The Innovation and Economic Growth: An Estonian Case in Point

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Abstract

A new race for global economic advantage is under way. It is a fierce race thatonly the most innovative nations will win. The first paper in series "The innovation and economic growth" has clearly denoted the leader role of Estonia in raising the investments in R&D sector and boosting their innovative export-oriented production. The present paper is a second in series and presents anonlinear regressive analysis of complete chain of innovation driving factors, starting from the investments in R&D and leading up to the boost of innovative export-oriented production in Estonia. The dynamic structures and time-series of outstanding driving factors arepresented to disclose the Estonian leadership in Baltic States. The main conclusions and suggestions are presented. The first conclusion is that a high-tech R&D based innovation matters at the later stages of economic development of country, when there are barely both factors of competitiveness and learning that allow for completing the "catch-up" processes clearly observed in Estonia.The next is that the actual regressive analysis clearly shows that the government-backed R&D policies retaining the growing levels of main innovation driving factors are highly effective and warrant a coming intensegrow of production underconsideration. Actually, the coming level of Estonian innovative export-oriented production was econometrically estimated to grow at 15.2% in 2014 ever after. The practical implication of these findings for local companies are that in order to improve performance they must avoid narrowly focusing on R&D, but must invest more in capabilities to commercialize technologies resulting from the exogenous R&D.The suggestion to continue the regressive analysis on the grounds of total factor production, product market competition and concentration of the sector, and knowledge diffusion in productivity improvements is on the agenda of forthcoming research.

Keywords: race for global advantage,innovations, high-tech exportdriving factors chain, investments in research and development, regressive analysis and prognosis.

1.Introduction

In modern-day global economy, the nations must compete untiringly to attract and retainthe mobile investment. But in contrast to states competing by "smokestack chasing" supposed to be forty years ago, the most nations now compete by "innovation chasing", trying to grow and attract the highest-value-added economic activities: the knowledge-intensive mass production, research, software, information technology, and innovative financial services that power modern-day global, innovation-based economy. The Estonia could be a case in point(Macys, 2013).

It no longer touts its abundant clay, but now markets itself as a place "where the innovation, discovery, and success are nurtured," and "that provides a pipeline of bright minds and new thinking". It is an intense and endless race for global innovation advantage that most clearly distinguishes a modern-day global economy from the collection of national economies that competed to attract "smokestacks" a generation ago (Atkinson, Ezell, 2012). Today most nations recognize that they have to be the intense competitors if they are to be successful, as more and more firms can now produce the same goods and services virtually anywhere on the globe. And most nations also realize that high-wage innovation- and knowledge-based industries would be the ones that play a key role in driving their prosperity.In other words, the technological progress or innovations has become a main engine of economic growth of modern-day society. This is a sort of growth that allows continuous improvement in incomes and welfare, and enables an economy to grow even as its population decreases.On these grounds the knowledge in overall and the innovation or new technologies especially have been seen as the major sources of economic growth and development.

However, a little progress has been done so far in measuring and assessing the driving factors of knowledge-based economy and the degree of economic dynamism that it brings forward.It follow that the**rational to investigate** is evident.

On other side, the policymakers devotemuch attentionto enhance theeconomic growth in overall and the productivity grow especially andemphasize its drivers such as the R&Dinvestments in order to put the most effective economic and industrial policies into practice.They must have a satisfactory answer to the question: on what termsthe technological progress maximizes the productivity and economic growth most effectively in the long run?An Estonia was a small peripheral country of backward-looking Soviet Union without any kind of natural resources in the past. It is positioned during past 5-6 years in the top of moderates European Union countries now and quickly straining ahead. An impressive path to the upcoming global leadership is obvious. What lessons can be drawn from Estonian experience and successfully adapted for Lithuanian economic boost in near future? It is under consideration too. The**practical importance** of present researchis clear and evident.

