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How economic variables influence citations?

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This paper explores the influence of select economic variables on total citations and citations per document as obtained from Scopus from 2016 to 2018. The analysis considered 32 countries that contribute 90% of the scholarly output. Variables considered in the study included citations, citable documents, total expenditure on R&D per capita ($), researchers in R&D per capita, GDP (PPP) per capita and university education index.

Based on multiple regression equation, the output broadly confirms the earlier observation of citation intensity going with wealth intensity of nations. However, on closer examination based on the obtained regression equation, aberration between expected and obtained total citations and citations per document could be observed for India and several other countries. The paper sees a need to include a taxonomy of motivations to cite and contributor taxonomy to make the citation measures meaningful.

Introduction

The influence of economic factors on the scientific performance of countries has engaged bibliometricians and economists alike. May[1] using the citation data, argued that large economies and large R&D spend correlates with scientific impact. India and China were, however, aberrations to this pattern in terms of the number of papers. Cole & Phelan[2], in their analysis, concluded: "Among more developed countries, we find that difference in scientific productivity cannot be completely explained by differences in national wealth." Rousseau & Rousseau[3], in their study of European countries taking patents and publications as output and GDP, active population, along with R&D expenditure, concluded that to obtain a maximum efficiency score, countries are forced to perform on every output goal.

There have been some studies on this issue in the 2000s. King[4], using the top 1% citation data from the Thomson ISI index, argued that wealth intensity (GDP per capita) and citation intensity go together. This study did not consider the extent of publications indexed in SCI. More recently, Docampo & Bessoule[5] reconfirm that research performance measures are highly associated with the wealth of countries and territories.

Vinker[6] found no significant correlation between the GDP and number of publications for EUJ (European Union, US, and Japan) countries. This study analysed data referring to consecutive time periods and found that there are no direct relations between GDP and information production of countries. The author also suggested that the R&D grants (which result in publications) do not depend on real needs, but rich countries can afford to spend more whilst poor countries have less money on scientific research.

The citations and scientific articles under 307 sub-domain for 238 countries as obtained from Scimagojr.com (Scopus) database were analysed by Ciminiet et al[7]. Technologically leading nations, they observed, employ scientific diversification, and the less developed countries mainly operate in the domains where other leading nations are present. The analysis also suggests that only nations that spend close to 3% of their GDP on R&D compete most successfully.

The study by Gantman[8] also explored linguistic and political factors in the context as possible reasons for low citations for certain countries. It indicated that only the size of the economy exerts a positive and significant effect across all disciplines.

Hatemi-J et al[9], in their study of research output and economic growth, show that among G7 countries, only the UK shows a causal relationship from the output of research to real GDP. Around the same period, Muller[10] used 16 macro-level predictor variables, including the economic system, political conditions, and structural and cultural attributes of countries, to predict the scientific output. Kumar et al[11], in their analysis, explore the link between scientific and technical research and economic growth

for China and the USA over the sample period 1981–2012 using the extended Cobb–Douglas model with capital per worker and the quantity of scientific technical journal articles per worker. The study indicates that research publications per worker for both countries positively influence the output per worker in the short and long run.

Increasingly more variables have been brought into the analysis, and yet a conclusive argument has not been put forth to explain the scientific performance. India, China, and sometimes Russia's contributions create the problem as their scholarly output indexed in citation sources is high, R&D spend, and citation impact is relatively low.

Prathap's[12] study indicates that the "richer" a country is, the more likely its scientific excellence will come from a highly concentrated group of premier institutions.

Allik et al[13], in their critical examination of Essential Science Indicators (ESI) of Clarivate Analytics for 97 countries reveal that the relationship between economies and scientific wealth only exists within a group of sufficiently wealthy countries – Gross National Income (GNI) median value of US$ 22,162. There is no guarantee that national wealth and investments into R&D automatically lead to an increase in scientific excellence. Pointing to several loopholes in the ranking (Panama and Iceland stand 1 and 2 in HQSI rank), they argue that scientific excellence needs good governance. The study has used selective top 1% citation data, ESI of Clarivate Analytics, or just the scientific output in terms of papers. Having found India, China, and increasingly Russia as aberrations, they have moved to consider other variables for an explanation.

