Science Indicators to measure papers with the Gross Domestic Product Output (GDP) and Economic Indicators

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ABSTRACT: *We in this work have worked on the Science and Technology Indicators(S&T) for scientific output in Indian agriculture as viewed from the citation dataset including the Science Citation Index Expanded (SCIE) database during 1993-2017. Besides we introduce economic indicators and try to correlated with the other science indicators which is based on the scholarly publications of Global and Indian Agricultural Scientists. Further we looked at the correlation coefficient of top fifteen countries in agricultural literature producers with their GDP's, GERD (Gross domestic expenditure in R&D) and Government expenditure on education. We tried to find the publications for India with an assumption that the publication of present year depends on the GDP of the present year, GERD of the previous year and Educational expenditure (EDP) of last second year by using Least Square linear Regression Analysis. In the analysis we found that both Observed and Predicted values fall on the same linear graph with correlation coefficient 0.9394 & 0.9613 respectively for Global agricultural publication and 0.929 & 0.9649 respectively for Indian agricultural publications.*

Keywords: Scientometrics, Scientific Productivity, Agricultural Literature, Collaborative Coefficient, S&T Indicators, Economic Indicators

Received: 9 June 2018, Revised 18 July 2018, Accepted 25 July 2018

DOI: 10.6025/jism/2018/8/4/135-144

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1. Introduction

Indicators are used to measure the scope of the perceived construct, whereas the construct is a measurable entity which can be expressed through measurement of directly observable variables. Science and Technology (S&T) indicators assist in knowing various dimensions and characteristics of science and technology such as research productivity, collaboration. Economic indicators direct us to know about the health of the country in terms of measurement of scientific activity. S&T indicators and economic indicators enable a better understanding of the structure, of the impact of policies and programs and of the impact of discipline on society and the economy.

Indicators are constructed from various input and output statistics of the system under study. Input indicators are constructed using the financial statistics. One more input indicator is derived from manpower involved in R&D of Agricultural Sciences is publication/patent count by a scholar, which is constructed from research papers, patents, standards, significant innovations is manpower indicator. The data of publication count is an output indicator which provides the final output. Counts of patents and papers provide valid indicators of R&D activity in the subject areas under study and also the institutions from which they originate. Impact Measurement and Linkage Measurement are the two indicators associated with citations and knowledge linkages among subject areas.

2. Relation between Number of Publications and Economic Indicators

Growth and development of a nation depends on research and developmental activities for certain extent. Many of the studies reveal that researchers have attempted to relate the research output of a country with economic indicators.

Developing countries where the economy is based on agriculture have become major forces in the global agricultural economy. The agricultural sector is being the core contributor to the Indian Economy contributes 17.35% to GDP in 2016-17. Indian agriculture stands among the top three nations in terms of production of various agricultural commodities and marks its presence at the global level. Presently the Indian Public Agricultural Research System (IPARS) has been based on central level tier, Indian Council for Agricultural Research (ICAR), which plays a vital role in agricultural education, research, and extension. IPARS also based on a system of state agricultural universities (SAU) which deliver statespecific research and education on Agriculture. Further, the income earned through agricultural research has a direct impact on GDP.

The GDP is defined as the total value of all goods and services produced within a country during a specified period. GDP is generally computed as:

$$\text{GDP} = \text{Consumption} + \text{Investment} + \text{Govt. Expenditure} + \text{Exports} - \text{Imports}$$

3. Literature Review

Several researchers have compared the economic indicators, such as the GDP and/or per capita income with the non-economic indicators such as the number of publications. An attempt is made to correlate the research impact with GDP, agricultural value added on GDP and R&D investment trends with top ten research output providing countries. **Kishida and Matsui (1997)** examined the machine-readable files of IBSS 1981-1985 in social sciences field. They examined the correlation between the number of published monographs, population, number of people attaining a university education and GDP. A regression model was incorporated to test the variation of the number of monographs by countries and R² value equal to 0.77 was found. Therefore there exists a low correlation between these two variables. **Hart and Somerfield (1998)** studied the relationship between GDP and publications counts of chemical engineering field were obtained from earlier studies. The study confined to five English speaking countries over a period of 26 years, they concluded that GDP is linearly correlated with the chemical engineering literature. They computed the correlation coefficient between a number of publications (x) and GDP (y) (dependent variable) for each country. Authors have opined that GDP and the number of publications are linearly related ($y = a + bx$) i.e. y can be estimated from x . But, in a practical sense, there are several aspects influence the GDP, it may be inappropriate to estimate y based on x . Possibly an attempt can be made to estimate the value of x using y as the independent variable. **Inonu (2003)** opted the clustering of countries share a common cultural attitude towards scientific research. A classification of countries with respective ranks in the scale of publications per million people and GDP per capita (PPP) was correlated and found that there was no correlation. **Meo, S. A. et. al (2013)** studied Impact of GDP per capita, Spending on R&D, Number of Universities and indexed Scientific Journals on Research Publications in various science and social science subjects among 40 Asian countries during the

