How to Make High-tech Industry Highly Developed? Effective Model of National R&D Investment Policy

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Abstract. The paper validates the relations between the share of public and private R&D spending and the effectiveness of national R&D sector. It states that in order to implement effective and profitable "high-tech policy", governments have to intensify the share of business sector in Gross Domestic Expenditures on R&D. At the same time it is necessary to preserve the definite "government share" in R&D investments, as reduction of it up to certain extent gives the negative effect.

Keywords. High-tech industry, R&D investment policy, Private v. Public R&D Spending, Exports of High Technology Products

Key terms. Development, MathematicalModel

1 Introduction

It is impossible to deny that people all over the world benefit from new technologies which lead to healthier lives, greater social freedoms, increased knowledge and more productive livelihood. Each day sees additions to the literature, much of which includes reports on the establishment or expansion of R&D facilities and programs that are designed to take the best advantage of highly qualified resources. Nowadays there are practically no governments and politicians that would miss a chance to stress the importance of innovations in economy. According to the judgments of some experts, GDP growth of developed countries up to 50-90% is determined by technological progress and innovations [7]. The developing countries, in their turn, extremely need competitive high-tech industry, not only because being usually one of the most profit-making and cost-efficient industries it contributes to economic prosperity by itself, but also because technological achievements give them a chance to promote and make competitive on the global arena all other economic sectors, narrowing in this way the economic gap between the highly-developed countries and the developing ones.

Still the results of R&D policy in the countries of post soviet space frequently leave much to be desired. The most prominent achievements in the sphere of industrial R&D belong to the most developed countries such as USA, Japan, European Union. Current literature is replete with reports on the expanding R&D activities in China, India, South Korea and Singapore. Meanwhile Belarus, Ukraine, Uzbekistan, Moldova still cannot boast prominent commercial achievements in R&D. That's why this research paper aims at analyzing and investigating of those factors and incentives that turn national innovative efforts, resources and potential into visible and profitable high-tech results.

Research and development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications [2].

The UNESCO Institute for Statistics claims that the clearest trend in global R&D activity between 1996 and 2005 was the increasing percentage of GDP devoted by countries all over the world to R&D (R&D intensity has more than doubled in 9% of the countries surveyed, including China, Thailand, Tunisia and others; in 48 out of 89 countries surveyed the percentage of GDP devoted to R&D has significantly increased) [4]. Surely, sustained R&D investment is a key to economic growth. But those are strong words that are easy to follow in good economic times, but more difficult to follow in bad economic times. R&D expenditures are among the first to be cut during recessions. Preliminary data (official statistics on R&D are available only until 2007) suggest that companies have reduced their R&D investment in the aftermath of the crisis. In 2008 the industrial companies despite the challenging economic times continued growing their R&D budgets, expanding by nearly 6,1%, or more than $60 billion, from what they spent in 2007. Despite their good intentions, when the downturn turned from mild to severe, industrial firms were forced to cut their R&D budgets. Total industrial R&D spending dropped by 1% or nearly $10 billion overall in 2009 from what was spent in 2008 [6]. These findings are consistent with historical trends showing that R&D expenditure exhibits larger variations than gross domestic product (GDP) over the business cycle. Hence, any drop in GDP would result in an even larger decrease in R&D expenditure [3].

The 2010 Global R&D Forecast, created by Battelle analysts and the editors of R&D Magazine, predicts overall global R&D will increase 4.0% in 2010 to $1,156.5 billion from $1,112.5 billion spent in 2009. This increase will mostly be driven by continued spending by China and India, who will drive a 7.5% increase in Asian R&D. American R&D spending is expected to increase 3.2% to $452.8 billion, while EC spending will only increase 0.5% to $268.5 billion in 2010. This forecast especially stresses a trend of falling the spending of both the Americas (U.S., Canada, Mexico, Brazil, and Argentina) and the EU behind the spending levels seen in Asian countries (India and China). Even Japan, the 2nd largest R&D spender in the world, is now trailing the level of spending by China and India [6].

