



## Patents, Publications, and Global Market: A Comprehensive Case Study of Global Emerging Technologies

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*Received: 24<sup>th</sup> August 2024; revised: 5<sup>th</sup> August 2025*

The study analyses patent and publication trends of the top ten emerging technologies to understand their transformative impacts. Technologies such as Semiconductors, 3D printing, AR/VR, blockchain, IoT, AI, quantum computing, edge computing, gene editing, and green hydrogen are examined quantitatively to identify key players, technological focuses, and innovative insights.

Six of the ten technologies exhibit higher patent counts than publications, indicating active exploration and adoption by industries. Conversely, four technologies show lower patent activity, signaling early development stages with significant future promise.

The study emphasizes the importance of collaboration between academia and industry to bridge the gap between patent filings and academic publications. Additionally, the distribution of companies across countries underscores the significance of global collaboration in driving innovation.

In conclusion, strategic investment in research and development, collaboration, and global cooperation are vital for maximizing societal benefits from emerging technologies. The study also underlines the need to strengthen the intellectual property base and leveraging these technologies for progress towards Industry 4.0.

**Keywords:** Knowledge Economy, Innovations, 3D Printing, Patents, Make in India

Throughout history, technology has been pivotal in shaping human civilization and propelling progress across various domains. The term "technology" finds its roots in the ancient Greek word "techne," which encompasses the concepts of art, skill, and craft.<sup>1</sup> From the earliest civilizations, humans have harnessed technology to enhance daily activities, constantly striving for greater efficiency and productivity. The evolution of technology has brought about significant advancements that have transformed economic activities and yielded remarkable gains. By integrating advanced technologies, businesses have revolutionized production processes, streamlined operations, and opened new frontiers for growth and innovation.<sup>2</sup> The strategic adoption of cutting-edge tools and equipment has empowered organizations to achieve unprecedented productivity, cost-effectiveness, and market competitiveness. By leveraging technology in economic activities,

businesses have witnessed a paradigm shift in how they operate and deliver value.<sup>3</sup>

In today's context, using technology in economic activities has become a catalyst for success. It has led to optimized production processes, automation, and digitization, enabling organizations to produce more output with fewer resources and achieve greater operational efficiency. In a rapidly evolving technological landscape, it is crucial to identify and comprehend the pivotal technologies that are projected to drive significant changes across industries.<sup>4,5</sup> Measuring and analyzing trends in emerging technologies has become crucial for comprehending their growth and influence. Patents and publications serve as valuable data sources for gaining insights into these trends. Patents are indicators of technological progress and innovation, representing legally protected inventions and ideas.<sup>6,7</sup> Publications, on the other hand, provide insights into the research community's contributions to emerging technologies. They offer detailed information on research findings, methodologies, and theoretical

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advancements. Analysing publication data helps uncover emerging trends, identify key contributors, and trace the evolution of knowledge within specific technology areas. Correlating the number of patents and publications facilitates the identification of potential research gaps and sheds light on the nature of the relationship, whether it is positive, negative, or non-existent, between Technological innovation and Academic research. Identifying organizations or institutions with significant patent portfolios sheds light on key players driving technological advancements and innovation. Harnessing the vast information within these sources provides valuable insights for informed decision-making and future technological advancements.

The primary objective of this study is to present the emerging technological trends that are expected to have transformative impacts. As the technology matures, assessing patent and publication trends becomes crucial to predict growth areas and foster further breakthroughs. This study analyzed patent and publication trends of top ten emerging technologies of the world. With the status of patent applications and academic publications, key technological focus, major contributors, and innovation insights were identified for the emerging technologies.

### **Methodology**

The research design for this study is quantitative analysis and interpretation of data related to top ten emerging technologies. At the time of research, our aim was to ensure that the selection reflected both relevance and consensus across reputable and diverse sources. We adopted a comparative synthesis approach, triangulating across multiple globally recognized foresight reports and publications.

Afterwards, we ranked the technologies based on the patents and publication count. Specifically, we referred to foresight studies by leading consulting firms (e.g., McKinsey & Company, Deloitte, and the World Economic Forum), innovation-focused publications (e.g., Forbes, MIT Technology Review), and Indian government reports such as TIFAC 2047. Technologies that consistently appeared across these sources were shortlisted, as their recurrence indicated broad emerging relevance.

