QUANTITATIVE ANALYSIS on INNOVATION INDEX of OECD COUNTRIES

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Abstract

This study aims to further build on earlier researchers conducted by the authors and provide a quantitative model on innovation related variables. For this purpose, top ranked countries on OECD innovation index are involved. In relation with the developments in the global economy and increasing completion, the interest towards innovation is continuously increasing. Innovation which contributes to economic growth towards increasing the productivity and competitive power is evaluated as factor which effects the direction of economic activities worldwide. In the global market where competitiveness has greatly increased, being innovative became vital both for companies and the countries. Panel data analysis is utilized to investigate the relationship between the innovation index developed by OECD as the dependent variable and four independent variables; real net national income, labour productivity, investment, and R&D expenditure. In order to control network effects as well as the endogeneity of variables, the Arellano–Bond dynamic panel estimation is adopted.

Keywords: Innovation, competitiveness, research and development, OECD, innovation index.

1. Introduction

In EU and OECD literature, innovation is described as: "transforming an idea into a marketable product or service, a new or improved production or distribution method or a new method of society service". Innovation also means the new or improved product, service or method at the end of this transformation process.

Innovation has technologic and organizational dimensions. In the organization level, networking and cooperation between companies has become even more important from the competitive power point of view. Moreover, intrafirm organizational innovations can play a significant role towards increasing the competitive power through technological changes.

Innovation is considered to be an important factor guiding the economic activities throughout the world by increasing the productivity and the competitive power, thus leading to economic growth. There are innovative ideas behind many developments that improves daily lives. The owners of these ideas have been the countries supporting the innovative activities, investing more in R&D activities and the productive research facilities, and establishing effective innovation systems. Such countries also have taken huge steps towards improvements in socio-economic dimension.

Being innovative has become a vital issue in a global market where the competitiveness has greatly increased. For this reason, innovation concept has been keeping its importance for over a half century and studied in many reseaches. From the economic perspective J. A. Schumpeter is known to be the first one to study innovation. He defines the innovation as "every outcome that stems from technologic developments and brings profit to the entrepreneur"(Schumpeter,1928).

Fischer defines innovation as; new ways of thinking, finding new ways of doing things, trying out what is produced and using in economic and social activities about human (Fischer, 2001:210). Innovation is classified into product and process innovation. While product innovation is grouped as goods and service innovation, process innovation is grouped as technological and organizational innovation (Edquist, 2001).

According to Drucker, innovation is trying to know/understand rather then doing. Innovation is a certain function of entrepreneurship and improving the welfare by using new sources or increasing the potential of current sources through entrepreneurs. (Drucker, 2002).

In the economics literature, Romer (1994) has consireded the technological advancement as an internal variable and evaluated it as the engine of growth. That is because new employment opportunities are enabled through the advances in technology, income levels are increased, thus the demand is expected to increase. On the other side, technological advances result in reduced production costs and increase the total supply. Shefer and Frenkel (2005) have emphasized the importance of Research and Development expenditure as an indicater of innovation activities. R&D investments is effected by various characteristics of the firms such as the size and age of the firm, organizational and managerial structure, the sector within it operates, and its location. For the success of R&D, it is important that large firms allocated more resources than smaller firms.

In the current state of the world where everything changes with a great speed has alot to do with information. Being able to produced information and transforming it to a value is only possible with innovation. Thus it is imporatant to understand innovation and take every step with this in mind. Although taking actions such as spending more in R&D activities, increasing the number of researches, providing the necessary infrastructure and auditing procedures, changing the educational system to encourage critical thinking, increasing the awareness in patent issues is required, probably the most important thing is preventing the brain drain and finding ways of utilizing them in optimum levels.

