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IMPACT OF INTERNET USE, R&D EXPENDITURE AND POPULATION ON ECONOMIC GROWTH: THE INDIAN PERSPECTIVE

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Abstract

This study examines the impact of internet use and expenditure on R&D activities on the economic growth of India. We used time series data for the period 1995 to 2018 in our analysis. We formulated an economic growth model following the works of Romer and Barro. The model comprises of three more variables other than internet users and R&D expenditure. Using econometric estimation techniques like Augmented Dicky Fuller unit test, Johansen Co-integration, Durbin-Watson correlation test and time-series regression estimation, we found a strong long run association between the variables. Results indicate that there exists a positive and significant impact of internet use and R&D expenditure in strengthening the growth of a developing country like India.

Abbreviations-ADF=Augmented Dicky Fuller,GDP= Gross Domestic Product,R&D= Research and Development.

1. Introduction

Therelationship between economic growth and R&D expenditure is quite extensively explored in existing literature. R&D expenditure most likely lead to growth through its positive effect on innovation and total/multi factor productivity (TFP) (Romer, 1990; Lucas, 1988). The spill over effect of R&D spillon economic growth has been explained long back by Romer(1990), Coe and Helpman(1995) in the endogenous growth model. With the investment of a firm in Research and Development, new ideas are generated, skills of workers are improved, innovation takes place and new cost-reducing methods leads to low cost final consumer products. It also allows for the improved quality of consumer goods, as a result, the demand

for the good will increase as consumers get better quality product at a lower cost. The firm's revenue will then increase and it will earn more and more profit which will allow the firm to become more efficient.R&D expenditure has private benefits of as well as positive spillover effects within the firms, industries, and geographic regions (Blanco, 2013).Likewise, many researchers have attempted to examine the effect of R&D expenditure on economic growth. However, the empirical results of these studies rather had mixed results. Some studies found apositive relationship between the two (Redding; Zachariadis 2004; Bravo-Ortega and Marin 2011;Van Reenen 2004, Edquist et.al. 2017) while others found a negative one (Gong, Greiner, and Semmler, 2004).

R&D expenditure is known to create new knowledge and use of Internet is related to the dissemination of knowledge (Choi & Yi, 2017). The internet is nothing but a general purpose technology that impacts society in various levels and in a vast range of activities ((Harris 1998). The internet facilitates economic growth by generating and spreading new knowledge and new ideas that helps in increasing productivity in the research process and increase diffusion of its products. The internet also affects the labour market (T. Ziesemer 2002), (Stevenson 2008) and product market (Levin 2011) by reducing costs of searching a job and facilitating the access to information. Conversely internet also impacts society in a less positive way as for instance online crime is spreading rapidly. (Moore et al. 2009) (Clarke and Wallsten 2006), (Freund and Weinhold 2004) and (Vemuri and Siddiqi 2009) all studied the impact of use of internet and economic growth. They investigated the causality of this relation and found in general that internet use causes economic growth. There are other studies which found a negative relationship between internet use and economic growth (Meijers, 2013). Many of the studies focused on other macro-economic variables such as trade (Meijers, 2013), inflation and trade (Freund and Weinhold 2004) and foreign direct investment (Choi 2003).

2. METHODOLOGY

This study is an empirical investigation into whether internet use and R&D expenditure has any impact on the economic growth of India. The objective of this study is to examine the impact of internet use and expenditure in R&D activities upon the economic growth of India. The study tests the hypothesis that internet use has a positive impact on economic growth. Equivalently, we test the hypothesis that economic growth is positively influenced by expenditure in Research and Development. We performed Augmented Dicky Fuller test, Johansen co-integration test, and Durbin-Watson correlation test. Also, a time series regression analysis has been estimated using data for the time period 1995-2018.

2.1Objectives:

1. To examine whether there exists any relationship (long-run) between internet use, R&D expenditure and economic growth.

2. To examine the impact of R&D expenditure and internet use upon economic growth of India.

2.2 Data Sources:

Time series secondary data (continuous) for the variables has been used for a time period of 23 years i.e. from 1995 to 2018. The purpose of choosing 1995 as the starting point is due to availability of data. Data for GDP growth rate has been extracted from IMF database. Data on the other variables i.e. Internet user, R&D expenditure, population growth, Gross fixed capital formation and government expenditure has been extracted from the World Bank database.

2.3 Variable description:

NO.	VARIABLE	DESCRIPTION
1	Growth	Annual GDP growth of India
2	Internet	Internet users as % of India's population
3	R&D	Expenditure in R&D as % of India's GDP
4	Population	Annual population growth Rate of India
5	GCF	Gross fixed capital formation as % of GDP
6	Expenditure	Expenditure of government as % of GDP

2.4Model Specification:

We set up an economic growth model following the works of Romer (1990), Barro (1997) and Choi & Yi (2017)-

$$Ln\ Growth_t = \beta 0 + \beta_1\ Ln\ Internet_t + \beta_2\ Ln\ R\&D_t + \beta_3\ Ln\ Pop_t + \beta_4\ Ln\ GCF_t + \beta_5\ Ln\ Exp_t + e$$

Where, subscript t represents the time period, $Growth_t$ is the dependent variable representing economic growth given the annual growth rate of India's GDP. $Internet_t$ represents internet users as % of population, $R\&D_t$ represents expenditure in research and development as % of GDP, Pop_t represents annual population growth rates, GCF_t represents Gross fixed capital formation as % of GDP and Exp_t represents Government expenditure as % of GDP.The logarithmic transformation of each variable has been taken in order to normalise the series.

