Investigating the relation between innovation and economic growth: The international approach

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Abstract: In this article the effect of innovation, as one of the most basic axes of science-based economy, on economic growth is investigated. To do so, the data for time series of selected countries from 1960 to 2004 will be used. Using the literature with the subject of economic growth within the frame of international study or through panel data economy measurement, the results show that during this period, by controlling effective variables, innovation has had a positive and meaningful effect on long-term economy growth of developing countries, members of OECD and developed countries; but the effect of innovation on economic growth of developing countries wasn't meaningful, although it was positive; also the research results show that other coefficients of variables like physical investment, human resources, growth rate in goods and service importing, the primary gross national product, intermediary and capital goods and services importing have expected and meaningful signs in all groups. Categorizing JEL: O3 O40, C23

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1. Introduction:

Today, as a fundamental issue in new policy of economy, the right of intellectual property is considered an important and basic issue for economic growth and the most valuable asset in trade and business.
Strong support for the right of intellectual property (due to its superiority over material capital) in many cases motivates and encourages the innovative inventors and research institutes toward innovative activities which is an important factor in facilitating technology transfer and absorbing direct foreign investment in certain areas of economy the importance of which is conspicuous in fulfilling and expediting development of different economic fields.
The primary goal of this study is to investigate the effect of innovation on economic growth of 88 countries in 3 groups of developing countries, countries as members of OECD, and developed countries from 1960 to 2004. On the other hand, the primary question of the study is what effects innovation has on economic growth of these 3 groups of countries. Accordingly, this article is organized in the following 6 sections:
In the first part, the theoretical basis of the subject will be discussed after introduction. In the second and third part, the literature and research methodology will be discussed. The fourth part is devoted to estimating the model and interpreting the model results. The final part is about the conclusion and giving strategic suggestion.

1. The theoretical basis of innovation and economic growth:

From the time of Young, Harod- Demar, Selo- Soan, Kaldor, Aro, Rnamez, Locas, Becer- Morphey- Temora, Bro, Monico- Bro- Roamer to 2004, the issue of economic growth has experienced much evolution about effective characters in growth, inbreeding or out-breeding of variables like human resources in model, the type of production function, production character's being rising or falling according to criterion, defining the asset and dividing it into physical and human resources and strategic variables. In other words, there have been 3 different trends about growth theory. The first one is related to Harod and Dumar; the second one is developing the neo-classic theory of development. The Solo's model of long-term growth is noticeable, being based on substitution of Labor and resources. The third wave or revolution in researching growth model is the inbreeding type of economic growth which came to existence as a reaction to deficiencies in Neo-classic model. In the basic growth models like Harod and Dumar's model, production relied on

per-capita recourses and growth with stability is reached when $g = \frac{S}{V} = n.$

In this equation, g is the growth rate, S is saving rate, V is the ratio of asset to production and N is the outbreed of population growth.

This equation says that the guaranteed growth rate of production $\frac{S}{V}$ has to be equal to normal growth rate. But the problem was that considering total employment and having production function with the fixed technical coefficient of Leon Tif and fixed saving rate, the probability of balanced growth is almost Zero. Therefore, the condition of Harod-Dumar is known as knife blade that is if g_L+A completely equals $\frac{S}{V}$, everything is ideal, and if unequal, the model will get out of total employment balance. The reason for instability of the model is premises that are so sticky and inflexible.

In Solo-Soan's growth model, through using Cub Douglas production function, the substitution of capital and workforce was possible. In this model, the change in per-capita capital is equal to this equation:

$K^{\circ} = sF(K) - nK$ and the long-term stable balance is when change in balance gets stable and $\delta K - sF(k0 = nK$.

Strategic variables in this model are rate of population growth, rate of amortization (δ), rate of saving and the amount of per capita investment. Until late 1970, the growth models of Harod-Dumar and Solo-Solan were the policy maker's reference in economy. According to these models, investments in physical resources is encouraged through increasing saving rate, and in countries in which saving increase wasn't possible, international loans were recommended for gaining economic growth.

