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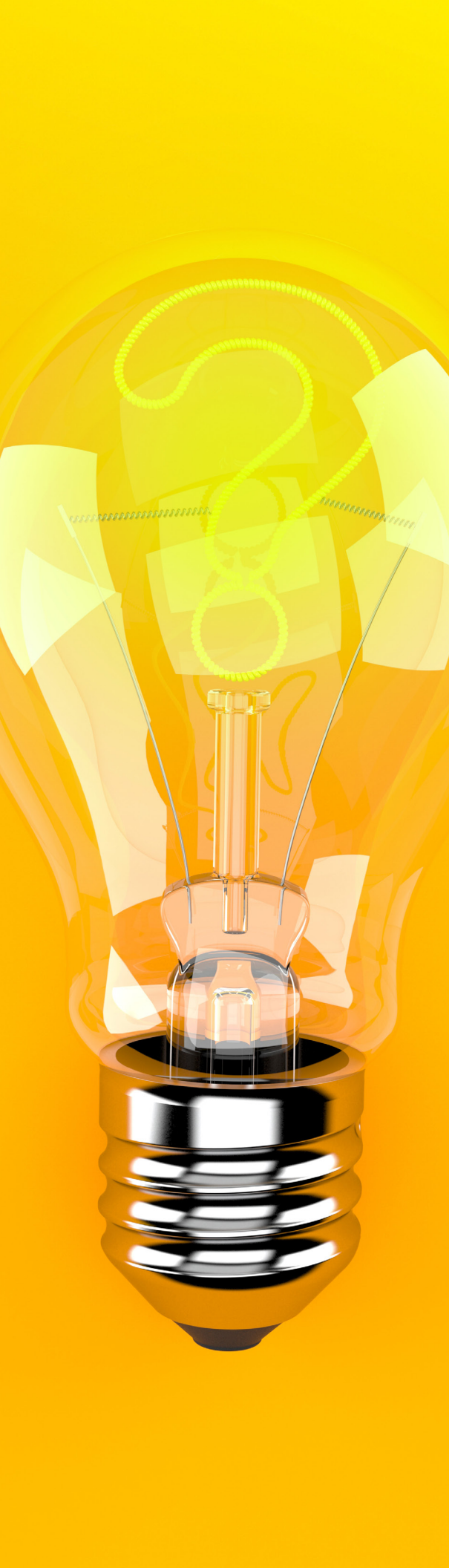
Industry-Focused

Patenting Trends



Introduction

American businesses face growing competition in an increasingly globalized economy. Innovation can be defined as the process by which new ideas are generated and put into commercial practice in the form of new products and services. Patent protection of innovation has always been key to American economic strength and a driving factor in U.S. businesses' ability to successfully dominate domestic markets.[1]

Winning in the new global economy requires an environment that supports and encourages innovation.[2] One important way to foster such an environment is through robust protection of intellectual property ("IP"), a strategy even appreciated by the Founding Fathers. The value of innovation and the importance of protecting it through the grant of IP rights is recognized in the U.S. Constitution: Congress is granted the power to "promote the Progress of Science and useful Arts by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries."[3] Those innovators who "reach for the stars" are rewarded with exclusivity for a limited time so that they can reap the rewards from their invention.

In many ways, patents are the carrot to capitalism that encourages the creative class to invest in a road less traveled. A strong climate of IP protection generates multiple benefits, including greater R&D activity, employment of high-skill and high-pay workers, adoption of sophisticated, cutting-edge technologies, and export of valuable, knowledge-intensive products.[4] Protecting innovation through patents is especially critical for startups. "[P]atent approvals help startups create jobs, grow their sales, innovate, and reward their investors… patents act as a catalyst that sets startups on a growth path by facilitating their access to capital."[5]

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[1] Economics and Statistics Administration and United States Patent and Trademark Office, Intellectual Property and the U.S. Economy: Industries in Focus. March 2012, http://www.uspto.gov/sites/default/fles/news/ publications/IP_Report_March_2012.pdf

[2] Id.

[3] U.S. Const. art. I, § 8, cl. 8.

[4] Meir Pugatch & David Torstensson, Inspiring Tomorrow (U.S. Chamber International IP Index, 7th Ed. February 2019) https://www.theglobalipcenter.com/wp-content/uploads/2019/02/023593_GIPC_IP_Index_2019_Full_03.pdf.

[5] Joan Farre-Mensa, Deepak Hegde & Alexander Ljungqvist, The Bright Side of Patents (USPTO Economic Working Paper No. 2015-5, 2015), Abstract, https://www.uspto.gov/sites/default/files/documents/Patents%20030216%20USPTO%20Cover.pdf.

In 2019, the United States ranked second in the U.S. Chamber's annual International IP Index, which quantifies the strength of IP protection in 50 global economies by evaluating each nation's IP infrastructure on the basis of 45 essential indicators.[6] This top ranking is a strong sign that the United States is highly hospitable to innovation and patent rights. The respect given to patent rights in the courts and at the patent office allows for a proper payoff to innovators who invent things that we as consumers love.

Other nations are also recognizing the value of patenting rights. China, for example, has made a strong push to increase patent filings, and the number of its domestically issued patents have risen over five-fold between 2009 and 2016 (even if critics doubt the inventive value of the majority of these patents).[7] In 2017, China's patent office became the second most prolific filer of international patent applications, rapidly closing the gap with the United States[8] and even eclipsing the number of filings at the U.S. patent office today.

Patents are valuable not only in their ability to protect innovation, but they also provide a signal that is helpful in identifying and forecasting industry trends. Because the patenting process is time-consuming and expensive, an industry's patenting investment choices can differentiate significant trends and disruptions from mere technology fads. Macroeconomic trends, legislation and legal decisions affect these trends in different ways for various industries.

Patent activity is a leading indicator for the development of new products and services. Therefore, it can forecast the focus of individual competitors within an industry, predict the entry of new players into a particular market (both technological and geographic), identify potential acquisition or joint venture targets, and flag competitors that may be gearing up for litigation by how they amass patents in a specific market segment. Patent activity is also helpful in analyzing smaller and newer entrants into the market – the very businesses for which competitive intelligence is harder to come by than it is for more established companies.

In the present study, we analyzed a proprietary dataset of patenting activity in the U.S. Patent and Trademark Office ("USPTO") to understand the impact and significance of current patenting trends for 12 important industry areas with significant investment in innovation:

- Artificial Intelligence ("A.I.")
- Automotive
- Blockchain
- Building Materials
- Cleantech / Green Tech
- Computational Biology and Bioinformatics
- FinTech
- Industrial Design
- Internet of Things ("IoT")
- Medical Devices
- Therapeutic & Diagnostic Molecules
- Wireless Phones

Our goal was to provide clear and actionable information that could help decision-makers envision the technological future of their respective industries and set their companies' strategies over the coming years and decades. Because of the rapid pace of innovation in these industries, this study, and the dataset on which it is based, will be updated annually.

[6] Id.; https://www.brookings.edu/research/eleven-facts-about-innovation-and-patents/.
[7] https://www.bloomberg.com/news/articles/2018-09-26/china-claims-more-patents-than-any-country-most-are-worthless
[8] http://www.xinhuanet.com/english/2018-03/21/c_137055370.htm

To make this annual study a valuable forecasting tool, we designed it to be different from traditional patent landscape studies in several key aspects:

1. In contrast with most patent landscape studies, which break down patent trends by following the USPTO's arcane taxonomy of Technology Centers, International Patent Classification and Art Units, the patents in this study are clustered into industry categories. By taking into account the range of technologies within each industry, this study provides a fuller picture of patenting trends in complex, modern industries and of the patenting strategies and technological advantages pursued by competitors within an industry.

The industry focus of this study is also helpful for prioritizing patenting decisions. By providing insight into the patenting strategies of competitors across technologies and calculating the chances of a patent being granted in a given technology, the study gives decision-makers the information they need to better allocate their patenting resources.

2. Unlike other patent datasets, which have no information about patent applications for the first 18 months after their filing until they publish, our proprietary dataset is the first to include patent filing data within that previously opaque window of time. This data allows our study to provide up-to-date information about patent filing trends. The timeliness of this information is especially important for fast-innovating industries where a lag of 18 months can render information stale and irrelevant.

3. Patents are notoriously cryptic as the vernacular for new technology takes time to coalesce into agreed-upon terminology and meanings. Our dataset was populated not solely by automated search but instead relied upon human review for characterization. Through this process, we were able to effectively and precisely map patents to their relevant industries according to the terminology used in each industry. This process also enabled us to create and populate meaningful industry subcategories that would be relevant to how industry insiders view the segmentation of their industry. Moreover, this process made possible the identification of early patents relating to technologies that predate the terminology now in common usage. For example, the dataset includes a number of patents relating to what has become known as "cryptocurrency" but in which the word "cryptocurrency" is absent. A fully automated keyword search would have missed these patents.

4. Our dataset enables us to analyze trends on many topographical levels, from an overview of an entire industry, to comparisons of sectors within the industry, to the patenting behaviors of individual competitors. We are also able to compare the actions of different USPTO Art Units in which patents relating to the various technologies in a given industry are examined. This flexibility allows us to zero in on trends that would have been invisible if these different topographical layers were not available for analysis. For example, we have 3G, 4G and 5G sectors broken out within the Wireless Phone industry.

5. The study highlights the geographical distribution of innovation because it parses the data by (1) the originating country for filed patent applications, and (2) the U.S. state for American applicants. The ability to study patent trends with respect to both geography and industry helps refine our understanding of where innovation hot spots are located for specific industries.

Building the Proprietary Dataset

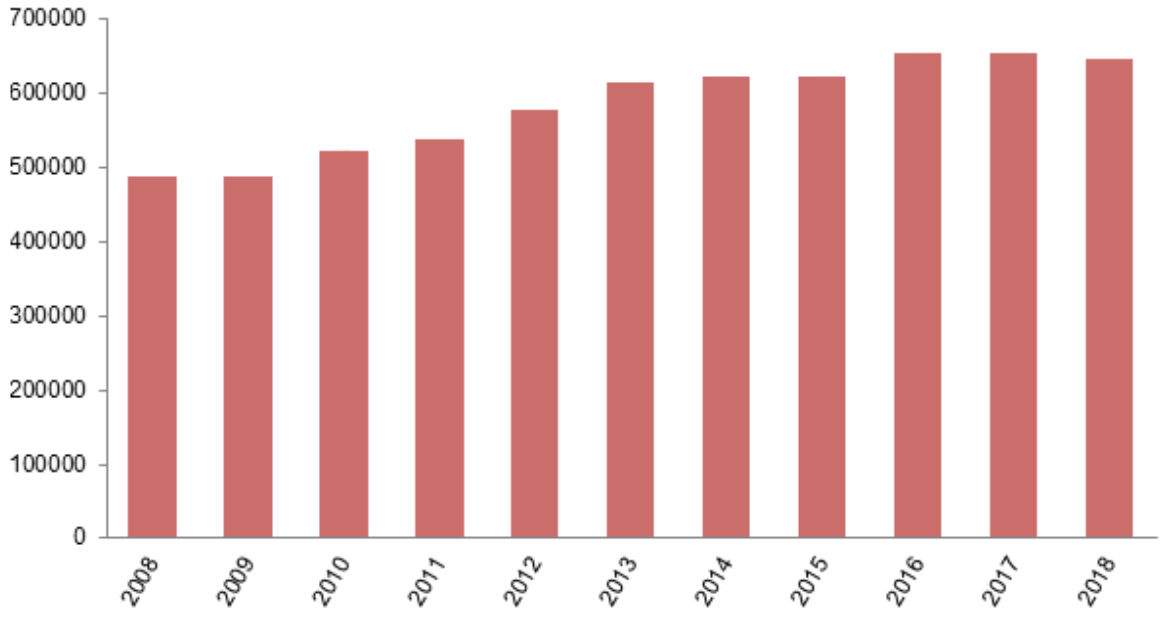
The dataset was built through a collaboration between Kilpatrick Townsend & Stockton LLP, a premier patent law firm, and GreyB Services Pte. Ltd., a leading technology research and intelligence firm. The process included the use of data science and categorization technology, followed by semi-automated filtering, and by data excavation to predict any gaps in the trends. We then populated the database and assigned the entries according to a defined topology of predetermined patent-applications focuses.

General Trends

Patent filings have risen to a record level

While most industries saw a significant downturn in the number of patent applications filed in the wake of the capital crisis of 2008 (with the notable exception of Cleantech), filings have rebounded with a subsequent seven-year period of rapid growth. The last three years have seen the overall number of applications filed in the USPTO hold steady at record levels, with approximately 650,000 applications filed per year.[9] However, patent filing trends vary dramatically across industries and within different sectors of individual industries (see chart on page 8).

Patent Applications Filed Per Year in USPTO



These numbers indicate that businesses continue to see patenting as a worthwhile investment. Despite factors such as the strengthening of protections for trade secrets through the passage of the Defend Trade Secrets Act in 2016, and a significant narrowing of patent eligibility of computer-implemented inventions in 2014,[10] the hypothesized shift to businesses favoring fewer patent applications is not evident in the data.

[9] https://www.uspto.gov/sites/default/files/documents/USPTOFY18PAR.pdf
[10] Manny Schechter, The Changing Trade Secret and Patent Equilibrium, TechCrunch, 2016, https://techcrunch.com/2016/06/20/the-changing-trade-secret-and-patent-equilibrium/

Long-standing technology leaders dominate the patent landscape

Despite the buzz generated by disruptors and startups, our data shows that when it comes to patents, entrenched incumbents are the dominant players in each of the industries we surveyed.

Technology	Top 5 Patent Holders (in alphabetical order)
IoT	Ericsson IBM LG Qualcomm Samsung
A.I.	Google IBM Microsoft Samsung Siemens
Blockchain	Bank of America Cognitive Scale IBM Intel Mastercard
FinTech	Bank of America IBM Mastercard PayPal Visa
Medical Devices	Boston Scientific Covidien Medtronic Olympus Corporation Philips
Computational Biology and Bioinformatics	General Electric IBM Philips Siemens University of California

Technology	Top 5 Patent Holders (in alphabetical order)
Therapeutic & Diagnostic Molecules	Bayer Merck Novartis Roche University of California
Automotive	Ford General Motors Honda Hyundai
Clean/Green Tech	General Electric Hyundai Samsung Siemens Toyota
Wireless Phones	Apple Blackberry LG Qualcomm Samsung
Building Materials	BASF Dow Chemical Halliburton Schlumberger Sika Technology
Industrial Design	Ford LG Microsoft Nike Samsung

An incumbent's patent portfolio can be a formidable barrier to entry for newer competitors, and the tactical advantages of having a solid patent portfolio is attractive to many companies (including those that may have been agnostic or even antagonistic to patents previously). Indeed, even companies committed to open-source efforts are concurrently investing heavily in obtaining patent protection for their inventions in competitive technologies.[11]

[11] Tom Simonite, Despite Pledging Openness, Companies Rush to Patent AI Tech, Wired, July 31, 2018, https://www.wired.com/story/despite-pledging-openness-companies-rush-to-patent-ai-tech/; https://www.kilpatricktownsend.com/-/media/Files/articles/2018/Blockchain-Patents-and-Open-Source-Software-Daily-Journal-041818.ashx

Software-related inventions continue to face patenting challenges

Alice Corp. v. CLS Bank,[12] the Supreme Court's 2014 decision on the subject-matter-eligibility requirement of U.S. patent law (codified as 35 U.S.C. § 101) (*"Alice"*), had an immediate and severe effect on the grant rates of patents for software-related inventions. *Alice* set forth a two-part test, which asks whether patent claims (1) are directed to an abstract idea, and if so whether (2) the claims are significantly more than the abstract idea.

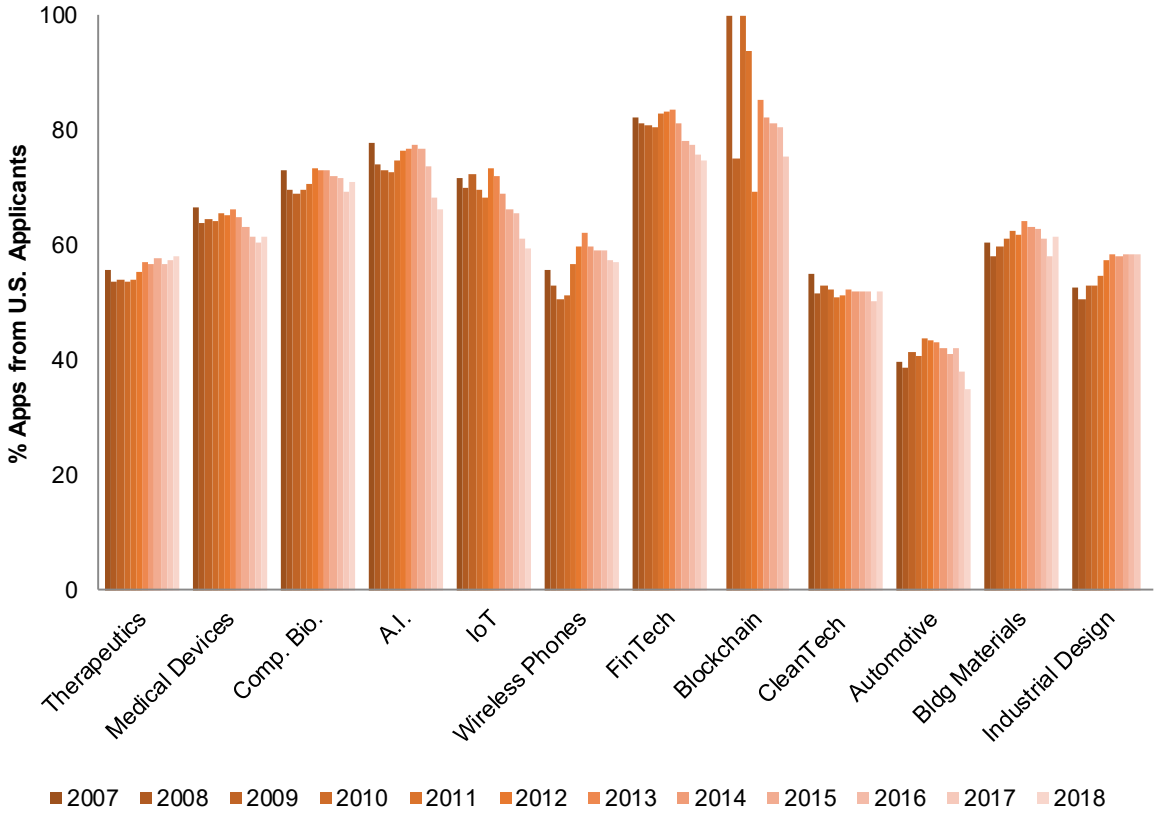
The USPTO's initial implementation of this test, encouraged by the Federal Circuit's early decisions interpreting *Alice*, led to a very high rejection rate of software-related patent applications.[13] There has since been a realization that this implementation may have been too stringent and that it may impede real innovation in cutting-edge industries from FinTech to bioinformatics.

Indeed, since 2016, there has been a significant increase in issuance of patents for software-related inventions in bioinformatics and computational biology and the allowance prevalence for these fields has recovered to levels now exceeding pre-*Alice* levels.[14] We expect the trend of higher issuances to continue for bioinformatics and to spread to other software-related and business-method fields such as FinTech.

The share of patent filings from foreign entities is growing

Underscoring the continuing effects of globalization, the share of patent applications from U.S. entities continues to decrease as a percentage of the total number of patent applications. The rapid rate of increase in the share of foreign applicants is particularly pronounced in A.I., IoT, FinTech, Blockchain, and Automotive. In Automotive, U.S.-based applications comprised less than 50% of applications during the entire period analyzed in our study (from 2007 to the present). The diminishing percentage of U.S.-originated applications is noteworthy because a decreasing slice of the patenting pie could result in U.S.-based innovators finding themselves locked out of the U.S. market, thereby losing any home-field advantage they may have had over foreign competitors.

[12] *Alice Corp. v. CLS Bank Int'l*, 134 S. Ct. 2347 (2014).
[13] Kate Gaudry & Samuel Hayim, Bioinformatics Innovations Thrive Despite 101 Chaos, IP Watchdog, February 6, 2019, https://www.ipwatchdog.com/2019/02/06/bioinformatics-innovations-thrive-despite-101-chaos/id=106020/.
[14] Id.



One reason for the increasing share of foreign applicants may be due to offshore outsourcing by U.S. companies of not only manufacturing but also of innovation activities, such as research, engineering, and design. A June 2018 report by MForesight: Alliance for Manufacturing Foresight, highlights the shift in offshoring from "invent here, manufacture there" to "invent there, manufacture there."[15] As the report notes, "[i]ndustry representatives recognize that many of the best ideas for manufacturing innovation come from the factory floor. Experience demonstrates in multiple industries that movement of manufacturing overseas fuels innovations in both products and processes."[16]

[15] Sridhar Kita & Thomas C. Mahoney, Manufacturing Prosperity: A Bold Strategy for National Wealth and Security (Report No. MF-TR-2018-0302, 2018), https://medium.com/@MForesight/manufacturing-prosperity-a-bold-strategy-for-national-wealth-and-security-65d2a97d6d0e.
[16] Id. at 21.

