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The Effects Of Science-Technology-Innovation On Competitiveness And Economic Growth

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Abstract

Under the highly globalized and competitive world economy conditions, science-technology and innovation oriented competitiveness strategy is the most important factor for countries not only to strengthen their global competitiveness but also to achieve sustainable long run growth. Main aim of this study is to investigate the effects of science-technology-innovation oriented global competitiveness strategies and transmission mechanism on the economic growth for the high-income OECD.

It is found that countries which have science-technology-innovation oriented global competitiveness strategies have sustainable competitiveness and long run growth. For this reason, countries should be designed science-technology-innovation oriented economic strategies and policies in order to achieve sustainable global competitiveness and long run growth.

Keywords: Competitiveness, Economic Growth, Technology-Innovation

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1. Introduction

The heart of the long run economic growth in the all economic growth models is technological change and innovation. On the other hand the heart of technological change and innovations is scientific developments. In this context, countries must design economy policies in order to develop science-technology-innovation environment in the society and economy, leading sustainable economic growth and global competitiveness. In this study, it is analysed the effects of science-technology-innovation on the sustainable economic growth and global competitiveness of the countries.

In order to achieve science-technology-innovation based global competitiveness level, it is required the transformation of the knowledge-based economy for the countries. The knowledge-based economy is an expression coined to describe trends in advanced economies towards greater dependence on knowledge, information and high skill levels, and the increasing need for ready access to all of these by the business and public sectors. Knowledge and technology have become increasingly complex, raising the importance of links between firms and other organisations as a way to acquire specialised knowledge. A parallel economic development has been the growth of innovation in services in advanced economies [1].

2. Science-Technology-Innovation And Competitiveness

The definition of OECD and Eurostat is that *an innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations.* The minimum requirement for an innovation is that the product, process, marketing method or organisational method must be *new (or significantly improved)to the firm.* This includes products, processes and methods that firms are the first to develop and those that have been adopted from other firms or organisations [1]**.** OECD definition enlarge by the time, new innovation types arise. The Oslo Manual third edition distinguishes innovation in four areas: product, process, marketing and organisational, these innovation definitions are [1] :

A product innovation is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics.

A process innovation is the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.

A marketing innovation is the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.

An organisational innovation is the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations.

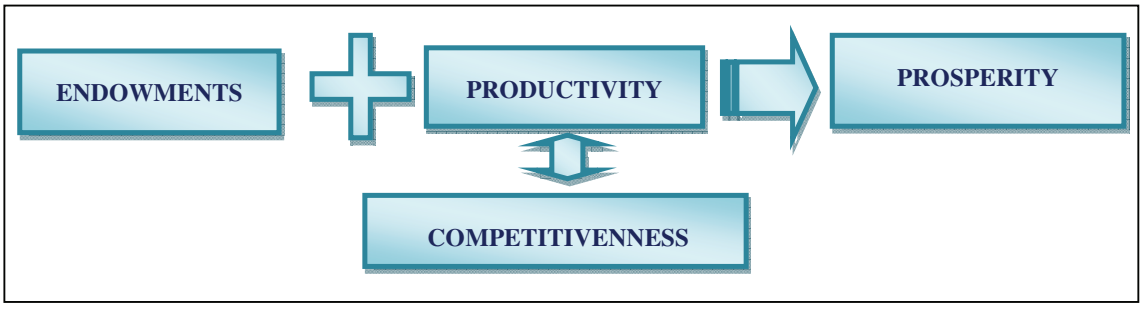

Fig.1. Defining Competitiveness,

Source : [2]

Innovation has very important effects on the competitiveness and sustainable economic growth in both micro economy level and macro economy level. WEF Global Competitiveness Index (GCI) define competitiveness as the set of institutions, policies, and factors that determine the level of productivity of a country. For this reason, it is clear that innovations are very important for the competitiveness of the countries. As innovations contributes of competitiveness by decreasing cost, increasing productivity and product diversity in the global market conditions. Innovations increasing productivity are the main sources of the competitiveness of nations with factor endowments of nations, which lead to the national prosperity (see figure-1). For this

reason, countries should be focus on both endowments and the productivity in order to achieve national prosperity.

Global structures of research and development (R&D), science performance, invention and innovation are in a multidimensional transition process. Although the OECD and other economies continue to be characterised by persistent diversity, strong trends are nevertheless in evidence and are reshaping global patterns of research, technology and innovation. Among the main elements underpinning developments have been the increasingly knowledge-driven nature of innovation; the quickly changing organisation of research, driven by informatics, collaboration and the sharing of knowledge; rapidly improving connectivity and the development of platform technologies and standards as globalisation accelerates; and changes in markets, the competition environment and technology [3].

