Fostering Innovation in Estonia: The View from the Governance Framework of the National Innovation System

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Introduction

The national innovation system has been broadly conceptualised to include all parts and aspects of the economic structure and institutional set-up affecting learning, as well as the quest for and exploration of knowledge (i.e. the production system, the marketing system and the finance system present themselves as subsystems – see Lundvall 1992). Next to this broad understanding, a more narrow definition is applied by Nelson (1993), referring to the system as a set of links between research institutions, firms and government in the area of R&D. The successful operation of these subsystems depends on the governance of the whole system in terms of the "processes of interaction and decision-making among the actors involved, leading to the creation, reinforcement, or reproduction of social norms and institutions" (Hufty 2011, 405). As these processes are extremely complex and differ vastly and across national systems, a 'scientification approach' aimed at explaining national innovation performance would not even be worth attempting (Lundvall 2007).

This paper therefore aims to explain some of the developments determining the innovation performance of Estonia during the last programming period of the EU Structural Funds (2007–2013), when the national innovation strategy, known as 'Knowledge Based Estonia 2007–2013' (hereafter KBE-2, as it was the second strategy and followed on from KBE-1, which covered 2002–2006) was implemented. The EU Structural Funds (hereafter EU SFs) have proven extremely important, accounting for around 64 percent of public R&D investments by ministries (ERAC 2012). The most relevant factors impacting the KBE-2 period externally were the waves of economic boom, recession and certain recovery, which led to the freezing of budgetary resources for R&D. Additionally, the new reality of KBE-2, with much larger funding volumes from the EU SFs, and the dominant logic of the funding process played significant roles (Ukrainski *et al.* 2015).

The governance concept as a viewpoint is interpreted in this paper as the coordination needed within national innovation systems to enhance their functionality, with performance relying on social processes outside the traditional policy framework (Hillman *et al.* 2011). Here we use the more specific analytic framework proposed by Bergek *et al.* (2008) and Hillman *et al.* (2011) to study technological innovation systems, defined as socio-technical systems related to the production, diffusion and application of a particular technology. This framework is simpler and sufficiently general to analyse the small national innovation system of Estonia. It is relevant because the system dimension is generally often neglected throughout Europe (Lundvall 2007) and in Estonia (Karo and Kattel 2010) in the emulation of different 'best practice-policy making'.

When innovation policies are developed, the focus in Estonia is often limited to the stimulus resulting from knowledge production in science and its subsequent application (Karo 2011). To some extent such an approach is also understandable, since the capacity of business to act as a stimulator of R&D is rather low in the economy's investment-based development phase and given Estonia's small size. It is also important to consider that the level of trust is relatively low in 'transition societies', which prevents more complicated, open innovation processes from functioning, especially those that involve many partners.

This article proceeds by presenting the theoretical framework in which the Estonian system is analysed.

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It then discusses the change in system archetype, as well as the growth of the system. The paper concludes with a summary of unresolved failures in the system.

Theoretical framework

Kaufmann and Tödtling (2001) interpret the innovation system based on the seminal approach of cell reproduction by Varela *et al.* (1974), which is more broadly extended to sociology and further elaborated there by Luhmann (1995), for example. They argue that the principle of cell reproduction can generally be applied when studying social systems. This implies that social systems reproduce themselves through communication. Communication serves the purpose of interpreting internal processes and relations to the environment, which separates the social system from its environment and from other systems (Kaufmann and Tödtling 2001).

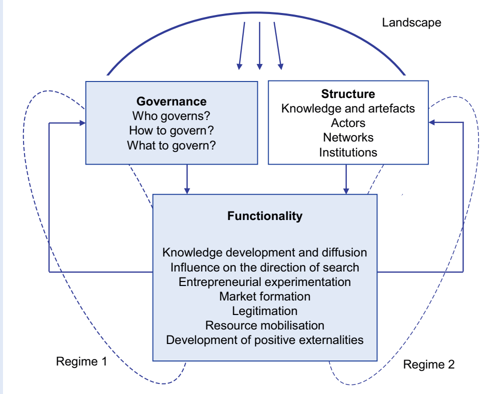
In studying innovation, we can interpret communication as an exchange of knowledge, given that the concept of the national innovation system in its broader definition is based on the following assumptions (Lundvall 2007):

- Knowledge that is important to economic performance is localised and cannot be easily transferred to other places;
- Knowledge is embodied in agents, in their routines and in their mutual relationships;
- Learning and innovation are best described as the outcome of interaction;
- Interactive learning is a socially embedded process, and therefore a purely economic analysis would remain insufficient;
- Learning and innovation are strongly interconnected processes;
- National systems of innovation differ in the specialisation of production, trade and also the knowledge base; and
- In national systems, different elements are interdependent and these interrelationships determine innovation performance.

