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## The Effect of R&D Intensity on Innovation Performance: A Country Level Evaluation

Mesut Savrul<sup>a</sup>, Ahmet Incekara<sup>b</sup>, a\*<sup>a</sup> Canakkale Onsekiz Mart University, Canakkale, 17200, Turkey<sup>b</sup> Istanbul University, Istanbul, 34452, Turkey

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### Abstract

Globalization led to technological advances and increased information flow which has resulted in the knowledge to turn into be the main drivers of economic growth. Investments in technology and innovation are made to advance economic performance and living standards the innovation process of the countries can be guided by deliberate government policies rather than a spontaneous phenomenon in global economic environment. In this regards the countries willing to make progress in innovation are focusing on innovation investments.

However whether this approach which is accurate in terms of firm behavior, is eligible for a country is questionable. In this study the reasons that cause innovation performance and R&D intensity ranks of some countries deviate and regarding their R&D intensity values, why some countries have better or worse innovation outputs than their inputs are discussed in this study. It's concluded that positive environmental factors have great impact on a country in transforming its innovation investments to innovation performance.

*Keywords:* R&D Intensity, Innovation, Economic Growth

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### 1. Introduction

Innovation is the process of knowledge into economic and social benefits. Companies increase productivity and profitability by the use of innovation. By the help of innovation firms can enter new markets easily and grow their share in existing markets. Efficient, profitable and highly competitive firms in the country, also gains a competitive advantage on a global scale via innovation. As a result innovation increases employment sustainable growth, social welfare and quality of life (Elçi, 2007: 38).

One of the widespread misconception is that innovation is that has to do with developing brand new, advanced solutions for sophisticated, well-off customers, through exploitation of the most recent advances in knowledge and it

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\* Corresponding author. Tel. + +90 286 3358738 (1194)

E-mail address: [msavrul@comu.edu.tr](mailto:msavrul@comu.edu.tr)

should be carried out by highly educated labour in R&D intensive companies with strong ties to leading centres of excellence in the scientific world. However there is another way to look at innovation that goes significantly beyond the high-tech picture just described. In this broader perspective, innovation may be the attempt to try out new or improved products, processes or ways to do things (Hall and Rosenberg, 2010: 835). And it includes not only technologically new products and processes but also improvements in areas such as logistics, distribution and marketing. Even in so-called low-tech industries, there may be a lot of innovation going on, and the economic effects may be very large (Fagerberg et.al., 2009: 1).

Another point is that innovation is not only an enterprise thing, countries invest in innovation too. Investments in technology and innovation are not made for their own sake but to advance economic performance and living standards. Thus a successful innovation performance will test how well a country performs against such economic and social indicators as GDP and productivity growth, morbidity rates for major diseases, etc. The effect of innovation on such variables will not depend on the introduction of new products, processes, services and systems, but on their subsequent diffusion throughout the economy and social system (OECD, 2005: 8).

Within this framework this study discusses if the amount of investment in R&D a country made correlates with the innovation performance of the country such as an enterprise does. In this regards, firstly the relationship between innovation and economic growth is discussed part and then some county level data containing investments to R&D, number of researchers in R&D and innovation performance is evaluated. In the final section the findings are evaluated.

## **2. Innovation and Economic Growth**

Traditionally, while a large part of economists argue that economic growth depends on factors of production the others are of the opinion that it will not be sufficient to explain the economic growth only with those factors. According to this second group of economists, the most important determinants of economic growth is technology (Helpman, 1998: 1). During the industrial revolution, new tasks such as financing, production, marketing, R&D came out as a result of development of industrialization and increase of division of labor and specialization in business. It is not possible to separate division of labor from the renewal. One of them is related to social organization and the other is mechanized production (Fukuyama, 1999: 90). In this process, new areas of expertise, new forms of governance and new sources of information have been developed and this gave rise to a new area of competition.

Emergence of globalization in the following period has led to increased competition in both national and international markets. Although this intense competition in international markets leads to some positive results in favor of consumers such as prices getting cheaper, it also brings a lot of challenges for manufacturers such as upgrading product quality, production technology, technological advances and marketing standards. In particular, the companies aiming to expand into the global market are forced to make their production more efficiently and with lower costs. One of the most effective ways of increasing competitiveness in the global markets is making production more efficiently and cost-effectively through technology and innovation. On the other hand the firms that don't invest or give proper attention to innovation and technology have to withdraw from the market after a period of time (Yves and Leblanc, 2002). Consequently the advances also let the emergence of new organizational forms by enabling large increase in access to information and the emergence of new markets. Technological advances and increased information flow on the other hand, have resulted in the knowledge to turn into be the main drivers of economic growth (European Commission, 2005: 10).