In recent years, the macroeconomic context for R&D and science, technology and innovation activities has been favourable. In OECD countries, there is considerable policy interest in a range of new technologies that promise growth opportunities or solutions to pressing social and economic problems. These include most notably biotechnology and general life sciences, nanotechnology, and environmental sciences and technologies. However, although many countries see these broad areas as priorities, there is considerable diversity in their expenditures and outcomes [3].

As one of the most important indicator of the innovation is patents that increased in the countries across the world, especially Japan and Korea. On the other hand, annual growth of rate of patent is high in China, India and Turkey. The nature of the competition has been changing as fastening and deepening the globalization. In a knowledge-based economy, the primary competition is to innovate first, not competition to cut prices as standard economics posits. Because sole ownership of an innovation bestows monopoly power, the economic laws of perfect competition do not govern innovators. Their monopolies reward their investment in innovation. But unlike monopolies in standard economic theory, innovation-based monopolies are temporary, for they last only until another innovator makes yesterday's innovation obsolete [4].

Although innovation is very important factor for productivity and economic growth, it is not satisfied fundamental elements of innovation which are definition, classification, product and processes, data of innovation. It has been going on the efforts to define and to classify the dimensions of innovation.

The first use of the word of innovation in its modern sense, of a useful and creative change, belongs to the Schumpeter[1]. The positive connotation of innovation, as a valuable improvement, is itself a new idea. This neatly illustrates the ambiguity that underlies the role of innovation in society. Schumpeter's concept of innovation as "creative destruction" highlights this ambiguity: Creative firms bring new products or better technology into the economy, but this destroys stagnant firms. This destruction is the downside of innovation. New ideas, new applications, and new solutions to old problems are thus economically unsettled and untidy concepts [4].

The most systematic innovation theory by developed Joseph Schumpeter has greatly influenced theories of innovation. He argued that economic development is driven by innovation through a dynamic process in which new technologies replace the old, a process he labelled "creative destruction". In Schumpeter's view, "radical" innovations create major disruptive changes, whereas "incremental" innovations continuously advance the process of change. Schumpeter [5] proposed a list of five types of innovations:

i) Introduction of new products.
ii) Introduction of new methods of production.
iii) Opening of new markets.
iv) Development of new sources of supply for raw materials or other inputs.
v) Creation of new market structures in an industry [1].

[1] Schumpeter considers the concept of innovation-new products, new methods of production and new markets and sources of supply. He considers these phenomena not timed to (in the sense of being caused by) the business cycle, but a cause of change outside the business cycle, which can then shape it. Schumpeter uses the metaphor "gales of creative destruction," when he speaks of innovation, because he thinks of innovation hitting the economy with the force of a hurricane. Innovations are the economic applications of inventions and discoveries which give the impulse of change to the entire economy.

Lange [6] stated that innovations are such changes in production functions, in the schedules indicating the relation between the input of factors of production and the output of products, which make it possible for the firm to increase the discounted value of the maximum effective profit obtainable under given market condition.

Blaug [7] classified innovations in two classes, process-innovations and product-innovations. He claimed that the distinction is to some extent an artificial one: the introduction of a cost-reducing process is sometimes accompanied by a change in the product mix, while new products frequently require the development of new equipment. In practice the two are usually so interwoven that any distinction between them is arbitrary.

Amara and Landry [8] stated that in spite of a large body of empirical literature on the determinants of innovation, there is not yet a consensus regarding the categories of factors that explain innovation. The pioneering studies on innovation implicitly assumed that innovation was the result of events initiated by isolated entrepreneurs or isolated inventors. The importance of the innovation for firms is that the competition forces the firms to be innovative in order to survive in the market. Otherwise natural economic selection clears weak innovative firms from the market. That is why all firms have to be strong innovative and competitive characteristics to survive in the market. Main reason for firms to be related in innovation is economical in other words profit maximization. On the other hand it is recommended that a firm's reasons for engaging in innovation activity should be identified via its economic objectives in terms of products and markets, and how it rates a number of goals that process innovation can bring within reach. The innovative behaviour of firm vary in terms of product differentiation, pricing, financing, marketing, management and organization. Firms mainly desire the lowest price elasticity of demand of their products, which leads to them monopoly power against the market. Amara and Landry [8] stated that firms which introduce innovations that are a world first (innovations which have the highest degree of novelty) are more likely to use a larger variety of sources of information to develop or improve their products or manufacturing processes than firms introducing innovations that are a first at the national level or a first for their firm.

Lerner [9] examined the strength of patent protection in 60 countries over a 150-year period. He explored three explanations for these patterns: relative economic strength, political conditions, and legal traditions. He founded evidence consistent with each view. Relatively wealthier nations more frequently have patent systems and allow patentees longer to put patents into practice. Countries with democratic institutions are more likely to have patent protection and longer awards. Even after controlling for these factors, differences in legal traditions are significant.

