

Relationship among Economic Contribution for R&D, Innovation and SDG9 of Indian State

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Abstract: In the present context, all the countries are trying to achieve sustainable Development Goals (SDGs). India is also trying to do the same with the help of different initiatives. Among these SDGs, one of the vital SDG is SDG9 which is related with industry, innovation and infrastructure. In the recent years Indian government has published SDG scores and innovation index for all the States. Government in general publishes Public Finance reports which consist of different expenditure for the people and states development. Considering this, it has been tries to find out whether or not the related economic contribution of the states and central government can be helpful to realise and estimate the innovation and SDG9 of the states. By using correlation analysis and linier regression model, it has been found that the significant contribution are found with respect to the research expenditure in agriculture and total research expenditure of the states. The results implied that the state governments should take proper initiative regarding the research expenditure in science and technology, that can enhance innovation capability more.

Keywords: Innovation, SDG, R&D, Economic Contribution by States, India

I. INTRODUCTION

As per UNDP India, the Sustainable Development Goals (SDGs), have been agree to by all United Nations Member States in 2015 as a collective call to battle to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030. The 17 SDGs are integrated—that is, they recognize that action in one area will affect outcomes in others, and that development must balance social, economic and environmental sustainability. Among these goals, the ninth goal (SDG9) is about innovation, industry and infrastructure.

Investment in infrastructure and innovation are crucial for economic growth and development. Technological progress is also key vital to both economic and environmental challenges, such as providing new jobs and promoting energy efficiency. Promoting sustainable industries, and investing in scientific research and innovation, is all important ways to facilitate sustainable development.

As per the Department of Science & Technology, India's gross expenditure in R&D has tripled between 2008 & 2018. As per the R&D Statistics and Indicators 2019-20. The S&T survey 2018 report discloses that "R&D indicators for the nation is an extraordinarily important document for the evidence-based policymaking and planning in higher education, R&D activities and support, intellectual property, and industrial competitiveness. These pertain to Investments in national R&D, R&D investments by Government and Private sector; R&D relationship with economy (GDP), Enrolment of S&T personnel, Manpower engaged in R&D, Outrun of S&T personnel, papers published patents and their international S&T comparisons.

However, India ranked in top 50 nations in the Global Innovation Index 2020. New Delhi: India climbed four spots on the Global Innovation Index 2020 and is now at 48th position in the list of top 50 innovative countries in the World Intellectual Property Organization (WIPO) annual ranking even after several decades of independence.

Considering these, in the recent year's Indian government is investing and initiating several approaches in the R&D and infrastructural development. The initiatives and outcomes are being disclosed by the Innovation Index and

governmental investments are also disclosed in the different public finance and statistic reports. As, the state level initiative in research taken and innovation has been justified by the government report, a simple question arises with respect to the success of research expenditure towards innovation and SDG 9.

With this simple objective and brief introduction in section one, objectives of the study have been mentioned in section two, section three is allotted for research methodology, findings are discussed in section four and in the section five conclusions, recommendation and limitations are mentioned.

II. OBJECTIVE OF THE STUDY

The objective of the study can be described in two parts. The first one is whether or not the governmental expenditure in R&D can have positive impact on the innovation capability of the states. The second is whether or not the R&D expenditure and the innovation can have any relationship with the SDG 9.

III. METHODOLOGY

This methodology part consists of sample, variables, hypothesis and statistical tools for analysis.

3.1 Sample

The sample consists of twenty seven states of India. Union Territories are not taken into this study. Public expenditure reports regarding the specified variables are being selected from the Handbook of Statistical Report of India from the years 2016 to 2018. All the data are secondary in nature. The Innovation Index and SDG reports for the years 2018 and 2019 are being considered.

