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Research and development on economic development

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Abstract
The paper overviews the research and development on economic development in the world. Technology and technological advances are key mechanism of innovation and economic growth in high-income economies. Technology has been the real force behind rising standards of livelihood, a role that has grown over the last century given the global trend towards knowledge-based economies. Romer's model of Endogenous Technical Change of 1990 identifies a research sector specialising in the production of ideas. This sector invokes human capital along with the existing stock of knowledge to produce ideas or new knowledge. The study is based on secondary data the data collected from RBI handbook of statistics, Ministry of Human Resource Department (MHRD) Government of India, Registrar General of India, Primary Census Abstract 2011, Indiastat, World Bank. Simple statistical tools such as percentage, ratio, and growth rate analysis used. India is lagging in almost human capital formation either health or education and which has direct and indirect effect on research and development consequence slow human capital formation during reform period.

Keywords: Research and Development, Technology, Innovation, Economic Development

1. Introduction
Technology and technological advances are key mechanism of innovation and economic growth in high-income economies. Technology has been the real force behind rising standards of livelihood, a role that has grown over the last century given the global trend towards knowledge-based economies. The most dynamic economic sectors in the global marketplace are individuals that are technology-intensive, and they depend on the capacity to generate, adapt and utilize knowledge as the foundation of productivity growth. This is equally true for the services sector as it is for manufacturing (Trajtenberg, 1990; Romer, 1990; Lichtenberg, 1992; Grossman and Helpman, 1994; Navarro *et al*., 2010) [12, 8, 3, 10].

2. Theoretical Framework: The Endogenous Growth Theory
2.1 Romer's Model of Technological Change
Romer's model of Endogenous Technical Change of 1990 identifies a research sector specialising in the production of ideas. This sector invokes human capital along with the existing stock of knowledge to produce ideas or new knowledge. To Romer, ideas are more important than natural resources. He cites the example of Japan which has very few natural resources but it was open to new western ideas and technology. It imported machines from the United States during the Meija era, dismantled them to see how they worked and manufactured their better prototypes. Therefore, ideas are essential for the growth of an economy. These ideas relate to improved designs for the production of producer durable goods for final production. In the Romer model, new knowledge enters into the production process in three ways. First, a new design is used in the intermediate goods sector for the production of a new intermediate input. Second, in the final sector, labour, human capital and available producer durables produce the final product. Third, and a new design increases the total stock of knowledge which increases the productivity of human capital employed in the research sector.

3. Review of Literatute
Brempong and Camacho (1998) used a four-equation instantaneous equations model and time-series cross-national data from 18 Latin American countries to examine the effects of political instability on human capital formation and economic growth. The study found that political instability has a direct unhelpful effect on economic growth in Latin American countries. In addition to this direct shock of political instability on growth, political instability decreases economic growth not directly through decreased investment in together human and physical capital.
Laroche *et al*. (1999) [7] found the technological changes, along with the globalization of markets were transforming industrial countries into knowledge-driven economies. This shift has made human capital one of the leading public policy themes. However, existing process of investment did not allow policy maker to realize fully the implications of human capital on economic performance and technological advancement. The author discussed the fundamentals of a comprehensive definition of human capital and identified the fundamental differences between human and physical capital.
Cervellati and Sunde (2005) examined in three aspects of human development. Firstly, it described the economic environment, state and attempted to solve the human being education problem, and describe the dynamic associates between generations. Secondly, it characterized the development process and contains a symbolic simulation of the model. Third, in order to isolate the role of the individual

human capital investment problem for the dynamics of the system, it openly ruled out scale effects related to population size or the stock of human capital, the presence of fixed factors of production (like land), or the survival of consumption subsistence levels as driving factors for the transition.

Shahzad (2015) observed the role of human capital formation on economic growth in Pakistan. The author has made use of time series data form the period of 1990 to 2013. The study included education enrolment index (Proxy of human capital), health (IMR) and physical capital (GFCF, IGR) as independent variables which were the major gives for the economic growth of Pakistan.

