

Growth Trend of Artificial Intelligence in Research and Development: Some Insights

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Abstract:

The role of AI in Research and Development (R&D) is crucial and significant. It accelerates innovation, enhancing data analysis, and optimizing workflows, leading to more efficient and effective research processes. The Institute for Human-Centered AI, Stanford University, Stanford published “The AI Index 2024 Annual Report” in April 2024. The numerical data on the different characteristics for the years starting from 2012 to 2022 are considered from the AI Index 2024 Annual Report.

In this paper, the approach is to quantify the influence of Artificial Intelligence (AI) in research and development globally based on the different quantifiable characteristics like number of AI publications, number of AI granted patents, number of AI projects completed, etc. Based on the numerical data, some trends and patterns on the growth are obtained and some future values are predicted for the year 2025. It is observed that there is an increasing trend in the overall contribution of AI in Research and Development.

Keywords: Number of AI publications, Number of AI patents granted, trend, growth in AI

1. Introduction:

The utility of Artificial Intelligence (AI) in higher education has risen rapidly in the last five to ten years. It transforms education by enabling personalized cost effective and interactive learning which improves the students engagement in learning. AI can help teachers to provide immediate assistance to the students with respect to the areas of difficulties by enhancing comprehension which helps in bridging the gap in understanding. In all, the role of AI in education helps to improve teaching and learning experience of the students.

The role of research and development (R&D) in the enhancement of AI is crucial. Similarly, the role of AI in enrichment of research and development is vital. A researcher can take help from AI to streamline the research process. The AI tools can help researchers to discover new sources which reduce time and efforts to identify quick and relevant literature. AI enables fast analysis of voluminous data, identifies patterns and trends and makes predictions which ultimately accelerate the process across various scientific fields. AI acts as a powerful tool to enhance decision-making and optimize R&D processes.

Ivanova, Grosseck and Holotescu (2024) presented a bibliometric study of scientific production indexed in Scopus and Web of Science databases carried out between 2018 and 2023. The finding of this study increased the understanding of AI in the teaching domain. The impact of AI on education from researchers’ and practitioners’ perspectives, Ifenthaler et al. (2024) in their article outlines policy recommendations for AI in education and suggests a research agenda for closing identified research gaps. Almasri (2024) attempted to undertake a systematic review which examined the impact, perceptions, and challenges associated with the integration of Artificial Intelligence (AI) in the teaching and learning of science. It revealed that AI-powered tools are integrated into science education to achieve various pedagogical benefits, including enhancing the learning environment, creating quizzes, assessing students’ work, and predicting academic

performance. Crompton and Burke (2023) provided a systematic review which revealed gaps in the literature to be used as a springboard for future researchers, including new tools, such as Chat GPT. The systematic reviews showed that the United States led by a large margin in the number of studies published and the trend has now shifted to China. Stanford University, Stanford recently published an annual report on AI Index 2024. The report is self explanatory and covers almost all dimensions. This report covers essential trends of AI in research and developments, economy, science and medicine, education, policy and governance, technical advancements in AI, public perceptions of the technology and the geopolitical dynamics surrounding its development.

Based on the data given in the annual report on AI Index 2024, the primary goal of this article is to explore the influence and trend of Artificial Intelligence (AI) in research and development based on the different quantifiable characteristics like number of AI publications, number of AI granted patents, number of AI projects completed, etc. The article is organized as follows: In Section 2, we study the number of AI publications over the last decade (from year 2012 to year 2022) and their Year on Year (YoY) growth rate will be computed to predict the trend. Section 3 illustrates the field of study wise yearly number of publications published between the year 2012 and year 2022. The number of AI patents granted over different years along with growth rate were presented in Section 4 and the estimated number of patents for the year 2025 were reported. Section 5 demonstrates the trend in the number of AI projects undertaken during the year 2012 to 2022. The article ends with concluding remarks.

2. Number of AI Publications:

The main characteristic to quantify the progress of AI in research and development is to study the number of publications published in different journals and conference proceedings. The annual report on AI Index 2024 issued the numerical data on the number of publications published in different journals and conference proceedings. Also, the total number of publications published globally were reported in that annual report. The same is given in Table 1 for the years 2012 to 2022. To obtain the year on year (YoY) growth rate, the following formula is used and the values are reported in Table 1.

$$\text{YoY growth rate} = \frac{\text{Value in the current year} - \text{Value in the previous year}}{\text{Value in the previous year}} \times 100$$

A simple ‘scatter plot’ graphical tool is used to represent the year wise number of AI publications. Also, the polynomial regression model of order two is used to model the data and the trendline of the polynomial regression model is depicted in Figure 1.