Knowledge economy is based on innovation. As one of the basic concepts that gave life to the concept of the new economy, innovation offers renewal of product, system, process, marketing and workforce (Kavak, 2009: 617-618). The Oslo Manual prepared by OECD and the European Commission defines innovation as implementation of a new or significantly modified goods or services or process, a new marketing method or a new organizational management in business practices, workplace organization or external relations (TÜBİTAK, 2005). New ideas are turned into commercial benefit through innovation. Although innovation is associated with products and services at the outset innovation can also be implemented in distribution, brand, customer experience, business models (Yücel, 2007: 36).

Innovation and exploitation of scientific discoveries and new technology have been the principle source of long-run economic growth for countries also and it helps increasing social well-being too. It is likely that the innovation performance of a country will be even more crucial to its economic and social progress. Countries whose firms fail to innovate will increasingly find themselves in direct competition with newly developing countries with lower labour costs and an increasing mastery of existing technologies and business methods. The development and exploitation of novel products, processes, services and systems, and the constant upgrading of those which a country already produces, is the only way in which the countries can maintain and increase their relative high levels of economic and social well-being (OECD, 2005: 7).

Consequently either developed or developing, countries all around the world is investing in innovation more or less. However the result they get from their investment is greatly affected by the embodiment, form and amount of their investment.

### **3. The Effect of R&D Intensity on Innovation Performance**

Growth theory has for long established that improvements in technology have an effect on long-run growth (Aghion and Howitt, 1998). Although the advantages of technology is first seized by developed countries, by the participation of developing countries in the globalization process created an opportunity for them to better utilize their comparative advantages, introduce foreign capital, management experience and advanced technologies (Incekara and Savrul, 2013:14).

Today, one of the most important lessons learnt is about the extraordinary capacity of innovation to drive growth since it can play a critical role in sustaining national competitiveness in the medium to long term (INSEAD, 2010: 6) and improving national innovative capacity is important to ensure long-run economic growth. Such national innovative capacity may be improved by fostering industrial R&D, by funding sufficiently academic research and by supporting effectively university-industry interactions to strengthen the linkage between R&D and product development. For what relates to government support to business R&D, this would be justified by the existence of market failures associated with R&D activities. The major policy tools used by government to support business R&D include grants, procurement, tax incentives and direct performance of research. The effectiveness of this support has also been long lastly debated in the literature (Mathieu and Potterie, 2010: 57).

Lately, rapid increase in the investment in information and communication technologies and the impact of these investments on productivity is one of the most important factors that show the role of technology on economy. However considering the recent growth performance of OECD countries, the new role of innovation is seen as quite beyond of information and communication technologies. Innovation is the essence of economic activities. In this framework the companies from all sectors have to be innovative in order to meet the needs of conscious consumers and to remain at the forefront in the global competition environment (Pilat, 2004: 3).

A notable case is that, differences in technology have been found to be an important determinant of differences in total factor productivity across countries. While most of them improve their technology by simply imitating or adapting existing production techniques to local conditions, others are truly engaged in the creation of new technologies (Almeida and Fernandes, 2006:2). In this regards country profiles show that some countries excel more than others at science and technology for the same level of public investment. In some countries, the challenge for efficiency starts at the reforms needed to achieve scientific and technological excellence. Growing investment has raised levels of excellence in science and technology in many countries, but the degree of improvement may still be lower than the EU average. For other countries the main challenge is to trigger fast-growing innovative enterprises and international competitiveness by disseminating knowledge (EC, 2013: 4).

Due to the problems encountered in measurement of technology and innovation, their contribution on economic growth didn't use to be included in the economic growth related studies, however recent studies of economic growth put technology and innovation in the center (Helpman, 1998: 2). Although technology and investment is measured through a number of variables R&D intensity is one of the most prominent.

The definition of R&D intensity is different for a firm and a country. While R&D intensity is the ratio of a firm's R&D investment to its revenue for an enterprise, it is defined as the R&D expenditure as a percentage of gross domestic product for a country. R&D is the main driver of innovation, and R&D expenditure and intensity are two of the key indicators used to monitor resources devoted to science and technology worldwide. Governments are increasingly referring to international benchmarks when defining their science policies and allocating resources (Eurostat, 2013). On country basis, beside a country invest in innovation efficient use of the existing innovation potential is also important. A comparison of innovation inputs with innovation performance of a country can provide preliminary information about how effective it can use the innovation. If the difference between these two indicators is too high it means that innovation efficiency of the host country is too high or low.