Bloch and Bhattacharya [10] examined how firm size, market structure, profitability and growth influence innovative activity in small to medium sized Australian manufacturing businesses. Regression analysis is conducted to determine the factors that affect subsequent innovative activity for the full sample of businesses, as well as for sub-samples of firms from high and low-technological opportunity industries. Most variables, including size, R&D intensity, and market structure and trade shares are found to be conducive to further innovative activity for the full sample and for high-tech firms. For low-tech industries, fewer variables are significant.

Crespi [11] reviewed the most relevant determinants of innovation. What has emerged is that innovation is a complex and multifaceted phenomenon and that a large amount of factors tends to influence it. This large consensus is enlightened by the importance attributed to public intervention in promoting innovation and technological change at a policy level. However, to increase R&D spending is not sufficient. According to what emerges from this review, an effective sustain to innovation derives from a set of policies oriented at designing a proper environment for innovative activities both at a national and at a local level. From the first point of view, it has been underlined for example the importance of patents, market structure, human capital and demand considerations in determining the pace of innovation.

Lehtoranta [12] claimed that innovation activities and innovation commercialisations are not pure random events. He found evidence that they are affected by R&D activities, patenting activities, share and inflow of highly qualified personnel (in large companies) and acquisition activities. The acquisition of innovative business units or start-ups increases the innovativeness of incumbent firms and reduces the probability that the (innovative) target firm will launch a product innovation onto the market.

There are many factor and actor triggering technology and innovation in the economy. Innovation as a engine of economic growth and national welfare results from firms, individuals, universities, state-supported researches and the efforts of the civil society (see Figure-2). For this reason, it is very important to design a national innovation systems to provide an environment for economic agents to create and to produce new technologies and innovations.

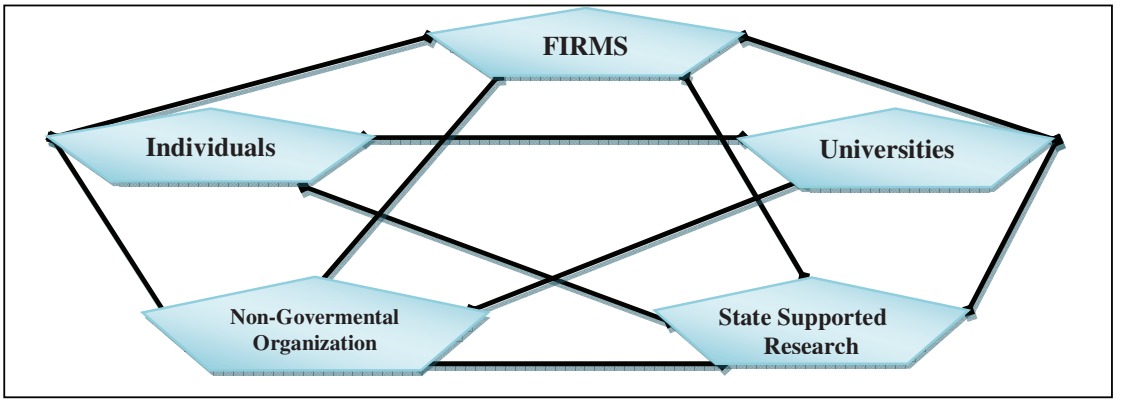

Fig. 2. Sources Of Innovation As A System,
Source : [13]

Figure-3 shows the national innovation systems affecting the development of science technology and innovation. In the system, there is a supportive and interactive network to provide innovative environment for economic agents in not only the micro economy and macro economy but also national and global level. It is very important market conditions, institutional and structural conditions to produce technology and innovations resulting in competitiveness of the country.