Patent data was collected from the Derwent Innovation database, encompassing variables such as the number of patents, assignees, technology classifications, and publication years at the

Department of Management Studies, IIT Roorkee. Similarly, publication data was obtained from the Web of Science, encompassing variables such as the number of publications and publication years. For patent data analysis, systematic searches were conducted in the Derwent Innovation database using relevant keywords and filters, resulting in the retrieval of patent titles, inventors, assignees, technology classifications, and publication dates (2001-2022). The collected data was then saved in Excel spreadsheets for further analysis. For publication data analysis, a search was conducted in the Web of Science using specific search terms related to each technology. The data related to the number of publications per year was extracted from the search results and recorded in an Excel spreadsheet. Graphical analysis using PowerBI was performed to visualize the number of patents in each selected technology by top corporations/organizations and by years.

This allowed for the identification of key players and trends in patent filings over time. It is important to acknowledge the limitations of this study, such as the reliance on patent and publication data, which may not capture the full extent of technological advancements or the impact of emerging technologies. Additionally, the quality and coverage of the data sources may vary, potentially affecting the generalizability of the findings. The analyzed data was interpreted in the context of the research objectives and research questions.

### **Results**

On the basis of a careful analysis of multiple reputed sources, including Forbes, the World Economic Forum, and McKinsey reports the top ten emerging technologies selected for the study were: Semiconductors, AI, IoT, AR/VR, Blockchain, 3D printing, edge computing, gene editing, quantum computing, and green hydrogen (Table 1, Fig. 1). The individual technologies were studied for their patent and publication trends over the years. During the last year of the study period (from 2001-2022) under investigation semiconductor technology leads the top ten emerging technologies with 64554 patents followed by AI (57276) and IoT (48138) in the top three technologies. On the other hand, in the year 2022 (the last year of the study period) AI technology leads the top ten emerging technologies with 40065 publications followed by semiconductors (24749)

Table 1 — Top ten emerging technologies (Number of publications and patents of year 2022)

Technologies	Publications	Patents
AR/VR	6532	36802
Quantum Computing	9586	2477
Edge Computing	10133	7792
Green Hydrogen	5988	201
AI	40065	57276
IoT	14017	48138
3D printing	10571	19322
Semiconductor	24749	64554
Gene editing	5766	4448
Blockchain	4983	21812

and IoT (14017) in the top three technologies (Table 1, Fig. 2).

### Semiconductor

Semiconductor technology has been the leader in the world of innovation and IPR. Semiconductor possesses a conductivity level that lies between conductors and insulators. They find extensive usage in the realm of electronics and play a vital role in driving contemporary technology. Typically, semiconductors are composed of materials like silicon or germanium. These materials possess a distinctive property wherein their conductivity can be regulated

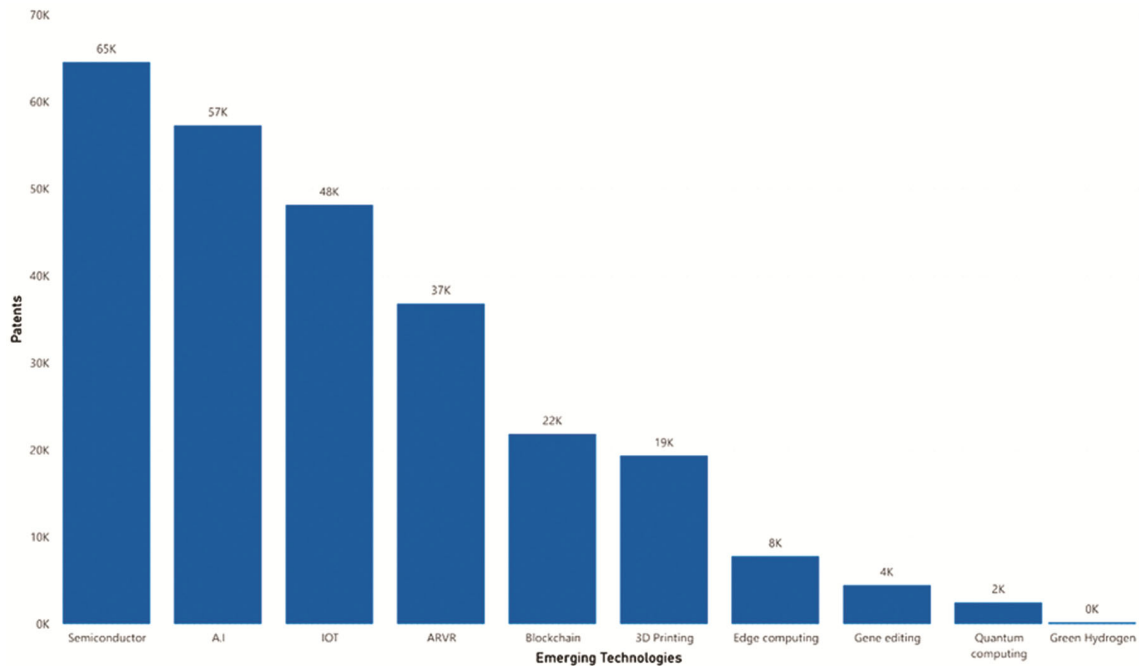


Fig. 1 — Top ten emerging technologies (Number of patents of 2022)

