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INTERNATIONAL POSITION OF ESTONIA IN IMPLEMENTING RESEARCH AND DEVELOPMENT POLICY[3]

Abstract

The research and development policy (R&D policy) plays a central role in innovation policy since it consists of public sector measures that initialize and promote innovation. When designing policies in other areas (education, employment, fiscal, tax policy, etc.) the mutual interactions with R&D policy should be considered. The article first discusses the theoretical reasoning for public sector intervention in R&D processes. In general, the existence of market and system failures is used as a justification for government intervention. The government should intervene with adequate measures and only in an extent that is needed to overcome the failures. At the same time, the government should avoid overreacting and prevent giving state aid that distorts competition in the market. This study examines the level and structure of R&D policy resources and expenditures in EU member states and in countries that are closely linked to EU. Thus, the evaluation of the role of the R&D policy in innovation system is given. However, it has to be considered that different countries (small and large, developed and undeveloped, with open and closed economies) have different innovation policy goals and measures to achieve them. In addition, the R&D policy is designed in even wider institutional conditions. All of these qualitative aspects have to be considered when interpreting the results of quantitative comparative analysis of countries' R&D policies. The aim of the articles is to assess the international position of Estonian R&D policy in the aspects of resources and expenditures among EU member states and other closely linked countries in order to create the basis for an international comparative analysis of Estonian R&D policy. In order to achieve the aim, the following research tasks are posed and resolved:

• on the basis of research literature, the necessity, essence, measures and anticipated outcomes of R&D policy are explained;

• on the basis of empirical analysis, the assessment on the international position of Estonian R&D policy implementation among EU member states and other closely linked countries is given.

The data used in the empirical analysis (32 countries in years 2004, 2006 and 2008) is gathered from Eurostat database (including Community Innovation Surveys) and the component analysis is conducted. The results allow to design Estonian R&D policy measures that are based on acknowledged theoretical viewpoints and international experience.

Keywords

Innovation policy measures, Market failures, R&D policy, System failures

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1. Introduction

The central role in innovation policy development is executed by research and development policy (R&D policy), which represents the major complex of public sector measures to initiate and promote innovation. The objective of the current study is to assess the international position of Estonia among EU member states and countries closely associated with EU in respect of R&D policy implementation from resource supply and cost aspect. In order to achieve the objective, the following research tasks were set and fulfilled:

- through scientific literature the necessity amd nature of R&D policy were identified;
- through empirical analysis an assessment was given to the international position of Estonia in implementing R&D policy among EU member states and countries closely associated with EU.

The results of the research help to design Estonian R&D policy development measures, also taking into account theoretical approaches and international experience.

2. Theoretical background of research and development policy

2.1. Elimination of market failures

Already for decades attention has been focused on an aspect that R&D outcomes have more the nature of public than private good (Nelson, 1959; Arrow, 1962). To large extent, their consumption has no rivalry – the invention or innovation can be used in parallel and the utility can be acquired by endless amount of consumers without changing the nature of the innovation or invention (see Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1992). Still, there is market competition in R&D activity – the utility of innovation or invention for the first marketer remarkably decreases after it is being applied by competitors. From the viewpoint of the first user of invention or innovation, it raises an important problem of excluding unentitled persons (competitors) from the consumption of R&D work (the protection of intellectual property). As the protection of intellectual property is often so difficult and expensive, the economic rationality of its application should be considered. Therefore, the necessity of R&D policy is derived from the fact that due to the absence of competitive rivalry in consumption, it is not a pure private good and firms cannot afford excluding unentitled persons from the consumption of R&D work. The application of exclusion principles demands intervention of the public sector, as the owners of inventions (innovations) cannot cope with it for themselves. Still, the public sector intervention for excluding market competition because of the practical absence of rivalry in the consumption of the R&D results in most cases cannot be justified.