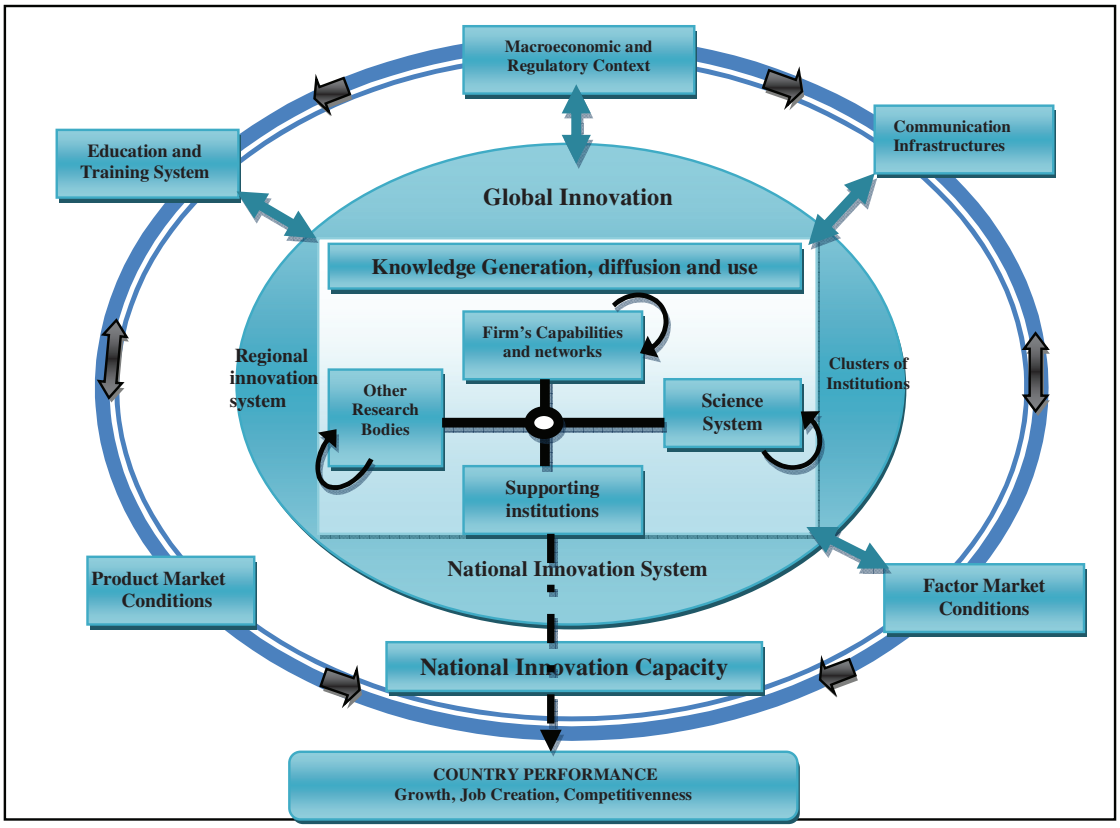

Fig.3. Actors And Linkages In The Innovation System,
Source : [14]

In order to increase innovation both in micro and macro economy level, it should be design efficient economic policies. In figure-4, it is given the interaction mechanisms between economic actors and science technology innovation policies for global competitiveness and welfare of the countries. In this context, the transmission mechanism from science technology innovation policies to economic growth, development and welfare increase across the world economy, as follows (see in figure-4) :

1) Development in science technology innovation policies
2) Development in science technology innovation infrastructure
3) Scientific development
4) Technological development
5) Development in innovation
6) Development in productivity, costs and product diversity
7) Development in global competitiveness
8) Increasing factor incomes and utility functions of economic agents
7) Development in global competitiveness
8) Increasing factor incomes and utility functions of economic agents
9) Economic growth, development and welfare increase

It is very important to manage economy policies among economic agents in the global economy without any economic damage to other countries welfare. For this reason, it is critical for the countries to establish a fair global innovation and competition system among the countries.

3. Science-Technology-Innovation And Economic Growth

Although, science-technology-innovation are very important variables for long run economic growth. In the classical growth models, it was stated that the technological change is exogenously determined and cannot be managed by economy policies until 1970s. On the other hand, by 1970s, endogenous growth models claimed that technological change can be triggered by applying the technology-driven policies efficiently, such as increasing research and development expenditures, researchers on science and development, education, qualified human capital, information and communication technologies, accessing internet, government policies etc. Therefore, it is very important for the countries to improve the environment stimulating science-technology-innovation. In figure-5, the effects of endogenous technological change on economic growth and welfare models are presented by considering the relationships among the economic actors and economic variables.

Romer [16] constituted an equilibrium model of endogenous technological change in which long-run growth is driven primarily by the accumulation of knowledge by forward-looking, profit-maximizing agents. This focus on knowledge as the basic form of capital suggests natural changes in the formulation of the standard aggregate growth model. In contrast to physical capital that can be produced one for one from forgone output, new knowledge is assumed to be the product of a research technology that exhibits diminishing returns. In the model Romer stated that In addition, investment in knowledge suggests a natural externality. The creation of new knowledge by one firm is assumed to have a positive external effect on the production possibilities of other firms because knowledge cannot be perfectly patented or kept secret. Most important, production of consumption goods as a function of the stock of knowledge and other inputs exhibits increasing returns; more precisely, knowledge may have an increasing marginal product. In contrast to models in which capital exhibits diminishing marginal productivity, knowledge will grow without bound. Even if all other inputs are held constant, it will not be optimal to stop at some steady state where knowledge is constant and no new research is undertaken.

Lucas [17] the economic growth is a function of human capital accumulation. Lucas (1998: 95) stated that what human capital means is the skill level of the worker and the theory of human capital focuses on the fact that the way an individual allocates his time over various activities in the current period affects his productivity in the future periods. Introducing human capital into the model requires both the way human capital levels affect current production and the way the current time allocation affects the accumulation of human capital. Research and Development expenditures, education and skilled human capital have most important role to produce innovation.