3.2 Variables

The necessary variables are described below:

- SDG9 : It is the score for SDG 9, disclosed in the SDG India Index & Dashboard
- INN : Innovation Index value as given in the India Innovation Index Report and sum of ENA & PER
- ENA: Index value of Enablers Index as given in the India Innovation Index Report and sum of HUM, INV, KNO, BUS & SAF.
- HUM: Human Capital Index as given in the India Innovation Index Report.
- INV: Investment Index as given in the India Innovation Index Report.
- KNO: Knowledge Workers Index as given in the India Innovation Index Report.
- BUS: Business Environment Index as given in the India Innovation Index Report.
- SAF : Safety & Legal Environment index as given in the India Innovation Index Report.
- PER: Performance Index as given in the India Innovation Index Report and sum of KOUT & KDIF.
- KOUT : Knowledge Output Index as given in the India Innovation Index Report.
- KDIF : Knowledge Diffusion Index as given in the India Innovation Index Report.
- AGRD: It is the state R&D expenditure in agriculture.
- STEX : It is Science & technology expenditure of the state.
- TOEX : It is total expenditure of the state in all types of initiatives.
- RDOTX: It is ratio of total R&D expenditure against the TOEX.
- RDODP : It is the ratio of total R&D expenditure against the State Gross Domestic Production.
- CENFU: It is the amount of central government fund allotment in to R&D of the states separately.

Note that the AGRD, STEX, RDOTX, RDODP, CENFU, TOEX are of one year lag value (i.e. t-1) and these are considered as economic variables. AGRD, STEX, TOEX and CENFU are Rupees in crore. The definitions and explanations of the above mentioned non-economic variables are given in the respective reports. So, these are not being redefined here.

3.3 Tools

Here, descriptive statistics, correlation analysis, multiple linier regressions are being used. The sample data are secondary in nature. Analyses are made by pooling data year wise. The SDG9 and INN are of 2018 and 2019, whereas lagged values are of 2017 and 2018. Here, lag values of economic variables are taken to realise the impact of those economic contribution in the next year on SDG9 and INN.

3.4 Hypothesises & Equations:

The below mentioned hypothesises are mainly alternative, null hypothesises are therefore self-explanatory.

Alternative H1: State economic contributions have positive impact on the Innovation.

$$INN = \alpha_0 + \alpha_1 AGRD + \alpha_2 STEX + \alpha_3 RDOTX + \alpha_4 RDODP + \alpha_5 CENFU + \varepsilon \text{ --- (1) for H1.}$$

Alternative H2: State economic contributions have positive impact on the Enabler.

$$ENA = \alpha_0 + \alpha_1 AGRD + \alpha_2 STEX + \alpha_3 RDOTX + \alpha_4 RDODP + \alpha_5 CENFU + \varepsilon \text{ --- (2) for H2}$$

Alternative H3: State economic contributions have positive impact on the Performance .

$$PER = \alpha_0 + \alpha_1 AGRD + \alpha_2 STEX + \alpha_3 RDOTX + \alpha_4 RDODP + \alpha_5 CENFU + \varepsilon \text{ --- (3) for H3}$$

Alternative H4: State economic contributions have positive impact on the Human Capital.

$$HUM = \alpha_0 + \alpha_1 AGRD + \alpha_2 STEX + \alpha_3 RDOTX + \alpha_4 RDODP + \alpha_5 CENFU + \alpha_6 TOEX + \varepsilon \text{ --- (4) for H4}$$

Alternative H1: State economic contributions have positive impact on the Knowledge Worker.

$$KNO = \alpha_0 + \alpha_1 AGRD + \alpha_2 STEX + \alpha_3 RDOTX + \alpha_4 RDODP + \alpha_5 CENFU + \alpha_6 TOEX + \varepsilon \text{ --- (5) for H5}$$

Alternative H1: State economic contributions and Innovation have positive impact on the SDG 9.

$$SDG9 = \alpha_0 + \alpha_1 AGRD + \alpha_2 STEX + \alpha_3 RDOTX + \alpha_4 RDODP + \alpha_5 CENFU + \alpha_6 TOEX + \alpha_7 INN + \varepsilon \text{ --- (6) for H6}$$

These hypothesises are being tested in the next section.

IV. FINDINGS

This finding section segregated as descriptive, correlation and regression parts.

4.1 Descriptive

The Table 1 is showing maximum (Max), minimum (Min), average (Mean) and standard deviation (SD) values of the selected variables in this study. Here, state names of some selected variables are also mentioned according to the maximum and minimum values.

