

A number of metrics can be used to compare the research output of country. A simple and commonly used approach is to consider the absolute count of research publications [24]. However, the method is flawed, as it favours countries with large population (such as USA, China and India etc.). To offset the large population factor, publications per million people is an alternative metric. The metric normalizes the publication count based on the population, and thus provides a level benchmark for comparing the research productivity of a country. Other factors such as number of higher education institutes, and country's GDP can also be considered [25]. For simplicity, we consider the absolute number of publication versus the GDP, and the publications per million population as our criterion for research performance of a country. The population and GDP data of a country are taken from the World Bank online database [26].

Figure 3 shows the world wide count of the computer science literature being published during the years 2000 to 2017. It shows that the top four countries including United States, China, Germany and United Kingdom accounts for almost 43% of the total pool of papers published. Next in line are the India, Canada, Taiwan and Australia in terms of the publication count. The percentage share of India, Malaysia, Turkey, Saudi Arabia, Pakistan and Bangladesh accounts for 3.66%, 0.84%, 0.78%, 0.36%, 0.29% and 0.14% respectively of the total pool of the publications which amounts to a total of 5126070 publications.

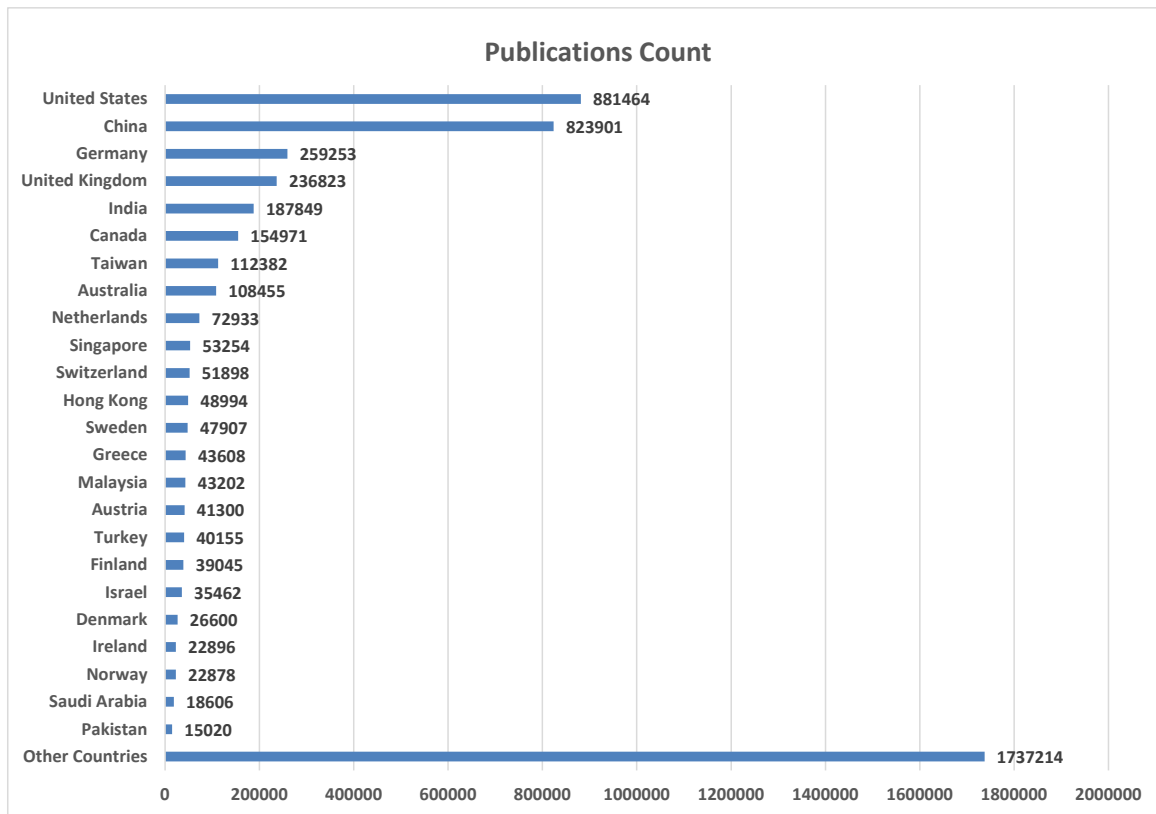


Figure 3 shows the world wide contribution of computer science publications

In order to present a more rationale view of the performance of these countries, we normalized the results by dividing the publications count over their population (in millions). This shows us a different result as smaller countries such as Singapore, Finland, Hong Kong, Switzerland and Taiwan came to the top such (see Figure 4). The countries at the top in Figure 3 shows a much lower performance as shown in the normalized graph in Figure 4. An important point to mention here is that the top 5 countries which

make it to the list in Figure 4 are shown in Figure 3 but the rest of the countries in the list are omitted. As it was not possible to show the countries in the graph for which we were comparing the results i.e., Pakistan, Bangladesh, India, Turkey, and Malaysia. Further the countries which were omitted, their publications count was added up to the “Other countries” entry in the graph as shown in Figure 3.