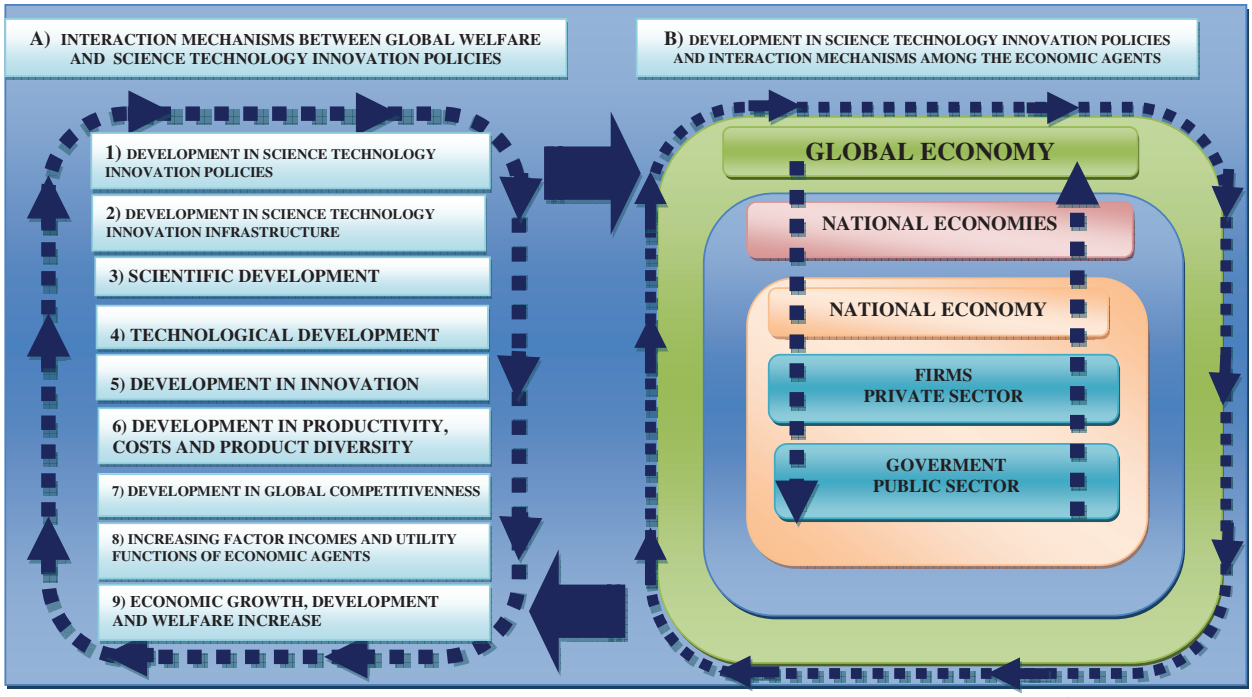

Fig.4. Interaction Mechanisms Between The Economic Actors And Science Technology Innovation Policies For Global Competitivenness And Economic Welfare, Source : [15]

