

## G-20 countries and research collaboration

The compound annual growth rate (CAGR) refers to the average increase in the value of a given measure during a specific time interval<sup>1</sup>. It provides an indication of the annual growth<sup>2,3</sup>. The metric has been exten-

sively utilized among the scientific community, regardless of the scientific field<sup>4-7</sup>. Therefore, this statistical technique must be a significant instrument for measuring growth.

Recently, Singh *et al.*<sup>8</sup> published an article entitled 'International research collaboration among the G-20 countries', wherein the authors have conducted commendable research. However, there is an error in the calculation of CAGR. The authors used the following formula

$$\text{CAGR} = \left( \left( \frac{V_{\text{final}}}{V_{\text{begin}}} \right)^{\frac{1}{t}} - 1 \right) * 100, \quad (1)$$

where  $V_{\text{final}}$  denotes the publication output of a G20 country in 2020,  $V_{\text{begin}}$  the publication output of a G20 country in 2001, and  $t$  denotes the number of years, which is 20 in this case. However, it is important to note that  $t$  represents the time period, and therefore, eq. (1) should be rewritten as follows<sup>9</sup>

$$\text{CAGR} = \left( \left( \frac{V_{\text{final}}}{V_{\text{begin}}} \right)^{\frac{1}{t-1}} - 1 \right) * 100, \quad (2)$$

To indicate this error, the growth rate has been calculated for the research output (table 1, Singh *et al.*<sup>8</sup>) and international collaborative papers (table 2, Singh *et al.*<sup>8</sup>) using the aforementioned equations. The information provided in tables 1 and 2 in Singh *et al.*<sup>8</sup> has been replicated here in Table 1.

It is evident that there is a substantial disparity between the values of CAGR using the two formulas. Additionally, the accuracy of CAGR calculation has been determined by considering the number of research outputs for Argentina, as presented in Table 2.

The growth, as determined by the actual formula, is from 5,103 in 2001 to 19,689 in 2020. It is noteworthy that the figure 18,402 obtained using the formula utilized by Singh *et al.*<sup>8</sup> falls significantly below 19,689. Thus, we urge diligent researchers to avoid such errors in the future.

**Table 1.** Comparison of compound annual growth rates (CAGRs)

Country	Total papers				Internationally collaborated papers			
	2001	2020	CAGR (1)	CAGR (2)	2001	2020	CAGR (1)	CAGR (2)
Argentina	5,103	19,689	6.98	7.37	1,790	9,034	8.43	8.89
Australia	31,644	129,546	7.30	7.70	8,976	76,052	11.28	11.90
Brazil	19,643	132,862	10.03	10.58	4,493	36,726	11.08	11.69
Canada	43,560	140,218	6.02	6.35	13,363	76,906	9.14	9.65
China	42,382	741,686	15.39	16.26	8,351	180,549	16.61	17.56
France	58,643	138,568	4.39	4.63	21,251	80,584	6.89	7.27
Germany	89,708	234,604	4.92	5.19	28,757	113,551	7.11	7.50
India	19,457	220,463	12.90	13.63	3,318	45,171	13.95	14.73
Indonesia	671	94,492	28.07	29.74	401	8,909	16.77	17.73
Italy	43,742	153,749	6.49	6.84	13,348	74,103	8.95	9.44
Japan	120,170	195,117	2.45	2.58	14,948	48,369	6.05	6.38
Mexico	6,224	31,345	8.42	8.88	2,500	13,400	8.76	9.24
Russia	30,584	143,602	8.04	8.48	9,263	29,547	5.97	6.30
Saudi Arabia	1,683	37,905	16.85	17.81	394	27,715	23.70	25.09
South Africa	4,852	31,862	9.87	10.41	1,467	17,616	13.23	13.98
South Korea	20,158	96,043	8.12	8.56	4,058	30,500	10.61	11.20
Turkey	8,216	53,454	9.82	10.36	1,374	15,489	12.88	13.60
United Kingdom	106,639	263,844	4.63	4.88	28,445	152,077	8.74	9.22
United States of America	383,956	862,510	4.13	4.35	65,457	302,560	7.96	8.39