It should be checked whether public sector R&D subsidies really stimulate private firms to increase R&D costs (supplement them) or replace (substitute) them (Leyden and Link, 1991; Lach, 2002). Public sector R&D costs increase total social R&D costs when public sector support influences the private sector to provide R&D funds to projects that without the support would not be profitable (Klette et al., 2000; Wallsten, 2000; Jaffe, 2002; Tokila et al., 2008). A threat that public sector support will substitute private sector R&D costs emerges

inevitably in cases where the private sector has necessary resources but they are more expensive than those offered by the public sector (Jaffe, 2002; Blanes and Busom, 2004).

2.2. Eliminating system failures

System failures restraining R&D work and the usage of its results can be classified as follows (Arnold, 2004): *capability failures* – the incapability of research institutions to act derived from bad management, lack of competence, weak study capabilities and other deficiencies; *failures in institutions* – the stiffness of the activities of organizations (universities, research institutes, patent offices, etc.) and thus the incapability to adjust to environmental changes; *network failures* – problems in the relationships of innovation system parties, which are characterized by the shortage of relations or their insufficient quality, the incapability to apply new knowledge and tangling in morally aged technology; *framework failures* – deficiencies in legal institutions, intellectual property protection, health and safety requirements and other background conditions, including social values; *policy failures* (Tsipouri et al., 2008) – deficiencies in the government related to R&D policy development, coordination with other policies and the assessment of policy outcomes, etc.

In order to overcome system failures reducing R&D work efficiency, the public sector must develop an evaluation system for research institutions, systematically direct research institutions to fulfil tasks important for economics, create networks to spread new knowledge and implement counselling programs, but also improve regulatory mechanisms that are important to develop R&D work. Still, it should be taken into account that public sector intervention should be in accordance with the nature and impact of the system failure, the efficiency of resources used should be maximum and regulations should not reduce private sector's initiative and responsibilities necessary for the research work. When considering the rationality of public sector intervention, different public sector failures (the instability of political decision process, the increase of bureaucracy, decision makers' irresponsibility for the results, the possibility of corruption, etc.) must be considered.

The diversity of R&D work means that when designing R&D policy, all institutions and organisations should be directed to cooperate to achieve common objective. This means, creating an institutional environment favouring interactions between organizations. Institutions are defined as the collection of habits, norms, routines, practices, rules or laws that regulates relationships and interactions between individuals, groups and organizations (Edquist and Johnson, 2000). The importance of institutions in guaranteeing the development of innovation is also emphasized by Klun and Slabe-Erker (2009).

3. International comparative analysis of research and development policy implementation

3.1. Data and variables used in analysis

In total 32 countries are used in the analysis (27 EU member states, Croatia, Turkey, Iceland, Norway and Switzerland). The statistical data used is from Eurostat on-line database and

Community Innovation Survey (CIS) studies. In the current study, data from three years is applied in order to follow the dynamics of different policy aspects. All variables in analysis have been taken from years 2004, 2006 and 2008. Given years have been chosen because for those years all the variables have values available. Several variables come from the CIS study, which is conducted every two years and data from year 2008 is the newest available.

Many theoretical approaches and empirical research (European Commission, 2003; Falk, 2004; OECD, 2005, 2007; Koch et al., 2007; Manjón, 2010) have brought out several variables that describe public sector R&D policy and which can be used to assess the level and structure of R&D policy in different countries. In the current study, the following variables will be used to comparatively assess public sector R&D activities in EU member states and countries closely associated with EU (see tables 1 and 2). Analysing different variables separately would give fragmented results. In the current analysis, data describing public sector R&D activities are considered as a whole complex taking into account the interconnections of variables.