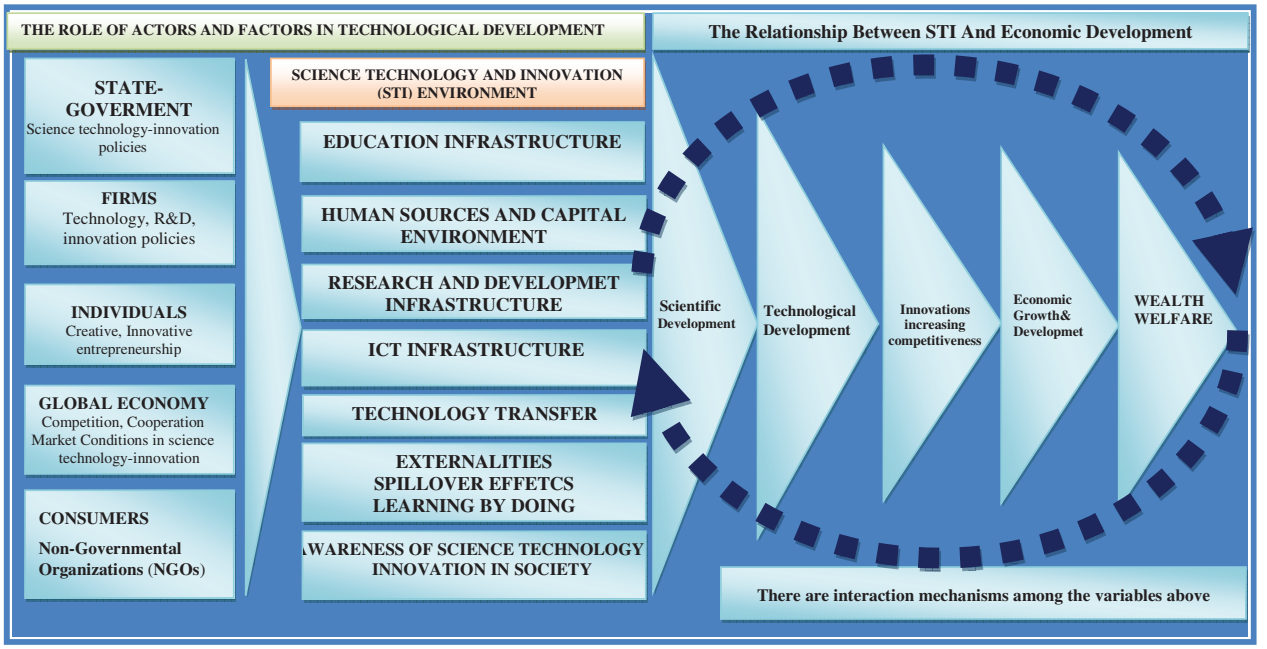

Fig.5. Endogenous Technological Change And The Effects On Economic Growth Models,
Source : [15]

Romer [18] developed a model in which R&D sector plays an important role as a driving sector of economic growth. Romer (1990:72) stated that *the growth in the model is driven by technological change that arises from intentional investment decisions made by profit-maximizing agents. The distinguishing feature of the technology as an input is that it is neither a conventional good nor a public good; it is a non- rival, partially excludable good. Because of the nonconvexity introduced by a nonrival good, price-taking competition cannot be supported. Instead, the equilibrium is one with monopolistic competition.* The main results obtained by Romer *are that the stock of human capital determines the rate of growth, that too little human capital is devoted to research in equilibrium, that integration into world markets will increase growth rates, and that having a large population is not sufficient to generate growth.* Romer, [18] explained endogenously the source of the technological change. Romer found that because research projects exchange current costs for a stream of benefits in the future, the rate of technological change is sensitive to the rate of interest.

Mankiw-Romer-Weil [19] shows how income per capita depends on population growth and accumulation of physical and human capital. Mankiw-Romer-Weil [19] also stated that *differences in tax policies, education policies, tastes for children, and political stability will end up among the ultimate determinants of cross-country differences.* Barro [20] and Barro and Salai-martin [21] class of models consider government expenditures on physical capital and social infrastructure investment to be complementary, not a substitute, for private investment and examine the effect of government on growth in this light.

Philippe Aghion and Peter Howitt [22] is developed a model of endogenous growth in which vertical innovations, generated by a competitive research sector, constitute the underlying source of growth. Equilibrium is determined by a forward-looking difference equation, according to which the amount of research in any period depends upon the expected amount of research next period. One source of this intertemporal relationship is creative destruction. Their model of economic growth based on Schumpeter's process of creative destruction.

Growth results exclusively from technological progress, which in turn results from competition among research firms that generate innovations. Each innovation consists of a new intermediate good that can be used to produce final output more efficiently than before. Research firms are motivated by the prospect of monopoly rents that can be captured when a successful innovation is patented. But those rents in turn will be destroyed by the next innovation, which will render obsolete the existing intermediate good.

In the world economy, countries based on science-technology-innovation oriented economic growth strategies have sustainable economic growth than other countries. According to *World Economic Forum (WEF) the Global Competitiveness Report* (GCR) innovation driven countries have a greater competitiveness and sustainable economic growth than other countries. WEF Global Competitiveness Index (GCI) define competitiveness as ***the set of institutions, policies, and factors that determine the level of productivity of a country*.** There twenty pillars of competitiveness for the countries. These are, *Institutions, Infrastructure, Macroeconomic environment, Health and primary education, Higher education and training, Goods market efficiency, Labour market efficiency, Financial market development, Technological readiness, Market size, Business sophistication, Innovation.* The efficiency of each pillar depends on the efficiency of others. they tend to reinforce each other, and a weakness in one area often has a negative impact on other areas [23]. WEF Global Competitiveness Index classify the levels of competitiveness of the countries by considering economic theory of stages of development. [23]:

- *In the first stage, the economy is* ***factor-driven*** *and countries compete based on their factor endowments: primarily unskilled labor and natural resources. Companies compete on the basis of price and sell basic products or commodities, with their low productivity reflected in low wages. Maintaining competitiveness at this stage of development hinges primarily on well-functioning public*

and private institutions (pillar 1), well-developed infrastructure (pillar 2), a stable macroeconomic environment (pillar 3), and a healthy workforce that has received at least a basic education (pillar 4).