4. Objectives of the Study

1. To analyze the India's position in research and development at global level.
2. To offer policy suggestions for the improvement of research and development in India.

5. Methodology

The study is based on secondary data the data collected from RBI handbook of statistics, Ministry of Human Resource Department (MHRD) Government of India, Registrar General of India, Primary Census Abstract 2011, India stat, World Bank. Simple statistical tools such as percentage, ratio, and growth rate analysis used.

6. Results and Discussion

6.1 Trends in Research and Development Expenditure at Global Level.

The case of the Republic of Korea is very interesting and has been the subject of considerable study. Table 1: provides some indicators about the remarkable growth of this country. Over a period of 45 years, GDP per capita increased 12 times over (expressed in constant 2005 PPP$). Total R&D expenditure has risen dramatically from 166 million in 1965 (in constant 2005 PPP$) to PPP$55 billion in 2011. This equated to an increase from 0.26 per cent of GDP in 1965 to 4.04 per cent in 2011, one of the highest in the world. While the government was the dominant source of R&D expenditure before 1980, since then the private sector took over as the main performer, registering 76.5 per cent of total R&D expenditure and 66.8 per cent of the total number of researchers in 2011.

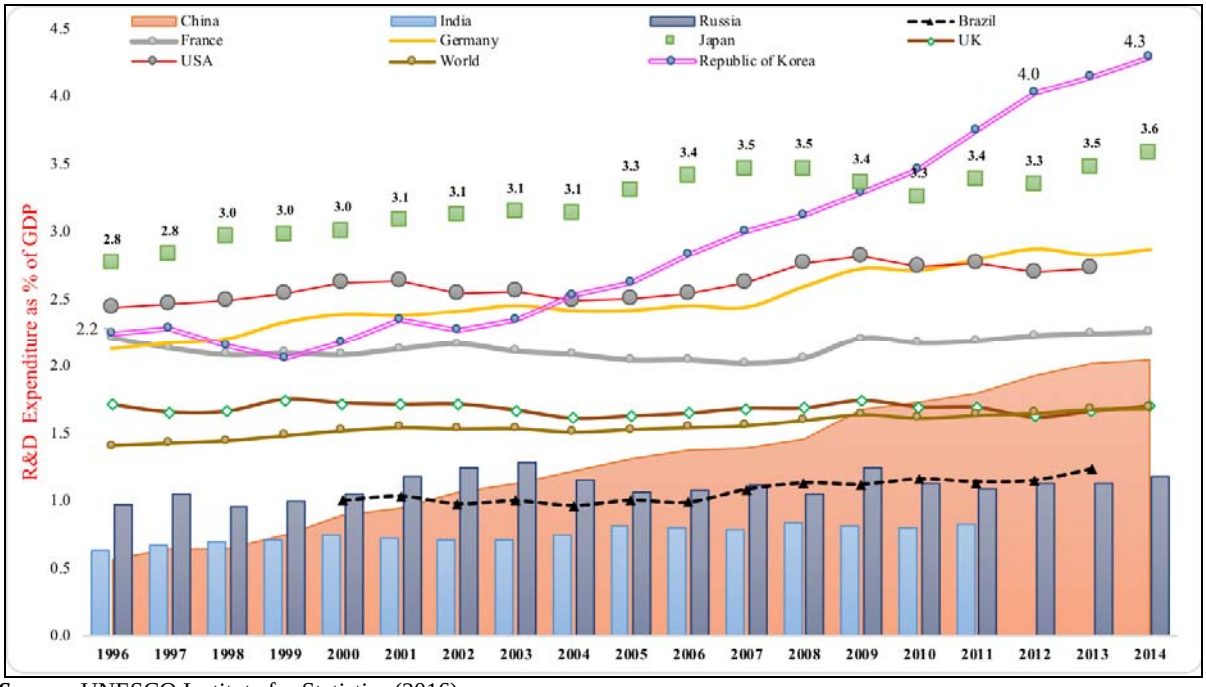
The developed nations are the major R&D investors and it is also followed by emerging nations especially China and Republic of Korea. Table1: shows the gross expenditure on research and development as percentage of GDP in major emerging, developed and region at international level during 1996-2014. Gross expenditure on R&D as per cent of GDP in India during 1996 was 0.6 per cent which is equal to China, higher than Sub-Saharan Africa and Latin America and Caribbean nations but lesser than world average 1.4 per cent and developed nations.