Table 1. Year wise number of AI publications (in thousands) with YoY growth rate

Year	Number of AI publications (in thousands)					
	Journal	YoY growth rate	Conference	YoY growth rate	Total	YoY growth rate
2012	81.220	–	13.648	–	89.097	–
2013	87.249	7.42	11.863	–13.08	92.240	3.53
2014	92.733	6.29	13.147	10.82	97.377	5.57

2015	96.890	4.48	15.908	21.00	104.872	7.70
2016	100.55	3.78	16.720	5.10	108.645	3.60
2017	109.949	9.34	18.898	13.03	120.519	10.93
2018	131.579	19.67	21.878	15.77	143.396	18.98
2019	163.777	24.47	24.350	11.30	177.182	23.56
2020	189.110	15.47	22.727	-6.67	201.635	13.80
2021	222.659	17.74	31.629	39.17	239.594	18.83
2022	232.673	4.50	41.174	30.18	242.289	1.12

Source: The annual report on AI Index 2024.

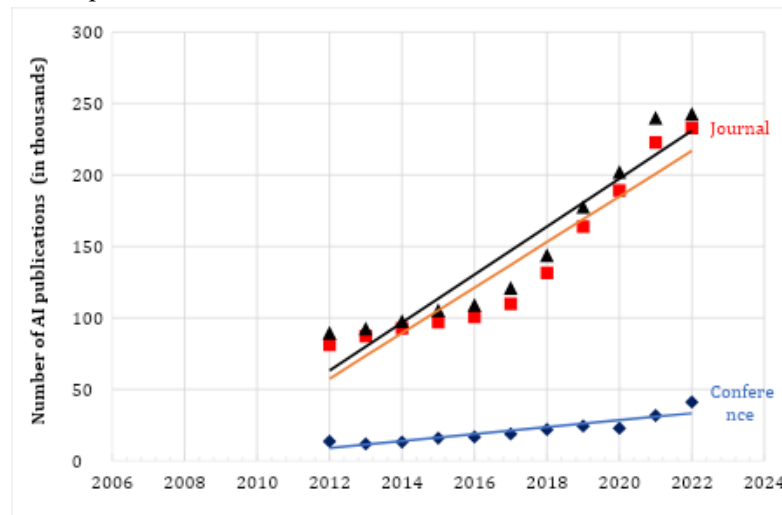


Figure 1. Scatterplot of Year wise number of AI publications (in thousands) with polynomial trendline of order two.

From Table 1 and Figure 1, it is observed that the number of publications in conference proceedings is comparatively smaller than that of the publications in journals. The YoY growth rate for the number of publications is always positive for all years except for 2013 and 2020 in the conference proceeding category. It means that, on average, there is an increasing trend in the number of publications.

A polynomial model of order two is used to model the number of publications in a journal. From Figure 1, it is observed that the value of R-square is 0.9841, which means the model fits well to the data and the predicted number of publications in journals for the year 2025 by using the same model is 361.107 thousands.

For the number of publications in conference proceedings, the same polynomial model of order two is fitted and the value of R-square is 0.9391. It means the polynomial model of order two fits

well to the data and the estimated number of publications in conference proceedings for the year 2025 is 57.500 thousand.

3. Field of Study wise Number of AI Publications:

In the annual report on AI Index 2024, the number of publications were classified in different fields of studies which includes machine learning, computer vision, pattern recognition, process management, computer network, control theory, algorithm, linguistics, and mathematical optimization. The following table represents the number of publications according to the field of study for the year 2012 to year 2022. Also, the same data is depicted graphically in Figure 2.

Table 2. Field of study wise number of AI publications (in thousands)

Year	Field of study wise Number of AI publications (in thousands)								
	Mathematical optimization	Linguistics	Algorithm	Control theory	Computer network	Process management	Pattern recognition	Computer vision	Machine learning
2012	2.929	4.237	6.237	5.912	1.089	11.95	10.604	11.456	6.894
2013	3.237	4.233	6.381	6.397	1.172	12.157	11.404	12.386	7.614
2014	3.455	4.857	6.579	6.776	1.248	12.165	12.274	12.634	8.676
2015	3.914	4.782	6.6	7.065	1.268	12.56	12.814	13.246	10.504
2016	3.85	4.854	6.051	6.897	1.702	13.063	12.397	12.034	12.78
2017	4.071	4.504	6.183	6.871	2.721	12.848	12.791	12.178	17.539
2018	4.622	5.002	6.702	7.391	4.658	14.516	13.967	13.598	27.132
2019	5.504	5.396	7.222	8.154	6.816	15.226	16.142	15.83	39.165
2020	6.093	6.399	7.258	8.253	7.954	15.045	16.646	16.59	50.81
2021	6.777	6.807	8.214	9.0	9.756	12.478	19.28	19.56	65.2