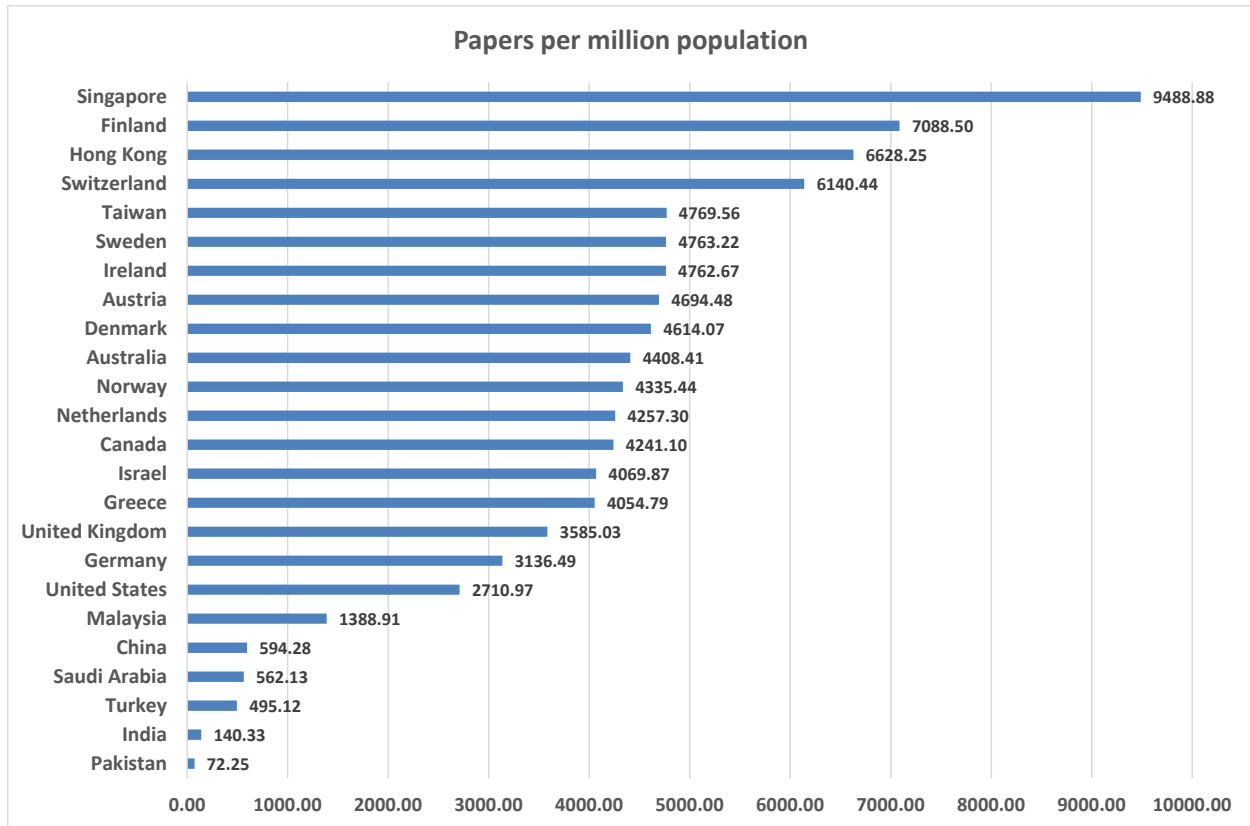


Figure 4 shows the normalized count of computer science literature published world-wide during the period 2000-2017

