Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.6, No.22, 2015

The Relationship between Innovations and Economic Growth in Sri Lanka

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Abstract
Innovation is widely recognized as a major incentive to national economic growth in industrial, newly industrialized, and developing economies (Pavitt and Walker, 1976; Kim, 1980; Archibugi et al., 1991; Ernst and Kim, 2002; Guan and Chen, 2012) and also there is widespread agreement among most economists on the positive link between innovation and growth. The objective of the study is to find out the impact of innovation on economic growth, the long run relationship between economic growth and other economic variables using Augmented Dickey-Fuller (ADF) unit root test and Johansen's test of co-intergration. The researcher used only secondary data for the study and the conclusion was that innovations positively influence economic growth in Sri Lanka.
Keywords: Innovation, Economic Growth, unit roots, co-integration, vector auto-regression model

1. Introduction

Innovation is broadly recognized as a major incentive to national economic growth in industrial, newly industrialized, and developing economies (Pavitt and Walker, 1976; Kim, 1980; Archibugi et al., 1991; Ernst and Kim, 2002; Guan and Chen, 2012). Innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, work place organization or external relations (OECD and Eurostat). The minimum requirement for an innovation is that the product, process, marketing method or organizational 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 organizations.

Innovation is important for nations because it is a driver of economic growth. It is caused to increased welfare, the creation of new types of jobs and the destruction of old ones. In a recent book, Boumal noted that, nearly all the economic growth that has occurred since the eighteenth century is ultimately attributable to innovation (Baumol, 2002). Innovation is considered an important driver of long-term productivity and economic growth. It is argued that countries that generate innovation, create new technologies and encourage adoption of these new technologies grow faster than those that do not.

There is widespread agreement among most economists on the positive link between innovation and growth. Economic growth depends on a variety of factors. Among them are a country's rate of savings, increase in the stock of productive inputs and technical changers. Innovation bears most directly on technical change, and thus is a major determinant of economic growth. Schumpeter, along with other economists, stresses the prominent role of entrepreneurship and innovation in the economic growth process. In "Theoretical Problems of Economic Growth", Schumpeter (1947) shows that scholars consider different factors that enhance economic growth; Physical environment, social organization, institutions, technology and so on. He explains, however, that all these factors are insufficient to explain the economic growth process because, "economic growth is not autonomous, being dependent upon factors outside of itself, and since these factors are many, no one factor theory can ever be satisfactory.

Sri Lanka is a relatively small sized island economy possessing significant resource and location advantages and demonstrating impressive human capital indicators. Research in Innovation in the context of Sri Lanka is limited. Therefore to fill the research gap, this research attempts to formulate systematic studies of innovation in Sri Lanka.

2. Literature review on growth and innovation

Traditional growth theory based on Solow (1956) and Piazolo (1996) shows that setting the output depends on the level of capital stock, the volume of labour employed and types of technology. Factors like savings and investment rate or the institutional framework (e.g. government consumption expenditure) are also cited as minor influences for long term economic development.

The new growth theory on the other hand focuses mainly on (i) technological change, (ii) the role of the government, (iii) trade policy, and (iv) human capital development as determinants of economic growth (Piazolo, 1996). Most literature however focuses more on technology factor as a determinant to output growth. The main objective of this study is to investigate the relationship between innovation and economic growth and causal pattern of several determinant factors (government expenditure, export, education, capital formation) towards economic growth in Sri Lanka.

Further studies on economic growth (Barro & Sala-I-Martin, 1995; Chenery & Syrquin, 1975; Denison,

1962; Jorgenson, Gollop, &Fraumeni, 1987; Porter, 1990) explain that the major factors for economic growth are saving and the stock of inputs, but point to several underlying factors also is important. Among them are: technology, aid and financial innovation, foreign direct investment, research and development, and the governance of economic institutions. Considering the above factors technology is a crucial factor for economic development. Because, technological change offsets the classical economic problem of diminishing returns and also technology affects economic growth (David, 1975; Grossman & Helpman, 1991; Jorgenson, 1995; Rosenberg, 1976; Schmookler, 1966; vonHippel, 1988). 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. 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.