Table 1		Descriptive Statistics			State Max	State Min
Variables	Min	Max	Mean	SD		
SDG9	0	88	45.07	21.002	Gujarat	Nagaland
INN	6.20	42.50	18.6672	8.84828	Karnataka	Jharkhand
ENA	7.75	38.98	22.4957	8.48754	Sikkim	Jharkhand
HUM	8.98	62.80	34.7831	11.71606	Tamil Nadu	Bihar
INV	.06	41.18	8.8265	9.13501		
KNO	1.02	36.86	13.1781	9.50772		
BUS	2.78	37.12	15.0285	9.60683		
SAF	7.08	99.20	40.6735	22.65026		
PER	1.01	50.19	14.8431	12.75631	Karnataka	Sikkim
KOUT	.94	34.57	12.0676	8.39180		
KDIF	0.00	72.26	17.6269	17.89951		
AGRD	0.00	1107.52	316.9380	288.91288	Maharashtra	Sikkim
STEX	0.00	361.59	74.8150	100.55755	Kerala	Jharkhand

TOEX	6675.77	397837.79	115087.1656	94903.47871		
RDOTX	.02	.80	.3520	.20282	Kerala	Tripura
RDODP	.01	.48	.0920	.08723	Arunachal	Tripura
CENFU	0.00	19.42	7.8946	5.62666		
Valid N (list wise)			54			

The descriptive results are showing that most of the Southern and Western states are having maximum score in SDG9, INN, ENA, HUM and PER and the Eastern and North-Eastern states have minimum score. The investment in R&D also higher for the Southern and Western states in comparison with the Eastern and Northern part of India. The average score of SDG9 is almost half of the maximum score 88 and the SD is also very high. These are showing that there are huge differences in the SDG9 scores among the states. Almost, same pattern has been followed in case of INN, ENA, PER, RDOTX and RDODP. Altogether, these are indicating a negative concern for the Indian stated regarding achievement of Innovation and SDG9. May be this has been reflected in the World ranking of Innovation and SDGs.

4.2 Correlation

The Table 2 is showing that Pearson's correlations among the selected variables under this study. Emphases are given on the SDG9, INN, ENA, PER variables with respect to the economic variables.

Table 2		Pearson's Correlations												
Variable	SD G9	INN	EN A	HU M	INV	KN O	PER	KOU T	KDI F	AGR D	STE X	TOE X	RDO TX	RDO DP
INN	.450**	1												
ENA	.353**	.741**	1											
HUM	.306*	.691**	.853**	1										
INV	.149	.499**	.529**	.322*	1									
KNO	.213	.460**	.630**	.461**	.345*	1								
BUS	.554**	.757**	.418**	.491**	.095	.321*								
SAF	.118	.316*	.777**	.549**	.237	.248								
PER	.390**	.895**	.362**	.391**	.341*	.218	1							
KOUT	.476**	.897**	.461**	.441**	.388**	.274*	.938**	1						
KDIF	.332*	.855**	.300*	.351**	.303*	.183	.987**	.868*	1					
AGRD	.483**	.690**	.324*	.417**	.152	.273*	.742**	.738*	.712**	1				
STEX	.410**	.367**	.256	.232	.200	.164	.340*	.380*	.306*	.531*	1			
TOEX	.349	.549	.029	-	.012	-	.742	.673*	.743	.689*	.441	1		

	**	**		.008		.038	**	*	**	*	**			
RDOT X	.393**	.264	.338*	.388**	.271*	.430**	.142	.272*	.075	.435*	.418**	-.072	1	
RDOD P	-.118	-.202	.017	-.037	.382**	.070	-.292*	-.200	-.322*	-.239	.030	.403*	.540**	1
CENFU	.029	.036	.171	.274*	.149	.106	-.063	-.067	-.059	-.003	.201	-.116	.418**	.354*
***. Correlation is significant at the 0.01 level (2-tailed). And *. at the 0.05 level (2-tailed).												N= 54		

Here, it can be seen that the SDG9 is having significant positive correlations with INN (0.450), ENA (0.353), PER (0.390), AGRD (0.483), STEX (0.410), RDOTX (0.393). These are showing that the innovation, infrastructure, research performance and other research expenditures are having positive association with SDG9. The RDODP (-0.118) has negative insignificant relation with the SDG9 and therefore it can be ignored for the time being.