Here, Gross fixed Capital formation and Government expenditure has been used as controlled variables which are anticipated to have impact upon the dependent variable.

3. Empirical Analysis:

In this study, we employed Augmented Dickey-Fuller test (1979, 1981), Johansen (1991, 1995) co-integration test and time series regression estimation to examine and forecast the relationship between the dependent and explanatory variables. The Augmented Dickey–Fuller test (ADF) tests is to test he the null hypothesis that a unit root is present in thesamplefor a

larger and more complicated set of time series models.. The alternative hypothesis is usually stationary or trend-stationary.

The Johansen Co-integration test is based on the following equation-

$$Y_t = A_1 Y_{t-1} + \ldots\ldots + A_p Y_{t-p} + B x_t + e_t$$

To make interpretations, we need to compare thetrace statistic and maximal eigenvalue statistic and then we must compare it with critical tabulated values. The trace statistic usually tests the null hypothesis that there are at most *r* co-integrating vectors. Meanwhile, in the maximal eigenvalue statistic test the null hypothesis of *r* co-integrating vectors is tested against the alternative of *r+1* co-integrating vectors (Lenum, 1992).

4. RESULTS AND INTERPRETATION:

4.1Table 1-Augmented-Dickey-Fuller (ADF) test:

TABLE-1 AUGMENTED DICKEY-FULLER (ADF) TEST RESULTS FOR UNIT ROOTS

Variables	ADF test-statistic	Probability	Conclusion
LN GDP GROWTH	-4.781870	0.0010	I(1)
LN INTERNET	-5.140391	0.0004	I(1)
LN POPULATION	-3.331146	0.0270	I(1)
LN R&D	-3.827750	0.0092	I(1)
LN GCF	-5.168310	0.0004	I(1)
LN EXPENDITURE	-3.367953	0.0238	I(1)

Source: Authors Computation

Table 1 shows the estimation results of Augmented-Dickey-Fuller (ADF) unit root test. The Augmented Dickey–Fuller test (ADF) tests that a unit root is present in a time series sample. The alternative hypothesis is usually stationary or trend-stationary. The test is performed on the logarithmic value of each variable- GDP growth, Internet use, Population growth, R&D expenditure, Gross Fixed capital formation and government expenditure.

For each variable, the t-statistic was insignificant at level i.e. each of the series were non-stationary at level. We performed the first differencing of each series and then the series became stationary on rejecting the null hypothesis will be thata unit root is present in the sample.

4.2Johansen co-integration test:

Table 2 shows the estimation results for Johansen co-integration test. This is a statistical procedure for testing co-integration of several, say *k*, I(1) time series. This test is better and more generally applicable than the Engle–Granger test which is based on the Dickey–Fuller (or the augmented) test for unit roots in the residuals from a single (estimated) co-integrating relationship because the Johansen co-integration testpermits

more than one co-integrating relationship so is. It shows whether there exists long-run association among the pairs of variables.

TABLE-2 JOHANSEN COINTEGRATION TEST RESULTS

Variable Pairs	**trace-statistic**	**Eigen value**	**Prob**
GDP – Internet use	32.8472	0.657268	0.0001
GDP- R&D expenditure	25.7261	0.595466	0.0010
GDP- Population	25.5237	0.645508	0.0011
GDP- GCF	22.6853	0.588383	0.0035
GDP-Expenditure	25.2592	0.607990	0.0013

Source- author's computation

We performed the Johansen co-integration test on the following pairs of variables to examine each of their relationship with the dependent variable i.e. GDP growth. The pairs are GDP growth and internet users, GDP growth and population growth, GDP growth and R&D expenditure, GDP growth and Gross fixed capital formation and finally on GDP growth and government expenditure.

As reported in table 2, the trace statistic reveals that there exists co-integration among the variable pairs. The inferences are made based on the trace statistic value and not on the basis on Eigen-values because Johansen and Juselius (1990) they recommended the use of the trace statistic. Thus, there exists a long run association between the variables used in our study.

4.3 Durbin-Watson test:

The Durbin-Watson test is used to detect whether there is the presence of serial correlation at lag 1 in the residuals from a regression estimation. In our analysis, the D-W test statistic is 2.147 which indicates there is no serial-correlation in our sample data.

4.4 Regression Results:

Table 3 reports the descriptive statistics of the time-series regression that we estimated. In the growth model, the dependent variable was GDP growth and the explanatory variables are internet users as % of population, R&D Expenditure (as % of GDP), Population Growth per annum, government Expenditure as % of GDP and Gross Fixed Capital Formation (as % of GDP). Our model performs well with R square value of 0.57 and adjusted R square value of -0.58 and f-statistic value of 0.90.

