Peer Review of the Estonian R&I system

Final Report

Horizon 2020 Policy Support Facility

Research and Innovation

Final Report – Peer Review of the Estonian R&I System

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Peer review of the Estonian R&I system

Final Report

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NATIONAL PEER EXPERTS

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The project was overseen by the PSF Team in the EC's Directorate-General for Research and Innovation. Ignacio Baleztena coordinated the exercise and ensured liaison with the Estonian authorities. The PSF contractor supported the EC's PSF Team in this activity. This involved work by Bea Mahieu, project manager at Technopolis Group, Jari Romanianen, who acted as the quality reviewer. Katre Eljas-Taal, Reda Nausedaite, Merle Tambur and Dominik Beckers prepared a background report about research and innovation in Estonia.

THE ESTONIAN AUTHORITIES

The Estonian authorities provided data and background documentation useful for the group's work and supported the visits to Estonia by inviting the representatives of government institutions and stakeholders to meet the group. The Ministry of Education and Research coordinated the Estonian authorities, ensuring the involvement of other relevant ministries, agencies and bodies and kindly made available facilities for meetings and workshops.

SUMMARY AND MAIN POLICY MESSAGES

At the request of the Estonian authorities, this report has been produced by an expert group appointed by the Policy Support Facility of the European Commission's Directorate General for Research and Innovation. The task of the group was to support the work of the Ministry of Economic Affairs and Communications (MEAC) and Ministry of Education and Research (MER) in preparing to produce a joint research, development, innovation and entrepreneurship strategy for the period 2021-27 and onwards via a general assessment of the effectiveness of the research and innovation (R&I) system and a specific assessment of the role and impact of the R&I system in promoting added value creation. Our report is based on document study, a specially-prepared background report and over 60 interviews with stakeholders in Estonia.

Research and innovation as drivers of development and growth

Behind the expert group's analysis and recommendations lie three fundamental results from the last 50 years of research about R&I.

- The most important driver of economic development and growth is innovation, especially innovation based on research and development (R&D)
- The capabilities necessary to generate innovations are needed so that the national innovation system can learn, generate the necessary human capital, keep up with international scientific and technological progress and maintain its productivity and competitiveness
- Innovators do not, by and large, innovate alone but in national and international 'innovation systems' that involve many actors and institutions. Policymakers therefore need to ensure that the mix of policies relating to different parts of the system are in balance and that interventions across the innovation system are coordinated

Government and society

Although the government in 2011 committed Estonia to increasing its spending on R&D to 1% of GDP over time, this has been hard to achieve for both budgetary and political reasons. There are now signs of a new political commitment to that goal. The Prime Minister's R&D Council provides a potentially strong mechanism for coordinating national R&I policy that has shown itself to be effective in the presence of the necessary political will.

Two R&I-related strategies[1] contribute to the current National Reform Programme. However, lack of clarity about relative priorities and aspects of implementation leave limited space for effective coordination at the thematic level. The current process of writing a new, single strategy – Estonia 2035

[1] The Estonian Research and `development and innovation Strategy 2014-2020, the Estonian Entrepreneurship Growth Strategy, 2014-2020 and (to a lesser degree) the Estonian Smart Specialisation Strategy

– provides a good opportunity to develop more consistent and systemic coordination of policy and to take a position on how Estonia can address and benefit from the opportunities associated with the 'societal challenges' such as climate change and the ageing of the population.

The business innovation system

Estonia offers very favourable macroeconomic conditions for business, foreign investment and foreign entrepreneurs wishing to set up in Estonia. It has an attractive start-up scene, excellent broadband capacity and other infrastructure as well as business-friendly regulation that have generated quite a number of successful companies, principally in software- and in Internet-based businesses with low entry and exit barriers.

However, there are significant skill shortages in certain specific areas (especially the ICT sector and industrial processes), owing to a mixture of demographic factors, emigration and mismatches between the numbers and types of graduates emerging from the education system and business needs. As a result, wages are rising faster than prices, despite stagnant total factor productivity. Leaving aside a peak in 2011, caused by one-time investments in the shale oil sector, both gross and business expenditure on R&D have grown no faster than GDP.

The structure of industry in terms of branches has been rather stable in the post-crisis period since 2008, with manufacturing providing 15-16% of value added and 18-19% of employment. ICT, scientific and technical services have seen some growth and account for about 8% of value added. In terms of firm size, Estonia has a low share of large firms and a super-normal share of micro-enterprises – a factor that helps account for the low R&D-intensity of Estonian business in international comparison. The low level of absorptive capacity in business is a major obstacle to innovation and needs urgently to be addressed in policy.

Innovation support

Estonia has chosen to invest large sums (principally from EU Structural Funds) in supporting research, business and broadly-defined innovation. Through Enterprise Estonia, MEAC supports foreign direct investment (FDI), company start-ups and innovation but little R&D in industry. The MER's agency, the Estonian Research Council, funds the state's research sector and a little bit of R&D-based innovation in industry, where this is done in partnership with the higher education and research sector. Just as there is a gap in business' 'absorptive capacity' – namely, its ability to use R&D in identifying and implementing innovation opportunities – so there is a corresponding gap in government support for developing that capacity that needs urgently to be filled in order to improve Estonian innovation performance. Filling the gap requires two things. First, a set of R&D activation and support programmes that address the whole range of companies, from those with minimal absorptive capacity to those with enough R&D capacity to serve as motors of development. Second, the creation of the kind of innovation support services to industry seen in richer countries such as Finland or Germany.

FDI has been very important as a source of capital and in modernising the Estonian economy after independence in 1991 and is to a considerable extent responsible for the country's strong export performance. At present, R&D activities have no particular priority in Enterprise Estonia's efforts to encourage FDI. One of the benefits of attracting multinational investment is that these companies tend to act as training schools for domestic personnel. To support R&D-based innovation, Enterprise Estonia should now devote more effort to attracting R&D, manufacturing and other FDI-based activities that generate more learning in the Estonian research and innovation system.

Estonia has a prominent and lively start-up scene, which has been well-supported by Enterprise Estonia and state credit organisations. So far, it has proved difficult to generate such activity outside software and Internet-based sectors. Continuing support of research-industry links and universities' efforts to develop and commercialise intellectual property will help make this transition.

However, at present the universities themselves do not give enough priority to working and exchanging knowledge with business. Their efforts to develop technology transfer offices (TTOs) are recent and appear not to be strongly supported by university leadership.

While Enterprise Estonia has launched a programme to support the use of state procurement to trigger innovation, it is little used and there are opportunities to increase the use of such demand-side instruments.

Higher education and research

Despite recent reductions, the Estonian higher education system has a large number of institutions, given the small population of the country. It has inherited a focus on research in which it is successful in terms of publication performance, but which is not always relevant to business or the state. There are similar difficulties in adjusting the focus of the higher education sector to societal needs and there is evidence that the economy would benefit from greater production of vocational or professional skills. These factors taken together cause the skills shortages experienced in business and the state. These shortages are further exacerbated by the low status of some parts of vocational education, which needs to be strengthened in order to generate the right balance of skills in the labour force. Change in the universities is impeded by the fact that most of them have out-dated governance structures that make strategy formulation difficult and the obstacles encountered by most institutions when they try to implement change.

Recommendations

We see five needs that are large and urgent, which we believe should receive priority in Estonian policy. These address the need to increase the national effort in R&I and to escape the 'middle-income trap' by creating distinct competitive advantages that will allow national income to grow above the middle level.

Key recommendations

- Ensure political commitment to the importance of R&I in national policy and the 1% target for government spend on R&D
- Establish and implement thematic priorities for R&I policy, in the light of the societal challenges and Estonia's smart specialisation strategy
- Establish an innovation agency to support R&D and build absorptive capacity
- Strengthen the system of 'intermediary organisations' able to support industrial innovation
- Modernise and 'profile' research at the universities, making them better adapted to innovation and the production of human capital to meet national needs

Ensure political commitment to the importance of R&I in national policy and the 1% target for government spend on R&D. R&D plays a central role for development and growth by enabling innovation. The government has already sought to establish a consensus on the 1% goal among all the political parties. This is important in order to ensure continuity across successive governments. A substantial part of the increase in R&D spending needs to encourage increased R&D and innovation activity by both business and government, and needs to be accompanied by a greater effort in support for non-R&D-based innovation. It should not be used solely in the research and higher education sector, nor should its primary use be to increase academic salaries. The government should set a realistic and affordable timetable for what amounts to a very significant increase in public expenditure, so that policymakers can plan and set priorities. It then needs improve coordination of R&I policy, to ensure that the government's intention to increase expenditure is matched by the implementation of spending programmes at the level of the ministries and the agencies.

Establish and implement thematic priorities for R&I policy, in the light of the societal challenges and Estonia's smart specialisation strategy*.* Successful R&I policy uses a mixture of bottom-up and thematically focused instruments. The thematic focus needs to take account both of the knowledge and human capital needs of society today and those of areas that are expected to grow. So far, the societal challenges have been little integrated into Estonian R&I policy. International efforts to tackle the challenges will shape new markets and opportunities. Estonia needs to decide which of these to address, otherwise it risks being excluded from important new growth markets. The Prime Minister's R&D Council should lead in setting thematic priorities through a national exercise in which there is broad consultation of citizens, business, the ministries and the research community to identify which sub-set of the societal challenges could be tackled and to ensure the social legitimacy of this choice. The smart specialisation priorities will be one important influence on this choice, but not necessarily the only one. The ministers on the R&D Council should form an implementation group that plans, monitors and ensures the translation of those R&D Council recommendations that the government accepts into policy and spending.

Establish an innovation agency to support R&D and build absorptive capacity*.* The biggest practical obstacle to increasing the rate of innovation in Estonia is the lack of 'absorptive capacity' or R&D capability in industry. Policies to help establish, activate and increase R&D capacity are therefore needed. Enterprise Estonia should take on the role of acting as an innovation agency. To do this, Enterprise Estonia will need new technological and programming skills. Becoming an innovation agency will also mean that Enterprise Estonia has to involve both the academic and the business communities in the design and governance of its innovation programmes to a greater extent than has been necessary in its existing activities. The agency will need to implement a hierarchy of instruments to support companies at different levels of developing absorptive capacity. The innovation agency function will need substantial funding, over and above what is spent on Enterprise Estonia today. Enterprise Estonia should also improve and focus its tactics in relation to FDI and use good international practice to guide the strengthening of its innovative procurement activities.

Strengthen the system of 'intermediary organisations' able to support industrial innovation*.* Most national innovation systems benefit from 'intermediary organisations' in the form of research and technology organisations (RTOs, such as Fraunhofer, Germany; VTT, Finland; or SINTEF, Norway) or university industrial extension services, whose job is to keep at least one step ahead of industry's innovation knowledge needs and to provide research and technical services to industry based on that more advanced knowledge. However, Estonia is too small to support an RTO with strong capabilities across many technologies. Conceivably, an organisation like VTT could be persuaded to establish a branch office in Estonia. However, it would be better to support university extension services, thus strengthening the national innovation system and making it more relevant by providing information and incentives for the universities to address specific national needs. Tasks that cannot be handled in Estonia can still be contracted ad hoc to the best qualified RTO abroad. Building partnerships with RTOs such as VTT around specific themes would also be very beneficial way to access relevant competences.

Modernise and 'profile' the universities with respect to research, making them better adapted to innovation and the production of human capital to meet national needs. MER should extend the university reform intended to professionalise management by requiring public universities to have a board with an external majority, one of whose tasks is to appoint the rector. We encourage the largest universities to appoint vice rectors for education, research and knowledge exchange with society. Academic affairs should remain in the hands of a senate (or an equivalent academic body) but strategy and resource allocation must be in the hands of the appointed management. Once the governance reform legislation is drafted, MER should launch a programme, which competitively reallocates a small proportion of the universities' institutional funding based on their research and knowledge exchange strategies while taking into account all three university 'missions': teaching, research and knowledge exchange. This provides an opportunity for increased profiling and readjustment of university strategies to align more closely with changing needs.

The analysis in our main text suggests the need for changes in policy and practice at a more operational level. These are set out at the end of each Chapter.

PEER REVIEW OF THE ESTONIAN R&I SYSTEM

1.1 introduction

This report reviews the Estonian research and innovation (R&I) system. It has been produced by an expert group appointed by the Policy Support Facility of the European Commission's Directorate General for Research and Innovation at the request of the Estonian authorities. The group comprised five experts in various aspects of R&I Policy and three policy practitioners.

This Chapter explains how we worked and describes the structure of the report. We then discuss some important, research-based ideas underlying our analysis and recommendations.

1.2 How we produced the report

Specifically, the task of the expert group producing this report was to support the work of the Ministry of Economic Affairs and Communications (MEAC) and Ministry of Education and Research (MER) in preparing to produce a joint research, development and innovation (RDI) and entrepreneurship strategy for the period 2021-27 and onwards by providing

- A general assessment of the effectiveness of the R&I system in creating knowledge and value for the society, paying particular attention to strengths and bottlenecks, the governance system, how to set priorities in making R&I investments, getting the best use of the Estonian science base and maximising knowledge and technology transfer between the research institutions and business

- A specific assessment of the role and impact of the R&I system in promoting added value creation in the business sector and productivity growth, including current inhibitors and potential enablers, focusing on how to increase innovation and the technological capacity in industry, facilitating the entrepreneurial discovery process, identifying the main sources of knowledge that Estonian business should be using, considering framework conditions and the surrounding environment, and how to attract foreign direct investment (FDI)

To support the work of the group, a background report was produced, summarising and synthesising available policy documents and studies (Eljas-Taal, et al., 2019). This is published by the Policy Support Facility in a separate volume. The expert group made two three-day visits to Estonia, in order to interview relevant policymakers and other stakeholders, to discuss issues concerning the funding system and to reflect on potential reforms. Earlier drafts of this report have been shared and discussed with these communities.

The structure of the report is as follows.

- Chapter 2 discusses the way the Estonian national research and innovation system is governed

- Chapter 3 discusses the business innovation system, industrial innovation and research-industry links, and innovation funding by the state
- Chapter 4 deals with the higher education and research institutions
- Chapter 5 summarises our conclusions and makes recommendations

1.3 The role of research and innovation in development

Behind the expert group's analysis and recommendations lie fundamental ideas, each of them backed up by research, about how R&I work, namely

- The most important driver of economic development and growth is innovation, in particular innovation based on research and development (R&D), which increases the amount of knowledge available to innovators and therefore extends their opportunities to innovate beyond the existing state of the art
- The capabilities necessary to generate new and original innovations are also needed so that the national system can learn, generate the necessary human capital, keep up with international scientific and technological progress and maintain its competitiveness
- Innovators do not, by and large, innovate alone but in national and international 'innovation systems' that involve many actors and institutions. Policymakers therefore need to understand that system and to develop policies that on the one hand maintain an appropriate balance among different parts of the system and, on the other, are able to change as industrial dynamics change

It is important to note that 'innovation' spans more than technological innovation and includes innovation in services, management and organisation, all of which are hard to quantify through traditional statistical approaches.

1.3.1 R&D as a driver of economic development and growth

The Frascati Manual (OECD, 2015), which defines how we collect R&D statistics, says that innovation is "putting new or significantly improved products on the market or finding better ways (through new or significantly improved processes and methods) of getting products to the market. R&D may or may not be part of the activity of innovation."

In fact, most innovation is based on reconfiguring existing technologies. Only some innovation needs R&D, because there are bits of knowledge missing and these need to be discovered before the innovation can be achieved. The boundary between the two kinds of innovation is built into the way we collect R&D statistics. The Frascati Manual defines R&D as: basic research; applied research; and experimental development. To qualify as R&D, these activities must be novel, creative, uncertain, systematic and transferable or reproducible.

There is now a large research literature about the returns from R&D and the links between R&D, the economy and wider society. Useful reviews and summaries can be found in (David, et al., 2000) (Martin & Tang, 2007) (Hall, et al., 2010) (Becker, 2015).

Available studies find large and positive returns to private R&D, though rates of return vary among industries. Some earlier studies suggest that publicly-funded R&D tends to crowd out privately-funded R&D, but most and more recent studies find the opposite: that public funding 'crowds in' private R&D. University research, the availability of high-skilled human capital and R&D co-operation also typically increase private R&D (Becker, 2015).

New knowledge 'leaks' from R&D performers to others, so the economic return to society to R&D is typically two to three times larger than the private rate of return to companies that do it. This happens through labour mobility, imitation, licensing and so on despite firms' attempts to monopolise the results of R&D. Despite the spill-overs, companies do R&D in order to gain knowledge advantages over others and to increase the 'knowledge space' within which they can innovate.

Rates of return to government-funded basic research are high because basic work tends to have long-term benefits and because the amount of spill-over is higher than that from applied research or development. The traditional 'market failure' argument (Nelson, 1959) (Arrow, 1962) for state funding of R&D is that the high risk, high rate of spill-over and the public goods character of basic research (i.e. the impossibility of appropriating and monopolising the results) makes it an unattractive investment for private enterprise.

Econometric work on the returns to R&D focuses on fairly short-term private returns, which are relatively easy to measure. As a result, business-to-business cooperations and cooperations with 'innovation intermediaries' show good returns (Cunningham & Gök, 2006) (Bilsen, et al., 2015). However, econometrics is a poor way to track returns to more fundamental research that often produces 'intermediate knowledge products' that are used as inputs to subsequent innovation processes. Studies that track longer-term effects of academic-business R&D collaboration show that these can generate large private as well as public returns because they allow the companies to access more basic knowledge than would otherwise be the case and that they exploit this knowledge over long periods of time (Arundel, et al., 1995) (Arnold, 2012) (Stern, et al., 2013).

The literature is therefore unequivocal in indicating that investment in R&D produces large economic benefits, that state investment has an especially high return when it funds R&D that private industry would not do or stimulates the private sector to increase its R&D effort.

1.3.2 Absorptive capacity at company and national level

R&D has two 'faces': an innovation face that develops new knowledge; and a learning face, where R&D skills enable a company to absorb and understand scientific and technological information from the outside world (Cohen & Levinthal, 1989). Taken together, we refer to these two faces as 'absorptive capacity' or "the ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends" (Cohen & Levinthal, 1990). The presence of absorptive capacity in companies, therefore, is a precondition for obtaining the benefits of R&D described in the previous section.

The idea of absorptive capacity is also important at the national level. Maintaining capacity in basic research is necessary because it keeps the university teachers up to date, ensures that someone is monitoring developments in world science and the opportunities they bring and can trigger the development of the human capital needed if and when particular areas of science become important in socioeconomic terms. At the same time, applied research and researchers are needed in order to enable innovation in the economy and society more generally. Some of these researchers will be in state research-performing institutions; most of them will be in business. The state needs to prioritise the funding of applied research in directions that match with the needs of the economy and society, otherwise there will be mismatches between the skills of the researchers trained in the research and higher education institutions and those needed in society. Because the funding of basic research and research for society tend to be done differently, many countries maintain separate organisations to fund basic research (research councils or national science foundations) and applied research for society (innovation agencies and specialised 'sector' funders such as agricultural research councils). Together, these two modes of funding ensure there is absorptive capacity at the national level.

1.3.3 National Research and Innovation Systems

The concept of a 'national innovation system' emerged in the late 1980s and early 1990s. It is now the dominant heuristic in analysis of research and innovation performance and is used, for example, in the OECD's Reviews of Innovation Policy as well as European Commission R&I policy reviews. Systemic approaches gave new insight into innovation by focusing on the interaction among actors and not just inputs (such as research expenditures) or outputs (such as patents) (Freeman, 1987) (Lundvall, 1992) (Nelson, 1993) (Patel & Pavitt, 1994) (OECD, 1997). Key elements of the idea include

- Economic actors have 'bounded rationality', so they do not always make optimal decisions. Past decisions, skills and resources affect future decisions, so behaviour can become 'path dependent' rather than being objectively rational. Hence, knowledge, learning and institutions become key to how economies innovate and develop

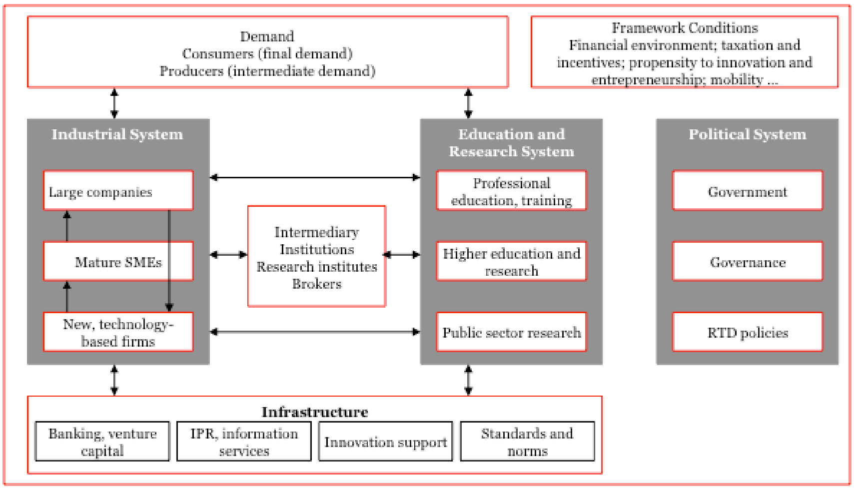
- The smooth operation of innovation systems depends on the fluidity of knowledge flows – among enterprises, universities and research institutions. Both tacit knowledge or know-how exchanged through informal channels and codified knowledge, or information codified in publications, patents and other sources, are important

- Firms and other institutions and their economic and social context are interdependent. These co-evolve and therefore their character often differs among countries. As a result, policies have to be tuned to the national context – they cannot simply be copy-pasted from one place to another

- Good system performance results from a combination of the level and balance of performance at multiple points in the system – policy development has to take account of bottlenecks in the system and can rarely improve performance by intervening only at one point

Because research is a key component of innovation systems, we prefer to refer to 'research and innovation systems'. Figure 1 is a widely-used illustration of the major components of a research and innovation system. Our analysis in this report takes account of these components.