period 1996- 2011 which were retrieved through World Bank, Scopus, and Web of Science. They concluded that there was no association between the per capita GDP and research outcome. Ye's study (2007) study reveals the strongest relationship between country development level and scientific indicators. The correlation was determined for 24 countries by using IMF, WIPO and UNESCO data between GDP and scientific production for a single year (2001). A report (IDEA Consult, 2008) correlates the levels of R&D spending with economic growth levels. Findings reveal that R&D intensities were temporarily influenced by the levels of GDP growth. However, GDP depends on governance structure, policy matters, and industrial structures and academic priorities; therefore 'one dress fits all' approach does not fit for all the countries. Vinkler (2007) related GDP and number of publications in the field of longitudinal studies resulted in meaningful correlation for countries. However, he found that there is no direct relationship between GDP and information production. It was observed that R&D expenditures do not depend on actual need; it should be noted there are other influential factors; for instance, developed rich countries can always afford to spend more money on scientific research than poor countries. Nguyen & Pham (2011), found that there exists a strong relationship between scientific output between scientific output and knowledge economy index of ten South East Asian countries. Akhmat, Zaman, Shukui, Javed & Khan (2014) studied empirical relationship between educational indicators and research productivity (publications, citations, and patents) for the top twenty countries worldwide and found that the educational indicators were important to increase research productivity. Many previous studies reveal that there exists a meaningful correlation between economic indicators and research output. However, it should not be ignored that these kinds of assessments can change from country to country and period to period.

4. Objectives of the Study

Main objectives of the present study were to analyze the data under the following headings:

- To ascertain the correlation coefficients of publication with economic Indicator GDP/ GERD/ EDP for top fifteen agricultural literature producing countries
- To predict the publication count (dependent variable) depending on the empirical formula derived using GDP, GERD and EDP.

Hypothesis:

1. Ho: There exists high level correlation between India Agriculture Publication and Economic Indicator;

H1: There is no correlation between India Agriculture Publication and Economic Indicator;

2. Ho: There is no difference between the observed value of the publications and predicted value of the publications obtained from the assumed equations.

H1: There is difference between the observed value of the publications and predicted value of the publications obtained from the assumed equations

5. Methodology

The indicator related to publications is known as a bibliometric indicator and is obtained from Web of Science (WOS) - Science Citation Index Expanded database. A total of 646279 articles global agricultural literature with 547403 articles for top fifteen countries producing agricultural literature including 41146 articles for Indian agricultural literature for the period 1993 to 2017 has been extracted using the advanced search feature of the web of science database. The retrieved records were examined, classified, and analyzed correlating to the objectives in view.

The input S&T indicator indicators used in our study are GDP (Constant 2010, US\$), which is collected from the World Bank database (IBRD, IDA). GERD is the total expenditure in R&D of a country with respect to the overall expenditure. Further, the data is analyzed using MS Excel spreadsheet.

6. Results and Discussion

6.1 Year wise Correlation Coefficients of Publication with Economic Indicator GDP

An attempt has been made to study the relationship between the GDP growth rate and numbers of publications. The yearly and country wise correlation coefficients were computed. The results are given under Table 1

<i>Country</i>	<i>Total Publications (top 15 countries)</i>	<i>Publication Contribution (%)</i>	<i>Correlation Coefficients (r)</i>
			<i>Pub/GDP</i>
1993	13039	2.38	0.80
1994	13524	2.47	0.79
1995	13656	2.49	0.79
1996	13470	2.46	0.84
1997	14586	2.66	0.88
1998	14586	2.66	0.91
1999	14418	2.63	0.90
2000	15119	2.76	0.89
2001	14398	2.63	0.92
2002	15151	2.77	0.94
2003	16461	3.01	0.92
2004	23460	4.29	0.93
2005	21543	3.94	0.94
2006	22544	4.12	0.94
2007	29511	5.39	0.93
2008	26391	4.82	0.87
2009	26096	4.77	0.87
2010	29314	5.36	0.89
2011	27298	4.99	0.84
2012	28118	5.14	0.84
2013	29192	5.33	0.86
2014	29068	5.31	0.86
2015	29981	5.48	0.84
2016	32514	5.94	0.86
2017	33965	6.20	0.89
Total	547403	Significant at p<0.05	

