The Impact of Innovation and Technology on the Economic Growth in OECD Countries

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Abstract

This paper investigates the impacts of innovation and technology on the economic growth in the OECD countries. This study is based on the economic growth model from the previous research study from the innovation – economic growth nexus: Global evidence (L. Hasan, et al.). We tried to adjust the original model by substituting a fee variables and focusing only in the OECD nations. In addition, we expect the results to show a positive between the evolution of innovation and technology on economic development in the 34 OECD countries from time period of 1991 to 2012. Moreover, we want to analyze the relationship between economic openness and electricity consumption of the OECD and the economic growth, since most of the OECD countries are high-level income countries.

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1.0 INTRODUCTION

Economic growth has been used as an important indicator of academic researchers and policy makers. The economic growth rates from previous research study shows that a broad range of outcomes. Some countries have achieved high income while many others still remain at lower levels over the past few decades. Therefore, we only focus the more developed countries, the OECD countries, to analyze how the technology and innovation advancement affect economic growth suitability.

The Organization for Economic Co-Operation and Development (OECD) is a high income forum where the governments of 34 democracies work together to address the economic, social and environmental challenges of globalization. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and global issues, such as corporate governance, the information economy and the challenges of an ageing population. The Organization provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies. The OECD member countries are: Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The Commission of the European Communities takes part in the work of the OECD.

Much of the improvement in living standards is due to innovation and technology advancement, this has been the case since the Industrial Revolution. Nowadays, innovative performance is an important factor in determining competitiveness and national economic development. Moreover, innovation is important to help address global challenges, such as climate change and sustainable development. The application of advanced technology helped both private and state-enterprises to deliver goods and services to help the people enjoy more advanced and civilized living standards. This results in economic growth if market structures and the regulatory environment enable the more productive activities to expand. This said, the innovative effort itself, including formal research and development, remains the unavoidable of growth.

The panel data model analysis is focused on the assumptions that endogenously determined innovation and technology enables sustainable economic growth, given that there are constant returns to innovation in terms of human capital employed and employment technique skills in the R&D sectors and expenditures in innovation and technology development. In addition, the model test the relationship among the OECD's economic openness, government consumptions percent in terms of GDP, foreign direct investments, and literacy rate of labor force. We also use high – technology exports in current US dollar, patent application including both residential and non-residential, and electricity production to determine the technology in the research study. This paper uses various panel data techniques and the data of 34 OECD countries for the period 1991 - 2012 to investigate the following postulations of innovation and technology development based endogenous growth models: (1) the expenditure of research and development in percent of GDP in the OECD countries has a positive relationship with GDP per capital growth annually. (2) The country's economic openness has a significant impact on the economic growth, which matches the policies of the OECD trade policies.

The rest of the paper is organized as follows: Section 2 covers a trend of the impact of innovation and technology in the OECD countries. Section 3 gives a brief literature review, what is currently know about this topic on the basis of research evidence. Section 4 shows the data sources and empirical methodology. Section 5 presents and discusses the empirical results of the panel data model. Finally, the conclusion of the research study is stated at the end.