Figure 1 A national research and innovation system heuristic



Source: (Kuhlmann & Arnold, 2001)

Innovation systems can conveniently be thought of as being national, with both geographical boundaries and boundaries in terms of the reach of laws and policies. But it also makes sense to think both of regional innovation systems and international ones, such as the European Union. Individual systems – especially those of small countries – are strongly involved in international systems via supply chains, international standards, FDI, trade agreements, migration patterns, and so on, Countries like Estonia with strong socio-economic ties to other countries and high international (researcher, entrepreneurial, other human resource) mobility need to take particular account of this in devising R&I policy.

Innovation systems thinking provides a set of reasons for policy intervention to address 'system failures'. There are examples of each of these in Estonia. They are typically thought of as being

- Capability failures or deficiencies in the ability of companies to take economically optimal decisions based on perfect information and rationality. In R&I policy this often means supporting the development and use of absorptive capacity and accessing external knowledge and knowledge providers

- Institutional failures, where organisations such as universities, institutes, patent offices, agencies perform sub-optimally and need reform

- Network failures, where the linkages among organisations are deficient, so that the connections needed to support innovation do not work well or old relationships, technologies or routines 'lock in' companies or the innovation system to patterns of behaviour that are no longer relevant or competitive

- Framework failures, where regulations, laws or various economic conditions that the government could control such as skill shortages get in the way of doing innovation

While individual national systems have unique characteristics, a universal principle is the need for balance among the different components of the research and innovation system. For example, the further and higher education systems need to produce roughly the quantity and type of people needed in the labour force; some of the research effort funded by the state needs to be orientated towards specific economic and social needs; but there also needs to be a balance between the amount of such orientated research and 'bottom-up' or investigator-initiated research (which is a source of unexpected ideas, of research-capable human capital and of the ability of the system to learn from global advances in science and technology).

The balance of R&D effort between the state and business and the balance between 'basic' and more applied research performed overall tend to change with development. In low-income countries, business tends to do little R&D. Most research is done in the state sector: universities and government laboratories. As industrial capacity and capability grow, the balance typically swings the other way so that business does the majority of R&D. This is reflected in the EU's Barcelona Goal to spend 3% of GDP on R&D, of which 2% should be funded by business and 1% by the state. Because the state system is the source of the human capital used by business, it has to grow over time in order to support the growing needs of the whole system – though business' expenditure on R&D should grow faster than that of the state if development is taking place.

The 3% R&D intensity target remains an ambitious objective for the EU. In 2017, the 28 members of the EU collectively devoted 2.06% of GDP to R&D. Of this, 1.36 percentage points were business expenditure on R&D while the rest came from government (and to a minor extent from the private, non-profit sector)[2]. Figure 2 shows Estonian expenditures on R&D in 2017 (on the left), the flow of funds among sectors and the sector in which the R&D is done (on the right). The literature discussed earlier would suggest that there would be large public and private returns to increasing these expenditures. Because of its enabling role in building capacity, state investment needs to lead the way but there should also be a major effort to increase R&D in business, which is where the translation from knowledge and human capital to employment and money is made.

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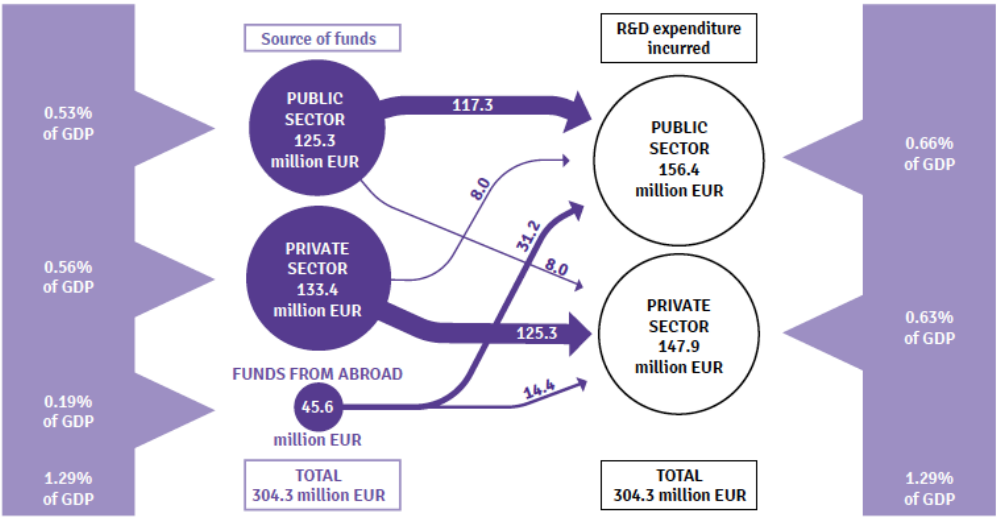
[2] Source: EUROSTAT, accessed 23/8/19. Note that these numbers are still provisional and liable to readjustment.

Figure 2 Flows of funding and expenditure on R&D between sectors in Estonia in 2017 (€m)



Source: Estonian Research 2019, Tartu: Estonian Research Council, 2019

Links between research and industry matter in making these investments in R&D pay off. The Community Innovation Survey (available from EUROSTAT) has consistently shown over the years that successful innovators make more use of knowledge from external research organisations such as universities than unsuccessful ones. These links operate also in relation to human capital. Research tends to inform the pattern of education in universities. As a result, companies make use not only of ideas from the research system but of relevantly-skilled people. It is essential therefore that aspects of research policy are in balance with the current and future needs of industry – and society more widely – for new ideas and educated people.

2 GOVERNMENT AND SOCIETY

Here, we start at the political level, which sets the context for R&I Policy. The political priority the Estonian government gave to research and innovation declined in recent years. There is now a welcome revival in policy interest. Next, we describe the way research and innovation fit into national governance and the various national strategies within which they are tackled. European R&I policy increasingly focuses on the 'societal challenges, so we discuss how these are treated in Estonia. We reflect on some issues associated with European structural funds. As in subsequent chapters, we conclude with a summary of findings and implications for policy.

2.1 Politics and commitment to the 1% goal

In 2011, the government committed itself to spending 1% of GDP on R&D and a target that the business community would spend a further 2%. To date, despite the good intentions of government, the 1% goal has never been achieved, normally falling victim to other priorities in the annual state budget negotiations.

During the economic crisis of 2008-10, Estonia avoided overall cuts in the national public R&D budget by increasing the use of EU Structural Funds above its previous level to replace national money in about 10 % of the R&D budget. Despite this commitment, political interest in R&I policy in Estonia declined for some years after 2012 but seems now to be reviving and there have been small, recent budget increases.

This political commitment needs to stretch beyond the current government to the political parties, in order to overcome the 'dynamic inconsistency' between the length of the electoral cycle and the longer time constants relevant to R&I. Central elements of R&I policy need to be consistent over time and across successive governments. There are signs of such commitment appearing. In December 2018. The political parties, research institutions and business organisations again committed to the 1% target; but again, it proved impossible to implement it in the course of the 2019 budget negotiations.

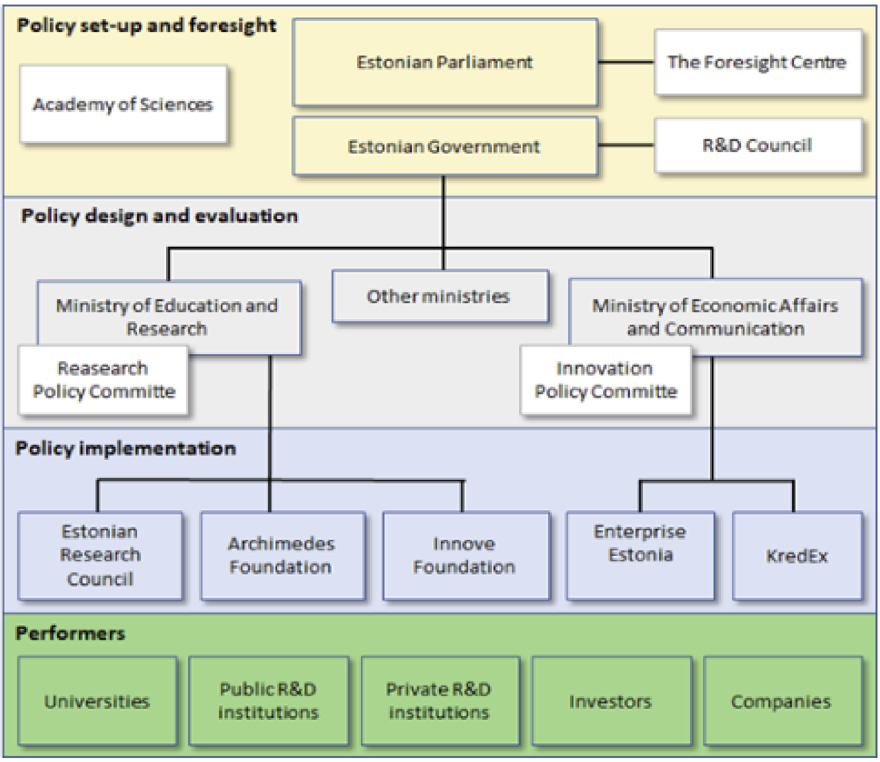
2.2 Governance

In terms of structure, Estonian governance has largely followed a West European research and innovation governance model since independence (Figure 3). It has a 'two-pillar' ministry system, in which the MER and MEAC play the biggest roles in R&I, a Finnish-style R&D Council chaired by the prime minister and an independent Foresight Foundation answering to the Parliament rather than the government.

The president is the formal head of state, but this is largely a ceremonial post and the government is led by the prime minister, who leads and is one of the four ministers sitting on the R&D Council together with four representatives of the research system and four representing industry. The work of the Council is supported by two permanent committees: the Research Policy Committee (23 members); and the Innovation Policy Committee (14 members). These are chaired by, and advise directly, the respective minister, who then prepares documents for discussion at the Council. They tend to tackle questions raised by the minister and tend not themselves to launch new initiatives or policies. Their memberships comprise researchers and industrialists. Civil servants from their parent ministries (and sometimes also other ministries) are observers on these councils. The Research Policy Committee meets fairly often. The Innovation policy Committee did not meet between 2012–18, but has started meeting again in 2019. They are charged with the yearly submission of a report on R&D in Estonia as well as budget-related advisory tasks.

The prime minister's overall authority in R&I and in economic development more generally is strengthened by the fact that he formally coordinates national strategies, supported by the Prime Minister's Office. The parliament is advised by the recently-established Foresight Centre, which assists it through scenario analysis and exploring the implications of policy options[3].

Figure 3 Governance of the Estonian innovation system



Source: Technopolis Group on the basis of the Ministry of Education and Research and the Ministry of Economic Affairs and Communications

The Academy of Sciences has a much smaller role than in the pre-independence period, when it was a major research performer through its institutes. The Academy today is independent of government and answers to its members. Twelve of its institutes were transferred to the university sector after

[3] In Finland, this is one of several roles of SITRA, which similarly answers to the parliament.

independence, leaving the Academy as a typical West European one that celebrates and lobbies for science, fosters public understanding of science and offers scientific advice to the government. It offers science for policy rather than policy for science, which is the business of MER. It also serves as an umbrella for various disciplinary scientific societies. The Academy argues that, despite its own presence, there is no effective science lobby in Estonia.

MER and the MEAC have lead responsibility respectively for research and innovation policies. More broadly, every ministry has a responsibility to plan, implement and finance R&I in their policy fields, in following the idea of 'sector responsibility' for research that is important in Sweden, Norway and Finland, though, so far, this principle has not been strongly enforced Estonia.

MER has five agencies relevant to R&I.

- The Estonian Research Council, which provides both institutional and project-based, competitive research funding

- The Innove Foundation, which coordinates and promotes general and vocational education

- The Archimedes Foundation, which coordinates national and international programmes in training education and research and has the Erasmus+ agency functions. It also functions as a back office to the other two, handling the specific administrative complexities of EU structural funds

- The Estonian Qualifications Authority (Kutsekoda), which operates the Estonian Qualifications Framework and manages the anticipation and monitoring system for labour and skills demand – (OSKA)

- The Information Technology Foundation for Education (HTSA)

R&I Policy capacity and attention is unevenly and inappropriately split between MER and MEAC. MER extends beyond research and a little way into innovation, in effect going beyond its remit and its capabilities while its innovation support is detached from the wider context of industry policy.

MEAC has two innovation-relevant agencies.

- Enterprise Estonia, which handles business development, support to start-ups, FDI, R&I funding for companies, academic-industry collaboration via competence centres and innovation procurement
- The Kredex Foundation offers loans, venture capital, credit insurance and guarantees to business

MEAC pays limited attention to R&D, leaving a gap where other countries would have an R&D-related innovation policy. As a result, innovation is insufficiently considered and integrated into the national policy mix. Enterprise Estonia is discouraged from working with R&D-based innovation, as opposed to business support. This means the system has a research council and a business support agency but not an innovation agency in the style of Sweden's Vinnova or the former Finnish Tekes agency (now part of Business Finland).

The current R&D strategy introduced the RITA programme with 'research counsellors' into the line ministries to help them take a more active role in public research and to provide a working-level channel for coordinating R&I across all the ministries. Currently, there are 10 counsellors who take part in planning R&D cooperation at the national and international level and coordinate the R&D planning and implementation of the current plans in the ministries.[4] The science counsellor scheme is an important, positive innovation. The counsellors provide potential for greater horizontal coordination, though their current role seems mostly to be to coordinate science policy within their ministry. This needs to develop to provide (1) a place in each ministry that does policy for science (and innovation) and (2) a separate mechanism to access science for policy.

The Ministry of Finance is to some degree playing a coordinating role in R&I policy by not only budgeting in terms of ministry silos but also establishing horizontal or cross-ministry budget lines for certain strategic actions, such as R&I. This is very positive intention – but it does not remove the need for a consistent strategic planning and governance framework and active policymaking on the part of the other ministries. The Ministry of Finance alone does not have the information or sector understanding to devise policy on other ministries' behalf.

The role of the Parliament's Foresight Centre is to provide a critical perspective on policy that is independent of government. That need not prevent it from cooperating, where appropriate, with the government system but it should remain separate from it.

2.3 Strategy, planning and capacity in the state

The current national priorities and strategic objectives related to R&I are defined in the following policy documents (Figure 4).

- The overarching national strategic objectives are set out in the National Reform Programme Estonia 2020

- These are further defined in the Estonian Research and Development Strategy 2014–2020 "Knowledge-based Estonia" and the Estonian Entrepreneurship Growth Strategy 2014-2020

- The Smart Specialisation Strategy is developed in order to support existing strong industries having further growth potential. The smart specialisation strategy objectives are integrated into both the R&D and entrepreneurship strategies

[4] Estonian Research Council (2018). Teadusnõunikud ministeeriumites: RITA tegevus
[3]Available at: https://www.etag.ee/rahastamine/rakendusuuringute-toetused/rita-rakendusuuringud/teadusnounikud-ministeeriumites-ja-riigikantseleis/

In addition, parts of the Estonian Life-Long Learning Strategy 2020[5] support the national strategic objectives.

There are thus currently separate R&D and entrepreneurship strategies, respectively owned by MER and MEAC. They will end in 2020 and the government wants to bring them together. This must be encouraged. Particular attention should be devoted to ensuring that the lower-level strategies are mutually consistent and do not leave important gaps.

Figure 4 Strategic framework of Estonian RD&I

The **National Reform Programme** sets goals at a high level. Specific measures are planned at lower levels. Key goals with respect to R&I are

- Priority 2 – aligning training and education with the needs of the modern labour market … and increasing the proportion of people with professional education at the vocational or higher education levels
- Priority 3 – making higher education more internationally competitive, attracting foreign students and researchers and integrating them into the labour force
- Priority 7 – attracting more FDI into sectors with export potential, increased entrepreneurial opportunities and transfer of skills into the R&D sector by developing an attractive and "comprehensive investment environment"
- Priority 8 – increased R&D and innovation in private business by increasing the absorptive capacity of business and the state and through a systemic approach to improving all parts of the national innovation system
- Priority 10 – human capital development, especially by increasing the supply of engineers, top-level specialists and higher-quality PhDs

The **Estonian Research and Development and Innovation Strategy** 2014-2020 "Knowledge-based Estonia"[6] is the third Estonian strategy for R&I

[5] https://www.hm.ee/sites/default/files/estonian_lifelong_strategy.pdf
[6] Riigikogu (2014). The Estonian Research and Development and Innovation Strategy 2014-2020 "Knowledge-based Estonia". Available at: https://www.hm.ee/sites/default/files/estonian_rdi_strategy_2014-2020.pdf

development. Thematically, it prioritises the same areas as the Smart Specialisation Strategy (below). It responded to several analyses including the ERAC Peer-Review of the Estonian Research and Innovation System (Christensen, et al., 2012), which set out the need for more direct links between research and the economy, a clearer focus for national R&I programmes, more cooperation among R&I institutions and among enterprises, and for making new specialists, both Estonian citizens and foreigners, available in the economy.

The Strategy has four main objectives.

- Research in Estonia is of a high level and diverse
- Research and development (R&D) functions in the interests of the Estonian society and economy
- R&D makes the structure of the economy more knowledge-intensive
- Estonia is active and visible in international R&DI cooperation

The **Estonian Entrepreneurship Growth Strategy** for 2014-2020 has two sets of goals.

- Primary goals: a) raise Productivity to 80% of the EU average; b) raise the employment rate in the age group 20-64 to 76%, especially through higher value added jobs
- Secondary goals: a) increase business investments in R&D; b) increase the volume of Estonian exports; c) encourage the development and use of (more) ambitious business models

Five major activities were undertaken in order to reach these goals.

- Enterprise Development Programme: Provision of the support and services needed in accordance with development dynamics
- Cooperation Programmes: Focused on smart specialisation areas
- Export Development: Facilitating and supporting activities in foreign markets
- Entrepreneurship Promotion: Sector-spanning and overarching campaign to spark interest in entrepreneurship
- Start-up Estonia programme

Notably, there is no wider industrial strategy that explains how to restructure in order to address declining productivity.

The **Smart Specialisation Strategy** has selected three growth areas.

- Information and communications technology (ICT) horizontally across sectors, namely 1) use of ICT in industry (incl. automation and robotics); 2) cyber security and; 3) software development. This is especially important, because – outside the small but important, software-based start-up sector – the level of digitalisation in Estonia is low
- Health technology and services. Estonia has the greatest potential for innovative research in health-tech is in 1) biotechnology and; 2) e-medicine (use of IT for the development of medical services and products)
- More efficient use of resources. Estonia's potential for further development was related to 1) materials science and industry; 2) development of the 'smart house' concept (both IT solutions and more efficient construction of houses (passive house)) and; 3) food that supports health

A common thread among the various strategies is lack of specificity about implementation and, especially, relative priorities. This has the benefit of creating 'space' for creative policymaking close to the users and beneficiaries, which is good practice. But it also means that there is little effective coordination at the thematic level, allowing mismatches to appear between needs and policies.

A new, overarching strategy "Estonia 2035" is in preparation. It is intended to bring together research and innovation policy into a single integrated plan that will include the R&D strategy, sectoral development plans and programmes. This provides a good opportunity to take a more integrated, whole-system approach to strategy development. It is positive that Estonia 2035 is being coordinated by the Prime Minister's Office together with the Ministry of Finance as this (1) creates a high-level 'place' in the government system where R&I strategy is anchored and potentially integrated with other policies and (2) enables horizontal coordination. For the shorter horizons against which the government plans, there is an ambition for the MER and MEAC to launch a joint innovation strategy. However, there appears to be no existing governance mechanism that could address its joint governance.

Creating an over-arching strategy in Estonia 2035 should encourage better alignment, facilitate mutual understanding and commitment, and enable prioritisation. Individual strategies will be articulated at lower levels, but the intention is that they will then reflect the Estonia 2035 priorities. It is important therefore to ensure consistency between the two levels and that the over-arching strategy clearly outlines priorities (specifically defining what is less important and what is selected out), and to strengthen the top/strategic level governance during implementation in order to ensure coherence.

2.4 Monitoring and Evaluation

A key requirement for effective governance and strategy is good information. There needs to be a feedback loop from policy implementation to policy development, which helps the strategists to understand the effects of their strategies and allows them to make mid-course corrections to policy and to abandon failing interventions. Evaluation needs to have both summative and formative aspects, if it is to be of use in governance[7].

- The summative dimension examines the outputs, results and impacts of policy interventions

- The formative dimension examines whether interventions effectively address the problems they were intended to fix, paying attention to causation mechanisms and identifying improvement opportunities

A Research and Innovation Policy Monitoring Programme (TIPS) ran from 2011-15, intending to build capacity and competence in R&D and innovation policy and related strategy development. With a budget of €1.3m, 85%-funded by Structural Funds, 10% by the government and 5% by the Universities of Tartu and Tallinn, it generated a body of studies of Estonian policy but did not to any significant extent evaluate individual programmes. TIPS has subsequently been continued into the current period.

