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Using Patent Development, Education Policy and Research and Development Expenditure Policy to Understand Differences between Countries: The Case of Estonia and Finland

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Abstract: *This article is an econometric study of patent development, education policy and research and development (R&D) expenditure policy, the aim of which is to investigate the key similarities and differences when it comes to the issue of competitiveness between Estonia and Finland, particularly in the utilisation of foreign patents, as well as ranking them on the international arena. The authors of the article intend to study how it is possible to increase the technological competitiveness of small European Union Member States and the special effect of investments in research and development (R&D) and education on the competitiveness ranking of Estonia and Finland. The authors attempt to explore how Estonia can advance by learning from the model of innovative growth adopted by Finland.*

Keywords: *econometrics, Estonia, Finland, human capital, Triadic patents, R&D*

1. Introduction

The present article is the second working paper in the series of research articles in which econometrics is used to study the key differences between countries which have an effect on their technological competitiveness. In the first article, the authors attempted to study, using patent development, education policy and research and development expenditure policy, how it is possible to increase the technological competitiveness of small European Union Member States (Ferraro *et al*., 2017).

Since there exist fundamental and structural economic differences within the EU Member States, it is important to understand the wider economic impact of the vastly varying per capita incomes, and the divergent national attitudes towards foreign trade, inflation, etc. (IndexMundi, 2018). The euro area accounted for more than 70% of the EU's Gross Domestic Product (GDP) in 2015 in terms of purchasing power standards (PPS). But interestingly the economies of the five largest EU Member States stood at 67.6% of the EU's GDP (Eurostat, 2017).[1]

Despite global industrial activity, there often exist huge technological gaps between industrialised nations. National innovation policies can help to fill such technological gaps by identifying the areas which are the most promising through public intervention (in the form of funding) for the positive impact on potential market inefficiencies. The policies, however, should be diverse enough so as to allow wholesome technological development in the society (Nikulainen, 2008, p. 1).

Patent data is advantageous for studying innovation trends because patent documents contain a wealth of information regarding the invention, the technological areas concerned, the geographic location of the inventors, details of the enterprise which buys the invention, etc. However, using patent data as an indicator of innovative activity also has disadvantages, namely that some technologies (e.g., software, biotechnology, etc.) are not easily patentable across the world, or patenting is often viewed as a strategic option (especially when technologies have short life cycles), which means that maintaining secrecy or lead times can be more important than actual patenting. Furthermore, several patents can cover single/multiple inventions resulting in a blurring of the technological meaning of the patent, which necessitates the study of detailed and complicated patent family data (Nikulainen, 2008, p. 6).

[1] Wherein it is stated that Germany, the United Kingdom, France, Italy and Spain were the largest economies in 2015, just as they were in 2005.

In this working paper, the authors will attempt to identify the key similarities and differences when it comes to the issue of competitiveness between Estonia and Finland, particularly in the utilisation of foreign patents. The main research question that is sought to be answered is how investments in research and development (R&D) and education impact the competitiveness ranking of Estonia and Finland. Or, to be more specific, the authors want to answer the question: What is the relationship between patent development, education policy and R&D expenditure policy when comparing Estonia with Finland, both being neighbours, EU Member States and members of the Organisation for Economic Co-operation and Development (OECD)? The authors want to explore how Estonia can advance by learning from the model of innovative growth adopted by Finland, its successful northern neighbour in the EU (in terms of innovation and patenting).

This series of working papers comes with the caveat that very often there is too much focus on patents, even though they may not be the ideal choice for enterprises. Sometimes using the number of patents filed as a performance metric can be misleading (PRO INNO Group, 2007). The authors will look into this aspect as well.

2. A short background note on Estonia and Finland

2.1 Estonia—a small but successful post-Soviet free economy

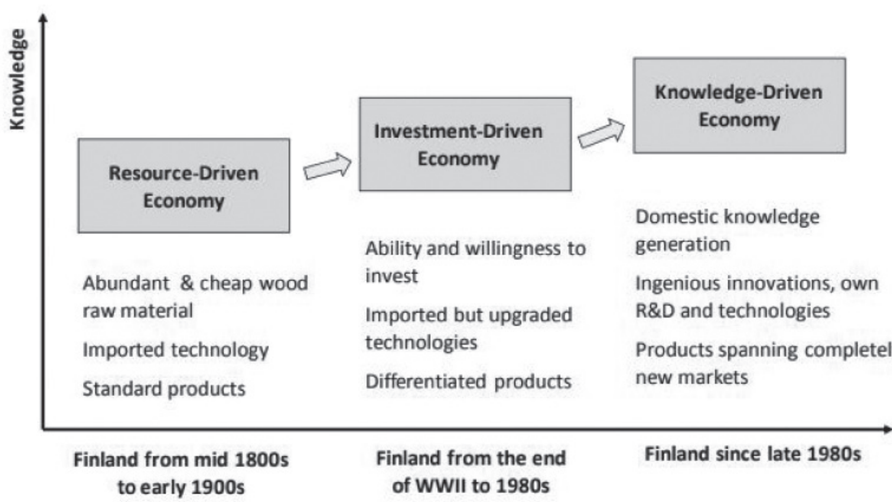
In the late 19th century, Estonia and Finland were originally part of the Russian Empire. During World War I, due to internal strife the Russian Empire disintegrated. Finland and Estonia, along with a host of other small nations, were born out of this tumult. Estonia and Finland enjoyed a period of peace and prosperity until the late 1930s. During and after World War II, Estonia suffered greatly and in 1944 was occupied and became a part of the Soviet Union (Hampden Jackson, 1948). Finland, on the other hand, managed to maintain its independence after World War II. After the collapse of the Soviet Union in the early 1990s, Estonia once again became independent and has made several efforts to become more Westernised, both politically and economically. Estonia is now a member of the EU, the euro zone, the North Atlantic Treaty Organisation (NATO), OECD, etc. Things have changed drastically since the 1990s and Estonia has excelled in new areas such as information technologies, eGovernance, etc. (Särav & Kerikmäe, 2016). Estonia can now be considered a role model for the post-Soviet countries of the Eastern Partnership (Kerikmäe & Chochia, 2016). In 2017, Estonia's GDP was at 23 billion euros, which is a small fraction of the GDP of the EU (EUROPA, 2018). The main trading partners of Estonia are Finland, Sweden, Latvia and Germany. A huge bulk of total trade is with other EU Member States. Activities such as programming and software development; information and communication; professional, scientific and technical activities; manufacturing and services, have all grown robustly (Statistics Estonia, 2018).

2.2 Finland—a mid-sized successful Nordic economy

2.2.1 Introduction

In Finland there has been rapid change from an economy driven by exploitation of resources to a knowledge-driven economy (Nikulainen, 2008, p. 2). Historical records show that the Finnish economy has transformed within a short time period from an agricultural economy to an economy which is technologically intensive (Grönqvist, 2009, p. 160)

Figure 1. Stages of industrial and economic development in Finland



Source: Nikulainen, 2008

In Finland, the manufacturing and service sectors are highly significant. Manufacturing industries have evolved and they produce higher value-added products (e.g., electronics and machinery especially in ICT) for export purposes instead of standard products (e.g., Paper and basic metal) (Nikulainen, 2008, pp. 3–4).