Table 1: Resources of Innovation

Customers, Competitors, and Sector -Customer of customer -Customer of alternative products -Focus groups -User panels -Customer surveys -Tracking professional users (Lead User) -Customer Follow up -Meetings with sector experts and focus groups -Market surveys -Participation in fairs -Membership in professional organizations -Participation in standard building committees **Internal Resources** -Using innovation strategy to detect the opportunities -Operational talent evaluation -Brainstorming with functional and cross-functional groups -Meetings with sales-marketing personnel and brainstorming -Collecting opinios of employees as customers -Company idea bank	**Government Organizations** -Legal instructions -EU projects -R&D incentives -Contact with venture capital establishments -Contact with public-pricate R&D units **Supply Chain** -Supplier visits and meetings with product development/engineering personnel -Partnership development projects with suppliers -Meetings with logistic and distribution companies -Reviewing the supply chain to detect the opportunities **Academic and Sectoral Researches** -Internet search -Following literature and publications -Analysis of competitors -Patent browsing -Following periodical sectorial publications -Contact with universities and academic personnel

Source: http://www.devlerinbulusmasi.com/arge/sunum/Temsa.pdf

2. A Comparison of Innovation Performances of Countries

In this section, the innovative performances of OECD countries selected for the purpose of the study in terms of some fundamental innovation indicators are provided as well some other developed countries such as Japan, USA, Russia, and China. The rankings in the Global Competitiveness Index according to the Global Competitiveness Report is also provided in Table 2 and observations are presented.

Table 2: The Global Competitiveness Index 2013-2014

	Overall Index		Innovation and Sophistication Factors			Overall Index		Innovation and Sophistication Factors	
Country	**Rank**	**Score**	**Rank**	**Score**	**Country**	**Rank**	**Score**	**Rank**	**Score**
Switzerland	1	5.67	1	5.72	**USA**	5	5.48	6	5.43
Finland	3	5.54	2	5.65	**Japan**	9	5.40	3	5.62
Germany	4	5.51	4	5.59	**China**	29	4.84	34	4.10
Sweden	6	5.48	5	5.46	**Turkey**	44	4.45	47	3.91
Netherlands	8	5.42	7	5.36	**Portugal**	51	4.40	38	4.06
UK	10	5.37	10	5.15	**Russia**	64	4.25	99	3.35
Norway	11	5.33	16	5.07	**Guinea**	147	2.91	142	2.69
Denmark	15	5.18	11	5.14	**Chad**	148	2.85	144	2.61
Belgium	17	5.13	15	5.07					

Source: World Economic Forum © 2013, Global Competitiveness Index rankings and 2013-2014 comparisons (http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2013-14.pdf)

Switzerland is ranked first with a 5.67 score, Germany is fourth with 5.59, USA is fifth with 5.48. In overall, it is observed that the developed countries are placed in the upper ranks of the list while developing countries are ranked lower.

All of the innovation leaders are ranked quite high above the EU average in terms of collaborative publications of public-private sector which indicates the relationship between the scientific base and companies. In overall, the developed countries in EU are ranked high in terms of their ratio of R&D expenditures in GDP.

Moreover, the technology leaders have also demonstrated a good performance in terms of commercialization of technologic information and the patent/license revenues obtained from abroad. The countries ranked high in terms of innovation indicators have various fields in their national research and innovation systems. Most of the innovation leaders such as Germany, Finland, Denmark and Sweden has a quite well performance in terms of R&D personnel employed in business enterprises, as well as other innovation indicators.

3. Related Literature

Innovation and factors around it have drawn considerable number of attention during the last decade. Applying various quantitative analysis methods, the researchers have studied the relationships exist among a wide range of factors. A selection of such researches that have been conducted specifically on OECD countries are mentioned below, followed by the next section where we present our analysis.

Färe etal. (1994) analyze productivity growth in 17 OECD countries over the period 1979-1988. A nonparametric programming method (activity analysis) is used to compute Malmquist productivity indexes. The productivity change is calculated as the geometric mean of two Malmquist productivity indexes and the productivity changes are compared.

