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High Technology Sector Internationalisation: Open Innovation Perspective

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Abstract. High technology sector faces contemporary management challenges related with open innovation processes. Innovation dissemination is influenced by various variables, which require broad level of collaborative, creative efforts and effective innovation management models for high technology companies. An open innovation development regarding inward and outward directions is important research topic. Main aim of the article is to discuss theoretical development in open innovation concept and internationalisation activities and to analyse cross border patenting activities as important element for internationalisation of innovation activities and sustainable inflow of new knowledge. To increase global competitiveness high technology sector actors need to understand important elements of innovation internationalisation process and adopt effective practice.

Keywords: 6–10 open innovation, high technology sector, technology transfer, innovation internationalisation, and patents.

1. Introduction

High technology sector is considered to be on of the important drivers of economic and employment growth in industrialised and developed countries. Globalisation of internationalisation activities and democratisation of research activities influences high technology sector developments. In European Union countries, high technology sector activities are considered to be crucial to achieve the desired structural transformation of economies (European Commission 2008). Development of innovations at global level is mainly related with high technology sector. Pharmaceutical and biotechnology industries, technology equipment and automotive sector investments accounts for 50,2 % of all global R&D investments (Hernández 2013). Classification of high technology sector is multidimensional and often is based on the regional contexts. In practical and theoretical studies OECD classification, which is focused towards industry (sectorial approach) and produced goods (product approach) (Hatzichronoglou 1997) is used. This classification includes direct and indirect scientific research and technological development, but other factors like scientific personnel, intellectual property of technology, licenses and know how, strategic technological partnership among companies.

Internationalisation processes drive high technology sector, which amplifies open innovation context. Internationalisation activities can be oriented towards inward and outward directions. In 2010 European Commission implemented new sectorial study, with revised evaluation (Loschky 2010). Evaluation is based on scientific research and development intensity, which could be described as ratio between investment into R&D, production output and value added. Authors (Glasson, et al. 2006) provides high technology classification and concept definitions (Table 1)

Table 1. Main high technology sectors definition concepts

Authors	Criteria used to identify high-tech sectors	High technology parameters
Butchard (1987)	R&D expenditure (as percentage of turnover) and qualified scientists & engineers (as percentage of all full-time employees).	Either R&D intensity at least 20% above the all-industry average, or R&D intensity above average (but by less than 20%) and an above- average percentage of qualified scientists & engineers.
OECD (1997)	Uses three measures of R&D intensity, based on R&D expenditure—direct R&D spending as (a) percentage of total output, (b) percentage of value added, plus (c) direct and indirect R&D spending as per-	Sectors defined as high-tech have the following values for the three measures: (a) at least 8.0%, (b) at least 18.7%, (c) at least 9.4%. A further category

	centage of total output.	of medium-high-tech sectors is also identified. For these sectors, the percentage values are: (a) 1.6–5.1%, (b) 4.0– 13.7%, (c) 2.6– 6.6%.
Hecker (1999)	Percentage of technology- oriented workers and percentage of workers engaged primarily in R&D.	If both percentages are at least twice the all-industry average, the sector is defined as high-tech.
Loschky (2010)	High-technology is usually defined via the R&D expenditure in relation to the production output or to the valued added. This ratio is called R&D intensity.	R&D intensity is below 1.0%: low-tech R&D intensity is between 1.0% and 2.5%: medium-low-tech R&D intensity is between 2.5% and 8%: medium-high-tech R&D intensity higher than 8%: high-tech

R&D intensity, e.g. investment level into scientific research is fundamental decision for technological strategy. Competitive advantage based on product and process innovations is crucial for success of technology-based companies. Investments in R&D could create barriers for existing companies through patents and enable new companies to overcome it by using of innovative technologies. In the context of this study its important to understand main factors related with open innovation output and input internationalisation, specifically to analyse internationalisation levels based on patent output.