The **purpose of this research** is to analyseeconometrically the relation between different drivers of innovative high-value-added production which can both steer national decisions about economic policies in the right direction and improve the governments' ability in facilitating the process that leads to long run increases in the wealth of nations, as driven by accumulation and effective employment of knowledge and technologies.The experience of Baltic States leader – Estonia – would be as follows.

The present paper is the second in series “The innovations and economic growth” that presents acase in point,an econometric analysis of Estonian high-value-added innovative and export-oriented production. The paper examines a large chain of economic activities from the gross domestic expenditure on R&D up to the final export of high-tech innovative production in accordance with the nonlinear regression model.Despite a large amount of economic literature on these topics, the relationship between the levels of R&D investment and productivity growth has not yet been still completely clarified. It refers to the **innovation of present research effort** and the present paper too.

The paper is structured as follows: the second section gives the corresponding literature overview. The third section describes anonlinearregressive model and data sources, processing, the fourth section provides the main findings of present research, the fifth section concludes with a discussion and suggestions for further research.

2.Literature Overview

There are many literature sources dealing with factors affecting the economic growth overall and productivity growth especially. Some of factors that have recently been examined include the managerial ability, technology and regulation (Bartelsman, Doms, 2000).The UK government emphasizes the following five drivers of productivity growth: the investment, innovation, skills, enterprise, and competition (DTI, 2006). The increasing interest in different factors of growth, other than the capital deepening or savings, over the past two decades, both at macro-, and microeconomic level, can be traced to the development of endogenous growth theory (Lucas, 1988; Macys, 1999;Aghion,Howitt, 1992; Aghion et al., 2005). Endogenous growth theory underlines the role of innovation, competition and incentives to create the knowledge for economic development. The core ideas of that strand of literature are related to the ideas of Joseph A. Schumpeter (Schumpeter, 1975). He states that the economic processes are organic and that the change comes from within the system and not simply as an exogenous factor. It means that the changes come through the innovations.Several models of economic growth have been developed in conformity with the Schumpeter’s process of creative destruction.Thearticle of P.Aghion and P.Howitthas increasingly been used as the basis for developing the endogenous growth models. The clearly documented evidence that the research and development (R&D) has an important effect on productivity growth and on competitiveness is presented in paper (Amendola et al., 1993).The R&D produces its complete effects on two forms of innovation: the aggregate productivity gains of factors and the improvements in product quality (Brécard et al., 2006).

A newgrowth theory has been introduced the endogenous technological change as a function of the level of human capital into the Solow model (Romer, 1990).The first generation of this model has considered the assumption of constant returns to technological knowledge and predicted that long run growth rate of an economy increases in the level of R&D inputs and thus larger economies should grow at higher rate (Grossman, Helpman, 1991).

C.I. Jones has found that the first-generation models of endogenous growth are inconsistent with empirical evidence for the USA and refutes the scale effect prediction (Jones, 1995). To solve the empirical problems associated with these models of economic growth, second-generation models of endogenous growth have been developed.

The endogenous growth theory does not postulate that the sole determinant of economic growth is an investment in R&D, and argues that the capital accumulation cannot be even seen in the mass as a sole determinant of economic growth. The important findings in these papers are based on population data about Estonian enterprises.They maintain that both the entry of high productivity firms and exit of low productivity enterprises contribute a lot to the productivity growth in Estonia (Masso et al., 2004; Bartelsman et al., 2004, Vahter, 2006). One key conclusion from this strand of literature is that the growth results from the technological progress, which in turn results from technological competition among firms that generate the subsequent innovations. The firms are motivated to innovate by the higher payoffs or the prospect of monopoly rents in the form of higher profits in the future that can be captured by the successfully innovative firms (Howitt, 2005). Those rents, however, are temporary and will be in turn destroyed by the next generation of innovations made by other firms that make the former innovation obsolete (Aghion and Howitt, 1992).