Table 1. Year-wise Correlation Coefficients of Publication with Economic Indicators

It is clear from Table 1 that the correlation coefficient (r) varies from 0.79 to 0.94 (high coefficient value) over a period of time and decreasing trend is seen for the total publication of fifteen countries to Publication count.; The correlation ranges between high to very high correlation, and the positive percentage indicates there is a linear relationship between the numbers of publications and other economic factors under consideration. Higher the GDP, the higher the number of publications to some extent can be predicted using the values of the table.

6.2 Country wise Correlation Coefficients of Publication with Economic Indicators

Correlation coefficients (r) were computed for top ten publication countries to study whether there exists a relationship between the number of publications and the GDP /EDP/GERD over a period of time. Table 2 presents the country wise correlation coefficients of publication with economic indicators for the period 1993 to 2017(25 years).

Country	Total Publications	Publication Contribution(%)	Correlation Coefficients (r)		
			Pub/GDP	Pub/EDP	Pub/GERD
USA	160,357	25	0.39	0.32	0.34
CHINA	48,485	8	0.99	0.99	0.99
BRAZIL	48,136	7	0.93	0.94	0.94
INDIA	41,146	6	0.95	0.92	0.91
CANADA	31,390	5	0.71	0.71	0.75
GERMANY	31,205	5	0.93	0.96	0.97
AUSTRALIA	28,230	4	0.88	0.89	0.87
JAPAN	27,250	4	0.34	0.59	0.70
SPAIN	28,447	4	0.95	0.89	0.96
FRANCE	24,820	4	0.88	0.85	0.89
UNITED KINGDOM	21,049	3	-0.37	-0.39	-0.39
ITALY	21,463	3	0.86	0.75	0.93
NETHERLANDS	14,225	2	0.82	0.82	0.89
KOREA	11,621	2	0.97	*	0.97
MEXICO	9,579	1	0.89	0.89	0.89
Global output	646279	100	0.97	0.96	0.98
Significant at $p < 0.05$; EDP- Government expenditure on education; GERD- Govt. expenditure on Research& Development					

Table 2. Country-wise Correlation Coefficients of Publication with Economic Indicators

It may be observed from the table 2 that most of the countries have $r > 0.90$ under GDP V/s publications, the correlation coefficient is very high for China, Korea, India, Spain, Brazil, Germany, Mexico, Australia, France, Italy, Netherlands, whereas Canada exhibits high correlation and a moderate level relation is observed for USA and Japan, and the United Kingdom shows no correlation. Similarly when correlation for Government expenditure on education to GDP and Publications is studies show that high correlation exists for China, India, Spain, Brazil, Germany, Mexico, Australia, France, Netherlands, Italy, whereas the UK shows no correlation between both entities. The relation between GERD to publication shows similar results as that of GDP and EDP. The negative low-level correlation for India and positive high correlation for US, China, Brazil and Canada. When the growth percentage of both GDP and publications is tested it shows a high level of correlation between most of the countries under study. Similarly, the Global agricultural output shows a very high correlation with all the economic indicators under consideration.

6.2.1 Correlation Coefficient of Indian Agricultural Literature Data V/S Economic Indicators

An attempt has been made to estimate the number of publications based on parameters like GDP (Gross Domestic Production), GERD (Gross domestic expenditure in R&D) of the previous year and Government expenditure on education (EDP) of previous two years for India over a period 1998-2017(20 years). An assumption is made that the publication of the present year depends on the GDP of the present year, GERD of the previous year and Educational expenditure (EDP) of last second year. Table 3 gives data on publication count, economic indicators, and their relationship both. The positive correlation values show there is a linear relationship between the variables.

The following equation has been used to fit the empirical data:

$$PUB = \alpha_1 * GDP(t) + \alpha_2 * GERD(t-1) + \alpha_3 * EDP(t-2)$$

Where $PUB \rightarrow$ Number of Publications; $GDP(t) \rightarrow$ GDP data for the current year (say t);

$GERD(t-1) \rightarrow$ Research and Development expenditure for $t-1$ year;

$EDP(t-2) \rightarrow$ Education expenditure of $(t-2)$ years; $\alpha_1, \alpha_2, \alpha_3$ are constants

Table 3 gives data on GDP, last year's GERD and previous 2nd year Government expenditure on education (EDP) for Indian scholarly publications in the field of agricultural science and it forms the preliminary data for the further study.