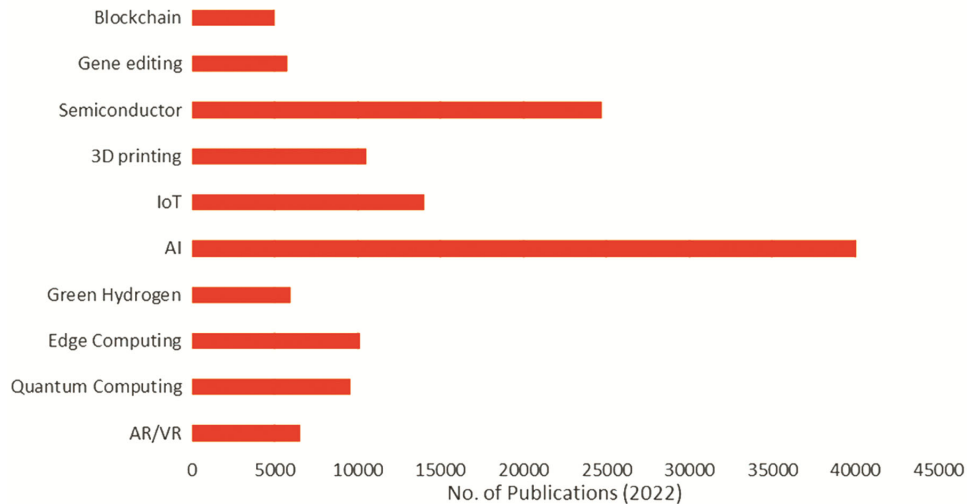


Fig. 2 — Top ten emerging technologies (Number of publications of 2022)

and manipulated by the introduction of impurities; a process commonly referred to as doping. Doping involves the inclusion of atoms from diverse elements into the crystal structure of the semiconductor, thereby modifying its electrical characteristics.<sup>13</sup> South Korea, the USA, Taiwan, and Japan are the topmost players of semiconductor technology (Fig. 3). South Korea is the world leader with Samsung as the topmost company as the global leader in the technology. USA follows the South Korea with IBM as the top corporation.

Unlike all other technologies, since the advent even the patents have always been much higher than the publications in semiconductor technology (Fig. 4). In 2022, the number of patents were more than 2 folds than that of publications.

**Artificial Intelligence (AI)**

AI refers to the development of computer systems that can perform tasks that typically require human intelligence. It involves the creation of intelligent machines capable of learning, reasoning, and

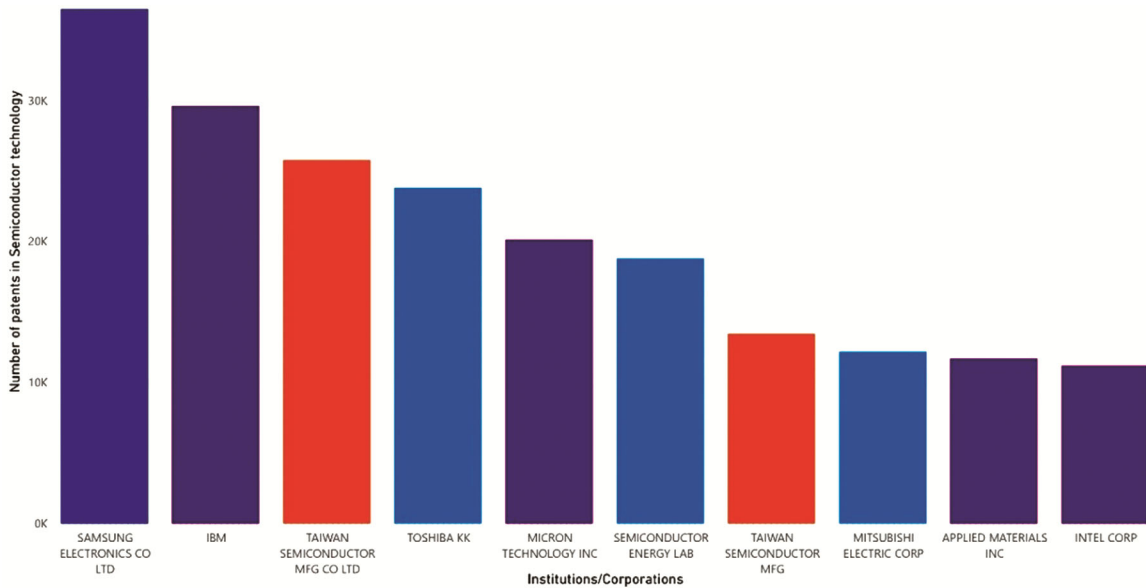


Fig. 3 — Top companies and countries contributing Semiconductor technology innovation through patents