So, when the technological progress affects the economic growth in overall and productivity growth especially most effectively?R. Griffith argues that innovation and technology transfer provide two potential sources of productivity growth for countries behind technological frontier (Griffith et al., 2004). They examine whether the R&D has a direct effect on productivity growth in a panel of industries across twelve OECDcountries and state that the greater the potential for technologies to be transferred through R&D, the higher will be the rates of productivity growth. The R&D contributes to growth not only through alocally originated innovation but also through a technology transfer. These scholars have argued that a R&D has played a role in the convergence of production volumes within industries across OECD countries (CIRCA, 2012). The growth impact of R&D has also received considerable attention within the context of spillovers (Griliches, 1979). The cross-country R&D spillovers are thegreatly important sources of productivity growth (Grossman, Helpman, 1991). The impact of R&D on productivity assessed from a macroeconomic perspective,has been analysedon base of model similar to that of P.M. Romer (Jones, Williams, 1998). They have estimated that an optimal investment in R&D is two to four times larger than actual investment in the United States. In addition, they haveargued that the own- country R&D determines productivity growth which in turn determines domestic output growth (Aghion, Howitt, 1998). M. Zachariadis foundthe evidence of a positive impact of aggregate R&D intensity on the growth rates of productivity and output, using the aggregate and manufacturing sector data for a group of ten OECD countries for the period 1971–1995 (Zachariadis, 2004). The coefficient for the impact of aggregate R&D intensity on aggregate economy productivity is estimated to be 1.66 for the most basic specifications. Moreover, the null hypothesis that growth is not induced by R&D is rejected in favour of the Schumpeterian endogenous growth framework without scale effects (Zachariadis, 2003).

Others scholars have investigated whether a directly observed measure of technical change - R&D intensity - is closely linked with the growth of more highly skilledworkers in the context of USA and other six OECD countries (Machin, Van Reenen, 1998).They show a significant association between skill upgrading and R&D intensities in all study countries. However, the macro level analyses of nonscale endogenous growth models are limited to a few studies that cover only a small number of OECD countries. For instance, other researchers examine the relationship between aggregate level of productivity and R&D intensity and find a positive relationship between these variables (Zachariadis, 2004), (Guellec, Van Pottelsberghe, 2004). Despite a large amount of economic literature on these topics, the relationship between the levels of R&D investment and productivity growth has not yet been still completely clarified.

It ought to be outlined that the role of R&D and innovation in economic growth is not always self-evident. The endogenous growth theory has undoubtedly given a lot to our understanding of growth. However, there are some other influential papers that are critical about this line of models. The growth accounting exercisesclaim that technological progress may be a less important source of economic growth than capital accumulation (Jorgenson, 1995).The enormous increase in R&D in the post WWII period in the USA has not been accompanied by the corresponding rise in productivity that might indeed be expected based on Schumpeterian growth models (Jones, 1995). He supposes that the relatively constant long-run growth in the face of enormous structural changes, such as trade liberalization, increases in years of schooling and in R&D.

He refutes also many of the implications of endogenous growth theory. Thus, the impact of innovation inputs or outputs on productivity, similarly to the effects of competition on productivity, may be not as clear, as sometimes expected.

It is also true that different types of innovation play different roles at various stages (OECD, 2012). In earlier stages, the incremental innovation is often associated with adoption of foreign technology, and a social innovation can improve the effectiveness of business and public services.

The high-technology R&D based innovation matters at the later stages of development, when there are both factors of competitiveness and of learning that allow for completing the “catch-up” processes. The latter innovation type can be denoted also in Estonia.

The first paper in series “The innovation and economic growth” stresses the leader role of Estonia in raising the investments in R&D sector and boosting the high-tech and export-oriented production (Macys, 2013). Two next figures remind the derivation of Estonian leadership.