Estonia has a national research information system (Estonian Research Information System, ETIS) that captures information about inputs to research, resources and outputs and that, among other things, supports the performance-based research funding system.

Programme evaluation in Estonia is strongly influenced by the requirements attached to European Structural Funds, which focus on monitoring performance indicators and the attainment of objectives at the level of the Operational Programmes. This needs to be complemented by instrument-level evaluations that explore the intervention logic and performance of individual instruments, in order to maintain a portfolio of instruments that individually work well.

2.5 Societal challenges

Over the last decade or so, there has been growing policy concern about the 'societal challenges' such as climate change, HIV/AIDS and ageing of the population, which pose systemic threats to society. Key triggers at the EU level included a 'manifesto' published in Nature (Georghiou, 2008) and the 'Lund Declaration', from an innovation conference under the Swedish presidency of the EU, which triggered the inclusion of the societal challenges in the EU Framework Programme. Tackling these challenges generally involves overturning existing technologies, structures and practices in socio-technical systems. Interventions therefore involve complexity at the same time as they need a wider and more difficult form of governance and collective action than before.

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[7] The UK Treasury's 'Magenta Book' is a good overview of requirements for evaluation (HM Treasury, 2011)

How small countries address societal challenges

Austria has Platforms in areas of societal challenges, where one institution takes the lead and assembles relevant research groups in the respective area to network, collaborate, exchange information on and prepare for participating in European and international/transnational Programmes. In a second step the platforms involve demand-side stakeholders including sectoral ministries. Each Platform has a budget of €100k per year.

Finland has created the Strategic Research Council, which – based on consultation with researchers and stakeholders – annually proposes research themes to the Finnish government. It then breaks down the themes into research programmes and calls for proposals from multi-disciplinary consortia assembled from academic, private, public and the 3rd sector organisations. Intended users of the research findings are involved from the very beginning. The Council operates under the governance of the Academy of Finland – the Finnish Research Council.

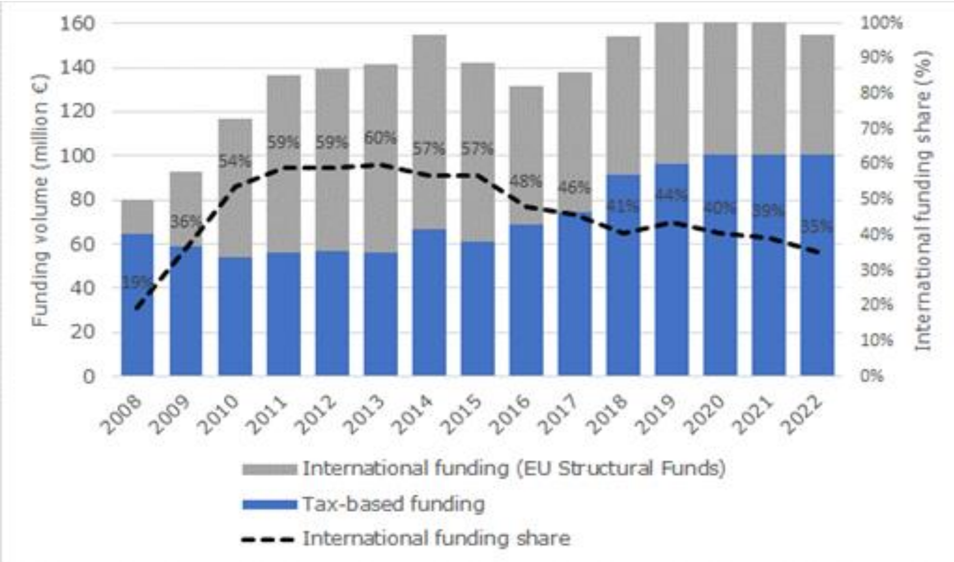
In both cases, these research activities affect the supply of skills through PhD production and the work's effects on research-based teaching.

At present, Estonia has no wider strategy driven by the societal challenges. While it is easy to argue that a country with Estonia's limited scale and resources can do little about them on its own, the fact that others are organising around the challenges will affect the structure and competitiveness of other economies – and Estonia needs to be in a position to operate on the new markets and within the new rules-of-the-game that will emerge. Therefore, Estonia needs a strategy on the theme 'How can we not only help mitigate but also make money out of the societal challenges'? This may in turn have implications for governance and is likely to require greater involvement in relevant EU R&D networks, identification of gaps in value chains and innovation niches where Estonia can build comparative advantage and connecting these to thematic funding in both research and innovation, including in the Smart Specialisation strategy. The Estonian Research Council and other funding bodies lack multi-disciplinary research programmes that address the societal challenges and fund research that the industry would need.

2.6 EU Structural Funds

EU Structural Funds have played a vital role in supporting the development and growth of the Estonian government R&I system. Their availability mitigated the effects of the 2008 financial crisis on R&I funding, but their importance has not declined as the economy has recovered from the crisis. This leaves a medium-term funding problem as they will need to be replaced by national money over time. That will increase competition for R&I budget, since – unlike Structural Funds – national funds are not partially earmarked for R&I activities.

Figure 5 MER R&D budget trends 2008-18



Source: Statistics Estonia; State budget strategy 2017-2020

Dependence on the structural funds (Figure 5) also raises a number of other issues.

- Their periodic allocation through operational programmes leads to risks of funding interruptions.
- Their administration is bureaucratic and this problem is compounded by administrative caution at the national level, so that accounting rules become burdensome and (sometimes excessive) requirements are imposed (such as using complex procurement processes for small purchases)
- Monitoring and evaluation are typically tied to short-term output expectations, which may conflict with the time constants of many research processes
- Equally, performance expectations reflected in performance monitoring indicators are that all projects should produce outputs and results. This expectation inherently conflicts with the risky character of innovation. While some targets are clearly necessary, innovation funding systems that cannot cope with risk become conservative (and arguably have limited additionality), promoting only limited levels of change
- The requirement that structural funds be administered by a Managing Authority rather than passing through normal budgetary channels imposes fragmentation and duplication of functions on the state system

Notwithstanding the problem of fragmentation, the administration of the structural funds in Estonia appears to be satisfactory. Archimedes provides a back office, ensuring compliance with the Commission's finicky rules while not interfering in policymaking. This is an important separation of responsibilities, which is central both to good governance and to the spirit of the structural funds, which is that the beneficiary state should itself govern them. As in many other countries, some of the complexity in administering structural funds is imposed by over-cautious national administrators. This could usefully be reviewed by someone tasked with simplification.

2.7 Findings and policy implications

Findings	Policy implications
While R&I are crucial to economic and industrial development, this is not always well understood at the political and societal level	Government reaffirms and implements its commitment to the 1% spending goal Establish political consensus about the 1% goal
The R&I policy mix is developed in a fragmented way, influenced by the separation of research and innovation policy responsibilities and the tendency of Structural Funds to drive business innovation rather than R&D-based innovation	Maintain the role of the R&D Council at the top of the governance hierarchy Sustain the revival of the Innovation Policy Committee Create a holistic, systemic planning perspective (based on the process for Estonia 2035) to support development of a balanced policy mix while maintaining the principle of subsidiarity as far as possible in detailed design and implementation The implementation of the strategy should be accompanied by monitoring of its deployment and where necessary the revision of individual plans based on experience and unexpected changes Ensure that objectives and initiatives are consistent between Estonia 2035 and lower-level plans and strategies Introduce an explicit exercise to identify opportunities for Estonia within the broad set of international societal challenges and use this to adjust thematic priorities at lower levels. This should involve the sector ministries, not just MER and MEAC
Inadequate coordination of R&I and related policies, both horizontally across ministries and vertically through effective policy implementation	Reinforce the 'sector responsibilities' of the ministries for securing the research needs of their own sector of society Further strengthen the Science Counsellor system, increase its role in policy coordination and over time develop a separate 'science for policy' channel for each ministry Create an R&I reporting channel from the sector ministries to the R&D Council to ensure they are involved in planning and implementing the national R&I strategy
Over-dependence on Structural Funds in R&I policy; negative effects of lumpy and bureaucratic allocation mechanisms for Structural Funds	Plan over time to substitute with national money, prioritising areas like research funding where continuous national input is permanently needed, and focusing Structural Funds on one-time investments in infrastructure and capacity-building

3 THE BUSINESS INNOVATION SYSTEM

This chapter looks at the structure and performance of the business innovation system and analyses the organisations and policy instruments that support it. As requested in our Terms of Reference, it pays special attention to Foreign Direct Investment (FDI), start-ups and entrepreneurship, each of which has its own section in the Chapter. Finally, we summarise key findings and recommendations.

3.1 Framework conditions for business and innovation

The macroeconomic context in Estonia is very favourable for business, with a minimal budget deficit and a small national debt together with low (14-20%) share dividend taxes and low personal income tax (20%). Companies' reinvested profits are not taxed. Social charges are covered by employers and are relatively high at 33%[8]. Consistent with its low absolute level of taxation, which means that tax incentives are not very attractive, Estonia has no R&D tax incentive.

Unemployment is low – 5.8% in 2018. It is expected to rise to 6.9% in 2021 as a result of a slow-down in growth from 3.6% in 2018 to 2.2% in 2021 and labour shortages[9]. Real wages grew by 7.1% to an average of €1,303 per month in 2018[10]. Recent growth has been driven by consumer demand. Real wages have been driven upwards by a 7% decline in the working-age population over the last decade, caused by a combination of emigration and demographic factors. This demographic trend is expected to last until 2030, putting pressure on the tax base[11].

Estonia is ranked 16th out of 190 countries for the ease of doing business in the Doing Business ranking[12] and 15th for starting a business. According to the World Economic Forum (WEF) 2018, the country ranks 32nd in the Global Competitiveness Index.

Business suffers from chronic skill shortages with all three main economic sectors (industry, construction, services) suffering higher shortages than the EU average. Demand for graduate skills is especially high in the ICT sector, where employment is expected to grow by 58% in the next 10 years[13]. Some 27-28% of HEI graduates qualify in STEM subjects but the supply of 'hard' and environmental scientists significantly exceeds demand while that for engineers is too small to meet the needs of business.

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[8] Republic of Estonia: Tax and Customs Board (2016). Social Tax.
[9] Bank of Estonia https://www.eestipank.ee/en/press/fall-competitiveness-economy-points-trouble-ahead-19122018 accessed 23/8/19
[10] Ibid.
[11] European Commission, European Semester Country Report: Estonia, 2019 (COM (2019) 150 final)
[12] World Bank Group, Doing Business 2019, Washington DC: World Bank
[13] Ibid

Some 11% of students leave school early, but participation in life-long learning programmes approaches 20%, so many people combine working with learning.

Government, academia and industry all report a lack of workers, technicians and operators specialised in industrial processes and too many academically qualified professionals compared with the needs of the job market. Wage inflation combined with shortages in manufacturing-related skills are especially dangerous in the international context of increasing industrial automation, as production jobs are likely to become increasingly skill-intensive.

The Aliens Act eases the employment of foreigners and a special category of visa – a start-up visa – has been established for foreign would-be entrepreneurs. In its first year, the scheme accepted 177 and rejected 200 applicants[14]. A category of 'e-residency' has been established for people wanting to run a location-independent e-business within Estonia, and therefore the EU, without physically living there. In its first five years this scheme is said to have recruited 54,000 e-residents from 162 countries, who have contributed €14m in taxes to Estonia and set up about 7,000 companies[15]. However, it is considerably more burdensome to employ non-EU than EU nationals.

3.2 Performance

Estonia is the Baltic state that has grown fastest in terms of GDP and expenditures on R&D following independence[16]. Its GDP per head now approaches €20k per head and the country risks falling into the 'middle-income trap' in development, where the benefits of urbanisation and industrialisation have been realised, shifting the focus of development strategy towards how to increase productivity in an industrial and services economy.

Estonia's productivity lags well behind the EU average – in 2017, labour productivity per hour worked was 74.7% of the EU28 average, putting Estonia in the 7th-lowest position in the EU28[17]. Total factor productivity (TFP) fell dramatically after the crisis of 2007-2008 then recovered slightly and is now stagnant at about 13% below the peak level. Employment is concentrated in low-productivity sectors (manufacturing, construction, wholesale and retail distribution). Correspondingly, employment is low in high-productivity sectors (energy and water supply – which typically do not generate exports – and real estate, where high productivity is mostly an artefact caused by appreciation in property values). While the level of productivity in all sectors contributes to national economic performance, achieving high productivity in manufacturing and services is especially important since these provide export opportunities.

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14 https://investinestonia.com/estonias-startup-visa-is-a-ticket-to-europes-liveliest-startup-community/

15 Ott Vatter, Managing Director of e-residency, quoted in *Forbes Magazine*, 25 April 2019

16 For numeric material to back up the analysis in this chapter, see the Background Report and the European Semester Estonia Country Report, 2019, SWD(2019) 1005 final

17 Eurostat, annual data available up to 2017, last visited 20 February 2019

Estonia's exports have grown and recovered quickly in volume and share terms since the financial crisis. The European Semester 2018 country report notes that while Estonian exports have gained market share in technology-intensive markets, the country will have to make further investments in R&D and human capital in order to sustain its position[18]. At present, technology-intensive sectors in Estonia employ few people, so their success has little effect on overall employment. Both structural change towards higher-productivity sectors and productivity improvement in other sectors are needed to underpin overall economic growth.

The European Innovation Scoreboard (2019) points out that, compared to the EU average, in Estonian production

- The proportion of medium-high technology employment is manufacturing is low
- The proportion of micro- and SMEs in employment is high, and the share of large firms is correspondingly low
- The share of foreign-controlled enterprises in overall business turnover is high

Thus, the firm population is dominated by small and micro firms with limited absorptive capacity and the structure has few of the large firms that elsewhere would do R&D and drive a lot of industrial innovation. Despite the great importance of foreign multinational companies (MNCs) in the turnover of the business system, they are not doing much high value-added activity. This rather 'lumpen' structure is not altogether promising – especially as current MNC investments seem not very conducive to functioning as 'training schools' for national innovators. A danger for small or peripheral host countries is also that MNCs do not necessarily assign their best managers to them, so that some degree of support to the MNC subsidiaries also becomes necessary.

The 2019 Scoreboard also shows that Estonia has

- A higher-than-average proportion of people with tertiary education and strong take-up of life-long learning courses, but a lower than average proportion of people with PhDs
- Good international research links, so there is a strong scientific basis for innovation (even if the science system is small)
- Good broadband and start-up support facilities, which have already helped establish some very impressive start-ups

[18] European Commission, Country Report on Estonia (2018), available at: https://ec.europa.eu/info/sites/info/files/2018-european-semester-country-report-estonia-en.pdf

- Low expenditure on R&D by business but a much higher than average spend by companies on non-R&D innovation activities

- A dramatic increase in the number of companies doing in-house and product/process innovation, but a low rate of marketing and organisational innovation compared with the EU average[19]

- A share of innovative enterprises only slightly below the EU average (48% vs 51%)

- Little use of patents, but significantly above-average use of trademarks and designs to protect intellectual property, supporting the impression that Estonia has a high rate of non-R&D-based innovation but a low rate of innovation that is R&D-based and therefore technologically novel

- Little employment in knowledge-intensive parts of industry and – despite Estonia being famous for some examples of 'unicorn' companies – a low contribution of employment in fast-growing firms to total employment

- Low high-tech and innovative exports and a low proportion of new-to-market innovations[20]

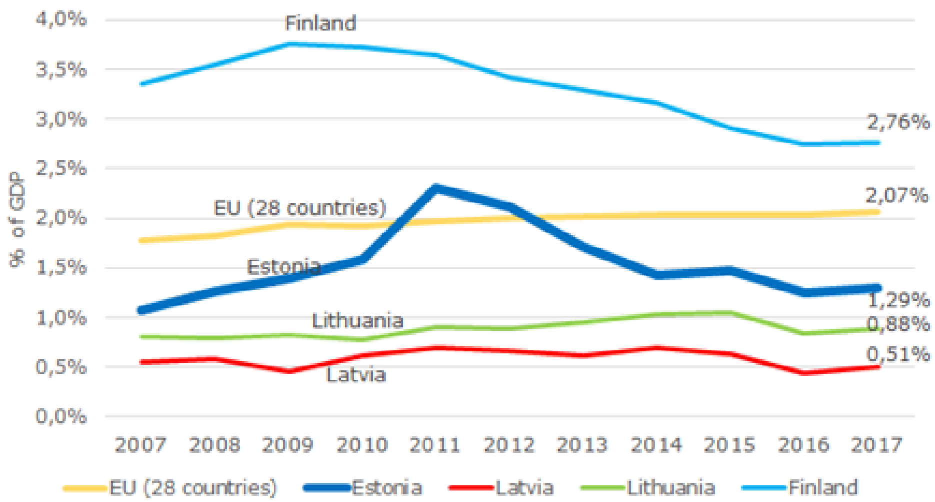
So, there are some bright spots, but most of them are rather fragile. Notwithstanding Estonia's leading position in certain types of web-and software-based enterprise and e-government, Estonia needs not only more entrepreneurship-related policies but also to work hard at increasing the wider innovation capabilities of business and the state.

Gross expenditure on R&D (GERD) as a percentage of GDP has been declining since 2011 (Figure 6), even if it remains higher than in the other Baltic states. The peak in R&D expenditure in 2011 is exceptional and is due to a large one-time investment in the field of manufacturing of coke and refined petroleum products.

[19] The proportion of companies defined as 'innovative' in the Community Innovation Scoreboard jumped from 26% to 48% between the 2014 and 2016 surveys. This increase was first recognised in the 2019 European Innovation Survey. The two previous Scoreboards, based on the earlier data, suggest a much poorer performance. Against the background, however, of little change in business expenditure on R&D as a proportion of GDP, much of the new innovation is likely not to be based on R&D. We are also inclined to treat with some caution the innovation surveys' finding that the proportion of innovative companies almost doubled in only two years

[20] European Innovation Scoreboard, 2019

Figure 6 Total intramural R&D expenditure (GERD), 2007-2017



Source: Eurostat (table code: t2020_20)

Table 1 shows how GERD was made up in 2017, with the state funding 52% in total and business 47%. That leaves considerable room for the proportion funded by business to rise and the same time to increase the total amount expended to somewhere closer to 2% (at least) than the 1.29% shown in Figure 6.

Table 1 Estonian R&D funding flows and expenditures in 2017 (in €m)

R&D funders	**R&D performers**				**Total R&D funding**
	HEIs	**Public research institutes**	**Business**	**Non-profit private research institutes**	
Government	83.2	31.7	6.3	1.6	122.3
HEIs	2.8	0	0	0.1	3.0
Business	7.0	0.6	124.7	0.2	132.6
Private research institutions	0.3	0	0	0.5	0.8
European Structural & Investment Funds (R&I)			1.106		
International sources (e.g.H2020)	27.3	3.9	12.5	1.9	45.6
Total	**120.6** (40%)	**35.8** (12%)	**143.6** (47%)	**4.3** (1%)	**304.3** (100%)

Notes: Government data includes Structural Funds as part of state budget. Statistics about European Structural Funds are only available per thematic area (entrepreneurship/innovation and research, not by institution).

Source: Ministry of Education and Research (2019), Statistics Estonia, HaridusSilm

As a result of the specialisation of the Academy of Sciences during the pre-independence period, there is asymmetry between current state and business R&D investments, with the state tending to invest in natural sciences in areas that are little relevant to industry. This poses a challenge to the research system to realign some of its activity further towards societal needs. Addressing that challenge requires a policy of deliberate thematic focusing of research funding in the state-funded sector. Academic funding systems under academic control and focusing solely on excellence have a strong tendency to reproduce themselves, locking in to existing themes (Rip, 2001) so they tend not to realign themselves to changes in societal needs without policy pressure. Correspondingly, the business community needs to specify its requirements for people with higher education and for research as well as mechanisms for improving linkages between academic research and business needs. (Since the state is a major user of human capital and research-based knowledge, a similar effort is also needed there.)

While Estonia is undoubtedly ahead of its Baltic neighbours, business expenditure on R&D (BERD) as a percentage of GDP is less than half that of the EU as a whole and about one third of Finland's. This suggests that few of Estonia's exports succeed because the level of technology involved – rather, Estonian advantages are likely to be based on cost and are therefore vulnerable to the effects of rising wages, whose increase is running ahead of productivity. It is of course desirable to be able to pay higher wages, but this depends on the ability to use more and better technology.