Lim and Song (1996) present an econometric model relating to the technological development problem of a technologically less developed country, by which its basic scientific research capacity (BSRC) and the gap in terms of time lag can be measured and forecasted in connection with factor analysis and the estimated BSRC progress function. Based on the analysis, the authors recommend some technology policies designed to promote total factorproductivity as well as the international competitiveness of Korea. There is an emphasis on the importance of research activities of universities in basic science, which yield a synergy effect with domestic innovation in the dynamic process of assimilation, absorption, improvement, and indigenization of the technologies imported from technologically advanced countries.

Machin and Van Reenen (1998) compare the changing skill structure of wage bills and employment in the United States with six other OECD countries. They outline the econometric strategy and give a discussion of the basic regression results which provide evidence that skill-biased technical change is an international phenomenon that has had a clear effect of increasing the relative demand for skilled workers. Their analysis leads to the conclusion that there exist important skill-technology complementarities across all countries.

Maudosa etal. (1999) analyze the Total Factor Productivity (TFP) evolution in OECD countries by breaking down productivitygains into technical change and efficiency change. Malmquist indices of productivity, including human capital, are estimated. The results indicate that, in fact, the inclusion of human capital has a significant effect on the accurate measurement of TFP.This note has confirmed the importance of human capital in the measurement of TFP growth in the OECD, highlighting the importance of efficiency as a source of variation in TFP other than technical progress.

Funke and Ruhwede (2001) have utilizedpanel data for 19 member countries of the OECD and found support for the hypothesis that a greater degree of product variety relative to the United States helps to explain relative per capita GDP levels.In order to illustrate the interaction between product variety and economic growth they adapt a simple semi-endogenous growth model and conclude that the index of relative product variety across countries is significantly correlated with relative per capita income levels. They have identified one channel through which increased trade may lead to growth, namely, a strongly outward-oriented trade regime makes a greater variety of products and technologies available.

Pryor (2002) attempts a quantitative evaluation of the extent of governmental regulation of industry in 21 OECD nations, using several business surveys as a data base. Employing this experimental measure, the essay then explores quantitatively the role of government regulations.Through use of econometric analysis, it is concluded that governmental ownership of the means of production is a complement, not a substitute, to governmental regulation of industry. It is shown that experimental measures of the extent of governmental regulation and the effectiveness of government are inversely related.

Research and Development expenditures are discussed to be the determinant of innovation initiative. However, as argued by Cabral and Traill (2001), these expenditures do not have an impact on the outcumes of innovation efforts. Only half of the Canadian firms that are involved in R&D activities have successfully applied innovation and been able to produce a new product or process.(Therrien, 2000; 2-3).

Howells (2005) investigates the issue of innovation policy within a regional context. It is presented that the perspective one takes is important both in how one interprets the processes and relationships involved, but also in the way one identifies barriers and problems in policy formation and how one resolves them. The paper explores a number of contrasting perspectives in relation to innovation policy and the regions and seeks to highlight the implications of this both for policy, but also in the development of conceptual understanding about innovation and geography.

Mohnen etal. (2006) proposes a framework to account for innovation similar to the usual accounting framework in production analysis and a measure of innovativity comparable to that of total factor productivity.On the basis of estimation of a generalized Tobit model and measuring innovation as the share of total sales due to improved or new products, it compares the propensity to innovate, and the innovation intensity conditional and unconditional on being innovative, across the seven countries and low- and high-tech manufacturing sectors. The innovation framework is claimed to account for sizeable differences in country innovation intensity, more so in the high-tech than in the low-tech sectors. It also shows, however, that differences in country innovativity can be even more sizeable.

Crescenzi etal. (2007) analyses and compares a wide set of territorial processes that influence innovation in Europe and the United States. The empirical analysis is based on the Knowledge Production Function (KPF). The analysis of the geography of innovation in the US and Europe reveals that knowledge production in both continents is governed by different geographical processes.The analysis suggests that, in both continents, the territorial dynamics of innovation, as well as its basic geographical foundations, are essential elements in considering the performance of these innovation systems.