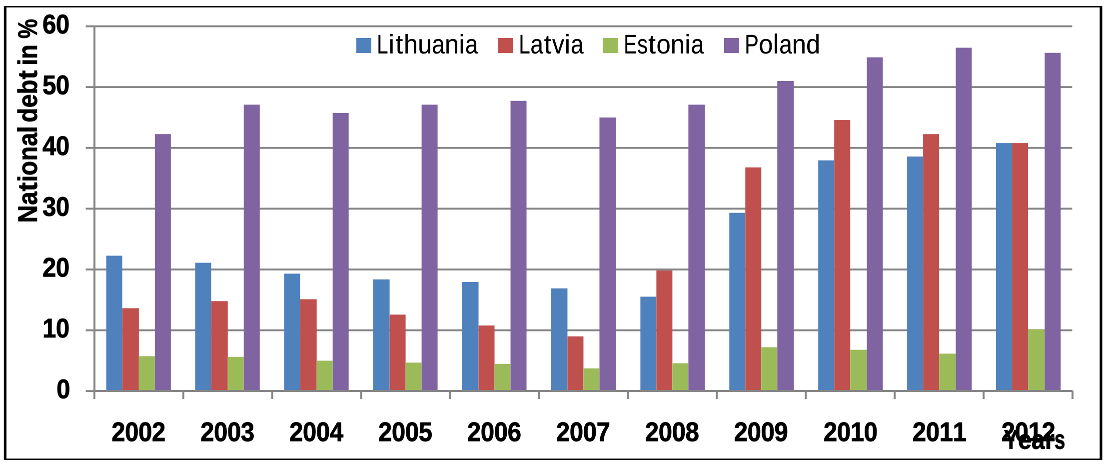

Fig. 1. The national debts of four Baltic states as a shares of national GDP in 2002-2012.
Source: Eurostat data, (Eurostat, 2013).

An index of national debt particularly clearly shows the leader role of Estonia. The public debt has been more or less declined before the crisis in all Baltic countries. A huge difference between these countries becomes evident if we are approaching the government policies during the crisis and economic recovery period: the national debt has clearly boomed in all three Baltic countries except in case of Estonia (Macys, 2013). The reasons were clear: the national GDP’s were promptly slumping and the budget deficits were booming even more in opposite way. Only the Estonia has adjusted the right counter crisis policymeasures -a strong fund of economic stability has been constituted before the crisis.

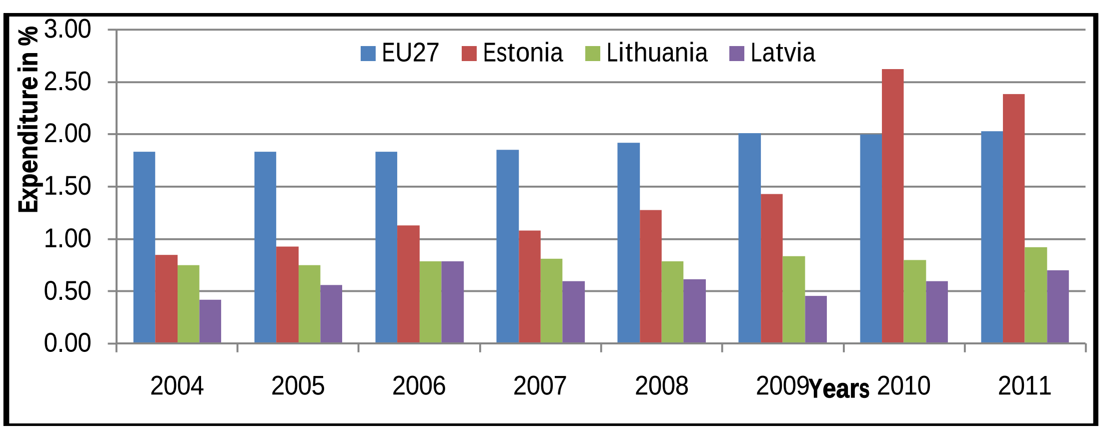

Fig. 2. The gross expenditures on R&D in the Estonia, Latvia, Lithuania, and EU27 as a share of national andEuropean GDP, 2004-2011.
Source: Macys, 2013.