Growth of one economy in comparison to some previous historical experience, or comparison to another economy with a higher rate of growth (Berthe´lemy Varoudakis, 1996; Bordo, Taylor, & Williamson, 2003; Olson, 1982). If innovation may depend in part on public sector intervention, it also may depend on financial innovation, international aid, and governance institutions. Mauro, Sussman, and Yafeh (2006) examine the role of financial innovation in historical perspective, and note the positive relationship between financial innovation and growth. This supports the findings of Levine (1997) and Berthelemy and Varoudakis (1996). However, financial innovation alone may not explain major differences in per capita income, which suggests that other factors such as foreign direct investment (Aghion & Howitt, 1996; DeMello, 1999; Granstrand, 1999) also are at work. One factor is the role of international aid. Although Burnside and Dollar (2004) found a positive relationship between aid and growth, this runs contrary to most findings, as summarized in Rajan and Subramanian (2006). The Burnside and Dollar findings point, however, to the quality of institutional governance, which has been examined in a number of related studies, notably Kaufmann, Kraay, and Mastruzzi (2003), Perotti (1996), and Saint-Paul and Verdier (1993).

Arrow (1962) pointed out, innovation derives from experimentation, and it is a key element in achieving cost efficiencies in production (Leibenstein, 1966). If innovation may depend in part on public sector intervention, it also may depend on financial innovation, international aid, and governance institutions. Mauro, Sussman, and Yafeh(2006) examine the role of financial innovation in historical perspective, and note the positive relationship between financial innovation and growth. This supports the findings of Levine (1990) and Bethelemy and Varoudakis (1996).

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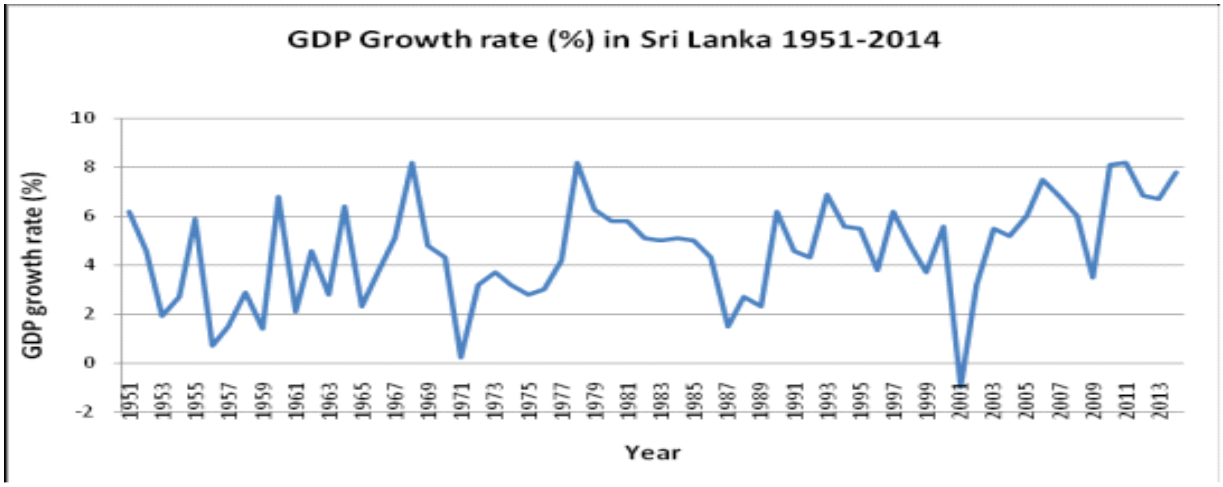
Sri Lankan perspective

Sri Lanka has experienced a lower average economic growth rate during the period from 1960 – 1976. Of which, period from 1970 -1976 country has shown a poor economic performance. This period is especially well known as the most trade restricted period of the economy. After that, the liberalization policy was adopted to the economy. As results of the liberalization policy, the economic growth rate was increased dramatically. Further, in the period of 1987- 89, economic growth rate was affected by the political instability. Later, in 2001, negative growth level has been faced by the economy. Again the Political instability was the reason for the particular economic recession. . However as a whole, country has performed well after 1977 with compared to the period before 1977. Meantime, Sri Lankan economy has achieved the 5 percentage growth level approximately for recent four decades. This level is the satisfactory one in the South Asian Region. Growth rate has been steadily increased for last decade (2001-2014).



Source: using Central Bank Annual Reports in Sri Lanka

3. Methodology

3.1 Data Collection

Sample period uses annual time series data over the period from 1990 to 2013. These annual data were obtained from the various issues of Economic and Social Statistics of Sri Lanka and Annual reports published by the Central Bank of Sri Lanka. The data consists of gross R&D expenditure, and other macroeconomic data. Research and Development expenditure is obtained from the Sciences and Technology Policy Research Division database, National Science Foundation. The remaining macroeconomic variables are obtained from the Central Bank Annual Reports in Sri Lanka. Per capita economic growth values are used as a proxy for economic growth. Table o1 shows the summary statistics of variables.

