factors of the innovation process and not only R&D and knowledge input measures.

From Table 3, one can see that no interviewee mentioned demand side activities as being an important function of the IS. There may be three explanations. First, demand side policy measures are not yet very widely used by policy makers in Europe and in Estonia. Second, the Estonian public sector does not have enough knowledge and experience to implement demand side measures. Third, the quality requirements and standards linked to demand side policies are put in place at the European level, and therefore, Estonia cannot introduce different requirements and/or standards alone.

4. Assessment of functions through innovation policy measures in Estonia

Innovation policy measures of Estonia follow the R&D and innovation strategy of Knowledge-Based Estonia (KBE) (2007–2013). This is a second strategy document of a kind in Estonia. The first one covering the years 2002–2006 was concentrating on supporting R&D projects in firms and universities, strengthening the knowledge base in universities and encouraging cooperation between industry and academia. The second strategy encompasses wider variety of measures by adding support for cluster initiatives, funding for the dissemination of innovations, but also increased funding for improving innovation awareness of the general public. As shown in Table 3, funds for R&D have increased substantially in the period of second KBE. This increase is associated in great part with the Structural Funds of EU, which have replaced rather than complemented the national funds.

Table 3. R&D expenditures in 2002-2010 (million EUR)

R&D Expenditures	2002	2003	2004	2005	2006	2007	2008	2009
Total expenditure	55.70	66.87	82.70	104.02	150.99	173.65	208.04	197.40
Total expenditure, % of GDP	0.72	0.77	0.85	0.93	1.13	1.10	1.29	1.42
Public sector expenditure	38.62	44.21	50.48	57.12	83.90	91.77	118.16	109.19
Share of public sector, %	0.78	0.74	0.67	0.58	0.50	0.48	0.44	0.36

Source: Ministry of Education and Research

The second KBE is certainly a step towards a more systemic approach to innovation, but it still omits some crucial activities related to entrepreneurship and networking generally held as relevant for systemic innovation approach (see for example Edquist 2005). It is also suggested that the second KBE was only a change in policy rhetoric without relevant changes in design, implementation and coordination of respective policies (Karo, 2010). In the following sections, the relative importance of different functions of Estonian NIS is assessed through the funding streams for various activities.

Provision of constituents of NIS

The governance mechanisms of Estonian NIS have been developed systematically since 2000 (See the review in Masso, Ukrainski, 2008). Figure 2 presents the scheme of its functioning according to the Ministry of Economic Affairs and Communication (MEAC).