Traditional industries (such as metal, forestry and chemicals) are growing steadily. Boom in the ICT sector has resulted in rapid growth in the electronics industry. Historically, it was the external shocks in the 1970s due to the energy crisis and in the early 1990s (due to the global economy slowing down, financial mismanagement in the national context and the fall of the Soviet Union, which affected exports), which spurred economic development in new areas, particularly in the ICT sector in the 1990s (Nikulainen, 2008, p. 4).

Finland currently has a mid-size economy compared with other EU Member States, at a 239 billion euros GDP rate, it is ranked 15th out of 46 European countries according to size of GDP (Statistics Times, 2016). Finland had 51.8 billion euros worth of product exports in 2016, and 54.7 billion in imports. The main export articles are chemicals; cellulose and paper products; metal and metal products; machinery and electronics. Over half of all trade was done with other European countries. Germany was Finland's largest trading partner. Russia is also an important trade partner.

Service industry exports accounted for around one third of all export revenue in Finland in 2016, with IT services being the main field of export (Confederation of Finnish Industries, 2018). The service industry has been dubbed the "new Nokia" in relation to its growing significance for Finnish export revenue, referring to the hole left in the Finnish economy by the downfall and sale of the Finnish mobile giant Nokia (Finnish Government, 2017a). However, although the decrease in value and acquisition on Nokia's Mobile Devices and Services department made a dent in the Finnish economy, the mobile giant continues to be a large player in its home country's economy and continues to bring in revenue and know-how in the tech department through its patent royalties and its continued investment in R&D in its remaining operations, as will be shown below.

2.2.2 History of patents/patent office in Finland

Finland has a long and colourful history when it comes to patent registration and protection. The Finnish Patent and Registration Office was founded in 1941, but the history of patent protection and advising in Finland dates back to the 19th century, when the first Finnish patent was awarded to a Mr. L. G. Ståhle for a device used in iron blast furnaces over 175 years ago in 1842. Finland joined the predecessor of the World Intellectual Property Organization already in 1921 (Finnish Patent and Registration Office, 2017).

The first modern law on patents in Finland was passed in 1943 and currently the most recent law on patents in Finland, the Finnish Patents Act, took effect in 1968. The current law has been constantly and consistently updated to keep up with EU standards and changing times, especially regarding changes in technology. The Patents Act was harmonised with EU standards already in 1980, much before Finland joined the European Union in 1995 (IPR University Center, 2013). The yearly amount of patent applications in Finland is nearly 2000, with trademark applications ranging around 300 yearly (Finnish Patent and Registration Office, 2018).

The number of Finnish patent families prior to the period of 1970s showcases the low level of innovation-related activities, since in those times most technologies were imported into Finland and did not undergo any further developments. Compared to that, commencing from the late 1980s an increase in Finnish patenting activity reveals the growing importance of patents in an increasingly knowledge-driven economy (Nikulainen, 2008, p. 9).

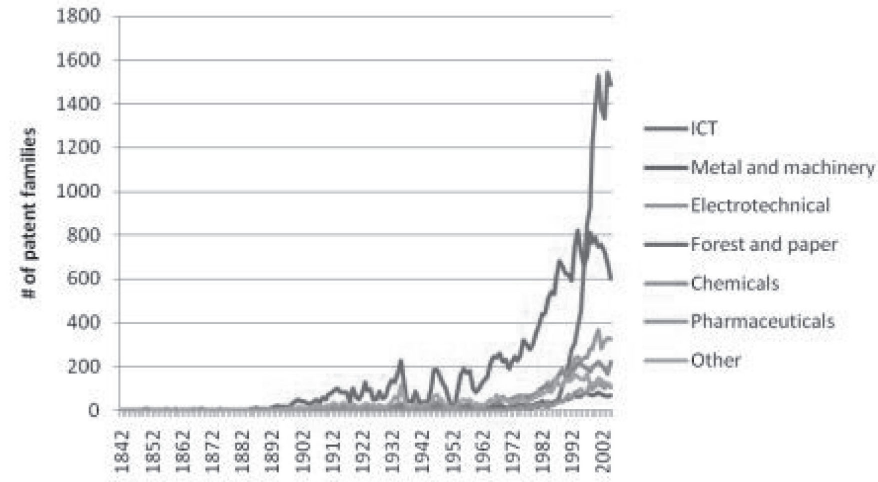
Thus, data shows that electrical engineering has seen high patenting activity, propelled by the emergence of ICT technologies and the need for commercialisation through patent thicketing, licensing, cross-licensing, etc. This is in sharp contrast to other technologies, which declined after 1995. Patent statistics thus show that starting from the 1970s there was significant development of indigenous technologies within Finland (Nikulainen, 2008, p. 10).

Within the field of electrical engineering, there has been an increase in patenting activity concerning telecommunications (e.g., mobile phones) mainly due to Nokia (Nikulainen, 2008, p. 11).

Concerning chemicals, diversification of technology is evident as more patenting emphasis is on pharmaceuticals, organic chemistry and biotechnology. In the field of process engineering, patent data reveals that thermal processes have increased while oil and basic material chemistry have declined, thereby indicating a change from production of standard goods (e.g., pulp and paper) towards higher value-added goods, particularly related to new areas such as nanotechnology (Nikulainen, 2008, p. 12).

With regard to mechanical engineering, patent trends show that it remains very active in Finland as far as the main traditional industries (e.g., handling and printing) are concerned, but there is a decline in food processing—once again indicating that industrial activity has undergone significant changes from primary production to the production of goods and services which are related to higher value (Nikulainen, 2008, p. 13).

Figure 2. Number of Finnish patent families per industry, 1842–2005



Source: Nikulainen, 2008

Figure 3. The most important patenting companies by decade

2000	1990	1980	1970	1960	1950	1940	1930	1920
Nokia	Nokia	Valmet	Valmet	Valmet	Ahlström	Kymmene	Automaatti Teollisuus Oy	Maskin och Brogyggnadds Ab
Metso	Valmet	Ahlström	Wärtsilä	Ahlström	Valmet	Ahlström	Tikkakoski	Suomen Suojeluskuntajärjestö
Kone	Ahlström	Neste	Ahlström	Tampella	Kymmene	Wärtsilä	Sportartikel Ab	G A Serlachius Ab
Borealis	Metso	Tampella	Outokumpu	Wärtsilä	Rauma Repola	SOK	Maskin och Brogyggnadds Ab	Fazer Ab Oy
Outokumpu	Kone	Nokia	Rauma Repola	Nokia	Kone ja Terä	Heinolan Faneritehdas	Wärtsilä	Lahden Rautateollisuus Oy
VTT	VTT	Outokumpu	Tampella	Kone	Enso Gutzeit	Enso Gutzeit	Tampella	Finska Forcit Dynamit Ab
ABB	Neste	VTT	Nokia	Outokumpu	Heteka	Orion	Hankkija	Kymmene Lämmityslaite Oy
TeliaSonera	Borealis	Kone	Enso Gutzeit	Sateko	Tampella	Tikkakoski	Tilgmann Oy Ab	
Orion	Orion	Partek	Kemira	MKT Tehtaat		Outokumpu	Valio	
Wärtsilä	Instrumentarium	Rauma Repola	Kone	Fiskars				

Source: Nikulainen, 2008

2.2.3 Recent developments in R&D and the role of Nokia

Finnish research shows that the biggest contribution towards the change from an investment-driven economy to a knowledge-driven economy came from the ICT industry (and especially Nokia) (Nikulainen, 2008, p. 19).