Table 01 Variable definitions and summary statistics

Variable	Definition	Descriptive Statistics				
		Obs1	Mean	SD2	Min3	Max4
GDPGR	GDP growth rate	24	5.5021	1.98486	-1.5	8.3
EXGDP	Export revenue as a percentage of GDP	24	28.1512	4.61656	21.33	36.10
CAPGDP	Capital formation as a percentage of GDP	24	16.6892	3.50142	10.17	28.97
GOVGDP	Government current expenditure as a percentage of GDP	24	19.4562	2.36700	14.44	23.09
EDUGDP	Education expenditure as a percentage of GDP	24	2.4712	0.32758	2.01	3.06
RDGDP	Research and development expenditure as a percentage of GDP	24	0.1650	0.03050	0.11	0.22

Notes:
1 observations
2 Standard deviation
3 Minimum
4 Maximum

Above graph shows that, the mean value of macro variables which are taken for the research. Mean value of annual growth rate is around 5.5 percent and Research and Development expenditure as a percentage of GDP is about 0.16 percent in Sri Lanka.

3.2 Data Analysis

Regression model builds on the approach to growth equations introduced by Barro and Levine (1991). Regression starts with OLS regression with robust standard errors.

Y= F(EXGDP, GOVGDP, CAPGDP, EDUGDP, RDGDP)

Where, Y = GDP growth rate, EXGDP = Export revenue as a percentage of GDP, GOVGDP = Government current expenditure as a percentage of GDP, CAPGDP = Capital Formation as a percentage of GDP, EDUGDP = Education expenditure as a percentage of GDP, RDGDP = Research and Development expenditure as a percentage of GDP.

Dependent variable is the growth rate of GDP in the country of Sri Lanka. This research consists of number of independent variables popularly used in the literature in cross- country growth estimation. Initial GDP values are

useful to understand the relative changes from country. Capital formation and education are common proxies for capital and human capital respectively of the country.

A major challenge was to determine what an appropriate proxy was for innovation. In the past, scholars have used R&D as a measure of innovative activities and in the firm –level studies argued that R&D is more of an input to the actual output (Schmookler, 1966). Further, country of the number of patent has been used as a proxy for innovation (Ahuja and Katila, 2001). The actual R& D variable considered is the total research and development expenditure in the country as a ratio to the GDP of the country. In this research Gross Expenditure on R&D as percentage of GDP was used as a proxy for innovation.

The following method were used for data analysis and evaluation

Test of Stationarity - an augmented Dickey-Fuller unit root test (ADF)

Test using Vector Auto-Regression (VAR) model

Test using Johansen Co integration Test

4. Results and discussion

Test of stationarity – to assess the long term co-integrated relationship among the different variables by applying VAR model, firstly, it was necessary to test for stationarity and the order of integration of the variables in the model. If some or all of the variables in the model are non-stationary (that is, showing a stochastic trend), conventional hypothesis testing and confidence intervals will be unreliable. In the presence of non-stationary variables, there might be a so-called spurious regression. A spurious regression has a high R^2 and a t-statistic that appears to be significant, but actually have no economic meaning (Granger and Newbold, 1975). Stationarity was, therefore, established by testing for unit roots in the variables by applying the Augmented Dickey- Fuller test (ADF).

In principle, researchers should consider that the relationships among variables have a long-run equilibrium. The Dickey- Fuller (ADF) test was applied to test each variable for stationary (including constant without trend and constant with trend) (table 02). The result indicate that the null hypothesis proposing non-stationarity of unit roots in the time series could be rejected in GDP growth rate constant with trend and constant without trend (table 02).But export as a percentage of GDP and capital formation as a percentage of GDP, the null hypothesis proposing non-stationarity of unit roots in the time series could not be rejected.

The test was, therefore, applied again at first difference for all variables those were found to be non-stationary at level. Therefore, the results indicate that the null hypothesis (proposing non stationary of unit roots in the time series) should be rejected at first difference for all variables (table 02). That means all variables are stationary. This implies that all variables in table 02 had one order of integration [1(1)].

