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The Role of Research and Development in Economic Growth: A Review

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Abstract. This paper reviews the role of Research and Development in the economic growth. The paper links back the story of economic growth to the studies of 17th and 18th century. The role of Research and development was confirmed in the models like Romer (1987), Romer (1990), Aghion & Howitt (1992), Grossman & Helpman (1991) and Barro & Sala-i-Martin (2004). In 1990s and 2000s, the empirical investigations made it a significant factor of economic growth. It is therefore conclude on the basis of the reviewed literature that Research and development play a significant role in the economic growth of a country.
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1. Introduction

The theory of economic growth has its foundationsin the seminal work of Adam Smith (1776), David Ricardo (1817), Malthus (1798), Ramsey (1928), Young (1928) and Schumpeter (1934). Later on with the passage of time, it took new directions. The introduction of Research and Development and imperfect competition began with the models of Romer (1987), Romer (1990), Aghion & Howitt (1992), Grossman & Helpman (1991) and other similar works (Barro & Sala-i-Martin, 2004). In 1992, Aghion & Howitt developed a model of endogenous growth by including the role of R&D in economic growth. This model used the idea of creative destruction. It assumes that the individual research can also affect the whole economy. The model derived equilibrium through forward-looking difference equation. It means that the pace of research in a period depends on present research and on the productivity of research. The research firms get monopoly rent of their innovations, which are replaced by future innovations. Each innovation result in a new intermediate good, which is then used to produce final good more efficiently. This study analyzed the positive and static properties of stationary equilibrium with R&D. Economic growth is the result of innovations, skilled Labour force and productivity of research.

According to Engelbrecht (1997) human capital enters into production not only as a factor of production but also as the endogenous theories predicted. Therefore, human capital and R&D has diverse role in domestic innovation and international spillover of knowledge. This spillover leads to economic growth. Fagerberg, Verspagen & Caniee (1997) used simultaneous equation model to find the interrelationship between GDP per capita growth, employment growth and

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innovation with technology diffusion in various regions of Europe during the period 1983-89. GDP per capita and unemployment proved to be inversely related as poor regions faced higher level of unemployment rates. The net inward migration showed positive relationship with GDP per capita growth. The backward regions have very little emphasis on R& D and raise in R&D expenditure is very crucial for growth of poor European regions. It will accelerate growth of these regions without effecting growth of any other region. The R&D expenditures growth should be supported by high quality of institutions

Borensztein, Gregorio & Lee (1998) analyzed empirically the role of Foreign Direct Investment (FDI) in technological diffusion and economic growth by developing a model of endogenous growth. The data was taken for 69 developing countries from Barro & Lee (1994), International Monetary Fund (IMF) and Organization for Economic Co-operation (OECD) publications for the period 1970-89. The study investigated the channels through which the FDI inflow from industrialized countries can affect economic growth. The study concluded that FDI is more productive in those countries where the human capital accumulation is comparatively low. This shows the affect of FDI on economic growth through the improved human capital and technology diffusion. The education and FDI are strongly and positively related. The aim of this paper is review the theoretical and empirical literature to find the role of R&D in economic growth.

2. The Research and development and Economic growth Literature

According to Blackburn, Huang & Pozzolo (2000), R&D leads to inventions and innovation, this improves the quality of manufacturing and updating of existing technologies. The model used the ideas of the models developed by Lucas (1988), Uzawa (1965), Grossmann & Helpmann (1989), and Romer (1990). The model recommends accumulation of skills and knowledge for people in an economy in order to get economic growth. Human capital accumulation not only accelerates economic growth but also provides incentives for research and innovations. It improves the quality of manufacturing.

Frantzen (2000) supports the view that both R&D and human capital play a significant role in Total Factor Productivity. Both domestic and foreign R&D show a significant impact on TFP but the impact of domestic R&D played more significant role in growth in richer countries as compared to smaller economies.