Most of these studies do not touch on the possible Mathew Effect for countries as suggested by Bonitz[14]. However, the aberrations seem to crop up in the citation analysis possibly due to adverse perception about low-income country[15].

Apart from these, a host of studies independently establish significant relations between citation yield and publication in high impact journals and those with international collaboration (Adams[16], Van Raan[17] Rousseau and Ding[18]). However, a cumulative country-level figure of publications in journals of varying impact levels is not feasible.

Objectives of the study

The current study analyses the citation impact of a set of economic variables for 32 countries, making up 90% of the citable documents in Scopus. The study had the following objectives:

1. To examine the citation impact of a set of variables, namely Citable Documents, Total Expenditure on R&D per capita $, Researchers in R&D per capita, GDP(PPP) per capita, University Education Index;
2. To understand whether the countries get the expected share of Total Citations and Citations per Document based on the relative investments on the indicators mentioned above.

Data and methods

Citation and citable documents related data were obtained from https://www.scimagojr.com/. The SCImago Journal & Country Rank is a publicly available portal that includes the journals and country scientific indicators developed from the information contained in the Scopus® database (Elsevier BV). The analysis period was considered for the three years (2016-2018). Earlier studies have used citation data for ten or more years, which may tend towards gathering, apart from primary citations, secondary and tertiary ones, giving snowball effect to some documents. Country-wise data on Total Citable Documents and Total Citations were collected from the source for 2016, 2017, and 2018. These were cumulated for analysis. Citation per document was obtained by dividing Total Citations with Total Citable Documents for the period. The extent of International Collaboration was also considered at the country level. Country-wise data on International Collaboration was also obtained from the Scimagojr.com database. A cumulative percentage for the said three years was calculated by considering the annual Citable Document output for the countries.

The entire data set on Citable Documents was rank-ordered initially to ascertain the international distribution of productivity (citable documents) and citation intensity. To make the analysis viable and meaningful, the analysis was narrowed to the top 90% of the science and technology literature output and the counties associated with that. This limited the countries to 32, viz., Australia, Austria, Belgium, Brazil, Canada, China, Czech Rep., Denmark, Finland, France, Germany, Greece, India, Iran, Israel, Italy, Japan, Mexico, Netherlands, Norway, Poland, Portugal, Russia, Singapore, South Korea, Spain, Sweden, Switzerland, Taiwan, Turkey, the UK, and the USA.

There are a host of economic variables that could be considered in conjunction with citations. These include education-related expenditure, R&D related expenditure, GDP (PPP) per capita, etc. As the data for the analysis about a set of countries, the data had to come from a widely accepted and preferably, for the sake of consistency, a single source. As the number of countries considered for the analysis was only 32, there was a limitation in the number of predictor variables that could be used. Consequently, only variables of immediate relevance in economic terms could be used.

Apart from four bibliometric variables, namely Total Citable Documents, Total Citations, Citations per Document and International Collaboration in publications - the other variables considered for the analysis and their scope are as follows:

- Business expenditure on R&D ($) (US$ millions)
- Business expenditure on R&D (%) (Percentage of GDP)
- GDP (PPP) Percapita ($) (US$ per capita)
- Researchers in R&D per capita (Full-time work equivalent (FTE) per 1000 people)
- Total expenditure on R&D ($) (US$ millions)
- Total expenditure on R&D (%) (Percentage of GDP)
- Total expenditure on R&D per capita ($) (US$ per capita)
- Total R&D personnel in business enterprise (Full-time work equivalent (FTE thousands))
- Total R&D personnel (Full-time work equivalent (FTE thousands)
- University education index (Country score calculated from Times Higher Education university ranking)

Source: *https://www.imd.org/wcc/products/eshop-factor-and-criteria/*

Data about these variables were collected from IMD World Competitiveness Yearbook 2019 online database. The IMD World Competitiveness Yearbook (WCY), first published in 1989, is a comprehensive annual report and worldwide reference point on the competitiveness of countries. It provides benchmarking and trends, as well as statistics and survey data based on extensive research. The Yearbook provides extensive coverage of 63 economies, chosen based on the availability of comparable international statistics and their collaboration with local partner institutions, which contribute to collecting survey data and ensuring that all data are reliable, accurate, and as up-to-date as possible. Indian collaborating institution for the Yearbook is National Productivity Council, New Delhi.