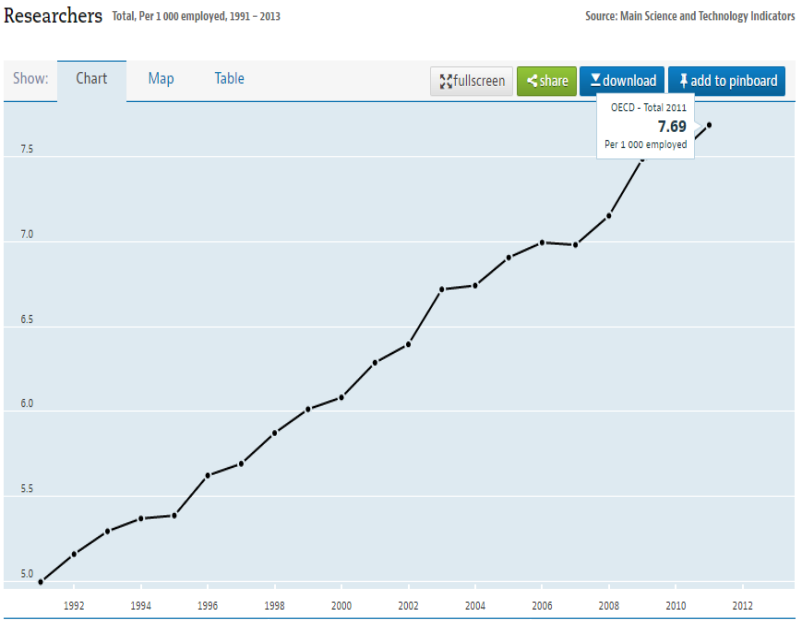
2.0 TREND

Innovation is pervasive in economic development literature, and easily the most oft – cited economic strategy of think tanks, political candidates and state, local and federal government bureaucracies. Innovation, Entrepreneurs and Education for the knowledge – Based Economy are the remedies for the post – 2008 recession. (Coan, Ron) Under PECD Working Party of National Experts on Science and Technology Indicators (NESTI) as part of its review of the measurement framework for R&D and innovation. The project has reviewed how the current measurement frameworks capture the board range of innovation activities in firms, and in particular how design activities are reflected. It highlights which concepts, definitions and

measurement approaches can be used to produce policy-relevant indicators on the role of design in innovation. It also demonstrates how survey data can be used to study the relationship between design use, innovation and economic performance, with a quantitative analysis of the results of a set of experimental design-related questions introduced by Statistics Denmark in its 2010 innovation survey.

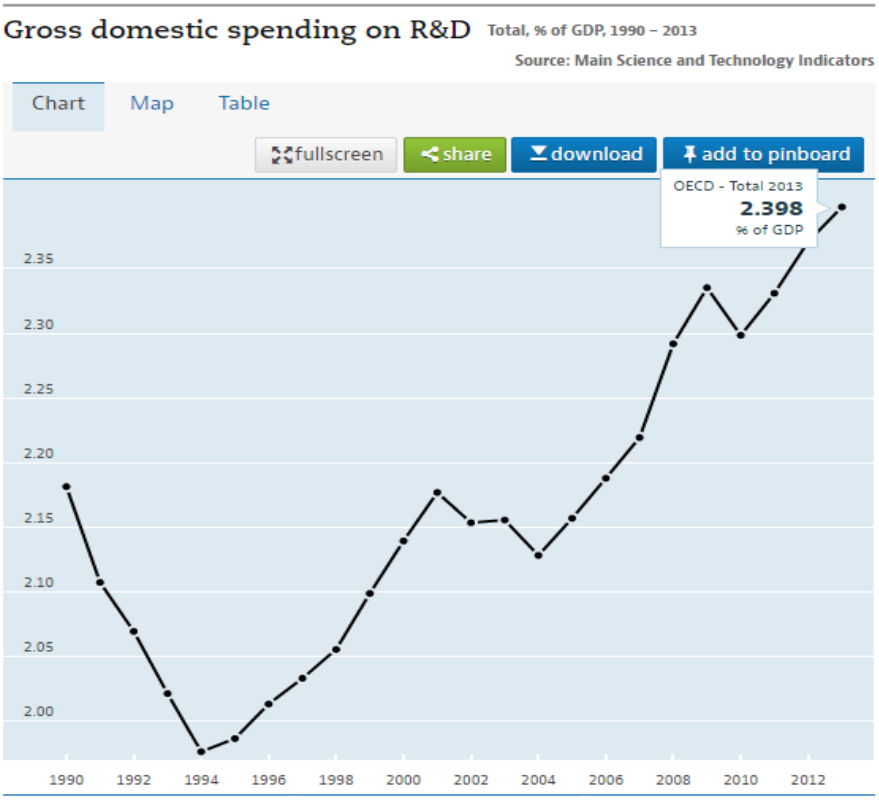
Research and experimental development (R&D) comprises creative work undertaken on a systematic basis in order to increase the stock of human knowledge and to devise new applications based upon it. The term R&D covers three activities: basic research, applied research and experimental development. Basic 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. Applied research is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective. Experimental development is systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed. After the economic crisis in 1994, the R&D spending in OECD countries has been increasing over the decades.

Figure 1. Researchers in OECD, 1991- 2012.