Table 02- Result of ADF Test

Variables	Constant without trend	Constant with trend
Level		
GDPGR	-3.845499***	-4.229247**
EXGDP	-1.137219	-1.325814
CAPGDP	-1.802982	-2.332525
GOVGDP	0.794886	-4.986792***
EDUGDP	-2.292156	-3.311195*
RDGDP	-2.536524	-4.411809**
First Difference		
GDPGR	-5.470213***	-5.322444***
EXGDP	-5.685525***	-6.828393***
CAPGDP	-5.303388***	-5.179210***
GOVGDP	-4.417755***	-4.658427***
EDUGDP	-6.866094***	-6.698216***
RDGDP	-4.420323***	-4.523448**

***, ** and * imply that the reject the null hypothesis is that the time series has a stochastic trend or contain a unit root at 1%, 5% and 10%, respectively.

Having established stationarity for the variables at first difference, it was then possible to conduct the test of co-integration for long-term equilibrium by applying the VAR model (table 03)

To investigate the long-term co-integrated relationship in a system of equations, the co-integrated VAR model considers the system to be a general framework with equilibrium demonstrating stationary behavior. The model implies that certain linear combinations of the variables of the vector process are integrated at a lower level than the process itself. Any such co-integrated variables are presumed to be driven by the same persistent shocks. Thus, if the non-stationarity of another corresponds to the non-stationarity of another variable, there exists a linear combination between them that, in itself, becomes stationary. Therefore, the co-integrated relationship can be interpreted as long-term economic steady-state relationships. In this study the model had a system of six equations.

Table 03- Results of estimated Vector Auto-Regression (VAR) model

	CAPGDP	EDUGDP	EXGDP	GDPGR	GOVGDP	RDGDP
CAPGDP(-1)	0.218078	-0.018638	-0.288952	0.289143	-0.230314	0.008111
	(0.40517)	(0.04078)	(0.39011)	(0.29020)	(0.24275)	(0.00314)
	[0.53824]	[-0.45705]	[-0.74069]	[0.99636]	[-0.94876]	[2.58231]
CAPGDP(-2)	-0.386429	0.036366	-0.269609	-0.062107	-0.246937	0.002857
	(0.50790)	(0.05112)	(0.48903)	(0.36378)	(0.30431)	(0.00394)
	[-0.76083]	[0.71139]	[-0.55132]	[-0.17073]	[-0.81148]	[0.72569]
EDUGDP(-1)	-5.774879	0.399764	-1.482101	4.031299	0.579215	-0.021339
	(3.57260)	(0.35958)	(3.43981)	(2.55883)	(2.14048)	(0.02769)
	[-1.61644]	[1.11177]	[-0.43087]	[1.57544]	[0.27060]	[-0.77054]
EDUGDP(-2)	-2.947399	-0.053937	-2.766778	0.490382	0.762422	0.014473
	(4.67752)	(0.47078)	(4.50367)	(3.35022)	(2.80248)	(0.03626)
	[-0.63012]	[-0.11457]	[-0.61434]	[0.14637]	[0.27205]	[0.39916]
EXGDP(-1)	0.204124	-0.015327	0.458378	-0.482949	0.046715	-0.001520
	(0.30953)	(0.03115)	(0.29803)	(0.22170)	(0.18545)	(0.00240)
	[0.65946]	[-0.49197]	[1.53803]	[-2.17839]	[0.25190]	[-0.63361]
EXGDP(-2)	0.219329	-0.011392	0.462919	0.010513	0.231208	-0.002363
	(0.36747)	(0.03699)	(0.35381)	(0.26320)	(0.22016)	(0.00285)
	[0.59687]	[-0.30801]	[1.30838]	[0.03994]	[1.05016]	[-0.82952]
GDPGR(-1)	0.316255	-0.018112	-0.205401	-0.368628	0.027169	0.006076
	(0.49575)	(0.04990)	(0.47732)	(0.35507)	(0.29702)	(0.00384)
	[0.63794]	[-0.36300]	[-0.43032]	[-1.03818]	[0.09147]	[1.58100]
GDPGR(-2)	0.285563	0.034183	-0.316550	-0.714127	-0.162543	-0.001372
	(0.65104)	(0.06553)	(0.62684)	(0.46630)	(0.39006)	(0.00505)
	[0.43862]	[0.52167]	[-0.50499]	[-1.53147]	[-0.41671]	[-0.27180]
GOVGDP(-1)	-0.126868	0.055779	0.128602	-0.049526	0.162718	0.008478
	(0.55728)	(0.05609)	(0.53657)	(0.39915)	(0.33389)	(0.00432)
	[-0.22766]	[0.99447]	[0.23967]	[-0.12408]	[0.48734]	[1.96264]
GOVGDP(-2)	0.436487	0.071039	0.664857	-0.477398	0.122654	-0.000907
	(0.74696)	(0.07518)	(0.71920)	(0.53500)	(0.44753)	(0.00579)
	[0.58435]	[0.94492]	[0.92444]	[-0.89233]	[0.27407]	[-0.15659]
RDGDP(-1)	23.07276	-0.342290	23.96173	61.12681	1.601695	0.093558
	(45.5990)	(4.58945)	(43.9041)	(32.6598)	(27.3201)	(0.35347)
	[0.50599]	[-0.07458]	[0.54577]	[1.87163]	[0.05863]	[0.26468]
RDGDP(-2)	-33.83237	3.655206	-0.571065	1.742944	-7.333037	0.058854
	(30.1497)	(3.03451)	(29.0291)	(21.5944)	(18.0638)	(0.23371)
	[-1.12215]	[1.20455]	[-0.01967]	[0.08071]	[-0.40595]	[0.25182]
C	21.53156	-1.035042	5.202858	9.992518	11.78060	-0.083354
	(14.0298)	(1.41208)	(13.5084)	(10.0487)	(8.40581)	(0.10876)
	[1.53470]	[-0.73299]	[0.38516]	[0.99441]	[1.40148]	[-0.76643]
R-squared	0.693645	0.710561	0.866228	0.637541	0.794079	0.787682
Adj. R-squared	0.285172	0.324642	0.687866	0.154261	0.519517	0.504591
F-statistic	1.698143	1.841219	4.856560	1.319197	2.892170	2.782438