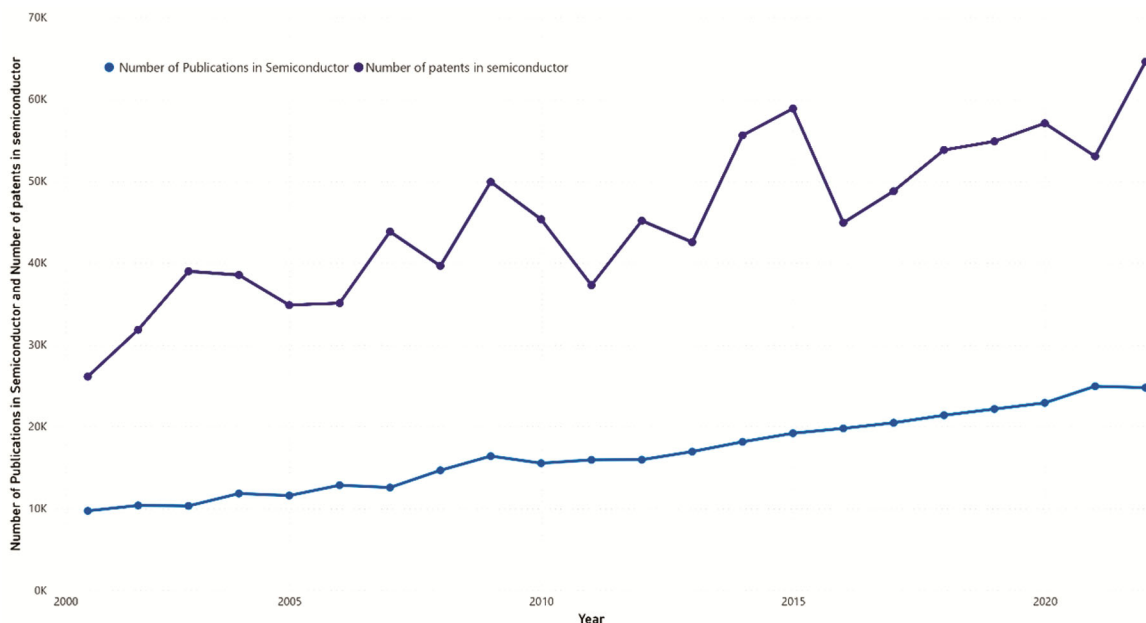


Fig. 4 — Global overview of publications and patents on Semiconductor technology

problem-solving. AI encompasses various subfields, including machine learning, natural language processing, computer vision, and robotics.<sup>14</sup> The study marked a striking observation is that China emerges as a significant driving force behind AI innovation, with six companies from China among the top 10. The remaining positions are occupied by two companies from South Korea and two from the United States. At the forefront of this section is Beijing Baidu Netcom Sci & Tech Co Ltd, demonstrating its strong leadership in AI patents. This pattern suggests that China has made remarkable strides in A.I. technologies, showcasing its commitment to technological advancements and positioning itself as a prominent player in the global A.I. landscape.

Tables 2 & 3 provide an insightful depiction of the number of patents and publications in the field of Artificial Intelligence (A.I.) over the years. A notable growth pattern emerges, revealing an interesting trend in the development of A.I. technologies. From 2001 to 2017, the graph illustrates the number of publications in AI was consistently greater than the number of patents, indicating a focus on the conceptual stage of the technology. However, in 2018, there was a significant shift as the number of patents in A.I. spontaneously exceeded publications, marking a pivotal moment in the commercialization and implementation of A.I. in various industries. This trend continued, with the graph showing that in 2022,

there were 57,276 patents in A.I. compared to 40,065 publications. This shift in 2018 signifies a crucial turning point in A.I. technology, indicating its progression towards practical applications and real-world implementation across different sectors.

### Internet of Things (IoT)

IoT refers to a network of interconnected physical objects, vehicles, appliances, and devices embedded with sensors, software, and connectivity capabilities.<sup>14-16</sup> These objects can gather and share data, allowing them to communicate and interact with each other and with humans via the internet.