It is really hard to measure innovations, as its manifestation within the economy is larger and more complex than what one indicator or index can capture and reflect. Many aspects of technology creation, diffusion and human skills are hard to quantify.

Still in order to estimate nation's technological achievements and the level of innovative progress it is possible to use a great variety of indicators. The most frequently used ones are the following:

- The number of patents granted to residents (per million people), the number of new trademarks
- Receipts of royalty and license fees (US$ per person)
- The number of researchers in R&D (per million people or per thousand employees)
- Population with tertiary education and youth education achievement level, new science and engineering (S&E) graduates per 1000 population
- Science and engineering degrees (% of all new degrees)
- % of firms with new-to-market product innovations (as % of all firms)
- Sales and exports of high technology products and many others

However, most of the indicators mentioned above describe only the quantitative side of innovation process, but not the efficiency of national R&D investment policy. Furthermore, some of these indicators are not representative due to considerable legislation differences among the countries (for example, low patenting activity in India and China is explained mostly by underdeveloped system of intellectual property rights' protection than by lack of innovations) [3]. That's why this research paper concentrates mainly on the share of high-technology exports as % of manufactured exports as the most representative indicator of competitive commercialization of national scientific researches (Y-variable).

While speaking about the factors of successful innovation policy, it is important to remember that there are no ideal models in complex economic systems, and each economic or social parameter is subjected to multitude of different impacts and factors. As regards national high-tech development, it is affected by such economic conditions as:

- International openness to trade and investments (assessed by such indicators as export and import ratio to GDP (Exp+Imp/GDP*100%), the level of trade weighted average tariff)
- The commitment to market values and developed market economy infrastructure
- The accessibility to the venture financing for start-ups
- The competitiveness of national economy on the global arena
- The volume of R&D spending (in billions of $)
- Industry innovation expenditures
- The influx of direct foreign investments and many others
- Public and private R&D expenditures (% of GDP)

Research and development (R&D) expenditure is one of the most widely used measures of the innovative efforts of firms and countries. Most surveys devoted to the technological achievements of the countries concentrate the attention mainly on the level of R&D intensity of this country as the main factor. But while R&D as a percent of GDP figures are bandied about as indicators of the strength of the national commitment to scientific research, they have relatively little meaning in terms of just how that investment contributes to the growth and welfare of the country.

The more important data are those that tell you who is providing the funding, who is doing the work, how the money is being spent, and what the priorities, thrusts, and

directions are. In brief, it is the internal structure of the R&D enterprise and the roles and interplays among the different sectors that have a bearing on the manner in which the investment in R&D has the desired societal benefit outcomes of economic security, improved health care, and the like. The R&D expenditure is generally broken down among 4 sectors: business enterprise, government, higher education and private non-profit institutions. In this research the share of business financed R&D was selected for thorough econometrical analysis (X variable).

2 Results

The basic hypothesis based on the preliminary insights into the statistical data suggests that, in order to implement effective and profitable "high-tech policy", governments have to intensify the share of business sector in GERD (Gross Domestic Expenditures on R&D). But at the same time it is necessary to preserve the definite "government share" in R&D investments, as reduction of it up to certain extent gives the negative effect.

Figure 1 illustrates the average indications of high-technology exports (red line) and business expenditures on R&D (blue line) during the period 2000-2005 for 20 countries (the countries were arranged in order of business R&D share extension) [1], [3], [7].

We can see from the graph that the supposed rule is valid for the countries disposed in the range of 0-60 % share of business sources in R&D expenditures: the higher share of business sector in R&D means the higher indications of high-tech export.