Divergence in international growth and neoclassic models inability to explain them caused a model with the nature of investment in physical resources to occur after inbreeding growth models.

With pioneers like Lucas, Roome, Saly Matin, and others, inbreeding growth models compensated for the deficiencies of neoclassic growth model, although they had problems themselves. According to recent theories, changes in investment in human work force bring about changes in long-term growth rate of the product and it means not only the production level but also the growth rate is influenced by the changes in investment in human work force. Therefore, allotting the budget optimally to investment in physical assets and human resources, either by government or households, can have effects on the countries development. Also in explaining the growth, the models of inbreeding growth have emphasized on factors like different structure, competitiveness, increasing efficiencies and production function excess.

Inbreeding growth considers growth as the result of forces inside the pattern and country to previous theories considers technical growth in the inbreeding way. In the growth models of Harod-Dumar, technical development was neutral.

Neoclassic models of growth considered technical development as external.

But in 1962, through "learning in practice" model, Aru made technical development inbreeding through learning. He raised the hypothesis that science is the result of experience. The important point in Aru's interpretation of education (learning) is that every investment now is beneficial to investments in future, while the economic market has paid nothing for this benefit.

Azava showed how it was possible in neo-classic model to gain the inbreeding rate in constant growth. He introduced the human resources of workforce and supposed that for its growth some services are necessary in the form of education institution. He analyzed the optimal path to growth accordingly. Nordhas and Shell designed the first models of growth in which technological change is a result of economic conscious choice. Both suppose that the research incentive is because of its exclusive economic benefits. After a long depression in research about growth, new researches were raised by models of human resources from Lucas and Roamer.

Lucas and Rumer brought Aru and Azavaz's believes to the theory. Lucas, in his model, entered human resources factors beside the physical assets as a factor of production in the function of production and thus the growth of investment in human resources such as physical investment rate was introduced as a determinant of wealthy communities. Rumer offers his growth model with the assumption that in the production function, the foreign effects should be considered. In his model, per-capita income production depends not only on the supply, but also on the total capital stock available in the economy. New researches emphasize on high quality workforce and technology or innovation elements that are the main proportion of growth.

Inbreeding growth model is distinguished from neoclassical models by the possibility of maintaining long-term growth model. Other studies also indicate that domestic R & D capital accumulation is the most important determining factor in the productivity of total production factor and economic growth. In these models, the new industrial innovations with the profit motive that are the result of research and development activities lead to the accumulation of knowledge and technology, and then because of their exclusiveness become a source for the growth of the country.

Some models of growth consider research and development activities as a source of growth in which the governments can gain patents and new business program that has effect on the long term growth rate of economy with providing market incentives for commercial investment in research and development.
Some other models also consider the facts that when a country has full access to the global storage of research and development can affect a significant effect on its economic growth by creating some openings in foreign trade. with These patterns, it is believed that international trade provide solutions through which developed countries knowledge and technology are imported into the country from other areas' of the world and the host country can expand it into domestic knowledge.
Thus, we conclude that the process of knowledge, research and development growth of a country is the result of the technological and knowledge growth of foreign world. Indeed, the storage (supply) of knowledge and technology of a country is the part of global storage (supply) of knowledge and technology which depends on the technical skill and ability of a country to transfer global knowledge and technology to the domestic economy. Therefore, policies that considered progresses in the global research and development have the same importance as policies that encouraged the activities of research and development.
Therefore, this is concluded that the process of piling up knowledge and research and development of a country depends on the growth of knowledge and technology of the outer world. In fact, a country treasury of knowledge and technology is part of technology and knowledge of a world which depends on the technical skill and ability of a country in transferring the global knowledge and technology to the domestic economy. So, the policies that consider acquiring accomplishment of global research and development (R & D) are as important and necessary as the policies that encourage research and development actions.