How effectively innovation systems operate can be analysed using the framework developed by Hillman *et al.* (2011) for studying the governance of technological innovation systems. This analytical framework consists of three blocks of characteristics that are interrelated and form a system that is also affected by

Figure 1

Schematic presentation of theoretical framework



Source: Hillman et al. (2011).

the external environment (or landscape; see Figure 1). This model adopts a narrower approach to the system of knowledge production and use (Nelson 1993). The system of innovation in this framework is analysed here via governance of the system, its structure and its functionality, which covers the key processes of innovation.

Governance is separately discussed as determining the system's functionality in interplay with its existing structure. Governance in this paper is viewed at the national level, impacting the system through regulatory, market, normative and cognitive mechanisms (Hillman *et al.* 2011). The question of 'how to govern' entails a governance focus on the supply or the demand side, or both. 'What to govern' reflects the target of governance determining the functionality pattern (key processes of innovation), but also the coverage of sub-sectors. The key processes that Hillman *et al.* (2011) highlight include the development and diffusion of knowledge, influence over the direction of the search, entrepreneurial experimentation, market formation, legitimation, resource mobilisation and the development of positive externalities. The extent to which the desired functionality of the system is achieved depends on the adjacent regimes determined by the environmental conditions. We can empirically analyse how governance arrangements are influenced by the environment and how they are aligned with the regimes of the sub-systems involved (Hillman *et al.* 2011).

Changing governance schemes shape the structure of the system *via* different channels, indicated by the feedback loops in Figure 1. This impact is created not only by public policy instruments, but also by the different regimes under which governance itself operates (policy-making routines based on ministries, open call-based funding systems etc. (represented by Regime 1), and the alignment of regimes under which sub-systems operate (alignment of different technological systems to public research specialisation etc.; Regime 2 in Figure 1) – see Breschi *et al.* (2000). Typically, the regimes are defined *via* public governance routines incorporating a bundle of governance instruments encompassing rules, norms and procedures (the latter also regulating behaviour and controlling outcomes) – see Krasner (1982). At the same time, similar regimes are described in the case of the private sector as regimes collecting routines, rules and procedures in global networks, see e.g. Haufler (2004). For the purpose of this analysis, the technological regimes are relevant because they enable us to analyse how horizontal innovation policy measures achieve different results across economic sectors with similar or diverging technological regimes (e.g. Pavitt 1984; Castellaci 2008).

As recognised in the OECD STI e-Outlook, R&D system governance is a concept that can have many different meanings. The OECD (2015) limits STI governance to the set of publicly-defined institutional arrangements, including incentive structures and norms, that shape the ways in which various public and private actors involved in socioeconomic development interact when allocating and managing resources for innovation. These arrangements affect how public and private sector actors co-evolve in distributing and managing the resources required for innovation. This is a narrower approach than is typically used (e.g. de la Mothe 2001), but it is necessary here for analytical purposes in order to disentangle the impact of policy coordination from that of the other actors in the system.

The role of institutions and their ability to adapt becomes crucial in conditions of rapid change. Economic and technological changes do not occur in isolation from social and institutional transformations, which are represented by the regimes in this model. As argued by Zysman (1996), distinctive institutional structures in different nation states stemming from historically-determined political and economic development define the choices that are available to individual actors (individuals, firms and organisations) when responding to new economic or technological trends. Institutions are essential to the accumulation of acquired knowledge and skills into collectives of workers organised into organisations (Wolfe and Gertler 2002). As discussed by Hodgson (1993), habits and routines within firms constitute an important mechanism for preserving and transmitting skills and technological learning internally. Similarly, in their role as knowledge providers, universities and public research organisations follow certain routines that can be even more rigid than those seen in the private sector.

The ability to change consists of two elements: the ability to learn; and the ability to forget. Johnson (1995) sees the latter as equally as important as the former in periods of rapid economic and technological change, because the inability to forget can pose the risk of an irrational lock-in of resources. This has been illustrated using international evidence by Gertler (1993), who highlights the tremendous struggle by manufacturers in old, mature industrial regions to accept new technology.