3.3 Industry structure

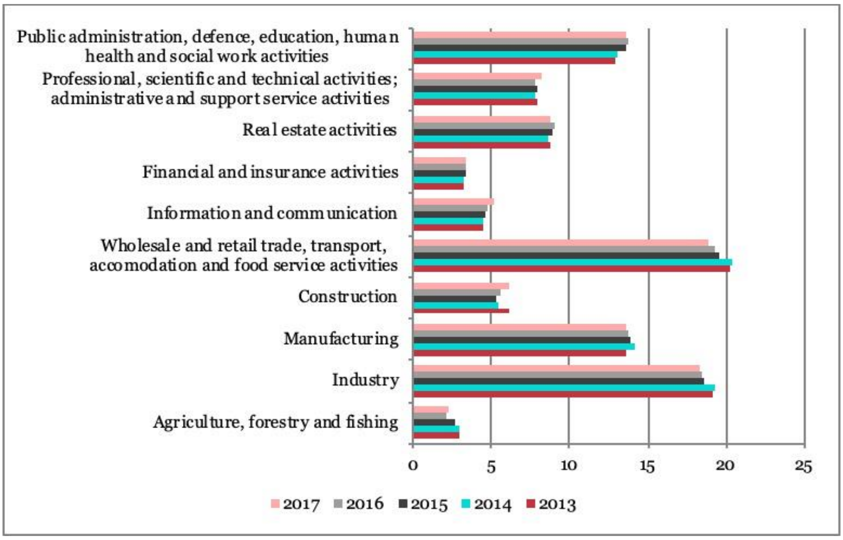
The structure of the Estonian economy has remained remarkably stable during the post financial crisis period (2010-2016) with the share of manufacturing in total value-added staying around 15-16% and in total employment around 18-19%. Other sectors, including knowledge intensive services, show similar stability both in valued added and in employment (knowledge intensive services made up 35.5% of total employment in 2016).[21]

In terms of the contribution of the economic sectors to Estonia's overall GDP, wholesale and retail trade together with industry (excluding construction) accounted for the largest shares of gross value added to the national GDP in 2017 (**Error! Reference source not found.**). Together with public administration (3rd highest contributor) they accounted for 50.8% of gross value added. However, gross value-added has been declining in all three sectors recently (wholesale & retail trade and industry since 2015, public administration since 2017).

At the same time, the information and communication and professional, scientific and technical activities sectors have seen an increase in their respective gross value added to national GDP. In 2017, professional, scientific and technical activities accounted for 8.2% of the contributions by economic sectors – the highest indicators displayed by the sector since at least 2013. The same was true for information and communication technologies that had their peak in 2017 with 5.1% of the gross value added to national GDP.

[21] Research and Innovation Observatory (RIO), Country Report on Estonia (2017), available at: https://rio.jrc.ec.europa.eu/en/country-analysis/Estonia

Figure 7 Gross value added to GDP (%) by economic sector



Source: Eurostat

The business sector is rather young (few firms are older than 20 years) and this is reflected in the lack of accumulated knowledge. Micro-sized companies with less than ten employees clearly dominate the picture, representing about 91% of the companies in Estonia. This is a common feature in middle-income countries. Some 8% are SMEs, which are more likely to invest in R&D and to be more innovative in applying for the current or future research and innovation support measures. There are about 100 companies, which employ more than 1000 people and which tend to be the focus of innovation policy.

There are 30 totally or partially state-owned companies in transport infrastructure, energy supply, or major single infrastructure entities of national importance[22]. Many operate in areas that readily become natural monopolies in a small country (ports, airports, railways, energy and so on). Together they employ about 15,000 people. Their R&D investment is generally modest. The electricity transmission company Elering has decided to invest 1% of turnover in R&D[23] and Eesti Energia cooperates very actively with TalTech both in research and higher education. The state-owned companies, especially the larger ones, are well positioned to increase the amount and level of innovation in the country but rarely do so. While they need to keep up to date with technologies, they rarely have opportunities to exploit more radical innovation by expanding beyond their existing role. There nonetheless appear to be policy opportunities to require them to increase their R&D investment, whether intra- or extramurally. This should have positive effects on the local parts of their supply chains and the research-performing institutions, increase the demand for research-capable

[22] https://www.eesti.ee/est/kontaktid/riigi_osalusega_ariuhingud_2

[23] Short interview with Ms. Regina Raukas, analyst in the budgetary department of the Ministry of Economic Affairs and Communications

labour and the number of such people active in Estonian industry and provide a demonstration effect within industry.

3.4 Support organisations and the instrument portfolio

The Estonian Entrepreneurship Growth Strategy 2014 – 2020 and the Estonian Smart Specialisation Strategy emphasise innovation and entrepreneurship as keys to raising productivity and overcoming the middle-income trap. The emphasis given by the Estonian government to innovation policy is also clear in the distribution of the European Structural Funds. Between 2014 – 2020 in total about €385m (11%) will be invested in R&D and about €535m (15%) in entrepreneurship and innovation. In addition to the measures listed in **Table 2, each county has a County** Development Centre, providing basic start-up and business support, but with no special focus on technology. Below, we focus on the instruments relevant to R&D.

Table 2 shows the Estonian support repertoire for innovation and related activities. The italicised programmes directly support R&D (in the sense of the Frascati Manual). It is notable that while Enterprise Estonia supports a wide range of business-related functions including the implementation of innovation (irrespective of whether that is based on R&D or not), it funds little or no R&D. The Estonian Research Council funds some programmes that in other countries would be the responsibility of an innovation agency, but the level of R&D-related innovation funding overall is low.

In addition to the measures listed in Table 2, each county has a County Development Centre, providing basic start-up and business support, but with no special focus on technology. Below, we focus on the instruments relevant to R&D.

Table 2 Innovation and related support programmes in Estonia

Operator	Programme	Function
Universities	ADAPTER	Web-based tool for companies to ask technical questions to which researchers can respond if they choose to do so
Estonian Research Council	*RITA*	*Sectoral R&D in companies and research institutions to support societal challenges defined in the S3 Strategy; science counsellors*
Estonian Research Council	*Investment aid to shared service and R&D centres*	*Up to €200,000 support to R&D centres established by foreign multinationals in Estonia*
Enterprise Estonia	Norway Grants Green ICT Programme	Supports innovation-led cooperation with Norwegian partners in digitalisation, ICT-led green products and services, and personalised medicine
Support to be phased out at end of current Structural Funds operiod	*Technology Competence Centres (national)*	*Consortia-based research and technology centres in health technologies, food and fermentation, information technology, food production, software, and manufacturing technology*
Enterprise Estonia (State Shared	Regional Competence	Technology centres, associated with regional clusters in small crafts, oil shale, health

Service Centre since August 2018)	Centres	promotion and rehabilitation, knowledge-based health goods and natural products, and wood processing and furniture manufacturing
Enterprise Estonia	Clusters	Traditional cluster networks; no special innovation focus hitherto, but the RITA programme is funding innovation advisers to be associated with four of the clusters
Enterprise Estonia	Innovation procurement	Traditional innovation procurement programme
Enterprise Estonia	Enterprise development	Funding company development and investment. Can include product development and innovation implementation. Use of the scheme for R&D is not forbidden, but is not promoted
Enterprise Estonia	Innovation voucher	Small grant for SMEs to acquire technical services
Enterprise Estonia	Development voucher	Supports evaluating or proving an innovation concept
Enterprise Estonia	Start-up Estonia	Start-up ecosystem support programme
Enterprise Estonia	Start-up grant	Funding to support start-ups to achieve employment and business goals
Enterprise Estonia	Export support	Typical export promotion services
Enterprise Estonia	Digitalisation support	A range of programmes supporting digitalisation in industry

ADAPTER is a network of Estonian universities, research and development organizations, intended to link companies and organisations to the R&D community. It organises events intended to improve academic-networking and cooperation. It lets the user present an inquiry to Estonian R&D institutions, search a database of the services offered by those institutions and see what R&D support mechanisms are available. ADAPTER aims to provide a relevant answer to all inquiries within 5 working days but appears to have no mechanism for ensuring that someone does so. The programme is relatively new, and its scale is as yet limited. Researchers described many of the questions put to ADAPTER as “uninteresting”. In other countries, such inquiry systems are run by intermediary organisations, or technology information services such as the now-defunct Manufacturing Advisory Service[24] in the UK, where someone is paid to answer the questions.

The UK Manufacturing Advisory Service

The Manufacturing Advisory Service (MAS) was an intervention by the UK government to assist SME manufacturing companies. It operated from 2002 to March 2016, when it was shut as part of the government austerity programme. It was tasked with offering strategic business advice and technical manufacturing support to UK SMEs. It helped companies increase their productivity and increase efficiency.

The service was delivered via experienced advisors, who had to have a varied practical background in manufacturing to gain credibility with the companies that were being supported. They had five levels of business involvement and a Supply Chain assistance:

Level 1 (Enquiries): Online and face to face at events etc.

Level 2 (Manufacturing Review): Typically, one day, by a manufacturing plant specialist.

Level 3 (Events): Both training and networking events

Level 4 (Consultancy): Up to £10 000 consultancy support in one of three ways:

1. funding up to £1,000 (or 50% maximum) for basic projects
2. funding up to £3.000 (or a maximum of 50%) for a more significant improvement program.
3. funding up to £10,000 (or a maximum of 50%) for the business’ strategic change.

Level 5: Third party support via partner organizations that MAS identified.

The top three help requests are Strategy 33% Operational Improvement 39% and Innovation (New Products/Processes) 20% (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/499601/BIS-16-7-mas-impact-analysis-report.pdf)

Since MAS was closed, a smaller ERDF-funded Manufacturing Growth Programme has been established to take its place.

[24] http://www.manufacturingadvisoryservice.com

NUTIKAS is a support programme for applied research in smart specialisation growth areas, supporting collaboration between R&D institutions and companies. The rate of take-up has been below expectations in recent years and this is attributed partly to lack of absorptive capacity in industry and partly to lack of proactive management by the Estonian Research Council. Nutikas requires companies to fund 30% (formerly 20%) of the project cost.

We note that Enterprise Estonia has this year decided to fund an additional five clusters with a total of three million euros to increase business cooperation and improve international competitiveness. Support will be provided by the Estonian Wood Houses Association, the Estonian Association of Information Technology and Telecommunications, the Tallinn Science Park Tehnopol, the NGO Digital Engineering and the Estonian Defence Industry Association. More broadly, however, clusters and trade associations appear not to be helping a great deal with innovation – presumably because they are owned mostly by companies with a low propensity to innovate. The RITA programme is recruiting innovation advisors for four trade associations.

The support for sectoral R&D (RITA[25]) programme was extended in 2017 to addressing societal challenges through supporting applied research. The aim of the programme is to stimulate usage of research results in solving socio-economic problems and to build up competences and a systematic well-coordinated approach to the commissioning of applied research (incl. areas of social innovation, eco-innovation, public service applications, demand stimulation, etc.) for corresponding policy fields of Estonia. Where necessary, participation of Estonia in EU and ERA research initiatives in addressing grand challenges will be supported. The themes will be in line with RIS3 strategic framework.

The innovation voucher funds an SME to buy services from a higher education institution, test laboratory, or intellectual property expert. It essentially supports preliminary research. The results should enable the entrepreneur to gain comprehensive knowledge on whether their development idea has the potential necessary for continuing the development process in other stages. The development voucher funds the next stage.

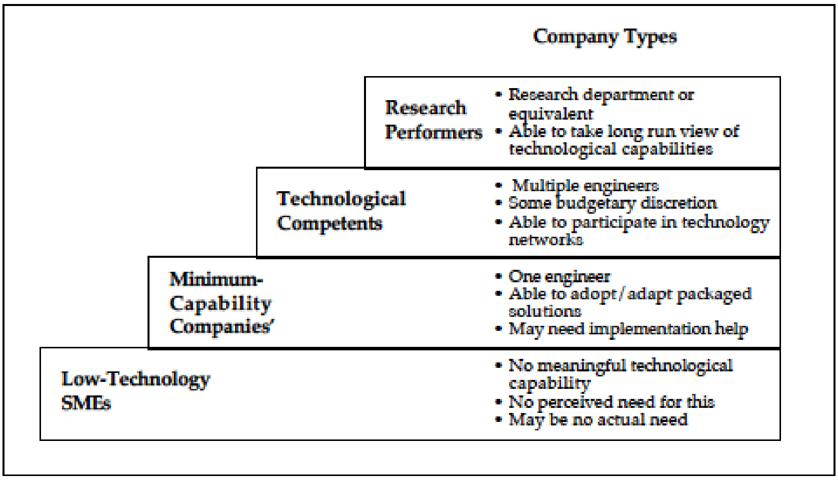
Enterprise Estonia has supported small Regional Competence Centres in the regions, to provide technology services to small firms. As of 2018, these have been transferred to the management of the State Shared Service Centre under the Ministry of Finance. Larger-scale Technology Competence Centres, comprising consortia of companies and academics doing joint research or projects where the academics research on behalf of the companies, are still supported but Structural Funds support will be phased out by the end of the current period.

In the light of the structure of Estonian industry and its insufficient level of technological or absorptive capacity, it is important to have a support system capable of raising this capacity, and not simply supporting or de-risking innovation. An important function of the needed innovation support system is

[25] A separate part of the programme funds the science counsellors

therefore to help companies climb to higher levels of technological or absorptive capacity, enabling them to do R&D-based technological innovation (irrespective of whether that R&D is done in-house or elsewhere). Figure 8 offers a simple way to describe different stages in that development.

Figure 8 Simple hierarchy of technological capacity



Source: (Arnold & Thuriaux, 1997)

At Level 1, Low-Technology SMEs, there effectively is no absorptive capacity. The main policy goal is to inject some, thereby bootstrapping a process of learning and development. At Level 2, Minimum-Capability Companies, it is important to increase the company's use of and interest in investing in R&D by demonstrating its value and providing the company with ways to build and link internal capacity with external knowledge sources. At Level 3, the focus shifts towards risk reduction and increasing access to knowledge networks and producers. At the highest level, companies are competent Research Performers and can easily cooperate with universities or participate in sophisticated international research networks such as the EU Framework Programme.

The Estonian system currently offers little to support R&D activation at the lower levels. Generating and activating absorptive capacity is no longer an acute problem in the richer countries in the EU, so it is more useful to look at what they were doing 15-20 years ago than at their current instrument portfolio. A table showing examples from 2004 is shown at the Appendix.

Relevant policy options for Estonia at the different levels today include

- Human capital programmes, typically subsidising the first engineer or scientist to be employed by a Level 1 company, transforming it into a Level 2 firm. Industrial PhDs are relevant at levels 2 and (especially) 3

- Activation programmes at Levels 1 and 2, such as technology audits, quality audits, manufacturing audits, in which an experienced consultant or manager does an initial diagnosis to identify development and profit-increasing options, thus enticing the company to act. These can best be delivered by organisations like Enterprise Ireland that take a proactive approach to identifying support needs and 'selling' the needed support to companies, rather than just waiting for companies to apply to schemes

- Simpler services from RTOs, Estonia's Technological Competence Centres and industrial extension services become relevant at Level 2. Advanced RTOs remain relevant right up to Level 4
- Outside extension schemes, universities tend not to be useful much below Level 4, at which company personnel can comfortably interact with faculty on a professional level

ADAPTER would be relevant at Levels 1-3. NUTIKAS and RITA are relevant at Level 3 and to some extent at Level 4. The EU Framework Programme is chiefly relevant at Level 4, with the SME Instrument at Level 3.

Other items missing from the Estonian support system for R&D-based innovation include

- A commercialisation scheme for research and higher education organisations that helps move research results towards the market and demonstrate concepts, so that the ideas are sufficiently mature to move into privately-funded R&D
- Supplier development programmes with a technological component, intended to support existing and current FDI
- Bottom-up (ie not thematically prioritised) funding to help companies take initial steps into doing R&D over and above the existing innovation and development vouchers

In addition, Estonia should be very active in its European Institute of Technology operations (EIT-Health, InnoEnergy, Raw Materials and Climate- KIC) and take advantage of the huge high-profile networks the KICs offer. By 2017, Estonia had only four organisations participating in the EIT: TalTech, University of Tartu and two companies. InnoEnergy should be very relevant due to Estonia's shale oil.

We understand that Estonian companies are not used to cooperating with each other and are concerned about commercial confidentiality. This can be addressed through cluster and supply chain development policies and is an area where the professional associations should be educating industry. Several people noted that the lack of trust over ownership of IP is a barrier to academic-industrial technology transfer. This is a common problem. One solution is a standardised IP agreement, such as the UK 'Lambert agreement'[26], which was created at the national level specifically to cope with this natural distrust.

[26] https://www.gov.uk/guidance/university-and-business-collaboration-agreements-lambert-toolkit

We are reluctant to recommend the introduction of an R&D tax credit without further study. In general, tax credits seem to produce an input additionality of a little less than one, they involve little or no test of the validity of the projects undertaken and are subject to high levels of free-riding. Since they involve forgoing tax, they do not appear in the national accounts, but they cost money, nonetheless. It is possible to give credit against social taxes rather than corporation tax, thus allowing companies currently making little profit to benefit. In most respects, grant or subsidy systems are better: they can be focused, quality-tested and rationed. But for a grant or subsidy system to play the same role as a tax credit, it needs to have a bottom-up component. Detailed study of Norwegian firms' behaviour when doing projects based on the R&D tax incentive (Skattefunn) or with grants from the Research Council of Norway shows that tax-funded projects focus on maximising private returns; they generate internal learning but few spill-overs (Arnold, et al., 2019). It is important that they are bottom-up because at this stage the entrepreneur is wholly focused on internal goals. Grant-funded projects involve external actors like RTOs and other firms, so they have lower private returns but higher spill-overs, justifying the use of public money.

It is hard to make good policy in the absence of good data. This is important for R&D. Statistics Estonia collects R&D statistics and runs the Community Innovation Survey in Estonia[27]. Currently, companies are legally required to report R&D to Statistics Estonia but doing so brings no further benefit to them. About 250 Estonian companies claim to do R&D. However, it is believed that there are many others that do R&D, with about 25-30% of them actually cooperating with universities. Given the lack of reward for reporting and the often-chaotic behaviour of start-ups, they may be especially likely to fail to declare their R&D activities. Closing this data gap is an important precondition for improved R&I policymaking.

3.5 Innovation intermediaries

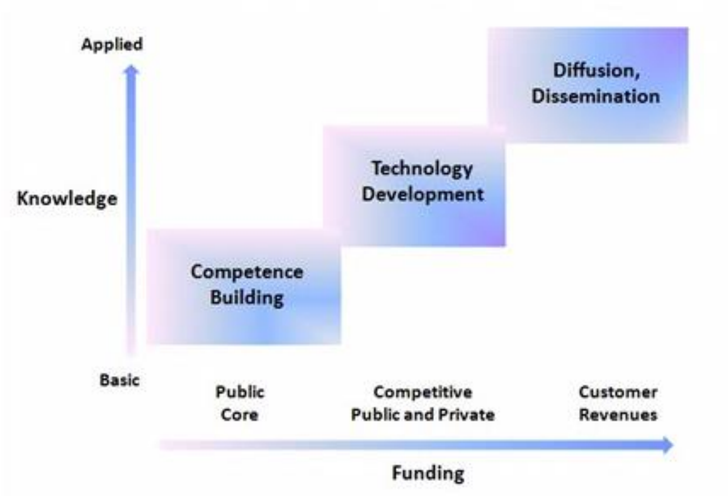
A crucial obstacle to improved innovation performance in Estonia is the lack of a system of 'intermediaries' to support innovation in companies.

Many countries have a system of research and technology organisations (RTOs) like Fraunhofer (DE), VTT (FI) or TNO (NL), which support industrial innovation. RTOs have a three-stage innovation funding model (Figure 9).

- They use core or institutional funding to develop knowledge and capabilities that are 'one step beyond' what industry can do
- They further develop that knowledge in doing advanced projects for – or, often, with – companies that have high absorptive capacity
- As the knowledge becomes routinised, they use it to provide services to both high- and low-capacity firms (Sörlin, et al., 2009)

[27] https://www.stat.ee/science-technology-innovation

Figure 9 RTOs' three-stage innovation dynamic and funding model



Source: European Association of RTOs (EARTO) http://www.earto.eu/about-rtos.html

Historically, many RTOs were set up with very high subsidy levels based on the idea that they should produce and transfer innovations to companies, in a context where many companies' technological capabilities were limited. As the technological capabilities of the business sector have grown, so the level of subsidy has declined. RTO practice has moved away from the idea that they should develop innovation on behalf of business and towards the principle of supporting company development by providing help with problems that were a little beyond their current technological capabilities (Rush, et al., 1996) (Sörlin, et al., 2009) (Arnold, et al., 2010). Today, in principle, the proportion of RTOs' income provided by the state as institutional funding determines the extent to which it can afford to do research at low TRL numbers as part of its competence building. In Scandinavian systems, the RTOs tend to get 15% or less in institutional funding while the 'continental' funding model used at VTT, TNO and Fraunhofer provides about one third. To some extent, RTOs can compensate for the limits their institutional funding puts on the amount of more fundamental research they can do by cooperating with universities.

Estonia has no RTO of its own and it may be the case that it lacks the scale to develop one. Certainly, an RTO dealing with multiple technologies in the style of VTT, TNO or Fraunhofer would be unaffordable, though creating one or two at sector level might be more feasible. The competence centres do not satisfy this need. They follow the 'Austrian' (shareholding) rather than the 'Swedish' (contractual) competence centre model, tending to make them rather closed organisations – and eventually undermining the 'public goods' argument for their existence. The government's policy of withdrawing core funding moves them further towards consultancy, so that they cannot duplicate the functions of an RTO.

An alternative would be to develop industrial extension services in some universities, combined with facilitating access to a foreign RTO such as VTT for bigger things. This would require appropriate changes in university governance, human resource and incentive systems. There appears to be no real industrial extension by the Estonian universities today. Many US universities (such as Georgia Tech) run such services. A good example that is close to hand is Riga University of Technology, which has an industrial extension activity (through what the Latvians call ‘competence centres’) that could be a model, at least for TalTech.