Madsen (2008) addresses two questions in international trade, namely why traditional estimates of income elasticities of exports are implausibly high and why export growth varies much more markedly across countries than can be explained by changes in price competitiveness and variations in income growth in export markets.,

Using data for 18 OECD countries it is shown that market integration and the level of technology and competitiveness can answer these questions. The paper has shown that when technology, product variety, and integration are allowed for in export equations, (1) the income elasticities of exports decline to levels that are much more consistent with economic theory than estimates from traditional export equations; (2) a large proportion of the cross-country variation in the export performance in the 1990s can be explained by differences in innovative activity; (3) a third of the export growth in the 1990s was induced by technology and product variety; and 4) that R&D stock is not influential for exports but only influential for the relative performance of a country against its competitors.

Wang (2010) investigates the determinants of R&D investment at the national level with an emphasis on the roles of patent rights protection, international technology transfer through trade and FDI, and economic growth, in addition to the essentials ofhumancapital accumulation and the number of scientific researchers. The Extreme-Bounds-Analysis (EBA) approach is applied to examine the robustness and sensitivity of these factors. The results of the EBA tests on data from 26 OECD countries from 1996 to 2006 showed that tertiary education and the proportion of scientific researchers in a country were robust determinants that had positive effects on R&D intensity. Foreign technology inflows had a robust and negative impact on domestic R&D. Patent rights protection and the income growth rate are fragile determinants of R&D investment.

Srholecy (2011), using a large sample of firms from many developing countries, estimates a multilevel model of innovation which connects micro and macro levels of analysis in an integrated framework. National economic, technological and institutional framework conditions are shown to directly predict the likelihood of firms to innovate.A multilevel model, also known as a hierarchical, random coefficient, variance component or mixed-effects model is used.Overall, the results show that national framework conditions have a substantial effect on the odds of firms to innovate, but at the same time much also depends on what firms are capable of doing themselves.

A need for a broad approach to innovation policy is firmly supported by the results, because generic conditions given by the extent of basic education, (dis)incentives to innovate rooted in the tax system, the way the political system is organized and macroeconomic stability turn out to be fairly relevant. In particular, the results call for improving the understanding of the relationship between democracy and innovation, which emerged from the analysis as one of the key connections.

Chen and Guan (2011) in their study, present a novel analytical framework to empirically and quantitatively map the innovation production process jointly associated with a path modeling approach, which helps in untangling the interactive mechanism between stage-specific innovation activities with distinct functions within an IPP from accumulative advantage to economic outcomes.

4. The Developed Model

A panel data analysis is conducted for the purpose of the study. The model involves five variables: the innovation index developed by OECD, real net national income, labour productivity, investment, and gross domestic expenditure on research and development. The innovation index is treated as the dependent variable and the relationship between the independent variables and it is analyzed.

The variables that are expected to have effect on the innovation index are analyzed in this study by working on the quarterly data available between 2006 and 2011. Lack of data before 2006 is the major restriction of the study. Panel data analysis is used since the countries and time dimension is used together. Dynamic panel data analysis is preferred as innovation index in previous years are expected to affect current index. The Arellano–Bond linear dynamic panel data estimation model (Arellano& Bond, 1991) is used in order to solve the endogeneity, heteroskedasticity, and autocorrelation problems that exist among the variables. Arellano-Bond (1991) and Arellano-Bover (1995) are models developed for this purpose. Both of them are especially designed for situations with small T, large N panels. Their usage on datasets of such characteristics is safe (Roodman, 2006). Its reliability for the models with large T and small N is still being tested.