Data about Iran was not included in IMD World Competitiveness Yearbook, and the country had to be excluded from the analysis.

Statistical processing of the data was done using SPSS.

Results and discussion

Table 1 presents the data relating to the citation, international collaboration, and the economic variables considered in the study. Correlation among these variables was initially calculated to understand the statistical relations among these economic variables with citations related variables, namely Total Citable Documents, Total Citations, Citation per Document. The results (Table 2) indicate the following.

Total expenditure on R&D, business expenditure on R&D, total R&D personnel, and University Education Index correlates very strongly (in some cases $r(30) = .9$ $p<.000$) and above) with Citable Documents and Total Citations. R&D expenditure per capita, Total R&D personnel per capita, and GDP (PPP) per capita, correlate significantly with Citations per document. The results indicate that Total Citations accrued to countries and Citations per Document do not necessarily align with the identified economic variables.

The analysis was initially taken with bivariate regression analysis between Total Citations as a dependent variable and each of the variables mentioned above as predictors. This analysis was also carried out with Citations per Document as a dependent variable (Table 3).

Analysis validated the model with a significant F value for variables Total Expenditure on R&D (R^2 .881 β.938 $p <.000$); Business expenditure on R&D (R^2 .872 β.934 $p <.000$); Total R&D personnel (R^2 .778 β.882 $p<.000$), University Education Index (R^2 .687 β.829 $p <.000$) when regressed with Total Citations accrued by the selected countries.

When the same variables were regressed against Citations per Document as a dependent variable, the results indicate the following: variables Total Expenditure on R&D per capita (R^2 .499 β.707 $p<.000$), Total Expenditure on R&D in Business per

Table 1 — Country-wise data about variables considered in the analysis

Country	Researchers in R&D Per capita	Total Exp on R&D per capita ($)	Univ Edu Index	GDP (PPP) per capita ($)	Citable Docs	Total Citations	Citations per document	International Collaboration (% of the total Citable Docs
Australia	27.50	980.07	82.09	52742.88	267090	2516066	9.42	53.25
Austria	38.30	1496.45	36.24	52376.75	71160	664633	9.34	63.20
Belgium	29.50	1128.70	31.89	48141.76	93374	950174	10.18	64.99
Brazil	19.20	110.12	11.95	16088.48	221633	1108757	5.00	32.92
Canada	39.80	716.72	52.03	49706.93	288663	2514217	8.71	51.24
China	48.40	187.39	59.00	18109.81	1599277	9982220	6.24	22.82
Czech Rep.	33.40	365.13	18.13	37248.78	71563	410293	5.73	43.97
Denmark	25.30	1753.37	42.78	52122.30	76939	851294	11.06	61.70
Finland	33.30	1262.94	48.22	46473.96	57576	553476	9.61	59.34
France	35.10	844.20	48.08	44225.52	335731	2625699	7.82	54.47
Germany	41.80	1350.41	77.49	52558.33	490424	3979968	8.12	49.70
Greece	38.00	212.76	17.15	28907.27	51905	433871	8.36	51.77
India	29.80	10.30	24.43	7747.62	447608	1939535	4.33	17.38
Israel	46.80	1844.08	20.93	37985.87	58438	534483	9.15	49.35
Italy	38.00	434.38	57.02	39636.95	314411	2616763	8.32	46.93
Japan	55.80	1231.43	45.57	44214.76	368436	2075842	5.63	29.17
Korea Rep.	40.90	1354.79	35.12	41373.49	242578	1555807	6.41	28.40
Mexico	40.10	42.68	3.59	20527.11	67515	353470	5.24	41.98
Netherlands	27.40	965.14	45.35	56011.79	163867	1773724	10.82	60.32
Norway	25.10	1593.18	28.29	74355.18	62306	569075	9.13	58.75
Poland	36.20	141.67	5.10	31577.67	137630	756293	5.50	32.68
Portugal	41.10	280.78	32.90	32077.26	69500	538646	7.75	53.21
Russia	31.60	97.77	18.72	29266.84	268088	871845	3.25	24.92
Singapore	57.60	1172.35	17.84	100344.66	60751	684512	11.27	62.68
Spain	35.10	340.18	44.98	39895.15	258170	2011942	7.79	48.99
Sweden	29.30	1760.87	45.26	52985.04	115146	1159150	10.07	62.43
Switzerland	30.40	2782.38	53.75	64649.10	128725	1452132	11.28	67.14
Taiwan	36.50	803.71	35.29	53053.97	105342	638182	6.06	33.31
Turkey	32.20	101.27	13.13	27956.12	126263	588867	4.66	23.51
UK	40.60	664.58	143.79	45704.42	524133	4842645	9.24	52.57
USA	39.20	1669.86	211.41	62605.54	1752909	14521394	8.28	34.59