3.6 Demand-side policy

While most R&I policy focuses on the supply side, the innovation systems perspective also implies that the demand side is an important factor in national competitiveness. This perception has led to a resurgence of interest in demand-side innovation policies since the turn of this century[28].

Demand-side innovation policy is public action to induce innovation or speed up the diffusion of innovation through

- Increasing the demand for innovation (i.e. the willingness and ability to buy and use an innovation)
- Defining new functional requirements for products and services
- Improving user involvement in innovation production (Edler, 2013)

A widely used categorisation includes public procurement of innovation (PPI), regulation, standardisation, tax incentives, awareness-raising campaigns and systemic policies, namely lead market initiatives and support to user-centred innovation (Izsak & Edler, 2011). Of those smart regulations, smart standards and norms, or measures fostering private demand have so far been less used, although they have proven quite effective in specific areas, as in automotive emission standards (Romanainen, et al., 2014). In Europe, public procurement of innovation is the most widespread (European Commission, 2016).

Used strategically, public procurement for innovative products and services can boost innovation, improving productivity and inclusiveness (OECD, 2017). However, while academics and policymakers agree on the value of PPI, the instrument is used sparingly because it involves many institutional, technical, financial, political and administrative risks (Edler, et al., 2015), which civil service procurers are reluctant to take.

A recent refinement is functional procurement, where calls for tender relate to solving problems and providing functions, rather than presenting specific and technical descriptions of the products that are to be bought.

3.6.1 Public procurement in Estonia

Demand-side instruments are not widespread in Estonia (Lember, et al., 2014) but could already be found before 2014, mainly in the areas of energy saving and

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[28] The panel did not address standards and regulation because these are context-specific issues that need technical advice and are strongly influenced by decision-making in the large, manufacturing-orientated economies.

awareness raising. A lead-market project created the first nationwide electric car charging network in a country without electric car manufacture, expecting to attract producers for pilot demonstrations and to generate indirect benefits via linkages (Tsipouri, et al., 2013). In e-government, many of the key changes have been based on procurement. Otherwise, the Government's annual planning cycle with its four-year perspective favours short-term solutions and a supply-side approach to innovation policy. Attempts to use demand-side instruments in the smart specialisation areas have been ad hoc and successes have been serendipitous, rather than the result of a long-term strategy.

Following the ERAC review (Christensen, et al., 2012), the Estonian Government launched a study to identify appropriate demand-side measures and decide how they could best be integrated with supply-side measures into a policy-mix for the smart specialisation areas (Romanainen, et al., 2014). The government adapted its regulatory framework and earmarked a budget for PPI. Enterprise Estonia launched a €20m programme in 2016[29], though it has not been used as actively as had been hoped.

Estonian law provides for joint procurement but does not currently feature a comprehensive central procurement body except for IT goods and services. Estonia is frequently cited for its early and effective adoption of e-procurement. Some prerequisites for successful PPI are in place. However, only 4% of procurements were undertaken with restricted calls (1%) or negotiated calls (3%). The most substantial weakness to be addressed in Estonia is the lack of systematic risk assessment tools and procedures to support anti-corruption efforts. As the risk-reward nexus is among the major hurdles for expanding PPI, this seems to be the major missing ingredient (PWC, 2016).

The more specialised Country Fact Sheet on the Strategic Use of Innovation Procurement in the Digital Economy finds Estonia among the well-performing countries in implementing policy measures for innovation procurement. Estonia has started developing dedicated but small-scale measures while national guidelines promote an approach to IPR that fosters innovation in public procurement. However, Estonia still lacks an action plan covering all procurement and a spending target for innovation procurement. A measurement system is being set up but still lacks an impact evaluation dimension and there is no dedicated structured approach yet for capacity building.

The interviews conducted during our visits to Estonia suggested that there is commitment to PPI from the side of the administration but less awareness and enthusiasm among other stakeholders, who consider electronic procurement a pioneering and successful case but know less about PPI.

3.6.2 Future innovation procurement policies

We consider PPI the most appropriate and relevant demand-side innovation policy intervention for Estonia. Public procurement of innovation is one of the few ways

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[29] https://ec.europa.eu/digital-single-market/en/news/estonia-launches-financial-support-program-innovation-procurement

to leverage more funding for innovation policy without increasing public expenditure. Preparations for PPI are already in place.

The challenge for implementing PPI is to overcome the reluctance of civil service procurers to take risk. Countries that take PPI seriously show political commitment, invest in their institutional set up, capacity building, monitoring and guidance. Effective implementation calls for coordination and long-term planning, hence instruments can be explicit government plans for PPI, budget shares committed, benchmarks and monitoring mechanisms. Risk management is equally important but setting up explicit mechanisms to tackle it are rare. Sweden appears to be the country with the most visible example of political commitment and administrative maturity and experimentation.

Innovation procurement in Sweden

Sweden is among the countries that started early with innovation-enhancing policies, as described in one of the first efforts to mobilise PPI policies in the EU (Edquist, et al., 2000) and has been constantly pursuing it. Sweden is the only country where the government has developed a national strategy for public procurement where innovation procurement - actually meaning functional procurement - is central. The government took a decision on that strategy in June 2016. It is now in the process of being implemented. A new separate public agency for procurement support was created, with support to innovation-enhancing procurement as an important task: the National Agency for Public Procurement. A National Public Procurement Strategy was simultaneously being formulated in close collaboration with the Swedish National Innovation Council, chaired by the Prime Minister. The application of this new strategy has great potential to increase the resources that will be used to obtain products with a higher quality (innovations). This, in turn, could lead to better needs satisfaction and/or problem solving and lower costs in the long run. The main reason for this proposal is that its implementation would release enormous creativity and innovativeness among suppliers – and for the public sector - within a very large proportion of the economy as a whole (European Commission, 2017). This potential has, so far, been harvested to a very limited degree (Edquist, 2017). However, if the implementation process continues well, Sweden will be the first country to systematically use functional regular public procurement as an innovation policy instrument. As a result of these recent changes, functional public procurement may develop into the most important instrument in Swedish innovation policy.

Estonia's experience of a slow take-off, despite the measures adopted, should not be worrying. It is similar to experiences in other countries. The time is now right to take the next steps. Concrete recommendations in that respect (using good practices from Sweden, the Netherlands and the UK) include

- Establish political commitment by earmarking a share of procurement funds for PPI

- Establish a national entity offering support for public procurers to manage PPI projects[30]

- Establish an entity which evaluates and grants permission to label procurements as PPI. PPI has distinct features and needs different skills to traditional procurement, so it needs to be treated as part of innovation policy. International experience is that treating it as mainstream procurement is a cause of failure. This entity should also be responsible for data collection and monitoring PPI in Estonia

- Require all public authorities to establish ambitious long-term strategies and as part of them, their procurement strategy including PPI (and pre-commercial procurement). These strategies should also include a description of societal challenges relevant for them and what their key R&D and innovation needs are. These strategies could be evaluated as well as monitored by the entity responsible for labelling PPIs, thus providing ministries and the government with feedback and impact information for future policy decisions

3.7 Foreign Direct Investment (FDI)

3.7.1 The structure of FDI in Estonia

Estonia is an open and internationally networked economy with high volumes of both trade and inward investment. It is among the leading new Member States in FDI per capita, helping to integrate the Estonian economy into global value chains. Exports account for over 50% of the turnover of foreign-owned firms, which directly provide 38% of private sector jobs in Estonia and produce 41% of value added. FDI so far tends to integrate Estonia into the Nordic economy, with Estonian subsidiaries often outsourcing work from Scandinavian (especially Finnish and Swedish) parent companies.

Estonia is an attractive location for investment. It offers a (constitutionally protected) balanced budget, a free trade regime, a fully convertible currency, a competitive banking sector and an investment-favourable environment. Corporation tax is low compared to its Nordic neighbours, and all reinvested corporate profits are exempt. While social charges are fairly high, those in the Nordic countries tend to be higher.

Estonia has no exchange controls or restrictions on the amount of foreign capital that can be invested. Companies can be in full foreign ownership. Foreign companies enjoy equal rights with local ones and few areas require operating licences[31]. However, labour costs are increasing rapidly and the transition from a manufacturing- to a service-based economy is impeded by skills shortages. In

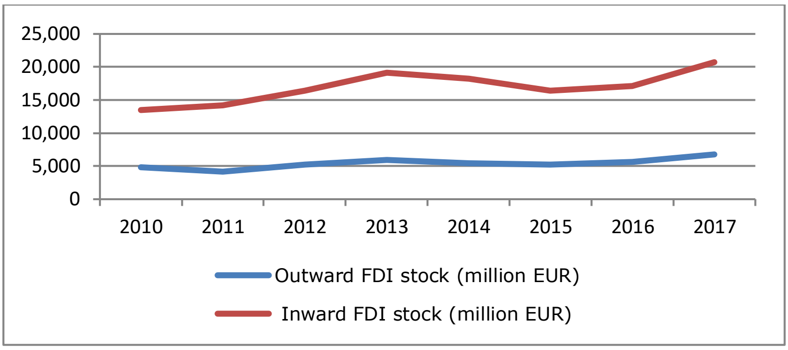
[30] See the Swedish experience https://www.upphandlingsmyndigheten.se/en
[31] Licences are needed only in mining, public utilities, railways, airports, ports and dams, long-distance telecommunications, retail sales of pharmaceuticals, production of alcohol and tobacco, gambling and banking. The basic rules for licensing are included in the Regulation of the Estonian Government from May 8, 1990, on Issuing Statutory Activity Licences.

the medium term, the country will no longer be able to offer cheap production outsourcing, one of the key strategies behind Estonia´s success story.

Estonia is one of the more export-orientated countries in the OECD, with 44% of its domestic value-added meeting foreign final demand. The top manufacturing export industries in Estonia are computers and electronics products, wood and wood products, and food products. The computer and electronics industries are deeply integrated into global value chains as measured by the import content of exports (57%), and a high share (90%) of value-added is produced by foreign-owned firms. Estonia also has a high services content in its exports at 62%

In small countries like Estonia, individual foreign investments can comprise large parts of the total, making statistics volatile. FDI in Estonia averaged €95m from 1993 until 2018, reaching an all-time high of €1,058m in the second quarter of 2005 and a record low of -€437m in the second quarter of 2015. In 2017, the net inflow of direct investment was EUR 784 Million (-15% compared to 2016). Estimated at US$23bn , the total stock of FDI is equal to 99% of the country's GDP[32].

Figure 10 Inward and outward FDI stock in Estonia 2010-2017, €m



Source: OECD Economy data - FDI stock. USD converted to EUR based on the European Central Bank Euro foreign exchange reference rates (2018.10.18)

Inward FDI flow is dominated by Estonia´s EU neighbours. Sweden is the largest (33% of direct investment) through the ownership of Estonia's largest banks and various telecommunications investments. Finland is in second place (24%), with investments going into banking as well as into manufacturing and woodworking. The remaining foreign investments are distributed among many European countries (Norway, the UK, Germany, Cyprus, the Netherlands, Luxembourg) and the USA.

While most partner countries supply Estonian consumers mainly through trade, Finnish firms do so more through sales by affiliates based in Estonia. The USA and UK are becoming bigger partners than Latvia, which was previously Estonia’s

[32] UNCTAD 2018 World Investment Report

biggest trading partner, because of their more extensive investment links with Estonia.

Table 3 summarises the strengths and weaknesses of Estonia's inward FDI.

Table 3 Strengths and weaknesses of Estonian FDI

Strengths	Weaknesses
• Public accounts at equilibrium with very low indebtedness • A very favourable business environment enriched by independent and stable institutions • All reinvested company profits are exempt from corporation tax • A geographical position at the crossroads of Europe and Russia • Effective international relations strengthened by EU • A highly skilled, multilingual educated and comparatively cheap workforce	• The small size of its domestic market makes it particularly sensitive to external shocks • Geopolitical position • High dependence on its imports from Finland and Sweden • Lower purchasing power than in other countries in the region, especially the Nordic states • Very unstable flow of FDI into the country

3.7.2 The role of Enterprise Estonia

Enterprise Estonia's Estonian Investment Agency promotes inward FDI, contains 30-40 of the agency's 266 employees and is primarily funded from European Structural Funds. Enterprise Estonia's total budget for 2018 was increased to €215m (+ 7%). €54m was assigned to export promotion, €8.3m[33] to FDI attraction, €11m to the tourism sector, and €133m to regional development projects. Enterprise Estonia has representative offices in Helsinki, Stockholm, Oslo, Copenhagen, Hamburg, Amsterdam, London, Paris, Kiev, Astana, Dubai, New Delhi, Beijing, Tokyo, Singapore and the Silicon Valley. These serve the organisation as a whole and are not specialised in FDI.

The Estonian Investment Agency (Invest in Estonia) aims to bring €1.5bn worth of foreign investments into Estonia over the next five years, which will hopefully create over 5000 high added-value jobs. In line with Enterprise Estonia's overall strategy, the Agency does not focus on attracting R&D in connection with FDI.

Given the national importance of attracting larger FDI projects, Enterprise Estonia's €5m FDI promotion budget (and its Invest in Estonia unit) is insufficient to cover the entire spectrum of national key sectors and target countries. A more strategic approach is required to identify FDI leads, taking account of the Smart

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[33] This compares to an OECD average of US $12m for equivalent functions, according to Enterprise Estonia https://news.err.ee/652207/enterprise-estonia-s-2018-budget-increased-to-215-million

Specialisation priorities and the need to attract R&D activity. Trade fairs should be approached strategically, to generate focused discussions, and Enterprise Estonia should work together with national clusters and industry associations across relevant sectors. Local multipliers are usually among the best FDI attraction ambassadors and sectoral experts one can find for their own business ecosystems.

A key element in host-country packages aimed at attracting FDI is an offer to help train the local workforce and to facilitate access to higher-level skills and research. Enterprise Estonia needs to maintain close links with the providers of both vocational and higher education in order to do this.

3.7.3 Opportunities to use FDI for learning

MNC investment tends to bring knowledge and skill spillovers. With or without local support, MNCs need to train or recruit a workforce with internationally competitive skills and thus often function as 'training schools' for people who later establish their own businesses. Typically, MNCs bring knowledge such as technology, generating technological spillovers.

Individual MNC plant have to compete with those in other countries, in order to get good access to capital and often to win important new activity. Inter-plant competition provides an incentive for local MNC managers to cooperate with the national 'knowledge infrastructure' of universities, colleges and institutes, in order to improve their internal competitiveness. Sometimes this can involve R&D; sometimes it involves education and knowledge transfer. In certain cases, it is done 'under the radar', using local budgets invisible to the headquarters, and in these cases, it may involve unglamorous subjects such as logistics or plant efficiency.

Estonia appears to have no policies that exploit its considerable volume of FDI to accelerate beyond the natural rate of learning. Policy opportunities include

- Offering incentives to new investors in relevant sectors to commit to doing a small amount of intramural R&D locally or to spend an equivalent amount in the national research system

- Providing training support to selected MNCs as part of a tailored offer so that they effectively train more people than they need, allowing a higher rate of human capital spillover into the local economy than would naturally occur

- Where relevant, organising supply-chain development programmes for both new and existing FDI investors, increasing the attractiveness of sourcing inputs within Estonia rather than from abroad

- Developing local STEM talent for FDI purposes through public-private educational programmes

Despite the current high production of STEM graduates, closing the gap between the human capital supply and private sector demand for STEM and IT skillsets should be a priority also from an FDI attraction point of view. Designing and launching educational programmes in cooperation with local and foreign universities, the government, and companies to improve the available curricula according to the market's necessities would be a successful strategy for Estonia if properly structured. The country's size should not be perceived as an unsurmountable impediment; other smaller countries such as Costa Rica have successfully recently adopted such path. CINDE – Invest in Costa Rica, proactively helped Texas Tech University in 2018 to launch an educational engineering programme and a local Costa Rican campus, while supporting the development of additional joint programmes in partnership with other US and Canadian Universities.

Reaching out to relevant tech-driven corporations to develop local academic and professional training programs, would be likely to generate tangible results if politically sustained. The tendency to adopt such practices is growing in the international FDI attraction arena. A particularly relevant recent case of public-private educational programme partnership took place in 2016, when Apple, in cooperation with the municipality of Naples and the Campania Region, launched an academy for software developers which was accompanied by Apple's expansion in the region. The academy teaches over 300 students how to design apps and launch them on Apple devices, while also serving as catalyst for the development of a local app development ecosystem and providing a solid FDI attraction asset. Apple has launched similar programmes in Brazil, India and Indonesia in the past five years.

3.7.4 Other issues in FDI policy

A number of other issues are evident in Estonian FDI policy.

- A key systemic problem is that FDI policy is not well linked to the Smart Specialisation priorities; nor does it have any focus on R&D

- Currently, national statistics on FDI are of insufficient quality and should be more centralised. The Bank of Estonia and others involved do not interact sufficiently and data are not adequately harmonised. It is therefore hard to monitor the effects of each investment, undermining the ability to develop an evidence-based FDI strategy or to create more targeted incentives for foreign investors. The impacts that FDI can have on communities should also be considered: there can be negative as well as positive externalities. In general, it is better to attract operations which enrich the ecosystem with sustainable, larger and structured companies that do not exclusively look for highly skilled workers or for cheap labour, while aiming to develop clusters and supply chains for the entire country

- Particularly because of Estonia's unique geopolitical position and size, government should develop an FDI screening process to evaluate the risks and benefits of individual investments for the national security and economic ecosystem, not only for military, energy-related or infrastructural investment.

The European Commission is currently in the process of developing a harmonised process for this across all Member States[34]

- Administration of incentives and tax breaks needs to be predictable, quick and efficient. The need on one occasion to obtain large repayments from Ericsson owing to administrative error has negatively affected Estonia's reputation in FDI

- Over time, FDI spending should be funded using national money, both to increase the continuity of funding and to simplify the rules governing administration

3.8 Start-ups and knowledge exchange

3.8.1 The start-up ecosystem

The government established Startup Estonia in 2011, aiming to create an 'ecosystem' by networking start-ups and those who could help them, increasing the availability of investment by educating local investors and attracting foreign ones and working with government to reduce regulatory barriers to start-up and growth, for example via the 'Startup visa'. Startup Estonia currently has a total budget of €7m from the European Regional Development Fund to cover the period up to 2023. Enterprise Estonia additionally provides Start-up Grants.

KredEx (a financial institution owned by the government and a group of Estonian banks) together with the Latvian financial institution ALTUM, Lithuania-based Invega, and the European Innovation Fund, cooperatively run and manage the Baltic Innovation Fund (BIF). This entity is the largest fund-of-funds investment initiative to date in the Baltics, from which start-ups in particular ultimately benefit. The first phase of the BIF stopped at the end of 2017. However, national and supranational agreement were recently renewed to launch a BIF II in not-too-distant future. The structural set-up of the new BIF largely resembles that of its predecessor, with funding volumes somewhat changed compared to BIF I (€26m from the state, €78m EIF, and €350m private capital)[35]. Another funds-of-funds organisation is EstFund, which is cooperatively coordinated by the Republic of Estonia, KredEx and the EIF, aiming to support VC funds offering equity funding from seed to growth for Estonian SMEs[36].

The start-up ecosystem in Estonia is one of the success stories of the country with scale-ups and even four unicorns[37] (a very rare case in very small countries) which generate profits, high-tech employment and exports. The success stories have created a favourable climate, with young people being inspired to set up their own new ventures. Successful entrepreneurs are a driving force: they have

[34] http://trade.ec.europa.eu/doclib/press/index.cfm?id=1953

[35] The Baltic Course (2019): Estonia to invest EUR 26 mln in Baltic Innovation Fund II. Available at: http://www.baltic-course.com/eng/good_for_business/?doc=147284

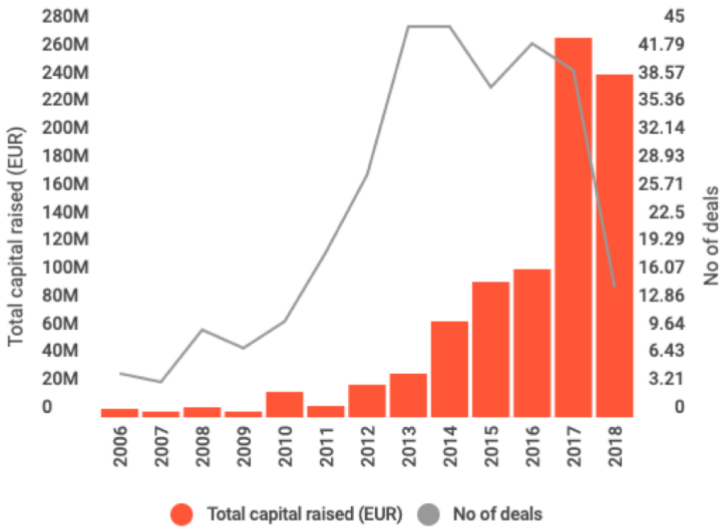
[36] EIF (2018): EIF and EstFund committed EUR 60 million for investments into Estonian SMEs. Available at: http://www.eif.org/what_we_do/equity/news/2018/eif-kredex-eur-60m-estfund.htm

[37] Skype (messaging software) Playtech (gambling software), Bolt (Taxify) (ride-hailing), and TransferWise (money transfer) – all software-centric

created a model; they are forming alliances between themselves; and they act as mentors to new start-ups. However, the ecosystem remains a small share of the overall economy, where the sectoral composition remains more traditional.