One of the goals of the R&D policy is to develop R&D activities carried out by the public sector. This aspect is described by first set of variables (see table 1). First four variables describe R&D activities carried out in the public sector. For those variables it must be accounted that not all R&D expenditure in government and higher education sector are financed by the public sector – some of the funding is provided by the business and non-profit sectors, but also from the external sources (mainly EU institutions). Therefore, it is important for each country to bring out those variables that describe R&D expenditure funded by the government sector of that country (variables 5-6). Variable 7 describes government budget – more specifically its share in R&D financing. It is important to note that government budget includes some specific funds acquired from EU institutions, namely EU structural funds that support R&D activities. Last two variables in the table 1 describe the share of public sector R&D personnel in total employment, which describes the supply of work force in public sector R&D activities.

No	Abbreviation	Variable description
1	GOVgdp	Government sector R&D expenditure (% of GDP)
2	GOVshr	Share of government sector R&D expenditure (% of total R&D expenditure)
3	HESgdp	Higher education sector R&D expenditure (% of GDP)
4	HESshr	Share of higher education sector R&D expenditure (% of total R&D expenditure)
5	GOVtoGOV	Government sector R&D financing from the government sector budget (% of GDP)
6	GOVtoHES	Higher education sector R&D financing from the government sector budget (% of GDP)
7	GBAORD	Share of government budget appropriations or outlays on R&D in government sector total costs (%)
8	empGOV	Share of government sector R&D personnel in total employment (% according to data converted to full time equivalents)
9	empHES	Share of higher education sector R&D personnel from total employment (% according to data converted to full time equivalents)

Table 1: *Variables describing public sector R&D activities (compiled by the authors)*

The second important area of R&D policy is supporting business sector R&D activities. Variables describing public sector support to private sector R&D activities are given in table 2. In different studies, six business sector R&D financing indicators have been used. First two measure the level of government sector financial support to business sector R&D activities. The following four variables are based on the CIS study. Variables 3-6 describe the share of innovative enterprises that received public financial support for innovation activities. The support may be obtained from different levels of government (local or regional authorities, central governments and EU institutions).

No	Abbreviation	Variable description
1	GOVtoBESgdp	Business sector R&D financing from the government sector budget (% of GDP)
2	GOVtoBESshr	Share of government sector financing in business sector total R&D expenditure (%)
3	funPUB	Share of innovative enterprises that received any public funding (% of total innovative enterprises)
4	funLOC	Share of innovative enterprises that received funding from local or regional authorities (% of total innovative enterprises)
5	funGMT	Share of innovative enterprises that received funding from central government (% of total innovative enterprises)
6	funEU	Share of innovative enterprises that received funding from EU (% of total innovative enterprises)

Table 2: *Variables describing public sector support to business sector R&D activities (compiled by the authors)*

3.2. The results of empirical analysis

Table 3 shows the statistical parameters of variables describing public sector R&D activities and the level and structure of the public support for private sector R&D activities. The table indicates that the values of variables vary remarkably through EU member states and countries associated with EU, both in absolute (the difference between minimum and maximum levels) and relative terms (the relationship of standard deviation to mean).

Variable	Mean	Standard deviation	Minimum value	Maximum value	Value in Estonia	Estonian difference from mean (in standard deviations)
GOVgdp	0.20	0.11	0.01	0.68	0.14	-0.54
GOVshr	17.74	12.51	0.74	67.01	12.72	-0.40
HESgdp	0.37	0.20	0.02	0.82	0.47	0.48
HESshr	27.83	11.92	1.23	67.87	43.01	1.30
GOVtoGOV	0.16	0.10	0.01	0.57	0.11	-0.58
GOVtoHES	0.29	0.17	0.02	0.65	0.36	0.41
GBAORD	1.27	0.48	0.35	2.36	1.41	0.31
empGOV	0.16	0.10	0.02	0.52	0.12	-0.39

empHES	0.33	0.14	0.08	0.75	0.39	0.43
GOVtoBESgdp	0.05	0.04	0.00	0.19	0.03	-0.55
GOVtoBESshr	7.74	7.54	0.28	47.00	6.29	-0.20
funPUB	21.17	9.96	4.90	45.79	10.76	-1.06
funLOC	5.80	6.20	0.00	25.73	1.03	-0.77
funGOV	14.52	10.23	1.41	42.78	7.96	-0.64
funEU	6.43	4.22	0.99	19.69	3.53	-0.72