Expenditure on research and development is one of the most widely used measures of innovation inputs. R&D intensity (R&D expenditure as a percentage of GDP) is used as an indicator of an economy's relative degree of investment in generating new knowledge. Several countries have adopted targets for this indicator to help focus policy decisions and public funding (OECD, 2011).

Table 1. Top Ten Countries in Research and Development Expenditure 2000 – 2012 (% GDP)

Rank	Country	2000	2002	2004	2006	2008	2010	2012
1	Israel	4,17	4,43	4,15	4,22	4,40	3,97	3,93
2	Finland	3,35	3,36	3,45	3,48	3,70	3,90	3,55
3	Sweden	..	..	3,58	3,68	3,70	3,39	3,41
4	Denmark	..	2,51	2,48	2,48	2,85	3,00	2,98
5	Germany	2,47	2,50	2,50	2,54	2,69	2,80	2,92
6	Austria	1,93	2,12	2,24	2,44	2,67	2,80	2,84
7	Slovenia	1,38	1,47	1,39	1,56	1,65	2,11	2,80
8	United States	2,62	2,55	2,49	2,55	2,77	2,74	2,79
9	France	2,15	2,24	2,16	2,11	2,12	2,24	2,26
10	Belgium	1,97	1,94	1,86	1,86	1,97	2,10	2,24
	World	2,10	2,09	2,03	2,03	2,07	2,12	..

Resource: OECD, Research and Development Expenditure, 2014.

Table shows that with some exceptions global trend in research and development expenditures is growing year after year. Israel which invests in research and development more than any other country for many years is on the top of the list. The other countries ranking among in the top of the list are Finland, Sweden, Denmark, Germany, Austria, Slovenia, United States, France and Belgium respectively.

Table 2. Researchers in R&D 2000 – 2012 (per million people)

Rank	Country	2000	2002	2004	2006	2008	2010	2012
1	Finland	6732	7428	7843	7671	7686	7717	7482
2	Denmark	..	4758	4847	5302	6496	6744	6730
3	Singapore	4245	4381	4882	5425	5742	6307	6438
4	Luxembourg	3773	..	4497	4406	4694	5190	6194
5	Norway	..	..	4503	4836	5353	5408	5588
6	Sweden	..	..	5432	6131	5438	5256	5181
7	Portugal	1624	1826	1974	2340	3823	4368	4781
8	Austria	..	2981	3168	3528	4137	4312	4565
9	Slovenia	2179	2333	2020	2915	3460	3750	4398
10	Germany	3088	3176	3223	3342	3628	3950	4139
	World	1677	1490	1855	2102	2029	1916	3092

Resource: OECD, Researchers in R&D, 2014.

Another element affecting innovation performance of the countries is the number of researchers in the population. At first sight it draws the attention that the number of researchers increased fairly in most of the countries and it almost doubled globally. Finland performing more than twice of the global figures ranks first in the list with 7482 people and the following countries are Denmark, Singapore, Luxembourg, Norway, Sweden, Portugal, Austria, Slovenia and Germany.

A further aspect worth considering is that although their rankings differ, Finland, Denmark, Sweden, Austria and Germany appear also in the previous list showing top ten countries in research and development expenditure. In this context it's obvious that rather than coincidence some countries are performing well in the tables as a result of intentional efforts. However whether the prominent factors such as investing more in R&D and having more researchers determine innovation performance and intensity is questionable. Table 3 presenting current innovation ranks of the countries may offer some answers to the investigation.

Table 3. The Most Innovative Countries in the World 2014

Economy	Total Score	Rank	R&D Intensity Rank
South Korea	92.10	1	3
Sweden	90.80	2	4
United States	90.69	3	10
Japan	90.41	4	5
Germany	88.23	5	9
Denmark	86.97	6	6
Singapore	86.07	7	17
Switzerland	86.02	8	8
Finland	85.86	9	2
Taiwan	83.52	10	7
Canada	83.21	11	24
France	82.42	12	16
Australia	80.79	13	14
Norway	80.39	14	25
Netherlands	80.32	15	19
United Kingdom	80.01	16	22
Austria	79.52	17	11
Russia	77.53	18	33
Belgium	77.02	19	18
New Zealand	75.09	20	29
Luxembourg	74.55	21	27
Italy	73.08	22	30
Czech Republic	73.07	23	20
Poland	71.23	24	40
China	70.51	25	21
Hungary	69.89	26	31
Hong Kong	69.61	27	44