The Estonian economy currently hosts about 550 start-ups, which collectively have 3,783 employees in Estonia and more than 5,000 employees worldwide. Their turnover was €275m in 2017 and just short of €300m in 2018. Nearly all the start-ups were started by graduates, but not usually in the in the field that they studied or researched[38]. Figure 11 shows the steep increase in the amount of investment in recent years and also the number of deals involved, indicating that investment is being focused on a smaller number of larger deals than before – reflecting some maturation of both the supply and the demand side.

Figure 11 Capital Raised by Estonian Start-ups (in €m) and Number of Deals Involved



Source: Startup Estonia

[38] Startup Estonia (2018). 2018 has started with a bang for Estonian startup sector. Available at: https://www.startupestonia.ee/blog/2018-has-started-with-a-bang-for-estonian-startup-sector

Figure 12 shows the Top-ten Estonian start-ups. Notably, eight of the ten are software-based; only two are hardware-based.

Figure 12 Top-ten Estonian start-ups, ranked by number of employees 2018

Rank	Company	Product(s)
1	Transferwise	Internet-based international money transfers
2	Pipedrive	Customer Relationship Management software and hosting
3	Bolt (formerly Taxify)	Ride/taxi hailing application and service
4	Sarship Technologies	Small, self-driving robotic delivery vehicles
5	Monese	Mobile phone-based international current account banking
6	Creative mobile	Game developer
7	Veriff	Online identity verification software
8	Rideango	Transit system ticketing and real-time information system
9	Scoro	Project management software and hosting
10	Skeleton Technologies	Ultracapacitors

Source: Startup Estonia

Government support measures – primarily Startup Estonia and Kredex – to promote start-ups appear to have paid dividends. So far, there appears to be little activity at the level of individual clusters or branches. Enterprise Estonia's cluster programme works with traditional aspects of cluster support rather than having any focus on start-ups. The Tartu Science Park, Taltech's Teknopol and the Pakri Science and Industrial Park (which is 51%-owned by Finnish Technopolis, has links to Teknopol and is still partly under construction) again provide general-purpose facilities rather than having a sectoral focus and there seems little sign of new industrial districts spontaneously emerging in which start-ups would naturally cluster.

The cluster network (organic cluster as oppose to a managed cluster) is not an uncommon way in which innovation thrives and has worked successfully in other regions across Europe and the world too. Examples are Cambridge cluster in the UK or the Utah cluster (USA). It should be seen as an important element and should be fostered and promoted as far as possible, while recognising that such clusters are rarely policy-driven but tend more often to occur spontaneously.

The universities could support local ecosystems more than they currently do by further stimulating interactions between themselves and industry. This could be via the provision of incubator spaces, of which we saw some evidence, and access to equipment by-the-hour to make access to equipment and the people needed to operate them affordable.

3.8.2 Universities and Knowledge Exchange

Internationally, some universities had industrial liaison offices already several decades ago. After the Bayh-Dole Act was passed in the USA in 1980 (transferring intellectual property rights for federally-funded inventions from the government to the research-performing institutions), laws have been passed in many countries abolishing 'professor's privilege' and universities worldwide have been setting up technology transfer offices (TTOs), focused on patenting inventions and exploiting them through licensing or spin-offs. In practice, only a few big and famous universities make substantial amounts of money from this activity, and most earn less than the cost of running the TTO. A useful side-effect has been the improvement of laboratory practice and record-keeping. A less helpful effect has been reluctance by some companies to do joint research for fear of losing intellectual property to the university.

In more recent times, thinking has shifted from technology transfer towards a broader concept of 'knowledge exchange' with society (not just industry) comprising: collaborative research; consultancy and contract research; mobility schemes; training and continuing professional development; licensing inventions; and outreach activities, aiming to educate the public and specialist audiences about research results of potential use to them. Among other benefits, this allows the university to trade off different dimensions of knowledge exchange, often in practice prioritising the ability to do collaborative research over potential income from patents and licensing.

Based on our interviews in Estonia, knowledge exchange appeared not to be considered as particularly important by Estonian university leadership teams. Successful university inventors felt that the TTO added little value and were very likely to circumvent it. The TTOs themselves appeared to feel under-used and under-valued.

Estonian universities' knowledge exchange activities appear decentralised and often not to be managed as a whole. TTOs focus on the classic patenting and exploitation functions. Most seemed to leave academics to decide for themselves how they should approach knowledge exchange, rather than educating researchers and implementing proactive processes for routine disclosure of inventions and identification of commercial potential. Some universities do run competitions to unearth ideas from researchers and this should be encouraged. TTOs were taking out patents and looking for licensing opportunities but did little beyond this. Nor was there much sign of outreach at the regional or cluster level.

The TTOs have poor visibility of the intellectual property (IP) that is latent in their organisation. Tartu University indicated that it has about 14 disclosures a year, with about 50% of them being commercialised. This success rate is far too high. It suggests that the university is only 'skimming the cream' and is missing a large number of other opportunities. A success rate of 5 to 10% would be more typical, internationally.

The universities that had an IP exploitation policy acknowledged that the amount of times it had been used was limited. The TTOs were small and relied upon academics taking the initiative in disclosing inventions. In practice, more commercially promising ideas were patented and exploited via academics' private companies. TTOs generally lacked the scale and skills to have a detailed understanding of markets and technologies and depended upon the academics to guide them. There is a severe shortage of funds for the first exploitation steps, i.e. the evaluation of IP, its usefulness to industry and the route to market. This inhibits IP exploitation.

The universities can take equity in spinouts, but do not appear to do so systematically and the amount equity taken varies. The university share in a spin-out needs to take account of market realities such as its potential value to investors. It can nonetheless be useful to have a default value and then to depart upwards or downwards from that according to the specific circumstances.

Part of the problem of the Estonian universities is scale. Internationally, few universities make a successful business of technology transfer; those that do are large, established and globally well known. Given the low inherent profitability of pure TTO operations, especially in a small country with a limited portfolio of exploitable inventions, Estonia should refocus on broader knowledge exchange to achieve societal impact, monitoring that through KPIs linked to the knowledge exchange activities rather than to fees or trying to make a TT office self-financing. It should be made clear what value a TTO should bring to a university. This value is linked to its experience in market evaluation, IP, connection to industry etc, building on competent TTO staff and allowing the academic to be free to concentrate on research. Where it is possible for the TTO to exploit intellectual property, it is important to take a generous approach to rewarding the academic inventors. However, the TTO also needs to consider alternative rewards such as obtaining increased research funding rather than pursuing intellectual property rights.

A 'light touch' approach, such as an Open Access IP policy, could be considered. In this approach, IP is licensed for nominal amounts, with the requirement that it is used by the company and that its results are reported; otherwise, the IP returns to the university for others to use.

Some thought should be given to utilising the Alumni networks, entrepreneurs and industry people in teaching positions (for example, via adjunct professorships) to foster better interactions between the academic and industrial communities. This could include encouraging industrial placements and industry-focused student projects, as well as career training to keep work skills current. It would also be useful to foster links with relevant trade associations and industrial clusters to provide knowledge about technological needs and exploitation opportunities.

Several companies reported that it is difficult to work with more than one university because they have different arrangements for working with industry, different licence rates, etc. This, together with the scale problems identified above, suggests that it could be useful to set up a common TTO function across multiple universities, building scale and increasing professionalisation, as has been done at the regional level in France.

3.8.3 Intellectual property rights (IPR)

The TTO should not only consider licensing and spin-outs but also look at the wider forms of protection that are available to them. It is by protecting the knowledge of the institution and then making it available to industry that the university can help support it. To do this the TTO needs to make sure that all forms of IP are captured and protected. This requires all university staff to have a good basic understanding of the different forms of IPR available i.e. design rights, copyright, trademarks, patenting etc. and how they apply to the work that they undertake. This will allow cost-effective protection to be obtained and reduce the minimal licencing fees that the university will seek from the industrial sector.

3.8.4 Options for improvement

It is central to the idea of a TTO, especially in a small country where the portfolio of opportunities will be limited, to work on the principle that the main purpose is socio-economic impact, not a rather vain hope to make money for the university.

- The TTOs could create a network to exchange experience and good practice, document and communicate success stories, create standard IP agreements (as the UK has done with the 'Lambert agreements')
- Grant support could be helpful, both to the TTOs themselves to add depth to TTO offices and to support a lightweight Proof of Concept grant scheme to fund initial steps with industry
- The universities could mainstream IP and commercialisation by introducing IP modules into science education, Entrepreneur in Residence and Fellowship schemes, or a scheme like the UK Royal College of Arts / Imperial College scheme, where as part of a final dissertation small teams scout out projects and write business plans
- A national competition with Ministry visibility could be run that showcases good technology transfer, which will help in developing and sharing best practice

3.9 Findings and policy implications

Findings	Policy implications
Estonia is in danger of falling into the 'middle income trap' where the initial benefits of industrial modernisation have been taken but greater comparative advantages have to be built in order to sustain further development. A symptom is the stagnation of total factor productivity (TFP)	Further modernise the economy through (1) fostering structural change towards newer, higher-productivity sectors and (2) improving the productivity of old and new sectors through product and process innovation, including automation
GERD and BERD stagnating as a percentage of GDP	Maintain government commitment to raise its own spending on R&D to 1% of GDP by coordinating spending plans across ministries and ensuring consistency between national strategies and implementation Increase spending programmes that support BERD. Some should focus on the societal challenges prioritised at the national level as well as the Smart Specialisation priorities. Seek FDI that has an R&D component
Industry structure overly dominated by small firms that do little R&D. Overall, industry's absorptive capacity is weak	Introduce and strengthen a portfolio of R&I programmes to build absorptive capacity and thereby enable a higher rate of innovation. These should address all levels of absorptive capacity Consider the opportunities to fill this gap, e.g. through grant-based human capital placement schemes and bottom-up, grants-based activation programmes These may be supplemented by measures aiming to build capacity in line with national objectives, for example through the Smart Specialisation strategy. Require state-owned companies to do a certain minimum amount of R&D (or to outsource R&D to an equivalent value)
There is no dedicated innovation agency in Estonia, handling R&D-based innovation, and this is not strongly prioritised by MEAC. Hence, MER reaches beyond its 'natural' research remit to industrial innovation and there is little expertise in technological innovation at the level of an agency	Extend Enterprise Estonia's mission and skill set into R&D-based innovation Transfer responsibility for innovation programmes from the Estonian Research Council to Enterprise Estonia
Estonia lacks an open system of 'innovation intermediaries' to support industrial innovation	Strengthen university role in industrial extension. Consider creating arrangements to 'retail' services from international RTOs, where these are not available in Estonia or universities are unwilling to supply them
FDI focuses in parts of the economy where it provides capital but limited learning for the Estonian innovation system	Refocus some FDI promotion effort on high-productivity sectors where Estonia can benefit from imported technology and experience Strengthen FDI offer by integrating training of the workforce, establishing links with the research-

	performing sector and running supply-chain development activities for incoming and existing MNC plant in Estonia
Potential learning benefits of FDI are insufficiently exploited	Focus some of the innovation policy effort on strengthening the ability of the Estonian plant to win internal competitions for activity, especially R&D Establish measures that support the MNCs in 'over-training' compared with their own needs, in order to accelerate human capital spill-overs Increase scale, capacity and strategic focus of FDI promotion at Enterprise Estonia
The Estonian technology-based start-up ecosystem is well supported and productive but over-focuses on software-based industries with low entry and exit barriers	Continue to develop science and innovation parks and broad university TTO functions focusing on societal impact rather than patenting
Universities' knowledge exchange activities over-focus on the TTO function, which is itself under-developed and under-critical, rather than focusing on knowledge exchange more broadly	Consider creating a single, national TTO (based in Tallinn and Tartu) Mainstream more comprehensive and proactive processes for disclosing inventions in universities Refocus activities on industrial liaison, collaborative research and science communications, while supporting the common TTO Increase the importance of knowledge exchange in the performance-based research funding system
Framework conditions are largely friendly to business but undermined by skill shortages	Adapt funding policies to incentivise university (and schools) teaching and research in areas of skill shortage Improve conditions for foreign researchers, to attract more into the country, while taking care to avoid creating a two-tier labour market
Demand-side measures are an important gap in the innovation policy repertoire	Establish or extend an existing entity with innovation policy skills in order to offer support for public procurers to manage PPI projects
R&D data are of poor quality and reliability	Review the incentives for companies to report

4 HIGHER EDUCATION AND RESEARCH

This chapter looks at the performance of the higher education system, especially in terms of research, graduates and life-long learning (LLL). It considers university governance and opportunities for strategy and performance improvement. It ends with a summary of findings and recommendations.

Knowledge exchange issues are tackled above, in Section 3.8.2.

4.1 Performance of the research and higher education system

4.1.1 Structural aspects

The Estonian university sector – in the sense of higher education institutions entitled to award degrees at bachelors, masters and doctoral levels – comprises seven universities (Table 4). Of these, three large universities (Tallinn University, Tartu University and the Tallinn University of Technology, TalTech) teach a wide range of subjects. A further three are specialised respectively in Arts, Music and Life Sciences. The Estonian Business School is privately-owned. All the universities (including the business school) are currently entitled to receive institutional funding for research because they have been approved in the seven-yearly accreditation process, which is based on international peer review. In 2018/9, the six public universities were teaching 35,353 of the 45,815 students registered in the higher education system. The private Estonian Business School was teaching a further 1,500 or so.

The middle column of Table 4 shows the other accredited higher education institutions, which provide professional and vocational training but do not award degrees at all three levels. Finally, the right-hand column shows the public and private research institutions currently competing for institutional funding for research, following their accreditation in the seven-yearly peer review process.

Because the institutes of the Estonian Academy of Sciences were largely merged into the universities in the mid-1990s, Estonia's public research institute system is small. It includes two big institutes: the National Institute of Chemical Physics and Biophysics, and the Estonian Crop Research Institute, plus the Literary Museum, Under and TUglas Centre, Estonian Language Institute, National Institute for Health Development and Estonian National Museum. The National Institute of Chemical Physics and Biophysics is a public research organisation; the others are state-owned institutes.

In addition, there is a small private research institute sector, with six organisations having qualified to receive institutional funding from MER (Table 4). This includes four of the national technology competence centres in food and fermentation technologies, dairy products, software, and health technologies. Cybernetica was set up in 1997 as the private-sector successor to the Academy's Institute of Cybernetics. The Protobios biotechnology company does substantial and sometimes fundamental academic research alongside providing products and services.

Table 4 Accredited Estonian Universities, Higher Education Institutions and R&D organisations

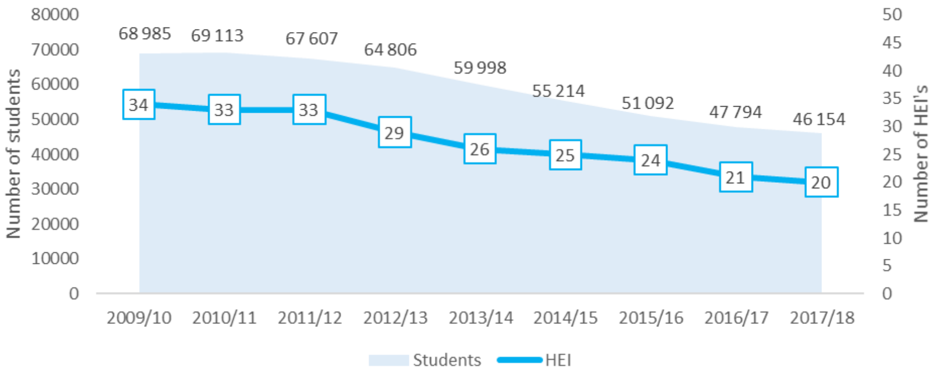
Universities	Other Higher Education Institutions	Research Institutions Receiving State Institutional Funding
Public		
University of Tartu	Estonian Aviation Academy	National Institute of Chemical Physics and Biophysics
Tallinn University	Estonian National defence College	Estonian National Museum
Tallinn University of Technology (Talltech)	Lääne-Viru College	Estonian Literary Museum
Estonian Academy of Arts	Estonian Academy of Security Sciences	Estonian Crop Research Institute
Estonian Academy of Music and Theatre	TTK University of Applied Sciences	National Institute for Health Development
Estonian University of Life Sciences	Tallinn Health Care College	Under and Tuglas Literature Centre
	Pallas University of Applied Sciences	Institute of the Estonian Language
	Tartu Health Care College	
Private		
Estonian Business School	Institute of Theology of the Estonian Evangelical Lutheran Church	Competence Centre of Food and Fermentation Technologies
	Estonian Methodist Theological Seminary	Bio-competence Centre of Healthy Dairy Products LLC
	Estonian Entrepreneurship University for Applied Science	STACC (machine learning and data science competence centre)
	Tartu Theological Seminary	Competence Centre on Health Technologies
		Cybernetica AS
		Protobios LLC

There are six national technology competence centres in total. These include ELIKO, which is now an embedded electronics and software company and the Innovative Manufacturing Systems Competence Centre (IMEC) as well as the four listed in Table 4.

There are nine inter-university centres of research excellence receiving substantial research funding from structural funds. Five university-based, regional technology competence centres work with companies to do R&D supporting innovation. These are in: small crafts; oil shale; health promotion and rehabilitation; knowledge-based health goods; and wood processing and furniture manufacturing.

As in the other Baltic states, the number of research and higher education organisations grew after the liberation, leading to fragmentation, and has since been rationalised through institutional mergers, partly driven by the performance-based funding system. The number of organisations in the higher education system in Estonia grew rapidly after independence to 49 institutions in 2005 but has since been shrinking(Figure 13, owing to declining population, demographic factors and the effects of performance-based funding. Many of the public vocational university colleges have been taken over by more comprehensive universities while some of the private-sector institutions have failed.

Figure 13 Number of students and higher educational institutions in Estonia

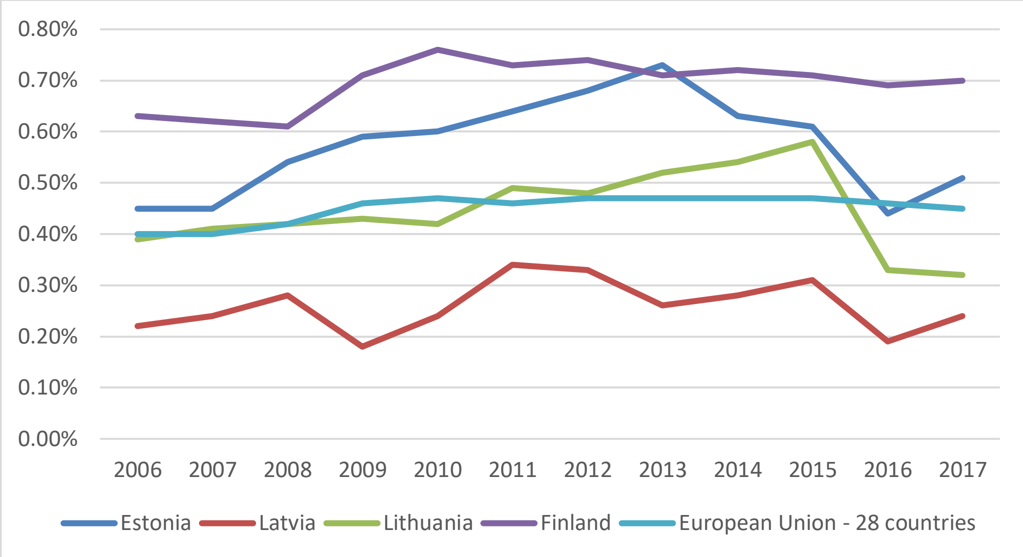


Source: HaridusSilm

In 2018, funding for higher education from the state budget was frozen for the third consecutive year. In 2018, €195.5m was allocated from the state budget to higher education, compared with €192m in 2017 and €193m in 2016.

Total state expenditure on R&D in higher education has been falling in recent years, from a peak in 2013 – a decline to a lesser extent shared with Estonia's Baltic neighbours (Figure 14).

Figure 14 Gross Domestic Expenditure on R&D in the HE Sector, 2007-2017



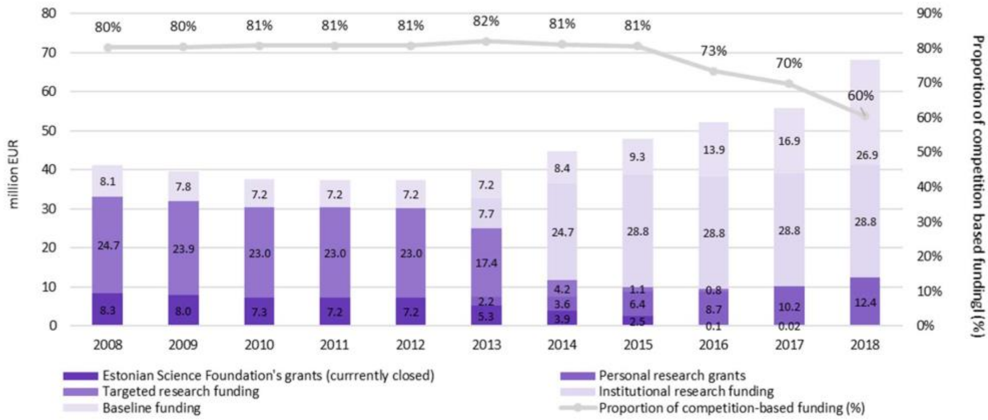
Source: Eurostat (table code: t2020_20)

Since joining the European Union in 2004, Estonia has spent more than €1bn of EU funds on capital investments and operating costs of research. Of that amount, some €384m has been committed during the 2014-2020 Structural Funds period, which is now drawing to a close. While structural funding will continue after that date, it may not be safe to assume that this will continue at the same level. The philosophy of the Structural Funds is that these are resources for restructuring and starting new things; they are not intended to be permanent. Estonia needs in any case to plan to replace them with national money in the medium term.