Innovation hot spots are spread across the United States

Populous California (with nearly 40 million residents) continues to dominate as the top state for patent applicants, averaging over 80,000 applications per year since 2014. But innovation hot spots are spread across the country, including states with just a small fraction of California's population.[17] Since 2014, residents from each of the following states have filed thousands of applications per year:

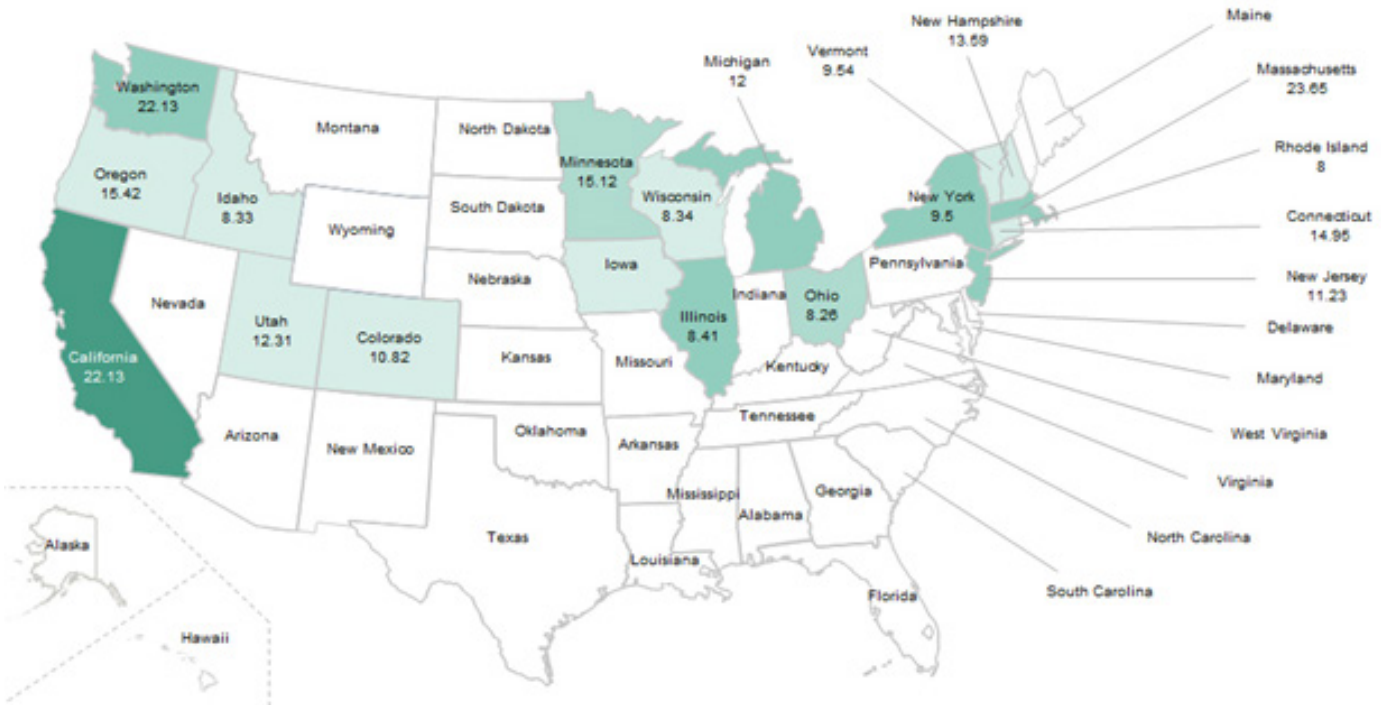
>10,000 applications/year	5,000-10,000 applications/year
Illinois	Arizona
Massachusetts	Colorado
Michigan	Connecticut
New York	Florida
Texas	Georgia
Washington	Minnesota
	New Jersey
	North Carolina
	Ohio
	Oregon
	Pennsylvania

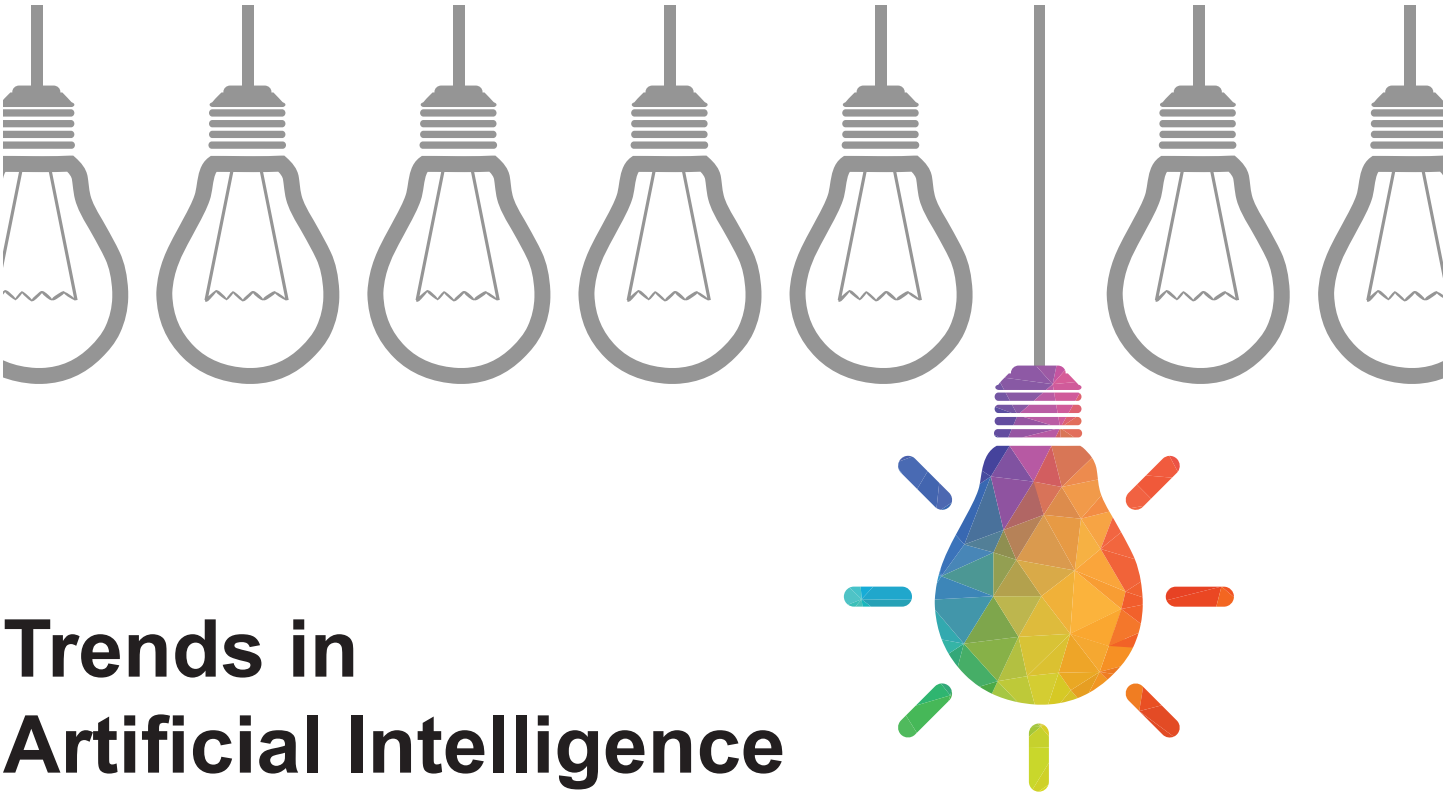
We have also analyzed the number of patent applications per capita for each state (using 2017 numbers for patent applications and estimated state populations). Under this analysis, other states are as innovative as California, and in the case of Massachusetts, even more so. On the other hand, some populous states, including Texas and Florida, file fewer patent applications than their population size would have suggested. The following chart lists the most innovative states by this measure (with a cutoff of 8 applications per 10,000 residents).

State	Patent Applications per 10,000 residents
Massachusetts	23.65
California	22.13
Washington	22.13
Oregon	15.42
Minnesota	15.12
Connecticut	14.95
New Hampshire	13.59
Utah	12.31
Michigan	12
New Jersey	11.23
Colorado	10.82
Vermont	9.54
New York	9.5
Illinois	8.41
Wisconsin	8.34
Idaho	8.33
Ohio	8.26
Rhode Island	8

[17] https://www.uspto.gov/sites/default/files/documents/USPTOFY18PAR.pdf

Most innovation states (Patent Applications per 10,000 residents)





Trends in Artificial Intelligence

The competition in A.I. innovation is global and A.I. is recognized by many countries as being of national importance. The increasing global competition for A.I. dominance is reflected in the rising percentage of patent applications filed in the USPTO by foreign entities.

Artificial intelligence ("A.I.") enables machines to learn from experience and/or to perform human-like activities. A.I. is being deployed in a growing number of industries and can achieve increasing accuracy and accomplish ever-more sophisticated tasks. National governments have taken notice of both A.I.'s promise and its national security implications, and have set national agendas for winning the A.I. race. Indeed, the White House unveiled a new initiative in February 2019, calling on federal agencies to focus on A.I. initiatives.[18]

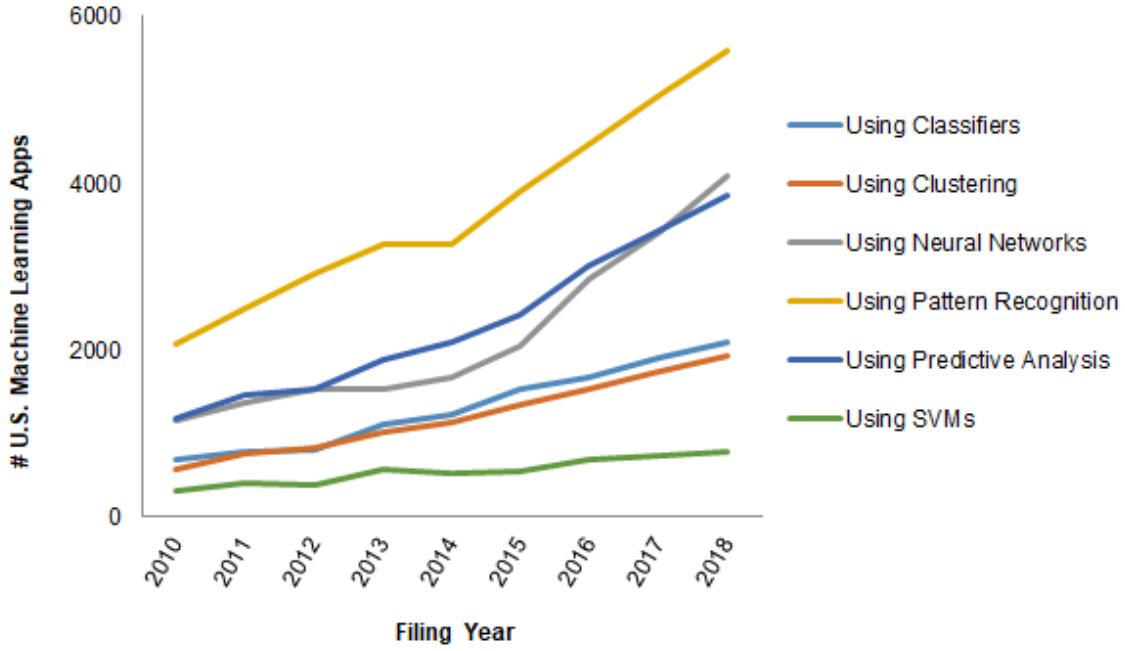
To delve deeper into the trends of patenting A.I. innovation, we have defined the following technology clusters within the general industry of A.I.:

Artificial Intelligence - Level I Clusters	**Level II Clusters**	**Level III Clusters**
Artificial Intelligence Systems	Machine Learning Systems	Utilizing Classifiers
		Utilizing Clustering
		Utilizing Neural Networks
		Utilizing Pattern Recognition
		Utilizing Predictive Analysis
		Utilizing Support Vector Machines
	Knowledge Based Systems	-
Application Areas/Industry	Computer Vision	-
	Entertainment	-
	Robotics	-
	Healthcare	-
	Natural Language Processing	-
	Fintech	-
	Digital Marketing	-
	Automotive	-
	Education	-
	Cognitive Security	-
	Augmented/Virtual Reality	-

Taxonomies and expanded definitions of these clusters are included in appendix A.

[18] https://www.nextgov.com/emerging-tech/2019/02/white-house-unveils-national-artificial-intelligence-initiative/154795/

Technology leaders emphasize patenting innovations in Pattern Recognition, Predictive Analysis, and Neural Networks



A.I. is a broad term that encapsulates many different types of techniques. Of those that we assessed, pattern recognition, predictive analysis, and neural networks correspond to the highest rate of innovation, as evidenced by the rapidly increasing year-over-year numbers of patent applications of these clusters.

Across the industry, generally, and in the top three A.I. techniques, the top filer of U.S. patent applications was IBM, followed by Microsoft and Google (switching positions between second and third position in different clusters).

The future patenting landscape for A.I. applications is dominated by IBM, but two small companies show specific strengths.

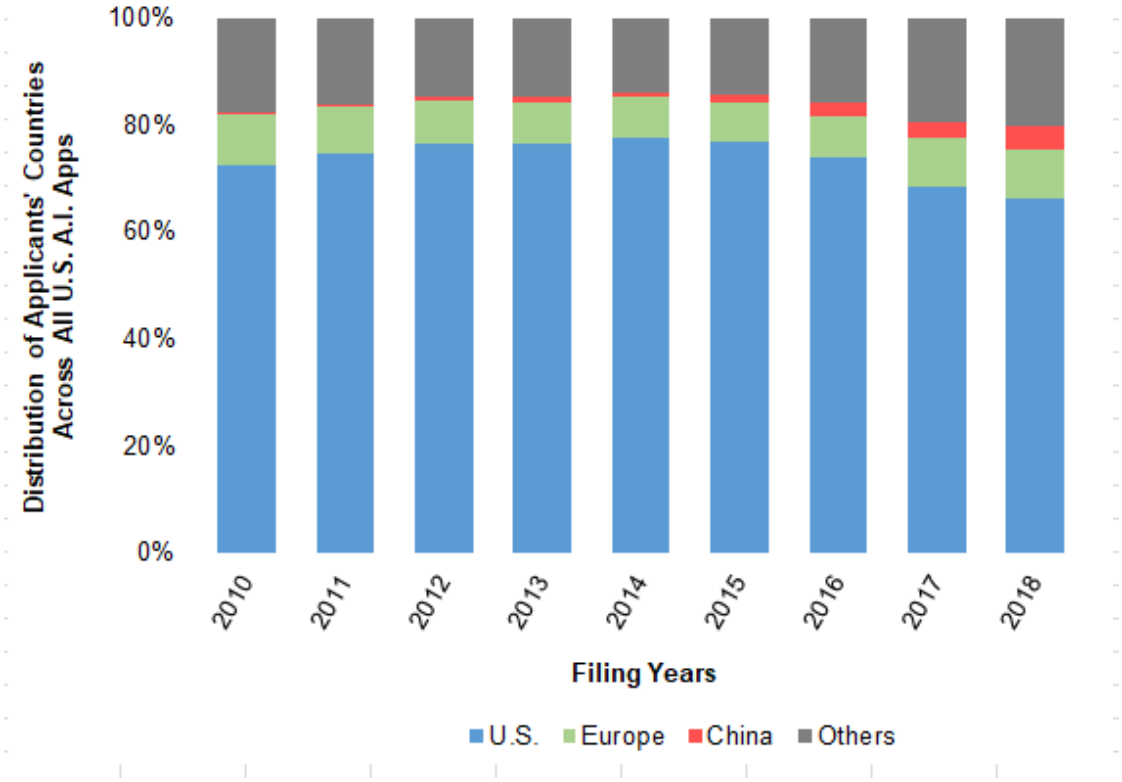
USING 2016 DATA:		
		Most Families Filed by
		(Applicants in alphabetical order)
Artificial Intelligence		Facebook, Google, IBM, Microsoft, Samsung
Level I		
Application Area/Industry		Facebook, Google, IBM, Microsoft, Samsung
Artificial Intelligence Systems		Google, IBM, Intel Microsoft, Samsung
Level I	**Level II**	
Application Areas/Industry	Augmented/Virtual Reality	Facebook, Google, Magic Leap, Microsoft, Sony Corp.
	Automotive	Ford, General Motors, Hyundai, IBM, Toyota
	Cognitive Security	Cisco, Cylance, Google, General Electric, IBM, Intel, Microsoft, NEC Corporation, Qualcomm, Symantec Corporation
	Computer Vision	Adobe Systems, Facebook, Google, IBM, Microsoft, Samsung, Siemens
	Digital Marketing	Adobe Systems, Facebook, Google, IBM, Microsoft
	Education	Fanuc Corp., Ford, Fujitsu, IBM, Intuit, Microsoft, Oath, Tata Consultancy Services
	Entertainment	Facebook, Google, IBM, Microsoft, Rom Guides
	Fintech	Cognitive Scale, Facebook, Google, IBM, Microsoft
	Healthcare	General Electric, IBM, Microsoft, Samsung, Siemens
	Natural Language Processing	Facebook, Google, IBM, Microsoft, Samsung
	Robotics	Fanuc, Google, IBM, Microsoft, Samsung
Artificial Intelligence Systems	Knowledge Based Systems	Facebook, Google, IBM, Microsoft, Samsung
	Machine Learning Systems	Google, IBM, Intel Microsoft, Samsung

IBM's dominance in applying for patents on A.I. applications is striking in its ubiquity. It is, however, consistent with IBM's stated focus on using its A.I. platform, Watson, to offer A.I.-related solutions to a variety of business problems[19] and its overall embrace of the patent system.[20]

[19] https://www.computerweekly.com/news/450411363/IBM-results-show-shift-to-AI-and-cloud-business-focus
[20] https://www.research.ibm.com/patents/

Meanwhile, several smaller entities have captured top patent-filing spots within particular application clusters. For example, Magic Leap, a startup developing a head-mounted virtual reality retinal display, is a prolific filer of patent applications in the Augmented/Virtual Reality cluster. Cognitive Scale builds industry-specific augmented intelligence solutions, with the financial services industry being its core constituency. Its patent filings in the FinTech cluster reflect its focus on that industry.

The percentage of foreign-based patent applications is rising



The competition in A.I. innovation is global and A.I. is recognized by many countries as being of national importance. To date, over 20 countries have released A.I. strategy documents, outlining policies to foster A.I. innovation and adoption to the benefit of their respective economies and social welfare, and addressing such issues as privacy, security, and ethics.[21]

The increasing global competition for A.I. dominance is reflected in the rising percentage of patent applications filed in the USPTO by foreign entities. Even though filings from China still comprise a small percentage, the quickening pace with which it files applications is notable. The number of patent applications filed by Chinese entities has risen over sixfold between 2012 and 2018. This acceleration may well continue as China spends heavily to implement its stated goal of becoming the world leader in A.I. by 2030.[22]

In view of the emphasis other countries are placing on winning the innovation race in A.I., and the declining percentage of A.I.-related patent applications filed in the USPTO by American entities, it is possible that American innovators will find themselves locked out of the U.S. market, unable to compete in their own backyard.

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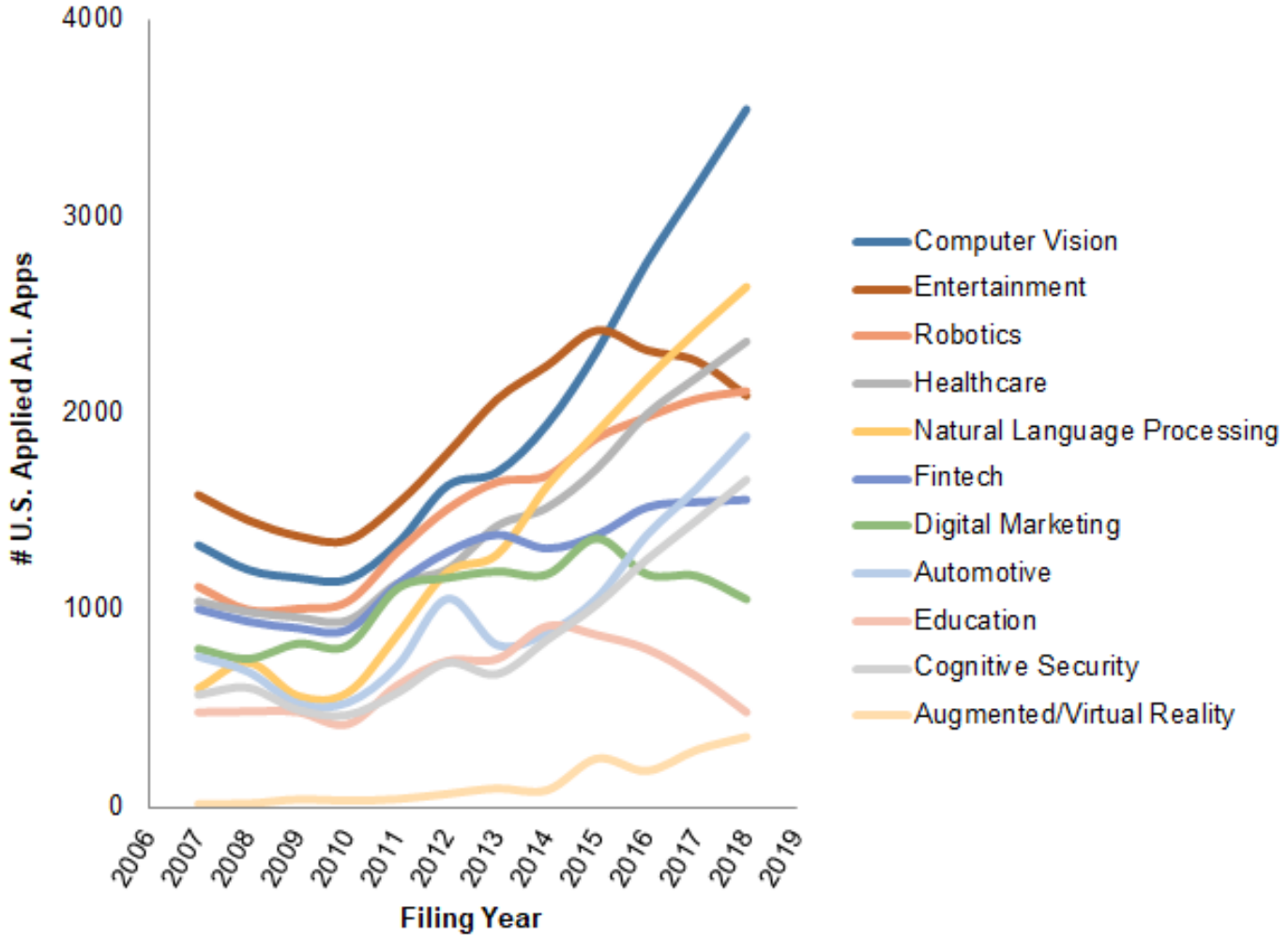
[21] https://www.strategy-business.com/blog/Is-AI-the-Next-Frontier-for-National-Competitive-Advantage?gko=9bfef
[22] https://www.nytimes.com/2017/07/20/business/china-artificial-intelligence.html

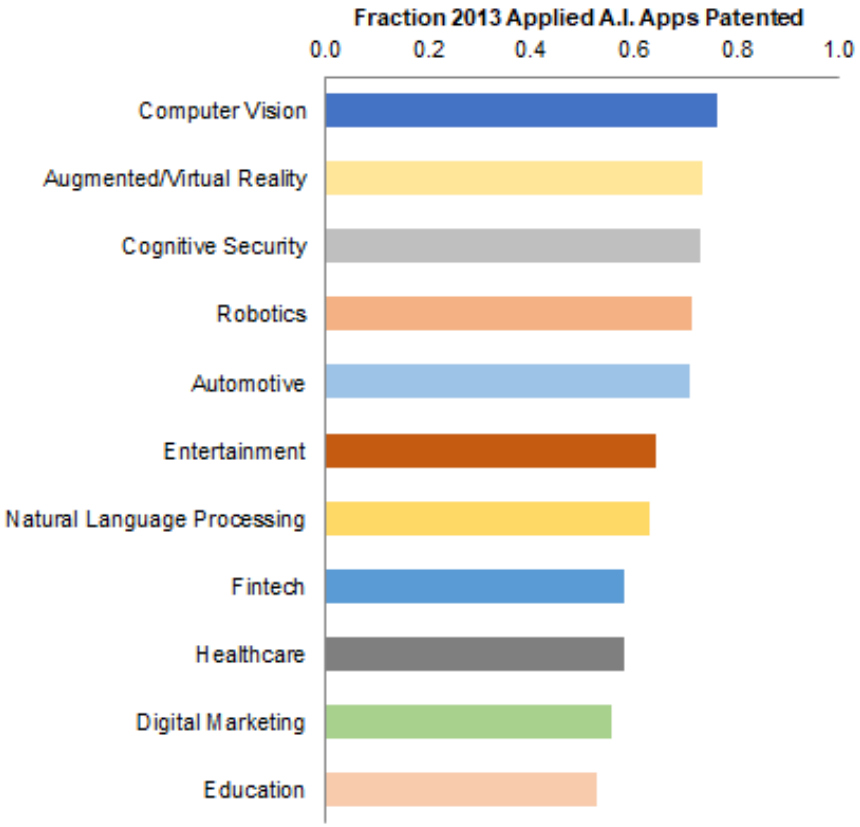
Trends in applications of A.I.