It permitted for Estonian government to retain the surplus national budget and stable slim budget debt. It permitted equally to keep the fast growing investments in R&D overtaking and surpassing even the average investment level of EU27 at this time.

Summing up, it is extremely interestingly to examine the way of undeniable Baltic leader - Estonia –in boosting the high-value-added andexport-oriented production from the endogenous growth model viewpoint. The present second paper in series "The innovation and economic growth" presents the nonlinear regressiveanalysis and forecast of whole driving factor chain, starting from the investments in R&D and leading up to the boost of productivity in Estonia.

3.Econometric Analysis, Data And Their Sources

The both high-tech production and innovation driving factorsin Estonia based on panel data from 2003-2012 were withdrawn in this paper from the Estonian national statistic surveys includingthe selected descriptive statistics on the high-tech production firms. Then the time-series of basic determinants of high-tech production, their dispersion, including inputs like the investments in high education, R&D, and labour and sector specific differences in technology etc. were evaluated, and finally, the endeavours to relate the remaining differences to the innovative activities of firms were undertaken.

A thoroughdiscussionofseveralproblemsrelated to theestimationofproductionfunctionsisprovidedinthe papers (Griliches, Mairesse, 1995), (Olley, Pakes, 1996), (Levinsohn, Petrin, 2003), (Vahter, 2006). The process of innovation is usually modelled as a function of the incentive structure, i.e. the institutions, assumed to have an access to the existing knowledge, and a more systemic part of creation and development of economically useful knowledge. An innovation also implies that the stock of knowledge increases. In other words, an innovation is one vehicle that diffuses and upgrades the already existing knowledge, thereby serving as a conduit for realizing the knowledge spillovers.

The present paper model examines the link between high-value-added productionfunction and eight familiar determinants: starting by the R&D budgeting and finishing by the labour resources and skills of R&D sector.InthecontextoftheCobb-Douglasproductionfunction the statistical relationship between the production and eight factorscould be presented as follows:

$$\mathbf{\Delta \ln(Y_{htp}) = \alpha_0 + F(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8) + \varepsilon.} \qquad \mathbf{(1)}$$

where$\mathbf{Y_{htp}}$ denotes a High-tech production function,$\mathbf{X_1}$- the investments in high education sector as a share of national GDP, $\mathbf{X_2}$ – the number of high-tech patents, acknowledged annually by the European Patent Office (EPO), $\mathbf{X_3}$ – the gross expenditure of high education institutions on R&D,$\mathbf{X_4}$- the gross expenditure of private sector on R&D, $\mathbf{X_5}$- the gross expenditure of public sector on R&D, $\mathbf{X_6}$ - the gross expenditure of Estonian national budget on R&D,$\mathbf{X_7}$ – the number of high-tech enterprises, working in Estonia and$\mathbf{X_8}$–the labour resources of R&D sector, $\boldsymbol{\alpha_0}$–the incept parameter, $\boldsymbol{\varepsilon}$ –the statistic error term.

The time series of determinants$\mathbf{X_3,...,X_8}$ demonstrate the relatively even and usually rising record in case of Estonian statistics. The time series of determinants $\mathbf{X_1}$ and $\mathbf{X_2}$ show slightly complicated record and are presented below.