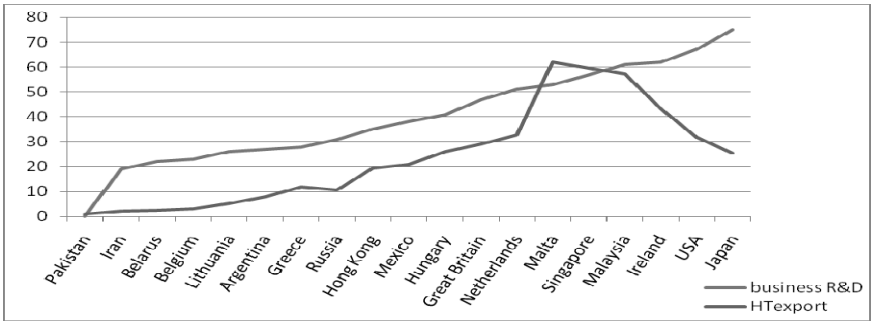

Fig. 1. The average indications of high-technology exports and business expenditures on R&D. Business R&D – % of Gross Domestic Expenditure on R&D financed by Business Sector; HTexport – % of high-technology export in total manufactured export

However we cannot fully rely on average indications, as each country has its own peculiarities, historic and geographic conditions and many other factors that can determine high-technological specialization of export. Moreover, here only 20 countries were taken into account.

That's why it is more interesting and important to examine the changes in the share of high-technology exports depending on the changes in the structure of R&D financing.

The Model description:

X (ΔprivR&D) – shift in the share of business sector in R&D financing. Business R&D expenditures as % of total R&D expenditures – the indicator reflects the percentage of total investment in research and development originating from the business sector;

Y (ΔHTexp) – shift in the share of high-technology exports as % of total manufactured export during the period 2000-2005.

High technology export is exports of products with a high intensity of research and development. They include high-technology products such as those used in aerospace, computers, pharmaceuticals, scientific instruments and electrical machinery [4].

The statistical analysis of the data across 63 countries in the world for the period of 2000-2006 intended to reveal the correlation between changes in R&D expenditures structure and export structure. It will be studied linear regression.

According to the statistical analysis it was revealed the following general tendency: the share of the high-tech export increases in most of the countries surveyed along with the growth of business financed share in R&D investments.

The econometric model on the basis of the statistical data has the following outlook (figure 2):

$$\Delta HTexp = -1{,}8071 + 0{,}7129 * \Delta privR\&D \ (R^2 = 0{,}636),$$

which means the increase of high-technology export share by nearly 0,7% if the share of private R&D expenditures grows by 1%.

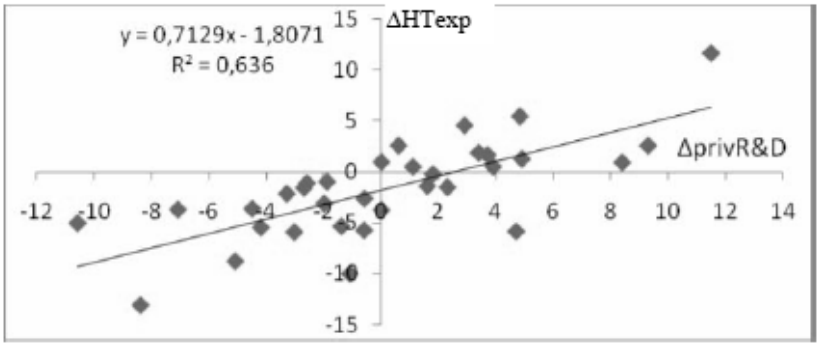

Fig. 2. The linear regression

With the purpose of further analysis the countries were classified into 3 categories:

The countries with traditionally high share of private sector in R&D (>60%). This group includes such countries as Belgium, Denmark, Finland, Germany, Ireland, Israel, Japan, China, Luxembourg, Switzerland, USA (figure 3).

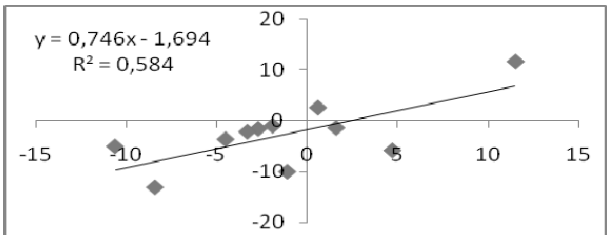

Fig. 3 The countries with high share of private sector in R&D

The countries with medium share of private R&D expenditures in the range from 40% to 60% are composed of such countries as Austria, Brazil, Croatia, Cuba, Czech Republic, France, Hungary, Netherlands, Spain, Great Britain (figure 4).