**Table 2.** Verifying the accuracy of calculated CAGR

Year	Growth rate	
	6.984%	7.365%
2001	5,103	5,103
2002	5,459.39	5,478.84
2003	5,840.68	5,882.35
2004	6,248.59	6,315.59
2005	6,684.99	6,780.73
2006	7,151.87	7,280.13
2007	7,651.36	7,816.31
2008	8,185.73	8,391.98
2009	8,757.42	9,010.05
2010	9,369.04	9,673.64
2011	10,023.37	10,386.11
2012	10,723.41	11,151.05
2013	11,472.33	11,972.32
2014	12,273.56	12,854.08
2015	13,130.74	13,800.78
2016	14,047.79	14,817.21
2017	15,028.89	15,908.50
2018	16,078.51	17,080.16
2019	17,201.43	18,338.11
2020	18,402.78	19,688.72

1. Sánchez-Gil, S., Gorraiz, J. and Melero-Fuentes, D., *J. Informetr.*, 2018, **12**(1), 42–58.
2. Terekhov, A. I., *Scientometrics*, 2017, **110**(3), 1217–1242.
3. Choi, D. G., Lee, H. and Sung, T. K., *Scientometrics*, 2011, **88**(1), 259–278.
4. Sharma, C., Tiwari, M. K. and Pathak, H., *Curr. Sci.*, 2008, **94**(11), 1439–1446.

5. Prathap, G., *Curr. Sci.*, 2009, **96**(10), 1294–1296.
6. Dwivedi, S., Garg, K. C. and Prasad, H. N., *Curr. Sci.*, 2017, **112**(9), 1814–1821.
7. Dixit, G. P., Srivastava, A. K. and Singh, N. P., *Curr. Sci.*, 2019, **116**(2), 239–242.
8. Singh, V. K., Kanaujia, A., Singh, P., Dua, J. and Lathabai, H. H., *Curr. Sci.*, 2024, **126**(1), 36–44.
9. Elango, B., *COLLNET J. Scientometr. Inf. Manage.*, 2019, **13**(2), 331–337.

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### Response:

We appreciate the interest shown by Elango in our article and his comments. In response, we would like to highlight that our article presents an analysis of international research collaboration among the G-20 countries from 2001 to 2020 (ref. 1). The research publication data for the G-20 countries has been analysed to understand the collaboration patterns and trends. The article also provides a set of values for res-

earch publication counts for various countries, along with a calculation of compound annual growth rate (CAGR). CAGR is a commonly used metric for assessing the growth of quantities (which is research publications in the present case). Its calculation is based on the assumption that the series of values follows a geometric progression with common ratio ( $r$ ) and holding period  $t$  (refs 2, 3). The formula for calculating CAGR, as provided in the relevant Wikipedia page<sup>4</sup>, which in turn has been taken from references 2 and 3 is as follows

$$\text{CAGR}(t_0, t_n) = \left( \frac{V(t_n)}{V(t_0)} \right)^{\frac{1}{t_n - t_0}} - 1, \quad (1)$$

where  $V(t_0)$  is the publication count in starting year,  $V(t_n)$  the publication count in last year and  $t_n - t_0$  is the time period.

In our article<sup>1</sup>, the value of  $t_n$  is 2020, and for  $t_0$ , it is 2001. Thus, while the formula used for computing CAGR is correct, there has been an inadvertent error in taking the value of time interval ( $t$ ) as 20 instead of 19. This error is regretted. However, the impact of this error is marginal and limited only to the computation of CAGR values, which will differ marginally, though the overall trend may remain the same. It does not affect any other part of our study, including the results obtained and the inferences drawn. As such, the

analysis presented in our article and its inferences stand valid and unchanged.

1. Singh, V. K., Kanaujia, A., Singh, P., Dua, J. and Lathabai, H. H., *Curr. Sci.*, 2024, **126**(1), 36–44.
2. Chan, E., In *Harvard Business School Confidential: Secrets of Success*, Wiley, 2009, pp. 184–186.
3. Anson, M. J., Fabozzi, F. J. and Jones, F. J., *The Handbook of Traditional and Alternative Investment Vehicles: Investment Characteristics and Strategies*, John Wiley, 2010, vol. 194.
4. [https://en.wikipedia.org/wiki/Compound\\_annual\\_growth\\_rate](https://en.wikipedia.org/wiki/Compound_annual_growth_rate) (accessed on 28 January 2024).

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