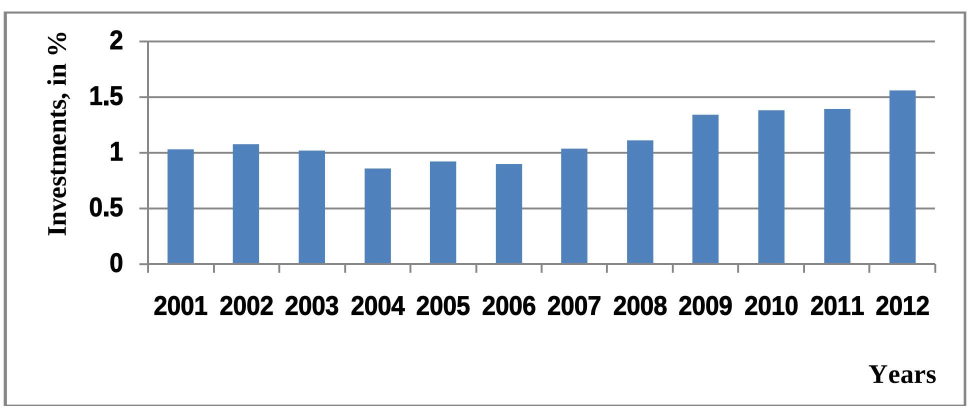

Fig. 3. The gross investments in High education sector as a share of national budget, 2001-2012.
Source: EstNDS data.

The gross investments of Estonian national budget in High education sector show two local slumps of education budgeting in 2004 - 2006 and in 2010 – 2011. The first denotes the beginning of Estonian membership in EU and the unforeseen deficit spending of Estonian government at the expense of education budgeting. The second denotes the period of reduced public expenses after the crisis (Macys, 2012).

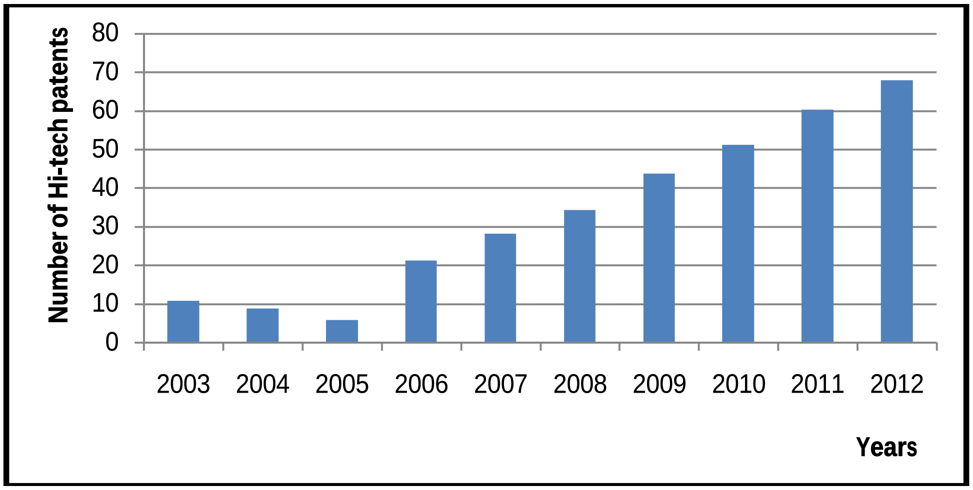

Fig. 4. The number of patents of Hi-tech production, acknowledged annually by the EPO in 2003-2012.
Source: EstNDS data.

The number of Estonian high-tech patents, acknowledged by the EPO, shows a clearly rising trend after the adhesion into EU in 2004. The high-tech patent increment has risen more than 11 times during the last seven years. This small fact illustrates excellently the successful R&D policy in Estonia. On the other side, the high-value-added production composes largest 38.7% part of Estonian national export.It is a highest level of export oriented high-value-added production in Baltic States (Macys, 2013). The high-tech export prevails in Estonian national export, and encompasses the electric appliances, machine components or air appliances. The high-value-added commodities for international mechanical engineering compose the biggest part of Estonian national export. A considerable part of export encompasses the conventional production.

The present econometric analysis has been accomplished by the well-known Nonlinear regression analysis program (NLREG, 2013). NLREG uses a model/trust-region technique along with an adaptive choice of the Hessian model. The algorithm is essentially a combination of Gauss-Newton and Levenberg-Marquardt methods. The adaptive nonlinear least-squares algorithm is always in use.