Ireland	69.59	28	23
Portugal	67.83	29	26
Israel	67.77	30	1
Slovenia	67.29	31	13
Spain	66.40	32	28
Iceland	66.39	33	12
Malaysia	63.60	34	35
Greece	63.15	35	53
Turkey	61.00	36	38
Romania	60.87	37	56
Malta	59.29	38	45
Estonia	59.28	39	15
South Africa	58.98	40	37
Latvia	57.80	41	49
Bulgaria	57.26	42	54
Croatia	56.56	43	43
Lithuania	54.73	44	36
Brazil	54.41	45	32
Slovakia	54.15	46	50
Tunisia	53.82	47	34
Argentina	53.44	48	51
Ukraine	53.20	49	48
Iran	48.30	50	39

Resource: Bloomberg, The Most Innovative in the World 2014: Economies, 2014, <http://www.bloomberg.com/visual-data/best-and-worst/most-innovative-in-the-world-2014-economies>

Innovation performance of 82 countries with available data is examined and five countries with the most successful innovation performance were respectively Japan, Switzerland, Finland, and the USA between the years 2004-2008. In 2008-2013 period while innovation performance index of Japan did not change, Finland increased, Switzerland, USA and Sweden dropped in small proportions. Examination of innovation performance growth rates shows that the countries in the top of list are consist of developed countries five-year growth expectations of which are fluctuate within 0% to 1%. However in line with the convergence hypothesis, the developing countries which have the middle and lower ranks of the list may have growth prospect up to 11% (The Economist, 2009: 4).

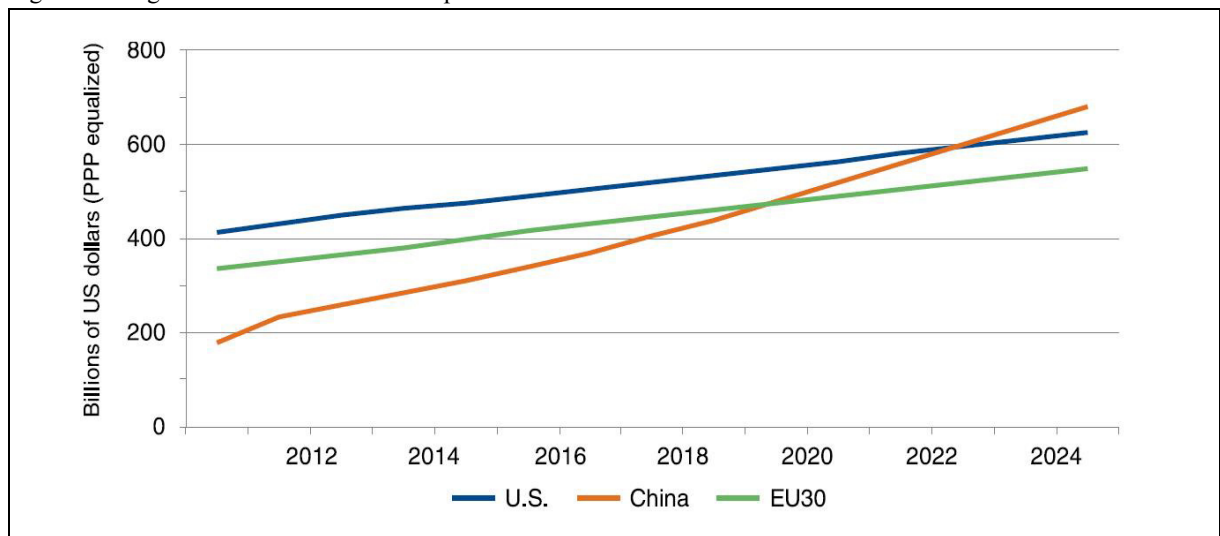
Table 1 showing the most innovative countries of 2014, presents that South Korea, Sweden, United States, Japan and Germany Sweden, Denmark, Singapore, Switzerland, Finland and Taiwan are the top ten most successful countries in over all innovation performance. Except for minor changes the table accords with the figures mentioned before. However R&D Intensity Rank of the same countries tells us another story. Although innovation and R&D intensity ranks of many countries somehow overlap few others display great distinctions. For instance while South Korea ranking 1<sup>st</sup> in innovation ranked 3<sup>rd</sup> in R&D Intensity Rank and Sweden 2<sup>nd</sup> in innovation and 4<sup>th</sup> in R&D, Israel in the 1<sup>st</sup> position in R&D Intensity has 30<sup>th</sup> rank in innovation rank list and USA in the 10<sup>th</sup> position in R&D Intensity has 3<sup>rd</sup> rank in innovation rank list. Rather than South Korea and Sweden which have relatively more expected figures with overlapping ranks let's focus on the countries such as Israel and USA innovation performance and R&D intensity ranks deviate.