The long-term effects of well-organised and consistent investment in research and development in any given country should not be underestimated. One cannot talk about research and development, patents and intellectual property law and their impact on a country's economy in the context of Finland without mentioning Finnish mobile giant Nokia. Even today, Nokia still has an impact on the Finnish economy, despite the company having sold its Mobile Devices and Services department to Microsoft in 2014 and its HERE maps services to a group of German auto manufacturers in 2015 (Nokia, 2015).

Regardless of changes in acquisition of certain departments and the sale of its mobile devices department, Nokia has continued to invest in its R&D branch. For example, in 2015 Nokia invested around 2.1 billion euros in R&D, while their sales were 12.5 billion euros (Nokia, 2015).

Over the past twenty years, Nokia has invested over 115 billion into research and development in mobile technology, and its technology patents resulting from this investment provide a stable stream of revenue for the company even today. As one of the world's leading innovators and after acquiring full ownership of Nokia Siemens Network and Alcatel-Lucent in 2016, Nokia has in its possession three major patent briefcases and its yearly revenue reflects this (Nokia, 2017).

At the end of 2017, it was reported that despite having sold some of its core functions, Nokia was still racking up large amounts of money in patent royalties; in January through September 2017, Nokia Technologies reported 1,062 million in patent royalty revenue. Out of Nokia's 1.6 billion euro profit at the beginning of 2017, 70% was generated by patent royalties. In an article by a leading Finnish economic outlet, it was easily concluded that while the world and technology often changes at a fast pace, technology patents could potentially generate stable revenue for many years to come. The mobile phone business is still a billion-dollar industry thanks to patents (Talouselämä, 2017). It is worth noting that such royalty revenue not only contributes to shareholders of the company, it also contributes significantly to tax revenue for Finland, making it an important contributor to the country's economy in general.[2]

After the fall of Nokia, the service industry, especially in IT services, gained

[2] See, for example, §52 of the Finnish Law on Income Tax

economic prominence. This should be recognised in political decisions and in investment into service innovation. While Nokia still brings in substantial income tax revenue through its patents, it is worth noting and exploring that a growing part of export revenue in Finland is coming from the services industry, with an emphasis on IT services being exported. This phenomenon has been dubbed by some as the "new Nokia", alluding to the fact that this industry is a growing source of revenue for the economy. The service industry, especially in the field of IT services, could also be the next high-quality "product" Finland could gain global recognition for. In 2016, the IT services industry alone accounted for 11.4% of export income, while the service industry has been a growing field of export since 2012. Even though the fall of Nokia in a short time period (starting in 2008) led to a five billion loss in export revenue in Finland's economy (or 10% of the country's export worth), the growing service industry already started filling out the gap left by Nokia only a few years later, and continues to grow. Finland is now competing with the quality of its exports instead of quantity, which is a smart move in today's world. Researcher Katariina Nilsson Hakkala from Etla has said that it would bode well for the country if politicians would recognise the importance of competing in the global economy with quality, and should make political decisions to support this changed perspective. This should be done especially by investing in the development of innovation in the service industry and marketing, among others (Finnish Government, 2017b).

3. Theories and practice

3.1 The practical niceties

It is never easy to answer the conundrum of the reverse causality—whether patents induce growth in industrial production or does industry growth induce growth of patenting (Nikulainen, 2008, p. 7).

The patent system is generally considered to give greater incentives for innovation. It enables diffusion of knowledge and is helpful for commercialisation. These benefits are however countered by the cost of acquiring patents (being the welfare loss to society and the administrative costs) (Grönqvist, 2009, p. 159).

So if technological changes in a society can be measured with the help of patents, then one of the challenges with regard to patent data is how to utilise it as a source of information. This is of course not as easy as it may appear due to a variety of reasons (de Rassenfosse *et al.*, 2013). A patent can be a source of information of technical nature and also an indicator of technology.

Some researchers have studied the relationship between technological change (as measured by patent statistics) and economic development. These can potentially reveal how progress in society is achieved (Basberg, 1987, p. 131). It must also be noted that broad patents tend to be more general in nature and therefore less valuable. Very specific patents being narrow in nature can become obsolete within a short time frame, thus making them less valuable as time passes (Grönqvist, 2009, p. 167).

Patent statistics however can be difficult to interpret and use (Griliches, 1998). The analysis of the innovation process requires a good understanding of R&D, patents and productivity (Nyman-Metcalf *et al*., 2014). Patents can be partial indicators but are still appropriate enough to highlight useful research undertaken by universities (Meyer, 2003, p. 19).

Patent data is plentiful. However, one must not forget that an invention can be protected through the use of different forms of intellectual property rights (e.g., patents, trade secrets, etc.). Different industrial sectors see the use of IPRs differently (Basberg, 1987 p. 132). Patenting is a good measure of output of R&D activity. A positive relationship between R&D and patenting has been the subject matter of various empirical studies (Basberg, 1987, p. 133).

Not all inventions are patented. Due to technological specialisation, different industries will have different propensities towards patenting. Hence if a country exhibits preferences for a particular set of technological specialisations then the observed number of patent filings are affected (de Rassenfosse & van Pottelsberghe de la Potterie, 2009, p. 788). An invention may not be patentable under the law. Furthermore, there could be a variance in patent laws of different countries, despite the TRIPS agreement. New technologies (microelectronics, bio-technology, etc.) may be subject to ambiguous legal requirements (Basberg, 1987, p. 133). Therefore, it would be incorrect to focus only on patents as their usage is influenced by the field or industry, rapidly evolving technologies, lack of resources for the purpose of patent litigation, etc. So using number of patents filed as a performance metric can be misleading in some instances (PRO INNO Group, 2007).According to the authors, foreign patents are a good indicator of technology since they are of higher quality and potentially more profitable, which is why enterprises apply for them despite the additional expenses (Basberg, 1987, p. 136). In order to eliminate "home bias", most studies investigate patents filed either at the European Patent Office (EPO) or the United States Patent and Trademark Office (USPTO), since they are perceived to be expensive, high quality and of higher market value. The OECD recommends using the triadic patent families. These include only the patents that were filed simultaneously at the USPTO, EPO and Japan Patent Office (JPO), and are thus a reliable measure of a perceived global protection strategy on the part of their applicants. The OECD database provides adequate and readily available coverage on such patent applications. Since they are translated and prosecuted in three different systems they are considered to be of high value and less susceptible to any potentially damaging "home bias" (de Rassenfosse & van Pottelsberghe de la Potterie, 2009, p. 782).