2. Open innovation and internationalization theoretical developments

Global research and development networking and fast developments in virtualization created open innovation platforms, which creates many possibilities. Open innovation activities plays important role for internationalisation of high technology sector. The open innovation idea is based on the new evolutionary business model, which encompasses opening of company innovation process to the external environment actors. In other words it discusses purposive inflows and outflows of the knowledge to accelerate the internal innovations, and to expand the markets for the external use of the innovation (Chesbrough 2011). This broad description of open innovation points towards effective transfer of knowledge and technologies to both directions (inward and outward). Open innovation processes combine internal and external ideas into architectures and systems (Chesbrough, et al. 2006). Main studies on open innovation are focused

on externalization of R&D activities (Enkel, et al. 2009). Open innovation can be categorized by using company perspective Enkel et al (2009):

(1) The outside-in process: enriching the companies own knowledge base through the integration of suppliers, customers and external knowledge sourcing. The ability to access knowledge, technology, and information through relationships with other firms facilitates open innovation, which helps the firm effectively implement it Sisodiya et al (2013).

(2) The inside-out process, which refers to earning profits by bringing ideas to market, selling IP, and multiplying technology by transferring ideas to the outside environment (Lichtenthaler 2009). Inside out process and results generally are characterised as high tech sector descriptive criteria or output measurements (Glasson, et al. 2006). In the context of this article detailed analysis of innovation activity external output is not considered for detailed analysis

(3) The coupled process refers to co-creation with complementary partners through alliances, cooperation, and joint ventures during which give and take are crucial for success. This process can be described as knowledge co-creation. Selection of strategic alliance partners requires multiple criteria evaluation: characteristics of partner, degree of fitness, intangible, marketing knowledge capabilities, complementary capabilities (Wu, et al. 2009). Open innovation stresses the abundant landscape of external knowledge outside firms waiting to be captured by them and converted into profitable innovating products and services (Chesbrough, et al. 2006). Open innovation performance is even greater in information rich contexts (Sisodiya, et al. 2013). It is very important for companies to create information and knowledge surrounding by including various actors (scientific, industrial, multidisciplinary) in network. Open innovation creates platforms for extensive collaborative research activities.

For analysis of newest technological models is important to understand system of high tech sector activities (see Table 2). Important aspect of high tech sector is to increase input parameters. External policy measures and public research directions has direct influence on input parameters, also new networking opportunities and flexible collaboration structures allows to achieve greater input results. New key enabling technology concept by EU has impact on input parameters by creating new opportunities and cross-sectorial collaboration possibilities. Key Enabling Technologies (KET) are one of the key factors to realise the overall policy objectives of Europe 2020, due to the importance of these technologies for the competitiveness and innovation of European enterprises as well as for the development of sustainable products and processes (Larsen, et al. 2011). This new strategy indicates transformation of traditional understanding

about high technology sector and opens new opportunities for industrial development in European Union. It also leads to the new theoretical and methodological research directions aimed at effective technology management and transfer processes among industry players.

Table 2. High technology sector understanding

OECD high- tech classification (1997)	Eurostat high tech classification	European Commission (2010), Key enabling technologies	Lithuania (2011), Key enabling technologies
Aerospace Computers, office machinery Electronics-communications Pharmaceuticals	Aerospace (35.3); Pharmaceuticals (24.4); Computers, office machinery (30); Electronics-communications (32); Scientific instruments (33)	Nanotechnology Micro- and Nano electronics Industrial biotechnology Photonics Advanced materials Advanced manufacturing systems	Biotechnology Mechatronics Laser technology Information technology Nanotechnology and Electronics

New focus on KET requires allocation of critical mass in knowledge and funding through increased synergy effects. Lack of market focus for R&D activities (European Commission 2012, Larsen 2011) creates challenges for search of effective technology transfer models. New policy directions are in line with global open innovation and networking trends. Understanding of open innovation processes and alignment with KET development issues is important contemporary research direction.