Table 3: *Statistical characteristics of variables describing public sector R&D activities and the level and structure of the public support for private sector R&D activities*[4]

Estonian position in public sector R&D activities and in the level and structure of the public support for private sector R&D activities can be seen on chart 1. On the chart, the difference in minimum and maximum values (in standard deviations) and Estonian mean value for each indicator is given. The chart shows that the position of Estonia is the best for the variable *HESshr* (share of higher education sector R&D expenditure in total R&D expenditure) and the worst for the variable *funPUB* (share of innovative enterprises that received any public funding).

Chart 1 indicates that according to variables describing higher education sector R&D financing, the share of higher education sector R&D personnel and government budget appropriations or outlays on R&D Estonia holds a higher position than the average of EU countries. For the rest of the variables describing public sector R&D activities and the level and structure of the public support for private sector R&D activities, Estonia has lower values than the EU average. Therefore, in Estonia the financing of government sector R&D activities, the share of government sector R&D personnel and the public funding for business sector R&D are lower than the average of EU. In Estonia, the main contribution of innovation promotion is expected from the higher education sector and public support for private sector R&D is seen to be rational on a lower level than the EU average.

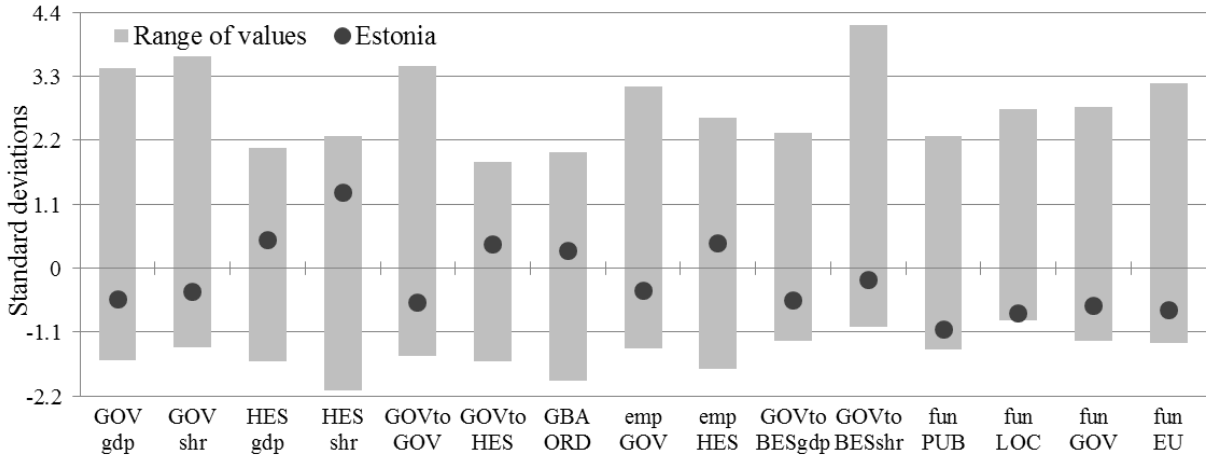

Chart 1: *Estonian position among variables describing public sector R&D activities and the level and structure of the public support for private sector R&D activities*

[4] Values have been calculated as the mean of three years (2004, 2006, 2008).

Subsequently, component analysis is conducted with the variables describing public sector R&D activities and the level and structure of the public support for private sector R&D activities. The results of component analysis (table 4) show the structure of public sector activities promoting and supporting innovation. Component analysis is based on the correlations in the set of variables.