The INN has significant positive correlations with AGRD and STEX. This is indicating that increase in the research expenditure for agriculture, science and technology can enhance innovation score of the states. So, states must do such investment effectively. The RDOTX correlation is positive but not significant. It might be significant, if number of data can be increased.

The ENA has significant positive correlations with PER (0.362), AGRD (0.324) and RDOTX (0.338). These are showing that the proper facilities for innovation can results into better innovation performance and more spending in R&D can improve the innovation enabling facilities.

As a whole, these results are showing that the states need to spend in R&D effectively, which will improve innovation and sustainability achievement score of the states and India ultimately.

3.3 Regression

The regression results are shown below in different tables on the basis of the hypothesis and equations formed in the Research Methodology section.

Table 3		INN Dependent								
Eq.1	R ²	Adj R ²	SE - R ²	F	F-Sig	Variabl e	Beta	S. Beta	SE	Sig.
	0.482	0.428	6.689	8.945	0.000	C	12.046		2.087	0.000
						AGR D	0.022	0.711	0.005	0.000
						STEX	0.000	0.003	0.011	0.984
						RDOT X	-2.804	-0.064	7.882	0.724
						RDODP	-2.428	-0.024	16.052	0.880
						CENFU	0.115	0.073	0.187	0.539

The Table 3 is showing that the INN is dependent and economic variables are independent. The beta value of AGRD (0.022) is positive and significant. Other variables are highly insignificant. So, the Eq-1 result is showing that the model is valid on the basis of R² (0.482) and F statistic (8.945 at p<1%) and only research expenditure in agriculture can improve the innovation index significantly. Increase in the agricultural research expenditure by Rs. 0.022 crore can increase the innovation index score by one.

Table 4		ENA Dependent								
Eq.2	R ²	Adj R ²	SE - R ²	F	F-Sig	Variable	Beta	S. Beta	SE	Sig.
	0.170	0.083	8.127	2.402	0.062	C	16.781		2.535	0.000
						AGR D	0.004	0.132	0.006	0.523
						STEX	0.004	0.045	0.014	0.782
						RDOTX	12.796	0.306	9.576	0.188
						RDODP	-14.495	-0.149	19.500	0.461
						CENFU	0.131	0.087	0.227	0.566

The Table 4 results are showing the regression equation two (Eq-2). Here, the R² and F statistic values are not satisfactory. And, therefore it can be said that there is no such considerable contribution on Enablers through the research expenditures of the states. This is a vital issue for the states and India. Researches are needed on this issue. The regression results are not at all supporting the hypothesis H2.

Table 5		PER Dependent								
Eq.3	R ²	Adj R ²	SE - R ²	F	F-Sig	Variable	Beta	S. Beta	SE	Sig.
	0.595	0.553	8.533	14.089	0.000	C	7.307		2.662	0.008
						AGR D	0.040	0.899	0.006	0.000
						STEX	-0.003	-0.026	0.014	0.816
						RDOTX	-18.393	-0.292	10.055	0.074
						RDODP	9.630	0.066	20.475	0.640
						CENFU	0.100	0.044	0.238	0.675

The Eq-3 regression results are shown in Table 5. Here, the R² is 0.595 and F statistic (14.089 at p<1%) values are satisfactory to valid the model. The coefficient of AGRD is positive and significant (0.040) at p<1%. This is showing that the R&D expenditure in agriculture can increase the PER significantly. However, the RDOTX beta value (-18.393) is negative and significant at p<10%. If it would have been significant at p<5% then it can be a vital cause of concern. It shows that the proportional expenditure in R&D has negative impact on the PER.