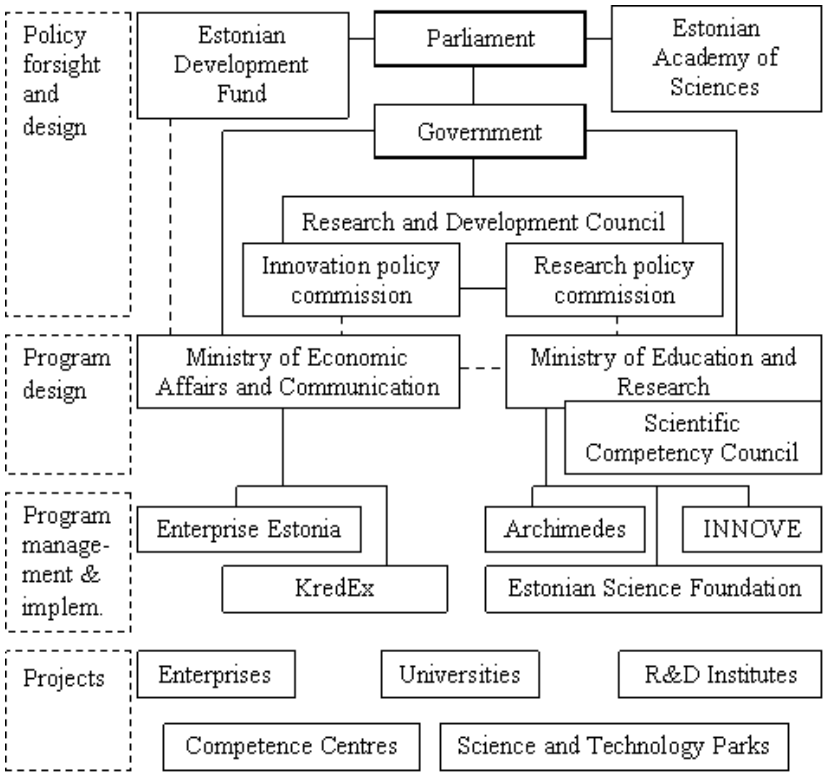

Figure 2. Estonian Innovation System (Eesti innovatsioonisüsteem 2009)

The highest level of political decisions of R&D funding is made by the Government and agreed by the Parliament. R&D policy preparation and management functions are the main responsibilities of the Ministry of Education and Research (MER) and the MEAC in respective fields. The division of responsibilities between MER and MEAC may create problems coming from the duplication of functions, barriers existing in information exchange, the lack of harmonization of activities etc. Therefore, intensive cooperation between those two ministries is essential to increase the effectiveness of the Estonian NIS. Research policy financing functions are in main part fulfilled by the Estonian Science Foundation (ESF) and Enterprise Estonia (EE). EE is intermediating innovation-related funds for enterprises (but also research institutions), ESF is funding predominantly basic research, whereby the funding criteria are purely academic (publications, especially in reputable journals, novelty and originality of the proposed research, involvement of graduate students etc.). In addition to the ESF, two additional intermediary bodies (Foundations Archimedes and Innove) have been created for internationalization of science and life-long learning projects. Recently it is recognized that this system is too complex and for achieving better coordination, coupling of competences, but also because of efficiency reasons, the structures should be merged to build Estonian Science Agency responsible for the intermediation of all science funding instruments.

Figure 2 presents enterprises and research institutes at the lowest level of the NIS. Following the logic of the figure, their position at the bottom may be grounded, but it also might reflect the thinking of the policy makers about the Estonian NIS, who look at the NIS from the top-down perspective, and not from the perspective of enterprises and research institutes. According to Lundvall (2007), the core of the IS consists of two groups of organizations – enterprises and organizations of knowledge infrastructure. Enterprises can develop, absorb and use new knowledge and technology, and organizations of knowledge infrastructure are responsible for creating new knowledge, and educating and training employees for enterprises (Lundvall 2007: 29). Therefore, these organizations should not be at the bottom of the figure, but in the centre of it. Figure 2 also indirectly reflects the abandonment of the demand side of innovation processes because markets and customers are not taken into consideration.