Table 1: Gross Expenditure on Research and Development as % of GDP

	1996	2000	2010	2011	2014
Australia	1.7	1.6	2.4	2.2	..
Brazil	..	1.0	1.2	1.1	..
China	0.6	0.9	1.7	1.8	2.0
France	2.2	2.1	2.2	2.2	2.3
Germany	2.1	2.4	2.7	2.8	2.9
India	0.6	0.7	0.8	0.8	
Japan	2.8	3.0	3.3	3.4	3.6
Republic of Korea	2.2	2.2	3.5	3.7	4.3
Russia	1.0	1.0	1.1	1.1	1.2
South Africa	..	..	0.7	0.7	..
UK	1.7	1.7	1.7	1.7	1.7
USA	2.4	2.6	2.7	2.8	..
World	1.4	1.5	1.6	1.6	1.7
Arab States	0.2	0.2	0.3	0.3	0.3
Central and Eastern Europe	0.8	0.8	0.9	0.9	1.1
Central Asia	0.2	0.2	0.2	0.2	0.2
East Asia and the Pacific	1.4	1.5	1.9	1.9	2.1
Latin America and the Caribbean	0.5	0.5	0.6	0.6	0.7
North America and Western Europe	2.0	2.2	2.4	2.4	2.4
South and West Asia	0.5	0.6	0.7	0.7	0.7
Sub-Saharan Africa	0.4	0.4	0.4	0.4	0.4

***Source*:** UNESCO Institute for Statistics (2016)

Figure 1: illustrates the trends and pattern of gross expenditure on research and development as percentage of GDP at international level during 1996 to 2014. R&D expenditure in India is not increasing as compared to other emerging and developed nations during last two decades and stagnant around 0.6 per cent to 0.8 per cent during 1996 to 2011. On the other hand, China is leading in R&D expenditure among BRICS (Brazil, Russia, India, China, and South Africa) nations and her spending on R&D increased to 2 per cent of GDP in 2014. However, Republic of Korea is the highest investor on R&D during last three decades. Korean investment on R&D as per cent of GDP in 1996 was 2.2 per cent which has almost doubled in 2014 to 4.3 per cent and helping economic development continuously.



***Source*:** UNESCO Institute for Statistics (2016)

6.2 Expenditure on Researchers and Research in the World

The investment on R&D also implies investment on human resource involved in the research and development.

Table 2: GERD researcher, FTE (in '000 PPP$, constant prices - 2005)

	1996	2000	2006	2010	2014	CAGR
Australia	130.2	135.2	171.2	181.5		2.4
Brazil		240.8	187.6	213.1		
China	31.0	53.4	83.7	160.2	205.4	12.4
France	221.8	214.1	190.8	178.1	172.2	-1.6
Germany	219.6	239.3	241.6	233.5	243.0	0.4
India	79.7	151.8		201.8		6.9
UK	188.7	184.0	139.4	140.9	143.9	-2.1
USA	281.9	307.9	303.3	311.0		0.7
World	144.4	166.8	173.5	180.3	190.8	1.6