In figure 1, the chart shows that researchers in the OECD countries have been increasing since 1991, and the number has been increased over the period. Researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems, as well as in the management of the projects concerned. This indicator is measured in per 1 000 people employed and in number of researchers.

Figure 2. Gross domestic spending on R&D in OECD, 1990 - 2013



In figure 2, Gross domestic spending on R&D is defined as the total expenditure (current and capital) on R&D carried out by all resident companies, research institutes, university and government laboratories, etc., in a country. It includes R&D funded from abroad, but excludes

domestic funds for R&D performed outside the domestic economy. This indicator is measured in million USD and as percentage of GDP

From 1953 to 2007, the United States invested a total of $3.9 trillion in federal R&D. Over the same period US GDP grew from about $2.4 trillion to $13.9 trillion, representing an annual growth rate of 3.3%. If we attribute half of that growth to federal R&D, or 1.65% of that 3.3% annual GDP growth rate, then that would imply a 2007 GDP of about $6 trillion in the absence of such federal investments. In other words, from 1953 to 2007 the economy grew by a cumulative $153 trillion more than it would have otherwise, representing an implausibly staggering 40 to 1 return on the federal R&D investment. (Pielke, Roger Jr.)

3.0 LITERATURE REVIEW

Rosenberg (2004) analyzed why technological innovation is considered as a major force in economic growth in the highly industrialized economies of the OECD area. In his study, he focused on some of the most distinctive features of innovation in economic growth. Examples of advanced innovation in the U.S., in 1983, "when AT&T was being divested in an anti-trust suit, it was considering whether it should attempt to retain the frequencies that would be essential for the operation of mobile phones. AT&T therefore hired one of America's best-known consulting firms to forecast the likely number of American subscribers for mobile phones by the year 1999. The forecast that was eventually given to AT&T was that there might be as many as one million subscribers to mobile phones in 1999. In fact, the number of subscribers passed the 70 million mark in that year." (Rosenberg, 2004). In addition, Rosenberg described what and how the uncertainties affect the innovation. Because the conduct of R&D in the high tech sectors of OECD economies has become hugely expensive and the outcome of this R&D spending is fraught with financial risks that derive from a variety of sources. It is easy to understand the nature of innovation would help economic growth in certain high-income developed countries, but it is extremely difficult to forecast how the market will respond to the introduction of some new member countries. Later, the author also talked about the impact of a technological innovation on economic growth and tourism.

Different research studies have their own measurements for innovation. In the original study research paper, Tucci and Hasan (2008) used technology index, an index developed from a number of variables: electric power consumption, fixed line and mobile phone subscribers, personal computers, radios and telephone sets, total research and development expenditures to GDP, ratio of patents granted in the USA. Some of other paper also use patents and applications from both residents and non-residents.

Foreign Direct Investment is an important affect to the productive and technological capacity of the OECD Countries. GVCs are changing the international division of labor and the greater mobility of talent has accelerated the internationalization of R&D. The size and growth of markets were traditionally the most important attractions for FDI (OECD, 2011a). More recently, access to strategic assets, such as technology, knowledge, expertise or the presence of supplies, competitors and lead users has been a key determinant of the location of innovation activities (OECD, 2008d).

Many Large international companies have supplemented their internal R&D efforts by collaborating with external suppliers, competitors, customers, PRIs and universities (OECD, 2008d). The internationalization of R&D is reflected in the relative importance of foreign sources of funding for business R&D (BERD). In the EU about 10% of business R&D is funded form abroad (OECD,2014g), although some European countries are more attractive than others. In Ireland, the United Kingdom and Austria, funding from aboard accounts for around a quarter of total business expenditure. Israel (50%) and Korea (0.3%) are the two extremes.

Trends in foreign-funded business R&D reflect the changing landscape of global R&D. Since 2007, the volume of funding from abroad has declined in Canada, the Netherlands, Russia and the United Kingdom. It has increased significantly in Israel and China, reinforcing a trend over the decade. Within Europe, foreign funding increased in Germany and Sweden.