	K1 Level of higher education sector R&D financing	K2 Level of government sector R&D financing	K3 Share of central government in financing R&D activities of firms	K4 Level of business sector R&D financing by public sector	K5 Share of EU in financing R&D activities of firms
HESgdp	**0.96**	-0.01	0.07	0.05	-0.03
GOVtoHES	**0.94**	0.02	0.11	0.08	-0.06
empHES	**0.85**	0.06	-0.02	-0.03	0.26
GBAORD	**0.78**	0.23	0.11	0.18	-0.34
GOVshr	**-0.68**	**0.45**	-0.14	-0.10	0.25
GOVgdp	0.10	**0.97**	-0.02	0.09	-0.01
GOVtoGOV	0.09	**0.96**	-0.05	0.10	-0.08
empGOV	-0.06	**0.94**	0.03	-0.13	-0.08
funPUB	0.11	-0.10	**0.96**	0.15	0.10
funGMT	0.09	0.03	**0.94**	-0.08	-0.10
GOVtoBESgdp	0.34	0.22	0.00	**0.83**	-0.08
funLOC	0.25	-0.21	0.27	**0.64**	0.02
GOVtoBESshr	**-0.45**	-0.01	-0.08	**0.62**	0.16
HESshr	0.11	**-0.47**	0.16	**-0.48**	0.28
funEU	-0.10	-0.12	0.00	0.01	**0.93**
Component eigenvalue	4.40	3.49	1.79	1.63	1.12
Cumulative variance explained	29.32	52.61	64.56	75.43	82.87
Significance of Bartlett test	0.00				
KMO	0.63				

Rotation method: Varimax

Table 4: *Component analysis in the set of variables describing public sector R&D policy*

The component analysis covering the indicators describing public sector R&D policy brought out five independent synthetic complex indicators (components) describing the internal structure of the variables. As the result of component analysis the number of variables describing public sector R&D policy decreased by two thirds (i.e. from 15 to 5), but less than half of the information (variation) included in initial variables was lost (82.9% of the variance of initial variables is explained).

Explaining the nature of synthetic components and giving adequate names for the new indicators is a complicated task. In the current study, the method applied by Karu and Reiljan (1983) is used to explain the economic nature of components as synthetic new variables.

With the first component K1 three variables, that describe higher education sector R&D funding and the share of higher education sector R&D personnel in total employment, are closely connected. In addition, variables that describe government budget appropriations or outlays on R&D and the share of government sector R&D expenditure in total R&D expenditure are strongly connected with the given component. In case of the last variable a reciprocal association exists that explains the crowding out effect of higher education sector R&D funding by government sector R&D funding. The nature of the first component is described with the name “Level of higher education sector R&D financing”, whereas the level of funding also affects the possibility of employing R&D personnel.

With the second component K2 three variables, that describe government sector R&D financing and the share of government R&D personnel in total employment, are strongly associated. With the given component, variables *GOVshr* (the share of government sector R&D expenditure in total R&D expenditure) and *HESshr* (the share of higher education sector R&D expenditure in total R&D expenditure) are weakly associated. The association with the variable *HESshr* is negative, which indicates the substitution of government sector R&D financing by higher education sector R&D financing. This component is characterized by the name “Level of government sector R&D financing”.

The third component K3 includes two initial variables that explain the share of innovative enterprises that received funding from the public sector (more specifically from the central government). The nature of the third component is described by name “Share of central government in financing R&D activities of firms”.

With the fourth component K4, three variables are strongly associated that describe the level and share of government sector financing in business sector R&D and the share of innovative enterprises that received funding from local or regional authorities. The nature of given component is in the best way explained by the name “Level of business sector R&D financing by public sector”.

The fifth component K5 is composed of only one indicator – the share of innovative enterprises that received funding from EU among all innovative firms. That is why this component is explained by the name “Share of EU in financing R&D activities of firms”.