The European Commission defines KETs as 'knowledge intensive and associated with high R&D intensity, rapid innovation cycles, high capital expenditure and highly skilled employment. They enable process, goods and service innovation throughout the economy and are of systemic relevance. They are multidisciplinary, cutting across many technology areas with a trend towards convergence and integration. KETs can assist technology leaders in other fields to capitalise on their research efforts (SEC 2009).

The initial open innovation concept was vague and lacked concrete adoption frameworks for business context, especially in high technology sector. The new findings and theoretical analysis fill this gap (Eelko 2011, Dahlande, Gann 2010).

The open innovation idea is based on the new evolutionary business model,

which encompasses opening of company innovation process to the external environment actors. In other words it discusses purposive inflows and outflows of the knowledge to accelerate the internal innovations, and to expand the markets for the external use of the innovation (Chesbrough 2011). This broad description of open innovation points towards effective transfer of knowledge to both directions (inward and outward). Open innovation processes combine internal and external ideas into architectures and systems (Chesbrough, et al. 2006). Main studies on open innovation are focused on externalization of R&D activities (Enkel, et al. 2009).

Outbound open innovation refers to the outward technology transfer, and it suggests that firms can look for the external organizations with business models that are suited to commercialize the technology for outside organisations (Chesbrough, Crowther 2006). Outbound open innovation points to actively pursuing external technology exploitation, which refers to the commercialization of technological knowledge using licensing and other transfer means (Lichtenthaler, Ernst 2006). Open innovation concept is mostly used for enhancing of the R&D input and output inside the company. Internationalisation activities of high technology sector are underpinned with above mentioned open innovation paradigm. Internationalisation processes for high technology sector encompasses holistic view (Spence, Crick 2006). Initial catalysts for pursuing and maintaining an international strategy plus the subsequent triggers for international development could be classified into three categories: (1) existence and utilisation of existing contacts; this supports the networking view, (2) utilisation of resources, defined in a general sense to include financial and managerial resources (experience), enabling firms to become prepared for international development, e.g. targeting growth markets, supporting the resource based view of the firm (3) Reaction to environmental, including serendipitous, events that is consistent with the contingency view (Spence, Crick 2006).

Fast development of the new ICT technologies influences internationalisation processes (Sedoglavich 2012). Author demonstrates that firms tend to be influenced by the entry decisions made by other firms in the same/similar industry targeting the same market; and that a firm's technological capabilities and the advantages of specialized knowledge act as the constraints in the development of the firm's future international strategy.

High technology sector internationalization influenced by multidimensional process, which are focused towards outward and inward directions. For high technology companies these companies internationalization important as multidimensional process, by building cross-boundaries and knowledge augmenting

process (Rodriguez, Nieto (2012). Innovation processes are driven and influenced by the exploration and exploitation of new knowledge, which is embedded in different locations and may rely on different social and inter-organizational ties scattered across the globe (Onetti, et al. 2012)

High technology sector plays important role in contemporary global economy. Global economical crisis demonstrated that high technology sector is most immune element in economical system. Focused and effective high technology sector development is main priority for the development of advanced economies. High technology sector is strongly interconnected with internationalization and innovation activities. Contemporary theoretical frameworks lacks holistic understanding, based on rapid changes in open collaboration platforms. Complex understanding of contemporary high technology sector activities requires broad approaches, combining creativity, innovation and internationalization contexts, which allows focused development of high technology sector. Systemic technology management processes and new open innovation challenges in high technology sector are main priorities in regional and national levels. Open innovation paradigm, which influences formation of the global research and development value networks, plays important role in the development of high technology sector (Chesbrough 2003). Firstly this impact is realised through significantly increased realisation of scientific potential and transnational dissemination of research results.

Three dimensions (internationalization of activities, local vs. global) if the open relationships with outside organisations and focused activities influence the development of high technology companies. These three areas of the strategic decision- making (locus, modus and focus) are required to be integrated into a systemic approach of the management, which reflects the above-mentioned holistic nature of the growth processes for technology-based firms, where innovation and internationalization are deeply inter-connected. (Ontetti, et al 2012).

