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THE STATE'S ROLE IN CREATING INNOVATION-DRIVEN ECONOMIC GROWTH

Summary: The hereby article considers issues related to the role of the state in creating growth in contemporary economies. The goal of the article – analysis of state's influence on the direction of innovation development has been partly achieved. As contemporary economies have been considered the knowledge ones, knowledge production targeted in provoking innovation and technological change has become the main goal to reach. The scientific method used here's been data analysis. As the presented data shows governments give a lot of support to objectives like: universities, defense, economic development and health and environment. Public investments' returns should be measured with new enterprises or new industries development. The data on the top three performing industries within OECD countries do show the leading role of chemicals and minerals (18 of 27 countries), transport equipment (12 of 27 countries), ICT equipment (9 of 27 countries), electrical equipment (8 of 27 countries). The question is if the industry structure would change if the state did not invest in objectives mentioned above. Or, on the other hand – are the changes already visible, yet the state's investment in new growth areas is still rather a long-run investment.

The presented findings show that the state's role is more than just funding – the state has resources not only to foster innovation-led growth, but also to shape it, dynamize it, to set the trend in economy. It means that innovation economy must be governed by innovative state.

Keywords: economic growth, R&D, new growth areas, innovation.

Introduction

The hereby article considers issues related to the role of the state in creating growth in contemporary economies. As contemporary economies have been considered the knowledge ones, knowledge production targeted in provoking innovation and technological change has become the main goal to reach. The main tool used for this purpose is of course public funding of R&D activity of public research

organizations. As the contemporary economies strongly rely on the knowledge, public support given to the new knowledge production often gives birth to the new industries. It also lowers firm's costs (thanks to public-private-partnerships), and limits the risk of investing in new industries. All these findings show that the state's role is more than just funding – the state has resources not only to foster innovation-led growth, but also to shape it, dynamize it, to set the trend in economy. It means that innovation economy must be governed by innovative state.

The goal of the hereby article is an analysis of state's influence on the direction of innovation development. By presenting the statistical data on gross domestic expenditures on R&D and the share of public support to R&D, the state's engagement in innovation creation will be shown. Government budget appropriations or outlays on R&D by socio-economic objectives will show state's investment profile. And the R&D specialization measured as industry R&D expenditure (percentage of total business enterprise R&D) will show correlation between publicly promoted scientific fields of interest and the business R&D targets. The information on patents in selected scientific fields will confirm the thesis, that private enterprises follow the publicly promoted (thus publicly financed) research. That proves the state's driving force in pro-growth innovation.

1. Drivers of innovation in knowledge-based-economies

Undoubtedly there is a lot of space for state's activity in shaping the widely described 'innovation landscape'. As the literature shows, the main discussion concerns the role that state plays, or should play, with respect to the innovation creation. The basic questions that should be asked here are: do the markets need state to foster innovation? If so – how far the state should go in this support. Do the capitalist markets need to be regulated in order to promote innovative behavior of the firms? The classical attitude to the role of the state in the economy concerns "market failure" approach. Standard economic theory justifies state's intervention when social return on investment is higher than private return, which makes it unlikely that private business will invest[1]. Is this attitude to the state's role in economy sufficient, with respect to the innovative behavior of firms?

State's role in leading economic growth is unquestioned. There are many examples of state's visionary projects that influenced economies and caused econom-

[1] M. Mazzucato, *The Entrepreneurial State: Debunking Public vs. Private Sector Myths*, Anthem Press, London-New York-Delhi 2014 (Kindle edition).

ic growth. The examples of the internet, biotechnology, nanotechnology, pharmaceutical industry constitute a great evidence of state's policy that led to the discoveries that permanently changed the directions of economies development. It is noteworthy that all these new areas of economic development have been discovered in a research university laboratory rather than during production process improvements, which is one the main characteristics of knowledge-based economies.