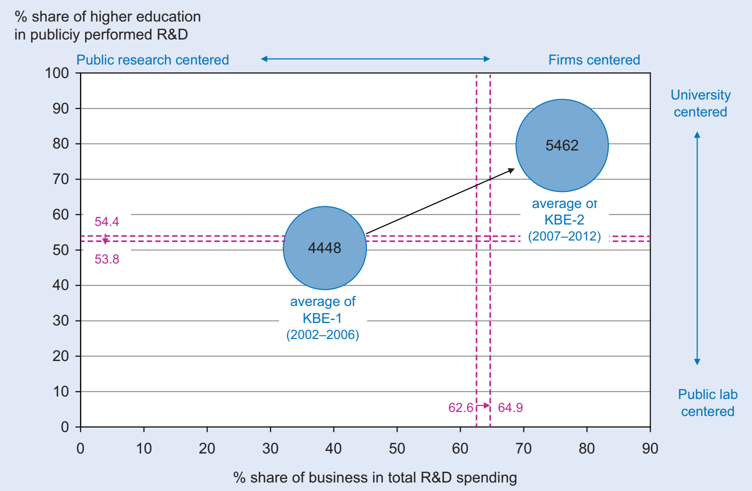
The role played by institutions within a nation or region in supporting or hindering learning assumes crucial importance. For the sake of innovation and technological change, the key challenge is to identify the socioeconomic and political coalitions that support change, and analyse how they contribute to this process (Hall 1997). The underlying argument of this positive impact is the recognition of the importance of tacit knowledge, which is accessed and transferred more easily through face-to-face contact. Proximity fosters such contact, but it also takes place within the context of social networks based on trust and shared culture (Maskell *et al.* 1998).

Shift in the archetype of the national innovation system

During KBE-2 the archetype of the national innovation system in Estonia was changed significantly (Figure 2). This change was initiated at the beginning of the transformation by dismantling the old Soviet-style Academy of Science and merging its institutes into universities, thus giving the latter greater responsibility and autonomy (Masso and Ukrainski 2008). Although these reforms were largely carried out at an early stage, the transformation has nevertheless been remarkable, especially when compared with the greater stability enjoyed by universities other countries (OECD 2013). One reason for this transformation is that the universities, which are generally larger and more successful in grant funding schemes, have grown even stronger *via* the Matthew effect in the process of competitive project funding (Masso and Ukrainski 2009).

Figure 2

Change in the archetyp of Estonian innovation system



Note: The left circle reflects the average of KBE-1 (2002–2006) and the right circle the KBE-2 period (2007–2012). The dotted lines represent the EU averages for the same periods (they have changed respectively: the vertical axis from 54.4 percent to 53.8 percent and the horizontal axis from 62.6 percent to 64.9 percent. The size of the circle and respective number reflects the average annual FTE of R&D employees.

Source: Author's calculation based on the methodology of the OECD (2013).

In institutions of higher education (HEI), the average level of KBE-2 R&D investments was 75.9 percent in 2013, but in 2014 it grew to 82.6 percent and planned reforms to further consolidate some institutes into universities mean that its role will continue to grow in the years ahead. At the same time, there is scope for efficiency improvement within the HEI sector that could be achieved by reducing the share of project-based research activities, especially since universities are struggling to develop strategic capabilities in this project-based environment and more closely align their internal decision-making procedures.

While the system was more public sector-centred during KBE-1, it shifted to an innovation-based system that relies more on enterprises and universities during KBE-2, making it similar to the small Nordic countries, but rather different to larger countries like the United States, Japan and South Korea, which rely more heavily on public labs. In view of this substantial change within the Estonian system, the question now is how to strategically strengthen the major players (universities and firms) in order to improve the functionality of the system.

The issue of how to improve the innovative capabilities of firms is critical, as are strategies for lowering barriers and deepening cooperation with universities, thus boosting the demand side of R&D. The R&D activities of firms over the observed period were highly concentrated, and Estonia may struggle to succeed as a knowledge-based economy by international comparison if only 10 percent of businesses are involved in R&D (European Commission 2012). Calculations based on data from Statistics Estonia show that the concentration of business R&D has increased over time. In 2009, the expenditure of the 50 largest companies totalled 30 percent; in 2012 this figure represented 85 percent of total R&D expenditure (Ukrainski and Varblane 2015). In other words, the investments of just a handful of companies in Estonia drove the rapid increase in business R&D expenditure.