Component scores describe each country in the analysis. As each country is represented in the sample with data from three years, there are three component scores for every country. In order to compare countries, they are characterized with the mean of three component scores. Component scores indicate that the structure of public sector R&D policy remarkably varies through countries – countries emphasize different R&D policy areas. To assess the international position of Estonia, a chart illustrating the results is used (see chart 2).

On chart 2 Estonian average positions among the analysed countries are shown using five complex indicators (components) that explain public sector R&D policy in a way that the

difference from the mean value and the distance from the extreme values can be seen. When in general Estonia is below the average level of R&D policy implementation, Estonian activities can still be considered balanced – in the case of three components the difference from the average level is smaller than the distance from the extreme values.

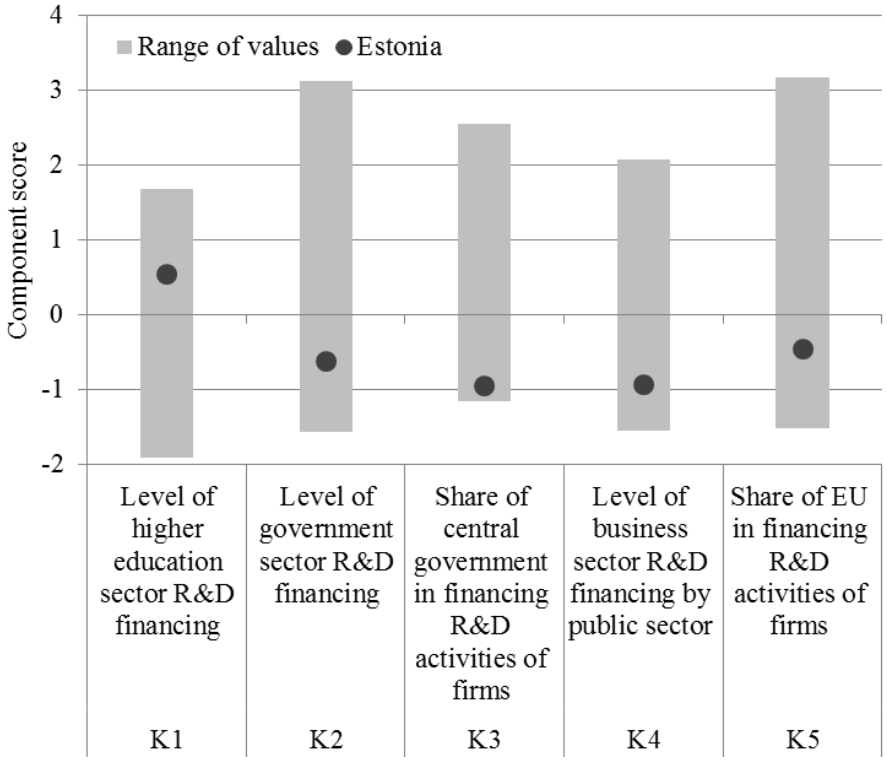

Chart 2: *Estonian position among analysed countries using the five components describing public sector R&D policy*

According to the component K1 (the level of higher education sector R&D financing), Estonian average component score is higher (by 0.54 standard deviations) than the average of analysed countries and Estonia is situated in the first third among all countries (on the 9th position). Thus, the public sector finances higher education sector R&D on higher level than the European average. This indicates that in Estonia many expectations are set on universities as promoters of R&D. In the case of small open country, it should be considered reasonable as new knowledge should mainly be transferred to specialists through the learning process and this is mostly done by the academics involved in R&D activities. In the case of the first component, the most similar country to Estonia is the Netherlands. The highest component values are in Finland (1.7) and Sweden (1.6), the lowest (negative) values in Romania (-1.9) and Bulgaria (-1.8).