As the state is the most influential actor in pro-growth policy sphere, in terms of contemporary economies its tools consist mainly of public money spent on R&D activity (directly – like subsidies, and indirectly – like by using tax policy instruments) of both private entities and public research institutions. The R&D activity support is about to contribute to the technological change. But many research project discoveries never get the market as products, or many discovered products just fail[2]. The high risk and uncertainty of the innovation process are the main reasons for which profit-maximizing companies would invest less in basic and more in applied research (D from R&D). The greater and more immediate returns from the latter are a good explanation to these. Investment in basic research is a typical example of fixing market failure where the market alone would not produce enough basic research, so the government must step in. Therefore enterprises mainly get involved in the development, which is a more predictable activity than research (especially basic research). Innovations that arise in this way are mainly improvements and developments of existing products or processes. But the mission-oriented, highly risky and unsecure, but potentially extremely profitable projects are based upon basic research. For the US economy, for example, government spending on R&D makes up only 26% of total R&D, with the private sector making up 67%, the proportion is much higher when basic research is considered in isolation. Indeed public spending accounts for 57% of basic research in the USA, with the private sector taking on only 18%[3].

The main difference between state's spending on R&D in Europe and in United states is the nature of research and development. While in Europe the public support is given to the "general advancement" of existing knowledge, in USA it is a more "mission oriented", subordinated to government agencies' programs or goals (like defense, agriculture, health etc.). As the literature shows, public support for R&D on general advancement of knowledge is usually re-

[2] B. Munoz, *Lessons From 60 Years of Pharmaceutical Innovation*, "Nature Review – Drug Discovery", Dec 2009, No. 8(12), pp. 959-968.

[3] M. Mazzucato, op. cit.

sponsible for less than 50% of total R&D[4]. On the other hand "mission oriented" public support for R&D makes more than 60% of publicly financed R&D in South Korea, USA, UK, France, Canada, Japan and Germany[5].

The fact that the economists were putting so much emphasis on innovation in the growth process, caused policy makers, since the 1980s, to begin paying much more attention to variables like research and development (R&D), as a predicator of innovation and therefore of economic growth. For example, the European Union's Lisbon Agenda (2000) and its current Europe 2020 strategy[6] set a target for 3% of the EU's GDP to be invested in R&D, along with policies that try to encourage the flow of knowledge between universities and business, the creation of credit and venture capital for SMEs, and other factors identified as important for innovation-led growth[7].

As the data presented in Fig. 1 shows only few EU countries reach the 3% guideline – Finland, Sweden, Denmark and Switzerland, the median for the 27 EU countries is 1,91% of GDP. Public expenditures on research activity can range from ca. 1% of GDP in Korea, United states, Finland, Sweden, to 0,29% of GDP in Greece. Israel is a leading country with respect to both – general R&D expenditures and public R&D expenditures (4,4% of GDP and 0,82% of GDP respectively). Public funding of R&D concerns both universities, public research institutions and enterprises. All these categories play an extremely important role in innovation systems, but these are universities and public labs that provide new knowledge, especially in areas in which economic benefits are uncertain or less immediate. It also gives the state a greater influence on the direction and the rate of economic growth.

[4] D.C. Mowery, *Military R&D and Innovation*, [in:] *Handbook of Economics of Innovation*, eds. B.H. Hall, N. Rosenberg, Amsterdam, North Holland 2010.

[5] M. Mazzucato, op. cit.

[6] European Commission, *Europe 2020: A strategy for smart, sustainable and inclusive growth*, http://ec.europa.eu/ europe2020/index_en.htm, obtained: 3.05.2014.

[7] NESTA, *From Funding Gaps to Thin Markets: UK government support for early-stage venture capital*, London 2009, http://www.nesta.org.uk/publications/funding-gaps-thin-markets, obtained: 3.05.2014.