3.2 The 4S framework theoretical model

IPR plays an important role in the wider social context. It not only enriches the inventor but the knowledge spill-overs generated are important for society. Higher education and absorption thereof, appropriate R&D strategies and commercialisation of knowledge are beneficial for the society as a whole in the cultural, economic, social and strategic context. But how can one truly value IPR? Is the social value of IPR an important matter for consideration?

It is not easy to value the results/outcomes/output of R&D and innovation expenditure and their impact on society as a whole. One method is to calculate the social rate of return (similar to the benefit-cost ratio method), another is to simplify the innovation process in order to measure the ultimate impact that innovation-related activities can have in the context of being profitable/loss-making or by measuring the output of innovation. But this ignores the wider social context. Other methods include using surveys (Ferraro *et al*., 2017).

To calculate the social value of IPR, one must add up various estimations. Thus, for example, by estimating the worth of the R&D to the overall strategy of the company or to a partner in the strategic alliance, one can estimate the value of the R&D (Groen *et al*., 2002). Cultural norms include finding the required resources being both human and organisational, including resources related to knowledge and technology, and include indulging in patenting activities (Leloux & Groen, 2009, p. 12). It is economically prudent to identify and mobilise financial resources in order to create an effective business model (where IPR can be used as one of the tools to create profits) (Leloux & Groen, 2009, p. 12). Networking is an important social strategy which enables effective commercialisation of IPR by entering into strategic alliances, forming joint ventures, licensing, subcontracting, jointly conducting R&D and/or marketing activities, sharing of interdependent activities and resources, etc. These networks could be local or global in nature (Groen, 2005, p. 72). However, it must be noted that the above activities can induce corruption, monopolistic behaviour, etc. which are deemed inappropriate. On the other hand, the use of financial incentives, cost cutting measures, training and education, new technologies, etc. are seen as appropriate forms of intervention within the dimensions of entrepreneurial networking (Groen, 2005, pp. 74–78).

R&D activities are not fully appropriable by the enterprise and knowledge leaks out to competitors and the social benefit is eventually higher than the rate of private return. But this also results in underinvestment by enterprises in innovative activity when considered from a social point of view. Therefore, in order to internalise knowledge spill-overs and increase rates of appropriability of returns within the research consortia, R&D collaboration is preferable. But the trick is in handling aspects such as coordination, free-riding and sharing of information (Czarnitzki *et al*., 2007, p. 1350).

Cooperating in R&D is always helpful for increasing the profitability of enterprises (provided that the costs of coordinating R&D are not ignored). Free riding is always problematic as often some partners may try to absorb knowledge from others while concealing their own knowledge. Absorptive capacity is also important for managing spill-overs. Engaging in own R&D in turn can develop absorptive activity. However, the risk of R&D collaborations turning into anti-trust style collusions is high and this can negatively impact the aim of enhancing welfare (Czarnitzki *et al*., 2007, p. 1351).

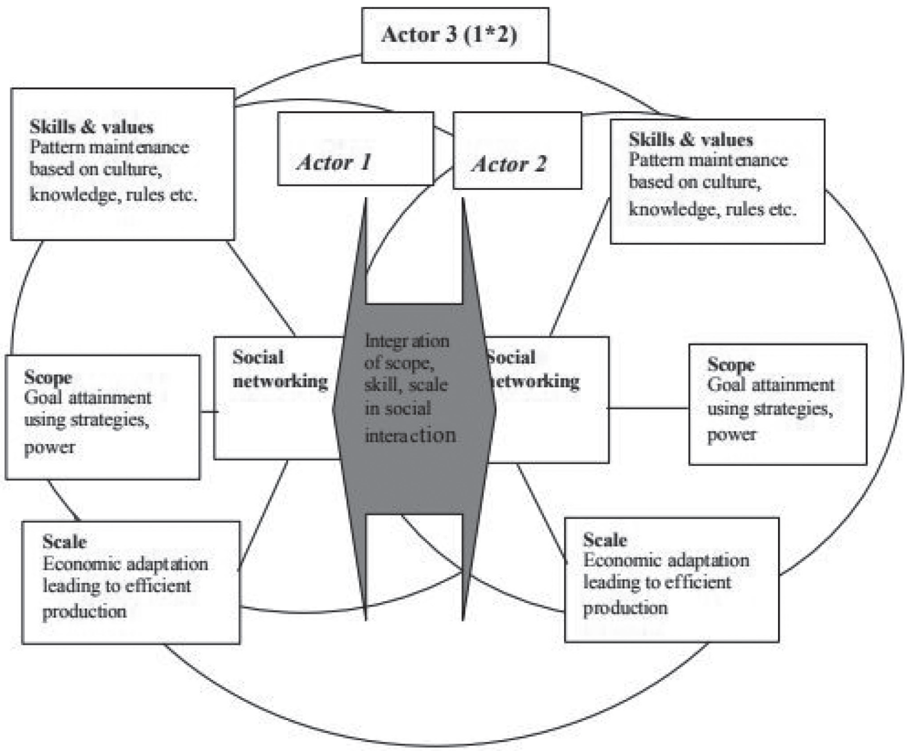
Of course the dynamics of horizontal (with competitors) and vertical (customers /suppliers/universities, etc.) R&D collaborations must also be considered. Public subsidies can sometimes also overshadow private investment. Selection bias with regard to the recipients of government subsidies is another factor as often the most promising candidates are chosen for successful research projects (Czarnitzki *et al*., 2007, p. 1352).

Hence it is important to focus on the social impact of IPR. In the entrepreneurial process, the focus is on the team of the inventor-entrepreneur. This team is the force that drives the process, by initiating it from the original idea all the way to giving it direction and leading to an exchange with the market. However, it should be noted that this team comprising of the inventor-entrepreneur is not an independent actor. It is embedded in a social context and has to interact with other actors. Only through such intense interaction with other actors can information and resources be exchanged, which in turn enables the exploitation of the available opportunity thereby leading to creation of value. Thus there are multiple actors and multiple levels of aggregation within this process, which leads us to Parsons famous functionalistic social system theory from 1964.

The social system is defined as:

a social system consists in a plurality of individual actors interacting with each other in a situation which has at least a physical or environmental aspect, actors who are motivated in terms of a tendency to the "optimisation of gratification" and whose relation to their situations, including each other, is defined and mediated in terms of culturally structured and shared symbols (Parsons, 1951).