***Source*:** UNESCO Institute for Statistics (2016)

Table 2: shows the gross expenditure on R&D researchers in terms of PPP $ during last three decades in world's major countries. In 1996, India spent 79.7 thousand $ (i.e. PPP$) which is higher than China 31 thousand $ but less than world average 144.4 thousand $ and other developed nations. Interestingly, India's spending on researcher in terms of purchasing power parity has almost matched developed nations in 2010 and reached 201.8 thousand $ whereas it is 160.2 thousand $ in China, 140.9 thousand $ in the UK, 181.5 thousand $ in Australia, 178.1 thousand $ in France but it is less than 213.1, 233.5 and 311 thousand dollars in Brazil, Germany and the USA respectively. The CAGR of gross expenditure of R&D on researcher has registered 12.4 per cent in China and 6.9 per cent in India which is higher than any other advanced economies during last three decades. However, per capita expenditure on researcher out of total R&D expenditure in India is least among developed and emerging nations which are shown in the table 3 In 1996, India has spent 12.1$ per researcher which is lower than world average 113.7, followed by China 13.7$, Russia 73.1$ and Australia, France, Germany, the UK, the USA which have more than 400$ per researcher. It has not improved over the period in India even though India doubled per capita expenditure on a researcher in recent years. In 2011, India's per capita expenditure on a researcher reached 34.3 $ which is $1/5^{th}$ of China's investment and $1/6^{th}$ of world level. Therefore, per capita expenditure on researchers in India should be up scaled at international level then only we can assure good researcher to do research in India.

Table 3: GERD per capita (in PPP$, constant prices - 2005)

	1996	2000	2004	2010	2011	2013
Australia	433.9	467.2	596.9	822.2	779.7	783.9
Brazil	--	101.2	102.9	148.8	150.6	167.5
China	13.7	29.2	55.7	144.7	163.7	211.0
France	587.5	620.4	647.5	688.9	704.8	721.3
Germany	617.5	753.4	783.6	952.1	1016.9	1033.5
India	12.1	16.7	19.8	31.6	34.3	--
Russia	73.1	90.4	127.5	159.4	160.3	174.3
UK	470.3	533.2	547.3	576.3	582.1	585.0
USA	880.3	1070.2	1074.8	1202.7	1222.0	1241.9
World	113.7	134.5	146.4	183.7	191.2	205.0

***Source*:** UNESCO Institute for Statistics (2016)

7. Research and Development in India

The research ecosystem in India presents a significant opportunity for multinational corporations across the world due to its academic capital available in the country. Overall India-based R&D Globalization and R&D Services market reached US$ 20 billion $ in 2015, up by 9.9 per cent over 2014. R&D Services market stood at US$ 7.76 billion and R&D Globalisation market (Captives) stood at US$ 12.25 billion. India's R&D globalisation and services market is set to almost double by 2020 to US$ 38 billion. India accounts for 40 per cent (US$ 12.3 billion) of the total US$ 31 billions of

globalised engineering and R&D in 2015. India is presently ranked 76th among a total of 143 economies, as per the Global Innovation Index (GII). India will likely get into the list of the top 25 nations in the Global Innovation Index, in the next 10 years. India-based R&D services companies, which accounts for almost 22 per cent of the global addressed market, which grew much faster at 12.67 per cent. India's R&D services market is expected to reach US$ 15-17 billion by 2020 and North America continues to be the largest market contributing to 55 per cent of revenues.