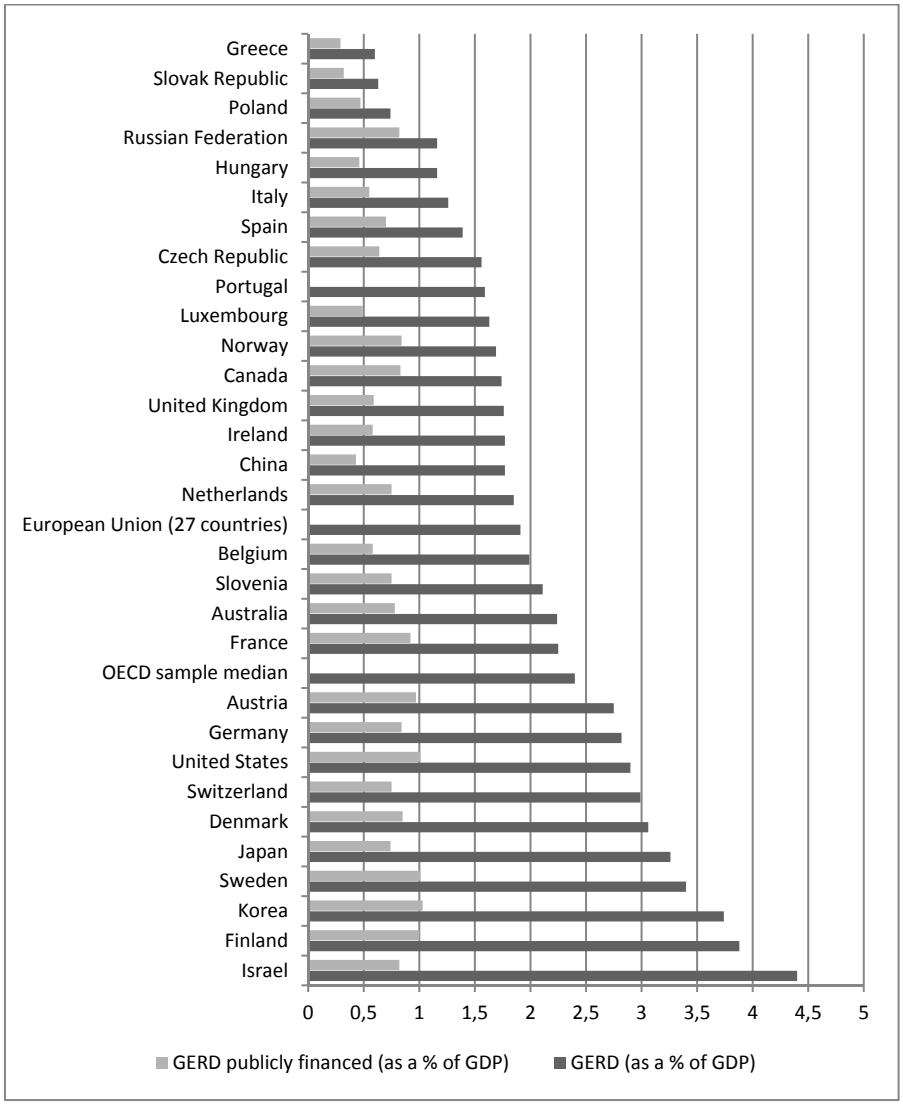

Fig. 1. Gross domestic expenditures on R&D as % of GDP in 2010

Source: *OECD Stats Extracts, Science, Technology and Patents, Key Figures: size of research system*, http://stats.oecd.org/#, obtained: 3.05.2014.

2. Public support to research activity

The relation between science institutions like universities, and the state, can be described by the principal-agent relation[8]. The principal-agent dilemma[9] reflects a situation in which the government or a governmental agency is attempting to enhance its own or wider societal targets, for instance, via public research funding programs. As it does not have the appropriate know-how and human resources to conduct the mission, it needs to "delegate" the actual implementation of tasks (research) to specialized organizations such as universities. The literature shows different aspects of principal-agent dilemma[10].