<i>Year</i>	<i>Pub</i>	<i>GDP</i>	<i>GERD (t-1)</i>	<i>EDP (t-2)</i>	<i>Total</i>
1998	1165	415730874171	2773272847	51644427614	470148574632
1999	1225	452699998387	2880807093	54663815557	510244621036
2000	1305	462146799338	3226619239	58864458139	524237876715
2001	1217	478965491061	3434028007	76777147105	559176666173
2002	1105	508068952066	3457939259	77319519767	588846411092
2003	1276	599592902016	3618111428	80133372787	683344386232
2004	1184	699688852930	4240740718	85002530448	788932124096
2005	1137	808901077223	5208203946	74414275765	888523556933
2006	1196	920316529730	6561643758	78343183491	1005221356979
2007	1713	1201111768410	7345046224	90665352500	1299122167134
2008	2171	1186952757636	9787019023	107619149079	1304358925738
2009	1984	1323940295874	10294203876	140454530903	1474689030654
2010	2132	1656617073125	11182132133	138798817198	1806598022456
2011	2027	1823049927772	13615735724	148164809786	1984830473282
2012	2190	1827637859136	15147721850	196038765792	2038824346778
2013	2213	1856722121394	15185842972	247295080772	2119203045138
2014	2119	2039127446299	15427504107	255725278562	2310280228968
2015	2517	2102390808997	16943109951	260872808236	2380206727184
2016	2740	2274229710530	13190399936	286501085508	2573921195974
2017	2648	2597491162898	14268517204	295389702117	2907149382218
Correlation Coefficient (r)		0.95	0.92	0.90	0.95

Table 3. Correlation Coefficient of Indian Agricultural Scholarly Publications Data V/S Economic Indicators under study

Table 4 provides an overview of the correlation coefficient(R), the coefficient of determination (R²), significance level. In the equation Publication (Pub) is the dependent variable. The values are predicted using the least square method of regression analysis at significance level 0.05(5%).

<i>Dependent Variable:</i>	<i>PUB</i>				
Method:	Least Square linear Regression Analysis				
Sample : 1998-2017	Level of Significance considered $\alpha=0.05$		Significance F	2.85E-10	
Observations :	20	Degree of freedom df: 19			
Variable	R	R ²	Adj R ²	SE	P value
GDP (t)	0.95	0.89	0.89	6.12E-11	0.000000003
GERD(t - 1)	0.92	0.84	0.83	1.05E-08	0.000000014
EDP(t- 2)	0.90	0.82	0.81	6.75E-10	0.0000000067
Total	0.95	0.90	0.89	5.44E-11	0.00000000054
R→ Correlation Coefficient; R ² →Coefficient of Determination Adj R ² →Adjusted R ² (more than 1 variable) ; SE→Standard Error (Regression);Total → GDP(t) + GERD(t-1)+EDP(t-2)					

Table 4. Estimation of the Publications based on GDP, GERD, EDP and Total Square Regression Analysis Values Considered to Predict the Significance

The table 4 shows that all the parameters are significant at 0.05%. 'R' value is above 90% for GDP of the present year, GERD of last year and the EDP of last two year. Overall R-value is 95% whereas R² is 0.90 and the adjusted R² is 0.89 .The significance value = 0. 00000000028 is very much lesser than 0.05. Thus the prediction of publications can be attempted as the data is highly significant for the above regression equation.

Table 5. Actual Vs Predicted Fitted value for the number of Indian Agricultural Publications

The table 5 interprets the values of Observed Publications V/S Predicted Publications in case of Indian Agricultural publication. The Graph 1 denotes Observed and Predicted values fall on the same linear graph.

The observed values for publications fit in the linear equation

$$y = 92.429x + 792.7 \text{ with } R^2 = 0.929$$

Whereas the predicted values for publication fall on linear equation

$$y = 89.145x + 827.18 \text{ where } R^2 = 0.9649$$

A similar study has been undertaken for global research agricultural output and is explained below.

Correlation Coefficient of Global Agricultural Literature Data V/S Economic Indicators

Table 6 gives data on GDP, last year's GERD and previous 2nd year Government expenditure on education for global agricultural literature and it forms the preliminary data for the further study.