- *As a country becomes more competitive, productivity will increase and wages will rise with advancing development. Countries will then move into the **efficiency-driven** stage of development, when they must begin to develop more efficient production processes and increase product quality because wages have risen and they cannot increase prices. At this point, competitiveness is increasingly driven by higher education and training (pillar 5), efficient goods markets (pillar 6), well-functioning labor markets (pillar 7), developed financial markets (pillar 8), the ability to harness the benefits of existing technologies (pillar 9), and a large domestic or foreign market (pillar 10).*

- *Finally, as countries move into the **innovation-driven** stage, wages will have risen by so much that they are able to sustain those higher wages and the associated standard of living only if their businesses are able to compete with new and unique products. At this stage, companies must compete by producing new and different goods using the most sophisticated production processes (pillar 11) and through innovation (pillar 12).*

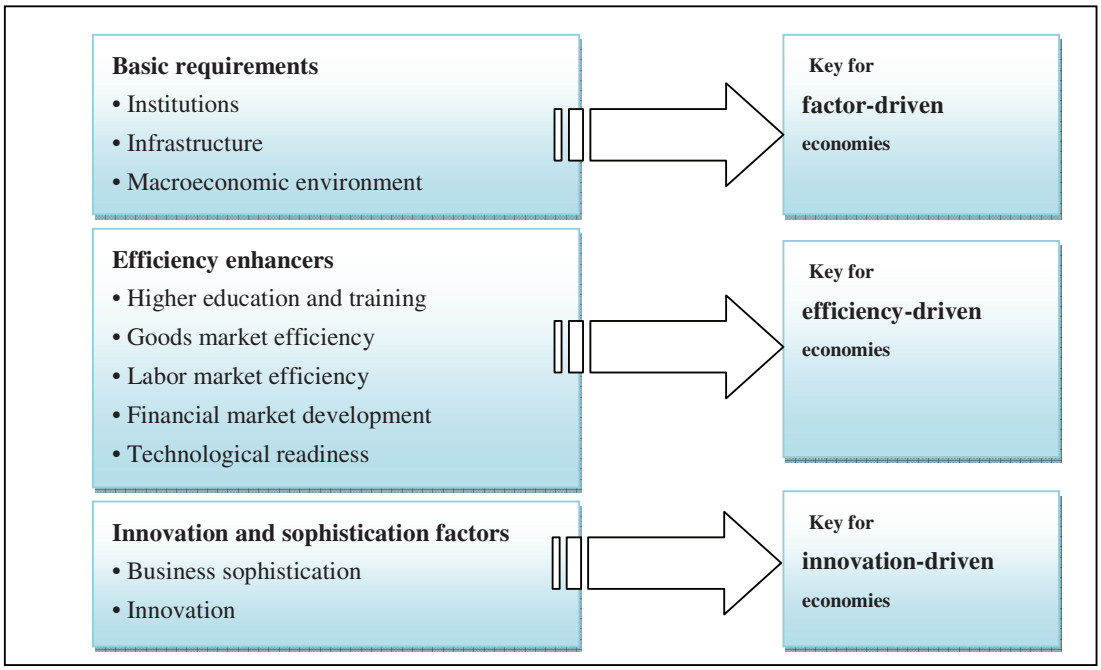

Fig. 6. The 12 Pillars Of Competitiveness,
Source : [23]

On the other hand, the GCI takes the stages of development into account by attributing higher relative weights to those pillars that are more relevant for an economy given its particular stage of development. That is, although all 12 pillars matter to a certain extent for all countries, the relative importance of each one depends on a country's particular stage of development. To implement this concept, the pillars are organized into three sub-indexes, each critical to a particular stage of development. In figure-6, the 12

pillars of competitiveness are presented, there three main group of country by level of competitiveness which are factor-driven, efficiency-driven and innovation-driven.

Table-1 shows The Global Competitiveness Index 2010–2011 results for first 27 countries. It is clear that, the innovation driven countries has a great success in overall competitiveness index. Table-2 displays the list of countries/economies at each stage of development according GCI classification. The results show that innovation driven countries are mainly advanced economies.

Based on these results, we can claim that the countries that have science-technology-innovation based economic policies and strategies have great superiority and sustainable competitive advantage in not only global competitiveness but also economic growth and development leading to wealth and welfare of the country. For this reason, it is vital for the countries to develop science-technology-innovation based economic growth, development and competitiveness strategies in order to achieve sustainable long run global competitiveness and economic growth in the world economy.