The great role of universities in creating the relevant knowledge for knowledge economies, makes them the most important recipient of public policies. There are two main standards of thinking about the development of science policy institutions[11]: one, especially supported by scientists and their representative organizations, draws on the notion of Merton on the normative structure of science[12]. According to Merton, the scientific ethos as a prerequisite of good science, requires societies and governments to be inclined to the autonomy of science. Consequently, in order to enjoy the fruits of knowledge, governments should not intervene in their growth (except funding). This attitude is represented mostly by the academic type of science[13]. The other standard of thinking emphasizes the application of scientific knowledge for specific purposes and the possibility to create institutions that foster dedicated scientific knowledge and its application. This line of thought has cumulated in the emergence of science policies stressing the function of science for national competitiveness and allocating resources to university – industry collaborations and critical technologies.

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[8] O. Auranen, M. Nieminen, *University Research Funding and Publication performance – An International Comparison*, "Research Policy" 2012, No. 39, pp. 822-834.

[9] B. Van der Meulen, *Science Policies as Principal-Agent Games Institutionalization and Path Dependency in the Relation Between Government and Science*, "Research Policy" 1998, No. 27, pp. 397-414.

[10] D.H. Guston, *Principal-agent theory and the structure of science policy, revisited: 'science in policy' and the US Report on Carcinogens*, "Science and Public Policy" 2003, Vol. 30, No. 5, pp. 347-357.

[11] B. Van der Meulen, op. cit.

[12] R.K. Merton, *The Sociology of Science, Theoretical and Empirical Investigations*, University of Chicago Press, Chicago 1973.

[13] E. Pohulak-Żołędowska, *Knowledge Production: Industrial Science as a Source of Economies Innovation*, "Argumenta Oeconomica" 2011, No. 1(26), pp. 43-56; E. Pohulak-Żołędowska, *Innovative Activity of Universities – Knowledge Creation in Developed and Fast Developing Countries*, "Transformations in Business and Economics" 2011, Vol. 10, No. 2A (23A), pp. 334-344.

The idea of controlling the scientific knowledge creation through scientific (or better innovation or pro-growth) policy tools is actively exercised in contemporarily developed economies[14]. And as the state's role in financing knowledge-driven development is potentially huge, there has always been a possibility of over- or underestimation of the size of public support. The literature shows a wide evidence on public support for private R&D[15]. In the cited literature, main research problem seems to be an attempt to answer the question of whether public support crowds-in or crowds-out the private R&D investment. Crowding-out is an economic concept where increased public sector spending replaces, or drives down, private sector spending. In contrast to this concept, crowding-in is a positive effect of attracting private investment by public spending. But one can notice a shift in a role that the state plays in contemporary economy, and it is visible, that the role of state does not limit to "crowd-in" or "crowd-out" issues. Assuming positive effects of public investment on R&D one must consider if the state's role is only to foster existing innovation or maybe its role is greater – like developing new paths of innovation-oriented development. In other words – is the state "a facilitator" or "a trend-setting moderator"?

The idea of the neo-liberal state is not valid in the world of innovation uncertainty. State "...is a key partner of private sector (…) willing to take risk that business won't"[16]. But state's role is not only to "de-risk" private sector decisions. It's role is to solve main socioeconomic questions like ageing, hunger, diseases, climate change, etc. A better understanding of state's role in private-public partnerships is nowadays an important issue. Rather than active correction of market failures its role is to shape and create the markets. The most adequate here are the findings of Karl Polanyi[17] (1944), who emphasized how the capitalist 'market' has from the start been heavily shaped by state's actions. In innovation, the state not only 'crowds-in' business investment but also 'dynamizes it in' – creating the vision, the mission and the plan.

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[14] E. Pohulak-Żołędowska, *In Finding Sources of Innovation – Transformation of Universities*, [in:] *Policies for Improving Growth Potential of Economy: International Perspective*, Wydawnictwo Naukowe UMK, Toruń 2010, pp. 289-308.