The model is run on STATA software and the results are provided below as follows:

Arellano-Bond dynamic panel-data estimation Number of obs = 80
Group variable: id Number of groups = 20
Time variable: year
Obs per group: min = 4
avg = 4
max = 4

Number of instruments = 15 Wald chi2(5) = 5.01
Prob > chi2 = 0.4149

One-step results

rank	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
rank						
L1.	.2371092	.1747725	1.36	0.175	-.1054386	.579657
inv	-.0002345	.0001811	-1.29	0.195	-.0005894	.0001204
lbpr	.0002925	.0031811	0.09	0.927	-.0059424	.0065274
ntinc	.000124	.0001297	0.96	0.339	-.0001301	.0003781
rd	.0788428	.0629634	1.25	0.210	-.0445632	.2022488
_cons	3.720765	.9634251	3.86	0.000	1.832487	5.609044

Instruments for differenced equation
GMM-type: L(2/.).rank
Standard: D.inv D.lbpr D.ntinc D.rd
Instruments for level equation
Standard: _cons

The results indicate that there is meaningful relationship between all independent variables selected and the dependent variable except for the labour productivity. An endogeneity problem between this variable and the variable reflecting the research & development expenditure seems to have caused this outcome.

5. Innovation Indicators and Comparison for Innovation Incentives

Among other indicators that measures the innovation and reflects on the innovation performances of the countries; World Bank-Databank, 2012; World Economic Forum-Global Competitiveness Report, 2011-2012; PRO European Commission-Innovation Union Scoreboard, 2011; INSEAD-Global Innovation Index, 2012 etc. can be listed. Employment in information-oriented sectors, Total Factor Productivity, R&D expenditures, patent applications, numbers of entrepreneur/researcher/technician, export of advanced technology, royalty and license fees, industry value added, and innovation capacity are some of these indicators.

With the ICT Policy Support Programme which is a part of Competitiveness and Inovation Programme (CIP) initiated to increase the competitiveness and innovation power in EU, it is aimed to support beneficial services to the public sector (EC CIP; 2010).

EU has been using five-year Framework Programs since 1984 to increase scientific research and technological development capacity. Participation of the member states through VAT and other payments as a ratio of their GDPs builds up a fund for this purpose. The budget used for such programs has increased substantially over the years which shows the importance given by the Union to the scientific research and technological development in order to become the strongest economy of the world.

Policies to advance research and deveopment are given priority in the government plans of UK. The government is focused on the scope of the incentives to be given the firms for R&D expenditures, thus has foreseen that more R&D can be encouraged to be undertaken. At this point, since the overflow effects is occured locally, UK tries to bring its economy to a good poisition from the footlose R&D. One of the important points in this framework is how UK will align R&D incentives with EU norms. It has become essential that UK government follow strategies that will both advance R&D and meet EU competiton goals (Bloom & Griffith,2001:337-338).

The outlines of EU technology policies are determined by the Lisbon Strategy. This strategy which was accepted in 2000, can be called as future projection of EU. Setting 3% of GDP aside for R&D is determined as a goal within this strategy.

There is no particular incentive model in EU. Various practices can be seen in member states. Incentives are provided from own resources oft he member states as well as from EU budget. Since the main attitute of EU towards incentives is protecting the free competition and free trade, it is still debated whether such incentives provided by the states should be in the form of financial supports of tax breaks. Both ways have advantages along with disadvantages but it is common to see the states using both together with changing portions.

6. Conclusions

For the countries and companies, innovation plays a significant role to protect and improve the overall level of economy, increase the competitiveness, and cope with the dynamic global economy.

It has an important role in producing information, creating new job opportunities, increasing production and productivity in the developing and developed countries. The governments need to pay attention to the econonomic trends and developments during their effort of designing new incentives and policies to encourage innovation. Many countries use innovation systems as a tool when preparing their development plan. Such countries that comprehend the imporatance of innovation system try to use innovation in the most efficient and productive way in the development processes.

In the developed EU countries, high R&D rates in GDP can be easily observed. However, for the new countries of EU, these rates are below the average. Consequently, a positive relationship can be concluded between the state of development and R&D expenditures. In countries such as England, France, Finland, Germany, and Denmark, the share of advanced technology export in the total export amount is also considerably high.

Through utilization of science and technology policies, EU has aimed to increase its competitive power against USA and other power houses in Asia, such as Japan and South Korea. The level of success in reaching this goal is still being debated, however.

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