Expansion of the system by activity: financial and human resources

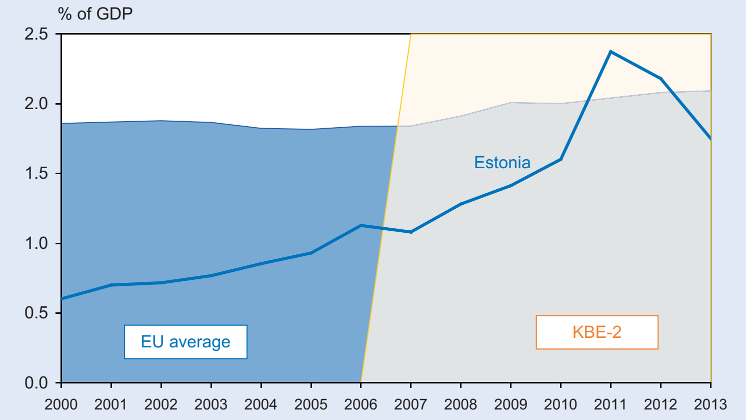
The number of R&D employees grew remarkably during KBE-2, with a faster increase seen in the business sector than in the HEI sector. Characteristic of this development is concentration in both sub-systems. In the business sector the R&D base did not expand (Mürk and Kalvet 2014), and expansion was not listed among the goals of the KBE-2 strategy. The Ministry of Economic Affairs and Communications saw it as one technical alternative among many for boosting R&D investment in the enterprise sector.

All KBE strategies to date have been based on an R&D expenditure target of 3 percent of GDP. During KBE-1, Estonia lagged far behind in terms of business R&D expenditure, remaining below 50 percent of the EU average. During KBE-2, expenditure increased substantially (Figure 3). This growth mostly originated in business-sector investments; with public expenditure remaining below 1 percent. The Estonian government contributed to this growth, specifically by launching timely business support schemes to overcome the crisis.

The science sub-system completed larger internal reforms during KBE-1 and saw a recovery in the number of its researchers (Figure 4). In public universities remarkable growth occurred in natural sciences and engineering; and to a lesser degree in social sciences

Figure 3

R&D expenditure in the EU and Estonia



Sources: Author's calculations based on Eurostat.

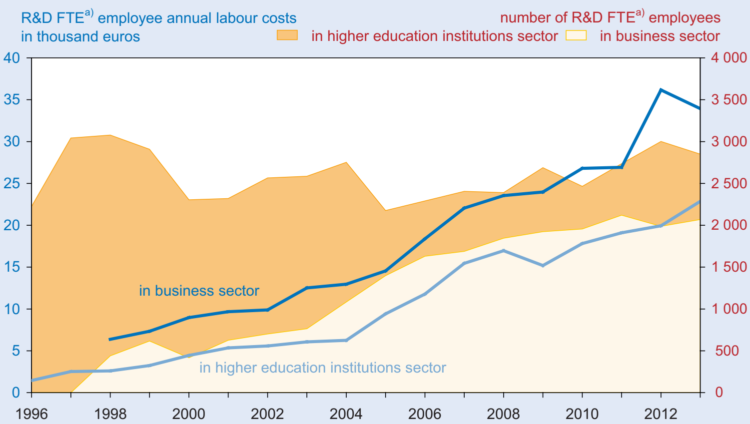
and humanities. It is fair to say that a large share of doctoral output has served as a basis for sustaining the science system; among the R&D employees hired by the business sector, Master's degree holders continue to dominate. At the same time, R&D labour costs per FTE have grown more rapidly in the business sector. This may also reflect the tendency of labour markets for R&D workers to operate separately. There seem to be substantial irreversible costs and different skill profiles, but also sufficiently large rewards from research projects in the careers of scientists in universities, which further hinder inter-sectorial mobility. The business sector is likely to become more attractive to doctoral graduates, which would enhance the system's functionality in terms of knowledge flows between academia and industry.