DATA AND EMPIRICAL METHODOLOGY

3.1 Data

In the research study, we used our own definitions of economic growth and innovations. Our dependent variable is GDP per Capita in US current Dollars. We choose GDP per Capital in US Current Dollars over Annual growth GDP per Capita, because the former one has a better results

by taking log in our model. Our independent variables are general government final consumption expenditure as percent of GDP, capital investment as percent of GDP, foreign direct investment, net inflows as percent of GDP, labor force with secondary education as percent of total labor force, combined imports and exports of goods and services as percent of GDP, high-technology exports in current US dollar, researchers in research and development as per million people, research and development expenditures as percent of GDP, patent application of both residents and non-residents, and electricity production in billion kilowatt hours. The data collected from many different data sources, the details of data sources and expected sign are listed in Appendix A. The data collected for 34 OECD countries from 1991 to 2012. Although many data sources provide enough data, some of the years are missing. Therefore, we had to use average number to fill in the missing spots.

Figure 3. Summary Statistics

Variable	Mean	Std Dev	Minimum	Maximum	N
GROWTH	1.9742588	3.1358866	-15	13	748
GCGDP	18.8349599	41.1419307	9.08	30	748
CAPGDP	22.2439439	4.0837585	10.86	38.7	748
RDEX	1.7573304	0.9662180	0.1239103	4.5232301	748
RDIN	3124.5	1765.66	182.938391	8003.51	748
FDI	5.513912	21.48441	-57.4296971	430.6406918	748
LRLF	44.8794189	15.25177	1.2019283	80.1999969	748
ECOOPEN	81.5872687	48.0334264	15.9239899	352.9037707	748
HITECHEX	23797.51	39413.89	1.85	220884.47	748
ELEC	279.8137166	639.5961541	0.06	4156.75	748
PATENT	31268.71	87805.67	22	542815	748

In Figure 3, the summary statistics shows the general information of the independent variables. There are total 748 observations for each variable.

3.2 Empirical Model

$$LOG\_GDPCAPITAL = \beta_0 + \beta_1 GCGDP + \beta_2 CAPGDP + \beta_3 FDI + \beta_4 LRLF + \beta_5 ECOOPEN + \beta_6 RDIN + \beta_7 RDEX + \beta_8 HTECHEX + \beta_9 ELEC + \beta_{10} PATENT$$

3.2.1 Dependent Variable

As we mentioned earlier, we took a logarithm of GDP per Capita, which transformed to a percentage of economic growth annually in GDP.

3.2.2 Independent Variable

Just like almost all other research studies, the major challenge in this paper was to determine what an appropriate proxy was for innovation. In the original paper, there were 9 different regression models to analyze high-income, middle-income, low-income countries in economic growth model and innovation model. But in our study, we did not have enough resources to access data, so we choose to look at the 34 individual countries, and use general government final consumption expenditure as percent of GDP, capital investment as percent of GDP, foreign direct investment, net inflows as percent of GDP, labor force with secondary education as percent of total labor force, combined imports and exports of goods and services as percent of GDP for economic growth factors. We use high-technology exports in current US dollar, researchers in research and development as per million people, research and development expenditures as percent of GDP, patent application of both residents and non-residents, and electricity production in billion kilowatt hours to measure innovations.

4.0 EMPIRICAL RESULTS

Figure 4.

Variable	Coefficient	t-Statistics	N	Expected Sign
CONSTANT	3.803***	104.34	748	+/-
GCGDP	0.000307	0.26	748	+
CAPGDP	0.00471***	7.42	748	+
FDI	-0.0000170	-0.18	748	+
LRLF	0.00257***	8.26	748	+
ECOOPEN	0.00211***	18.54	748	+
RDIN	0.00000378	1.03	748	+
RDEX	0.0415***	4.70	748	+
HTECHEX	0.000000381*	2.57	748	+
ELEC	0.000275***	5.11	748	+
PATENT	-0.000000377*	-2.55	748	+/-

Notes: ***, **, and *denotes significant at the 1%, 5%, and 10% respectively.

Figure 5. Fixed – effects (within) regression

F-Test	F(10,704)=115.29	Prob>F = 0.0000	
R^2	Within=0.6209	Between=0.1323	Overall=0.154
Rho	0.97584282		

Test: Ho: difference in coefficients not systematic.