02 1				59			4	2	48
2 02 2	6.832	7.176	8.309	9.1 71	10.38 6	12.052	19.84 1	21.30 9	72.2 29

Source: The annual report on AI Index 2024

Table 2 and Figure 2 represents the field of study wise number of publications published during 2012 to 2022. On an average, it is seen that the number of publications in almost all fields goes on increasing as time passes. For the year 2022, it is observed that the number of publications in the machine learning field is comparatively larger than that of the remaining fields while the number of publications in mathematical optimization are smaller. Up to year 2017, the number of publications in the computer network field are less than that of the other fields. From the year 2018, the number of publications in mathematical optimization are smaller than that of the other fields except 2019.

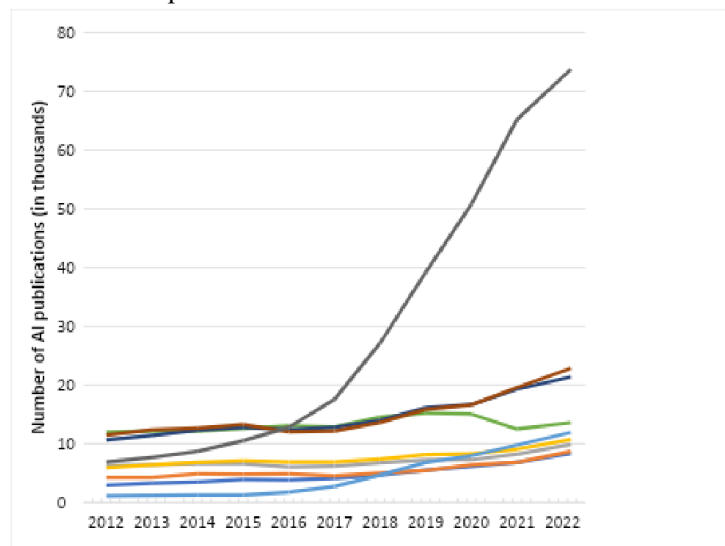


Figure 2. Line diagram showing field of study wise number of AI publications (in thousands)

4. Number of AI Patents Granted:

To reveal the evolution of innovation, research and development within AI, it is important to study the number of AI patents granted over the years. The annual report on AI Index 2024 summarized the noticeable data on the number of AI patents granted globally. Table 3 represents the number of AI patents granted from the year 2012 to year 2022. Also, the YoY growth rate is obtained and reported in Table 3. To study the trend, a polynomial regression model of order two is trained on the data on number of AI patents granted and the same is reported in Figure 3.

Table 3 and Figure 3 studies the trend in the number of AI patents granted over different years. It is observed that in the year 2019, there is a drastic increase i.e. 93.80% in the number of AI patents granted as compared to previous year 2018. Over time, the number of AI patents granted increases. For two years, 2021 and 2022, the total number of AI patents granted were 100.532 thousands while for the remaining years (i.e. from 2012 to 2020) the total number of AI patents granted were 68.193 thousands. It means that for 2021 and 2022, the total number of AI patents granted were increased by 47.42%.

From Figure 3, it is observed that the value of R-square is 0.9581, which means the model fits well to the data and the predicted number of AI patents granted for the year 2025 by using the same model is 111.714 thousands.

Table 3. Year wise number of AI patents granted (in thousands) with YoY growth rate

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Number of AI patents granted (in thousands)	2.648	2.723	3.120	3.505	3.761	5.136	8.144	15.783	23.373	38.268	62.264
YoY growth rate	-	2.83	14.58	12.34	7.30	36.56	58.57	93.80	48.09	63.73	62.71

Source: The annual report on AI Index 2024

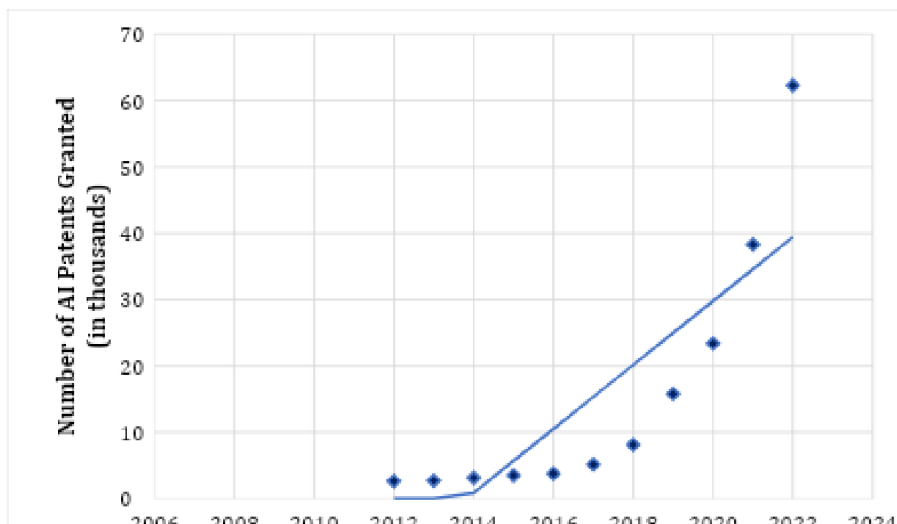


Figure 3. Scatterplot of year wise number of AI patents granted (in thousands) with polynomial trendline of order two.