Internationalisation process can be oriented towards activities focused on product sales and export in international markets or extensive R&D activities based on effective research infrastructure and support (Dachs, Pyka 2010). Scientific excellence of the host country can be a major determinant for cross-border innovation activity. There is positive relation between the scientific capabilities of the host country and the number of patent applications due to the ‘asset-augmenting’ motive. A general proxy for the scientific and technological capabilities of the host country is its overall R&D intensity, measured by the share of aggregate R&D expenditures on GDP (Dachs, Pyka 2010). It is important to understand that intensive international research activities can connect

input and output activities and enhance organisational knowledge and lead to international patent activities (see fig 1.)

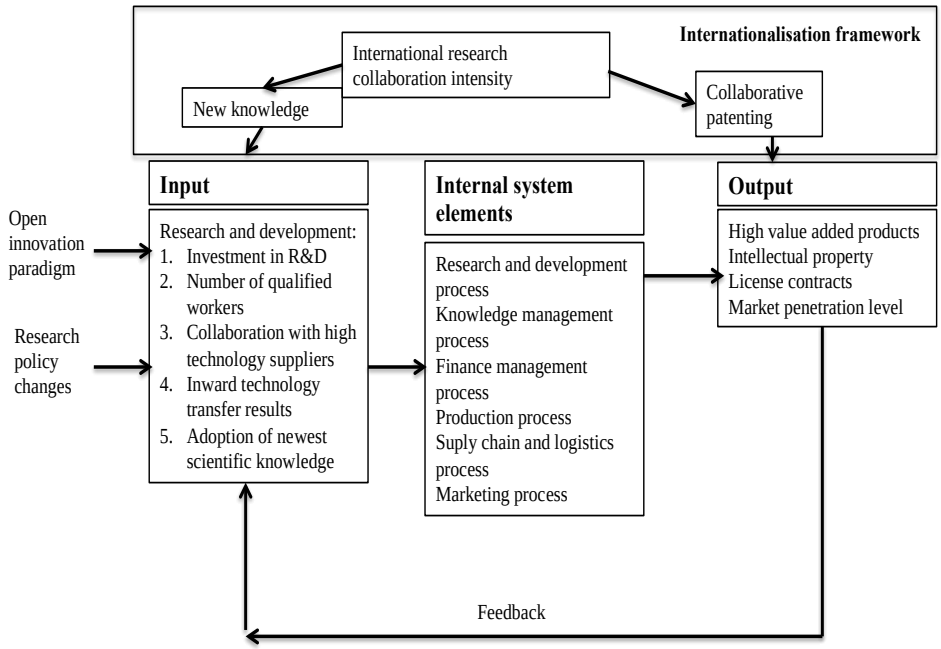

Fig. 1. System framework of high technology sector activities

Relations between innovation activities and internationalization are influenced by output criteria (patent cooperation) (Salomon and Shaver 2005, Pla, Alegre 2007). Internationalisation, commonly understood as the process of adapting firms operations to international environments, is an issue of importance for firms that often results on vital growth, useful learning outcomes and enhanced financial performance (Prashantham 2005). Technological advancement in information and communication technologies, innovative production methods, transportation, and international logistics, virtual collaboration creates new internationalization frameworks. The relation between collaboration and internationalization has already received attention in the literature. Alliances allow firms to ease or accelerate the internationalization process by providing them with access to partners' resources and capabilities that they need for international operations (Rodríguez, Nieto 2012). Cross-border collaboration allows firms to develop knowledge and capabilities for operations in foreign markets. High technology companies tend to internationalize quickly as a result of the rapid, technological and short life cycles in the industry and the dynamic nature

of the industry in which they operate as well as high R&D costs (Johnson 2004). Furthermore, the studies found that intense international competition and the extensive internationalization of their high technology industries necessitated rapid internationalization. (Johnson 2004). Internationalisation partnering can take a variety of forms, but mostly it happens in two forms—partnering with universities and partnering with other firms in alliances (including research consortia, joint ventures, and strategic alliances) to undertake R&D development (Fey, Birkinshaw 2005). Open innovation output and internationalisation level could be measured by evaluation of international activities related with patenting processes. Patent documents are widely used as indicators of R&D activities at the level of industries and individual firms because of certain advantages over other types of data (Smith 2005, Dachs, Pyka 2010). It is important to evaluate current developments in Lithuanian high technology sector development related with output activities.