As far as the investment proportions in KBE-2 (Figure 5) are concerned, investments in developing the capabilities of players in the science sub-sector dominate (mostly along the lines of the supply-push philosophy). The focus to date has been on large infrastructure investments. Estonia has been advised to learn from Ireland's rapid exit from the economic crisis and use it to justify the consolidation of investments in certain focus areas. For example, from 1989–1993 over half of all EU structural funds in Ireland went to supporting businesses still recovering from the crisis, but also to attracting FDI. From 1994–2006, covering the two subsequent programming periods, business support decreased and co-funding rates increased. Investments in human capital and infrastructure gained in importance (36 percent and 48 percent of funds, respectively) because the challenges in these areas shifted (Best and Bradley 2006).

KBE-2 funding (EU and national funding together) in Estonia was distributed between supporting capabilities in the business sub-system (circa 13 percent) and the science sub-system (44 percent) – see Figure 5. Infrastructure (in its broadest meaning, involving physical and human capital infrastructure) accounted for 24 percent of funding, which is understandable given the outdated nature of research infrastructure at the end of KBE-1. In this small system, a certain over-investment has become evident (in terms of duplicating equipment, investment in overly large buildings, etc.), reflecting weak strategic planning capabilities, but also a lack of coordination among actors (strategic responsibilities by field of education among HEIs only being agreed after the investments had been made). In the short term, since budgetary expenditure on R&D did not increase after the crisis, a certain imbalance between 'salary-instruments' and 'infrastructure instruments' emerged, creating issues at the research-unit level and giving rise to criticism of the Ministry of Education and Research. In the years ahead, the return on that investment will depend on the activities of research

Figure 4

R&D expenditure and number of R&D employees

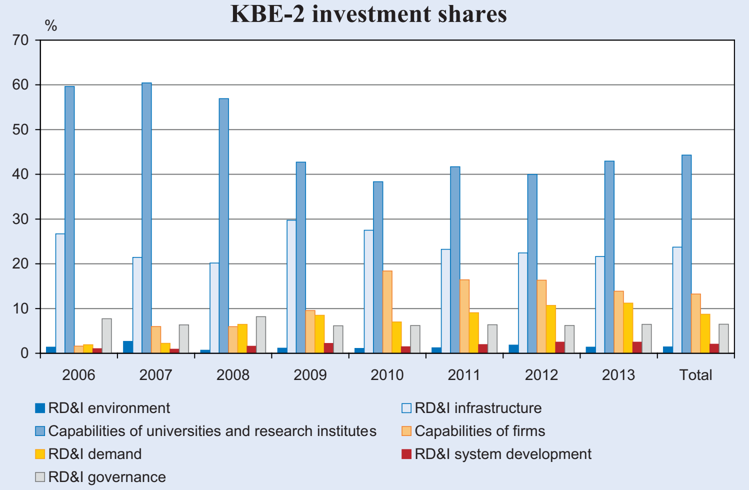


[a] FTE = full time equivalent.

Sources: Author's calculations based on Statistics Estonia.

Figure 5

KBE-2 investment shares



Sources: Estimates based on KBE-2.

groups in obtaining international grants and business R&D contracts.

The interplay between regimes, structure and governance

Several aspects of the functionality of the innovation system are related to tighter knowledge flows between higher education and business sectors. The improved intersectoral mobility of employees, as well as more frequent formal and informal connections, would allow the business sector to employ more R&D employees. Estonia has 8–9 FTE R&D workers per 1,000 employees compared to 15–20 in the Nordic countries. This contrasts with business sector R&D investments, which have been relatively high, even compared to EU innovation leaders (namely 1.5 percent and 1.25 percent in 2011 and 2012, respectively).

The science sub-system has also developed remarkably: scientific output in terms of publications and citations increased 1.7 times during KBE-2. It has even been considered an international success story (Allik 2013). It can be argued, however, that the successful development of both sub-systems is hampering the functionality of the innovation system as a whole to some extent, as it is enabling the survival of old routines that do not rely on mutual cooperation.