A comprehensive view of the number of patents in the field of Internet of Things (IoT) was categorized by top institutions/corporations in the study. Interestingly, there is no single leading country and the companies figuring in the top 10 list are widely distributed across different nations. Notably, companies from China, South Korea, Sweden, and the USA make up this list, highlighting the global nature of IoT innovation. However, it is worth mentioning that Samsung Electronics from South Korea stands out with the highest number of patents in the field of IoT. This emphasizes Samsung Electronics' significant contributions and leadership in driving IoT advancements. The study underscores the collaborative and diverse nature of IoT development, with companies from various countries actively participating in shaping the future of this technology.

Table 2 — Number of patents in emerging technologies from 2001 to 2022

Year	3D printing	AR/VR	Blockchain	Gene editing	Green hydrogen	Internet of things (IOT)	Quantum computing	Semiconductor	AI	Edge Computing
2022	19322	36802	21812	4448	201	48138	2477	64554	57276	7792
2021	18924	31290	31985	3431	46	44760	1696	53000	42055	5177
2020	16580	27762	25442	2393	6	33950	1115	57032	24436	3134
2019	15069	24307	11404	1815	4	25532	837	54824	13413	1521
2018	13194	19222	3763	1073	3	20582	408	53772	6147	581
2017	10515	13471	706	567	3	12803	239	48758	2772	198
2016	7158	7723	135	322	1	7232	156	44886	1613	37
2015	4059	5075	26	145	2	4600	132	58824	1330	29
2014	1669	3978	2	66	1	2488	126	55558	1227	23
2013	660	3014	2	14	5	2292	103	42518	1058	23
2012	404	2706	1	5	1	1921	100	45139	982	14
2011	222	1709	2	1	1	868	94	37255	905	8
2010	191	1265	1	6	0	250	93	45311	833	6
2009	157	1200	3	6	1	69	86	49881	780	0
2008	152	1026	0	7	1	3	85	39613	762	12
2007	171	981	1	7	0	2	84	43800	723	13
2006	171	969	1	1	0	7	83	35068	694	13
2005	153	885	0	7	0	2	80	34832	605	10
2004	128	909	2	6	0	1	77	38503	549	8
2003	93	964	3	0	0	5	67	38950	520	7
2002	87	1066	0	0	1	0	48	31819	465	4
2001	93	796	0	0	0	0	18	26103	343	3

Table 3 — Number of publications in emerging technologies from 2001 to 2022

Year	3D printing	AR/VR	Blockchain	Gene editing	Green hydrogen	Internet of things (IOT)	Quantum computing	Semiconductor	AI	Edge Computing
2022	10571	6532	4983	5766	5981	14017	9586	24749	40065	10133
2021	9626	6088	3768	5463	5162	12111	8862	24924	29833	8899
2020	7452	4974	2462	5193	3837	9586	7754	22891	18956	7322
2019	5869	3925	1169	4790	3108	7112	6774	22140	10581	5687
2018	4233	2920	395	4037	2560	4621	5882	21379	5580	4468
2017	3031	2177	115	3537	2190	283	5385	20462	3606	3629
2016	1980	1703	19	3201	1892	1734	5018	19775	2811	3076
2015	1209	1302	3	2406	1617	929	4584	19181	2535	2754
2014	690	1212	0	1975	1487	654	4168	18135	2396	2665
2013	285	1213	0	1635	1273	394	3916	16941	2233	2443
2012	175	960	0	1443	1196	179	3494	15951	1938	2201
2011	132	863	0	1218	1002	90	3334	15930	1815	1996
2010	94	855	0	1076	831	46	2946	15526	1577	1843
2009	98	742	0	910	736	24	3130	16391	1627	1778
2008	69	592	0	456	583	9	2470	14654	1539	1466
2007	60	627	0	177	547	18	2116	12554	1466	1312
2006	39	685	0	182	416	17	2049	12836	5817	1544
2005	42	582	0	157	399	11	1986	11572	6978	1399
2004	20	515	0	164	330	9	1781	11819	3856	1314
2003	24	466	0	126	337	13	1612	10306	4360	1094
2002	8	342	0	136	279	18	1566	10370	2562	956
2001	19	354	0	121	238	8	1339	9704	1878	834

Table 2 & 3 provide insights into the number of patents and publications in the field of Internet of Things (IoT) over the years, as well as the number of patents in IoT specifically. From 2001 to 2009, a slow and steady pace is observed in both patents and publications. However, starting in 2010, there has been a noticeable acceleration in the number of patents, indicating a significant shift in the pace of innovation and development in IoT. This trend continues to advance, creating a substantial gap between patents and publications in IoT by 2022, with 48,138 patents compared to 14,017 publications. This significant difference highlights the rapid and exponential growth in IoT patents, signifying the ever-increasing implementation, growing demand, and continuous innovation in the field of IoT. The remarkable surge in IoT patents demonstrates the industry's dynamic nature and the widespread adoption of IoT technologies, underscoring its potential to revolutionize numerous aspects of our daily lives.