Figure 15 shows the development of research funding since 2008. During this period, the Estonian Research Council has phased out its earlier funding instruments (personal and institutional research grants, targeted grants and the baseline funding of institutions) and simplified the system by replacing them with two instruments: institutional funding and research grants. The amount of institutional research funding has increased, driving the total research spend by the Council upwards and reducing the earlier extreme degree of competition in the funding system.

Between 1996 and 2005, there was no institutional funding for research in the universities. Such institutional funding was introduced in 2005 but was allocated by the Estonian Research Council based wholly on the basis of past performance. Figure 15 shows how the proportion of competitive funding for research has been brought down from over 80% to about 60% in the last few years, bringing Estonian practice closer to wider European norms.

Figure 15 The volume of competition-based funding (personal and institutional research funding, targeted research funding, Estonian Science Foundation's grants) and baseline funding of research institutions in the period from 2008 to 2018 (€m).



Source: Estonian Research Council, Estonian Research 2019

4.1.2 Vocational education and training (VET) and Life-long learning (LLL)

Estonian school education splits after Year 9, with over 70% of students progressing to gymnasia and 26% (typically, those with the lowest grades) going to vocational schools. About 9% of vocational school graduates go on to higher education, normally to the institutions listed as Other Higher Education Institutions in Table 4. The vocational schools are said to have a poor reputation with employers, even though their curricula are closely based on interaction with industry[39]. Over 80% of recent VET school graduates are in employment in Estonia, with two thirds of these working in a field related to their studies (European Commission, 2018). Nonetheless, some vocational school graduates find they can get better pay abroad for low-skilled jobs, creating shortages in the Estonian labour market. There is a particular shortage of construction skills.

Estonia is currently implementing a LLL strategy for the period 2014-20, which was launched in part because "There is a considerable difference between what is offered by the education system and what the labour market needs."[40] To a considerable extent, it focuses on VET at the level of the secondary schools. It includes a goal for the regular survey of the working population to show that 20% of the working population have received some form of training in the most recent 4 weeks. This compares with an actual value of 13% when the strategy was devised and the EU's target of 15%. The strategy triggered the creation of The Estonian Qualifications Authority's 'OSKA' labour market survey in 2015 to plan and forecast labour market needs. A national qualification framework has been put in place, the number of state-owned VET providers has been rationalised from 54 in 2001/2 to 26 in 2017/8 and there have been many smaller reforms at the

[39] Source: MER
[40] Ministry of Education and Research, The Estonian Lifelong Learning Strategy, Tallinn: MER, 2014

level of VET education. The European Centre for the Development of Vocation Training (CEDEFOP) review of progress is very positive[41].

International good practice is moving in the direction of more extensive LLL offerings, designed in close cooperation with employers. The larger universities are largely taking their own initiatives in wider LLL. TalTech, Tallinn and Tartu Universities as well as the Estonian Business School have all established open learning activities, which in effect sell access to individual university courses to people who are not registered as students with the university. Unlike interventions at the VET level, these initiatives are not coordinated nationally.

4.1.3 Performance-based institutional funding

Estonia was the first of the Central-Eastern European countries to merge of the Academy of Sciences' research institutes into universities (with four exceptions). At the same time, the Estonian Research Council (ETAG) was established to provide competitive research funds. That Council operates according to the good practices of modern research funding organisations, requiring applications to be written in English and using international experts for peer review.

The Estonian performance-based research funding system has two components – both managed by ETAG – and applies to any research-performing organisation, not only to universities.

- A "Regular evaluation" process based on peer review, in which success entitles an organisation to compete for both performance-based institutional funding for research and for competitive calls at the Estonian Research Council (ETAG)

- An annual, metrics-based research assessment, which determines the level of performance-based institutional funding paid. In parallel, institutions benefit from the projects they are able to win in ETAG's competitions

In general, competition boosts quality but the ratio between external and institutional research funding has in the past been too high and created an overly competitive system. This undermines the universities' sustainability and prevents them from developing long-term strategies, within which they can anchor measures and funding decisions. Average institutional funding for research in the public universities was 12.4% of total research income in 2017 and 17.8% in 2018, whereas in European countries with mature research systems it tends to be in the range 50-80%.

4.1.4 Performance

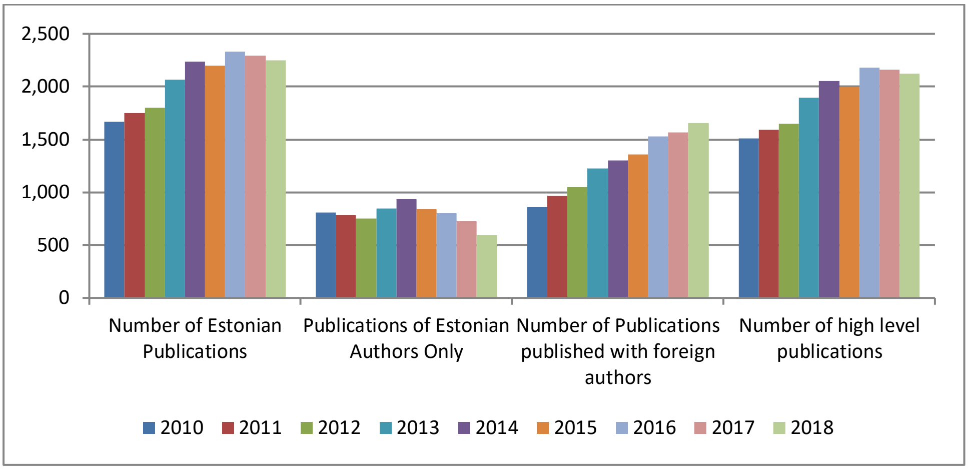
The challenges for the Estonian funding system of academic research include achieving an adequate level of public spending on R&D, replacing the structural funds over time with national money, and increasing the share of baseline funding

[41] CEDEFOP, Developments in vocational education and training policy in 2015–17: Estonia, CEDEFOP 2019

of research in public universities to around 50%, which is still at the lower end of the range typically found in European countries.

Figure 16 gives an impression of the development of Estonian scientific research in recent years, indicating that the number of scientific papers has grown but then tailed off a little as R&D funding has fallen. As elsewhere, Estonian authors are increasingly publishing together with international partners, reinforcing the impression that Estonian science is increasingly embedded in international research.

Figure 16 Publications in Estonia (total, Estonian author only, co-published with foreign authors and high-level publications)



Source: Haridussilm

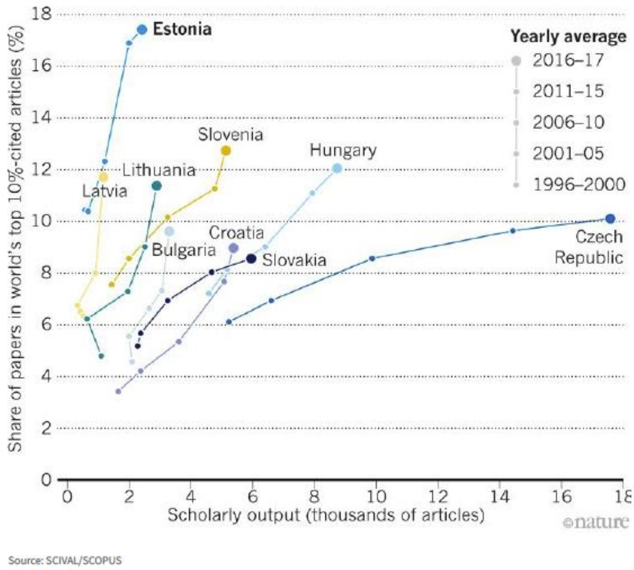
Note: Estonian authors are considered to be those with an institutional address in Estonia. "High-level" publications are those indexed in the Web of Science

The quality of Estonian research has risen remarkably in the period 2007-2017, though the bibliometric evidence from different sources is somewhat contradictory. Based on the SCIMAGO (SCOPUS) Journal Rank Indicator, the OECD places the proportion of Estonian papers published in Top-quartile journals only behind that of the UK, Sweden, Slovenia, The Netherlands, Finland and Denmark – and well above the world and EU averages (Eljas-Taal, et al., 2019).

A recent article in Nature plotted the growth of Estonia's publications and its share of publications in the Top-10% of journals in SCOPUS, showing a rapid growth in quality (less so quantity) to levels well above those in other New Member States (Figure 17). They credit the solid basic research foundations left behind after independence, combined with good scientific management.

However, while Estonian performance in the Top-10% of journals as measured in SCOPUS is impressive, analysis for 2017 based on the Web of Science suggests that the proportion of Estonian papers published in the 10% most highly-cited journals is still only about three-quarters of the EU average level[42].

Figure 17 Growth in Scholarly Output and Share of Articles in Top-10% Journals, 1996-2017



Source: Quirin Schiermeier, How Estonia blazed a trail in science, Nature, 22/1/19

Lauk and Allik's analysis (2018) of Thomson-Reuters' Essential Science Indicators for 2007-2017 suggests that 2.4% of Estonian papers appears in the 1% most high-cited journals, ranking Estonia 9th on the international list. They say that the most successful Estonian research fields are environment & ecology, molecular biology & genetics, physics and plant & animal science.

Taken together, these indicators suggest a rather small science system with high average quality. The 'upper middle' is improving but still not strong in international terms, while there are perhaps more pockets of global excellence in specific domains than would be expected given Estonia's size.

These levels of quality have been achieved despite the fact that investment in public R&D has continued to fall to from its peak of 0.88% of GDP in 2012 and 2013. The scientific success is probably based on several factors.

- Competition for funds from the Estonian Research Council, which are awarded solely based on scientific excellence
- The Council's requirement to write applications in English improved researchers' literacy and thereby helped them to publish in international fora and to integrate into international networks. It also enabled the Estonian

[42] European Innovation Scoreboard, 2018

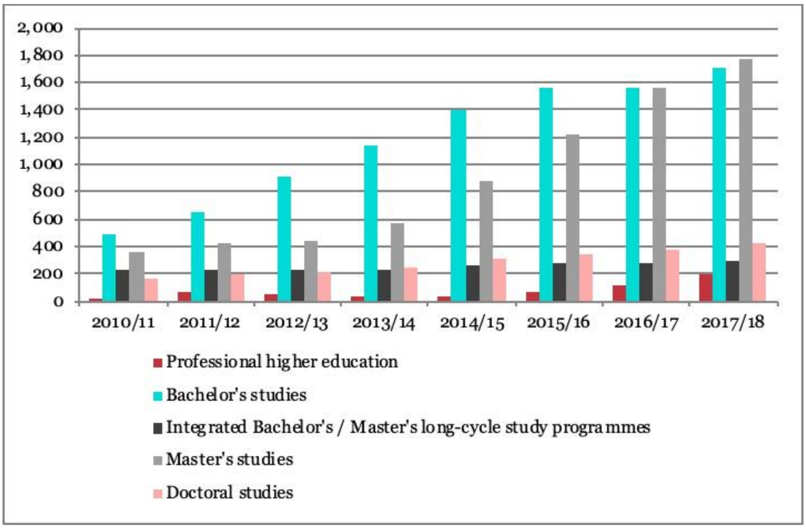
Research Council to use international experts for peer review, which raised the quality of assessment and international awareness of Estonian science

- Internationally co-authored papers, which are generally cited more highly than nationally co-authored ones, and in 2017 as much as 60% of Estonian researchers' publications were written with international collaborators

The size (in terms of numbers of researchers and capacity in R&D-performing institutions) of the system needs to increase a little ahead of societal demand because (1) this tends to drive up R&D activity in industry (and potentially the state) and (2) developing high-quality capacity takes time.

The proportion of foreign students studying in Estonia is one indication of internationalisation and is rising, though from a low base (Figure 18). Since 2013/14 all examined study levels have increased in terms of foreign students – an annual increase that has lasted for 5 years. An especially positive metric is the growth of foreign Doctoral students, whose number has grown from 170 in 2010/11 to 426 in 2017/18.

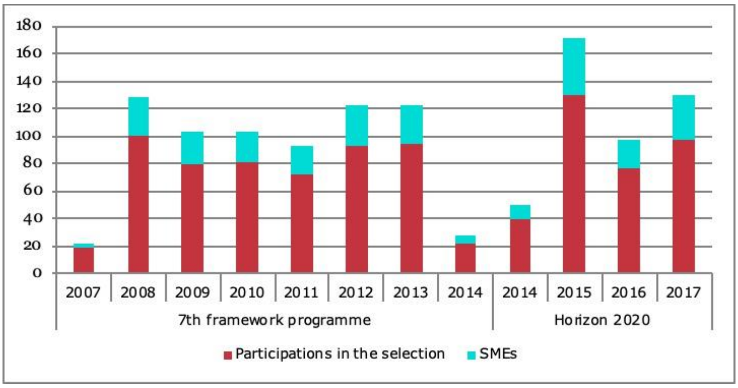
Figure 18 Foreign students studying in Estonian HEIs by study level



Source: Haridussilm

Participation in the EU Framework Programme is good, and the number of applications has risen in Horizon 2020, compared with FP7 (as it has in most countries). Estonia's success-rate was 20.6% in FP7 and 13% so far in Horizon 2020, which are normal values, suggesting the quality of proposals with Estonian participation is neither much better nor much worse than others'. The peak number of Estonian participants in FP7 was 100 and this has risen to 171 in Horizon 2020.

Figure 19 Estonia’s participation in FP7 and Horizon2020 programmes (number of participants)



Source: Estonian Research Council

One of the most important success factors was Estonia’s decision to dedicate as much as 15% of the EU Structural Funds to science, particularly to the development of research infrastructure. A key challenge is now to maintain and increase expenditure based on national money.

International practice is moving strongly towards the idea of ‘entrepreneurial universities’ – not only in the sense of universities that encourage and enable entrepreneurship but universities that are themselves entrepreneurial, seeking out ways to respond to the social and economic needs of society through graduate employability, facilitating social mobility and access to higher education, contributing to national and local development stimulating new enterprises and innovation and continually adapting to changing needs in order to be competitive in national and international arenas[43].

A particular issue in our interviews in Estonia was that universities and employers alike complained about mismatches between the number and type of graduates. This, the universities said, was partly influenced by the thematic socialisation pattern of university research. It should partly be addressed by changing the incentives to the universities, partly by supporting the development of increased absorptive capacity in industry and the state, and partly by establishing research programmes in fields of societal challenges. MER has the power to commission additional degree courses from the universities. The mismatch is also one symptom of the lack of an innovation agency and means that new, selective funding instruments are needed to encourage R&I activity in more relevant areas.

[43] HEI Innovate (2018) The Entrepreneurial and Innovative Higher Education Institution: A Review of the Concept and its Relevance Today, Brussels: DG-EAC, and references therein; OECD (2018), Supporting Entrepreneurship and Innovation in Higher Education in the Netherlands, Paris: OECD

4.2 Governance and profiling of the universities

4.2.1 Governance

Estonian universities are autonomous, in the sense of not being under the control of the state (Pruvot, et al., 2015)[44]. The Estonian Universities Act was last amended in 2014, increasing organisational, financial, staffing and academic autonomy to a medium-high to high level as compared to other European countries[45]. The reforms have introduced boards with external members to replace elected bodies, but governance is still uneven. The rectors continue to be elected, except in the case of the Tallinn Technical University, where the rector is appointed by the board.

The traditional system of electing rectors is inherently conservative, because candidates tend to feel accountable to the electorate rather than to the board. International experience is that when the majority of university board members and the chair are external, and the rector is appointed by the board, the rector is able to have the authority and executive power to effect significant strategic change in the university. European university systems are therefore increasingly being reformed so that rectors are appointed, not elected. The Estonian system needs a similar reform, in order to increase universities' ability to devise and implement strategies[46].

The main responsibilities of the board should be strategy, finance and the appointment of the rector. Individual members of the rectorate should be responsible for teaching, research and knowledge exchange with society. An Academic Senate elected from amongst professors, students and staff should be responsible for all education- and research-related issues.

4.2.2 University Research Profiles

The Estonian universities would benefit from 'profiling'; that is strategically specialising, so that the national HE ecosystem is coherent, does not contain too many overlaps or gaps, and allows 'small' subjects in one university to be transferred to another where they are not under-critical. The aim should be a university ecosystem, where the diverse strengths of the individual universities complement each other and benefit from synergies, decreasing fragmentation of intellectual and financial resources. For this, the universities need to identify their strengths and potential for excellence, and target resources to the chosen focus

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[44] See also https://www.university-autonomy.eu

[45] See the European universities Association Autonomy Scorecard here: https://www.university-autonomy.eu/countries/estonia/

[46] See Impact evaluation of higher education reforms (in Finnish). Publications of the Ministry of Education and Culture, Finland 2018:33. http://urn.fi/URN:ISBN:978-952-263-589-1

areas. A regular national bibliometric study of the quality of research in the different subject areas in all universities is necessary.

Profiling also requires incentives, such as a competitive funding instrument to be governed by the Estonian Research Council. An example could be provided by the Academy of Finland's university profiling programme, for which 2.8% (€50m) of the aggregate annual baseline budget of the universities was shifted to the budget of the Finnish Research Council Academy of Finland. The universities were invited to compete for that money with a long-term research strategy defining their profile and to commit their own funds to their chosen focus areas' research, especially after the 4-year funding period was over. Eventual collaborations with national universities and universities of applied science, and international public and private organisations were invited, as well as de-selection of sub-critical research and education domains.

An alternative approach is that of Germany, which launched the Excellence Initiative in 2005 to promote excellence and researcher training and to link academic and non-academic research, thereby increasing the competitiveness and international attractiveness of German science. The funding lines are (1) institutional strategies for research that are similar to the Finnish universities' profiling programme, (2) graduate schools and (3) clusters of excellence and are awarded based on the quality of the applications and the institutional strategies. The calls and selection have been done by the Deutsche Forschungsgemeinschaft, DFG. The Excellence Initiative has sharpened the profiles of the universities funded, catalysed new inter-disciplinary research networks and increased international visibility. Cooperation between universities, other research organizations and the private sector has increased (Imboden, 2016).

Given that the profiling of higher education is already addressed in the contracts between MER and the universities, the profiling exercise in Estonia should focus on the second and third university missions of research and knowledge exchange with society.

4.2.3 Researcher careers

A growing number of European universities have adopted the tenure track career concept. For example, Aalto University in Finland has implemented a comprehensive reform of the career ladder, transforming all vacant professorships to tenure track positions. The track usually consists of 5-year assistant professor, associate professor and tenured professor positions. When one is over, the position holder's accomplishments are judged against pre-set, transparent criteria. If successful, he/she proceeds to the next position, without competition with other candidates. The international attractiveness of the tenure track positions has been overwhelming, over one third of academic staff now being international.

In the context of the Germen Excellence Initiative, sustainable researcher career structures have been constructed by creating positions for early career researchers, group leaders and junior, assistant and full professors.

In Estonia, the employment contracts of academics are permanent, and the performance of staff is evaluated every five years. Some Estonian universities have started tenure-track-like developments, but they are mutually inconsistent and not yet widespread. If a tenure track is adopted across all universities, it should be the same in all of them, otherwise mobility among universities is inhibited. Renewal of Estonian science badly needs greater mobility within the country and across borders. International researcher recruitment requires a transparent and predictable academic career system, and tenure track is a powerful attraction.

4.2.4. Research infrastructures

All scientific and scholarly disciplines need modern research infrastructures (RI), the establishment, maintenance, up-dating and replacement of which require considerable long-term investments and should be anchored to national as well as institutional strategies and roadmaps. Estonia has a national Roadmap for key RI in place, managed by the Estonian Research Council, and up-dated recently. However, the funding of RI is not sustainable, as the resources have come from the Structural Funds and may end in 2020.

The national RI roadmap provides an overview of the country's entire national ecosystem of infrastructures and helps to avoid investment in redundant RI. The universities and other public research organisations typically propose, in a competitive process, RIs to be included in the RI roadmap. The proposals are peer reviewed using criteria such as 1) potential for world-class research, scientific breakthroughs and potential to introduce new cutting-edge technologies, 2) accessibility to a wide community of public and private researchers, 3) sustainability in the form of a long-term plan for scientific goals, maintenance, finance and utilisation of the RIs, and 4) feasibility of access to and preservation of data and/or materials collected.

A strategic RI co-operation body supported by the European Commission has drawn a European-level roadmap (www.ec.europa.eu/research/esfri). The aim of this body (ESFRI; European Strategic Forum for Research Infrastructure) is to promote access to research infrastructure across borders, generating synergies and promoting cross-border collaboration. Most EU member states are partners in multiple ESFRI infrastructures.