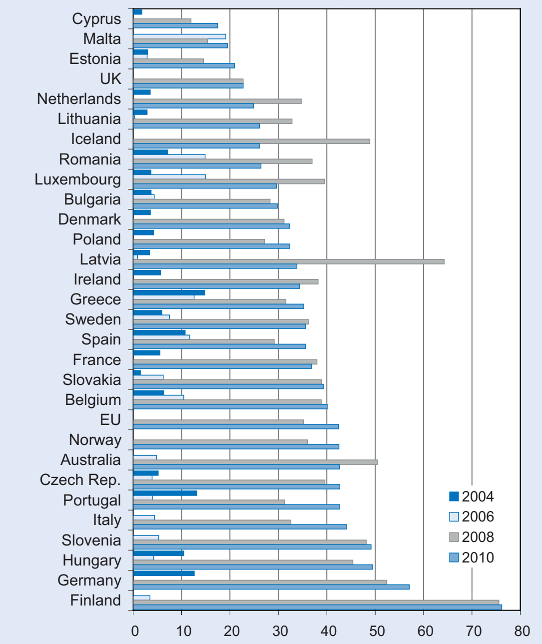
Typically, the share of business-funded R&D in universities and public research organisations is one proxy indicator that reflects the knowledge flows between two sub-systems (OECD 2013). This indicator has remained fairly stable in the EU at around 6.4 percent, but in Estonia it actually fell from 5.5 percent to 4.4 percent during KBE-2 (calculations based on Eurostat database). This measure, however, excludes companies that innovate *via* processes outside of formal R&D (mostly the traditional manufacturing industry that also dominates industry structure in Estonia). The relevance of universities and HEIs as a knowledge source for innovation is presented here (Figure 6).

By using several subsequent Community Innovation Surveys as a basis, we can see that this share is still very low by EU-wide comparison, although it has increased. Interestingly, several indicators of knowledge use show inverted U-shaped dynamics in Estonia, where the peak was achieved in 2008–2010 – showing that the idea of open innovation is not spreading extensively. Similar developments concerning, for instance, the share of innovative firms are also evident in other CEE countries (Havaš *et al.* 2015). This trend has been attributed to the firms' failure to raise their profile in the context of the crisis.

Figure 6

Percentage of companies engaged in innovation cooperation with universities and higher education institutions

%-share of the number of companies that have participated in any type of innovation-related cooperation



Source: Author's calculation based on EUROSTAT Community Innovation Survey Data.

This could still imply that the increase in the capabilities of firms appeared to be larger if judged by R&D investments, which were also partly driven by public subsidies.

On the other hand, the regimes associated with science funding also played a relevant role in discouraging universities from actively engaging in business cooperation. An analysis of the funding system shows that project funding as a funding mode remained between 90–96 percent of total research funding from 2007–2013. It was highest in the larger universities (University of Tartu and Tallinn University of Technology) and lower in smaller universities. Compared to Finnish universities, the same indicator for Aalto is 74 percent, Tampere 70.2 percent and Helsinki 60 percent, while regional universities also remain at much lower levels in Finland. An analysis of the budgets of a sample of institutes within the University of Tartu reveals that the average share of academic (teaching) funds stemming from project-funded instruments also grew to 50 percent on average (Ukrainski *et al.* 2015).

This kind of funding mechanism would typically endow funders with a high capacity to steer research. However, weak goal-setting within the framework of the 'open calls' funding mode on the one hand, and the measurement of research outcomes predominantly in publication (and citation) counts on the other, have led to a routine whereby business cooperation and applied research are only appreciated as a source of funding. Here the specific joint influence of incentives can be seen, because although project results may not be measurable in publications, publications are nevertheless the only incentive similarly understood at all levels of the system: the strategy level, the funding instrument level (which is directly included in baseline funding, but also used in competitive calls as an indicator of quality), the university level (through rankings) and the level of individual scientists through career aspirations. Butler (2003) has shown how including publications in funding formulae results in a substantial increase in publications. There is no similar motivator or indicator supporting science-economy links to date.

Conclusion

KBE-2 has boosted capabilities in both sub-sectors, but left the regimes there largely unchanged, thus leading to little improvement in the system's functionality. This implies that the focus of public-sector policies should be further shifted to create greater scope for innovation and R&D in the business sector, but also to place a greater emphasis on enhancing the system's functionality.

It can also be argued that powerful actors were further strengthened during KBE-2 (this being similar in both sub-sectors), but that the shift in capabilities did not occur more broadly. Activities related to the diffusion of knowledge have also proven temporary or fragmented as a result, and have not yet yielded the desired results. The lack of a broad shift in capabilities has also heavily hampered resource mobilisation *via* networks to boost functionality. The system's functionality is further constrained by the poor alignment of science and industry specialisation, which limits the availability of sector-specific human capital. This is not quite the European Paradox that Bonaccorsi (2007) discusses, as dynamic scientific fields (life, computer and material sciences) are fairly well-developed in Estonia, but it does mean that these fields are dominated by international cooperative (basic) research activities that do not build links to applied research for the Estonian business sector.

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