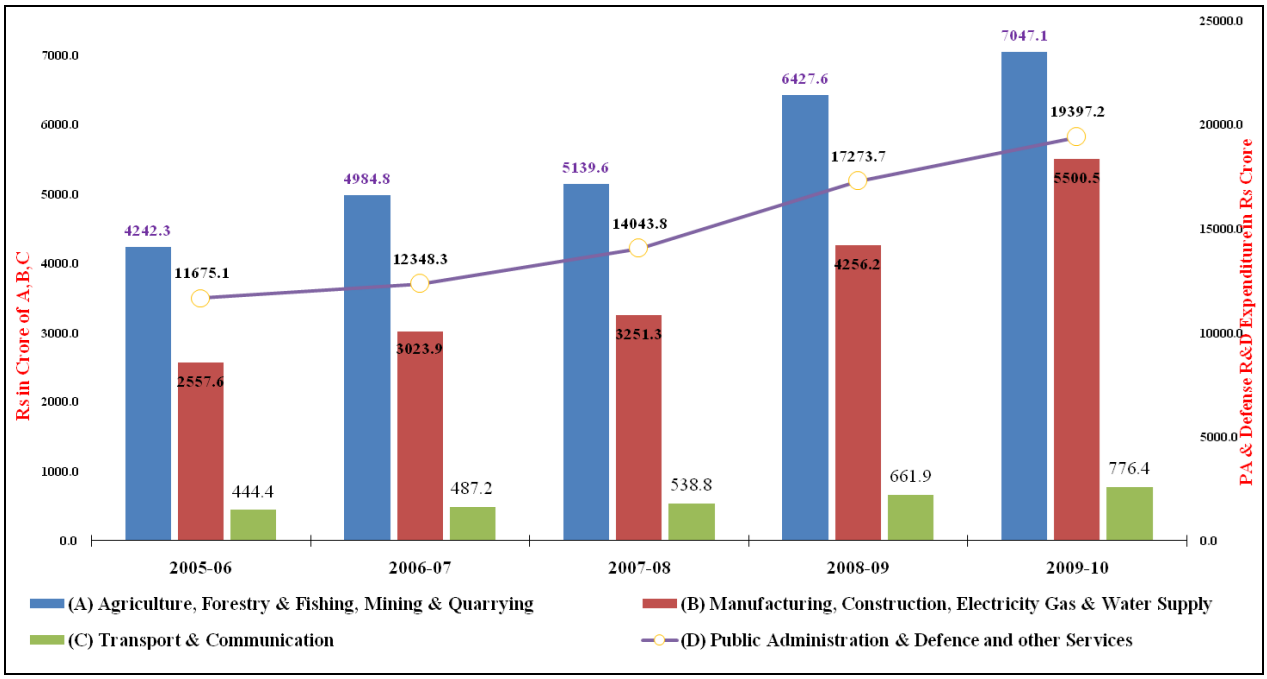
Table 4: Ratio of R&D expenditure to GDP by industry of origin In India (In %)

Sectors	2005-06	2006-07	2007-08	2008-09	2009-10
(A) Agriculture, Forestry & Fishing, Mining & Quarrying	0.58	0.6	0.53	0.59	0.57
(B) Manufacturing, Construction, Electricity Gas & Water Supply	0.3	0.29	0.27	0.31	0.36
(C) Transport & Communication	0.05	0.05	0.05	0.05	0.05
(D) Public Administration & Defence and other Services	2.54	2.44	2.45	2.45	2.19
All Sectors (A+B+C+D)	3.47	3.38	3.3	3.4	3.17
All Sectors Excluding Public Administration & Defence	0.93	0.94	0.85	0.95	0.98