Figure 4. Two-actor network model of actors in a social system perspective



Source: Groen, 2005

Parson has inspired the 4S framework theoretical model of Groen *et al*. (2002) whereby entrepreneurs strive for goal attainment by developing novel action patterns within the framework of existing patterns of behaviour, which are shared within a cultural context. If one were to adopt a social system theory model that is in turn based on an approach which encompasses an entrepreneurship-in-networks viewpoint, then it becomes necessary to understand the entrepreneurial process of value creation. For this, one may regard entrepreneurship as a process wherein through interactions among themselves, the various actors recognise available opportunities, take steps accordingly in order to prepare and exploit the recognised opportunities and thereby create value (Van der Veen & Wakkee, 2004, p. 117). This process is not tension free however, as resistance to such opportunities arises from other actors and systems within the established structure of society (Groen, 2005, p. 69). Further, through their above actions the entrepreneurs try to optimise their rewards continuously, resulting in higher effectiveness and efficiency in their processes. This leads to greater integration of their actions through directly and indirectly interacting with other actors. This results in the creation of a four-dimensional space which accurately describes the development of the entrepreneur. In each of the dimensions, there is accrual of capital by the entrepreneur (Leloux & Groen, 2009, pp. 10–11), namely:

i. Strategic capital

Actors that strive for goal attainment through motivation—this results in an establishment of the scope of their actions thereby resulting in strategic capital. These goals, when combined with the ability to influence other actors through power or authority, can influence the behaviour of the other actors leading to an alignment of goals resulting in *strategic capital* of an actor within the network. Knowledge of the goals and power basis of the various actors can help to determine the degree of cooperation or conflict. Further, by estimating the worth of the R&D to the strategic capital of the own company or to a partner in the strategic alliance, one can estimate the value of the R&D (Groen *et al*., 2002, pp. 4–5). Strategic capital includes strategy to develop its knowledge so that it can facilitate its entry into the market, make use of intellectual property licensing possibilities, etc. (Leloux & Groen, 2009, p. 12). An entrepreneur's strategic choices—whether to focus on domestic or foreign markets determines the potential customers and competitors (Van der Veen & Wakkee, 2004, p. 129). Using international IPR instruments (such as triadic or European Patents) can help in formation of suitable strategic choices.

ii. Cultural capital

Maintenance of patterns of culturally structured and shaped symbols—this results in gaining knowledge of how to do things efficiently and effectively leading to relatively fixed skill patterns. The maintenance of these patterns is a basic mechanism within the social system. Further, actors can also learn, leading to the institutionalisation of such patterns of behaviour. Changes in technology or markets results in adaptations within such patterns. To know and to have experience about successful behaviour patterns results in *cultural capital*. These can be influenced by old traditions or new practices. When societal values and old norms apply, it shows that earlier traditions can be built upon. The absorptive capacity of a company is the key and it depends on explicit and tacit knowledge. Physical and environmental constraints can work on the actors, who nonetheless develop their positions using various resources while interacting with other actors (Groen *et al*., 2002, pp. 4–5). Cultural capital includes finding the required resources being both human and organisational, including resources related to knowledge and technology, including indulging in patenting activities (Leloux and Groen, 2009, p. 12). Entrepreneurial behaviour is often seen as being socio-psychological in nature. It could also be perceived as having socio-cultural tones. Outside factors such as ethnicity, masculinity/feminity issues, family background, etc. are known to influence entrepreneurial behaviour (Van der Veen and Wakkee, 2004, p. 121). Studies on specific ethnic groups have shown how they encourage new business start-ups.

iii. Economic capital

Optimisation of economic processes—this results in behaviour which is economically efficient. This leads to *economic capital* of the actor. It helps to make production of R&D more efficient and answers questions regarding the amount of financial or monetary contribution (Groen *et al.*, 2002, pp. 4–5). Economic capital includes identification and mobilisation of financial resources in order to create an effective business model (Leloux & Groen, 2009, p. 12).

iv. Social capital

Actors bring with them financial capital (cash, reserves, etc.), human capital (charm, intelligence, health, etc.) and social capital (relationships with other actors which provide opportunities to use the above financial and human capitals). Parties in a relationship own social capital jointly. It helps to convert financial and human capital into profitable ventures. Social capital is thus very important for being competitively successful (Burt, 1995).

Actors who interact among themselves by means of scope, scale and skills—such interaction results in integration of the actions in the larger system as a whole and also to mutual adjustments of actions. This interaction is based on cohesiveness of relations and the position of actors in social networks, leading to the *social capital* (Groen *et al*., 2002, pp. 4–5). Entrepreneurial opportunities can be recognised depending upon the degree of embeddedness within a social context (Van der Veen & Wakkee, 2004, p. 122). Acquisition by entrepreneurs of information, advice and resources is possible through the network (Van der Veen & Wakkee, 2004, p. 121).

Networks are voluntary, patterned relationships between interdependent actors and encompass durable exchanging, sharing or co-developing of new products, services and/or technologies. They could be created by entering into strategic alliances, forming joint ventures, licensing, subcontracting, jointly conducting R&D and/or marketing activities, sharing of interdependent activities and resources, etc. Thus one can see that networks comprise multiple levels of aggregation. These could be micro (for example, individual actors) or meso levels (for example, trade organisations). These networks could also be global in nature (Groen, 2005, p. 72).

The interactions within a network could take place in the form of relational patterns (for example, intensity, multiplicity, etc.) or positional aspects (for example, equivalency of positions). Other aspects include hierarchy, brokerage relationships, or even structures, which become redundant (Groen *et al*., 2002, pp. 4–5). Social capital is most often recognised as being attainable through networking (Leloux & Groen, 2009, p. 12). When it comes to the aspect of networking, generally those entrepreneurs will likely succeed in regard to entrepreneurial networking that share more complementary capitals with their partners (Groen, 2005, p. 81). However, it should be noted that the overemphasis on consensus in relations is a flaw when it comes to using social systems theory in the structural functionalist approach in sociology. This is because there are bound to be differences between the actors who cooperate among themselves, and thus only those entrepreneurs who are highly aware of the differences in the 4S capitals compared to their partners will succeed in networking (Groen, 2005, p. 82).