5. Number of AI Projects:

The annual report on AI Index 2024 reported a GitHub AI project which is related to a collection of files of source code, documentation, configuration files and images that together make up a software project. To study the progress of research and development, the count on the number of AI related projects in the annual report on AI Index 2024 is considered. Table 4 represents the number of AI projects (in millions) from the year 2012 to year 2022. Also, the geographic area wise AI projects percentage of total is recorded in Table 4. To study the trend, a multiple line diagram is used and the same is presented in Figure 4.

Table 4 and Figure 4 illustrate the year wise trend in number of AI projects ((in millions) with percentages according to geographical area. It is observed that as the year passes, the number of AI projects increases. For three years, 2020 to 2022, the total number of AI projects were 2.651939 millions while for the remaining years (i.e. from 2012 to 2019) the total number of AI projects were

0.979671 millions. It means that for 2020 to 2022, the total number of AI projects were increased by 170.70%.

Table 4. Year wise number of AI projects (in millions) with percentages according to geographical area

Year	Number of AI projects (in millions)	Geographic area wise AI projects (% of total)				
		China	European Union and United Kingdom	India	United States	Rest of the world
2012	0.002272	3.2570	27.2007	2.9930	52.2447	14.3046
2013	0.005520	5.9058	24.8007	3.6413	47.8080	17.8442
2014	0.014004	5.8555	24.0146	5.0486	45.2942	19.7872
2015	0.032298	5.7434	22.1500	5.4895	43.8944	22.7228
2016	0.065476	6.6757	20.7908	6.3825	41.8382	24.3127
2017	0.150139	8.2490	19.3108	8.8671	37.1802	26.3929
2018	0.277995	8.8476	18.3608	12.0085	33.1524	27.6307
2019	0.431967	8.7995	17.8940	14.4083	29.7643	29.1339
2020	0.646613	7.7621	17.6098	17.6995	26.6728	30.2557
2021	0.869692	6.1875	17.5588	19.6548	24.0446	32.5544
2022	1.135634	3.9959	18.2240	19.4575	23.4544	34.8682

Source: The annual report on AI Index 2024

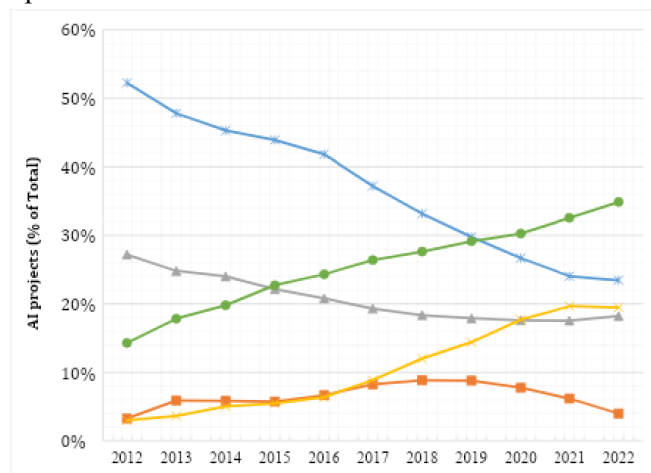


Figure 4. Line diagram showing geographic area wise AI projects (% of total)

It is also observed from Table 4 and Figure 4 that 23.45% stake of AI projects were located in the United States while India is in second position with 19.46% share during the year 2022. Notably, it is seen that the proportion of AI projects from the United States and European Union and United Kingdom shows a declining trend. However, the proportion of AI projects from India steadily increases. The proportion of AI projects from China has declined during the last five years (i.e. from 2018 to 2022).

Conclusion:

This research is mainly based on the study of the contribution of AI in research and development during the year 2012 to 2022. The main finding increased our understanding about the AI based publication of research articles, patent granted and projects completed during the last decade. In essence, our study affirms that the role of AI in research and development goes on increasing as years passes.

Data Source: The secondary data is taken from “The AI Index 2024 Annual Report” published by Institute for Human-Centered AI, Stanford University, Stanford, CA.

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