***Source*:** UNESCO Institute for statistics (2016)

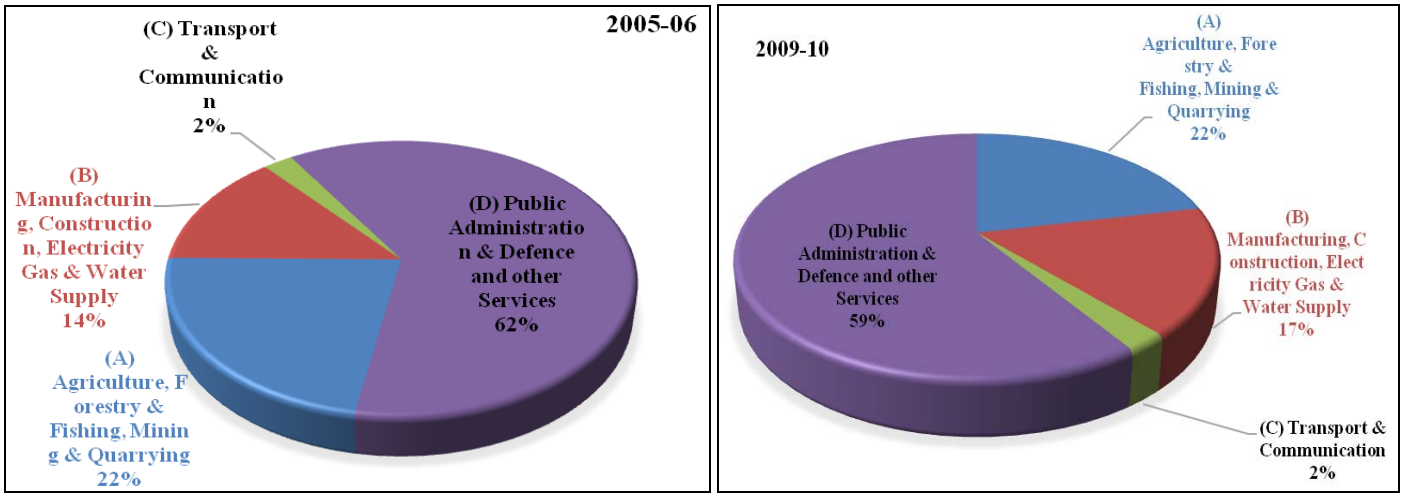
Major proportion of Research and Development (R&D) expenditure in India is public administration and defense. Data illustrated in the table 4 shows the R&D expenditure as a percentage of GDP from different sectors in India during 2006 to 2010. In 2005-06, agriculture, forestry and fishing, mining & quarrying R&D expenditure accounted 0.58 per cent followed by manufacturing, construction, electricity, gas and water supply 0.3 per cent, transport and communications 0.05 per cent and public administration & defence and other services had highest research and development expenditure as percentage of GDP at 2.54 per cent. Total R&D expenditure (Except public administration & defence and other service as percentage of GDP ratio in India was 0.93 per cent in 2005-06. The R&D expenditure as a percentage of GDP in India is stagnant around 0.9 per cent since 2005 while it slightly increased to 0.98 per cent in 2009-10. Public administration and defence and agriculture sector are still dominant sector in R&D expenditure.

The data illustrated in the figure 2 shows the sector wise R&D Expenditure in India during 2005-06-2009-10. Total research and development expenditure in India was Rs 18,919.4 crores during 2005-06 which further increased to Rs 32,721.2 crores in 2009-10 and it has registered 14.7 per cent compounded annual growth rate (CAGR) during 2006 to 2010 period. Manufacturing, construction, electricity gas and water supply registered highest CAGR at 21.1 per cent, followed by transport and communications 15 per cent; agriculture, forestry & fishing, mining & quarrying; and public administration and defence each registered 13.5 per cent CAGR in the same period. The pie charts in figure 3 shows the share of each sector in total R&D expenditure in India during 2005-06 and 2009-10. There is no considerable variation in the share of R&D expenditure on different sectors in India. Manufacturing, construction, electricity gas and water supply sector slightly improved from 14 per cent in 2005-06 to 17 per cent in 2009-10 by offsetting the share of public administration & defence.



***Source*:** UNESCO Institute for statistics (2016)

Fig 2: Sector wise R&D Expenditure in India, 2006-2010 (Rs Crore)



Source: UNESCO Institute for statistics (2016)

Fig 3: Sector wise share of R&D Expenditure in India during 2005-06 and 2009-10

8. Conclusion

This study has examined that research and development where India needs to change policies to encourage more innovations and research to boost the economy through technology. India is lagging in almost human capital formation either health or education and which has direct and indirect effect on research and development consequence slow human capital formation during reform period. India has advantage of demographic dividend and if it is properly nurtured, human productivity in India has increased and has helped human capital formation which has led to economic growth.

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