Estonia is member of five ESFRI infrastructures, namely BBMRI (Biobanking and Biomolecular Resources Research Infrastructure), CLARIN (Common Language Resources and Technology Infrastructure), ESS (European Social Survey), ESS (European Spallation Source) and ELIXIR (European Life Science Infrastructure for Biological Information). It was also member of EATRIS (European infrastructure for translational medicine) but withdraw from it in 2018.

Estonia is member of ESA (European Space Agency) and has started the accession process to CERN (European Organization for Nuclear Research), building on an existing cooperation agreement. Moreover, Estonia has (together with Finland) a beam-line in MAX IV. The national RI road map recommends membership in further ESFRIs and the European Molecular Biology Laboratory (EMBL).

Through the ESFRI memberships the Estonian researcher community has access to RI unavailable in Estonia. National RIs are excellent platforms for inter-university collaboration in a small country and attract foreign students and researchers. The Estonian RI has been funded from the Structural Funds, due to which the quality of Estonian science has taken a tiger's leap. It is of critical importance how RI will be funded after the European structural funding ends in 2020. A dedicated competitive funding instrument for RI should be established, resourced and entrusted to the Estonian Research Council, which is already responsible for the governance of the national RI roadmap.

4.3 Findings and policy implications

Findings	Policy implications
The state higher education and research system has many actors, but is focused on three comprehensive universities and performs well in terms of research excellence, especially in areas underpinned by the capabilities built up before Estonia's independence	Tread cautiously for fear of damaging a strong achievement, but add incentives to make the balance of effort more relevant to economic and social development
There is a mismatch between societal needs and both the research, and the number and subject of degrees granted by the universities and societal needs	Modify the universities' contracts for higher education and include thematic research incentives for societally relevant themes established by government in consultation with relevant stakeholders Establish a Finnish-style university research 'profiling' programme to establish and fund a more rational specialisation of tasks among the universities
University governance has been reformed but this does not go far enough to provide university rectors with strategic powers	Require public university boards to comprise a majority of external members and that rectors should be appointed by the boards, not elected by the academics
Lack of clearly defined research careers is a factor undermining the development of the R&I system in Estonia	Establish a clear and uniform tenure-track career system for academics and researchers across the higher education system
Estonia is part of the European Strategy Forum on Research Infrastructures (ESFRI) but is not fully able to deliver the needs identified	Centralise responsibility for significant research infrastructure from the universities to the Estonian Research Council Ensure the Estonian research community is able to make best use of the country's participations in international research infrastructures
The Estonian research system is insufficiently receptive to non-Estonian researchers	Modify visa requirements and the availability of non-Estonians to be able to benefit from Estonian social welfare arrangements
Life-long learning activities at the universities need development	Address this through the terms of the contracts with the universities A government decision is needed about whether and how to fund life-long learning courses at university level

5 CONCLUSIONS AND RECOMMENDATIONS

Our detailed suggestions are shown at the end of each chapter, above. At a high level, our overall conclusions and recommendations are as follows.

5.1 Conclusions

The Estonian economy has been successful in reaping the benefits of modernisation and integration into the European Union but now faces the 'middle-income' problem: namely, how to create distinct competitive advantages that will allow national income to grow above the middle level. Despite rapid GDP growth, poor total factor productivity is likely to become a constraint, especially if Estonia's overall R&D spending and business expenditure on R&D do not keep up with GDP growth. Policy needs include the development and exploitation of new, higher-productivity branches of industry and increased productivity in existing branches. In order to do this, policymakers need to address weaknesses in the research and innovation system and its governance.

In government and society, this means addressing

- A culture and political mood that under-estimates the importance of R&I for economic well-being, fails to fund it sufficiently and relies too much on temporary EU structural funds to address a permanent funding need

- A governance system that needs further development in order to coordinate R&I policy adequately at the national level. In particular, it needs consistency between the level of overall strategy and the development and implementation of lower-level plans together with further improved coordination across the ministries and between industry, government and the research and higher education system

- The 'R&D-driven innovation gap' between the research-focused policies of the MER and the business development focus of the MEAC, which is reflected in a corresponding gap at the level of agencies and support programmes for R&I

- The need to coordinate research and higher education priorities with societal needs, which would require greater involvement from the other sector ministries

- The fact that very business-friendly framework conditions are not matched by focused policies elsewhere in the policy mix. In particular, the overall system lacks 'directionality' in the sense of a widely-agreed vision of the directions of future development and a corresponding set of priorities based on opportunities to build national competitive advantage at the level of research organisations, higher education, ecosystems and clusters

In business, key issues are

- Low levels of innovation capacity ('absorptive capacity') in an industrial structure overly specialised in low-productivity branches and further disadvantaged by small firm size

- An approach to foreign direct investment that provides insufficient opportunities for learning in the national innovation system

- A healthy start-up scene, which is however focused in software-based businesses with low entry barriers that can only make a limited contribution to overall employment and growth in Estonia. This means that paying attention to the weaknesses of existing industry is also crucial in addressing development

- Linkages between the research system and society more broadly are under-developed

- Generally weak academic-industry linkages (though with some honourable exceptions)

- Sub-critical knowledge transfer and outreach functions in the universities

- A weak system of innovation intermediaries, where the national competence centres have effectively been privatised and there is no coherent 'public goods' offer, either from university-based industrial extension programmes or from RTOs

Among higher education and research organisations and innovation intermediaries

- Research quality is often good and researchers reasonably well integrated into international networks

- But higher education and research profiling do not well match the current needs of industry and society

- There are weaknesses in governance at both system and organisational level that impede the re-profiling of the universities to reduce duplication and adapt to national needs

In R&I policy interventions

- A very conventional instrument portfolio that neglects the redefinition of R&I policy and competitive arenas that are resulting from international efforts to address the societal challenges
- A failure by MEAC to ensure that Enterprise Estonia acts as an innovation agency, rather than focusing principally on business support and inward FDI. Policy therefore does not address the gap in industry's absorptive capacity
- Inadequate effort to develop and activate absorptive capacity and therefore the R&D function in companies
- Under-exploitation of the opportunities provided by demand-side policy, including (but not only) innovative procurement

5.2 Recommendations

Our discussion and conclusions suggest the need for changes in policy and practice. Many of these can be tackled at the operational level. However, we see five change needs that are large and urgent, which we believe should receive priority in Estonian policy. These address the need to increase the national effort in R&I by filling important gaps in the policy mix. These changes require action by different organisations and can therefore be implemented in parallel.

Ensure political commitment to the importance of R&I in national policy and the 1% target for government spend on R&D. R&D plays a central role for development and growth by enabling innovation. The importance attached to R&D in Estonia was demonstrated in 2011 when, consistent with the EU's Barcelona Goal, the government decided to increase its spending on R&D over time to 1% of GDP. More recently, other priorities have meant that limited progress has been made towards this goal.

The government has already sought to establish a consensus on the 1% goal among all the political parties. This is important in order to ensure continuity across successive governments. A substantial part of the increase in government R&D spending needs to be orientated towards encouraging increases in R&D and innovation activity in business and government through a new innovation agency with new R&D support programmes, and needs to be accompanied by an increased effort in support for non-R&D-based innovation. It should not be used solely in the research and higher education sector. The next step is for the government to set a realistic and affordable timetable for what amounts to a very significant increase in public expenditure, so that it is possible for policymakers to plan and set priorities on the basis of it. That needs to be done rather immediately. It then needs to ensure improved coordination of R&I policy, to generate the assurance that the government's intentions to increase expenditure are matched by the implementation of spending programmes at the level of the ministries and the agencies.

Establish and implement thematic priorities for R&I policy, in the light of the societal challenges and Estonia's smart specialisation strategy. Successful R&I policy uses a mixture of bottom-up and thematically focused instruments. Thematic focus is especially important in small countries, which cannot pursue a large number of priorities at sufficient scale to be effective. This idea lies at the heart of the smart specialisation strategy that Estonia has already adopted.

The thematic focus needs to take account both of the knowledge and human capital needs of society today and those of areas that are expected to grow. Growth areas are likely in part to correspond to the smart specialisation priorities and in part to the thematic priorities emerging from the international trend towards addressing the societal challenges in R&I policy. This is expected to trigger big changes in products and markets, creating new economic opportunities. While Estonia alone can have little influence on this big change, it can and should decide where to focus its own work on the societal challenges in the light of Estonian needs and bringing Estonian comparative advantages to bear in chosen niches. This means not only that policy will address important societal needs – some of which, like addressing climate change, are existential – but will generate wealth by virtue of the fact that these needs will ultimately be addressed through economic means.

So far, the societal challenges have been little integrated into Estonian R&I policy. The R&D Council should take the lead in setting thematic priorities through a national exercise in which there is broad consultation of citizens, business, the ministries and the research community to identify which sub-set of the societal challenges could be tackled and to ensure the social legitimacy of this choice. The smart specialisation priorities will be one important influence on this choice. A foresight exercise involving panels of informed citizens and stakeholders should then develop scenarios to guide further focusing of the thematic priorities. The R&D Council should invite the Parliament to participate in this exercise through the Foresight Foundation and then itself set the final priorities based on that work and oversee their implementation in the policies of the various ministries. To this end, the ministers sitting on the R&D Council should form an implementation group that plans, monitors and ensures the translation of those R&D Council recommendations that the government accepts into policy and spending.

The exercise should take about a year. The R&D Council should establish a secretariat for the purpose and should also exploit the network of science counsellors to ensure that the whole of government is involved. The exercise should be given considerable publicity, so that it not only establishes priorities but also underpins a consensus, visibility and legitimacy for those priorities and R&I policy more generally.

Establish an innovation agency to support R&D and build absorptive capacity. The biggest practical obstacle to increasing the rate of innovation in Estonia is the lack of 'absorptive capacity' or R&D capability in industry. Policies to help establish, activate and increase R&D capacity are therefore needed. These should be based on support services and grants rather than on R&D tax breaks, which are inherently inefficient, and which are likely to be ineffective in Estonia's low-tax environment.

Enterprise Estonia proposes that it should take on the innovation agency role. This appears sensible. However, Enterprise Estonia and MEAC should note that the skills needed address the needed scientific and technological elements are not currently present in Enterprise Estonia and that effective programming of innovation support programmes involves a role for the industrial and academic communities in governance that is not necessary in the kind of business support services Enterprise Estonia currently provides. There must therefore be changes in skills and governance. The agency will need to implement a hierarchy of different instruments to support companies at different levels of developing absorptive capacity. The innovation agency will need substantial funding, over and above what is spent on Enterprise Estonia today.

Enterprise Estonia should itself design and develop the innovation agency function, based on consultation with other members of the TAFTIE network of European innovation agencies, especially those in the Nordic region, one of which could usefully be asked to do a design review. It should give priority to activation, then take over the innovation programmes of the Estonian Research Council before expanding its R&D funding and support activities further. We anticipate that it will take not less than two years to establish a fully-functioning innovation agency within Enterprise Estonia.

Enterprise Estonia should strengthen its activities in two areas that are complementary to the innovation agency function. One is to improve and focus its tactics in relation to FDI. The other is to use good international practice to guide the strengthening of its innovative procurement activities.

Strengthen the system of 'intermediary organisations' able to support industrial innovation. Most national innovation systems benefit from intermediary organisations in the form of RTOs (such as Fraunhofer, Germany; VTT, Finland; or SINTEF, Norway) or university industrial extension services. Their job is to keep at least one step ahead of industry's knowledge needs for innovation and to provide research and technical services to industry based on that more advanced knowledge. These organisations are needed because it is only the most advanced companies that can work directly with universities and because the type of support companies need tends to be more short-term and applied than that which universities normally can provide. Where universities offer such support via extension services, they have to organise it separately from their mainstream activities because they require different kinds of skills and people and funding.

Estonia has no RTO. It does have some extension services in the form of the Regional Competence Centres, but these are small, limited to specific branches and outside the major urban centres, which typically contain most of a country's innovation activity. The national Technology Competence Centres formerly funded by Enterprise Estonia have been privatised and focus on the needs of specific groups of companies or branches.

Estonia is too small to support an RTO that can deal with a large number of different technologies, in the style of Fraunhofer or VTT. Conceivably, an organisation like VTT could be persuaded to establish a branch office in Estonia, but since its core funding is provided by Finnish taxpayers, Estonia would be likely to have to provide equivalent subsidy. Strengthening university extension services would have the advantage of strengthening the national innovation system, providing information and incentives for the universities to address nationally relevant research questions. Tasks that cannot be handled in Estonia can still be contracted ad hoc to the best qualified RTO abroad.

As the ministry responsible for industry and innovation, MEAC should therefore offer core funding on a competitive basis for at least one university to develop an industrial extension service offering services across a range of technologies relevant to Estonian industry. In general, the services should be paid for by the industrial customers. Role models could include the so-called 'competence centres' at Riga Tech and reference could also be made to the considerably larger and more ambitious industrial extension service at Georgia Tech in Atlanta. The university involved should either be a university of technology or have a strong set of relevant applied sciences. Such a university should be able to recruit the needed people and start to offer services within a year.

Modernise and 'profile' the universities, making them better adapted to innovation and the production of human capital to meet national needs. Despite the modernising reforms of 2014, most universities in Estonia still have rather traditional European governance with (except at TalTech) an elected rector. There are persistent mismatches between the number and specialisation of the degrees provided by the universities and societal needs. The higher education sector is fragmented so the universities tend to be sub-scale and they continue to have an inefficient division of labour.

Reforming university governance is necessary, so that a majority of the members of the board are external to the university. This will enable universities to act strategically and flexibly in response to national needs. Even with such leadership, however, it is difficult for universities to restructure or rationalise their education and research 'offer'. National authorities responsible for university systems therefore often provide funding to help with the transaction costs of change and sometimes also offer larger monetary incentives.

In the case of Estonia, MER should launch a further university reform intended to professionalise management by requiring public universities to have a Board with a majority of experts with diverse competencies external to the university, which appoints the rector. The largest universities should in addition appoint vice rectors for education, research and knowledge exchange with society. Academic affairs should remain in the hands of a senate (or an equivalent academic body) but strategy and resource allocation must be in the hands of the appointed management.

MER should launch a profiling programme. Its scope should consider all three university missions and the synergies among them, not just research. These reforms would in effect create the strategic governance capability needed to modernise the universities and mobilise the means needed to readjust universities' strategies to national needs and improve the efficiency of the division of labour within the university system.

A related question of modernisation is to improve the function of the university technology transfer offices. An option would be for MER to offer to set up a central TTO to look after intellectual property, as has been done in France, with individual university TTOs operating as satellites and focusing more on industrial liaison and knowledge exchange.

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6 APPENDIX: OVERVIEW OF INSTRUMENTS FOR SUPPORTING ABSORPTIVE CAPACITY IN FIVE COUNTRIES

This table was compiled in 2004, at which time the countries considered had instrument portfolios mote strongly orientated to absorptive capacity and activation than is the case today.

Country	Scheme	Target	Type of measure	SME specific
IE	RTI	R&D for all manufacturing and international countries	Funding	No
IE	IMI	Companies who want to undertake R&D for the first time	Funding of training courses	No
IE	EI Tailor-made support	Companies who wish to undertake large R&D projects	Funding	No (excluded)
IE	Innovation partnership initiative	Companies wishing to link up with universities and institutes of technology	Funding for research project	No
IE	R&D Awareness initiative	Companies who want to understand more about R&D	3 days consultancy	No
IE	Initiatives in specific advanced technology	All companies wanting help with sector specific R&D	Funding given to centres of excellence	No
IE	Fusion scheme	Companies with specific technology needs undertake research with a graduate (From NI)	Technology Transfer	No
IE	Work of country enterprise boards	All companies needing business support	All – General business support	More focused on SMEs
UK	DTI – Technology programme	Companies wishing to undertake collaborative R&D	Funding	No
UK	Grants for investigating an innovative idea	For companies who have an idea but are not sure whether they can take it forward successfully	Grant	No – although more focused that some
UK	Grant for R&D	For helping SMEs and individuals to research and develop new products	Grant	Yes
UK	Knowledge Transfer Partnerships	Companies who wish to join up with research institutes to do research	Funding towards person	No but more so
UK	Management and Leadership programme	Companies wishing to undertake more informal learning	Not yet started	Yes

UK	LINK	All industry – wishing to link up with research base	Funding	Any size
UK	Faraday partnerships	All businesses	Funding/ Knowledge	Any size (specific mention of SMEs)
UK	Phoenix Fund	Enterprises in disadvantaged areas	Funding/advice	Yes
NL	Training facility	Firms - to increase the attractiveness of investing in training	Tax deduction	No
NL	Scholingsimpuls " training initiative	Training of individuals based on gap in industry	Training	No
NL	Knowledge Transfer Branch Organisations/ SMEs	Companies that want to get a knowledge position study carried out by a third party or a knowledge transfer project	Funding	Yes
NL	Knowledge transfer Entrepreneurs	For SMEs to help boost innovation	Feasibility study Knowledge carriers	Yes
NL	Dreamstart	Technostarters - many schemes	Funding	Yes
SE	TUFF	SMEs who wish to cooperate with R&D centres	Funding	Yes
SE	VINNVAXT	Regional innovation systems	Funding for regional networks of companies and knowledge infrastructures	No but supported
SE	VINST	Companies with self developed products	Funding collaborative projects	No
SE	IT.SME.SE	Companies wanting to do IT	Funding/ consultancy	Yes
FI	Entrepreneur-ship policy programme	All businesses	A number of measures	A specific focus on SMEs
FI	TE-keskukset	SMEs looking for general advice – Regional centres	Funding for development and export assistance	Yes
FI	Centre of Expertise	All companies	R&D support	No but supported
FI	TEEs – Technology programme	All companies- research centre set up to pass on knowledge	Funding for the centres to do research	No
FI	R&D funding for companies	All companies wanting to do R&D	Funding	No
FI	TEKES Feasibility Studies	SMEs wanting to work with RI and Universities	Funding	Yes

FI	TEKES TULI	Companies wishing to define business/research ideas	Funding	Yes
FI	Technology Clinics	Technology Transfer for SMEs	Clinics	Yes

Source: (Arnold, et al., 2004)

8 APPENDIX: ABBREVIATIONS AND ACRONYMS

Abbreviation	Meaning
ADAPTER	Enterprise Estonia tool for companies to find answers to technical questions
BBMRI	Biobanking and Biomolecular Resources Research Infrastructure
BERD	Business expenditure on R&D
BT	British Telecom
CERN	European Organisation for Nuclear Research
CLARIN	Common Language Resources and Technology Infrastructure
COST	European Cooperation on Science and Technology
EATRIS	European Infrastructure for Translational Medicine
EIT	European Institute of Technology
ELIXIR	European Life Science Infrastructure for Biological Information
EMBL	European Molecular Biology Laboratory
ERAC	European Research Area and Innovation Committee
ESA	European Space Agency
ESF	European Science Foundation
ESFRI	European Strategy Forum on Research Infrastructures
ESS	European Social Survey
ESS	European Spallation Source
EU	European Union
FDI	Foreign direct investment
GDP	Gross domestic product
GERD	Gross expenditure on R&D
H2020	Horizon 2020 (8^{th} Framework Programme)
HEPTech	CERN TTO
HERD	Higher education expenditure on R&D
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome
ICT	Information and communications technology
MEAC	Ministry of Economic Affairs and Communications
MER	Ministry of Education and Research
MNC	Multinational corporation
NGO	Non-government organisation
NUTIKAS	Enterprise Estonia programme to support research-industry collaboration
OECD	Organisation for Economic Cooperation and Development
PPI	Public procurement of innovation
R&D	Research and development

R&I	Research and innovation
RDI	Research, development and innovation
RDTI	Research, development, technology and innovation
RI	Research infrastructure
RISE Group	Research, Innovation and Science Expert group
RITA	Estonian Research Council programme to fund sector research relevant to the smart specialisation strategy. Also funds science counsellors
RTO	Research and technology organisation
SME	Small or medium-sized enterprise
STEM	Science, technology, engineering and mathematics
TFP	Total factor productivity
TTO	Technology transfer office
VC	Venture capital
WEF	World Economic Forum

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To support countries in reforming their research and innovation systems, the Directorate-General for Research & Innovation (DG RTD) of the European Commission set up a Policy Support Facility (PSF) under the European Framework Programme for Research & Innovation 'Horizon 2020'. It aims to support Member States and associated countries in improving their national science, technology and innovation systems.

The Estonian government requested specific support from the PSF, to support the work of the Ministry of Economic Affairs and Communications (MEAC) and Ministry of Education and Research (MER) in preparing to produce a joint research, development, innovation and entrepreneurship strategy for the period 2021-27 and onwards via a general assessment of the effectiveness of the research and innovation (R&I) system and a specific assessment of the role and impact of the R&I system in promoting added value creation.

The PSF panel of five independent experts supported by three national peers from other countries worked from October 2018 to September 2019, including four missions to Estonia to consult stakeholders and discuss potential recommendations. This final report was formally presented to the Estonian government in Tallinn in September 2019. The panel's overall recommendations are that the government should

- Ensure political commitment to the importance of R&I in national policy and the 1% target for government spend on R&D.
- Establish and implement thematic priorities for R&I policy, in the light of the societal challenges and Estonia's smart specialisation strategy.
- Establish an innovation agency to support R&D and build absorptive capacity.
- Strengthen the system of 'intermediary organisations' able to support industrial innovation.
- Modernise and 'profile' research at the universities, making them better adapted to innovation and the production of human capital to meet national needs.

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