capita (R^2.252 β .502 p<.004), and GDP(PPP) per capita (R^2 .529 β.727 p<.000). It has to be noted here that variables Total R&D Personnel and R&D Personnel per capita had incomplete information as the corresponding data for the USA and Australia were not available in the WCY compilation. A complete set of data for all the countries was available for Researchers in R&D per capita, and that variable was used in bivariate regressions.

As we can notice, there is no commonality among the variables that show promise catering to two different criterion variables in the context of the multivariate application. Total R&D investment across the countries varies with the size of the economy. It is so with Business Expenditure on R&D and Total R&D personnel. To prevent this disparity, it was found appropriate to use these variables normalised to per capita, along with the GDP (PPP) per capita and University Education Index as the index based on an international survey of universities by Times using a set of common criteria.

As there was a constraint on the number of independent variables that could be used between the two bibliographic variables, namely Total citable documents and International collaboration, the first one was preferred, as it is more basic in the context. It was also noted that international collaboration generally corresponds to R&D Expenditure per capita and higher GDP (PPP) per capita, and to that extent, the information is subsumed in these variables.

The multivariate regression model explored the following two research questions:

1. Total citations are a function of independent variables, namely Researchers in R&D per capita, Total expenditure on R&D per capita($), University education index, GDP (PPP) Per capita-2018, Total citable documents

Table 2 — Correlation matrix of bibliometric and economic variables

		Researchers in R&D per capita	Total Exp. on R&D ($)	Total Exp. on R&D per capita ($)	Bus Exp. on R&D ($)	Total R&D personnel	Total R&D personnel per capita	University Edu. Index	GDP (PPP) Per capita 2018 ($)	International collaboration (% of total Citable Docs)
Total Citable Doc.		.253	.915**	-.037	.915**	.956**	-.305	.712**	-.102	-.414**
	N	31	31	31	31	29	30	31	31	31
Total Citations		.230	.938**	.076	.934**	.882**	-.185	.829**	.034	-.268
	N	31	31	31	31	29	30	31	31	31
Citations Per Doc.		-.020	-.063	.707**	-.068	-.289	.654**	.281	.727**	.899**
	N	31	31	31	31	29	30	31	31	31

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

Table 3 — Summary of bivariate regression on Total citation and Citations per document and a host of independent variables

	Total citations	Citations per document
Total Exp. on R&D	R^2 =.88	R^2 =.004
	β =.938**	β =.063
	F =214.166**	F =.117
Total Exp. on R&D per capita	R^2 =.006	R^2 =.499
	β =.076	β =.707**
	F =.170	F =28.919**
Total Business Exp. on R&D	R^2 =.872	R^2 =.005
	β =.934**	β =-.068
	F =196.785**	F =.133
R&D Personnel in Business per capita	R^2 =.003	R^2 =.252
	β =-.057	β =.502*
	F =.096	F =9.746*
University Education Index	R^2 =.687	R^2 =.079
	β =.829**	β =.281
	F =63.646**	F =2.486
Researchers in R&D per capita	R^2 = .053	R^2 = .000
	β = .230	β = .001
	F = 1.623	F = -.002
GDP (PPP) Per capita	R^2 =.001	R^2 =.529
	β =.034	β =.727**
	F =.034	F =32.517**
International collaboration	R^2 =.072	R^2 =.808
	β =.268	β =.899**
	F =2.236	F =122.091**
Total citable documents	R^2 =.976	R^2 =.022
	β =.976**	β =.646
	F =585.956**	F =.148