Ballot, Fakhfakh & Taymaz (2001) studied the effects of human and technological capital on productivity of firms in France and Sweden economies by using Generalized Method of Moments (GMM). Panel data for the period 1987-1993 was used which was taken from large Swedish and French firms. The study used R&D and Human capital stock as inputs in the model. Technological capital was measured by R&D and human capital by firms sponsored training. The results show significant role of human and technological capital in determination of firm's productivity in Sweden and France. The interaction effects between R&D and human capital stock were not found robust. The study suggested the importance of training as input for France. R&D showed more significant result in Sweden as compared to France. The rate of return for R&D was found 38% for France and 32% for Sweden which within the range as in industrial countries. Zeng (2001) developed a multi-sector dynamic general equilibrium growth model to view the role of innovation and imitation in economic growth. This model assumed investment in innovation and imitation endogenous. This model considers innovation and imitation in same sector at same time. Changes in these variables occur in natural way. This model shows that subsidy to innovation will push

economic growth and subsidy to imitation will move it in opposite direction. The welfare consequences of innovation and imitation are not sure.

Chou (2002) examined the contribution of research and development, and human capital in Australian economy using country-level data during the period 1960-2000. This model shows that long run steady state growth is the result of local as well as global research and development of new ideas. The growth accounting method was used for the analysis. The study concluded that the growth of Australian per capita income is not totally due to factor accumulation but also due to enhancing efficiency of transformation of inputs into outputs. 28 % of growth was due to educational attainment and 27-57 % due to research intensity in Australia as well as in G-% countries. Australian economy is expected to continue its growth and the R&D will continue its role in economic growth of Australia.

Jones (2002) introduced world of ideas in his growth model. This model states that the economic growth of an economy in long run depends on globally developed ideas. The hoard of ideas in long run is directly proportional to the worldwide research and the population of that economy. The model was applied to United States economy. The US economic growth per capita remained almost constant in last century but stock of human capital increased to great extent. The sources of economic growth in US include education, R&D, world population growth and other factors. The education, health and related factors explain about 80% of US economic growth while 20% of growth is result of world population expansion. In future the contribution of research (Ideas) will continue for sometime and market for ideas will expand. The world population will resultantly become sufficiently skilled.

Lee (2005) assessed Korean economy by using methods of growth accounting and level accounting. The results show that output per worker gap between Korea and United States has been fallen during past three decades. The study finds Korea on path of sustained growth due to increasing stock of human as well as physical capital. The manufacturing industries got good pace but the performance of the service industry is not up to the mark. The study suggested Korean economy to increase R&D expenditure for innovation in technology and improve quality of education so that desired level of growth may be achieved. For educational quality, improvement is needed in educational institutions and their management. Liberalization of educational institutions and inter school competitions can be helpful in achievement of desired goals.

Kwack & Yang (2006) analyzed Korean growth experience from neoclassical growth perspective. Annual data for the period 1971-2002 was used for this purpose. Investment rate, R&D, Education and size of government emerged as major determinants of longrun economic growth in Korea. The Study provided evidence for endogenous growth theory. The study showed that public and household's expenditure on education and R&D investment are major contributors to innovation and improving quality of labour. Higher dependency ratio of youngs and older people adversely affected Korean growth rate. Improvement of political, cultural and social institutions was recommended to achieve longrun sustained economic growth rate.

Ornaghi (2006) analyzed the role of knowledge spillovers in the productivity and demand of firms. The model modified the Griliches (1979) approach by introducing demand equation in production function. The model concludes that knowledge spillovers improve the quality of product produced by firms and it adds to the productivity of firm. The study finds difference technology innovation and process innovation. The former's effect was found greater than the latter one. The model gives justification to subsidies to R&D small and medium projects as adopted by several industrialized countries.

Grossman (2007) developed a model to find the contribution of R&D subsidies and publicly provided science education to economic growth. The study concluded that R&D subsidies may not contribute economic growth and public welfare and the intertemporal knowledge spillovers are the externalities of Firms expenditure on R&D. The subsidies to R&D increase income inequality. The model confirmed that publicly provided education aiming at higher skills in science and technology will contribute positively to economic growth of a country. As public education contributes to economic growth more efficiently than R&D subsidies, therefore, it was suggested to develop R&D through promotion public education of scientists and other skilled persons.