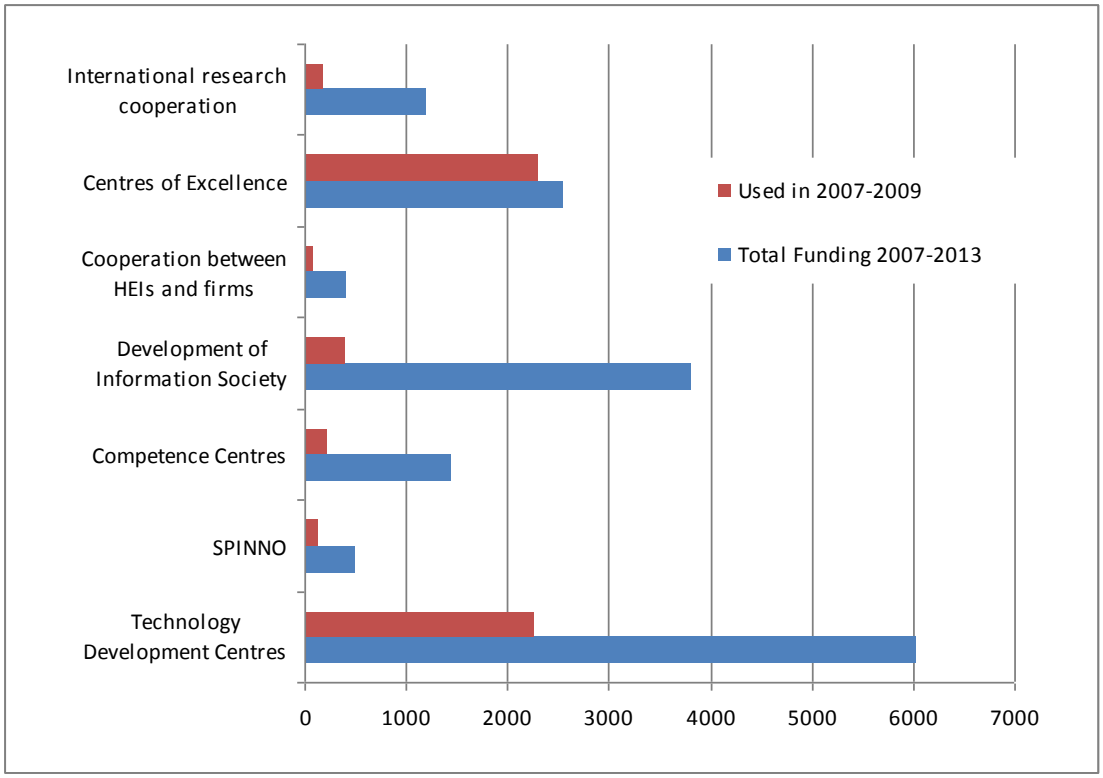

Figure 3. Measures for provision the constituents of NIS (in thous. Euro; Struktuurivahendite rakenduskava…, 2009)

The processes in building public governance structures in Estonian NIS reflect a kind of "over-doing" as many public actors of the IS have been created, but the division and coordination of tasks should be better organized between these actors and more importantly the network failures need to be addressed. Problems like involving industry representatives, and opposition between MEAC and MER needs to be addressed. Figure 3 shows that most of the resources associated with the provision of constituents of NIS are related to creation of different actors (centres) for IS and less resources are devoted to collaboration activities or the activities yielding a behavioural value-added (the importance of which is brought out by Nauwelaers and Wintjes, 2003). The measures for providing the constituents of Estonian NIS comprise in 2007-2013 about 22% of the innovation policy measures.

Industry representatives are involved in different strategy development commissions, but the outcomes are considered to be almost non-existent by the enterprises. Therefore, all actors in the IS should evaluate their efficiency on the basis of the objectives and tasks given to them, and look at innovation as a process covering science, R&D, application and marketing (Tamm, 2010).

Provision of knowledge inputs to innovation process

Though the Estonian NIS has been acknowledged in some cases for its quick development in the right direction, the high-tech orientation of its innovation policy has also been criticized (Radocevic, 2002; Varblane *et al*. 2007). It can also be said based on Figure 4, that public funding measures are more oriented towards financing

basic research in public research performing institutions (mainly universities). Estonian innovation policy has been viewed to follow first generation science push innovation models instead of taking a more practical strategy of focusing on practical scientific applications.