#### Augmented Reality (AR) and Virtual reality (VR)

AR are advanced technologies that provide users with immersive and interactive experiences in real or virtual environments. AR combines digital elements with the real world, overlaying computer-generated images, videos, or information onto the user's physical surroundings. By seamlessly blending digital content with the real environment, AR enhances the

perception of reality and enables users to interact with virtual objects and information in their immediate surroundings.<sup>14</sup> VR on the other hand, transports users into entirely virtual environments, disconnecting them from the physical world and immersing them in computer-generated surroundings. Using VR headsets and controllers, users can explore and interact with virtual worlds, experiencing a heightened sense of presence and immersion.

The study revealed that the United States is the leading country in this technology, with six companies among the top 10. South Korea and China also have representation in the top 10 positions. While the United States holds the overall lead, it is worth mentioning that the company with the highest number of patents in AR/VR is Samsung Electronics from South Korea. This showcases the significant contribution of Samsung Electronics in driving innovation in the AR/VR domain. The dominance of the United States and the noteworthy presence of Samsung Electronics underscore the global significance of these countries and companies in advancing AR/VR technologies.

From an analysis of results of the study (Table 2 & 3) it becomes evident that both patents and publications were steadily increasing until 2010, demonstrating a gradual progression in the field. However, in 2011, a notable change occurred as the number of patents in AR/VR begins to accelerate,

leading to remarkable growth over time. This acceleration creates a significant gap between patents and publications, with the graph illustrating 36,802 patents in AR/VR compared to just 6,532 publications. This substantial difference indicates a rapid rise or boom in AR/VR patents, highlighting a surge of interest and investment in this technology. The surge in patents reflects the dynamic nature of the AR/VR industry and its potential for innovation and development in various sectors.

### **Blockchain**

Blockchain is a decentralized technology that enables secure recording, verification, and storage of transactions across a network of computers. It uses blocks of transactional data linked together using cryptographic techniques. Blockchain's key features include transparency, immutability, and security.<sup>14,17</sup>

The study revealed that the distribution of patents in Blockchain shows a strong concentration in China, with seven companies leading the way. Other companies from the Cayman Islands, Switzerland, and the USA also contribute to the landscape. Within the corporations and organizations represented in the graph, Alibaba stands out as a prominent leader, showcasing a significant number of patents in the field of blockchain. Alibaba's substantial contribution highlights its dedication to innovation and establishes its position as a respected frontrunner in this rapidly evolving domain.

The results of the study show a consistent upward trend of patents until 2016. In 2017, there was a significant surge in blockchain-related patents, reaching a peak of 31,985 in 2021 before declining to 21,812 in 2022 (Table 2). However, a notable gap exists between the number of patents and academic publications, indicating a discrepancy between the pace of innovation and scholarly research in the field (Table 3). This gap suggests that academic publications are falling short in capturing and disseminating knowledge in the rapidly evolving landscape of blockchain technology. The graph highlights the challenges faced by academia in keeping up with the dynamic nature of blockchain innovation and raises questions about the ability of scholarly research to effectively contribute to the advancements in the field. It underscores the need for better alignment between academic endeavours and the rapid pace of innovation in blockchain technology.

### **Additive Manufacturing / 3D Printing**

3D printing or additive manufacturing (AM), is a groundbreaking technology that enables the fabrication of three-dimensional objects from digital designs. It operates by layer-by-layer deposition of materials, including plastics, metals, and even living cells, to construct physical objects based on computer-generated models.<sup>18</sup> The global boom of 3D printing technology and its applied industry is very promising business area to be studied by global strategy planners and managers.<sup>19</sup> The AM has gained significant market footing due to enhanced customizability, a decrease in errors, zero material waste, inexpensive development costs, and quick turnaround times. The emergence of 3D printing has transformed industries like aerospace, healthcare, and consumer goods. Its efficient creation of intricate objects has triggered a surge in patent applications and research publications.

As per a recent study by the author, the major contributors to 3D printing technologies are the USA, Germany, China, France, and Taiwan.<sup>20</sup> HP is the market leader with a significant number of patents in the field of 3D printing. In AM, the patents and publications grew at a gradual and steady rate until 2011 (Table 2). And after 2011 the number of patents outpaced several publications with a huge difference with almost 2 times more patents than that number of publications in the year 2022 (Table 3).