Table 6		HUM Dependent								
Eq.4	R ²	Adj R ²	SE - R ²	F	F-Sig	Variable	Beta	S. Beta	SE	Sig.
	0.455	0.385	9.186	6.533	0.000	C	92.137		18.419	0.000
						AGR D	0.030	0.738	0.009	0.001
						STEX	-0.003	-0.023	0.016	0.863
						RDOTX	12.045	0.209	11.049	0.281
						RDODP	-42.567	-0.317	22.190	0.061
						CENFU	0.567	0.272	0.257	0.033
						TOEX	-6.406	0.644	1.720	0.001

The Table 6 is showing the Eq-4 regression results. Improvement in HUM may be due to the total expenditure by the state. So, TOEX is taken as control variable. Here, it can be seen that the AGRD (0.030) and CENFU (0.567) have positive significant coefficient at $p < 5\%$. It shows that improvement in human capital is caused by the AGRD and CENFU. The TOEX is also highly significant but negative. It indicates that the increase in total expenditure can cause decrease in human capital. This is a possible one because in correlation negative or insignificant correlations are found to have been reported earlier. The Max and Min comparison also show that the Northern and Western states are having more expenditure without good score in INN and SDG9. This is reverse in case of Southern states.

Table 7		KNO Dependent								
Eq.5	R ²	Adj R ²	SE - R ²	F	F-Sig	Variable	Beta	S. Beta	SE	Sig.
	0.357	0.275	8.095	4.350	0.001	C	55.959		16.232	0.001
						AGRD	0.013	0.409	0.008	0.082
						STEX	-0.001	-0.009	0.014	0.952
						RDOTX	23.468	0.501	9.737	0.020
						RDODP	-34.605	-0.317	19.555	0.083
						CENFU	-0.030	-0.017	0.227	0.897
						TOEX	-4.648	-0.576	1.516	0.004

Considering, Eq-5 the regression results are showing a valid model on basis of the R² is and F statistic values. To the improvement of knowledge workers (KNO), RDOTX is having positive and significant impact. The AGRD is having positive impact but not significant at $p < 5\%$.

Table 8		SDG9 Dependent								
Eq.6	R ²	Adj R ²	SE - R ²	F	F-Sig	Variable	Beta	S. Beta	SE	Sig.
	0.464	0.383	16.502	5.692	0.000	C	-61.909		33.615	0.072
						AGRD	-0.033	-0.045	0.018	0.068
						STEX	0.029	0.137	0.028	0.313
						RDOTX	64.638	0.624	19.884	0.002
						RDODP	-68.647	-0.285	39.875	0.092
						CENFU	-0.541	-0.145	0.464	0.250
						TOEX	8.198	0.460	3.094	0.011
						INN	0.623	0.262	0.357	0.087

The last equation Eq-6 regression results are shown in Table 8. This is showing that the R² is 0.464 and F statistic is 5.692 at $p < 1\%$. These results are showing validity of the model. Here, the intercept is negative but insignificant. The RDOTX (64.638) and TOEX (8.198) beta values are significant and positive. These are indicating that increase in total R&D expenditure and total state expenditure can also increase the SDG score of the states significantly. INN has positive impact but significant at $p < 10\%$. Increase in number of data may give considerable outcome.

V. CONCLUSIONS, RECOMMENDATION & LIMITATIONS

Altogether, it can be said that R&D expenditure in agriculture is having considerable impact on the innovation. The total state expenditure and total R&D expenditure have considerable positive impact on the improvement of SDG9 of the states. So, out of the R&D expenditure for agriculture, science & technology, only R&D in agriculture is having substantial impact on the state level innovation and other facilities for innovation outcome and facilities. Here, it has also been realised that the total expenditure of state and total general R&D expenditure have positive impact on the SDG9.

The study results are able to trace out that there are significant disparities in the SDG9 and innovation including R&D expenditure among the states. This should be taken care of for a holistic approach towards innovation and sustainable development goals. Expenditure for science and technology has no such considerable impact on innovation. This must be taken care of by the states immediately. However, with the increase in the number of data may be helpful to get better outcome to generalize present study results. However, this research is in initial stage and this may be enhancing further by considering other R&D expenditures.

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