[15] D. Czarnitzki, A. Fier, *Do Innovation Subsidies Crowd Out Private Investment? Evidence from the German Service Sector*, Discussion Paper No. 2002-04, ftp://ftp.zew.de/pub/zew-docs/dp/dp0204.pdf, obtained: 3.05.2014; M. Marino, P. Parrotta, D. Sala, *New Perspectives on the Evaluation of Public R&D Funding*, 2010, http://infoscience.epfl.ch/record/161988/files/WP_online.pdf, obtained: 5.05.2014; P.A. David, B.H. Hall, *Is Public R&D a Complement of Substitute for Private R&D? A Review of the Economic Evidence*, NBER Working Paper 1999, No. 7373, http://ideas.repec.org/p/nbr/nberwo/7373.html, obtained: 10.05.2014.

[16] M. Mazzucato, op. cit.

[17] K. Polanyi, *The Great Transformation. The Political and Economic Origins of Our Time*, Beacon Press, Boston 1944(2001) (Kindle edition).

3. From "picking winners" to targeting "new growth" areas

As previously shown, the role of state in fostering or dynamizing innovation-led growth is not a new idea. As it is agreed, state's role is not only to fix the "market failures", it also can choose the socially and economically adequate goals to follow. The "picking winners" problem has been widely discussed in literature. For example, government large-scale and long-term investments have been considered to be the main factor of the development of general purpose technologies (like aviation, space technologies, IT, nuclear power, American "mass production") in the XXth century. The "Internet case" is also a good example here, as a result of research conducted by a small Defense Department network project (ARPANET)[18]. In the past, the state has often effectively interfered with technological innovation[19]. There are numerous examples of governmental initiatives aiming in picking technology winners and supporting them. For example in the USA, in the period from World War II to the present, there have been established governmental agencies that have played the "picking winner" role: the Office of Scientific Research and Development (OSRD), the Defense Advanced Research Projects Agency (DARPA), the Small Business Innovation Research Program (SBIR) and the Advanced Technology Program (ATP)[20].

In general, state's impact on technological change is at least twofold. First – state can provide a direct or indirect support to the main beneficiary – enterprises. Second – knowledge-based economies are strongly dependent on new knowledge. There are new industries that are based on the university research (like chemical industry in XX th century, biotechnology or nanotechnology – nowadays). These have been new areas of scientific research that gave rise to the new industry branches. On average, units in the government and higher education sector perform more than three-quarters of all OECD basic research. The higher education sector's contribution to basic research ranges from 80% in Denmark to approximately 20% in Korea, the United Kingdom and the Russian Federation[21]. But it is noteworthy, that the support given by the state may concern publicly conducted basic research funding, and also – what is more important, be more focused on current social needs (identified by the state). The idea that innovation and technological change are important means of dealing

[18] M. Castells, *Galaktyka Internetu. Refleksje nad internetem, biznesem i społeczeństwem*, Rebis, Poznań 2003.

[19] H. Etzkowitz, M. Ranga, *A trans-Keynesian vision of innovation for the contemporary economic crisis: 'picking winners' revisited*, "Science and Public Policy" 2009, No. 36(10), pp. 799-808, http://www.ingentaconnect.com/content/beech/spp, obtained: 5.05.2014.

[20] Ibid.

[21] OECD, *Main Science and Technology Indicators Database*, www.oecd.org/sti/msti.htm, June 2013, obtained: 20.03.2014.

with global and social challenges is well established. With this in mind, many countries have developed research priorities and implemented funding programs aimed at maximizing research quality and impact. In the literature[22] one can find a term "new growth areas" that are the subject of state's multidimensional support.

As the data in Fig. 2 show, public policy plays an important role in influencing the direction of innovation efforts. Government R&D budgets (GBAORD) provide an indication of policy priorities in the relative importance of various socio-economic objectives.

In 2012, OECD governments invested the equivalent of 0.8% of GDP in direct funding of R&D at home or abroad[23]. In relative terms, R&D budgets are largest in Finland and Korea at over 1% of GDP. The importance attributed to different objectives varies widely across countries, reflecting national priorities and differences in their innovation systems. For example, the United states devotes a significant share of funds to defense, while Ireland and Korea place comparatively more emphasis on economic development. Most countries, especially Switzerland, dedicate the largest shares to support for advancement of knowledge and general university funds[24].