The estimated parameters of internet users as % of population, R&D Expenditure as % of GDP, and Population Growth per annum turned out to statistically significant whereas the other two parameters government Expenditure as % of GDP and Gross Fixed Capital Formation as % of GDP turned out to be insignificant in our study.

Our study was mainly concerned with the two variables- internet users and R&D expenditure and its impact upon the dependent variables GDP growth. The other three variables were considered as controlled variables which are anticipated to have an impact on the dependent

As reported in table 2, the trace statistic reveals that there exists co-integration among the variable pairs. The inferences are made based on the trace statistic value and not on the basis on Eigen-values because Johansen and Juselius (1990) they recommended the use of the trace statistic. Thus, there exists a long run association between the variables used in our study.

TABLE-3 DESCRIPTIVE STATISTICS OF REGRESSION

SL NO	Dependent Variable: GDP GROWTH			
	EXPLANATORY VARIABLES	**COEFFICIENT**	**T-STATISTIC**	**PROBABILITY**
1	Internet Users as % of population	0.035419	**0.437095***	0.0002
2	R&D Expenditure as % of GDP	0.651255	**0.513385****	0.0339
3	Annual Population Growth	-0.21775	**-0.20985***	0.0014
4	Gross Fixed Capital Formation	-0.167670	-0.136788	0.8927
5	Government Expenditure as % of GDP	0.438443	0.264152	0.7947
6	**CONSTANT**	0.727722	**0.099003**	0.0002
7	**R^2**	0.57		
8	**ADJUSTED R^2**	-0.48		
9	**F STATISTIC**	0.90		
9	**DW**	2.14		

*** implies significant at 5% level* * *implies significant at 10% level*

The other variable i.e. R&D expenditure is also found to be positively and significantly related with GDP growth. The estimated parameter value is 0.651255 which is significant at 5% level. It implies that an increase in expenditure in R&D activities will positively facilitate economic growth. Similar results were found by many researchers across the globe (Redding and Van Reenen, 2004, Bravo Ortega 2011, Henrekson, 2017 etc)while some others found an opposite one (Gong, Greiner, and Semmler, 2004).

5. CONCLUSION

In this study, we attempted to examine the long-run relationship between internet use and expenditure in R&D activities with economic growth of India. We also attempted to examine the impact of internet use and

expenditure in R&D activities upon economic growth of India. Thus, we hypothesised that internet use and R&D expenditure positively influences economic growth. The results of Johansen co-integration test indicated that there exists long run association between the dependent variable and each of the explanatory variable i.e. internet use and R&D has significant long-run association with economic growth of India.

The result of regression estimation indicates a significant impact of internet users as % of population, R&D Expenditure as % of GDP, and Annual Population Growth. Whereas the other two parameters government Expenditure as % of GDP and Gross Fixed Capital Formation as % of GDP turned out to be insignificant in our study. Our study was mainly concerned with the two variables internet users as % of population and R&D Expenditure as % of GDP while the other three variables were considered as controlled variables.

The estimated coefficient of internet users is found to be 0.035419 which is positively and significantly (at 10% level) related with GDP growth. This implies that a rise in the % of internet users in the total population is likely to increase the GDP growth rate of India.

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The policy implications that follows from the results of our study is that the spill-over effects of R&D activities will be enhanced as expenditure on R&D is increased. For instance, if a firm makes expenditure in improvement of R&D activities, the results will be the generation of new ideas, reduction of production costs, improvement of skills of the workers and many more. This will eventually lead to production of high and improved quality final consumer goods. When consumers are satisfied with the quality and price of goods, market demand for that good will increase, which in turn will increase the profit of the firm. More profit will allow the firm to become more and more efficient.

In case of internet use, the results of our study indicated that the increased use of internet in the country will help to boost economic growth. Internet helps by disseminating the knowledge gained from R&D activities among the users. To take advantage of it, the accessibility of internet must be increased. This can be done by reducing the cost of internet to make it more accessible among people. Also education for internet use must also be provided by the government to reap the maximum benefits of the spill-over effect

6.APPENDIX

Dependent Variable: LN_GDP
Method: Least Squares
Date: 02/19/20 Time: 01:45
Sample: 1995 2018
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.727722	7.350538	0.099003	0.0002
LN_INTERNET	0.035419	0.081033	0.437095	0.0002
LN_R_D	0.651255	1.268551	0.513385	0.0339
LN_GCF	-0.167670	1.225761	-0.136788	0.8927
LN_POPL	-0.21775	1.063006	-0.20985	0.0014
LN_GOVT_EXP	0.438443	1.659815	0.264152	0.7947

R-squared	0.575758	Mean dependent var	1.883066
Adjusted R-squared	-0.480976	S.D. dependent var	0.278356
S.E. of regression	0.302497	Akaike info criterion	0.658825
Sum squared resid	1.647077	Schwarz criterion	0.953339
Log likelihood	-1.905904	Hannan-Quinn criter.	0.736960
F-statistic	0.295084	Durbin-Watson stat	2.147601
Prob(F-statistic)	0.909357		

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