The tests of normality, Kolmogorov–Smirnov and Shapiro–Wilks, applied on variables show a level of significance equal to 1%, such that it is possible to apply correctly the econometric models of parametric estimations. Models estimated with OLS method present negative serial correlation. As a result, this model has been corrected by the Prais–Winsten estimation method. In the OLS model, this method eliminated the problem of negative serial correlation at the fourth and final iteration. These corrections have made the estimates robust and unbiased, the t-test returns meaningfulness of the parameters equal to 1%. The explanatory power of the model is good, as indicated by uniformlyhigh adjusted R^2 (0.95). The result of the Durbin–Watson test, after the correction with the Prais - Winsten estimation method, is no serial correlation (5% significance level). Briefly put, the performance of corrected model is excellent. The specification of general dynamic nonlinear regression model (the lagged dependent variable) also shows robust and unbiased estimators. The estimated relationships are polynomial functions (continuous and differentiable functions) such that it possible to apply classic optimization methods (Rudin, 1991).

4. Main Findings

The main findingsare:

a) The high-value-added export-oriented innovative production curve has followed the curve of investments in the high education and R&D sectors.

The clearly expressed upturn in 2004-2006 denotes the opened European markets after adhesion into EU. The present upturn shows the upsurge of Western demand and the reorientation in turn of Estonian export in overall and high-tech export especially to Western markets.

b) The present-day upturn of Estonian high-tech production has achieved the highest level in Baltic States -**€**1,421 billion - and retains a relatively stable range. It was already denotedthat the goodness-of-fit was no less than 0.95. The differences between the actual and calculated are small (less than 5%); in the issue they are not revealed in the fig. 5.

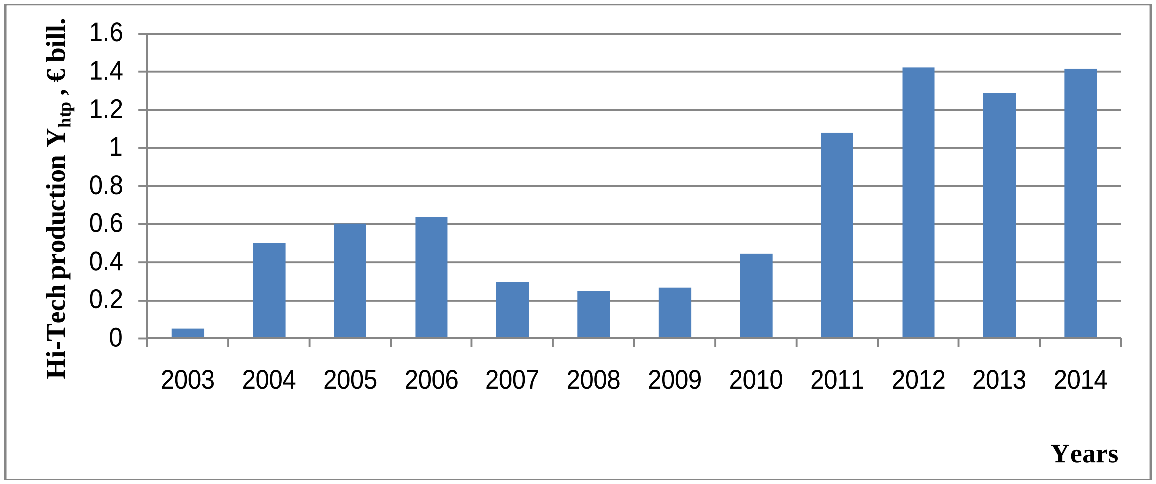

Fig. 5. The dynamics of the Hi-Tech export-oriented production **(Y_{htp})** in 2003-2014, in **€** billions.

c) The future level of Estonian high-tech production was estimated to grow at 15.2% and achieve **€**1.415 billionin 2014. It ought to be outlined that the regressive prognosis of mentioned level is notably daring but high level of model fitness of past periods allows to trust completely on the estimation of future level of Estonian high-tech production in 2014.

d) The most impacting on level of Estonian high-tech production driving factors are the investments in high education sector and their gross expenditureson R&D. It proves the statement of endogenous grow theory that the growing budgeting for R&D gives the direct and strongest effect on the level of high-tech export-oriented production.