2. A review of research background:

2.1. Domestic studies:

In his studies, Comeron (1996) tried to study the experimental evidence about the relation between innovation and economic growth in countries like Germany, Japan, the U.S, England and Netherland.
In this study, in order to inspect the relation between innovation and growth, different criteria are used such as: cost of research and development, cost of patent right and number of innovations. The result of this study shows that the innovation has a meaningful influence on economic growth, and also has meaningful extra influences between countries, agencies and industries. This study analyzed all the researches that have been conducted in these countries in different periods.
Rensmond & Coper (1999) evaluated the role of research and development costs and registered innovations on the economic growth in Germany, Japan, the U.S, England and France between 1957 and 1991. The result of this study shows that the expenses of research and intra-development have positive and meaningful influence on efficiency of these countries. In the period of 1974-1991, the cost of research and domestic development just has a positive influence on production industries in France.
In his studies, Jons (2002) concluded that the longtime growth of the U.S is the result of innovation and new ideas.
Tigzeria & Fortana (2003) studied the relationship among development, innovation, human resources and economic growth of Portugal between 1960 - 2001. The result shows that the human resources and domestic innovation has meaningful influence on economic growth in that period. In addition, indirect effects of human resources on innovation show that the large treasury of human resources is necessary for actions related to domestic innovation.
Ouanglista & Sarna (2003) evaluated the relationship among innovation, unemployment and skilled service agencies. The result shows that agencies that devote more expenses to innovation for each workforce, faced more positive effect of innovation and development and efficiencies of agencies (this study is taken from the article of Mansoori & Hiave (2007) and the year and study of samples are not mentioned.)
Hoegro and Jamandrow (2004) researched about the relationship among background of agencies, process of innovation, growth and efficiency of more than 2300 agencies between 1990 -1998.
The result shows that the process of innovation increased the growth rate of innovation in sample agencies.
Kainli et.al (2004) studied the relationship between innovation and efficiency growth in agencies of Italy during 1993-1998. The result shows that there is a meaningful and positive relation between efficiency growth of agencies and innovation.
Esneider (2005) studied the international businesses, economic growth and intellectual ownership in 47 developing and developed countries during 1970-1990. The result of the study shows that important technology in both groups depends on innovation; and foreign technology has more influence on GDP growth of the countries per capita. Supporting intellectual proprietorship rights has the influence on innovation but this influence in developed countries is more meaningful.
Tider (2005) evaluated the relationship between innovation and growth in 3000 European agencies. The result of this study shows that the relationship between innovation and efficiency growth in sample

agencies was positive (this research was taken from experimental study of Mansoori & Hiave's article and the year was not mentioned).
Ben habib and Spigle (1994-2005) researched about the relationship of human resources, technological knowledge and economic growth of developing countries. The result shows that human resources and technological knowledge are considered as complimentary tools for growth and economic development (this study was taken from experimental study of Parlo's article 2008 and the year was not mentioned).
Yang (2006) studied the effect of innovation on economic growth of Taiwan between 1950 & 2000. The results revealed that the increase in the number of domestic registered inventions resulted in the increase in economic growth in this country. In addition to these causes, the long term growth of Taiwan was discovery of new ideas and thoughts.
Parisi et.al (2006) studied the relation between efficiency, innovation, research and development in Italy's agencies during 1992-1997. The results on efficiency & the cost of research & development can make the growth of efficiency through absorbing new technologies. Mansouri,H (2007) studied the relationship between innovation efficiency & growth in the business services in American agencies.
The results of the study showed that innovation in service department always had positive effective growth but didn't have any influence on efficiency. The foreign relations of agencies have positive & meaningful influence on their efficiency.
Forkava (2007) studied the relation between supporting of the intellectual proprietorship rights (IPR) & economic growth in closed economy. The results show that the increase in (IPR) can cause decrease in economic growth by increasing the share of exclusive Parts, excessive support of IPR will decrease the efficiency in final part & decrease the economic growth.
Parlo (2000) inspected the supporting of IPR and growth of skills in developed and less developed countries. The results show that excessive support of IPR in less developed countries has temporary effect on invention rate & in long time it has negative effect. For developed countries, the proven of skill growth is negative and increased inequality of wages is these countries. Skill has an important role in absorbing direct foreign investment & expanding the support of IPR is very ineffective in absorbing technological knowledge when the level of skill is very low.

