The Indian Evidence of Nexus between Economic Growth and Innovation

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Abstract

The relationship between innovation and economic growth has been extensively studied in the literature, with numerous authors highlighting the positive impact that innovation can have on economic performance. In India, this relationship is particularly relevant, as the country has experienced significant economic growth in recent years and is widely recognized as one of the world's leading innovation hubs. One key factor contributing to India's economic growth has been the country's investment in research and development. According to the National Science and Technology Management Information System (NSTMIS), India's spending on research and development as a percentage of GDP has grown from 0.7% in 2006 to 1.2% in 2016 (NSTMIS, 2016). This increase in investment has helped to create an environment that is supportive of innovation and has provided the resources necessary for firms to pursue new and cutting-edge technologies. This paper is an attempt to examine the causal relationship between economic growth and innovation in India for the period 2001 to 2020. Research and Development Expenditure (% of GDP) and the number of patents filed by Indian Residents are the innovation indicators that are examined for causality with the per capita economic growth of India. The Granger Causality Test was used to determine the direction of causality between innovation and economic growth. The findings of the study suggest that innovation plays a crucial role in the economic growth of the country and supports the body of economic theory, which states that "economic growth is the result of appropriate knowledge, innovation, and entrepreneurship operating within an institutional environment of systems of innovation.

Keywords: Economic Growth; Innovation; Granger Causality; India

Introduction

"Innovation promotes economic growth" – Schumpeter

The World Bank report, 2021 indicates that India's Gross Domestic Product (GDP) has grown at an average rate of 7.5 percent per year over the past decade, making it one of the fastest-growing major economies in the world (World Bank, 2021). This growth has been driven by several factors, including increased investment in research and development, favorable government policies, and the rise of a new generation of innovative start-ups. One key factor contributing to India's economic growth has been the country's investment in research and development. According to the National Science and

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Technology Management Information System (NSTMIS), ndia's spending on research and development as a percentage of GDP has grown from 0.7 percent in 2006 to 1.2 percent in 2016 (NSTMIS, 2016). This increase in investment has helped to create an environment that is supportive of innovation. In addition to investment in research and development, government policies have also played a key role in promoting innovation and economic growth in India. For example, the government has established many programs and initiatives that support the growth of start-ups. (Department of Industrial Policy and Promotion, 2016). The government has also worked to create a more favorable regulatory environment for innovation by streamlining the patent process and reducing barriers to entry for new firms (Karnani, 2007). Another important factor contributing to the relationship between innovation and economic growth in India has been the rise of a new generation of innovative start-ups. According to a recent report from NASSCOM (2021), the Indian start-up ecosystem has grown rapidly in recent years, with over 6,000 start-ups operating in the country today. These start-ups are at the forefront of innovation in a range of industries, from technology and software development to health care and biotechnology.

The relationship between innovation and economic growth in India is also reflected in the country's standing on the Global Innovation Index. According to the World Intellectual Property Organization (WIPO), India has moved up the rankings on the Global Innovation Index in recent years, rising from the 76th position in 2015 to the 52nd position in 2020 (WIPO, 2020). This reflects the growing recognition of India's strengths in innovation and its ability to leverage those strengths for economic growth and development. The conducive environment that promotes innovation has therefore contributed significantly to economic growth. Hence, an understanding of the causal relationship between innovation parameters and economic growth will help to create an environment that will promote sustainable growth and development for India.

Review of Literature

Studies in the literature have given evidence of the existence of causality between innovation parameters and economic growth in countries across the world. Over the years 1970 to 2016, Nazir, Tan, and Nazir (2021) examined the causal link between financial innovation and economic growth in China, India, and Pakistan. Using the Granger Causality-based Error Correction Model (ECM) and Autoregressive Distributed Lag (ARDL) bound testing, this study discovered that, in general, financial innovation has both short- and long-term benefits and statistically significant effects on economic growth. In the context of the Indian economy, Zameer, Yasmeen, Zafar, Waheed, and Sinha (2020) looked at the relationship between the climate for innovation and economic growth. The study used ARDL bound testing and VECM techniques to capture the effects of technical innovation, trade openness, FDI, energy use, and economic growth on CO2 emissions using data from 1985 to 2017. Long-run cointegration is real, according to empirical estimation. Similar findings were made on the long-term effects of trade openness, energy use, and economic growth on CO2 emissions. On the other hand, technical advancement and FDI serve to increase CO2 emissions over time. Additionally, VECM showed that the relationship between innovation, trade openness, and energy use is reciprocal over time.