New business models could be strong catalyst for internationalisation of high tech results (Onetti, et al. 2012), as well knowledge intensity and models for accumulation of innovation and scientific knowledge (Brennan, 2009). Bridging together two broad areas, commercialization of university-developed technology and international entrepreneurship, could be realised through the stages of internationalization (Styles, Genua 2008). Growth of high tech companies could be analysed by using dynamic capabilities models, expressed by opportunity search, resource acquisition and resource reconfiguration (Andersson, et al. 2014). Main objective of the research is to understand internationalisation levels of patenting activities in high technology sector.

3. High technology sector output context

Many high-tech firms are relatively new high growth businesses, but they can also include more established businesses in mature sectors, and indeed such firms appear to account for a disproportionate share of high-tech employment. Those characteristics are very important for knowledge management inside those companies.

The innovation activities and expenditures of Lithuanian companies in the innovation field indicate low involvement in external knowledge acquisitions. Also systematic R&D activities are low, which points out to weak internal knowledge creation systems. This shows lack of effective knowledge acquisition practices and systematic procedures.

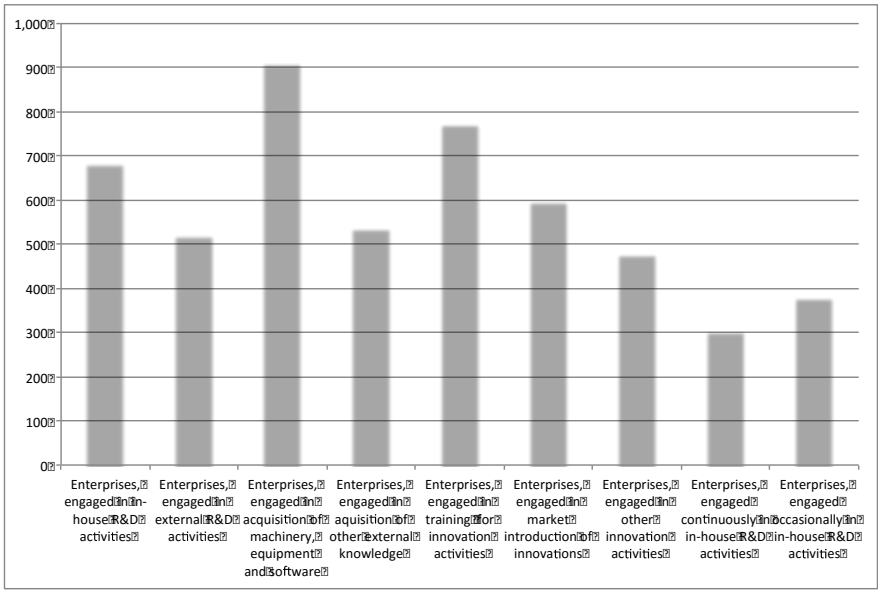

Fig. 2. Innovation activities and expenditures of Lithuanian companies in 2010 (Community innovation survey 2010)

Figure 2 indicates high level of engagement on the acquisition of machinery and software. This shows a clear direction towards the process efficiency. Results showed in figure give new possibilities for the development of the external collaboration tools. High level of the innovation training activities can foster innovation culture and create friendly knowledge absorption systems. The new statistical information (Innovation union scoreboard 2013) shows decreasing collaboration activity of innovative companies by 3.9 %. This indicates the slowing rate of open innovation practice. It is important to stress that innovation activities decreased by 3 %. Those figures represent the slowing innovation activity rate among innovative companies. From the statistics it is not clear how companies adopt knowledge for the development of innovation.