2.2. domestic studies:

Kimjani & shohAloadi (1386) inspected the influence of domestic & foreign R&D on the efficiency of all the production factors in Iran between 1347&1387.
The sample business companies were in countries that are member of OECD and were in Middle East. The results show that the capital growth in domestic R & D and capital growth in R&D of business companies is stronger than the capital growth of domestic R&D capital growth.
Entezari (1384) presented a pattern for analysis & policy making of development of sciences, technology & innovation. In this study based on an Economy based view on knowledge, for science analysis, policy making, technology and innovation in Iran, a new pattern based on human as a factor compatible to the market was presented. In this pattern which is called innovative economy, Human factors and economic organizations cause development of knowledge entrepreneurship and innovation based on knowledge in the form of service markets, higher education, human resources, idea, risk taking resources, credits of human capital resources and services. Although there are theoretical principles and experimental studies, it seems that researchers are unanimous about the positive effect of innovation on economic growth and efficiency growth of agencies. It should be mentioned that according to the results, excessive support of IPR cause decrease in both the efficiency in final part and economic growth.

3. Research methodology:

The model that is used in this section is designed according to the common framework of inter-country growth. Economic theories (Solo 1907, Ramer 1990, 1986) show that the technological advancement is the main source of efficiency growth and the invention and innovation is the significant factor for technological advancement. The efficient system of inventions and innovations has created a suitable environment for R&D and resulted in discovery of goods and technological advancement. The model which is used in this study is based on the inter-country growth studies of Adams (1990), Guellect and van pottersberghe (2001)
Landerman , Maloney (2003) , chen and Dahlman (2004)

$G_{it} = B_i + B_2 (GDP_{oit}) + B_3 Inv_{it} + B_4 HC_{it} + B_5$ paty B_6 (gim)teit (1)

In which
INV= physical investment
HC= Human capital
Pat = number of patent right
Gimp= annual growth rate of imports of goods and services

In order to evaluate the above-mentioned pattern the Unbalanced Panel Data method with a time period of 5years and Fixed Effects method will be used. Lack of statistical data of other values in some periods made using the asymmetric method inevitable.
The time period is during 1960 – 2004, so nine periods with the range of 5 years was considered. The first period started from 1960 to 1964, the second period start from 1965 to 1969 and so on so fourth to the ninth period which started from 2000 to 2004.

Sampling data:

Statistical data in the study includes 88 countries that are divided in 3 groups as:
a) Developing countries (54 countries)
b) Members of OESD (27 countries)
c) Developed countries (24 countries) (table 2)

Operational definition of variables and statistical sources used in research are as follows:

Real Growth rate GDP (git): the average five-year growth rate of real GDP is used for calculation (Source: World Bank, 2007).
Initial GDP (GDP0): is the real GDP at the beginning of five year period (Source: World Bank, 2007).
Physical investment (INV): the average five-year investment to GDP ratio is used for calculation (source: PWT 6.2).
Human resources (HC): the average years of education of adults over 15 years at the beginning of each five-year period is used (source: Barrow and Lee's data, 2000).
Number of patent invention (Pat): the mean number of five-year patents is used (source: USPTO data).
Imports Growth rate of goods and services (gimp): five-year average growth rate of imports of goods and services are used (Source: World Bank, 2007).

4. Estimating equation and interpretation of estimation results:

The main Model of the study has been estimated using panel data technique. To do so, the F-test method is used to show the significance of fixed effects method. Statistic resulted from the F-test (Table 1) has confirmed the significance of fixed effects method and its use.

Critical amount	F-test amount	R^2 model *Pooling*	*Fixed effect model* R^2
1.57	4.47	0.9307	0.9367

In order to choose the appropriate model between the fixed and random effects method, Housman test should be used. The results of Housman test (Table 2) show that the fixed effects method is considered an appropriate method for assessing the model over the random effects model.