In the case of component K2 (the level of government sector R&D financing), Estonia is by 0.62 standard errors lower than the average of analysed countries and situates on the 24th position. This means that the government sector with its research and scientific personnel does not create remarkable support potential for the business sector and neither is a supportive cooperation partner. In order to find out whether setting such objective would be reasonable at all, it is necessary to study the impact of government sector R&D activities on the business sector. The comparison with other countries offers a few standpoints in this

respect. In the case of K2, Estonia is similar to Greece and Denmark. The highest values are in small countries Iceland and Bulgaria (3.1 and 1.6) and the lowest in Malta (-1.6) and Turkey (-1.3).

The value of the component K3 (the share of central government in financing R&D activities of firms) is -0.96 in Estonia and it situates on the 28th position in the list of countries – only in four countries the component scores are smaller. The financing of business sector projects by the central government demands enough competence to create long-term innovation policy strategies on government level, but also capability to set and solve very specific development tasks to eliminate market and system failures. Profound research is needed to find out the presence of such competence and capabilities in Estonia. Thus, the modesty of Estonia in this R&D field can be considered natural. According to the third component, the similar countries to Estonia are Iceland and Slovakia. The central government supports R&D processes the most in Norway and Cyprus (component scores 2.6 and 2.1), the least in Romania (-1.2), Latvia (-1.0) and Bulgaria (-1.0).

According to the component K4 (the level of business sector R&D financing by public sector), Estonia is situated on remarkably lower level than the average (component score -0.94) and is analogically to the previous component on the 28th position. The low level in that policy field is derived from the fact that Estonia has no regional government level and the local government generally does not have resources and competence to support R&D activities. According to the fourth component, Portugal and Turkey are the most similar countries to Estonia. The highest component scores are in Austria (2.1) and Romania (1.9). The lowest level is in Lithuania (-1.5) and Croatia (-1.1).

Estonian component score for the component K5 (the share of EU in financing R&D activities of firms) is -0.47 and it is situated on the 23rd position among analysed countries. In the given field some deficiencies of Estonian R&D policy must be admitted – namely, the public sector is not able to help the business sector in applying and implementing EU support. According to this component, Estonia is most similar to Bulgaria and Ireland. In this policy field, the best results are in Greece (3.2) and Poland (2.2). The lowest levels are in Luxembourg (-1.5), Turkey (-1.3) and Croatia (-1.1).

When viewing all five innovation policy components together it is revealed that among all analysed countries the best results are in Finland – all five component scores have positive values. The worst results are in Malta – all five components have negative component scores. Estonia is with one over average and four below average values situated on the negative side, but in order to give a specific assessment, more elaborate analysis is needed.

As component analysis includes data from three years, it is also possible to view the dynamics of component scores. On chart 3 the value of Estonian component scores for each year have been given.