The countries such as USA, Germany, Singapore and Canada have better innovation performance scores than their R&D intensity scores. This favourable situation is the result of positive environmental factors which allow the countries use their innovation potential they obtained through relatively with lower investment more efficiently. The second group of countries such as Israel and Finland face the opposite case. Much of the innovation in these countries is produced by private sector, they have more scientists working in R&D industry and the quality of higher education is quite successful. Their economy is focused on high-tech companies and the general trend is on innovation-intensive activities. However, environmental factors and input constraints preclude their superior innovation potential to be converted into same amount of output. As a result although they invest much more than any other country in the world they don't get the best results in over all innovation performance.

Similarly, the Central and Eastern European countries also get lower output than expected from their innovation inputs. The largest share in the reasons of this occasion include that the most of the educated workforce and major scientific organizations which are significant innovation performance indicators have been left in central government and failed to be fully integrated with the global economy. And this returns as a low innovation performance score. As it can be concluded from the current data, even though the progress in a positive direction in the last five-year period these countries fail to transform their potential to innovation output and they need creation of a more favourable environment to be able to use their inputs more efficiently.

China is also within the most debated countries which one of the most striking leaps in terms of innovation in the last decade. It moved up to 25<sup>th</sup> from 54<sup>th</sup> and it's also successful in converting its potential into use. When the reasons behind the success of China are examined it's seen that the primary factor is its efforts towards a more innovative economy. In the mentioned period the country invested in R&D and education a lot and innovation environment in China has developed accordingly.

Figure 1. Long-Term Outlook for R&D Expenditures



Resource: Battelle and R&D Magazine, 2014 Global R&D Funding Forecast, December 2013, p.13.

According to OECD data, private and public R&D expenditures of China were about \$ 87 billion in 2006. Although the value fell behind Japan (139 billion) and EU (243 billion) when the increase of 19 percent between 2001-2006 is considered, the efforts of the country is notable (The Economist, 2009: 9). According to current trends displayed in Figure 1 China is investing almost as much as the EU at the moment and expected to be the leading country by 2024.

However as it is mentioned before the only factor underlying success is not the investment on innovation but China managed to support the investment with social support. As a result of investments in innovation in the last ten years, China had the largest number of people engaged in science and technology in the world. It has the second rank in

published articles worldwide following USA and the number of students who graduate from university of science and engineering correspond to 40% of the total number of graduates. This value is more than twice the OECD average, while the US is over 15%. Finally, the foreign direct investment policy implemented in the country is aimed at innovation-intensive sectors (Smirnova, 2010: 4). When all these developments are evaluated collectively, it's apparent that successful results can be seen in the development of innovation deliberately conducted practice in innovation policy. However taking into consideration that innovation is a complex term having both economic and social sides, merely monetary investment may result in inefficiency.

#### 4. Conclusion

Initially come out as a firm level term stating the ratio of a firm's R&D investment to its revenue for an enterprise, R&D intensity is the R&D expenditure as a percentage of gross domestic product for a country. R&D expenditure and intensity are two of the key indicators used to monitor resources devoted to science and technology worldwide. The data including innovation performance and R&D intensity ranks of the countries display that the most innovative eight countries are within the top ten investors of R&D sectors. This clearly shows that developments in the innovation process of the countries can be guided by deliberate government policies rather than a spontaneous phenomenon in global economic environment. In this regards the countries willing to make progress in innovation are required to focus on innovation investments.

In this framework from developed to the least developed, many countries are investing to innovation more or less. Particularly in the last decade some of the countries doubled or tripled their investments in R&D industry and the number of people working in it. Not much different from a company investing in R&D many of the countries got better results as they invest in innovation more but some didn't. The innovation rank and R&D intensity data evaluated in this study shows that innovation performance and R&D intensity ranks deviate. Some countries such as Israel may have a much worse innovation performance score than expected in return of its R&D intensity in contrast some other countries may have much better innovation performance with lesser investment.

This instance shows that the more investment input yields the more innovation output prospect has some shortcomings since the governments don't pursue the same goals as a firm. Except for the purpose of obtaining profit, a country should get use of its innovation in ensuring social welfare to its citizens. And in practice when innovation is diffused into social aspects such as education system, health services, governance and international relations rather than kept limited with some high tech firms, favourable environmental conditions are formed which let a country yield more innovation performance than it invested.

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