### **Edge Computing**

Edge computing refers to the decentralized method of processing and evaluating data at or near the network's edge, which is nearer to the data source or end-user. Unlike traditional cloud computing models where data processing takes place in centralized data centers, edge computing brings computation and data storage closer to the point where the data is generated, resulting in reduced latency and improved real-time processing capabilities.<sup>16</sup>

From the analysis of the data of the study, China emerges as the leading country in this technology, with six companies among the top 10. South Korea, Finland, and the USA also have representation in the top 10 positions. While China holds the overall lead, it is worth mentioning that the company with the highest number of patents in Edge computing is Intel Corporation from the USA. This showcases the significant contribution of Intel in driving innovation in the edge computing domain. The dominance of

China and the noteworthy presence of Intel underscore the global significance of these countries and companies in advancing Edge computing. A discernible pattern becomes evident, indicating that the magnitude of publications in Edge computing consistently eclipses the number of patents (Table 2). This pattern conveys the fact that Edge computing primarily resides in the conceptual domain, with ongoing endeavors in research and development. While the tally of patents may be relatively modest, it does not imply a dearth of progress. Rather, it reflects the intricate and evolving nature of Edge computing, necessitating a rigorous foundation of theoretical comprehension and comprehensive experimentation prior to attaining widespread implementation and commercialization. The greater volume of publications serves as a testament to the active engagement of researchers and scholars in expanding the frontiers of knowledge, advancing theoretical frameworks, and delving into the vast potential applications of Edge computing (Table 3).

#### **Gene Editing**

Gene Editing refers to the process of making precise alterations to an organism's DNA arrangement, enabling scientists to change or control specific genes. It encompasses methods like CRISPR-Cas9, which serves as molecular shears to slice the DNA at a targeted spot, followed by the insertion, removal, or adjustment of genetic material.<sup>21</sup>

Upon examination, a clear pattern emerges, revealing the heavy dominance of the United States in this industry. Remarkably, eight out of the top ten companies are based in the USA, with the remaining two originating from Switzerland. This evident concentration of patents underscores the strong presence and significant contributions of US-based institutions and corporations in the field of gene editing. Furthermore, it suggests that the United States is poised to assume a leading role in shaping the future of gene editing technology.

Interestingly unlike all other emerging technologies, for Gene Editing technology publications consistently outnumber patents, indicating active research and early-stage development (Table 2 & 3). Although patent numbers show a gradual increase, the overall trend suggests that gene editing is still in its infancy, with significant potential for future advancements. The abundance of publications reflects ongoing scientific exploration, while the rising number of patents indicates growing

interest in commercial applications. Overall, gene editing remains an emerging field with promising prospects for further innovation and implementation.

#### **Quantum Computing**

Quantum computing is a cutting-edge field of study and technology that utilizes the principles of quantum mechanics to manipulate and process information. Unlike classical computers, which use bits to represent data as 0 or 1, quantum computers utilize qubits or quantum bits that can simultaneously exist in multiple states due to the phenomenon called superposition.<sup>22,23</sup>

The United States demonstrates full domination in this industry. With seven companies from the USA occupying the top 10 positions, including IBM, which holds the highest number of patents, it is apparent that the United States is at the forefront of quantum computing innovation. This dominance suggests that the USA has a promising opportunity to establish itself as a leading force in the quantum computing industry in the near future. The graph underscores the significant contributions and advancements made by American corporations and institutions, positioning the United States as a key player in shaping the future of quantum computing. Like Gene Editing, a discernible pattern emerges out of the result, indicating that the number of publications in quantum computing consistently surpasses the number of patents (Table 2 & 3). This pattern suggests that quantum computing is still primarily in the conceptual stage, with ongoing research and exploration. While the number of patents may be comparatively lower, it does not imply limited progress. Rather, it reflects the complex and evolving nature of quantum computing, which requires extensive theoretical understanding and experimentation before widespread implementation and commercialization can be achieved. The higher number of publications signifies the active engagement of researchers and academics in expanding the knowledge base, advancing theoretical frameworks, and exploring the potential applications of quantum computing.