Lithuanian strongest key enabling technology is advanced material and photonic sectors (See Fig. 3) other sectors is weak, specifically in intellectual property area.

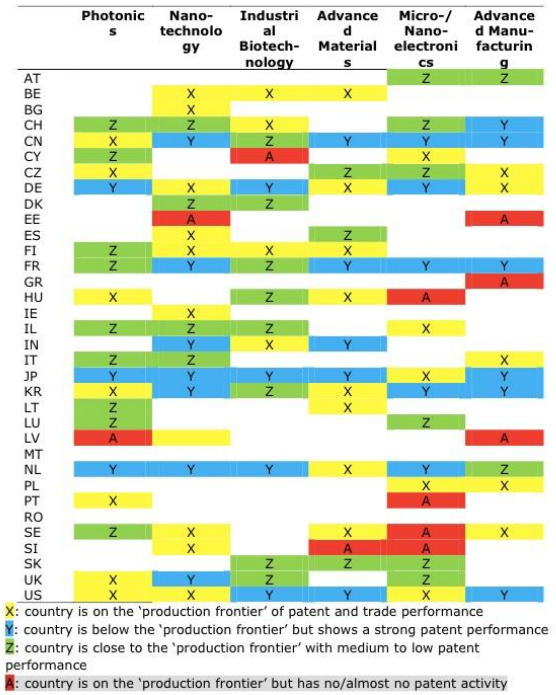

Fig 3. Overview of performance profile per country and Key enabling technology

Main innovation challenge for Europe in KET is to overcome the various barriers to commercial deployment of R&D base, the "Valley of Death" by linking together the various parts of the value-chain using for instance technology transfer mechanisms, supporting demonstration projects, and creating favourable market conditions for innovative (yet often relatively expensive) products (Larsen, et al. 2012). This gap between basic knowledge generation and its subsequent commercialisation into goods and services could be bridge by innovative public support services and mechanisms. During economical crisis high technology sector demonstrated better growth potential (see Fig. 4)

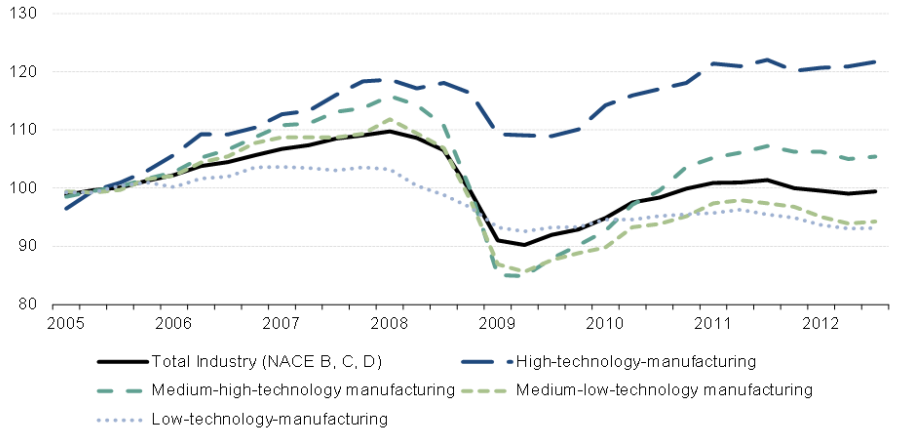

Fig 4. Index of production for total industry and main technology groups in manufacturing, EU27

Table 5. High- tech exports- exports of high technology products as share of total exports

	2007	2008	2009	2010	2011	2012	2013	2014
EU (28)	16,1	15,4	17,1	16,1	15,4	15,7	15,3	15,6
Estonia	7,8	7,5	6,9	10,4	14,8	14,1	15,0	16,3
Latvia	4,6	4,6	5,3	4,8	6,7	6,4	8,0	9,2
Lithuania	7,3	6,5	5,8	6,0	5,6	5,8	5,8	6,4