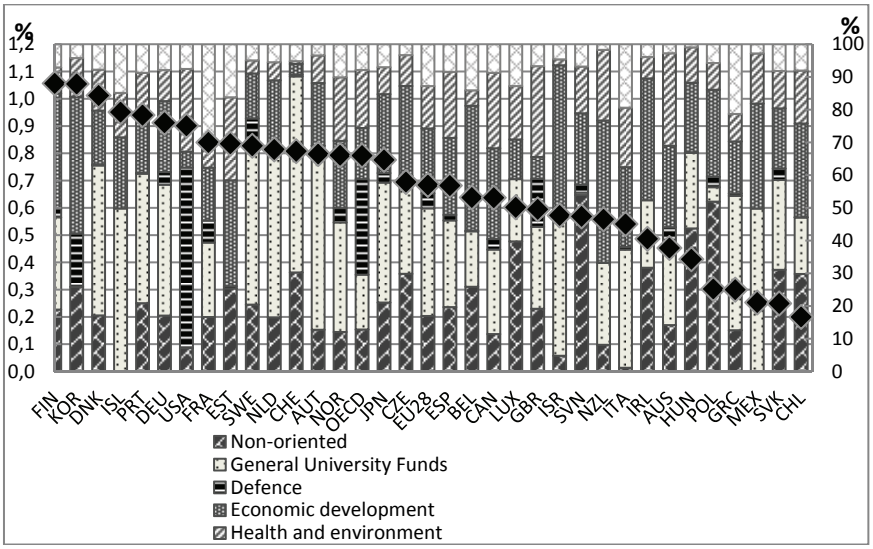

Fig. 2. R&D Budgets by socio-economic objectives, 2012 (Government budget appropriations or outlays on R&D, percentages)

Source: OECD, *Main Science and Technology Indicators Database*, www.oecd.org/sti/msti.htm, June 2013.

[22] OECD, *OECD Science, Technology and Industry Scoreboard 2013*, OECD Publishing, pp. 151-177, http://dx.doi.org/10.1787/sti_scoreboard-2013-en.
[23] Ibid.
[24] Ibid., p. 152.

On the data presented two trends can be observed. First is the confirmation of the cited statement, that Europe's knowledge investment is more about the enlargement of the general knowledge resource. In European countries non-oriented public R&D funding and public expenses for the general university funds constitute the vast majority of state's expenses on building the knowledge base. For comparison the USA has technically no funds in general university funds category, and Israel spends very little money on non-oriented R&D. The second trend seems to be that every country invests in some specific – 'new growth' giving industries. Defense R&D in the USA is a very capacious category. It is worth recalling that Internet was created as a military project. Also OECD countries spend a lot of public money on defense R&D. Another example can be health and environment, which is also a very broad data aggregate based on environmental sciences.

The distribution of business R&D by economic activity reveals a pattern of specialization that is influenced, but not entirely driven, by a country's economic structure (Fig. 3). In most OECD countries, a limited number of activities account for a large share of total business R&D. Chemicals, broadly defined to encompass fuels, pharmaceuticals, other chemicals and minerals, is the major R&D activity in 8 out of the 27 countries for which data are available. ICT equipment manufacturing is particularly important in Finland and Korea, while information services prevail in Ireland, Poland and Portugal. In the Czech Republic, France, Germany, Italy and Spain, transport equipment, including motor vehicles and aerospace, ranks first[25].

[25] Ibid.