N=31 **. Correlation is significant at the 0.01 level*. Correlation is significant at the 0.05 level

2. Citations per document is a function of independent variables, namely Researchers in R&D per capita, Total expenditure on R&D per capita ($), University education index, GDP (PPP) Per capita-2018, Total citable documents

The regression values on the above are presented in Annexures I and II.

Multivariate linear regression with the predicator variables - Researchers in R&D per capita; Total Expenditure in R&D per capita; University Education Index, GDP (PPP) per capita, Citable Documents with Total Citations as dependent variables returned (adjusted) R^2 of .991. β values that are significant in the context are University Education Index (β .231 p <.000), GDP (PPP) (per capita) 2018, (β .058 p<.052), and Total Citable Documents (β .820 p<.000). Citable documents on their own contributed 47.6% of the variance explained by the model. The β value indicates that every unit increase in Citable Documents results in citations increasing by .820 units. Next in the order is the University Education Index, which accounted for 13.3% of the explained variance on its own. These two are followed by GDP (PPP) per capita as the predictor (Annexure I).

When the same predictor variables were regressed against Citation Per Document, the model could explain 57.4% (Adjusted R^2 .574) of the variance. Total expenses on R&D per capita (β .342 p<.000) and GDP (PPP) per capita (β .407 p<.000) comes out significant (Annexure II)

The results indicate the following:

If we want higher citations against the country, we can rely on more Citable Documents, focus on improving the university standards, and general economic development as reflected in GDP (PPP).

However, the same variables do not explain higher Citations per Document. It is the total R&D expenditure that matters more, along with better economic development as reflected in GDP (PPP).

A higher number of Citable Documents does not result in higher Citations per Document. This could be explained by understanding that relative depth of R&D and resultant publications could attract researcher attention as they set the agenda and would be at the cutting edge of science.

These results validate earlier observations that citation impact goes with wealth intensity.

Estimated and actual citations to Indian contributions:

The regression equation for both the analyses is as follows:

$Y_t = \beta_0 - \beta_1$ *Researchers in R&D Per capita* $- \beta_2$ *Total R&D expenditure per capita* $+ \beta_3$ *University Education Index* $+ \beta_4$ *GDP (PPP) per capita* $+ \beta_5$ *Total Citable Documents*

When we replace the β values, the same will be-

Total Citations = -643332.092 + (-4021.265 (*Researchers in R&D Per capita*)) + (-22.012 (*Total R&D expenditure per capita*)) + (1701.278(*University Education Index)) +* (9.48 (*GDP (PPP) per capita*)) + 6.151 (*Total Citable Documents)*

Citations per Document = 5.054 + (-.015 (*Researchers in R&D per capita*)) + (.001 (*Total R&D per capita*)) + (.013(*University Education Index*)) + (4.979E-05(*GDP (PPP) per capita*)) + -1.424E-06 (*Total citable documents*)

Do countries get the expected citations given their output of Citable Documents in Scopus and a host of related variables? This question was examined by using the unstandardised regression coefficients for the same set of variables using the equation – y^=a+ a1x1 + b2x2 + c3x3 + d4x4 + e5x5, where a, b, c, d, e stood for obtained unstandardised coefficients corresponding to *Researchers in R&D per capita, Total R&D per capita, University Education Index, GDP (PPP) per capita, Total citable documents, and x1,x2, x3,x4,x5* the observed values respectively. The predicted value for both Citations per Document and Total Citations were obtained from the SPSS.

The expected Total citations and Citations per Document for the present values of independent variables are presented in Table 4. For comparison, the original citation values are also included in the table.