As shown above, patent filings are increasing across all types of reviewed A.I. techniques. However, a different picture is uncovered when data is tagged based on the type of application that A.I. is performing. Where the A.I. applications are traditionally associated with business-method classifications at the patent office (*e.g.*, FinTech, Education, and Entertainment), filings have dropped over the last year, in contrast to the overall increase across the rest of the applications.

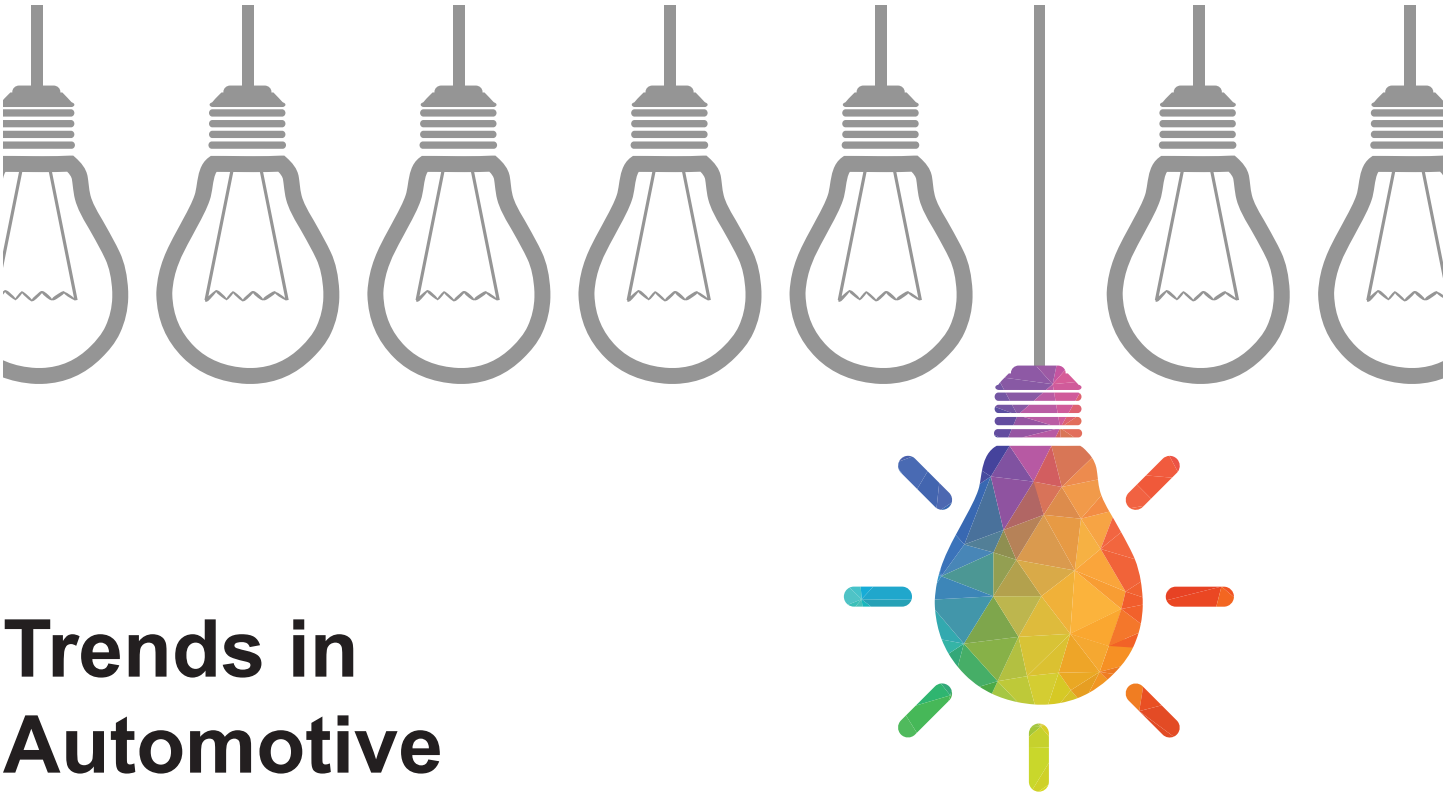
This trend is similar to many other software-related innovations, for which filings have dropped significantly since the Supreme Court's *Alice* decision, which significantly curtailed the scope of software-related patentable subject matter.



A.I.-related patent applications have a high chance of being allowed



Although A.I.-related innovations are often software-related, their allowance rate is strikingly different than similar innovations in FinTech. This divergence in allowance rates is directly tied to the Art Units that are predominantly charged with examining these industries' respective patent applications. While FinTech applications are often examined in business method Art Units, A.I. patent applications are examined in Art Unit 2122 (A.I. & Simulation/Modeling), where the allowance rate is nearly double that of the business method Art Units.



Trends in Automotive

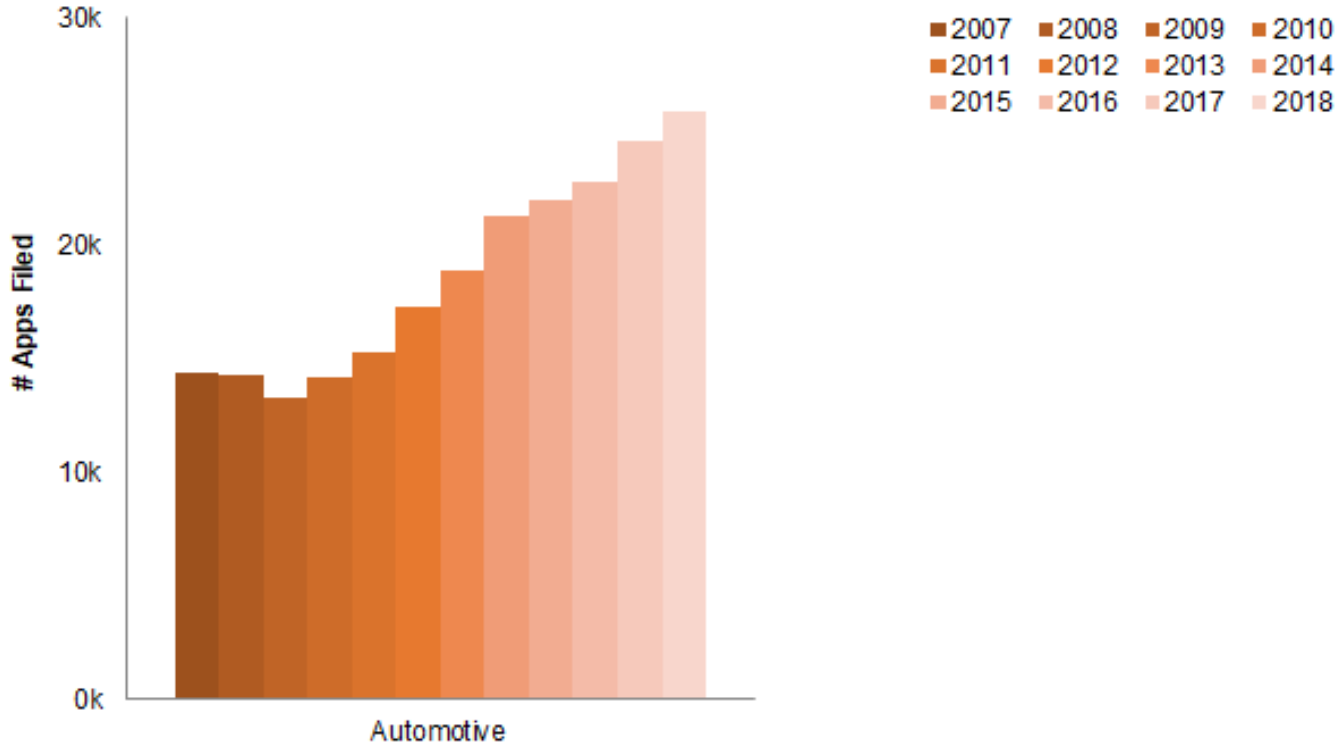
Consumers are increasingly prioritizing in-car technological innovations over brand loyalty. The decrease in brand loyalty means an increasingly competitive field, in which patent dominance can provide a significant advantage.

The last decade has seen huge changes in the automotive industry. New competitors have entered the market, electric motors and hybrid drivetrains have become viable alternatives to the internal combustion engine, which continues to evolve toward higher efficiency. Driver-assist features are offered on many cars today with brands working toward more autonomous driving technology. This wave of innovation is reflected in the steep rise in the number of patent filings by the automotive industry. To better understand the trends of patenting automotive innovation, we have investigated the following technology clusters within the general automotive industry:

Automotive - Level I Clusters	**Level II Clusters**
AI-Integrated Vehicles	Autonomous Vehicles
	Connected Vehicles
Ancillary Vehicle Systems	-
Battery	Lead Based Battery
	Lithium Based Battery
	Other Aspects (Battery Management System/Packs)
Electric Vehicle	Battery Electric Vehicles
	Fuel Cell Based Vehicles
	Hybrid Electric Vehicles
Vehicle Controlling System	-
Vehicle Design	-
Vehicle Navigation System	-
Vehicle Propulsion System	Electric Motor
	Internal Combustion Engine (Ice)
Vehicle Safety System	-

Taxonomies and expanded definitions of these clusters are included in appendix A.

Since the Great Recession, automotive patent filings have been on a steep uptrend



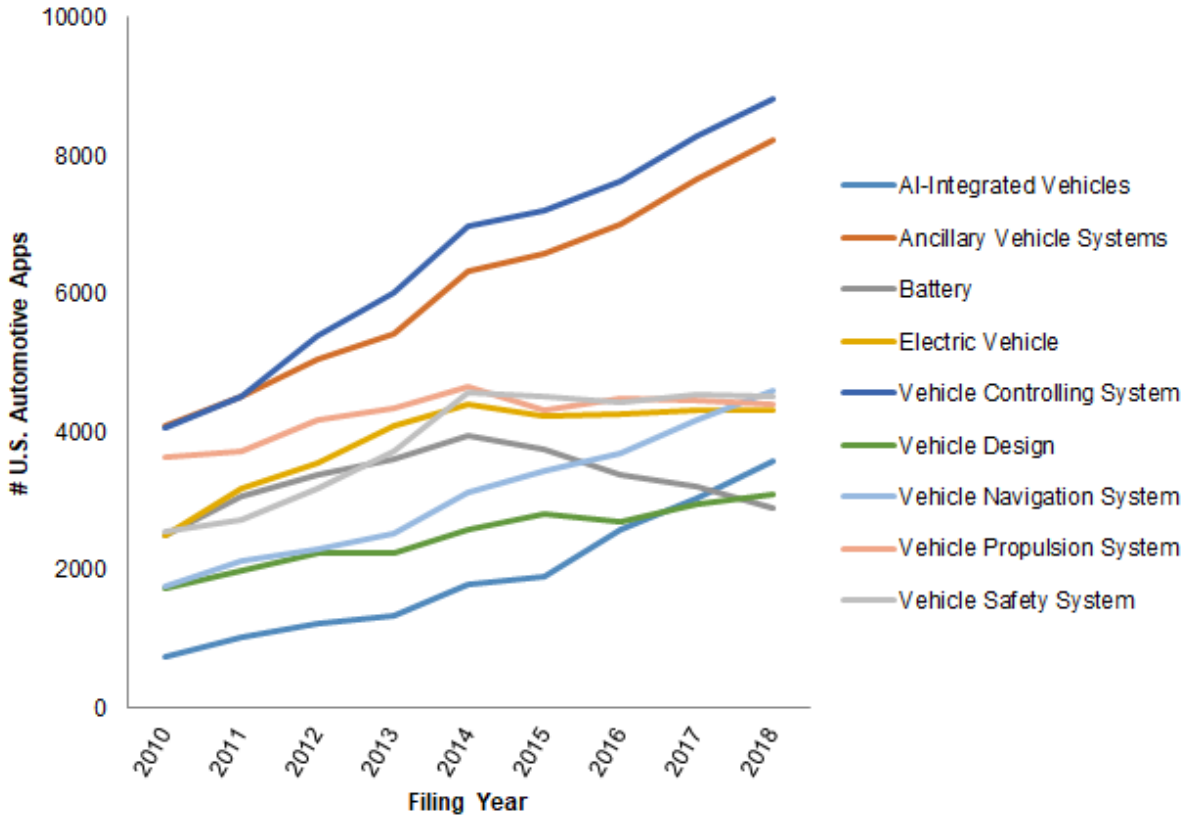
The automotive industry is heavily dependent on the availability of credit (both to its consumers and to manufacturers), so it was hit especially hard by the credit crunch of 2008. The situation was so dire that the U.S. government had to step in and bail out the big three American car manufacturers - General Motors, Ford and Chrysler. Predictably, R&D took a hit during that time,[23] and the number of patent filings reflect that downturn.

As the credit markets began to recover, so did the fortunes of the automotive industry and its R&D programs. Indeed, increasing their R&D efforts to produce energy-efficient vehicles was one of the promises that the bailed-out car companies made in order to receive government money.[24]

Other factors made the recent push for innovation imperative in the automotive industry. First, traditional car companies now have to compete with new entrants who focus on simpler electric propulsion without the burden of the combustion engine, and they see even more potential competition on the horizon from Big Tech powerhouses developing autonomous vehicle technology. Second, consumer tastes are evolving, and there is evidence that they are prioritizing in-car technological innovations over brand loyalty.[25] The decrease in brand loyalty means an increasingly competitive field, in which patent dominance can provide a significant advantage. The boom in innovation and in competition is reflected in the steep uptrend we found in patent filings from the automotive industry.

[23] https://newatlas.com/worlds-top-20-corporate-rd-spenders/13406/
[24] https://www.treasury.gov/press-center/press-releases/Pages/tg31.aspx
[25] https://www.prnewswire.com/news-releases/autotrader-study-finds-48-percent-of-car-buyers-prioritize-in-vehicle-technology-over-brand-or-body-style-300387862.html

The steepest innovation trend is around the Vehicle Control Systems cluster



Vehicle control systems are the subject of significant R&D efforts, which are resulting in increasing patent filings. Innovation in vehicle control systems relates to several areas, including fuel efficiency, cybersecurity, safety, and emissions control.[26] All of these areas are likely to continue to be significant hotbeds of innovation - and of patent filings - for years to come.

[26] https://www.marketresearchfuture.com/reports/automotive-electronic-control-unit-market-4835; http://www.ti.com/lit/wp/sszy009a/sszy009a.pdf; https://www.nhtsa.gov/technology-innovation/vehicle-cybersecurity

The number of fuel cell-related patent filings is small, but fuel cell cars are a strong bet for at least one industry leader.

Our study indicates that only approximately 5% of patent applications in the Hybrid/Electric Vehicles cluster are related to fuel cells. One reason why this may be the case is that the manufacturing process is more complicated for fuel cell vehicles as compared to electric and hybrid vehicles. Another factor may be the lagging development of infrastructure, such as fueling stations, to accommodate fuel cell vehicles.[27] Yet a third consideration is the cost of clean-source (not from natural gas) hydrogen, which is still significantly more expensive than traditional fuels and needs innovation to be more competitive.[28]

However, despite the obstacles, Toyota is selling a fuel cell car, the Mirai,[29] which currently comes with three years of free hydrogen to soften the blow of fueling costs.[30] One of its considerations may be that fuel cells for automotive applications is an emerging technology where innovation does not face as much prior art.

The race for market share in electric cars is heating up

Car manufacturers are putting great R&D resources into electric cars, indicating that they see this technology dominating the automotive industry of tomorrow. Toyota, Ford, and Hyundai are all competing in this space and filing hundreds of patents related to this technology cluster. Although not on the patenting leaderboard, Volkswagen is in this race, too. It has recently unveiled its new electric car platform, called Modular Electric Toolkit ("MEB"), which it is willing to share with other car manufacturers.[31] Volkswagen's path to an electric car appears to be through partnerships with other innovators. For example, it recently invested $100 M in a solid-state battery company[32] and is looking for partners to adopt their MEB platform for vehicles from competing brands. Other brands are developing their own platforms for their affiliate brands as volume is required to develop the economies of scale that will allow continued relevance as the internal combustion engine era fades.

The patenting space for electric cars also includes component manufacturers who are innovating and filing for patent protection in this technology cluster. This trend has been noticed by Investors who are betting that component manufacturers will be the early winners in the shift to electric.[33]

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[27] https://www.japantimes.co.jp/news/2017/12/22/business/infrastructure-needs-put-drag-fuel-cell-vehicle-popularity/#.XHrfcFNKi9Y
[28] https://www.theicct.org/publications/developing-hydrogen-fueling-infrastructure-fuel-cell-vehicles-status-update
[29] https://www.ft.com/content/328df346-10cb-11e7-a88c-50ba212dce4d
[30] https://ssl.toyota.com/mirai/ownership-experience.html
[31] https://www.volkswagenag.com/en/news/stories/2019/01/volkswagen-offers-electric-cooperations.html
[32] https://www.cnet.com/roadshow/news/2018-volkswagen-quantumscape-solid-state-battery-technology/
[33] https://www.reuters.com/article/us-autos-ev-investors/investors-bet-on-component-makers-in-electric-car-shift-idUSKCN1GJ1IE

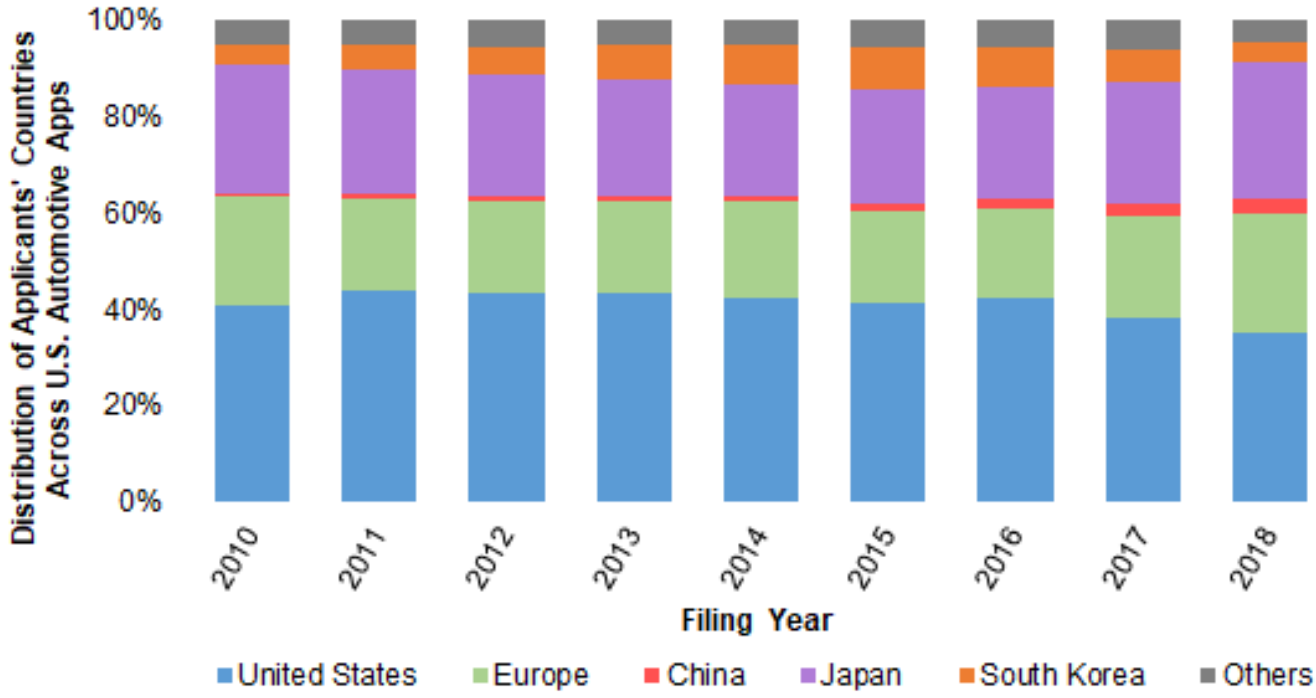
Toyota, Ford, Hyundai, and General Motors are the top filers in most technology clusters

Automotive leaders like Toyota, Ford, Hyundai, and General Motors, continue to patent broadly across all technology clusters, signaling their intent to maintain their leadership in automotive technology.