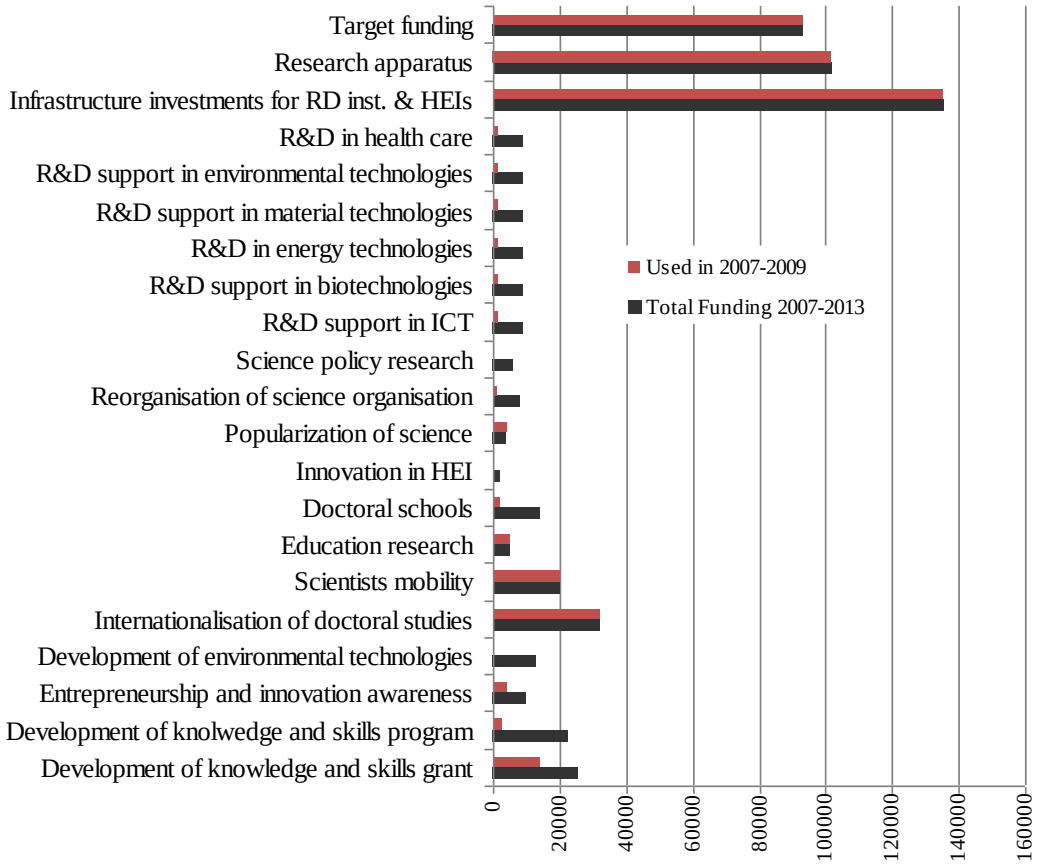

Figure 4. Funding of measures for providing knowledge inputs (in thous. Euro; Struktuurivahendite rakenduskava…, 2009)

One reason for this tendency could be that science policy in Estonia is driven by the large public universities as main research performers and therefore following scientists' curiosity rather than user needs in society (Masso and Ukrainski (2009)). This is also supported by the low appreciation of applied research projects in research funding principles and instruments. From Figure 4 one can also see that the investment-related funds for R&D infrastructure in research and higher education institutions have been disproportionally high in comparison with other types of instruments. This is also reflecting a kind of overinvestment.

For ensuring the research prioritized in society, several National Programmes were created following the second KBE strategy (noted as R&D programs in different sectors on Figure 4); however, these are not succeeded yet mainly because of the governance difficulties – it has proven very hard to engage different ministries in funding the National Programmes. Altogether the measures for performing this function comprise 37% from all innovation policy measures.

Support services for innovating firms

Public sector role in supporting innovation in firms has generally grown through the ten year period (comprising 40% from all measures for 2007-2013). The number of measures designed and implemented to support the innovating firms has also grown and as presented on Figure 5, is currently rather high. When we assume that the innovation process consists of three different stages – generation of ideas, evaluation of ideas and implementation of ideas with overlapping areas between those stages – the whole chain is covered by measures. But policy makers should also take into account existing bottlenecks existing in implementing innovation of support measures in Estonia. So far the support grants have been focused on product development and technology acquisition, various start-up related funding mechanisms are very small even among catching-up countries. Here the larger engagement of public-private co-funding mechanisms with commercial banks is also needed.