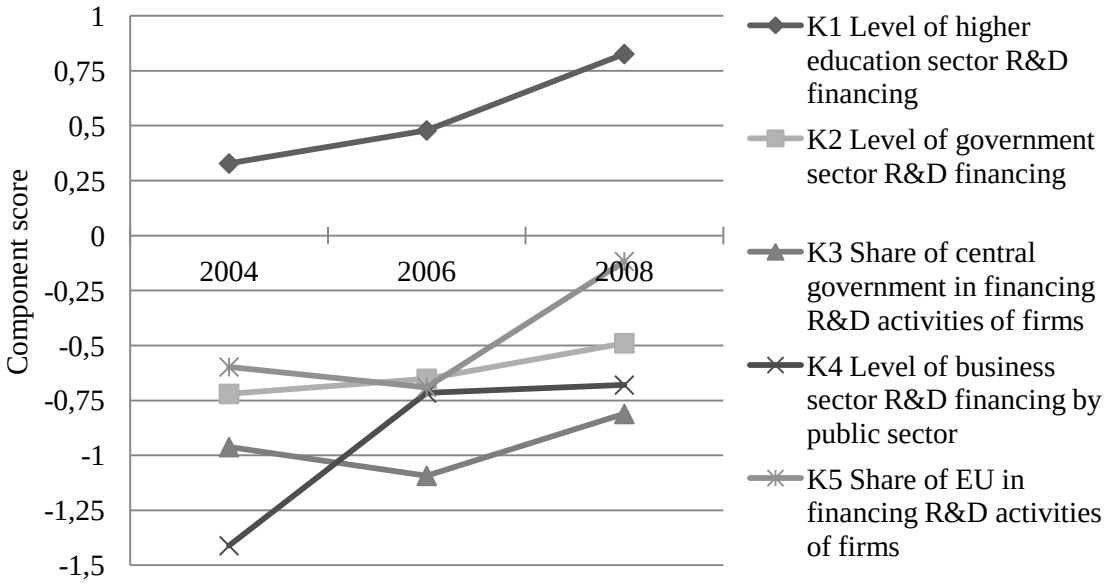

Chart 3: *Component scores describing Estonian public sector R&D policy in 2004, 2006 and 2008*

Chart 3 shows that for all five components Estonian component scores have grown in time, which means that the position in comparison to the average level of analysed countries has risen. Although in 2006 there was a small decrease in the position (the decrease of component score) of two components (K3, K5), Estonia has considerably moved towards the average of EU countries in the respect of R&D policy implementation. The largest increase has occurred in the value of the fourth component (the level of business sector R&D financing by public sector) and the modest is the growth of the third component (the share of central government in financing R&D activities of firms).

4. Summary

Designing national R&D policy is a difficult task from the aspects of making a choice among the variety of instruments, as well as the several-folded nature of the impact that different instruments create. There are large discrepancies in both R&D policy theoretical and empirical approaches. The current study systematised available theoretical approaches, analysed problems brought out in empirical studies and gave an assessment to the international position of Estonian R&D policy implementation based on the empirical analysis of the dataset of EU member states and countries closely associated with EU.

The reason for public sector R&D policy implementation is to eliminate the market and system failures restraining R&D progress. Market failures are mostly derived from the aspect that from the viewpoint of rivalry, the results of R&D have principally public good nature and the exclusion from the usage of those results is often unpractical. The positive externality of R&D must be taken into account, because the private demand is inevitably lower than the social rational level and with R&D policy measures the demand must be brought to the social utility level. Information constraints do not enable firms to risk with long-term R&D investments and public sector must fulfil the investment gap threatening state development.

Due to the system failure, the cooperation between different parties of national innovation system does not function smoothly or some institutions and organisations do not fulfil their tasks efficiently. The creation of formal institutions and cooperation organizations promoting R&D development is the immediate responsibility of the public sector. Innovation policy determines the tasks of the R&D policy in promoting innovation in a country and reciprocal connections with the supportive components of the innovation policy (education policy, cooperation development policy and business environment policy).

Still, the intervention by the public sector needs careful analytical justification, as incompetent intervention can distort market processes and shape a R&D policy with irrational scope or structure.

Empirical analysis showed that according to most indicators, that describe public sector R&D activities and the level and structure of the public support for private sector R&D activities, Estonia is below the average level among the countries analysed. Component analysis brought out five dimensions of public sector R&D policy:

- K1 – the level of higher education sector R&D financing;
- K2 – the level of government sector R&D financing;
- K3 – the share of central government in financing R&D activities of firms;
- K4 – the level of business sector R&D financing by public sector;
- K5 – the share of EU in financing R&D activities of firms.

Only in the case of K1 (the level of higher education sector R&D financing) Estonian level is higher than the average of analysed countries, whereas according to other R&D policy components Estonia is below the average level. This is a somewhat expected result, as in the case of a small open country external sources are considered important for obtaining innovative knowledge.

Although the position of Estonia according to most components describing public sector R&D policy is relatively modest, an important progress has occurred during the four year period (2004–2008) and Estonia has become remarkably closer to the average level of EU member states and countries closely associated with EU. After the CIS data is published for year 2010, the impact of world economic and financial crisis on Estonian public sector R&D policy can be analysed.

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