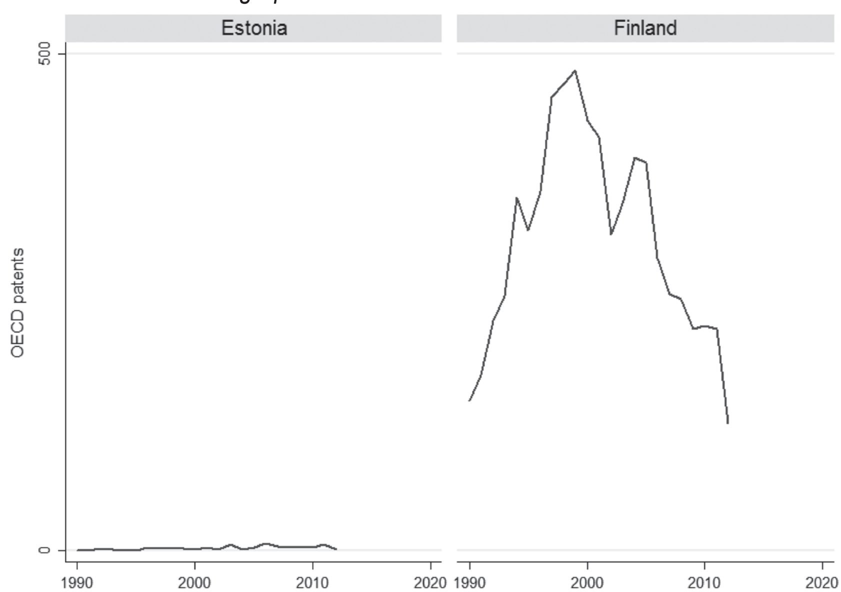
Thus, inspired by Parsons, one could state that entrepreneurs act purposefully while interacting with other actors. All the four mechanisms work in a concurrent manner and cast an influence (in a structured, non deterministic manner) upon the outcomes of a social system. However, each of the above listed mechanisms results in the production of its own types of processes and as a consequence their own types of capital, and consequently there exist specific methods of intervention for each such process. It is imperative that the processes have to be appropriate (in an economic context). Thus corruption, monopolistic behaviour, etc. are deemed inappropriate. On the other hand, the use of financial incentives, cost cutting measures, training and education, new technologies, etc. are seen as appropriate forms of intervention within the dimensions of entrepreneurial networking (Groen, 2005, pp. 74–78).

4. Collection of data for conducting this research and the preliminary results

Patent data is obtained from the OECD database (2018).[3] It includes 26 countries for years 1990–2015 and all patent applications. The study mainly focuses on the triadic patent with priority date, which is the indicator for assessing technological strengths of nations. Triadic patents are those patents registered in the triad regions, i.e. in North America, Europe, and Asia with "priority date" where priority date means that when a first application is submitted in a country—the priority—and is then extended to other offices.

The definition of triadic patent family is "*A patent family: the same invention in order to be protected is registered in various countries as a set of patents. Triadic patent families are a set of patents registered in the EPO, the JPO and the USPTO. Numbers and per million inhabitants express triadic patent families.*" (OECD, 2018).

Figure 5. Number of Triadic patents (calculated from the OECD database), Author's own graph



3 The data is for a group of OECD countries for years 1990–2015. The countries are: Estonia, Latvia, Finland, Sweden, Norway, Denmark, Germany, France, Italy, United Kingdom, Luxembourg, Austria, Belgium, Czech Republic, Greece, Hungary, Iceland, Ireland, Netherlands, Poland, Portugal, Slovak Republic, Slovenia, Spain, Switzerland, and Turkey.

In this paper, the variables the authors are interested in are the number of patents for each country 'oecd_pat', the population level 'pop', the education level mainly as tertiary education expressed in thousands 'ed3_1000' and as per cent 'ed3_pcent' as indicator for education policy and highest level of education completed by each person; the expenditure for each country in R&D (in thousands and per cent) as gross domestic expenditure on R&D 'rd_mpps' and as a percentage of GDP 'rd_gdp' and the expenditure for R&D personnel total 'rd_per_tot' and only personnel researchers 'rd_per_re'. Descriptive statistics are presented in Table 1.

Table 1. Descriptive statistics

Variables	Estonia				Finland				OECD countries			
	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
oecd_pat	2.37	2.09	0	7.11	312.0786	103.9119	128.2246	483.8497	572.01	1195.42	0	7637.78
ed3_1000	253.68	16.16	227.4	273.4	1086.742	80.11386	964.1	1209.2	2797.23	3459.43	33.3	13716.40
ed3_pcent	29.93	2.40	26.4	33.3	31.46667	2.396715	28.2	35.5	23.83	7.22	8.4	39.60
rd_mpps	219.68	124.61	69.40	457.43	3829.16	1349.108	1798.529	5504.323	9068.56	13733.64	56.45	71842.57
rd_gdp	1.17	0.53	0.57	2.31	2.9664	.6019266	1.82	3.75	1.59	0.83	0.33	3.91
rd_per_tot	8444.69	1490.08	6531	10284	69882.5	12557.71	42508	80817	114287.6	145783.1	2180	860842
rd_per_re	6145.69	1242.58	4458	7646	54781.3	2469.263	50773	57549	73047.12	84862.04	1321	549283

Notes: OECD Dataset, 2018

5. Analysis

One can easily see the vast disparity between Estonia and Finland when it comes to the number of triadic patents, the population level, the education level mainly as tertiary education (as indicator for education policy and highest level of education completed by each person), the gross domestic expenditure on R&D as a percentage of GDP and the expenditure for total R&D personnel and for personnel researchers.

But this is not simply the result of ad-hoc Finnish policies. Research shows the role that higher education levels, increased technological sophistication of society, universities as centres of excellence, IPR generation through government and private funded R&D activities, and commercialisation of IPR through networking, collaborations, etc. have played in Finland.

According to Statistics Finland, research and development expenditure amounted to 5.9 billion euros in 2016. Expenditure was reduced by 145 million euros from the previous year, but this reduction was because of the business enterprises sector. The Finnish Government and Finnish research institutes maintained R&D expenditure levels as previously (OSF, 2017).

Considering the impact that innovation policy tools (such as subsidies, grants, low interest loans, tax incentives, etc.) and R&D collaboration have on enterprise behaviour, a study of Finnish enterprises shows that public funding by TEKES (the Finnish National Technology Agency) is a very important source of finance for their R&D purposes (Czarnitzki *et al.*, 2007, p. 1347).

In Finland direct subsidies (as matched grants where costs are shared between the applicant and government, preferably in the field of collaborative research agreements) and loans are very important innovation policy tools. Furthermore, in Finland universities and/or government research institutes cooperate very closely and develop deep networks with industry. Since Finland is a small country, emphasis is also laid on international cooperation. Collaborative research for R&D projects is seen as being potentially beneficial due to positive spill-overs. It also helps to share costs and risks (Czarnitzki *et al.*, 2007, p. 1349).

Research shows that in the case of Finnish enterprises, export orientation has a significant (and positive) influence on the providing of funding by TEKES to that enterprise. Economic viability of the results of the funded project is another important factor that is considered by TEKES, along with the enterprise's competitiveness and the competitive advantage of the technology involved in the project (Czarnitzki *et al*., 2007, p. 1359).

The data further shows that collaboration and funding result in increased R&D spending. Finnish enterprises tend to spend significantly more on R&D when they are provided subsidies. Conversely, Finnish enterprises that do not receive/apply for funding or collaboration spend less on R&D. Thus one can see that in the case of Finland, collaboration by enterprises in the field of R&D and also receipt of R&D subsidies by enterprises results in positive effects in the groups actually receiving such treatment, when compared with the absence of such treatments (Czarnitzki *et al*., 2007, pp. 1362–1363).

Finland is a small country with approximately 20 institutions which hold a university rank. The Finnish case study also showcases the high concentration of inventive academic activity that can be found in a limited number of key actors (both organisational and individual) (Meyer, 2003, p. 26).