In order to show a clear picture of the performance of all the countries over time we plotted a graph showing the percentage share of the selected set of countries (Bangladesh, India, Malaysia, Saudi Arabia and Turkey) along with Pakistan. Figure 5 shows the percentage distribution of the publications over the years from 2000 to 2017. The figure clearly shows that the Bangladesh started at 1.29% in 2000, and over the years reached at 3.05% in 2017. India starting with 61.37% in 2000 ended up with the value 61.10% which is a slight decrease but over the years it has shown fluctuations. Such as after 2000, the next year the contribution dropped to 58.27% and again next year i.e., 2002 it reached the maximum at 65.36%. Malaysia performance shows an increase by starting at 7.61% and ending at 14.13% which is almost the double of the starting value. It shows a steady increase over the years but a few are interesting to note where the improvement is major such as in 2003 the value switched from 7.77% (in 2002) to 13.72% which shows a great difference but immediately the next year it dropped back to 7.75%. Similarly, in 2007 starting at 11.48% and the next year i.e. in 2008, it reached a maximum of 17% which consequently moved on to next year of 18.77% but after that it shows a decline and ended up at 14.13% in 2017. Pakistan overall showed an increase from 1.29% to 5.61% but there are a lot of ups and downs along the way. Such as immediately after 2000 i.e. in 2001, the value increased from 1.29% to 3.10% but after that in 2003 it again moved up to 3.88% and so on up to 6.05% for 2005 and the next year it dropped back to 4.64%. In 2009 it reached a peak value of 6.47% but it then went on declining the years onwards and in 2017 it stopped at 5.61%. Saudi Arabia however showed an overall decline by starting at 6.78% in

2000 and ended up at 6.35% in 2017. The peaked value was observed immediately after the next year from the starting year i.e., 2001 which is 7.80% but the following year it dropped to a low value of 4.56% from where onward it shows a decline in values over the years till 2009, after which it jumped back to 5.02% the next year from 3.55% in 2009. Then onward it shows a rise till 2015 for which the value is at 7.50%, for which the next year i.e. in 2016 we noted a downfall to 6.13% and then in 2017 it finally reaches 6.35%. Turkey overall showed a much worse performance amongst all the countries by starting at 21.65% in 2000 and ended up at 9.76% in 2017 which is a huge loss in numbers. For the first three years it shows a decrease in numbers reaching to 19.13% in 2002, but the next year i.e. in 2003, it performs well at 20.28% and continue to escalate the next year forward. But immediately after this it starting declining till the very end reaching to 9.76% in 2017.

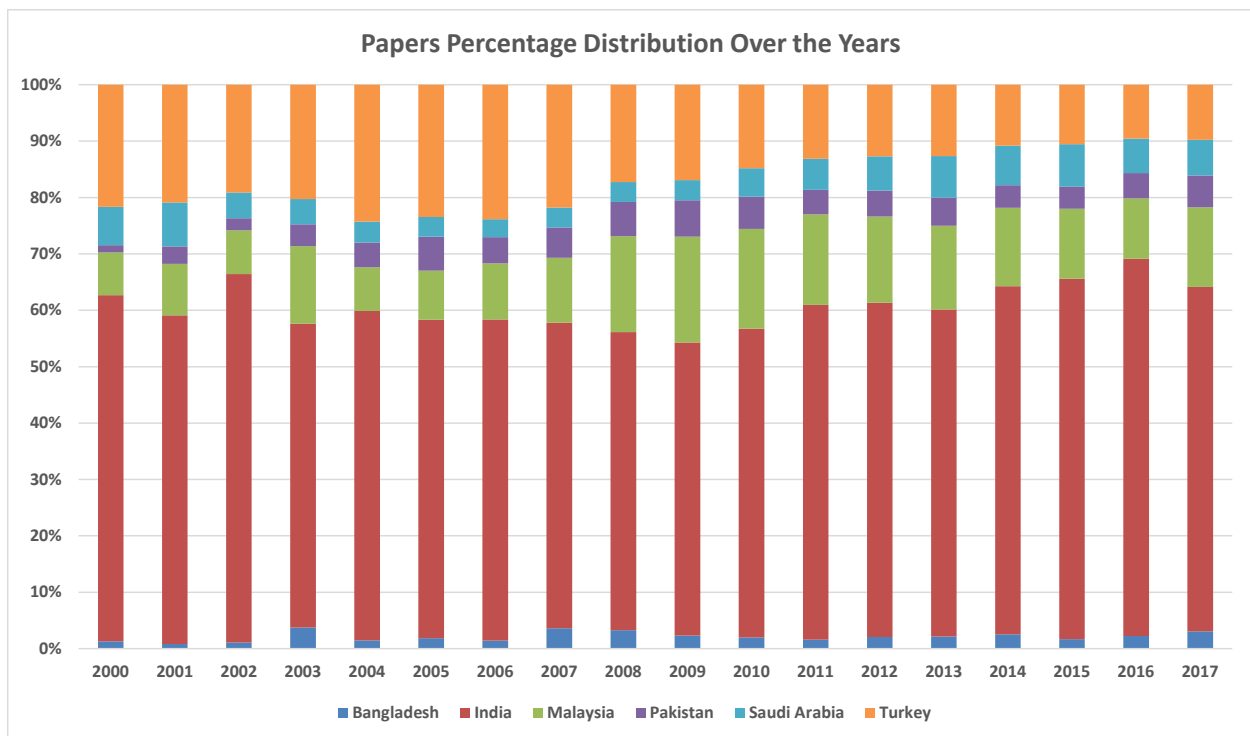


Figure 5 shows the percentage count of the computer science literature published over the years from 2000-2017