Indian scholarly contributions have appeared both in Indian and foreign journals. During 2016-2018 our contributions had accrued 1,939,535 total citations against the estimate of 2,471,582 based

Table 4 — Observed and predicted total Citations and citations per document

	Total Citations (observed)	Total Citations (predicted)	Citations per Doc. (observed)	Citations per Doc. (predicted)	Total Citations Gain/Loss	Total Citations gain/ loss (%)
Australia	2516066	2738861	9.42	9.05	-222795	-8.13
Austria	664633	709491	9.34	9.1	-44858	-6.32
Belgium	950174	776791	10.18	8.53	173383	22.32
Brazil	1108757	992608	5	5.53	116149	11.70
Canada	2514217	2296948	8.71	7.99	217269	9.46
China	9982220	10152817	6.24	3.93	-170597	-1.68
Czech Republic	410293	310625	5.73	6.94	99668	32.09
Denmark	851294	898602	11.06	9.65	-47308	-5.26
Finland	553476	795250	9.61	8.81	-241774	-30.40
France	2625699	2484622	7.82	7.81	141077	5.68
Germany	3979968	3968393	8.12	8.85	11575	0.29
Greece	433871	79145	8.36	6.3	354726	448.20
India	1939535	2471582	4.33	4.68	-532047	-21.53
Israel	534483	197262	9.15	8.45	337221	170.95
Italy	2616763	2456760	8.32	7.23	160003	6.51
Japan	2075842	2552132	5.63	7.84	-476290	-18.66
Korea Rep.	1555807	1633676	6.41	8.1	-77869	-4.77
Mexico	353470	-135451	5.24	5.46	488921	-360.96
Netherlands	1773724	1522055	10.82	8.86	251669	16.53
Norway	569075	781688	9.13	10.41	-212613	-27.20
Poland	756293	439365	5.5	6.1	316928	72.13
Portugal	538646	466549	7.75	6.67	72097	15.45
Russia	871845	1466824	3.25	6	-594979	-40.56
Singapore	684512	722706	11.27	10.61	-38194	-5.28
Spain	2011942	1925823	7.79	7.11	86119	4.47
Sweden	1159150	1166992	10.07	9.62	-7842	-0.67
Switzerland	1452132	1476066	11.28	11.4	-23934	-1.62
Taiwan	638182	932798	6.06	8.34	-294616	-31.58
Turkey	588867	486155	4.66	6.06	102712	21.13
UK	4842645	5238048	9.24	8.6	-395403	-7.55
USA	14521394	14069791	8.28	9.72	451603	3.21

on (unstandardised) Beta coefficients in the regression model. We accrued 532,047 citations less. Our Citations per Document was only 4.33 for the period as against the estimate of 4.68, a shortfall of 0.35 per citable document. India loses overall 21.52% of the total citations as per the obtained regression equation.

Similar calculations for other countries indicate that such a shortfall in Total citations occurs, given their present levels on the independent variables considered in the regression analysis, for 16 of the 31 countries. Sweden (0.67%), Switzerland (1.62%), China (1.68%), South Korea (4.77%), Denmark (5.26%) Singapore (5.28%), Austria (6.32%), UK (7.55%), Australia (8.13%) tend to lose less than 10%. Japan (18.66%), Norway (27.20%), Finland (30.4%), Taiwan (31.58%), Russia (40.56%) and Mexico (360.96%) lose considerably more, despite the citable documents in Scopus, relatively better GDP (PPP) per capita, and R&D investments.

Countries such as Germany (0.29%), USA (3.21%), Spain (4.47%), France (5.68%), Italy (6.51%), Canada (9.46%) gain less than 10 per cent in total citations. On the other hand, countries which gain substantially on Total citations include Brazil (11.7%), Portugal (15.45%), Netherlands (16.53%), Turkey (21.13%), Belgium (22.32%), Czech Republic (32.09%), Poland (72.13%), Israel (170.95%), Greece (448.20%) given their R&D investments and GDP (PPP) per capita. A detailed analysis of the citable documents of Israel and Greece are required to understand what helps them gain citations given their output is relatively less.