Chi2(8) = (b-B)'[(V_b-V_B)^(-1)](b-B)

= -23.35 chi2<0

As shown above, we have done Hussmann test to decide which regression is more appropriate in our analysis, we choose fixed within regression for our empirical results. The overall model is significant at 95% significance level. The economic growth has a significant relationship with independent variables. Surprisingly, the government consumption as percent of GDP does not have any significance at any level. It might refer to different government policies has different impacts on the economic growth in OECD countries. The FDI also has no significant impacts on economic growth. After we took closer of the results, we think it could be FDI is part of capital investment, and they are highly correlated. Capital investment has a significant impacts on the economic growth. When capital investment as percent of GDP increase by 1%, the economic growth increase by 0.471%. From the result, we can also see that labor force in secondary education and economy openness, combined imports and exports as percent of GDP, are significant at 95% of significance level. Although the total researchers in research and development departments does not have any significance, the expenditures of research and development has very significant impacts, which shows that the expenditure in GDP are more important than actual number of researchers in OECD countries. Moreover, electricity production also has a significant impacts at the 95 % of significance level, which means electricity production is an important factor in our economic growth model.

Under the current specification, our initial hypothesis that the individual-level effects are adequately modeled by a random-effects model is resoundingly rejected. This result is based on the rest of our model specification, and random effects might be appropriate for some alternate model of GDPCAPITAL. Even though the within R^2 is very small, in fixed panel data analysis, we use Rho to determine the how well the variance is explained. In our results, we have Rho = 0.9785, which means 98% of the variance is due to difference across panels.

5.0 CONCLUSION

Through our study, we try to find the relationship among technology and innovation on economic growth in the OECD countries from 1991 to 2012. We realized that although OECD are all high income countries, their innovation policy still are big factors in determine how innovative application affects the economic development. Therefore, it is very hard for all the

countries to stay on the same page regarding the innovation policies and how much investments individual countries would like to invest. Despite the difficulties, the OECD has been improving the innovative environments by fostering entrepreneurship businesses, especially new and young firms, are the main source of job growth from innovation. Meanwhile, barriers for firm to entry and exit the markets need to be reduced. Since firms planning to enter the market may have little idea of their chances of survival, costly exit can discourage them from entering. In many countries, including at EU level, bankruptcy laws are needed to facilitate the restructuring of ailing businesses, with due regard to risk management and the need to avoid moral hazard. The OECD countries are working together to build the foundations for innovation in business with sound framework conditions, sound framework conditions are an essential basis for policies to strengthen innovation. Stable macroeconomic policies help reduce uncertainty and open and competitive markets are essential drivers of innovation. The importance of strong and effective public research is a key factor to economic growth. Based on the record, science remains a key driver of innovation, public research institutions should enhance excellence, which will benefit from new mechanisms to finance research.

Although government consumption was not significant in our model, it still has the significant performance in real world. Government should find a way to invest in a knowledge-supporting infrastructure. General –purpose technologies notably ICTs, play a key role in fostering innovation.

In further studies, we should focus on the tax policies of the OECD countries and the significance of different type of firms' creativity performance. Moreover, we should focus on the comparison of developed countries and developing countries and look at different time period.

Appendix A: Variable Description and Data Source

Acronym	Description	Data Source	Expected Sign
GCGDP	General government final consumption expenditure (% of GDP)	World Bank and OECD Data	+/-
CAPGDP	Capital investment (% of GDP)	World Bank	+
FDI	Foreign direct investment, net inflows (% of GDP)	IMF, IFS and Balance of Payments databases, World Bank, IDS, and OECD Data	+
LRLF	Labor force with secondary education (% of total)	International Labour Organization, Labour Market database.	+
ECOOPEN	Imports and exports of goods and services (% of GDP)	World Bank national accounts data, and OECD National Accounts data files.	+
HTECHEX	High-technology exports (cureent US dollar)	United Nations, Comtrade database.	+
RDEX	Research and development expenditure (% of GDP)	United Nations Educational, Scientific, and Cultural Organization	+
RDIN	Researchers in R&D (per million people)	UN, Scientific, and UNESCO	+
PATENT	Patent application	World Intellectual Property Indicators	+
ELEC	Electricity production, billion kilowatthours	The U.S. Energy Information Administration	+ / -

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