High technology sector dominates global patent market with international and high-level research results. Patent documents are widely used as indicators of R&D activities at the level of industries and individual firms because of certain advantages over other types of data (Smith 2005). Patents are useful for studies of the internationalisation of innovation: since a patent protects both the owner's and the inventor's rights, it contains information on the location of the applicant (owner) and on the inventor's place of residence (Dachs, Pyka 2010) and cross-border patents, which can be used as an indicator for the internationalisation of R&D activities.

High technology patent internationalisation

Patent activities in Baltic stated show uneven distribution of patenting activities with total output and sectorial perspective (see Fig. 5)

		Estonia	Lithuania	Latvia
Field of technology[1]		**Total**	**Total**	**Total**
Electrical engineering	Electrical machinery, apparatus, energy	**8**	**5**	**6**
	Audio-visual technology	**1**	**0**	**2**
	Telecommunications	**2**	**0**	**2**
	Digital communication	**8**	**1**	**1**
	Basic communication processes	**0**	**0**	**1**
	Computer technology	**12**	**1**	**3**
	IT methods for management	**3**	**0**	**0**
	Semiconductors	**1**	**2**	**2**
Instruments	Optics	**4**	**9**	**5**
	Measurement	**11**	**2**	**7**
	Analysis of biological materials	**13**	**0**	**1**
	Control	**6**	**1**	**3**
	Medical technology	**9**	**5**	**3**
Chemistry	Organic fine chemistry	**2**	**2**	**42**
	Biotechnology	**13**	**16**	**14**
	Pharmaceuticals	**6**	**3**	**22**
	Macromolecular chemistry, polymers	**1**	**0**	**2**
	Food chemistry	**2**	**4**	**2**
	Basic materials chemistry	**6**	**2**	**7**
	Materials, metallurgy	**7**	**5**	**12**
	Surface technology, coating	**1**	**0**	**4**
	Micro-structural and nano-technology	**0**	**0**	**0**
	Chemical engineering	**8**	**1**	**4**
	Environmental technology	**1**	**3**	**0**
Mechanical engineering	Handling	**4**	**3**	**3**
	Machine tools	**3**	**2**	**4**
	Engines, pumps, turbines	**2**	**1**	**3**
	Textile and paper machines	**2**	**1**	**1**
	Other special machines	**6**	**7**	**4**
	Thermal processes and apparatus	**4**	**2**	**0**
	Mechanical elements	**2**	**0**	**1**
	Transport	**4**	**0**	**2**
Other fields	Furniture, games	**2**	**1**	**2**
	Other consumer goods	**1**	**1**	**2**
	Civil engineering	**14**	**6**	**4**
	Total	**169**	**86**	**171**

Fig. 5. European patent applications by field of technology, 2014

Lithuania shows strongest results in biotechnology and optics sectors, but has lack in computing technology sector. Overall innovation output results for Lithuania in 2014 shows weak performance and requires adequate measures for development of international activities for high technology sector. Other internationalization indicators show inward and outward innovation activities related with patenting. It's important to understand level and quality of international research collaboration, which enables strong intellectual property results (see tables 6,7,8)

Table 6. Patents with foreign co-inventor (source: EPO)

	Total patents			Total co-operation with abroad			% Of patents with foreign co-inventor(s)			
	EE	LV	LT	EE	LV	LT	EE	LV	LT	EU
2012	19	31	48	6	3	10	31,6	9,7	20,8	10,9
2011	47	29	21	12	7	5	25.5	24.1	23.8	11.3

2010	70	22	22	35	12	4	50.0	54.5	18.2	10.9
2009	53	39	16	9	13	3	17.0	33.3	18.8	10.5
2008	60	31	53	24	9	11	40.0	29.0	31.4	10.4
Total	**249**	**152**	**160**	**86**	**44**	**33**				

Baltic countries demonstrate high level of international partners in their patent portfolio, comparing with EU union. Low percentage of foreign inventors means that markets are mature and capable to sustainably develop innovations domestically. This factor indicates that country has strong innovation potential. Also knowledge export is quite high in Baltic states (table), because high-level participation in external knowledge creation indicates strong research potential. Further studies regarding outward patenting process and research infrastructure and potential could reveal possible reasons for this phenomenon.