Interestingly, an analysis of Finnish patents before 1990 shows that the Finnish patent office granted 3 times more patents than in 1971. Two thirds of the patents belonged to firms (Grönqvist, 2009, p. 161). Finnish patents for inventions in the fields of chemistry, pharmaceuticals and electrical engineering were 10 times more valuable than patents for other technologies. Firm patents were 1.5 times more valuable than private patents (Grönqvist, 2009, p. 160). Firm patents were more valuable perhaps because firms have more means for innovation purposes and subsequently more incentives to use such patents, often in a strategic manner. Private applicants on the other hand may be inclined to patent their inventions for non-economic reasons (Grönqvist, 2009, p. 166).

Although Finland is one of the world's most ICT-intensive economies, the data shows that while Finnish academic patents are generally related to the telecommunications field, the Finnish economy is very specialised in that particular area alone, much more than university patents in that field (Meyer, 2003, p. 24).

Most Finnish university related patents are assigned to large companies such as Nokia, Orion, Valmet, etc. which dominate the cooperation field with Finnish universities. Start up companies utilise academic patents to a lesser degree (Meyer, 2003, p. 25).

The small size of the Finnish economy enables effective networking because of low transaction costs in finding appropriate partners for collaborating. Furthermore, Finnish technology policy prioritises strong networking and cooperation between firms themselves and also at the science-industry level. This includes horizontal and vertical cooperation at a pre-competitive stage as well as networking between SMEs and R&D institutions and/or large companies. Large companies are only eligible for funding if they cooperate with SMEs and R&D institutes (Czarnitzki *et al*., 2007, p. 1350).

When comparing Finnish academic patents to university-owned patents, research shows that only 36 Finnish universities owned patents were found in the USPTO database, hence highlighting the inadequacy of this indicator. The number of Finnish scientific articles cited in Finnish–US patents is higher. Most citations referred to highly science-related subjects such as biotechnology, pharmaceuticals, ICT, etc. (Meyer, 2003, p. 20).

When studying patented inventions owned by university researchers (between 1986 and 2000), 530 US patents were found. Telecommunications, instrumentrelated patents, biotechnology, pharmaceuticals and organic chemistry patents were on top of the list (Meyer, 2003, p. 21).

It is important to note that in Finland, the law dictates that researchers (and not the university where they work) own all the rights to their inventions. The data shows that Finnish university researchers are located in key institutions (in 2–3 top universities). University-associated patents were owned by a minute number of institutions. Key inventors were responsible for most university-related inventiveness (Meyer, 2003, pp. 22–23).

Thus, research shows that public incentives and collaboration both positively impact the treated Finnish enterprises and also result in increased innovation output, which can be measured by the increase in subsequent patenting activity (Czarnitzki *et al*., 2007, p. 1364).

6. Conclusion and suggestions

The conclusion for Estonia from the abovementioned Finnish example is that the 4S framework theoretical model of Groen *et al*. (2002), whereby entrepreneurs strive for goal attainment by developing novel action patterns within the framework of existing patterns of behaviour, which are shared within a cultural context, is important for the wholesome development of Estonian society. To make the Estonian economy knowledge-driven and technologically intensive, the state must focus on cultural, economic, social and strategic factors. Education, collaboration, coordination and grants are the way forward.

It is essential that IPR consultancy services should be offered as an integrated package, serving as a one-stop shop. This helps to pool resources and experts to provide critical information and knowledge (PRO INNO Group, 2007, Ch. 7 §10).

Support is very important for entrepreneurs. Studies have shown the impact of venture capitalists, universities, regional development support systems and incubators. Factors such as socio-economic, cultural, technological and political factors play a big role in inspiring and stimulating new business ideas (Van der Veen & Wakkee, 2004, p. 122).

In view of the above observations and prior published research (Ferraro *et al*., 2017) in this matter, the authors are of the opinion that the Estonian state should involve itself more in matters of development of IPR strategies by Estonian

SMEs and entrepreneurs. Fears that such direct action by Estonia would be violative of the provisions regarding State Aid under Article 107 of the Treaty on the Functioning of the European Union are unfounded as Article 107 (3) (c) specifically provides that facilitation of the development of economic activities of economic areas, within reasonable limits, is allowed. Further, as provided in the State Aid Rules, innovation aid can be provided to SMEs for various IPR-related activities. The rules also provide for subsidising RDI cooperation between SMEs and large enterprises (Nyman-Metcalf *et al*., 2011).

Raising awareness among SMEs regarding good management practices related with IPR, coupled with an efficient support architecture and followed with practical professional advice on IPR issues will help SMEs to exploit their RDI outcomes and to face cross-border IPR challenges. In this connection an easily accessible website where supporting legal documents, support service, list of frequently asked questions catalogued based on subjects, case studies, e-learning tools, IPR news service, etc. would prove to be invaluable for providing user-friendly information which is easily understandable by business persons with a non-legal background. A free of charge helpline, which promises adequate responses from a pool of IP experts within a prescribed period, would also be very helpful. Such a helpline could feed the above website with a wide database of frequently asked questions. Also important are IPR training programs and e-learning tools using EPO tool kits. Awareness about IPR issues should be increased by the use of promotional tools and a focussed marketing strategy. There is also need for an enhanced cooperation between the national patent office and state universities, other national IPR organisations, institutions responsible for enforcement of IPR, innovation agencies, agencies responsible for development of local regions, etc. at the national level and with the EPO, European Union Intellectual Property Office, World Intellectual Property Organisation, etc. at the international level. All of the above should be subject to measurement of satisfaction of the users through the use of effective monitoring tools such as surveys, website feedback mechanisms, etc. (European Commission, 2014a).

In view of the above, the authors recommend as follows:

a. Compulsory advanced training regarding IPRs in schools and universities:

Awareness of the various modes of commercialisation of IP, the different models, where for instance Competition Law considerations (such as patent pools, state aid, settlement agreements, licensing criteria) are relevant, the legal obstacles arising as a result of the above and awareness regarding how the state (for example, Enterprise Estonia) can help the businesses.

Management of intellectual assets should find prominence in the curricula of business schools. It should also be promoted when a business is registered or when any type of public assistance is provided to SMEs (European Commission, 2014b). General and specialised courses on IPR and commercialisation of IPR should be taught in an imaginative manner during all levels of education (PRO INNO Group, 2007, Ch. 7 §3). Prior knowledge and experience are good sources for business ideas. If an individual is offered relevant education and training, then the probability of discovering promising ideas increases (Van der Veen & Wakkee, 2004, p. 136).