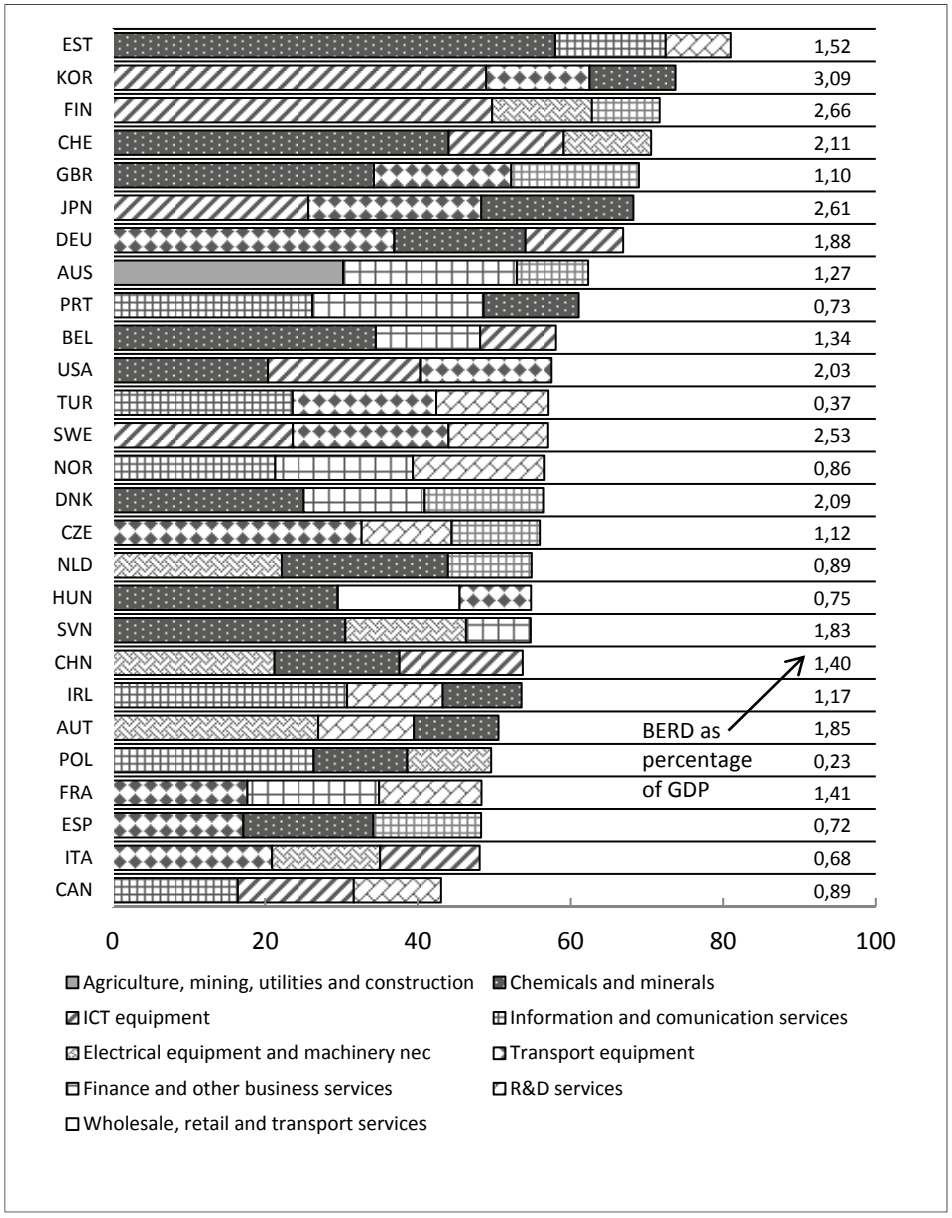

Fig. 3. R&D specialization, top three performing industries. Industry R&D expenditure as a percentage of total business enterprise R&D

Source: OECD, *ANBERD Database*, www.oecd.org/sti/anberd; *Research and Development Statistics Database*, www.oecd.org/sti/rds; and national sources, June 2013.

Due to assumptions on the state's role in shaping the technology-driven landscape of innovation and growth, one can notice, that the presence of categories like ICT equipment, chemicals and minerals, agriculture, ICT services, D&R services can be understood a result of state's support to the research on these issues. New technology-based industries strongly rely on basic – publicly funded research, which, on the above example, may show, that that share of business expenditures on research and development is a consecutive step in innovation. Enterprises' expenditures on R&D in new industrial areas are the development phase (D of R&D) of publicly invented products. Or else – intensity of business R&D in new industrial areas is a result of public investment on predevelopment phase of the product.