USING 2016 DATA:		
		Most Families Flied by
		(Applicants In alphabetical order)
Automotive		Ford, General Motors, Honda, Hyundai, Toyota
Level I		
AI Integrated Vehicle		Ford, General Motors, Honda, Hyundai, Toyota
Ancillary Vehicle Systems		Ford, General Motors, Honda, Hyundai, Toyota
Battery		Ford, Honda, Hyundai, Samsung, Toyota
Electric/Hybrid Vehicles		Ford, General Motors, Honda, Hyundai, Toyota
Vehicle Controlling System		Ford, General Motors, Honda, Hyundai, Toyota
Vehicle Design		Bridgestone, Ford, General Motors, Goodyear, Honda
Vehicle Navigation System		Ford, General Motors, Honda, Hyundai, Toyota
Vehicle propulsion System		Ford, General Motors, Honda, Hyundai, Toyota
Vehicle Safety System		Ford, General Motors, Honda, Hyundai, Toyota
Level I	**Level II**	
AI Integrated Vehicle	Autonomous Vehicles	Ford, General Motors, Honda, Hyundai, Toyota
	Connected Vehicles	Ford, General Motors, Honda, Hyundai, Toyota
Battery	Lead Based Battery	Ford, Hyundai, Johnson Controls Tech, Co., LG, Toshiba Corporation and affiliates
	Lithium based battery	Ford, Gs Yuasa International Hyundai, Ltd., Hyundai Toshiba Corporation and affiliates, Toyota
	Other Aspects {Battery Management System/Pads)	Ford, Honda, Hyundai, Samsung, Toyota
Electric/Hybrid Vehicles	Battery Electric Vehicles	Ford, General Motors, Honda, Hyundai, Toyota
	Fuel Cell Based Vehicles	Ford, Honda, Hyundai, Toyota, Volkswagen
	Hybrid Electric Vehicles	Ford, General Motors, Honda, Hyundai, Toyota
Vehicle Propulsion System	Electric Motor	Ford, General Motors, Honda, Hyundai, Toyota
	Internal Combustion Engine (Ice)	Ford, General Motors, Honda, Hyundai, Toyota

Other manufacturers, however, appear to be focusing their patenting efforts on vehicle design. Notable examples of this trend are Fiat Chrysler, Ferrari, and Daimler AG - the parent company of Mercedes Benz.

European and Japanese companies are filing a higher percentage of automotive industry patent applications

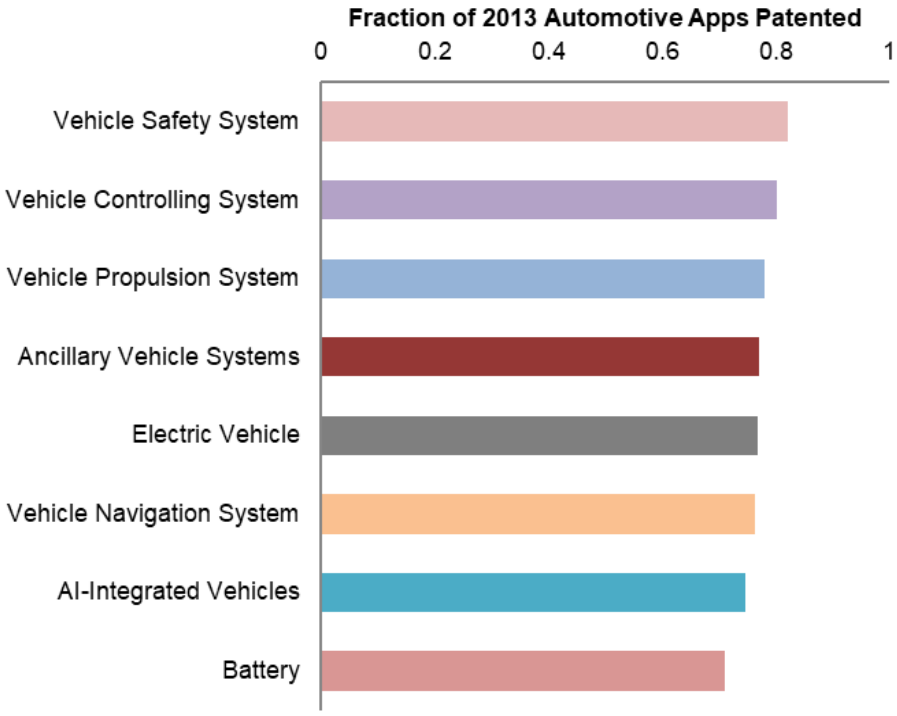


In the past 5 years, U.S.-based companies have been filing less than 45% of patent applications in the USPTO, and that percentage appears to be falling. The decrease is especially noticeable since 2017 when the present U.S. presidential administration began its tenure. This administration has rolled back a number of regulations that impact the automotive industry, potentially reducing the urgency of some R&D initiatives.

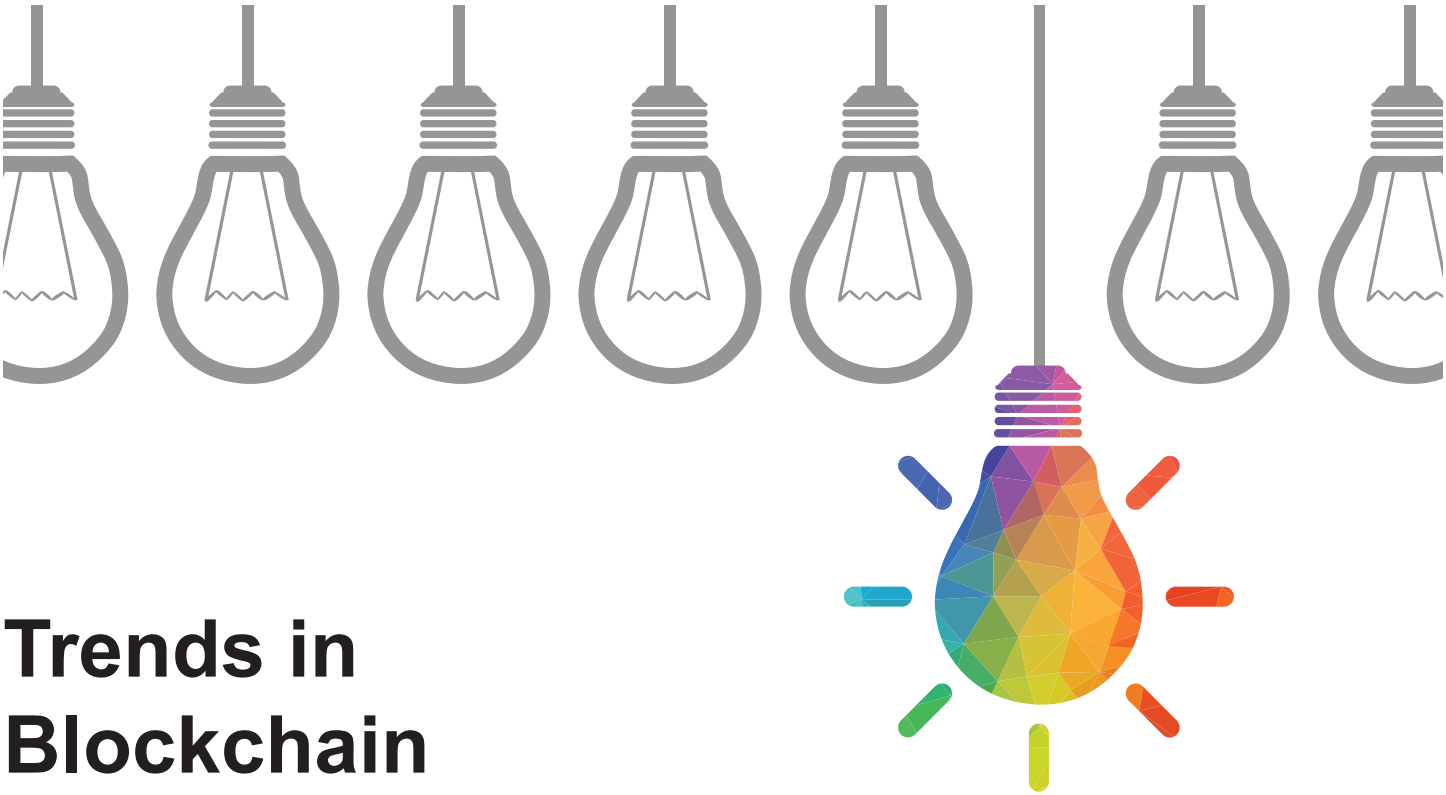
On the flipside of this trend, European and Japanese companies are filing a higher percentage of patent applications. It is likely that the uptrend in European and Japanese patenting activity relates at least in part to the more stringent regulatory environment in those markets, including much higher mandated fuel efficiency standards.[34]

[34] https://www.nytimes.com/interactive/2018/04/03/climate/us-fuel-economy.html

The majority of Automotive Industry patent applications are granted allowances



An automotive Industry patent application filed in the USPTO has a better than 75% chance of being granted allowance, which exceeds the average of the U.S. patent office. Although not shown, design patents have allowance rates higher than utility patents generally.



Trends in Blockchain

Blockchain patent filings are quickly diversifying. In addition to a growing number of patent filings for non-cryptocurrency-related FinTech applications, patent filings for supply chain logistics and healthcare applications are growing at a steep pace as well. We foresee growing diversification as more industries incorporate blockchain technology into their operations.

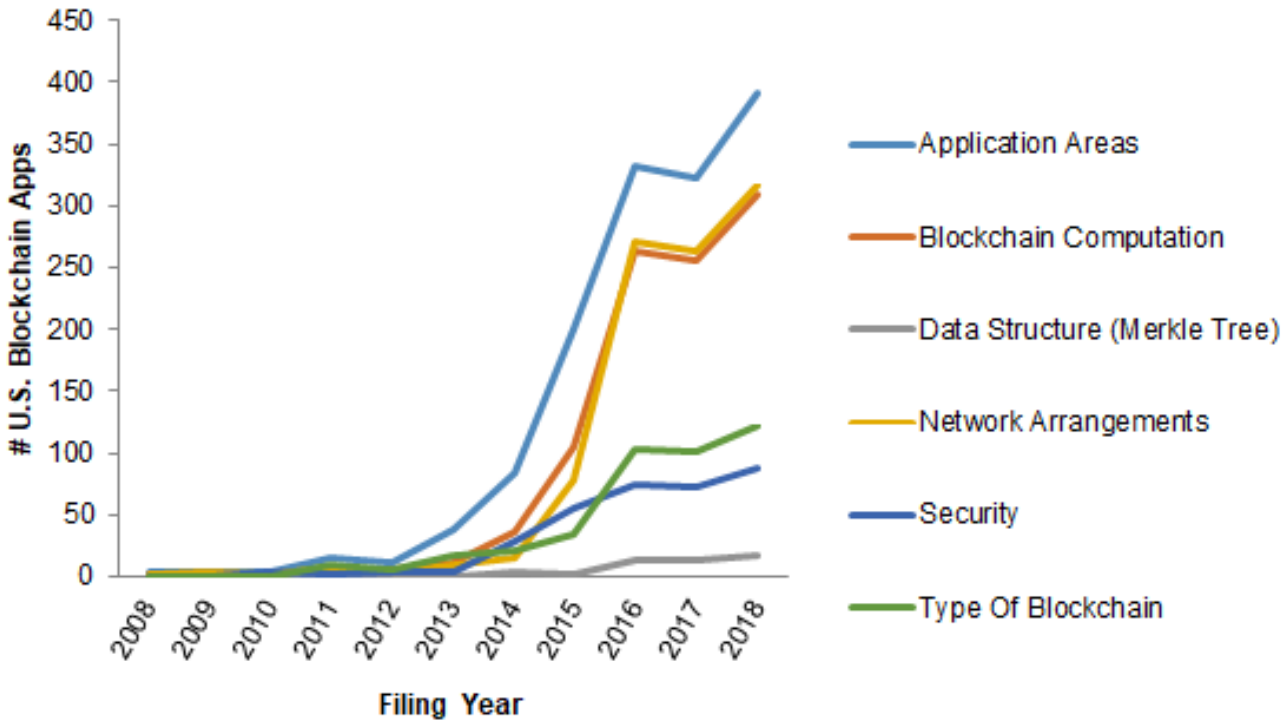
Blockchain and distributed ledgers hold the promise to make transactions more transparent and trustworthy using algorithms and technology. Blockchain is perhaps best known for its essential role in cryptocurrencies, but it has a wide variety of other applications - from ensuring supply chains to managing contracts - that will eclipse its value to cryptocurrency. Therefore, it is increasingly being adopted by businesses that see it as being foundational and disruptive in a way that no industry is immune to.

For our study, we have defined the following technology clusters within the general blockchain industry, which has enabled us to observe several distinct trends about this industry:

Application Areas	**Level II Clusters**
Application Areas	Digital Media
	Energy Distribution/Smart Grids
	Fintech (Cryptocurrency)
	Fintech (Other Aspects)
	Gaming
	Healthcare
	Internet Off Things
	Supply Chain/Logistics/E-Commerce
Blockchain Computation	Block Generation
	Block Hashing
	Block Mining
	Block Sharing
Data Structure (Merkle Tree)	
Network Arrangements	Decentralized Database/Ledger
	Peer-To-Peer Networking
Security	
Type Of Blockchain	Federated/Consortium Blockchain
	Private Blockchain
	Public Blockchain

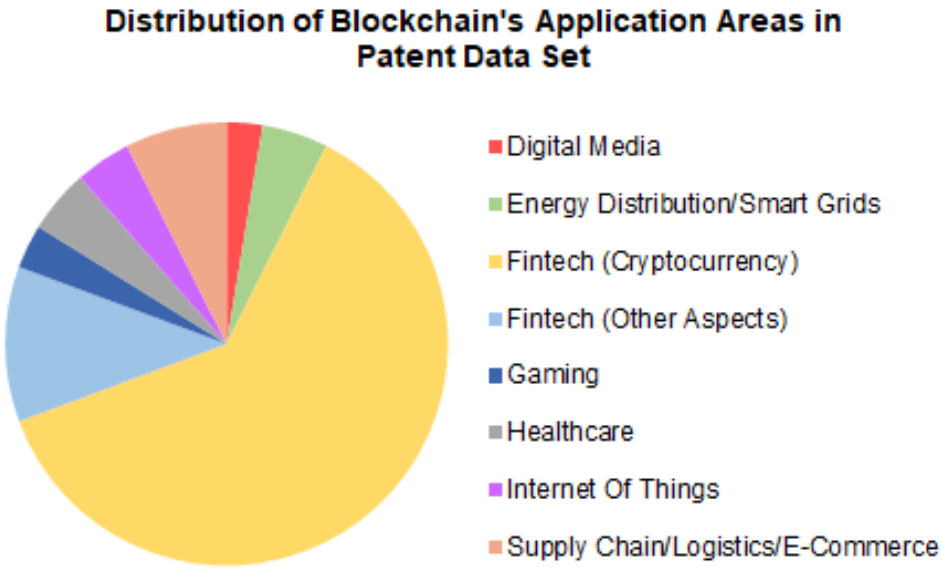
Taxonomies and expanded definitions of these clusters are included in appendix A.

Blockchain patent filings are growing in every technology cluster



Within five years of Satoshi Nakamoto's seminal 2008 white paper, which first described Bitcoin and the blockchain, technology leaders have seized on the promise of blockchain and launched robust programs of innovation that will revolutionize all sectors of the economy. Moreover, in many countries, fiat currency - although government-backed - has less credibility than algorithm-created, secure cryptocurrency, such that the pace of innovation is stoked by political manipulation of government-issued money.

Since its inception, the technology cluster where patenting activity has been the highest for blockchain relates to its possible applications. Although there is significant and increasing patenting activity around blockchain computation and data structure, the most heated patenting race is for protecting the innovative ways in which blockchain can be used, which are predicted to disrupt many industries.



While the highest number of patent filings for blockchain applications still relate to cryptocurrencies, patent filings are quickly diversifying. In addition to a growing number of patent filings for non-cryptocurrency-related FinTech applications, patent filings for supply chain logistics and healthcare applications are growing at a steep pace as well. Currently, more than a quarter of patent filings relate to non-FinTech applications, and we foresee this percentage rising as more industries incorporate blockchain technology into their operations.

IBM and Bank of America lead in all technology clusters of blockchain patent filings[35]

USING 2016 DATA		
		Most Families Flied by
		Applicants in alphabetical order)
Blockchain		Bank OF America, Cognitive Scale, IBM, Intel, Mastercard
Level I		
Application Areas		Bank Of America, IBM, Intel, Mastercard, The Toronto- Dominion Bank
Blockchain Computation		Bank Of America, IBM, Intel, Mastercard, The Toronto- Dominion Bank
Network Arrangements		Bank Of America, Cognitive Scale., IBM, The Toronto-Dominion Bank, Walmart
Security		Bank of America, Deutsche Bank, Fujitsu, IBM, Idm Global, Microsoft
Type Of Blockchain		Bank Of America, Business Information Exchance System Corp., IBM, Intel, Mastercard
Data Structure (Merkle Tree)		Coinplug, IBM, Idm Global, Mastercard, Nec Corp., Workday
Level II	**Level II**	
Application Are	Fintech (Cryptocurrency)	Accenture, IBM, Id m Global, Intel, Mastercard, PayPal, VISA
	Fintech {Other Aspects)	Bank Of America, The Bank Of New York Mellon, Deutsche Bank, JPMorgan Chase Bank, Mastercard, Monetago
	Supply Chain/Logistics/E-Commerce	Bank Of America, Cisco, Cognitive Scale, IBM, Raise Marketplace, Walmart
	Energy Distribution/S mart Grids	Causam Energy, Inc., IBM, Intelligent Energy Limited, Netspective Communications Llc, Sichuan Energy Internet Research Institute (Tsinghua University), Walmart
	Healthcare	Acron's International Gmbh, Bank Of America, Cognitive Scale, IBM, Walmart
	Internet Of Things	Cisco, IBM, Intel, SAP SE, VISA
	Gaming	IBM, Priv8Pay, Spur Trail Investments, Swirlds
	Digital Media	Dot Blockchain Music, IBM, Intel, Oxford-Downing, Priv8Pay, The Toronto-Dominion Bank, VISA
Blockchain Computation	Block Generation	Bank Of America, Coinplug, IBM, IP Morgan Chase Bank, Mastercard
	Block Mining	Bank Of America, IBM, Intel, Mastercard, The Toronto-Dominion Bank
	Block Hashing	Cisco, Coinplug, IBM, Mastercard, Sony Corp., Walmart
	Block Sharing	Bank OF America, Deutsche Bank, IBM, JP Morgan Chase Bank, Mastercard, Nasdaq, Sony Corp.
Network Arrangements	Decentralized Database/ Ledger	Bank OF America, Cognitive Scale, IBM, Intel, The Toronto-Dominion Bank, Walmart
	Peer-To-Peer Networking	Accenture, Bank OF America, IBM, Mastercard, Nasdaq
Type Of Blockchain	Public Blockchain	Bank OF America, Business Information Exchange System Corp., Coinplug, IBM, Intel, PayPal
	Federated/Consortium Blockchain	Bank OF America, Capital One Services, Causam Energy VISA, Vmware,
	Private Blockchain	Bank Of America, Cognitive Scale, Coinplug, IBM, Mastercard

[35] Although patent filings are growing in this industry, the actual numbers are still small. In some clusters, more than one entity has filed the same number of patent applications, necessitating listing more than five leading filers per cluster.

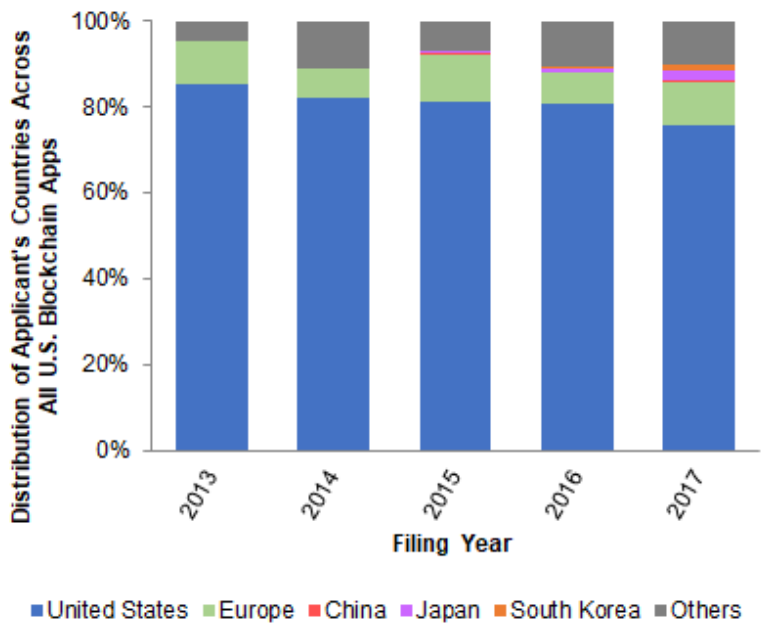
From the increasing number of its patent filings in this industry, it appears that IBM intends to continue its push for leadership in blockchain. Indeed, IBM's patent filings are compatible with its statements about blockchain being a current and future research priority. With the recent open sourcing of IBM's Hyperledger code base,[36] we can expect the value of these patents to increase with broader adoption of their technological approach.