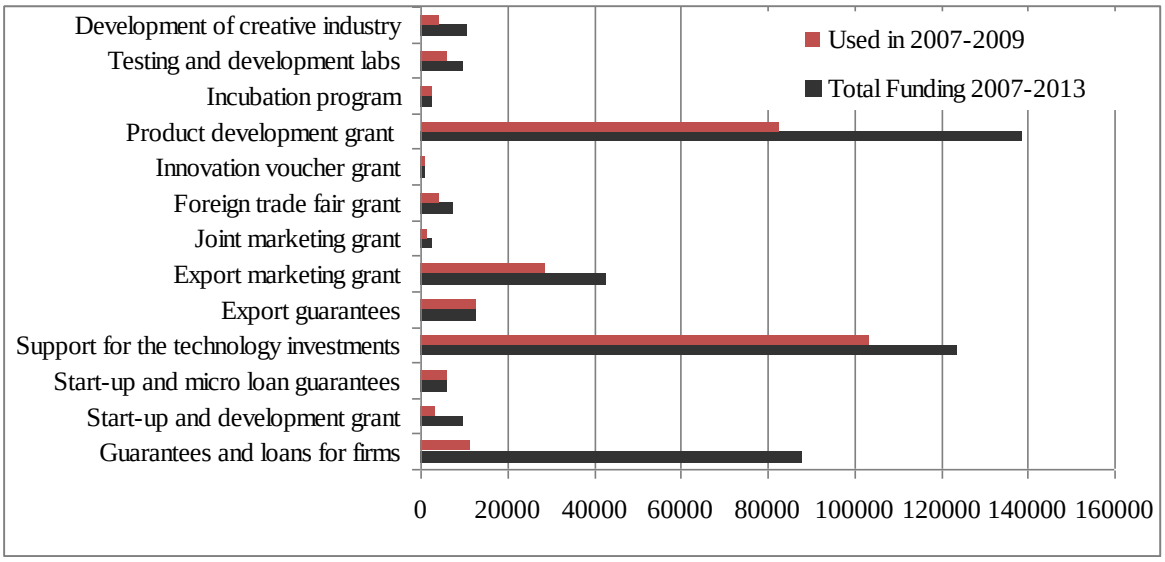

Figure 5. Support measures for innovating firms (in thous. Euro; Struktuurivahendite rakenduskava…, 2009)

As in other catching-up economies, Estonian innovation strategy is targeted towards user-friendly information and communication technologies and the development of an information society, biotechnology (in Estonia, biomedicine) and materials technology. The problem here is that the strategy imitates similar strategies in other countries without aligning with the structure of the national economy and without seeing the importance of traditional industries as customers of high tech industries. (The first problem is more deeply discussed in Edquist, 2001; and the second in Von Tunzelmann and Acha, 2005; and Hirsch-Kreinsen *et al.*, 2005.)

By looking at the side of innovating firms, in period of 2004-2006, the public support for private innovation activities was focused more on manufacturing and tourism industries, then in later years it has somewhat expanded to other industry sectors. At the same time, the firms in more science based manufacturing industries (e.g. machinery, equipment, chemicals etc.) received less support in recent years. However, those are the industries that should generate the innovative inputs for the economy. Traditional manufacturing industries have received relatively more innovation support (associated with importing new machinery and equipment). Public

sector innovation support is still lower in service industries, although it has grown during 2006-2008 (Masso *et al.* 2011).

Demand-side activities

As also shown by interviews with public officials, demand-side activities are not seen as an option for pursuing innovation policy in Estonia. There are only two existing measures that can be classified under this function (Awareness of the Information Society with abut 3 million Euros and Cluster Development Program with 6 million Euros), comprising less than 1% of the funding.

Demand-side activities include public procurement, the value of which has been in Estonia about 12-20% from GDP recent years (in EU about one sixth of total GDP) (Statistics Estonia; DG Enterprise, 2010). However, the share of firms participating on public tenders is low in European comparison and also the firms recognize that low cost rather than innovation is the criterion for winning public tenders (Innobarometer, 2009) at the same time the SME-s are relatively more active in European comparison (DG Enterprise, 2010). For Estonia as well as for other small open economies, the use of demand-side policy instruments may have constraints in terms of the ability to monitor and influence lead markets as these may lay elsewhere (outside the small domestic economy). Therefore the policy implications of globalization are extremely relevant for a small country (cf. Archibugi, Iammarino 1999)). It is very important to develop capabilities of government structures to apply demand-enhancing measures (e.g. conduct public procurement) etc. The reason for negligence of such type of measures could also be that the barriers for indigenous innovation may be observed to be much higher because of small domestic market size (Hadjimanolis, Dickson, 2001).