Bara, Mugano, and Le Roux (2016) empirically demonstrated the link between financial innovation and SADC's economic expansion. The study discovered that financial innovation has a favorable long-term association with economic growth for SADC using an Autoregressive Distributed Lag (ARDL) Model calculated by Pooled Mean Group and Dynamic Fixed effects. However, the long-run projections indicated the existence of a weak link. Panel Granger causality tests showed that there was no relationship between financial innovation and growth in either the short- or long-term, in either direction. During the years 1989 to 2014, Maradana, Pradhan, Dash, Gaurav, Jayakumar, and Chatterjee (2017) looked at the long-term correlation between innovation and per capita economic development in the 19 European nations. To examine the long-term relationship with per capita economic growth, this study used six different indicators of innovation: patents-residents, patents-nonresidents, research and development expenditure, researchers in research and development activities, high-technology exports, and scientific and technical journal articles. The study showed evidence of a long-term association between innovation and per capita economic development in the majority of the examples using the cointegration technique. The study discovered that there was both unidirectional and bidirectional causality between innovation and per capita economic growth using the Granger causality test.

Hsu, Tian, and Xu (2014) examined the effects of financial market growth on technological innovation. The study examined the economic mechanisms through which the growth of equity markets and credit markets affects technological innovation. The study used a large data set with 32 developed and emerging nations using a fixed effects identification technique. It demonstrated that in nations with more developed stock markets, the amount of innovation is disproportionately higher in industries that are more high-tech intensive and dependent on external financing. However, the growth of credit markets seemed to stifle innovation in sectors that shared these traits. Hasan and Tucci (2010) conducted an empirical investigation into the impact of innovation's quantity and quality on economic growth using global patent data while accounting for earlier assessments of innovative contributions. The study studied the relationship between innovation inputs and per-capita growth across a range of economic structures and stages of economic development. The empirical findings showed that nations hosting enterprises with higher-quality patents also have higher economic growth, based on a sample of 58 countries over the years 1980–2003. Furthermore, it was demonstrated that nations that improve their patenting levels also have concurrent increases in economic growth.

Qamruzzaman and Jianguo (2018) studied the connection between financial innovation and economic expansion in Bangladesh, India, Pakistan, and Sri Lanka from the first quarter of 1975 to the fourth quarter of 2016. Long-run correlations were evaluated using the Autoregressive Distributed Lag (ARDL) limits test, and the asymmetry between financial innovation and economic growth was investigated using the Nonlinear ARDL (NARDL) test in a sample of Asian nations. In the sample countries, the results of the limits tests showed long-run cointegration between financial innovation and economic growth. One of the key areas of focus in the literature on innovation economics is the role of government in promoting innovation. Several studies, including those by Baumol (2002) and Osborne and Collins (2009), have shown that government policies can play a significant role in driving innovation by providing funding for research and development, creating favorable regulatory environments, and supporting the development of human capital and technological infrastructure.

Das and Radhakrishnan (2007) and Jain and Kant (2014) have identified that government policies play an important role in promoting innovation in India by providing funding for research and development, creating favorable regulatory environments, and supporting the development of human capital and technological infrastructure. Shukla (2010) and Singh (2006) have found that intellectual property rights play a key role in promoting innovation in India by providing incentives for firms to invest in research and development and protecting the value of their innovations.

The recent studies from the literature highlighted above indicate that the economic growth of a country in the recent past has been significantly influenced by innovation parameters. Hence, the present study is an attempt to estimate the direction of causality between innovation parameters and economic growth. The specific objective of the study is

Objective and Hypotheses

- To determine the presence of a causal relationship between GDP, number of patents, and R&D expenditure as a percent of GDP in India for the period 2001 to 2020.

The following hypotheses are set to test the above objectives empirically:

$\mathbf{H_{01}}$: R&D expenditure as a percent of GDP and the number of patents applied does not Granger-cause GDP.