The overall results for goodness of fit (calculated by R^2 and adjusted R^2) indicate that the estimated regressions were mostly explained by the independent variables on the right side of the equations. In addition, the F-test indicated that the null hypothesis (proposing no co integration among variables) should be rejected at the 5% significance level which means that long-term relationship exist among all the variables.

Unit root tests revealed that the series are stationary at first level, so they are integrated. But, even the

series are integrated; it does not guarantee that they behave in the same direction in the long run. Long run relationships between two non-stationary series can be detected by co-integration analysis. There are certain tests to perform co-integration analysis. In this study, long run relationship between the co-integrated series is tested by a Johansen co-integration test (1988). Johansen co-integration test provide us to determine the number of co-integration relationship and the parameters of this relationship. Prior to the implementation of the Johansen Co-integration Test, the unrestricted Vector Auto regression (VAR) model was applied on the series to determine lagged ratios. Lagged ratio is taken as 2. The Johansen Co-integration test results, the Trace Test and the test results are illustrated in Table 4.

The Johansen co-integration test results indicate that the null hypothesis (proposing no co-integrated) should be rejected at the 5% significance level. This supports the findings of the existence of a long-term relationship between economic growth and innovation (table 04).

Table 04- Johansen Co integration Test for PCGDP, INFLR, MACAC & TURA
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.816648	103.6073	95.75366	0.0129
At most 1	0.729914	66.28767	69.81889	0.0926
At most 2	0.654068	37.48932	47.85613	0.3248
At most 3	0.346527	14.13602	29.79707	0.8329
At most 4	0.192346	4.776024	15.49471	0.8321
At most 5	0.003464	0.076349	3.841466	0.7823

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

5. Conclusion

Recent research indicates that a nation or region's innovation policies can contribute to economic development (Wolff, 2002). Innovation activities do not only directly influence economy wide productivity, but also promote economic growth through spurring new business formation, which further promotes employment growth and other outputs (Kirchhoff, 1994; Wennekers, 1999).

In an attempt to clarify some of the issues involved, the present study investigated the relationship between economic growth, innovation and other macro variables in Sri Lanka. By applying the modern econometric techniques, the study was able to identify important aspects of the long-term relationship between these variables from 1990-2013. Time series of the data are found non-stationary so that the long run relationships between the variables are tested with co-integration analysis. According the results of the model, there is a relationship between the economic growth, innovation and other macro variables. The VAR model consisting of a system of six equations provided support for the preposition that innovation has led economic growth in Sri Lanka. The results also indicate co-integration between innovation and economic growth, thus implying that a steady state can be reached in the long run.

Despite these findings, scholars looking to make inferences from the conclusion that innovation (R&D expenditure) positively influence economic growth in Sri Lanka. If policymakers try to increase R&D expenditure can see what happed to the economy and then achieving some suitable economic growth level, central bank in Sri Lanka and government should adjust policies that promote innovation.

Acknowledgement

I am grateful to professors Zhao Yulin and Wang Fang for their insightful comments and suggestions to improve their paper. All remaining errors are of author.

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