Conclusions and Discussion

Considering different functions of IS, innovation support services for firms have been recognized as most important function of IS by interviewed Estonian officials. Those services comprise also 40% from all measures foreseen for 2007-2013 (see also Figure 6 summarizing all the analyzed functions by respective shares of funding). Provision of knowledge inputs comprises 37% from all measures, however this was not considered as important by government officials. Provision of constituents of IS was considered as important as support services of firms, however from policy measures in comprises only 22%. It has to be noted, that this share is underestimated, because the maintenance of several organizations that function as intermediaries have not been accounted here for. However, the analysis of specific measures has shown that Estonian IS requires a more systematic approach and clear communication to solve existing problems. It is important not to create new organizations, but rather make the existing ones work more effectively and link all of them into one consistent system moving towards one overall objective. As expected, demand-side activities that are not considered as important comprise about 1% of the innovation policy measures for 2007-2013. The difficulties of using such measures are presented in Edler and Georghiou (2007), however, empirical evidence shows that there can be found successful policies in small countries (like from Nordic countries Finland (Lemola, 2003)) or Asian countries like Singapore and Taiwan

(Lundvall *et al.* 2006)). Therefore, the potential of this function of IS can be enhanced in Estonia.

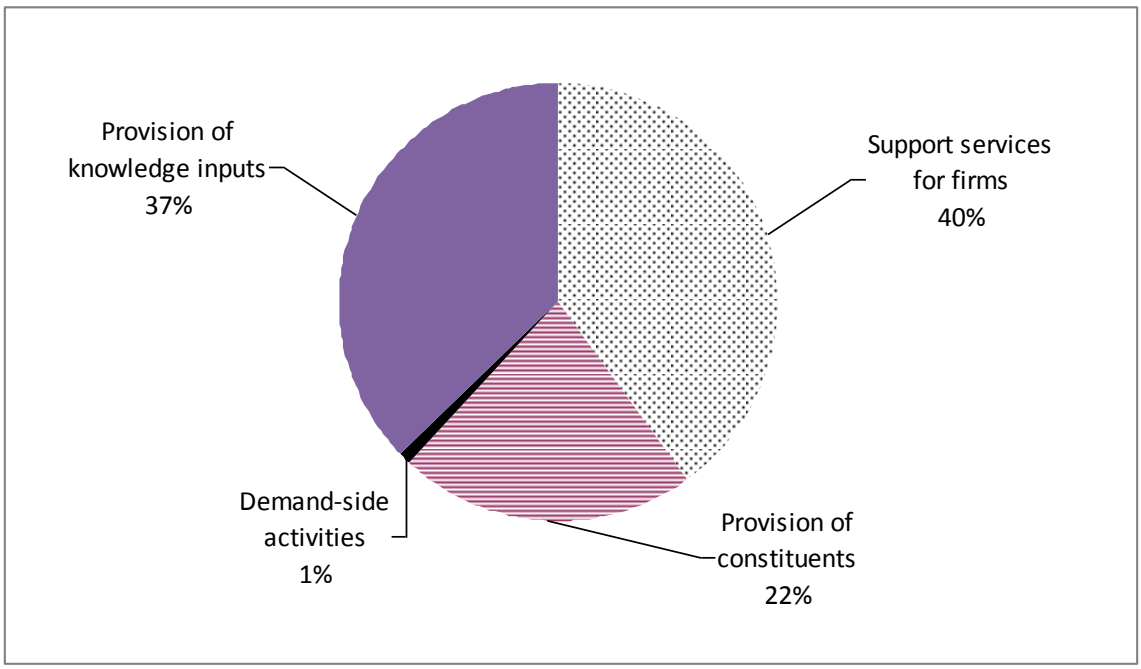

Figure 6. Division of funding for different functions over the period of 2007-2013 (Authors' compilation based on Struktuurivahendite rakenduskava…, 2009)

We suggest that by aligning the structure of the IS, more coherent logic of public-private co-evolution and better alignment of respective innovation policy measures should be followed. The functions that public sector performs in a national innovation system, should be designed and developed carefully in a balanced way, which is especially important for a small catching-up country, where the risk to create misalignments in the system is larger.

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