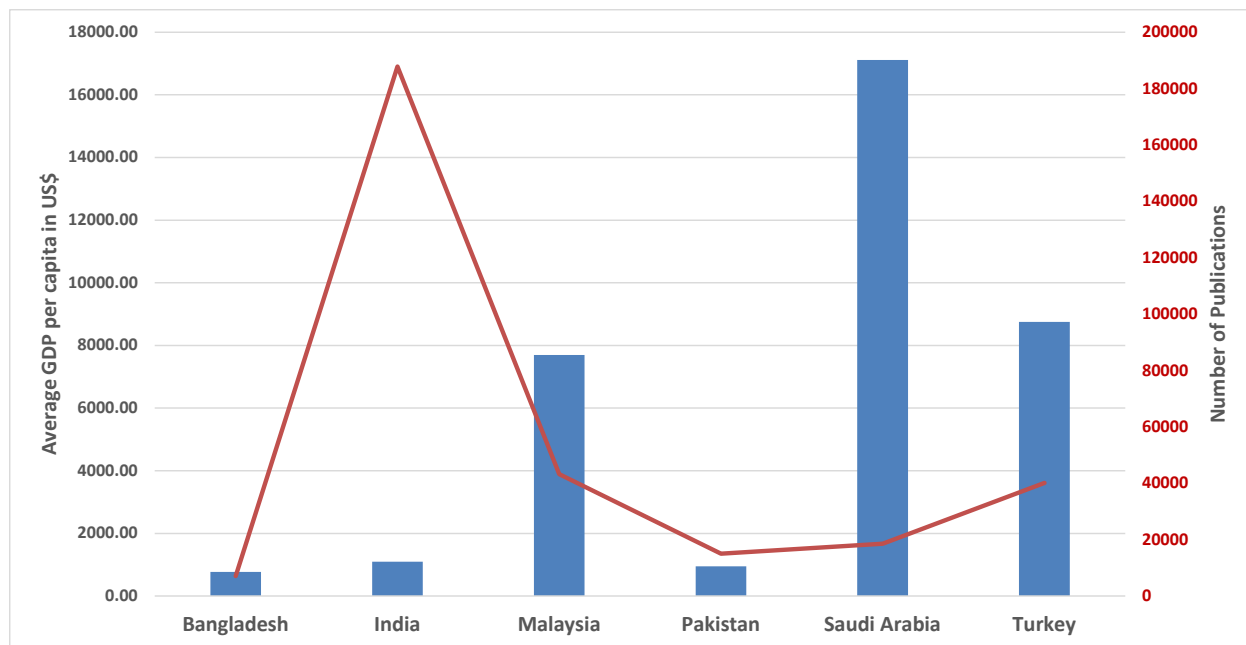


Figure 6 shows the comparison of the GDP per capita against the Number of publications over the years from 2000-2017 by Bangladesh, India, Malaysia, Pakistan, Saudi Arabia and Turkey.

GDP shows the growth of the country in terms of how much a person can generate given the suitable environment by the government in that particular country. GDP per capita shows the average GDP generated by each individual in a particular year. We take a look at the GDP per capita in comparison to the number of publications among the selected countries. The results are shown in a graph in Figure 6. From the figure it is evident that the Bangladesh with the lowest GDP per capita has the lowest outcome in terms of publications. Bangladesh in comparison to India and Pakistan with the almost the same levels of GDP per capita, Pakistan shows some improvement as its publications mark surpasses its GDP per capita mark. In contrast India shows a huge peak if we look at its publications line in the graph almost in level to the GDP per capita mark of Saudi Arabia. Malaysia shows an average performance as its publications are somewhat in the middle of its GDP per capita readings. Saudi Arabia on the other hand having the highest GDP per capita among the selected countries shows a very low value in terms of publications. Turkey does show average performance but if we compare it to Malaysia, its GDP per capita is high but its publications show a lower value than Malaysia. From the comparison it is concluded that the GDP per capita does not necessarily result in higher publication count.