Bank of America is also a prolific patent filer in the blockchain space. Its patenting strategy suggests that it does not want to be left behind and risk being shut out of this emerging industry that could displace some traditional financial services. Even if its patents do not relate to any particular product or service in its current pipeline, a strong patent portfolio gives Bank of America a defensive advantage, should it face a patent war relating to blockchain in the future as new competitors begin to dominate beyond their emerging roots in the blockchain area.

Not to be left out, Mastercard has emerged as a patenting powerhouse.[37] Their innovation effort in blockchain technology is notable. Traditional card brands may benefit from blockchain technology, but their legacy systems are well established and mature. Blockchain innovation could disrupt that status quo to displace entrenched incumbents who do not extend their brands to address displacing innovation.

While familiar names are the dominant players in blockchain patenting, it is of note that hundreds of other entities and individuals have filed patent applications in this space. Because blockchain is a young and fast-evolving technology, it is possible that some of these smaller entities may have a seminal patent on a core pioneering innovation that could shape the future of this technology.

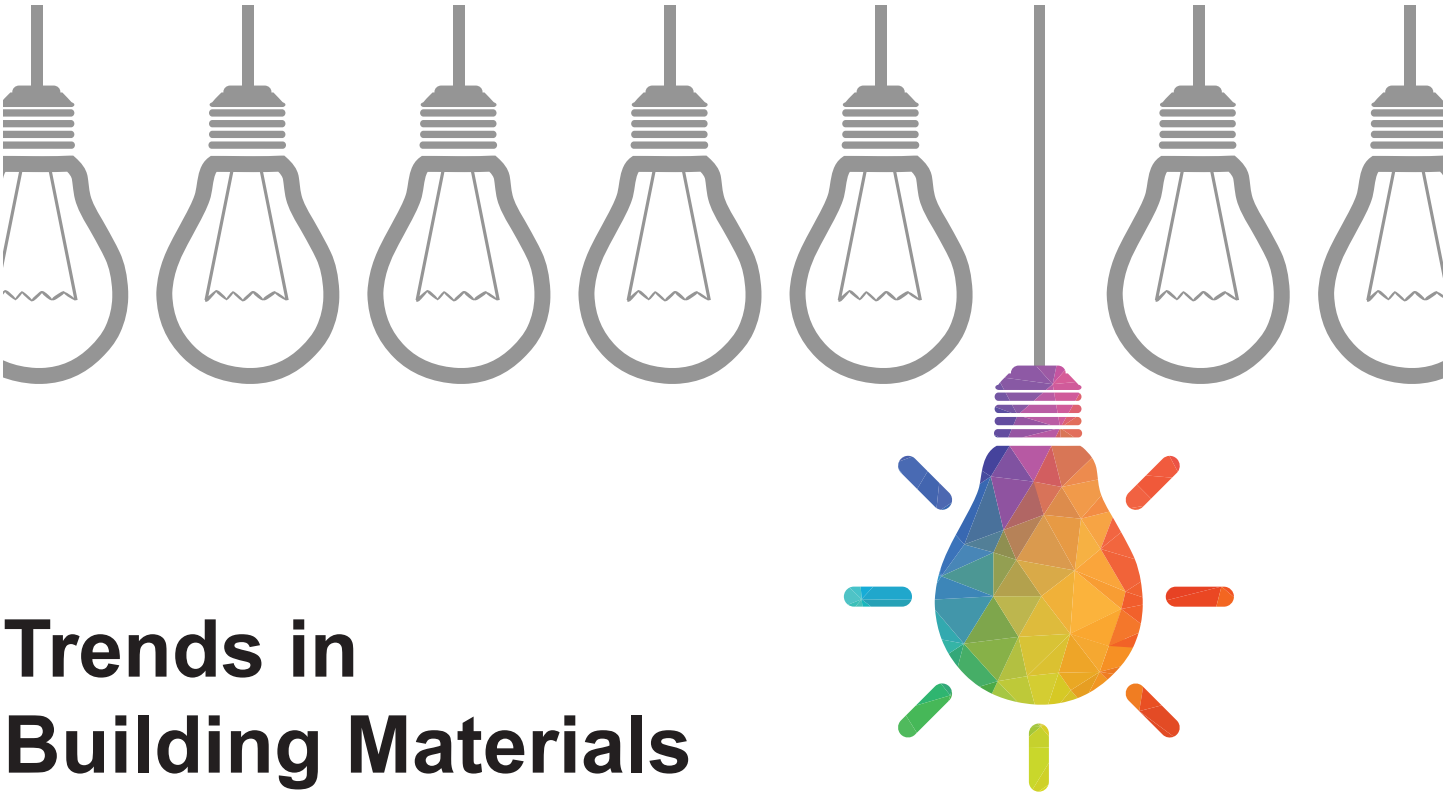
The percentage of U.S.-based applications is declining



Despite the push for filing patents on blockchain innovations by American corporations such as IBM and Bank of America, an increasing percentage of patent applications are filed by foreign entities. As blockchain's economic significance continues to rise globally, we expect this trend to continue.

For example, Japan is an early adopter of digital currency and the use of blockchain for other business and civic applications. Bitcoin became legal currency in Japan in 2017, and a municipal election held last year allowed voters to start using blockchain technology. It is, therefore, not surprising to see a trend of an increasing blockchain-related patenting activity by Japanese applicants in the USPTO.

[36] https://www.kilpatricktownsend.com/-/media/Files/articles/2018/Blockchain-Patents-and-Open-Source-Software-Daily-Journal-041818.ashx
[37] https://ethereumworldnews.com/mastercard-investing-heavily-blockchain/



Trends in Building Materials

The rapid innovation in protective and decorative materials is reflected in the rise in the number of U.S. patent applications filed in this space over the last five years. In fact, the number of patent applications for these materials dwarfs all other types of building materials in our study.

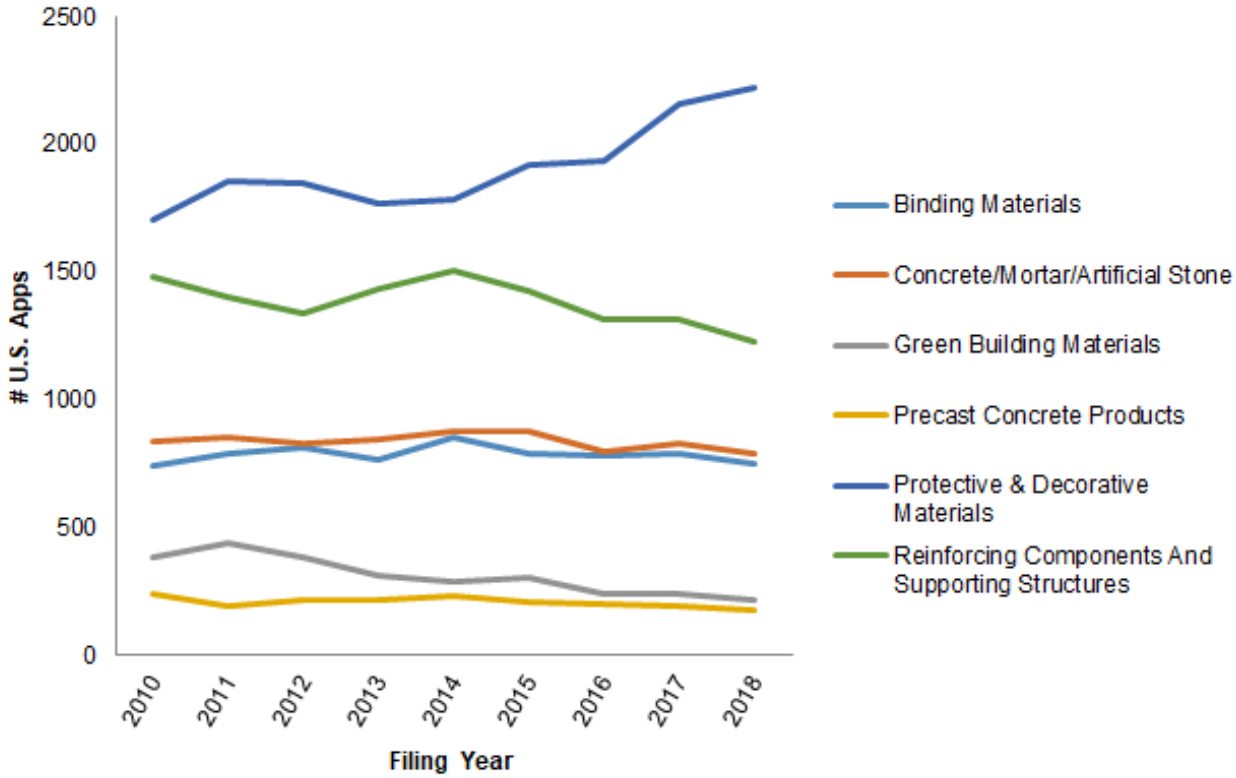
These are exciting times for innovation in building materials, from transparent aluminum ceramics[38] to self-healing concrete[39] to floors made of mushrooms.[40] The rapid pace of innovation in this field is reflected in the steady flow of patent applications filed in the USPTO and the number of patents issued to industry businesses.

To delve deeper into the trends of patenting innovation in building materials, we have defined the following technology clusters within the general building materials industry:

Taxonomies and expanded definitions of these clusters are included in appendix A.

Building Materials -Level I Clusters	Level II Clusters
Binding Materials	Cement
	Polymeric Materials
	Pozzolanic Materials
Concrete/Mortar/Artificial Stone	-
Green Building Materials	-
Precast Concrete Products	-
Protective & Decorative Materials	-
Reinforcing Components Arid Supporting Structures	-
Smart Building Materials	-

Patenting of protective and decorative materials is on an upswing while it is slumping in green building materials



[38] https://hackaday.com/2018/04/03/whats-the-deal-with-transparent-aluminum/
[39] https://www.cnn.com/2015/05/14/tech/bioconcrete-delft-jonkers/index.html
[40] https://www.smithsonianmag.com/innovation/fungus-material-future-180962791/

Innovative protective and decorative materials promise significant benefits in both new construction and the remediation of older buildings. These materials, which include paints, vapor barriers and polishes, improve the service and decorative quality of buildings and structures, as well as protect structural members from atmospheric and other dangers such as water, heat, fire, and even microbes.

One of the biggest promises newer protective and decorative materials hold is energy savings. Because the heating and cooling of buildings account for 35 to 60 percent of total energy demand and produce nearly 40 percent of emissions in urban areas, reducing the energy consumption associated with these activities offers a fast and significant payoff in terms of urban sustainability and lower greenhouse gas emissions.[41] Energy-efficient materials can be used not only in new construction, but also with envelopes for existing buildings.

The rapid innovation in protective and decorative materials is reflected in the rise in the number of U.S. patent applications filed in this space over the last five years. In fact, the number of patent applications for these materials dwarfs all other types of building materials in our study.

On the other hand, since 2011, there has been a pronounced decline in patent filings on innovations in green building materials. Even though several industry reports describe rising public awareness and strong interest in green technologies and materials, that has not translated into significant increases in patenting in this technology cluster. One possible explanation for this paradox is that the industry is prioritizing capitalization on its existing innovative technologies rather than moving ahead with resource-intensive new R&D. Another possibility is that the industry is relying on other forms of intellectual property protection (*e.g.*, trade secrets), opting to patent only its most promising and groundbreaking innovations.

The drop-off in green building materials innovation also corresponds to the end of government incentives that were promulgated to help the U.S. economy recover from the Great Recession, suggesting that this industry is sensitive to the cost of innovation.[42] This sensitivity may be caused in part by the uncertainty surrounding the commercial adoption of new green building materials. The adoption of new green building materials is uncertain for at least the following three reasons. First, the construction of LEED-certified buildings has declined since 2013, likely because of how long and expensive the certification process is.[43] Second, many green building materials have not demonstrated the performance and durability required in construction materials, creating doubt as to their suitability in construction, especially if the construction must withstand extreme heat, cold or humidity. Third, the credit-crunch and housing-market collapse in 2008 also made green building products less sellable because they are more expensive than traditional products. The consequence of diminished demand for green building products during the credit crunch is reduced budgets for R&D, which in turn, may be resulting in fewer patent filings as we see in this study.

[41] https://www.eesi.org/files/climate.pdf
[42] https://journalistsresource.org/studies/environment/cities/governmental-incentives-green-building-construction/
[43] https://www.questia.com/newspaper/1P2-38986962/leed-dwindles-number-of-new-certified-sustainable; http://www.sandbergphoenix.com/construction-litigation/blog/leed-certification-on-the-decline-while-energy-efficiency-is-on-the-rise

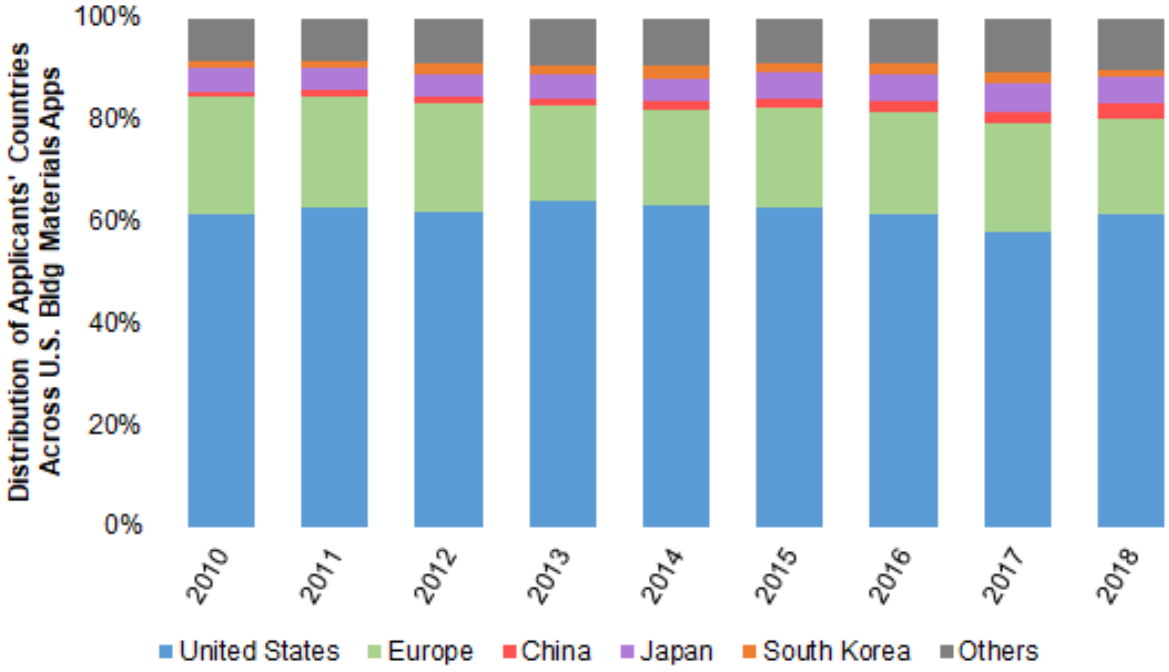
Incumbents dominate the building material industry, in terms of both owning the majority of patents and filing the majority of new patent applications.

USING 2016 DATA:	
	Most Families Filed by
	(Applicants in alphabetical order)
Building Materials	Baker Hughes, Boeing, Caterpillar, Schlumberger -Technology Corp., United States Gypsum Co.
Level I	
Binding Materials	Baker Huges, Nano And Advanced Materials Institute, Schlumberger Technology Corp. Soldia Technology, United States Gypsum Co.
Concrete/Mortar/Artificial Stone	Black & Decker, Columba Machine, Herostone Quartz Surfaces, Quipip, Nano And Advanced Materials Institute
Green Building Materials	Baker Huges, Council OF Scientific & industrial Research, Recover Energy Services, Sk Energy Co., Sk Innovation, Co., University of Florida
Precast Concrete Products	Corning, Covestro, Corruven Canada, Halliburton, Midwest Concrete & Masonry Supply, Inc.
Protective & Decorative Materials	Boeing, Covestro, General Electric, Owens Corning, United States Gypsum Company, Usg Interiors
Reinforcing Components And Supporting Structures	Boeing, Campvalley (Xiamen) Co., Caterpillar, Columbia Insurance Co., Hunter Douglas
Smart Building Materials	Baker Huges, General Electric, Heliotrope Technologies, Saudi Arabian Oil Co., Schlumberger Technology Corporation

Companies at the forefront of innovation with respect to materials and building R&D are also the leading patent filers in our study. New building materials is an important category of innovation that has the potential to transform the building industry in a matter of years rather than decades. It is also a competitive industry, where R&D is expensive.[44] It is not surprising, therefore, that leaders in this industry are seeking to protect their investment in innovation and their competitive positions with patents.

[44] https://www.inc.com/greg-satell/materials-science-may-be-most-important-technology-of-next-decade-heres-why.html

The percentage of U.S.-based patent applications is holding steady near 60%

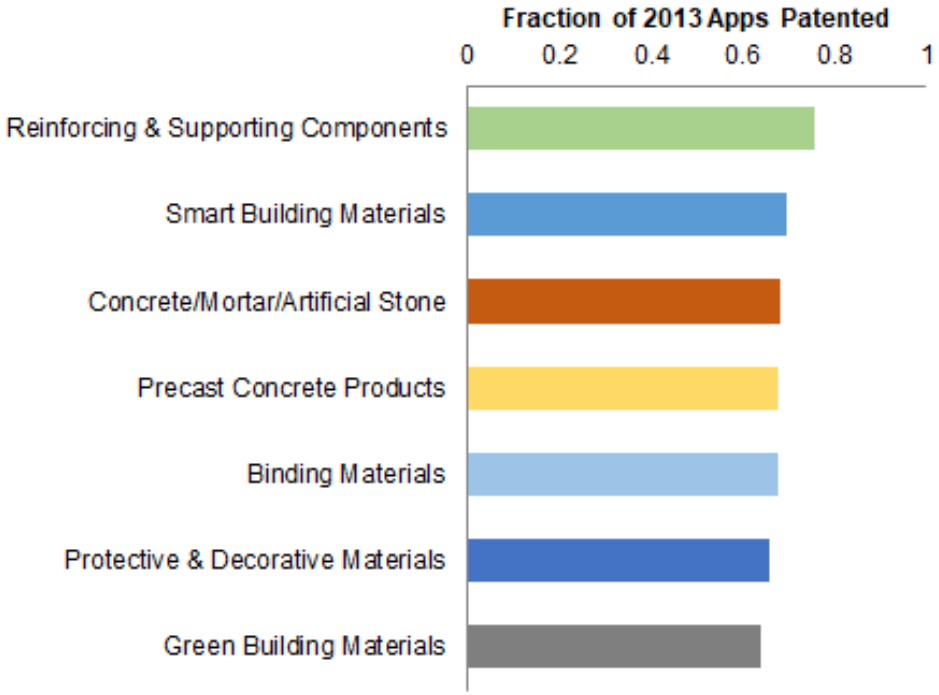


While patent applications originating in the United States and Europe continue to dominate in the building materials industry, China's entry into this industry is noteworthy. Although the overall number of Chinese applications remains small, our data show a significant year-over-year increase in these applications. This trend is consistent with China's relatively recent focus on green buildings, pollution reduction and urban sustainability,[45] and its policy decision to encourage patent protection for its companies' innovations, both domestically and internationally, with generous tax benefits.[46]

[45] https://www.weforum.org/agenda/2017/06/china-clean-green-buildings-future/
[46] https://chinapower.csis.org/patents/; https://www.managingip.com/Article/3538144/How-patent-subsidies-boost-R-D.html?ArticleId=3538144

Patents are granted on the majority of building materials patent applications

Of patent applications filed in 2013, over 60% have been allowed to issue as a patent (and more may be forthcoming). Applications relating to reinforcing and supporting components are allowed more than 75% of the time making those patents easier and thus cheaper to obtain.