Table 7. Domestic ownership of inventions made abroad

	Total patents			Total co-operation with abroad			% Of patents invented abroad			
Year	EE	LV	LT	EE	LV	LT	EE	LV	LT	EU
2012	19	27	42	7	1	7	36,8	3,7	16,7	13,4
2011	37	23	19	4	1	5	10,8	4,3	26,3	13,4
2010	40	16	20	10	6	4	25	37,5	20	13,2
2009	40	26	18	6	1	5	15	3,8	27,8	12,9
2008	34	25	26	11	3	2	32,4	12	7,7	12,6
Total	**170**	**117**	**125**	**38**	**12**	**23**				

On the other side knowledge import activities and indicators related inward patent activities are much stronger in Baltic region. It indicates that for development countries inward research activities creates effective innovation output results and could be important factor for measurement of innovation potential.

Table 8. Foreign ownership of domestic invention

	Total patents			Total co-operation with abroad			% Of patents invented abroad			
Year	EE	LV	LT	EE	LV	LT	EE	LV	LT	EU
2012	19	31	48	5	5	11	26,3	16,1	22,9	14,4

2011	47	29	21	11	7	5	23,4	24,1	23,8	14,0
2010	70	22	22	34	12	5	48,6	54,4	22,7	13,5
2009	53	39	16	14	14	3	26,4	35,9	18,8	13,3
2008	60	31	35	33	9	11	55	29	31,4	12,9
Total	**249**	**152**	**160**	**97**	**47**	**35**				

Patent analysis is important to understand possible innovation and internationalisation intersection, with clear cross border collaboration.

4. Conclusions and further research directions

Theoretical analysis of open innovation in high technology sector indicates strong variation in methods for the development of innovative activities. Different directions towards outward or inward innovation developments require clear understanding of contemporary models. High technology sector faces challenges in European Union context, with growing impact of key enabling technologies. This new framework creates possibilities for creation of effective methods focused towards intellectual property transfer. New policy directions (Larsen, et al 2012) focused towards creative and useful transfer of knowledge among various industrial sectors for creation of sustainable economic development. Broad analysis of internationalisation theories shows strong intersection of innovation and internationalisation activities, mostly visible in intellectual property format. Also its important to understand that patents as output indicators refuel high technology system with new knowledge and creates constant innovation inflow. This indicates the importance of analysis for cross border inventive activities in high technology sector. Inward and outward patent collaboration indicators could be used in further evaluation models, based on multicriteria evaluation, including research input indicators. Quality of patent collaboration links indicates strong potencial for innovative activities in high technology sectors. It is important to understand that outward collaboration links shows strong research potencial and creates knowledge export possibilities. Analysis of international patent collaboration shows unstable development and radical changes, especially in case of Latvia. It’s important to stress that patent activites demonstrates higher level of international collaboration, than European average. First of all it is related with low patent activities in general and lack of sustainable practice. Each country also demonstrates patent specialisation in high technology sectors. In case of Lithuania it is important to stress that strong international science links are in biotechnology sector, which has strong scien-

tific base. It is important to evaluate that Estonia dominates innovation output results in case of patenting and have strong links with international corporations, which influence those results.

Research shows that developed countries has clear focus on inward research activities, despite high level of skilled staff (Lithuania case). Further research could identify main reasons for weak domestic inventive activities, which mainly are related with traditional input factors, based on investments for R&D activities and scientific human resources. New research directions could be focused towards creative factor influence on innovation output in high technology sector.

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