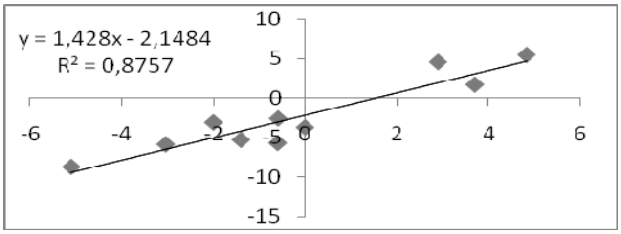

Fig. 4 The countries with medium share of private sector in R&D

The countries with traditionally low share of private sector in R&D (<40%) are such countries as Azerbaijan, Belarus, Bulgaria, India, Iran, Latvia, Pakistan, Poland, Portugal, Russia, Ukraine.

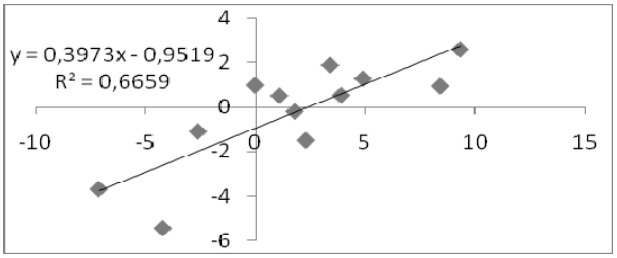

Fig. 5 The countries with low share of private sector in R&D

3 Conclusions

1. For 3 groups of countries (with different level of business expenditures) the trend line has the positive angle, which confirms the basic hypothesis. The peculiarity here is that the elasticity of high-tech exports to the private R&D investments is higher for the 2nd group of countries (where 40-60% of R&D is financed by business sector). It is the diapason in which the most drastic changes in export structure happen with the increase or decrease of business share in R&D investments.

Also it is important to highlight that the 3rd group of countries (with low participation of business sector) mainly has the tendency to declining share of high-tech export (most of the countries are located in the 3rd quadrant on the graph).

2. The share of business investments in R&D to the extent more than 80% may cause the decline in high-tech export. So the government expenditures are an important factor of accelerating the further R&D investments. According to the Harrod–Domar theory more investment leads to capital accumulation, which generates economic growth. Regarding the R&D investment policy, it is possible to make an assumption that expenditures of the government on R&D create the basis and indispensable minimum from which further R&D investment activity is multiplied.
3. Time lag according to statistical data is no more than 1 year.

Explanation of the results, received in the research.

The government is involved mainly in financing the fundamental investigations and basic research (basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view [2]), which implies low degree of commercializing of that kind of R&D.

The main commercial projects of the government in R&D sphere are concentrated in such fields as defense, healthcare, space programs, infrastructure. The governments of the developing countries invest in import-substituting industries, which also mean low level of transforming the financed R&D into high-technology export.

Finally, even in the cases when the government takes the lead in innovation financing and implements different governmental programs for innovative development, it cannot respond better to the changing market necessities and conditions, than private investors and companies that are interested to the maximum extend in the commercial success of their investigations. The governmental programs on the other side frequently tend just to expand the range of goods, but not the technological structure of industry and its qualitative parameters.

Policy recommendations.

It is important to focus on increasing efficiency in R&D spending rather than meeting a specific spending level. The efficiency and competitiveness of R&D investment policy, in its turn, can be achieved by expanding of the role of business sector in R&D financing up to 70-80% (it is important to use economic incentives such as tax exemptions, for example)

It is necessary to preserve the government spending on R&D within the level of 15-20% of the total expenditures, maintaining at the same time flexibility in allocating public R&D funds. The government should concentrate mainly in the basic researches sphere and accelerate in this way other fields of R&D investments.

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