Very often there is too much focus on patents. Even though they may not be the ideal choice for SMEs, especially if there is a lack of resources for the purpose of patent litigation. So using the number of patents filed as a performance metric can be misleading. Perhaps it would be advisable to see the situation in the US, where exists a network of experts who give free advice to SMEs. In Japan, there has been a focus on creating the right type of IP culture since 2002. Accordingly, IPR is included in the syllabi of high schools and universities. Also, IPR days are commemorated and larger enterprises are encouraged to cooperate with SMEs. This has led to greater awareness regarding IPR issues among the general public. The key is to increase the quality of human resources. Support services should be subject to regular review and assessment (PRO INNO Group, 2007, p. 30).

b. Government support in development of IPRs by offering tax credits or deductions for obtaining the newly developed Unitary Patents (UP) in Europe

Technology transfer through licensing for profit is very important for increased economic development. Fiscal incentives can help in this regard. Tax measures can be used for reducing the following: patenting costs, costs for acquisition of patents, costs for acquiring license rights and/or taxes on royalties earned from licensing of patents. Reducing taxes on royalties earned from patent licenses can be either general in nature (which are designed to encourage more patenting—for example as followed in Ireland, Hungary, Switzerland, South Korea, etc.) or specifically applicable only when it relates to non-exclusive licenses (which are understood as being more economically efficient as they are better at promoting the wide spread of research, as compared to exclusive licenses which bring immediate benefits only to the licensor and not to society as a whole). Tax incentivisation of RDI expenses should also be extended to acquisition of patents. Since taxation is in the area of national competence, Estonia would have to decide whether such measures should be covered by its State Aid rules (PRO INNO Group, 2007, Ch. 7 §13).

Such tax incentives are often advantageous (when compared with grants) as they allow firms to decide which R&D projects they want to be funded. They can also lead to a rise of private investments in R&D and boost R&D start-ups. However, they have the potential to increase tax competition between countries or regions. They can be in the form of expenditure based tax incentives (e.g., special R&D tax credits/tax allowances and payroll withholding tax credit for R&D wages), income-based tax incentives (e.g., preferential rates on royalty income). Some interesting instances of R&D tax credits/allowances by various countries are mentioned in the OECD report (OECD, 2010).

c. Grants/subsidies for obtaining UPs

Some experts are of the opinion that grants or subsidies could be useful to encourage higher patenting by SMEs, when compared with tax incentives. However, such subsidies carry the risk of distorting competition and/or creating a situation where patenting activities become over-emphasised, often to the detriment of the actual business plan of the SME. Designing such subsidies is an exercise not entirely devoid of controversy, since it can impact SME business behaviour and can sometimes be open to abuse. To counter such tendencies, in some countries (like France, Germany, etc.) patent subsidies are provided to SMEs only when they apply for a patent for the first time. Other countries, such as Ireland, provide subsidies for multiple patent applications by the same SME on a case-by-case basis (PRO INNO Group, 2007, Ch. 7 §12).

d. Subsidised loans for obtaining UPs

Providing micro-financing options to SMEs in order to help them to acquire UPs can be very helpful. For example the European Investment Fund and local banks can help micro-businesses to coordinate their efforts with the EPO to partly finance UP applications. Such instruments have been used recently to provide funding under the EU Programme for Employment and Social Innovation (EaSI) whereby loans of up to 25,000 euros have been provided in specific instances (ERR, 2018).

e. Loan guarantees for obtaining UPs

f. Lower official fees / Refund of official fees for UPs

Costs for acquiring patents and for legal protection of IP are very often the main stumbling blocks for SMEs to subscribe to a formal IPR system. Thus SMEs very often focus on informal protection systems such as trade secrets. As we are aware, the cost of patenting is very high in Europe compared to USA or Japan. The UP will hopefully help to reduce costs. But Estonia can do more by allowing small companies to be subject to lower filing costs (like in USA) (PRO INNO Group, 2007, Ch. 7 §12). Since the level of fees for the UP will be decided by the EPO (with a provision for sharing of this revenue between the EPO and the Estonian Patent Office), Estonia can decide that from the above share received by the Estonian Patent Office, a small sum can be refunded back to the Estonian SME UP applicant.

In USA and Japan patent applications and their maintenance costs are reduced by 50% for SMEs. Italy had in 2006 abolished patent renewal fees but these were later reinstated (PRO INNO Group, 2007, Ch. 7 §13).

g. Certification standard

Creation of certification standard for management of intellectual assets, which would serve as a common reference point and training aid. Care should be taken to avoid it turning into another meaningless formal burden on SMEs (European Commission, 2014b).

h. Cooperation through licensing

Technology transfer through licensing for profit is seen as the key to development of the economy. In Japan, the Technology License Offices (TLO) have been very successful since 1999 and are worth emulating. They employ IPR experts who are initially encouraged and later obliged to work for profit. Some of the revenue generated through getting a share of the IPR license income obtained from supported SMEs is given as bonus/rewards to the TLO managers. This has resulted in patent applications by SMEs to substantially increase, resulting in higher revenue earned from licensing (PRO INNO Group, 2007, p. 31).

Development of toolkits to provide solutions for greater cooperation between SMEs, universities and larger companies, both within and outside Estonia could be helpful. Model contracts for collaborating in research activities with special emphasis on IPR provisions should be made available. Existing coordination networks should be rationalised so that access for SMEs is made simpler (PRO INNO Group, 2007, Ch. 7 §8–9).

i. Coordination between different offices to provide support

IPR support services can be provided within Estonia by the national patent office or by specialised agencies, which deal with technology or its development. It is important to strengthen the links between these organisations and also have a high level of exchange of staff between them. IPR support could be provided by the public sector (especially in the fields of raising awareness, providing passive information, general IPR training, and providing subsidies and/or legal framework) or through the private sector (especially in the fields of IPR training, detailed consultations and legal advice, etc.). Thus the Estonian Patent Office can provide low-cost patent searches while the private sector can provide specialist legal/business advice. The public–private partnership can be very helpful for developing IPR. More important is that the services (database searches, grant of IPR rights, etc.) should be delivered quickly and smoothly (PRO INNO Group, 2007, Ch. 7 §6–7). Local SMEs should be provided with IPR services at the national and regional level (PRO INNO Group, 2007, Ch. 7 §10). Thus, for example, regional outlets in Tartu, Pärnu and Narva can promote these services and also refer potential SME customers to the head office in Tallinn.

j. Insurance

Insurance companies and retail banks are more aware of IPR valuation methods and thus accept filed patents as collaterals for commercial loans (PRO INNO Group, 2007, pp. 30–31).

Since most SMEs find enforcement of patents to be extremely burdensome and expensive, they often tend not to possess patents. Some experts opine that providing SMEs with some form of legal insurance scheme would help avert this situation by giving SMEs the freedom when to litigate and also whether to litigate or not. Such legal insurance schemes coupled with low-cost legal opinions regarding chances of success with regard to patent litigation (as provided in the UK) would be very helpful (PRO INNO Group, 2007, Ch. 7 §12).

k. Lobby to EPO for making licensing of UPs easier and more cost effective by providing for standardised agreements and cash incentives

l. Make obtaining UPs a mandatory/preferred outcome for EU funded science projects under Horizon 2020

The authors hope that by following the above recommendations the Government of Estonia can provide meaningful and substantial support to SMEs to improve their IP portfolios, thereby aiding in the overall development of IPR in the Estonian society. This could prove to be the robust foundation on which Estonian enterprise can be built to master the challenges of the Fourth Industrial Revolution.

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