There is another factor that might be interesting to take such as the GDP spending on the R&D of a country. This could give us more insight into the spending at the research area that could yield the development. The data is taken from the UNESCO online database [27]. We have taken the values for each year for the eighteen years i.e., from 2000 to 2017 and then we calculated the average of these values. The results are shown in Figure 7. The result shows that India shows an exceptional case where it spends a mere of 25.98\$ per year on the R&D which results in a massive amount of publications. Malaysia and Saudi Arabia spends a huge amount on R&D i.e. 205.01\$ and 167.33\$ respectively but their results are not satisfactory at all in publications. Pakistan on average have a spending of the lowest among the selected countries i.e. 12.75\$ but the publication results are promising. Turkey also despite having a large spending on the R&D with 127.44\$, does not show promising results in its publications. Bangladesh is not shown here in the figure as there were no given values for R&D spending of Bangladesh on the UNESCO site.

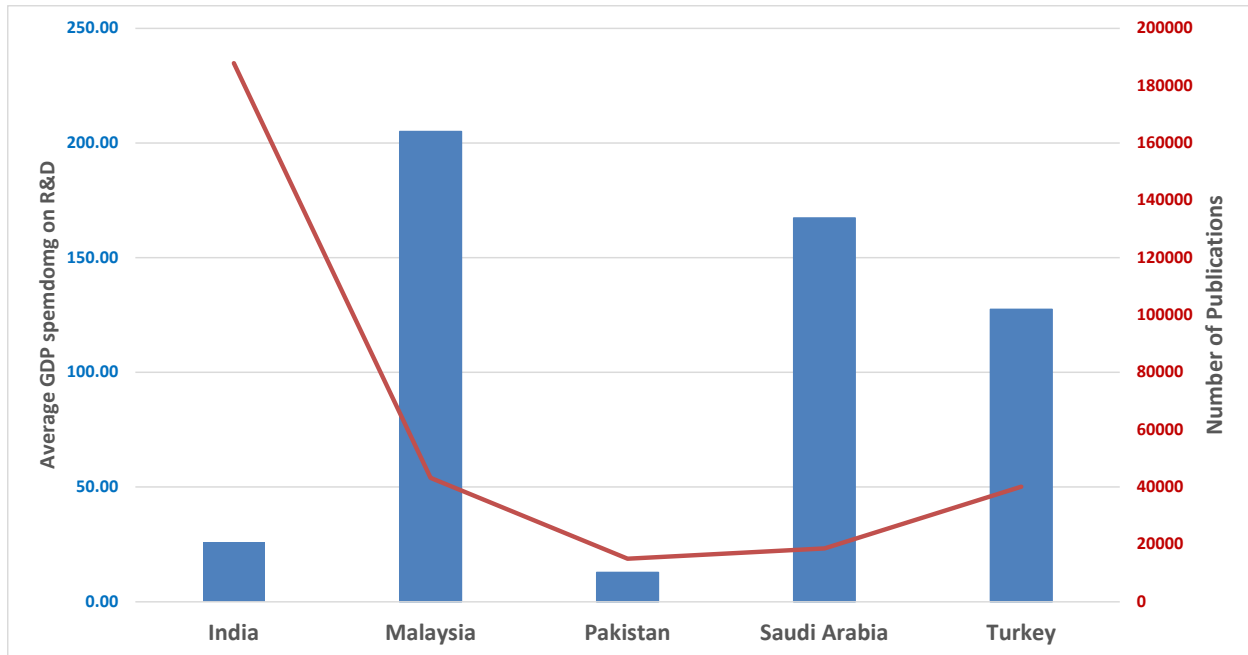


Figure 7 shows the comparison of the Average GDP spending on the R&D against the number of publications for India, Malaysia, Pakistan, Saudi Arabia and Turkey (except Bangladesh).

5 Limitations of the study

Like many scientific studies, our study has its limitation. For example, replicating the study might show slightly different results as the number of citations vary from source to source. Citation count for a paper in Scopus might vary than the one reported by Google Scholar or ISI Web of Knowledge. Further the data was taken from Scopus on 10th April 2018 which might be subject to change if searched afterwards.

6 Conclusion

This work presents a systematic analysis of the research work performed by the Pakistani researchers in the field of computer science over a span of eighteen years i.e., from 2000 to 2017. We found out that almost 38% of the publications get zero citations and on average each publication gets 4.48 citations. Moreover, single authored papers account for a mere 4% whereas 2 and 3 authored papers account for more than 50% of the total pool with an average of 3.57 authors per publication. The leading institute with most publications is the NUST followed by COMSATS.

This work can be extended to form a citation network and its various types can also be used to calculate the citation relations such as direct citation, co-citation analysis and bibliographic coupling relation. Further keyword co-occurrences of the publications and co-authorship relationships can also be discovered. The historiography can be used to illustrate the publication network of publications that are published and cited over time.

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