#### **Green Hydrogen**

Green Hydrogen refers to hydrogen gas that is produced through a process called electrolysis, using renewable energy sources like solar or wind power. It is considered "green" because the production process generates no greenhouse gas emissions, making it a clean and sustainable energy carrier. The production

of green hydrogen involves splitting water molecules (H<sub>2</sub>O) into hydrogen (H<sub>2</sub>) and oxygen (O<sub>2</sub>) using an electrolyser. This electrolyser is powered by electricity from renewable sources, such as solar or wind farms. The electricity is used to drive the electrolysis reaction, separating hydrogen atoms from the water molecules.<sup>24,25</sup>

In Green Hydrogen technology innovation China is the world leader with all the Top companies with patents from China Only. Moreover, there is a huge gap between publications and patents in the technology. The publications are about 30 times times than that of patents (in 2022). In recent years the pace of academic research and innovation is very high in green hydrogen technology, and it is evidence of the high demand of search of alternative power sources after oil, electricity, and solar power. In line of the ongoing technological advancement in technology recently, China has successfully tested the Hydrogen powered Train test.

## Discussion

The top ten emerging technologies selected for the study were: Semiconductors, 3D printing, AR/VR, blockchain, IoT, AI, quantum computing, edge computing, gene editing, and green hydrogen.

The analysis offers intriguing insights into the present landscape of emerging technologies. Six out of the ten technologies examined—semiconductors, 3D printing, AR/VR, blockchain, IoT, and AI—have a higher number of patents compared to publications. This strongly indicates that these technologies are either already being implemented or are on the verge of widespread adoption.<sup>14</sup> This trend signifies the active exploration and utilization of these six technologies by industries, driving innovation and technological progress. The surge in patent filings reflects a competitive environment where organizations are investing in research and development, safeguarding their intellectual property, and pushing the boundaries of what these technologies can accomplish.

Conversely, the analysis also reveals that four technologies—quantum computing, edge computing, gene editing, and green hydrogen—are still in the early stages of development, primarily existing as conceptual ideas.<sup>25,26</sup> While these technologies have not yet reached the same level of patent activity, it signifies the immense potential and anticipation surrounding their future implementation. This

observation emphasizes the cutting-edge nature of these technologies, holding great promise but not yet fully realized. As they continue to advance and mature, these technologies have the potential to revolutionize various sectors, ushering in groundbreaking advancements in computing, healthcare, and sustainable energy.

Except for Edge Computing and Gene Editing, in all the emerging technologies number of patents have surpassed the number of publications. The sustained difference between patents and publications emphasizes the importance of fostering collaboration and knowledge sharing between academia and industry to ensure a comprehensive understanding of the advancements in this rapidly evolving technology. In general, from 2010-11 onwards, the rate of patent filings began to surpass that of academic publications, indicating a shift in the dynamics in most of the emerging technologies (except edge computing and Gene Editing).

The distribution of companies across countries in various emerging technologies reveals an interesting trend. Among these technologies, the United States dominates in four areas: 3D printing, Quantum Computing, AR/VR, and Gene Editing. On the other hand, China takes the lead in four technologies: Blockchain, AI, green Hydrogen, and Edge Computing. The remaining technologies display a mixed distribution of companies from different countries, highlighting the collaborative nature of innovation in these fields. This diverse landscape emphasizes the interconnectedness and interdependence of nations in shaping the future of emerging technologies. It showcases the global cooperation required to drive innovation and ensure that breakthroughs in these technologies benefit humanity as a whole.<sup>27,28</sup> A comprehensive Intellectual property base strengthening framework is required for faster economic growth in the knowledge economy.<sup>29</sup>

Moreover, developing countries specially India is also having a tremendous amount of potential, despite of several obstacles and preparing itself for Industry 4.0 with innovation and adaptation of emerging technologies with Make in India campaign. Under the initiative “Development of Semiconductors and Display Manufacturing Ecosystems in India” of the Semiconductor Mission of the Government of India, the recent launching of three semiconductor plants in India is evidence of the preparation of upcoming third economic power.<sup>30,31</sup>

It is crucial to recognize that this study has some limitations. Instances where the chosen technology was only mentioned in passing rather than as the main topic of the document may be included in the patent and publication data that was obtained from Derwent Innovation and Web of Science. Therefore, rather than being exact measurements of committed innovation or research, the reported counts are indicators of technological visibility. Furthermore, the results are a snapshot of trends that were noted at the time of data collection; because emerging technologies are dynamic, these patterns may change over time.

### Conclusion

In conclusion, the top ten emerging technologies (Semiconductors, 3D printing, AR/VR, blockchain, IoT, AI, quantum computing, edge computing, gene editing, and green hydrogen) have revolutionized a wide range of sectors. This analysis examined patent and publishing trends to identify important contributors, key technological focuses, and innovative insights. Important revelations from the analysis can direct firms, investors, and politicians to realize the full potential of these technologies. Patent data study showed US and China are dominating in IPR in some major fast developing emerging technologies, with no one nation predominating in rest of the technologies.

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