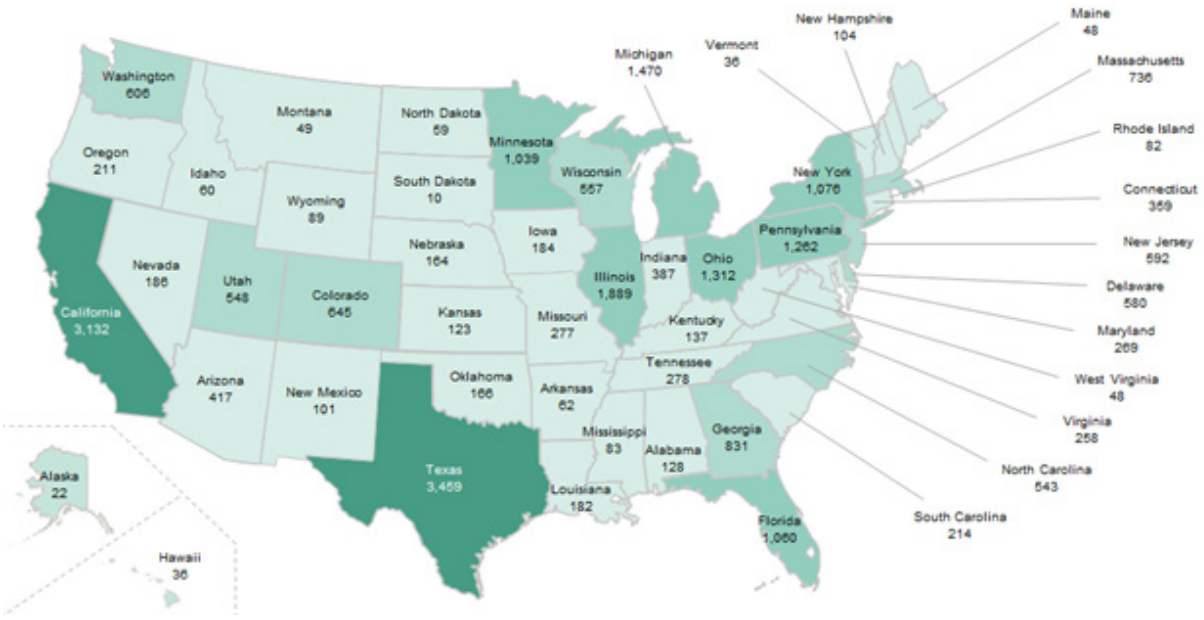


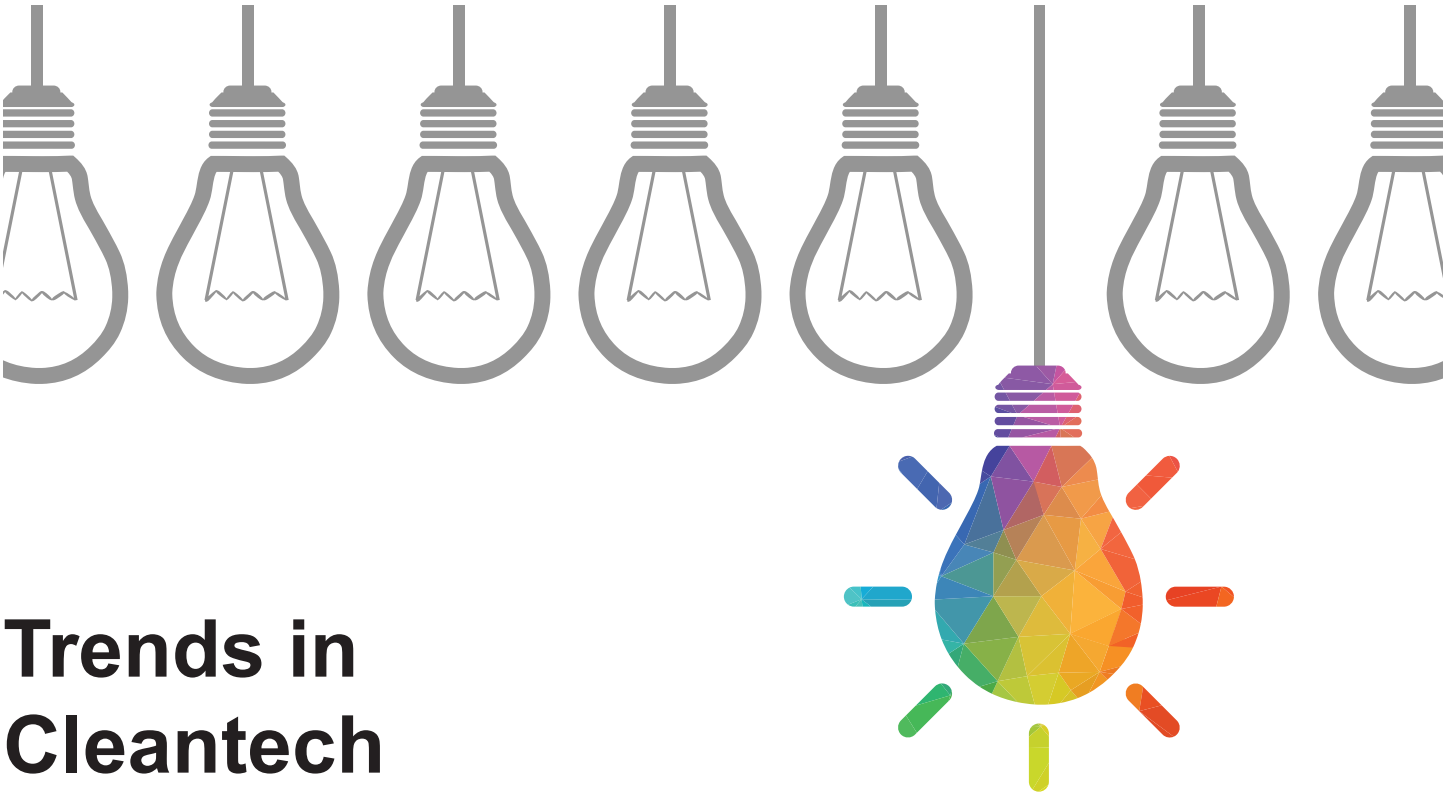
Applications for building materials are predominantly examined in Technical Centers 3600 (examining applications in the Transportation, Electronic Commerce, Construction, and Agriculture fields) and 1700 (examining applications in the Chemical and Materials Engineering fields), in both of which, allowance rates tend to be consistent with the overall average allowance rate of the USPTO if you exclude the business method Art Units.

Texas is the dominant patent hub for Building Materials

California dominated each of the industries surveyed in this study except Building Materials. The population advantage explains California's dominance in innovation, but Texas has a notable hub for this technology due to the strength of its hydrocarbon and aerospace industries. Hydrocarbon production relies on cutting edge building materials such as underwater concrete along with the exotic materials needed to support NASA and other aerospace efforts.

Distribution of filings across states for the Building Materials





Trends in Cleantech

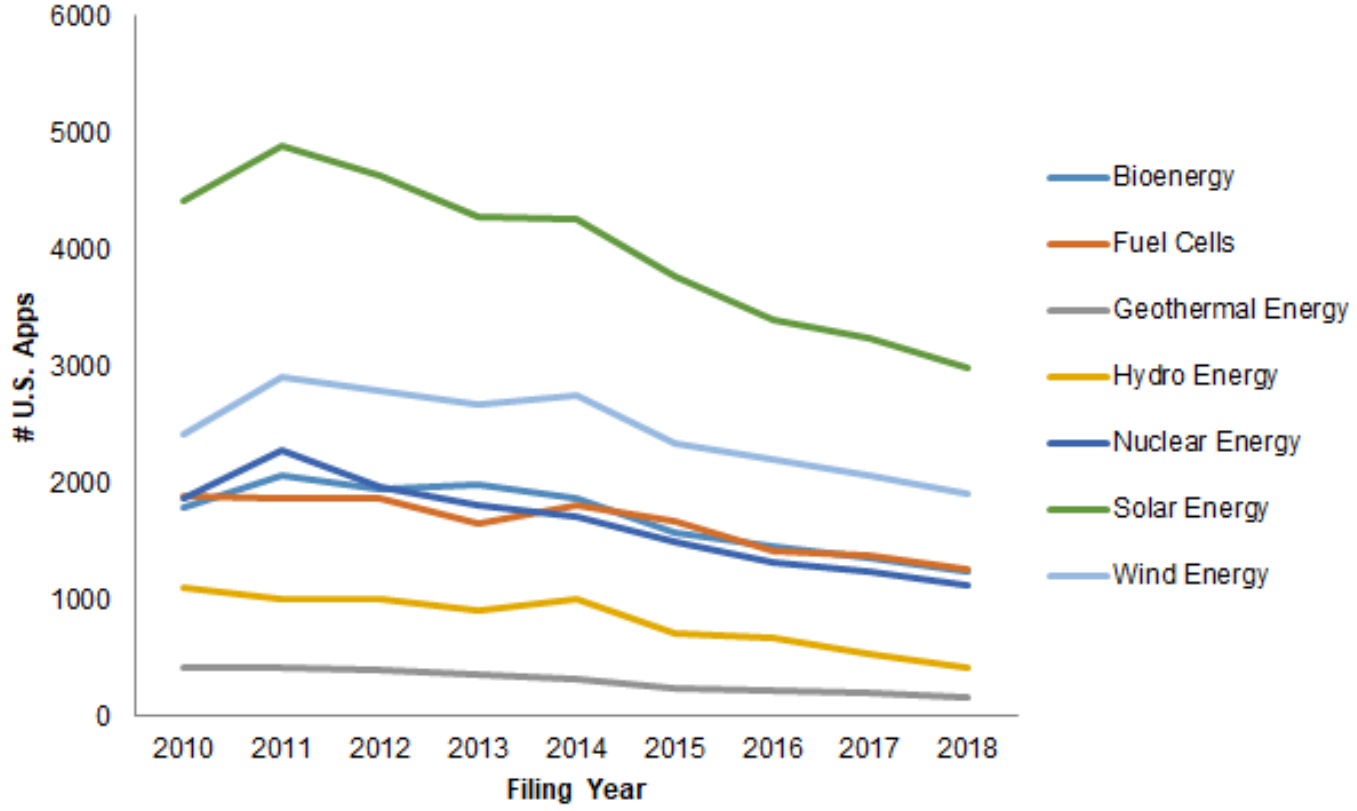
The broad impact and potential benefits of cleantech are underscored by the diversity of the leading patent filers. From automotive companies to home appliance manufacturers to personal consumer product companies, businesses in different sectors of the economy are investing in innovations and patenting in the Cleantech industry.

Cleantech has encountered significant headwinds in the last few years, and the patenting trends in this industry reflect this history. To delve deeper into the trends of patenting cleantech innovation, we have defined the following technology clusters within the general Cleantech industry:

Taxonomies and expanded definitions of these clusters are included in appendix A.

Level I Clusters	Level II Clusters
Clean Energy Harvesting	Bioenergy
	Fuel Cells
	Geothermal Energy
	Hydro Energy
	Nuclear Energy
	Solar Energy
	Wind Energy
Energy Efficient Systems	Electric Vehicles
	Smart Grids
	Smart/Green Homes
Environment Protection	Air Pollution
	Soil Pollution
	Sustainable Materials
	Waste Treatment & Recycling
	Water Pollution

Patenting of clean energy harvesting innovations has been on a steep downward trend since 2011



In 2009, the Obama administration loosened the requirements for obtaining a loan under the American Recovery and Reinvestment Act, which was passed to help businesses in the aftermath of the Great Recession. Under the new terms, the government agreed to shoulder more risk for renewable energy projects. These loans were in very high demand, and all available money was distributed by September 2011.

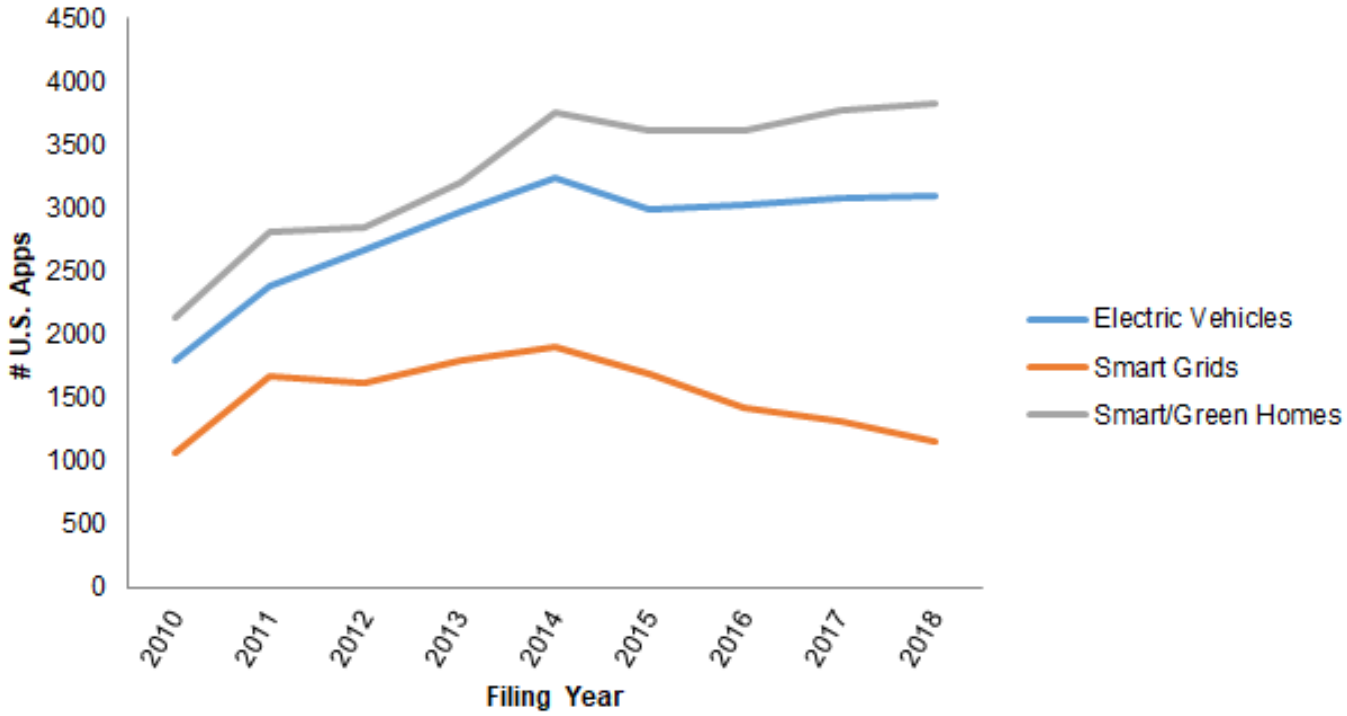
The easier credit terms attracted venture capital ("VC"), causing a boom in cleantech innovation and a corresponding rise in patenting activity. But once the credit spigot was turned off in September 2011, VC money started to dry up as well.

The lack of government-backed credit was partially responsible for the downturn in clean energy investing, but there were other factors as well. First, clean energy became a less attractive investment because natural gas became cheaper, starting in 2008, making emerging sources of energy uncompetitive. Second, China made an aggressive push to become the leading producer of solar panels, thereby commoditizing them and reducing the incentive to innovate in this technology area.[47]

It is also of note that the catastrophic meltdown in the Fukushima nuclear plant in 2011 has made nuclear energy politically untenable in most first-world countries. Germany, for instance, shut down eight nuclear reactors following the Fukushima disaster and plans to phase out nuclear power by 2022. The Fukushima disaster has likely contributed to a sharp drop-off in nuclear energy innovation and patenting activity.[48]

[47] https://www.brookings.edu/research/cleantech-venture-capital-continued-declines-and-narrow-geography-limit-prospects/
[48] https://spectrum.ieee.org/energywise/energy/nuclear/the-biggest-energy-story-of-2011

Efficient energy systems are diverging in their patent filing trends



In contrast to the uniform downward trend for patent filings in clean energy harvesting technologies, efficient energy systems show significant divergent trends in their patent filings.

Smart-grid innovation as evidenced by patent filings has been falling off since 2014. One potential reason for this trend is the discontinuation of the Smart Grid Investment Grant program ("SGIG"), which was part of the federal government's broader economic stimulus after the financial crisis. Another potential reason for the trend is the lack of uniformity in state smart-grid regulations, which may impede smart grid deployment across the country and reduce incentives to innovate and patent in this technology cluster.

On the other hand, technologies relating to Smart/Green Homes continue to experience growth, both in their adoption by consumers and in innovation and patenting activity, despite the removal of the SGIG stimulus, suggesting that there is enough market interest to support ongoing innovation. One particular area of innovation is in hardware interoperability that would allow consumers to use digital A.I. assistants (*e.g.*, Siri or Alexa) interchangeably.[49]

Electric vehicles are also experiencing growth in innovation and patent filings after the end of SGIG. This trend may be driven in part by regulatory requirements in Japan and the European Union, where fuel efficiency standards are significantly higher than in the United States.

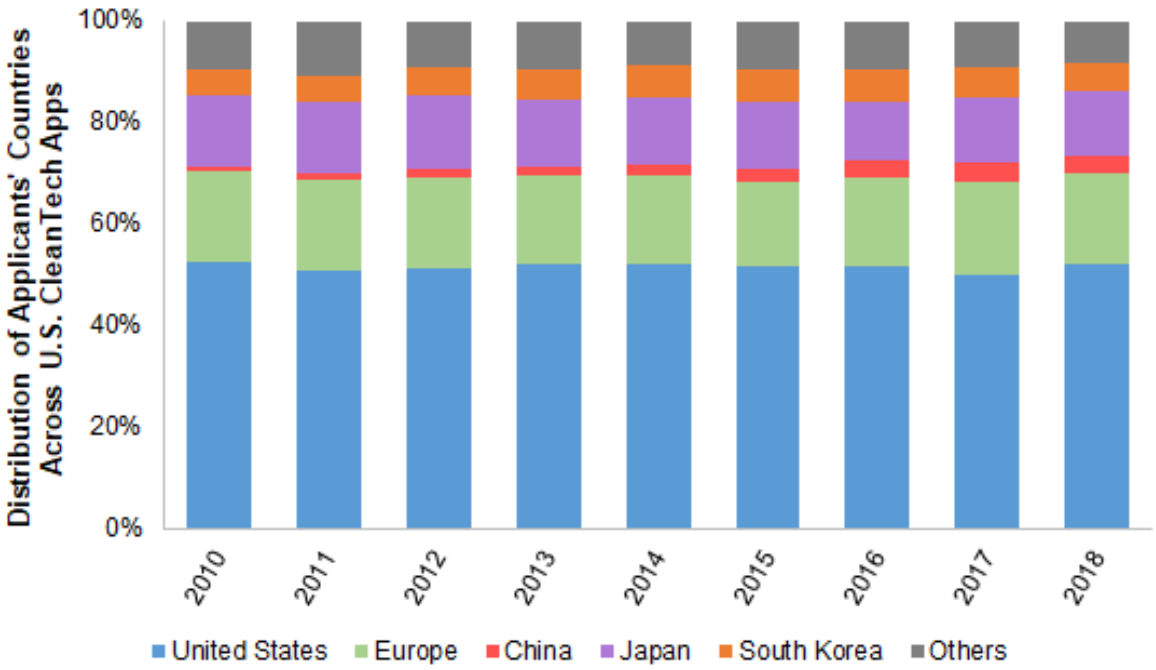
[49] https://www.businesswire.com/news/home/20180329005105/en/New-IDC-Smart-Home-Device-Tracker-Forecasts

Leading Cleantech patent filers come from a variety of industries

USING 2016 LIAM:		
		Most Families Flied by
		(Applicants in alphabetical order)
CleanTech		Ford, General Electric, Hyundai, Samsung, Toyota
Level I		
Clean Energy Harvesting		General Electric, Honda, Hyundai, LG, Toyota
Energy Efficient Systems		Ford, Honda, Hyundai, Samsung, Toyota
Environment Protection		Ford, General Electric, Hyundai, LG, Procter & Gamble
Level I	**Level II**	
Clean Energy Harvesting	Bioenergy	Beijing Huashi United Energy Technology And Development, General Electric, Industrial Technology Research Institute, Iowa State University Research Foundation, Lonza, Massachusetts Institute of Technology, Shell Oil Co., Uop
	Fuel Cells	Ford, Honda, Hyundai, Panasonic, Toyota
	Geothermal Energy	Ecolab USA, King Fahd University Of Petroleum And Minnerals, Sharp Kabushiki Kaisha, Toshiba Corporation and affiliates, University Or California
	Hydro Energy	Caterpillar, Ingine, Libherr-Mining Equipment Colmar Sas, Raytheon, South Dakota Board of Regents
	Nuclear Energy	Mallinckordt Nuclear Medicine, Siemens, Terrapower, Toshiba Corporation and affiliates, Westinghouse Electric Co.
	Solar Energy	IBM, LG, Panasonic, Solarcity Corp., Sunpower Corp., Toyota
	Wind Energy	General Electric, IBM, Mitsubishi, Nordex Energy, Siemens, X Development
Energy Efficient Systems	Electric Vehicles	Ford, General Motors, Honda, Hyundai, Toyota
	Smart Grids	ETRI, General Electric, Hyundai, Mitsubishi, Qualcomm, Siemens
	Smart/Green Homes	Google, Honeywell, Johnson Controls Technology Co., LG, Samsung
Environment Protection	Air Pollution	Ford, General Electric, Hyundai, LT, Toyota
	Soil Pollution	Ecolab USA, Procter & Gamble, Recover Energy Services, True Organic Products, Whirlpool Corp.
	Sustainable Materials	BOE Technology Group Co., Monosol, Procter & Gamble, Shenzhen China Star Optoelectronics Technology Co., United States Gypsum Co.
	Waste Treatment & Recycling	Edgewell Personal Care Brands, Emerson Electric Co. General Electric, IBM, Rubicon Global Holdings, True Organic Products, Whirlpool Corp.
	Water Pollution	Doman Heavy Industries & Construction Co., Ecolab USA, Ford, Haler US Appliance Solutions, King Fahd University Of Petroleum And Minerals, Nanjing University

The broad impact and potential benefits of cleantech are underscored by the diversity of the leading patent filers in the various cleantech technology clusters. From automotive companies to home appliance manufacturers to personal consumer product companies, businesses in different sectors of the economy are investing in innovations and patenting in the cleantech industry.

Patent applications by U.S.-based filers represent less than half of patent applications in Cleantech



The percentage of patent filings by U.S.-based applicants has been hovering around 50% over the past few years. In part, this low percentage may reflect the difficult and unpredictable climate facing investors in cleantech due to its dependence on high oil and natural gas prices for viability and its sensitivity to regulatory changes.

Our data show that the proportion of patent filings originating from the United States has remained stable over the past nine years, as has the proportion of patents originating from Europe, Korea, and other nations. The two notable changes over time are the decreasing proportion of filings originating with Japanese enterprises and the increasing proportion of filings from China.