Table 1. The Global Competitiveness Index 2010–2011

	OVERALL INDEX		Basic requirements		Efficiency enhancers		sophistication factors	
Country/Economy	Rank	Score	Rank	Score	Rank	Score	Rank	Score
Switzerland	1	5.63	2	6.05	4	5.41	2	5.71
Sweden	2	5.56	4	5.98	5	5.32	3	5.67
Singapore	3	5.48	3	6.05	1	5.49	10	5.07
United States	4	5.43	32	5.21	3	5.46	4	5.53
Germany	5	5.39	6	5.89	13	5.11	5	5.51
Japan	6	5.37	26	5.35	11	5.17	1	5.72
Finland	7	5.37	5	5.97	14	5.09	6	5.43
Netherlands	8	5.33	9	5.82	8	5.24	8	5.16
Denmark	9	5.32	7	5.86	9	5.20	9	5.15
Canada	10	5.30	11	5.77	6	5.32	14	4.95
Hong Kong SAR	11	5.30	1	6.12	2	5.48	24	4.46
United Kingdom	12	5.25	18	5.58	7	5.28	12	4.98
Taiwan, China	13	5.21	19	5.58	16	5.05	7	5.23
Norway	14	5.14	17	5.65	12	5.13	17	4.83
France	15	5.13	16	5.67	15	5.09	16	4.83
Australia	16	5.11	12	5.74	10	5.20	22	4.54
Qatar	17	5.10	13	5.73	26	4.68	23	4.48
Austria	18	5.09	15	5.67	19	4.93	13	4.97
Belgium	19	5.07	22	5.45	17	5.01	15	4.91
Luxembourg	20	5.05	10	5.81	20	4.92	19	4.76
Saudi Arabia	21	4.95	28	5.32	27	4.67	26	4.41
Korea, Rep.	22	4.93	23	5.42	22	4.81	18	4.81
New Zealand	23	4.92	14	5.71	18	4.97	28	4.30
Israel	24	4.91	39	5.12	23	4.75	11	5.05
United Arab Emirates	25	4.89	8	5.82	21	4.82	27	4.37
Malaysia	26	4.88	33	5.19	24	4.72	25	4.45
China	27	4.84	30	5.27	29	4.63	31	4.13

Source : [23]

Table 2. List Of Countries/Economies At Each Stage Of Development

Stage 1	Transition from 1 to 2	Stage 2	Transition from 2 to 3	Stage 3
Bangladesh	Algeria	Albania	Bahrain	Australia
Benin	Angola	Argentina	Barbados	Austria
Bolivia	Armenia	Bosnia and Herzegovina	Chile	Belgium
Burkina Faso	Azerbaijan	Brazil	Croatia	Canada
Burundi	Botswana	Bulgaria	Estonia	Cyprus
Cambodia	Brunei Darussalam	Cape Verde	Hungary	Czech Republic
Cameroon	Egypt	China	Latvia	Denmark
Chad	Georgia	Colombia	Lithuania	Finland
Côte d'Ivoire	Guatemala	Costa Rica	Oman	France
Ethiopia	Guyana	Dominican Republic	Poland	Germany
Gambia, The	Indonesia	Ecuador	Puerto Rico	Greece
Ghana	Iran, Islamic Rep.	El Salvador	Slovak Republic	Hong Kong SAR
Honduras	Jamaica	Jordan	Taiwan, China	Iceland
India	Kazakhstan	Lebanon	Trinidad and Tobago	Ireland
Kenya	Kuwait	Macedonia, FYR	Uruguay	Israel
Kyrgyz Republic	Libya	Malaysia		Italy
Lesotho	Morocco	Mauritius		Japan
Madagascar	Paraguay	Mexico		Korea, Rep.
Malawi	Qatar	Montenegro		Luxembourg
Mali	Saudi Arabia	Namibia		Malta
Mauritania	Sri Lanka	Panama		Netherlands
Moldova	Swaziland	Peru		New Zealand
Mongolia	Syria	Romania		Norway
Mozambique	Ukraine	Russian Federation		Portugal
Nepal	Venezuela	Serbia		Singapore
Nicaragua		South Africa		Slovenia
Nigeria		Thailand		Spain
Pakistan		Tunisia		Sweden
Philippines		Turkey		Switzerland
Rwanda				United Arab Emirates
Senegal				United Kingdom
Tajikistan				United States

Source : [23]

4. Conclusion

In this paper it is investigated the effects of science technology and innovation on the competitiveness and economic growth for in macroeconomic level. By analysing WEF-GCI 2010-2011 results, It is found that the countries that have science-technology-innovation based economic policies and strategies have great superiority and sustainable competitive advantage in not only global competitiveness but also economic growth and development leading to wealth and welfare of the country.

For this reason, it can be claimed that countries must design and develop science-technology-innovation based competitiveness, economic growth and development strategies by improving the

conditions for research and development, qualified human capital, infrastructure, higher education, cooperation between the state, industry and university, information and communication infrastructure, accessing the internet, patent protection laws, royalty fees, financial, institutional and structural deficiencies, government policies and externalities.

As a result the advances in science-technology-innovation are main driving engine of global competitiveness, economic growth and development in both in economic theory and country practices. Therefore countries can direct global competitiveness, economic growth and development in the long run by applying appropriate economic policies stimulating developments in science-technology-innovations.

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