Critical amount	χ^2 Test amount
9.49	36.08

Moreover, regarding the result of Housman test, the main model of the study is estimated using fixed effects method of which the results are presented in table (3).
A) Developing countries: the estimated Results of equation (1) showed that the innovation has a positive but meaningless effect on economic growth in developing countries which is probably due to the fact that technology transfer from industrial countries to this country lacks adequate facilities and suitable environment for research and development (R & D) and technological growth. Huge part of world research and development is done in industrial countries and the results are transferred through various channels to developing countries

But it should be kept in mind that technology transfer doesn't mean that and internal research and development in developing countries is an added extra item. A prerequisite for the successful absorption of technology by developing countries is that these countries should not only be involved in adapting the technology, but also they can create some new technologies of their own. In the absence these activities, effective absorption of new technologies will be increasingly difficult. Also, it should be mentioned that other variables have the expected signs and are significant, that is during the research time on physical investment, human resources and growth rate of imports of goods and services marked with positive and initial GDP marked with a negative are significant. It must be pointed out that importing intermediate goods and services and resources can also increase investment and increase the economic growth of countries.

B) OECD countries:

The results indicate that innovation has a positive and significant effect on the economic growth of these countries. Also, like the first group, other variables have the expected signs and are significant.

C) Developed countries:

The results specify that innovation has a positive and significant effect on the economic growth of these countries. And as the first and second group, other variables also have the expected signs and are significant.
It should be mentioned that the results of this study are compatible with the results of studies done by Snyder (2005), Young (2006), Parlo (2008) and many other studies.
Table 3) estimated coefficients economic growth in developing countries; OECD members and developed countries
Numbers within parentheses indicate Pearson T White (variance heterogeneity correction). *, ** And *** indicate significant coefficients levels of 99, 95 and 90, respectively

5. Conclusion:

In this study, the effects of innovation, as one of the main sections of a knowledge based economy, on economic growth of 88 developing countries, OECD members and developed countries between 1960 and 2004 period of 5 years with a mean measurement data time series were studied. This study shows that during the research period, with effective control of other variables, innovation had a positive impact on long-term economic growth of developed countries and OECD members, but its impact on the economic growth in developing countries in spite of being positive was meaningless. It should be mentioned that other variables coefficients which have the expected signs and were significant could be found in all three groups that is during the time of the research the physical investment, human resources and growth rate of goods and services imports were marked positive and were significant, and the initial GDP marked negative and was significant. It must be pointed out that intermediate goods and services and resources import can also increase investment and increase the economic growth of countries.

6) Strategies and implications:

One of the main strategies for the development of a country is technology transfer from industrial countries to developing countries. However, technology transfer doesn't mean that the internal research and development in developing countries is not needed. Despite the common belief of Neoclassicism of free technology dissemination and development, one of the prerequisite factors for the successful absorption of technology by developing countries is that these countries should not only involve in compromising the transferred technologies, but also they must create their own technologies. In the absence of these activities, effective absorption of new technologies will be increasingly difficult.
Local (internal) Research and development (R & D), cannot occur without human resources, the accumulation of human resources through educating the work force in a country will provide the basis for success in research and development. Experiences show that countries that allow for new technologies to be invented first they must transfer new technologies and adapt the localization of the new technology.

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Algeria, Guinea-Bissau Peru Argentina Haiti philippines Bahrain Senegal Honduras Bangladesh India South Africa Bolivia, Indonesia, Sri Lanka Brazil, Iran Chile Jordan, Syria China, Kenya, Tanzania Colombia Thailand Kuwait Trinidad and Tobago Costa Rica Malawi Malaysia Cyprus Tunisia Dominican Mauritania Turkey Ecuador Morris Uganda Egypt, Mexico, Uruguay El Salvador Nicaragua Venezuela Fiji Pakistan, Vietnam Ghana, Panama, Yemen Guatemala Paraguay Zimbabwe Australia, Japan Austria Mexico Belgium Netherlands Canada, New Zealand Check Norway Denmark in Poland Finland Portugal France Spain Germany Sweden Greece Switzerland Hungary, Turkey Iceland, Britain Ireland USA Italy Other Countries Bulgaria, Kazakhstan, Romania, Croatia Latvia, Slovakia Maldives Estonia Slovenia