On Citations per Document, China (2.31), Greece (2.06), Netherlands (1.96), Belgium (1.65), Denmark (1.41), Italy (1.09), Portugal (1.08) gain more than one citation per citable document in Scopus than the estimated values. Finland (0.8), Israel (0.7), Canada (0.72), Singapore (0.66), the UK (0.64), Spain (0.68), Sweden (0.45), Australia (0.37), Austria (0.24) and France (0.01) also obtain more than expected Citations per Document for their levels of GDP (PPP) per capita and other related variables considered in the analysis. Losers on this count are Mexico (-0.22), India (-0.35), Brazil (-0.53), Germany (-0.73), Poland (-0.60), Norway (-1.28), Czech Republic (-1.21), USA (-1.44), Turkey (-1.40), South Korea(-1.69), Japan (-2.21), Taiwan (-2.28), and Russia (-2.75).

Only India, Norway, South Korea, Japan, Taiwan, and Russia lose both on Total Citations and Citations per Document given their output of Total Citable Documents and current investments on R&D, GDP (PPP) per capita, and other variables considered.

Conclusion

Through R&D investments, researchers in R&D per capita, University Education Index, apart from the GDP (PPP) per capita, can help boost Total Citations and Citations per Document. Given the shortfall of citations for Japan, Korea, Taiwan, and even the US in the Citations per Document, we may have to reconsider whether citations are the appropriate measure as it stands out for scientific productivity. Perhaps there is a need to include a taxonomy of motivations to cite in the citable documents and contributor taxonomy values for authors to make the measure more meaningful.

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Annexure I

Regression Analyses for Variables Predicting Total Citations

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.996[a]	.991	.989	304478.85099	.991	564.628	5	25	.000

a. Predictors: (Constant), CitableDocsPrev3Yrs, Total expenditure on R&D per capita_$, Researchers in R&D per capita, GDPPPPpercapita2018, University education index

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	261725927088726.000	5	52345185417745.300	564.628	.000[b]
	Residual	2317684267532.560	25	92707370701.303		
	Total	264043611356259.000	30			

a. Dependent Variable: Total Citations

b. Predictors: (Constant), Citable Docs, Total Expenditure on R&D per capita ($), Researchers in R&D per capita, GDP(PPP)percapita2018, University Education Index

Coefficients[a]

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	-643332.092	262583.876		-2.450	.022			
	Researchers in R&D per capita	-4021.265	7239.449	-.011	-.555	.584	.230	-.110	-.010
	Total Expenditure on R&D per capita ($)	-22.012	113.782	-.005	-.193	.848	.076	-.039	-.004
	University Education Index	16701.278	2357.727	.231	7.084	.000	.829	.817	.133
	GDP(PPP) per capita 2018	9.486	4.650	.058	2.040	.052	.034	.378	.038
	Citable Docs	6.151	.242	.820	25.400	.000	.976	.981	.476

a. Dependent Variable: Total Citations

Annexure II

Regression Analyses for Variables Predicting Citations Per Document

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.803[a]	.645	.574	1.45405	.645	9.090	5	25	.000

a. Predictors: (Constant), Cites Per Document, Total Expenditure on R&D per capita ($), Researchers in R&D per capita, GDP(PPP)percapita2018, University Education Index

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	96.094	5	19.219	9.090	.000[b]
	Residual	52.856	25	2.114		
	Total	148.950	30			

a. Dependent Variable: Citations Per Doc

b. Predictors: (Constant), Citable Docs, Total Expenditure on R&D per capita ($), Researchers in R&D per capita, GDP(PPP)percapita2018, University Education Index

Coefficients[a]

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	5.054	1.254		4.030	.000			
	Researchers in R&D per capita	-.015	.035	-.058	-.442	.662	-.020	-.088	-.053
	Total expenditure on R&D per capita_$	.001	.001	.342	2.026	.054	.707	.375	.241
	University education index	.013	.011	.245	1.180	.249	.281	.230	.141
	GDPPPPpercapita2018	4.979E-05	.000	.407	2.243	.034	.727	.409	.267
	CitableDocsPrev3Yrs	-1.424E-06	.000	-.253	-1.231	.230	-.148	-.239	-.147

a. Dependent Variable: Citations Per Doc