The shrinking percentage of filings from Japan may be due to an overall decrease in Japanese scientific output. A recent study has found that Japan-based scientists published fewer articles in 2015 than in 2005, and that publications fell by more than ten percent in materials science and in engineering.[50]

Filings from China, although still comprising a small percentage of overall filings in the Cleantech industry, have more than quadrupled. This is likely due to a combination of factors, including China's push to compete in the solar energy market, its focus on Cleantech as a way to combat soaring air pollution, and its recent focus on protecting innovation through patenting.[51]

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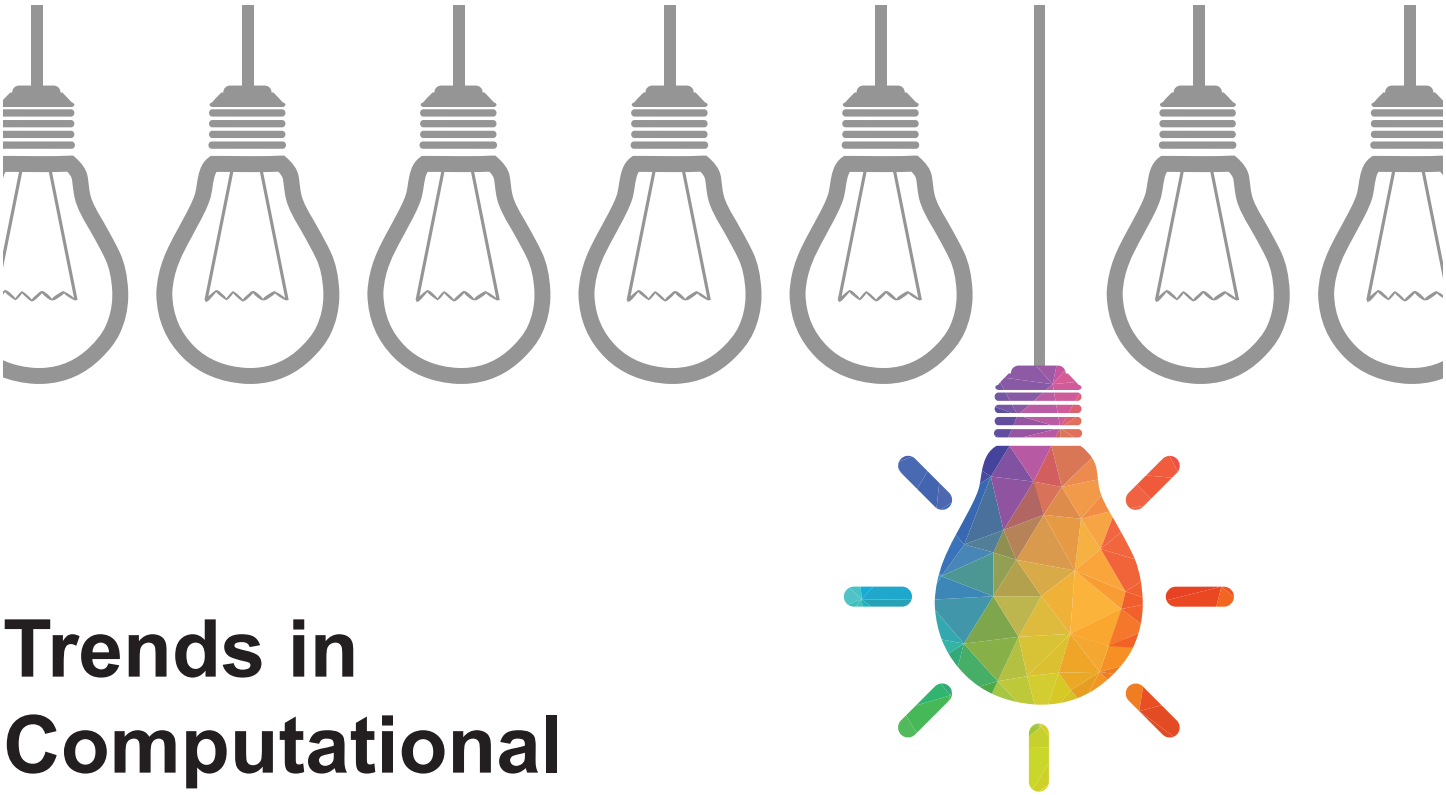
[50] https://www.natureindex.com/news-blog/the-slow-decline-of-japanese-research-in-five-charts
[51] https://www.csis.org/east-green-chinas-global-leadership-renewable-energy; https://www.managingip.com/Article/3538144/How-patent-subsidies-boost-R-D.html?ArticleId=3538144; https://chinapower.csis.org/patents/



Trends in Computational Biology / Bioinformatics

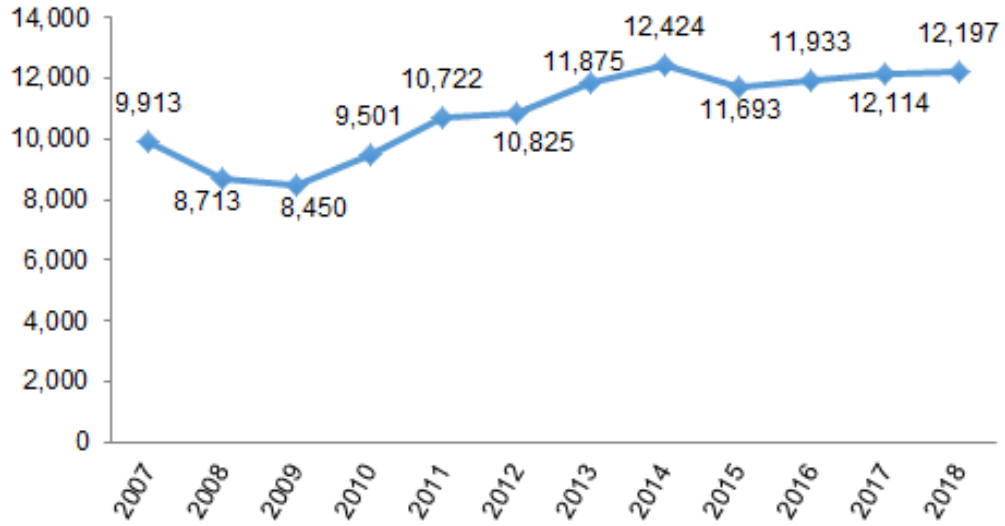
Both high-tech leaders (*e.g.*, IBM, Google, and Microsoft), and university laboratories supported by government funding are prolific patent filers.

The global bioinformatics market is projected to reach $16 billion by 2022,[52] growing primarily on the strength of genomics research and personalized medicine. To further explore innovation hot spots in this area, we turn to patenting data. We have defined the following technology clusters within the general industry of Computational Biology/ Bioinformatics:

Taxonomies and expanded definitions of these clusters are included in appendix A.

Level I Clusters	Level II Clusters
Analysis Of Gene Expression	-
Computational Biomodeling	-
Computational Neuroscience	-
Patient Data Analysis	-
Protein Analysis	-
Computational Evolutionary Biology	
Sequence Analysis	Functional
Genomics/Proteomics Genetics Of Disease/ Mutations Responsible For Disease	
Genome Annotation	
	Pharmacogenomics
	Sequence Alignment/ Comparison
	Sequence Assembly
	Sequence Identification
Structural Bioinformatics	-

Despite being a software-heavy industry, patent filings in the Computational Biology/Bioinformatics industry have not dropped significantly after *Alice*



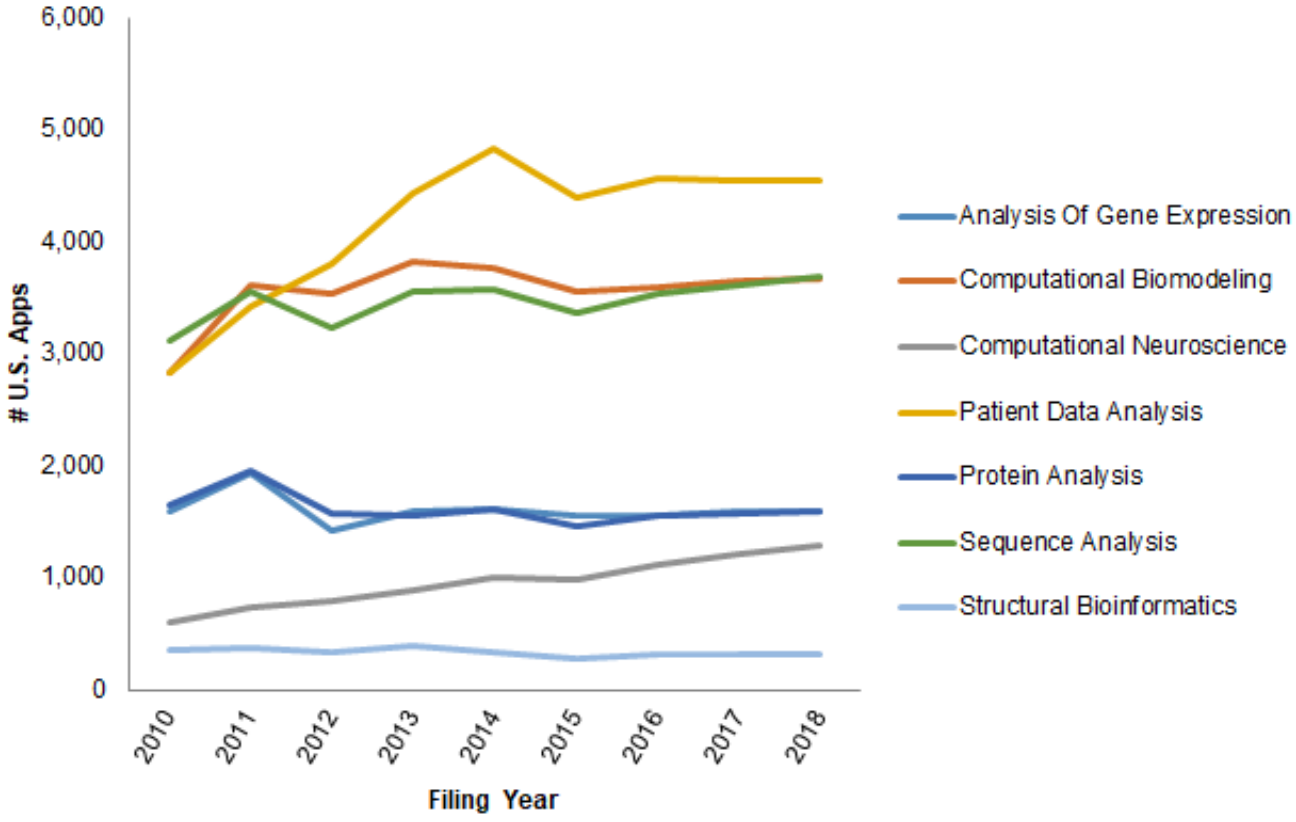
[52] https://www.marketwatch.com/press-release/bioinformatics-market-is-set-to-grow-us-16-billion-by-2022-2019-01-21

In 2014, following the Supreme Court's *Alice* decision, the USPTO implemented new examination procedures for software-related and business-method patent applications. The impact was severe, with allowance rates plummeting. This shift was predominantly seen in the FinTech and bioinformatics Art Units.[53] For FinTech, the reduced allowance rates caused an almost immediate drop in patent filings. For Computational Biology/ Bioinformatics, however, no significant drop in filing rates occurred.

The divergence in filing behavior between these industries may reflect different perceived value that tech leaders ascribe to the patents that do get through examination and are granted. Alternatively, it may reflect the different expectations tech leaders have held about the future chances of patent allowances in the FinTech and Computational Biology industries. Indeed, recent data indicate that allowance rates for computational biology applications have recently risen and are now above pre-*Alice* levels.

The slight drop in patent filings that did occur immediately post-*Alice* is likely due to smaller entities (*e.g.*, startups) changing their patent filing strategies in view of a less favorable funding environment for biotech startups where VC funding has been less available in recent years.

Patent filings related to Patient Data Analysis and Computational Neuroscience are increasing



[53] https://www.ipwatchdog.com/2019/02/06/bioinformatics-innovations-thrive-despite-101-chaos/id=106020/

Personalized medicine, an important priority for the healthcare industry, is dependent on advances in the Patient Data Analysis technology cluster. A number of tech leaders, including IBM, Google and Microsoft, have active initiatives in this area. For example, IBM's Watson for Genomics helps molecular pathology labs provide precision oncology programs and personalized cancer care.[54]

Computational neuroscience, which is concerned with the development, simulation, and analysis of neural function models and theories, is also showing increasing patenting activity. Not only is computational neuroscience important for understanding brain function, but it can also advance A.I. capabilities. The interconnection between researching cognition and behavior and helping improve A.I. is demonstrated by IBM's Neural Tissue Simulator, which mimics the way neurons communicate in the brain that has been used to both research neurological conditions like Huntington's disease and model neural networks for A.I. research.

Reduced patent filings for innovations relating to diagnostics may contribute to the fall off in the Sequence Analysis, Protein Analysis, and Analysis of Gene Expression technology clusters

In 2012, The Supreme Court struck down a diagnostics methods patent in *Mayo v. Prometheus Laboratories*, stating that the claimed steps involved natural laws and routine, conventional activity, and therefore were not patentable. This ruling had a chilling effect on patent filings relating to diagnostics, and it is likely a contributing factor to the dip in patent filings we observe in our study for the Sequence Analysis, Protein Analysis, and Analysis of Gene Expression technology clusters, in which a subset of research is directed to diagnostics.

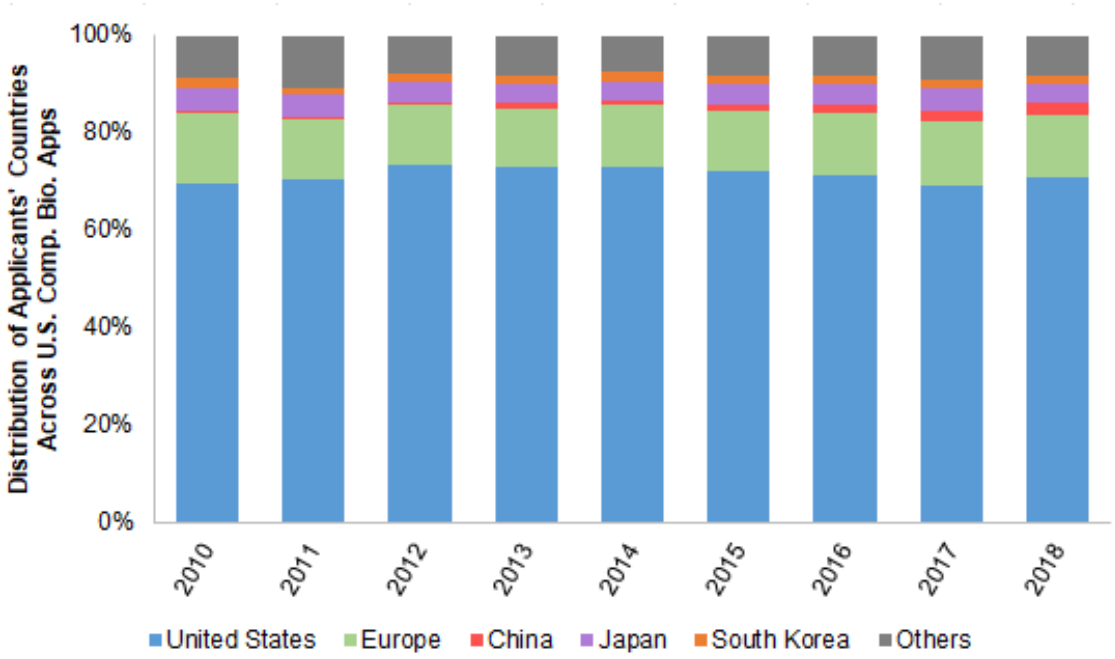
[54] https://www.ibm.com/us-en/marketplace/watson-for-genomics

High-tech leaders and government-funded research laboratories dominate patenting in the Computational Biology / Bioinformatics industry

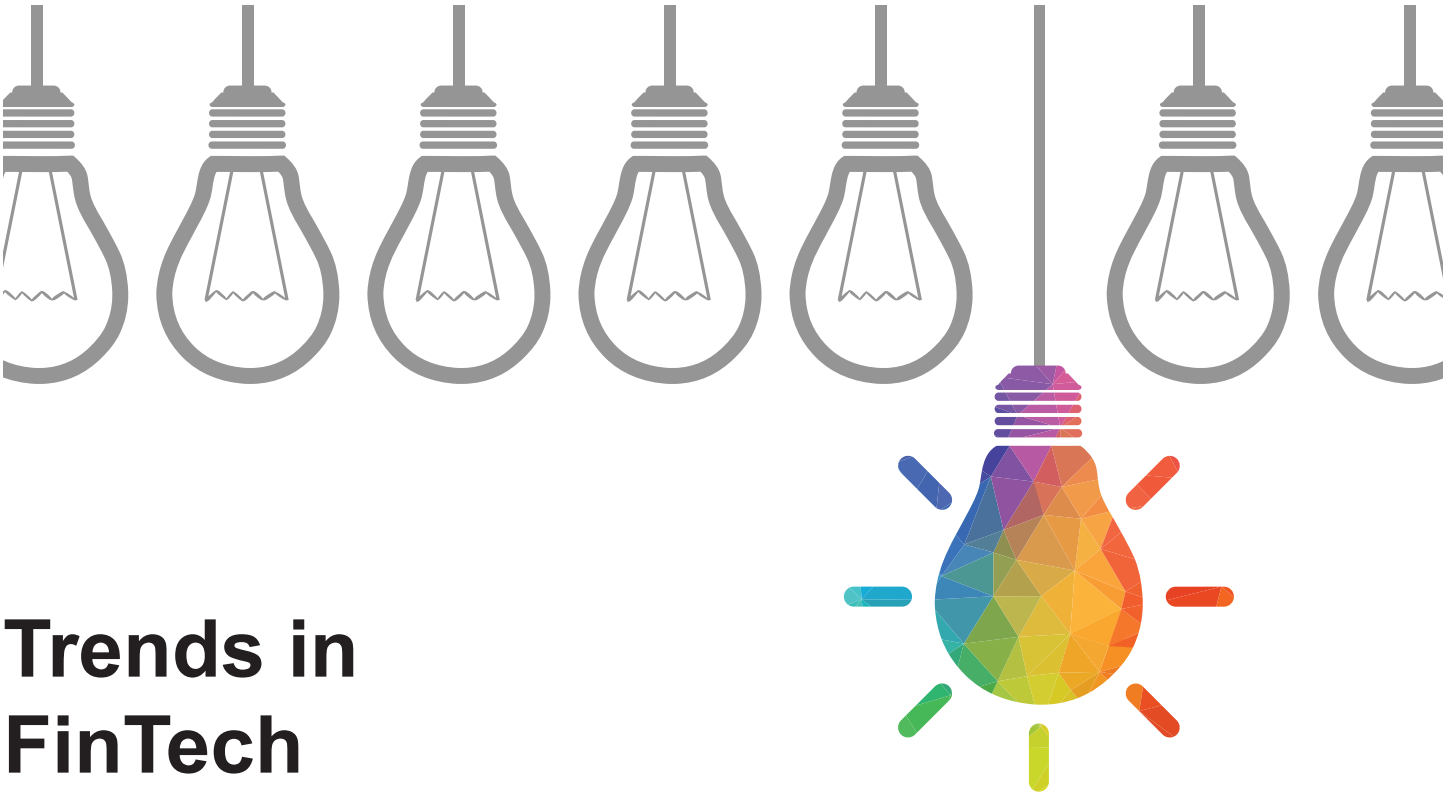
USING 2016 DATA:	
	Most Families Flied by
	(Applicants In alphabetical order)
Computational Biology - Bioinformatics	General Electric, IBM, Microsoft, Samsung, Siemens
Level I	
Analysis Of Gene Expression	Dow Chemical Co., Macau University Of Science And Technology, Monsanto Technology, Regeneron Pharmaceuticals, Regents Of The
University Of Minnesota, Stanford University, University of California	
Wisconsin Alumni Research Foundation, Stanford University	
Computational Biomodeling	Goggle, IBM, Microsoft, Samsung, Siemens
Computational Neuroscience	Boston Scientific, Ecole Polytechnique Federale De Lausanne IBM, Intel, Medtronic, Microsoft
Patent Data Analysis	Fujitsu, General Electric, IBM, Medtronic, Siemens
Protein Analysis	Expression Pathology, /BM, Massachusetts Institute Of Technology, Sensors Unlimited, Thermo Finnigan, University Of California
Sequence Analysis	IBM, Rijk Zwaan Zaadteelt En Zaadhandel, Seven Bridges Genomics, Syngenta Participations Ag
Structural Bioinformatics	Academia Sinica, Goggle, Glysens, Parsagen Diagnostics, University Of California

While computational biology is being increasingly used for real-life applications, it is also an academic research area for which government funding is relatively abundant. This is reflected in the patent filing trends observed in our study, where prolific patent filers are both high-tech leaders (*e.g.*, IBM, Google, and Microsoft), and university laboratories supported by government funding.

U.S.-based filings are hovering near 70% of the overall number of patent filings in the Computational Biology/Bioinformatics industry



The percentage of U.S.-based patent filings has been hovering near 70% for the past decade. The stability of this percentage is somewhat unusual among the industries surveyed in our study, where we see declining percentages of U.S.-based filings in the majority of other industries. The relatively high and steady percentage of U.S.-based filings reflects the dominance of American high-tech companies and universities in this field.



Trends in FinTech

The low allowance rate on software-related and business-method innovations is likely responsible for the sharp drop-off in the number of applications filed in the FinTech industry. There are, however, some indications that the USPTO may revise its practice and once again allow valuable FinTech innovations to be protected by patent rights.

FinTech, the technology that powers the financial services industry, is closey tied to developments in software and business methods. Thus, when recent changes in patent law and the USPTO's implementation of these changes substantially impacted the prospects of patenting business-method innovations, FinTech patenting was bound to be affected by the unfavorable Supreme Court decision in *Alice*.