<i>Year</i>	<i>Pub</i>	<i>GDP</i>	<i>GERD (t-1)</i>	<i>EDP (t-2)</i>	<i>Total</i>
1998	18193	31346914162278	621591140322	4574651726394	36543157028994
1999	17807	32512421581403	618928366738	4559159255470	37690509203611
2000	18191	33571705209640	621737900749	4546962309880	38740405420269
2001	17551	33367434839454	669509462935	4716022596938	38752966899327
2002	18004	34644767861719	690351065028	4485233488423	39820352415170
2003	19150	38882914196342	694335829700	4734451912249	44311701938291
2004	26537	43787738174825	707131905592	5032225417769	49527095498186
2005	25760	47411807968475	790335151071	5744038772147	53946181891693
2006	25579	51340956869474	868010548069	6014156114406	58223123531949
2007	33184	57833267163667	934985817792	6532166436744	65300419418203
2008	31314	63433456720740	1016525762691	7177088523682	71627071007113
2009	30518	60138443581995	1130820162574	8071777663485	69341041408054
2010	33842	65956672976971	1274563156750	9106012165010	76337248298731
2011	32238	73297338575870	1232636797696	8522227731934	83052203105500
2012	32798	74965622671175	1342716298515	9450007964452	85758346934142
2013	33514	77050588613142	1482701211412	10002898859504	88536188684058
2014	32802	79131444226985	1566617831537	10680738486026	91378800544548
2015	35712	74842734112388	1589328171147	10877851854930	87309914138466
2016	38117	75936811478760	1703788969307	11056538290619	88697138738687
2017	39829	80683787437858	1667066534070	10457303838846	92808157810773
Correlation Coefficient (r)		0.95	0.91	0.92	0.95

Table 6. Correlation Coefficient of Global Agricultural Scholarly Publications Data V/S economic Indicators under Study

Table 7 provides an overview of the correlation coefficient(R), the coefficient of determination (R²), significance level. In the equation Publication (Pub) is the dependent variable. The values are predicted using the least square method of regression analysis at significance level 0.05(5%).

Dependent Variable:	PUB				
Method:	Least Square linear Regression Analysis				
Sample:1998-2017	Level of Significance considered $\alpha=0.05$			Significance F	0.0000000001051
Observations :	20	Degree of freedom df: 19			
Variable	R	R ²	Adj R ²	SE	P value
GDP (t)	0.95	0.91	0.90	0.0000000002926	0.000000003
GERD(t - 1)	0.91	0.83	0.82	0.00000000185133	0.000000014
EDP(t- 2)	0.92	0.84	0.83	0.00000000028400	0.00000000067
Total	0.95	0.91	0.90	0.0000000002567	0.000000000054
R→ Correlation Coefficient; R ² →Coefficient of Determination Adj R ² →Adjusted R ² (more than 1 variable) ; SE→Standard Error (Regression);Total → GDP(t) + GERD(t-1)+EDP(t-2)					

Table 7. Estimation of the Publications based on GDP, GERD,EDP and Total Square Regression Analysis Values Considered to Predict the Significance for Global Agricultural Literature

The table 7 shows that all the parameters are significant at 0.05%. R-value is above 90% for GDP of the present year, GERD of last year and the EDP of last two year. Overall R-value is 95% whereas R² is 0.91 and the adjusted R² is 0.90 for the formulated formula with respect to Global agricultural literature. The significance value F = 0.00000000010 is very much lesser than 0.05. Thus the prediction of publications can be attempted as the data is highly significant for the above regression equation.

The table 8 interprets the values of Observed Publications V/S Predicted Publications in case of global Agricultural publication. The Graph 2 denotes Observed and Predicted values fall on the same linear graph. The observed values for publications fit in the linear equation.

$$y = 1230.2x + 15115 \text{ with } R^2 = 0.9394$$

Whereas the predicted values for publication fall on linear equation

$$y = 1184.9x + 15591 \text{ with } R^2 = 0.9613.$$

It can be interpreted from the data that the research output depends on GDP of the present year, GERD of the previous year and EDP of last second year in both the cases. It is obvious that the as GDP value increase the publication count also increases, thereby relating both the Publication count and Economic Indicators.

7. Conclusion

The relation between the GDP and number of publications show that there exists a linear relationship between these indicators. For most of the countries, a positive high correlation is seen. The correlation is significant between the economic indicators indicating that the higher the GDP higher the number of publications. The correlation coefficient among other indicators like GERD, EDP shows that the increase in budget in the Research and Development results in an increase in the number of publications.

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