5.Conclusions

The innovation has become the central driver of national economic wellbeing and competitiveness – and this is why so many nations are engaged in the race for global innovation advantage. But what actually is the innovation? Most believe it pertains only to the R&D, transfer of technology to the production enterprises, the production and deployment, or the marketplace usage. The innovation traditionally has been understood in an engineering context, entailing either the creation of new or improved consumer-product goods, enhanced machines and devices like the computer-controlled machine tools by which products are manufactured. But the innovation in services has become increasingly important, as services industries now account for more than 80% of U.S. economy and 75% or more of most European ones.

The innovation – the wellspring of that "gale of creative destruction" of which Schumpeter wrote – achieves its outsize economic impact through two principal channels: empowering the productivity improvements and spurring the dynamic creation of new firms or activities that create a new value. As a result, the production and innovative use of information technology has been responsible for at least 50% of acceleration in the growth in U.S. total factor productivity between 1995 and 2008, contributing to U.S. economy that is approximately $2 trillion larger in terms of annual GDP than it would be otherwise (Atkinson, Ezell, 2012).

Now, more than ever, the nations need innovation to remain globally competitive. This is true for developed nations, which without innovation have a hard time competing with low-income, low-wage nations.

Especially critical is their ability to lead in the process innovation and to move up the value chain to develop the higher-value-added products and services that less-developed nations simply can't make, at least not as well for the near and medium term. Finally, a healthy traded sector enables economies to avoid high trade debts that will ultimately have to be paid off by the future generations consuming less of what they produce.

The innovation is greatly important at all stages of development. The creation and diffusion of technologies matter for economic growth across all economies. However, it was already discussed thatthe different types of innovation play the different roles at various stages. In earlier stages, an incremental innovation is often associated with the adoption of foreign technology, and a social innovation can especially improve the effectiveness of business and public services. The high-technology R&D based innovation matters at the later stages of development, when there are the both factors of competitiveness and of learning that allow for completing the "catch-up" processes. It can be clearly denoted in Estonia.

The countries leading the world in developing innovation policy have followed a three-step process. First, they recognized the need to approach innovation systematically. Second, they effectively brought attention to the need for innovation to the political and institutionalbody, putting forth and inspirational vision and strategy for action, replete with the clearly articulated goals and ambitions. Finally, these countries made the tough decisions necessary to not only implement institutional reforms to drive their innovation strategies but also to adequately fund them, including R&D budgeting, even at expense of other government spending or lower taxes for individuals. It is a way that an Estonia is following on.

The models of R&D-induced growth can serve as empirical templates to assess the potential of different growth policies for countries. The present regressive analysis of Estonian high-tech export-oriented production clearly shows that the government-backed R&D policies retaining the growing levels of main driving factors are highly correct and warrant a high future grow of production in question.

The following suggestions can be denoted:

a) To raise up more R&D finances from the private sector. It would raise the efficiency of R&D overall and especially the high-tech part of gross export.

b) To rise up to the 3% of national GDP the public R&D finances in Estonia. An appropriate progress can be noticed. The revised strategies and policies for innovation, entrepreneurship, and the functioning of knowledge economy in Estonia, and the flexibilities in order to respond to the challenges of world race for leading position are reasonable too.

c) To continue the analysis on the grounds of total factor production, productmarketcompetitionandconcentrationofthesector, andknowledgediffusioninproductivityimprovements.

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