Afza & Nazir (2007) worked on the role of human resource management in economic competitiveness in South Asian economies with special reference to Pakistan. It was observed that Pakistan did not avail the golden opportunities created by globalized world. Weak skill base is one of the major factors keeping Pakistan away of taking advantages from global markets. The study suggested improvement in skill base, expansion of education and training, and development of R&D for better economic consequences. Basic education is key to for human resource development in Pakistan. It was also suggested to accelerate the manpower export to reduce poverty and improve macroeconomic indicators. Similarly, integration of available physical and human capital and joint technological ventures can reduce the regional economic disparities to a great extent.

Falk (2007) developed a dynamic empirical model to know significance of R&D investment in long run economic growth of OECD countries using panel data set. The study provided a new evidence for R&D-economic growth relationship. The results were derived through GMM (generalized method of moments). The study investigated whether higher R&D investment push economic growth keeping investment ratio, industrial R&D intensity and human capital constant. Five yearly and ten yearly averages were used. Higher R&D investment was found positively related to GDP growth in working age populations. The results were robust in both 5-year and 10-year cases.

Goel, Payne, & Ram (2008) premeditated the trends in various components of R&D and its contribution to economic growth in USA by using disaggregated data of half century. Surprisingly, USA experienced decline in defense R&D outlays and federal R&D expenditure. The non-federal R&D funding expanded sharply during the period. Interestingly, the estimation showed strong association of economic growth to federal R&D expenditure rather than non-federal R&D outlays. The economic growth posed strong relationship to defense R&D instead of non-federal R&D. The study proposed substantial push up in defense R&D and non-federal R&D in USA for sustainable economic growth.

Kuo & Yang (2008) examined the effects of knowledge capital and technology spillover on regional economic growth in China. The results showed that R&D, capital and technology import contribute significantly to economic growth in China. The elasticity of R&D to economic growth was as large as of technology showing same contribution to economic growth of China. The study suggests the existence of R&D spillover as well as international knowledge spillovers. Tax incentives, financial assistance and R&D grants can be helpful tools to encourage research activities and innovation in economy. Similarly policies which encourage investment in education and job training were were recommended for China.

Sterlacchini (2008) conducted a study to find out the association of regional disparities in R&D and higher education with regional economic growth. The data was taken from197 regions of 12 European countries for the period 1995-2002.The empirical evidence supported positive and significant impact of knowledge,

educational attainment and intensity of R&D expenditure on economic growth of European regions. The results showed that equal growth opportunities in EU regions may not be achieved by only gearing investment in public and private education. R&D expenditures were found significant only in most developed regions of EU. Therefore to reap the benefits of innovation and knowledge, public support for higher education and R&D can be effective tool. The study concluded that weak relationship between public universities and business firms may be one of the most important reasons keeping European Union (EU) regions away from reaping the fruits of R&D and higher education.

Jin (2009) analyzed the causal relationship between rising research productivity and economic growth in five Asian countries by using Granger causality framework. The relationship was found bidirectional in Hong Kong. Hong Kong is small open economy offering numerous kinds of services and tertiary education may have direct and immediate effect on services in management and other sectors. In Japan, the relationship was unidirectional as from economic growth to Research and productivity. In Korea and Taiwan, research productivity caused economic growth during the study period. Singapore with a small number of higher education institutions has limited number of publications and that the reason that research-economic growth relationship is not significant. Khan & Khattak (2013) suggested the development of R&D in Pakistan for sustained economic growth.

3. Conclusion

The review of theoretical and empirical studies relevant to the role of R&D in economic growth of countries around the world agree on the significant role of different form R&D in productivity or economic growth. Therefore, it can be conclude that the developing countries should concentrate on R&D to achieve the sustained economic growth.

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