Patents are the top aspects of technology development both as innovation and as an enterprise's asset. Also R&D efforts by firms and governments may become reflected in patented inventions. Medical technology is the leading patenting field in the United states and the United Kingdom, while electrical machinery dominates in Germany, Japan and the EU28. Digital communication technologies feature as the top technology field for patenting in Canada, Korea and China[26].

The presented data shows strong R&D activity in selected scientific areas. Both public and private. Undoubtedly some areas – like finance or electrical equipment are the general development activities, and it is hard to prove the presence of breakthrough innovations there. One must also remember, that some innovations in nanotechnology are successfully used in other industries, as they relate to the materials used. But medical technology, agriculture, chemicals, defense, environment are definitely the areas of great importance for future economic development. And – on another hand – the areas of state's great pro-growth intervention.

Conclusions

In the hereby article the state's role in fostering pro-growth innovations has been discussed. It has been stated that the role of the state goes far beyond fixing market failures. Investing in risky but potentially profitable economic activity, incurring high costs of uncertain research increases the attractiveness of new technologies, that without 'sunk costs' covered by public funds would have never come up to the market. It means, that state by de-risking of some fields of scientific interest points out 'the winners' – new industry branches. It means that state's role goes beyond innovation support. It also crowds-in private investment, dynamizes-in innovation and growth, creates the vision, mission and the plan.

[26] OECD, *Main Science and Technology Indicators*…, op. cit.

Given examples show, that public support for specific research areas provokes the development of specific industries. Although public R&D expenditures indicator does not show the immediate 'winner', one can easily notice, that there are two aggregated data categories – defense, and health and environment that are the most often (health and environment) and to a larger degree (defense) financed by the public. The pro-growth fields of interests are shown on an example of business expenditures on specific R&D. This category shows which scientific disciplines have developed properly and allowed enterprises to continue development process. These fields of interest are correlated with promoted scientific areas – biotechnology, nanotechnology and ICT.

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ROLA PAŃSTWA W KREACJI OPARTEGO NA INNOWACJACH WZROSTU GOSPODARCZEGO

Streszczenie: Niniejszy artykuł dotyka problematyki roli państwa w kreowaniu wzrostu współczesnych gospodarek. Cel artykułu – analiza wpływu państwa na kierunek rozwoju innowacji został osiągnięty częściowo. Analizowane dane wskazują, że państwa krajów OECD najczęściej finansują następujące socjoekonomiczne cele: działalność uniwersytetów, obronność, rozwój gospodarczy, ochronę zdrowia i ochronę środowiska. Takie inwestycje powinny przynieść zwrot pod postacią rozwoju poszczególnych rodzajów przemysłu. Tymczasem dostępne agregaty makroekonomiczne pokazują w dość ogólny sposób, jaka działalność dominuje w badanych krajach. Dominująca działalność w 27 krajach OECD to chemikalia i minerały, sprzęt transportowy, sprzęt ICT, sprzęt elektryczny.

Powstaje pytanie, czy uprawnione jest stwierdzenie, że te rodzaje działalności rozwinęły się dzięki publicznym inwestycjom, że to nowe dyscypliny naukowe wpłynęły na obecny kształt gospodarek. Z drugiej strony można zadać pytanie, czy zmiany struktury przemysłu będące wynikiem inwestycji w innowacje będą już widoczne. Taka forma inwestycji na charakter długookresowy i w takim również okresie należy oczekiwać zmian.

Można jednakże zauważyć, że rola państwa sięga daleko poza finansowe wsparcie działalności innowacyjnej. Dzięki publicznym środkom państwo może wspierać innowacyjną działalność podmiotów, ale również – co istotniejsze – może kształtować kierunek i tempo rozwoju nowych dziedzin nauki i przemysłu, może kształtować trendy w gospodarce.

Słowa kluczowe: wzrost gospodarczy, B+R, nowe obszary wzrostu, innowacja.