$\mathbf{H_{02}}$: R&D expenditure as a percent of GDP and the number of patents applied does not Granger-cause GDP.

Methodology

The test of causality between the innovation parameters Research and Development Expenditure as a percent of GDP, the number of patent applications filed, and GDP were determined using secondary data collected from the World Bank database for the period 2001 to 2020. The Granger Causality test, a statistical hypothesis test that helps to verify the predicting ability of one factor to another, was used to estimate the presence of causal relationships and the direction of causality of the select variables of the study.

GDP: GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for the depreciation of fabricated assets or for the depletion and degradation of natural resources. The data are in constant 2015 prices, expressed in U.S. dollars. Dollar figures for GDP are converted from domestic currencies using 2015 official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.

Research and Development Expenditure (% of GDP): The number of researchers engaged in Research and Development (R&D), expressed as per million. Researchers are professionals who conduct research and improve or develop concepts, theories, models, techniques, instrumentation,

and software of operational methods. R&D covers basic research, applied research, and experimental development.

Patent Applications: Patent applications are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office for exclusive rights for an invention, product, or process that provides a new way of doing something or offers a new technical solution to a problem. A patent provides protection for the invention to the owner of the patent for a limited period, generally 20 years.

Analysis and Interpretation

The first step of time series analysis is to test for the stationarity of the data. The lag length selection of (4) was determined using the AIC criterion. Table 1 shows the results of the ADF unit root test, which indicate that the GDP value was found to be level stationary, and R&D expenditure and patent applications were found to be stationary at the second difference.

TABLE 1 : ADF Test Statistic Values (with trend and intercept)

Study Variables	ADF Unit Root Test	
	ADF Statistic	Order of Integration
GDP	-3.54*(0.06)	0
R&D (% of GDP)	5.54**(0.00)	Ⅱ
Patent Applications	4.12**(0.02)	Ⅱ

*Significant at the 10% level; **Significant at the 5% level

Testing for Granger Causality: The Granger causality test was used in this study to determine whether there exists a causal relationship between the GDP, R&D expenditure as a percent of GDP, and the number of patent applications. The results of the Granger causality test are given in Table 2.

TABLE 2 : Results of the Granger Causality Test

Null Hypotheses	F Value	Results
R&D expenditure as a percent of GDP does not Granger cause GDP in India.	4.14**	Reject
GDP does not Granger cause R&D expenditure as a percent of GDP	2.13	Accept
Number of patent applications does not Granger cause GDP in India	4.78**	Reject
GDP does not Granger cause the number of patent applications	5.22**	Reject

Note: Appropriate lag length was determined by the Akaike information criterion.**Significant at 5% level

It is evident that R&D expenditure as a percent of GDP Granger causes GDP, with the F value (4.14) leading to rejecting the null hypothesis. The Granger causality test further showed the presence of a unidirectional relationship between R&D expenditure as a percent of GDP and GDP, due to the fact that GDP does not Granger cause R&D expenditure. The results support the literature study by Ndlovu and Inglesi-Lotz (2020), where the causal relationship between GDP and R&D expenditure for BRICS economies has been found to be unidirectional. India is part of the BRICS economies and hence the findings hold significance for the present study, validating the fact that increased R&D expenditure fosters innovation and thereby contributes significantly to GDP growth in India.

The hypothesis of the number of patents does not Granger cause GDP and GDP does not Granger cause the number of patents was rejected, with F values significant at 5 percent levels. This leads to the presence of a bidirectional relationship between the number of patent applications and GDP in India. A similar finding has been found in the study by Maradana et al. (2017) on the relationship between innovation and economic growth in India, which indicated the bidirectional relationship between innovations and economic growth parameters.

Conclusion

The study investigated the presence of causality between innovation parameters and economic growth in India for the period 2001 to 2020. The statistical analysis of Granger causality confirms that there exists a causal relationship between R&D expenditure as a percent of GDP, the number of patent applications, and GDP in India. Further, a unidirectional relationship was found between R&D expenditure and GDP, and a bidirectional relationship was found between the number of patents and GDP. The policy implication of the findings of the study is to create more avenues to foster innovation, like supporting training for innovative startups and creativity for design thinking, that will yield higher innovation output from R&D expenditure and increase patents, leading to higher economic growth for India.

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