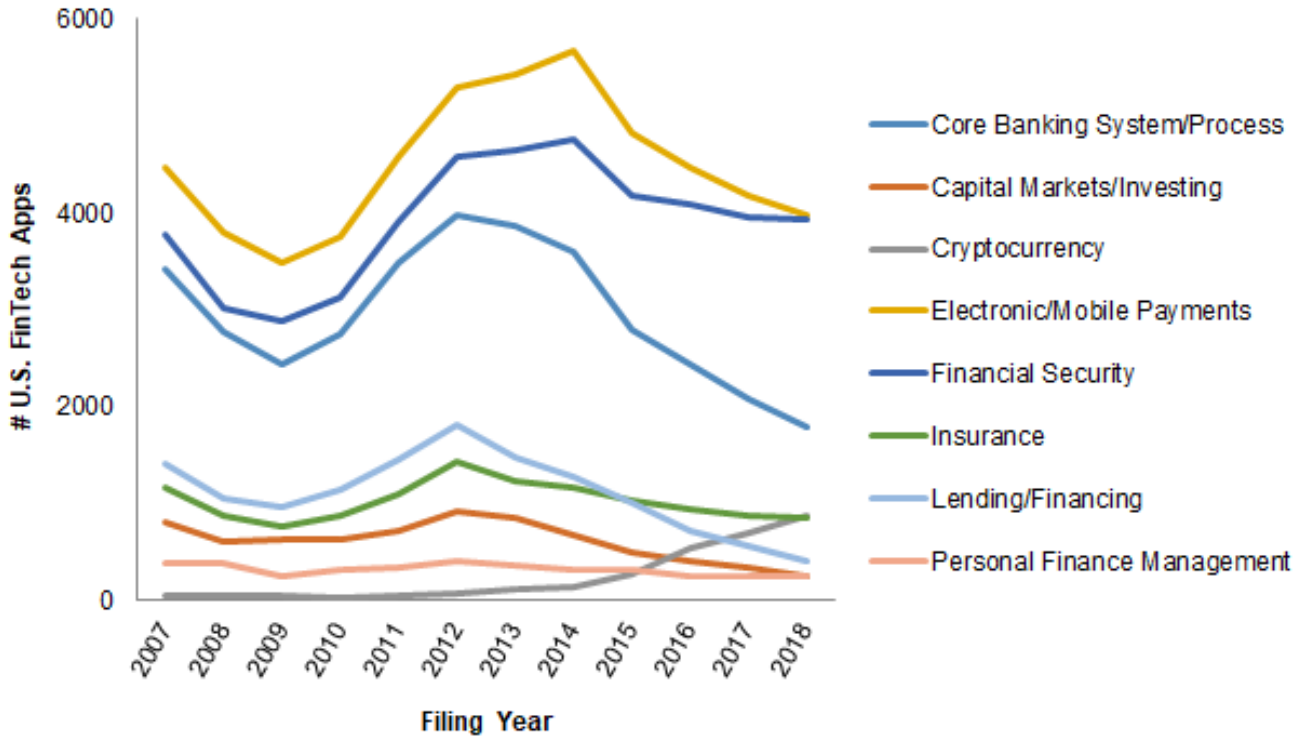
To better understand the trends of patenting FinTech innovation, we have defined the following technology clusters within the general FinTech area:

Taxonomies and expanded definitions of these clusters are included in appendix A.

FinTech Technology Clusters

- Core Banking System/Process
- Capital Markets & Investing
- Cryptocurrency
- Electronic/Mobile Payments
- Financial Security
- Insurance
- Lending/Financing & Crowdfunding
- Personal Finance Management

FinTech patent application numbers reflect a turbulent recent history



FinTech has been experiencing an innovation boom in the past decade, fueled by several technology trends, including the rise in mobile banking, growing interest in cryptocurrency and blockchain, developments in RegTech to address the complexity of the financial regulatory environment, growing need for greater accuracy for real-time risk decisions, and adoption of alternative lending practices. With all this innovation, one might expect that patenting activity in this industry would keep to a steady upward trajectory. Several events, however, conspired to put a damper on FinTech patenting.

First came the liquidity crunch and the credit crunch of 2007-2008, both of which hit financial institutions hard.[55] FinTech patenting activity declined dramatically in the aftermath of the credit crunch, but it rebounded as soon as more liquidity was injected into the economy and continued its rising trend through 2012. Then, beginning in 2012, the legal environment became highly unfavorable for software-related and business-method patents – the very types of patents that are most common for FinTech innovation.[56]

The Leahy-Smith America Invents Act ("AIA") was passed by Congress in 2011, but its impact began to be felt only in 2012, when three new administrative proceedings became available to challenge the validity of business-method patents.[57] These proceedings were meant to be a shortcut to the lengthy and costly ordeal faced by defendants in a patent infringement lawsuit.[58]

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[55] https://www.bostonfed.org/news-and-events/speeches/implications-of-a-credit-crunch.aspx
[56] https://www.forbes.com/sites/danielfisher/2015/10/30/courts-are-drawing-the-line-on-business-method-patents/#3eb25a592b03
[57] https://www.gao.gov/assets/700/690595.pdf
[58] Id.

Continuing the turmoil, in 2014, the Supreme Court (in its *Alice* decision) invalidated a set of business-method patents. This decision was interpreted as setting forth a two-part test to assess whether patent claims were eligible for patent protection: is a patent claim (1) directed to an abstract idea, and if so, (2) not significantly more than the abstract idea.[59] If the answer to either question is "no," the claim is eligible for patent protection; else, it is not.

In response to the AIA and the *Alice* decision, the USPTO changed its examination guidelines and Examiner training. These changes were particularly consequential to software-related and business-method patent applications, resulting in very high rejection rates.[60]

Unfortunately for FinTech applicants, the vast majority of FinTech patent applications are classified as business methods applications and are assigned to business-method Art Units in the otherwise-reasonable 3600 Technology Center.

USING MI6 DATA:	**# Apps Filed in this Year assigned to Art Unit w:**		
	Most Industry Apps Art Unit	**2nd Most Industry Apps Art Unit**	**3rd Most Industry Apps Art Unit**
FinTech	3635	3691	3697
Core Banking System Processes	3685	3896	3697
Capital Markets & Investing	3685	3897	3691
Cryptocurrency	3685	2122	3697
Electronic/Mobile Payments	3685	3687	3627
Financial Security	3685	2376	2887
Insurance	3697	3696	3695
Lending/Financing & Crowdfunding	3696	3691	3697
Personal Finance Management	3697	2876	3691

The continuing low allowance rates on software-related and business-method innovations is likely responsible for the sharp overall drop-off in the number of applications filed in the FinTech industry as innovators choose not to file applications that have a low chance of being granted allowance.

There are, however, some indications that the USPTO may revise its practice and once again allow valuable FinTech innovations to be protected by patent rights. Specifically, other studies of ours have indicated that patenting prospects for business-method innovations are now approaching pre-*Alice* levels[61] due in large part to patent office guidelines to the examination corps in the last year.

[59] *Alice* Corp. v. CLS Bank Int'l, 134 S. Ct. 2347 (2014).
[60] Kate Gaudry & Samuel Hayim, Bioinformatics Innovations Thrive Despite 101 Chaos, IP Watchdog, February 6, 2019, https://www.ipwatchdog.com/2019/02/06/bioinformatics-innovations-thrive-despite-101-chaos/id=106020/.
[61] Kate Gaudry & Samuel Hayim, Bioinformatics Innovations Thrive Despite 101 Chaos, IP Watchdog, February 6, 2019, https://www.ipwatchdog.com/2019/02/06/bioinformatics-innovations-thrive-despite-101-chaos/id=106020/.

Tech and banking stalwarts lead the patenting rankings in FinTech

Top Patent Holders (in alphabetical order)
Bank of America
Google
IBM
Intuit
Mastercard
Microsoft
NCR Corporation
PayPal
Toshiba Corporation and Affiliates
Visa

USING 2016 DATA:	
	Most Families Filed by (Applicants In alphabetical order)
FinTech	Bank Of America, IBM, Mastercard, PayPal, Walmart
Core banking System/ Processes	American Express Travel Related Services Co., Bank Of America, IBM, Mastercard, NCR Corp., American Express
Capital Markets & Investing	Axioma, Chicago Mercantile Exchange., Mastercard, The Stevens Institute Of Technology
Cryptocurrency	Bank Of America, Cognitive Scale, IBM, Intel, Mastercard
Electronic/Mobile Payments	IBM, Mastercard, PayPal, Toshiba Corporation and affiliates, Walmart
Financial Security	Bank Of America, IBM, Mastercard, PayPal, Samsung, VISA
Insurance	Allstate Insurance Co., IBM, State Farm Mutual Automobile Insurance Co., Swiss Reinsurance Co., The Hartford
Lending/Financing & Crowdfunding	American Express Travel Related Services Co., Bank Of America, IBM Intuit, Mastercard
Personal Finance Management	AT&T, IBM, Intuit Mastercard, PayPal

The patenting strength of tech companies in FinTech suggests that the future of the financial sector is likely to be impacted by technological advances that will also impact other industries. IBM, for example, a leading player in the majority of FinTech technology clusters, has had a long-standing interest in blockchain, cloud computing, and artificial intelligence, all of which are at the forefront of innovation not only in FinTech but also in other industries, such as healthcare.[62]

Of the financial companies leading in FinTech patenting, both Bank of America and Mastercard are signaling their intent to compete in the blockchain and cryptocurrency space. Each has received a number of patents – and has filed additional applications – that indicate it foresees the wide adoption of cryptocurrency in banking and finance, including as a means for simplifying business-to-business transactions.[63]

Mobile Banking

As our data show, the biggest surge in FinTech patenting relates to Electronic/Mobile payments, and this patenting trend has predicted the increasing adoption of mobile technology as a means of transacting banking activity on the Internet. Over the past decade, the share of total Internet browsing conducted on smartphones has increased steadily,[64] and this trend also holds true for mobile banking.[65] The share of banking transactions conducted on mobile phones has grown steadily since 2012, and by 2017, nearly half of U.S. adults with a bank account were using their mobile phones to access their bank accounts.[66]

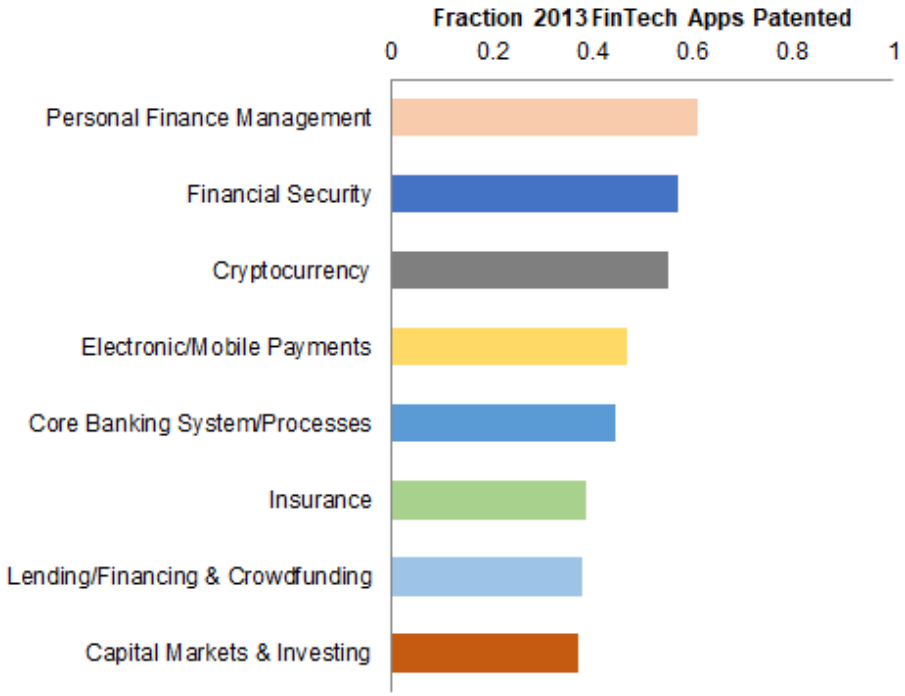
[62] http://research.ibm.com/
[63] http://fortune.com/2018/06/20/bank-of-america-blockchain-patent-why/
[64] https://www.statista.com/statistics/241462/global-mobile-phone-website-traffic-share/;
[65] https://www.federalreserve.gov/econres/notes/feds-notes/mobile-banking-a-closer-look-at-survey-measures-20180327.htm
[66] Id.

Cryptocurrency patents are on the rise since 2014

Cryptocurrency holds the promise to both increase the security of financial transactions, reduce transaction costs and speed them up. Therefore, it is a significant area of innovation, and many FinTech entities are investing in protecting their patenting rights in this space. Despite attempts at creating a cryptocurrency defensive patent license to discourage patent wars,[67] the race for patenting supremacy is strong, and patent filings have increased year over year since 2014. This trend shows no sign of slowing, indicating that the number of patents and applications will grow significantly in the coming years.

There is a significant difference in allowance rates between Art Units

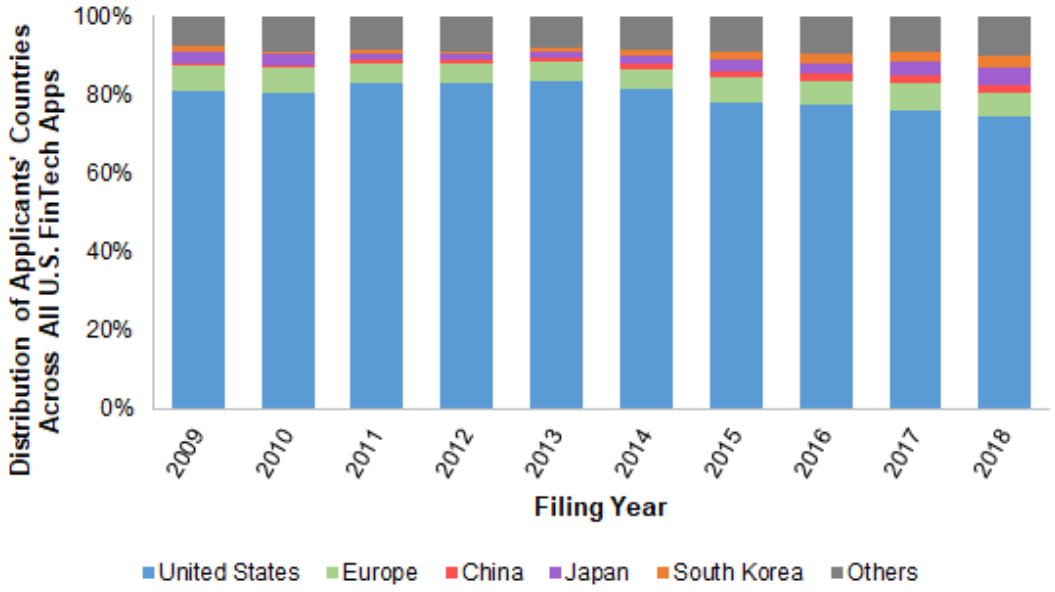
Our data indicate that FinTech patent applications examined by business-method Art Units have only an approximately 40% chance of being allowed. On the other hand, FinTech patent applications examined by non-business-method Art Units have a better than 80% chance of being approved. This discrepancy is further evident in the overall chances of allowance for the different technology clusters of FinTech: technology clusters more tightly aligned with non-business-method art-unit assignments (*e.g.*, Cryptocurrency, Financial Security, and Personal Finance Management) have higher chances of being allowed as compared to other FinTech technology clusters (*e.g.*, involving Capital Markets & Investing, Insurance, and Lending/Financing & Crowdfunding).



[67] https://bitcoinmagazine.com/articles/there-bitcoin-patent-war-going-initiative-could-end-it/

Part of the art of writing patent applications is identifying, describing and claiming the inventions in them in a way that maximizes their chances of allowance. Our data show that it is important to describe and claim FinTech inventions so that they are examined by the appropriate Art Unit at the USPTO if they are to stand a good chance of being allowed.

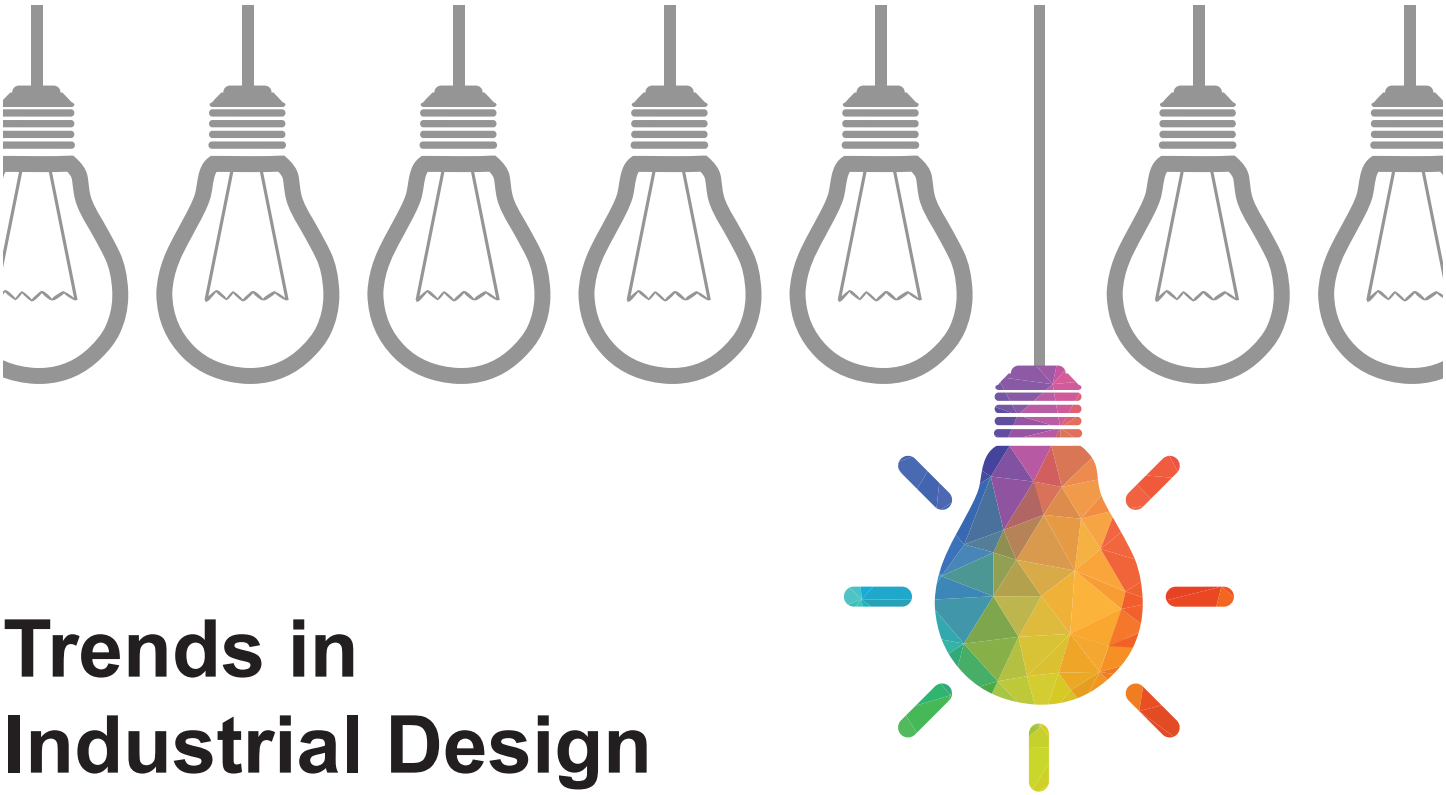
The percentage of U.S.-based filings is decreasing



There is a notable downward trend in the percentage of U.S.-based applications. The beginning of this trend coincides with the *Alice* decision, further indicating that a significant portion of FinTech applications are for software-based inventions that are likely to be examined by business-method Art Units. The fall in patent filings also suggests that filers may be reluctant to file patent applications that do not have a high chance of being granted allowance.

In contrast to the falling percentage of U.S.-based patent applications, patent filings from Japan have been growing. Japan has been an early adopter of cryptocurrency and Bitcoin was recognized as legal currency in Japan in April 2017.[68] Since then, its regulators granted licenses to multiple companies to run cryptocurrency exchanges. Japanese enthusiasm for cryptocurrency may be the reason for the increasing number of Japanese patent filings in the USPTO.

[68] https://www.techinasia.com/japan-financial-blockchain-adoption



Trends in Industrial Design

Graphical User Interface (“GUI”) design patents offered a new approach to protecting software-related innovation just as the USPTO was changing its examination practices to make software-related utility patents harder to obtain. GUI design patents are especially attractive because they are inexpensive and provide better damage recoveries in many cases.

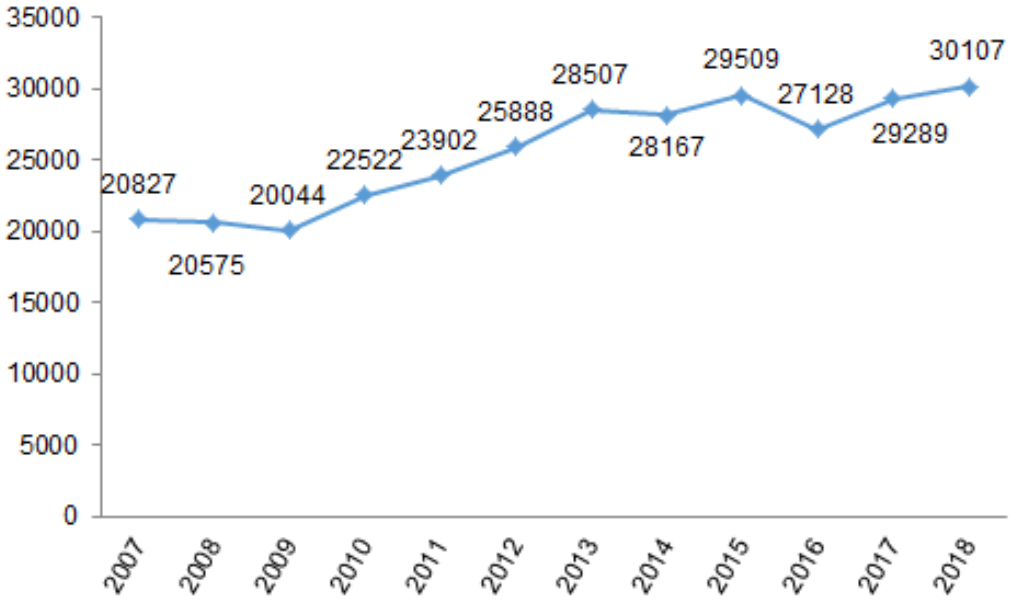
Trends in Industrial Design

As consumers become ever more discerning and global competition continues to rise, the role of industrial design is increasingly vital for providing a positive customer experience and for product differentiation in all economic sectors. Industrial Design is focused on design patent protection of the ornamental features of a functional product. The term of a design patent is 15 years from issuance and typically less than a utility patent term of 20 years from filing. To delve deeper into the trends of patenting industrial design innovation, we have defined the following technology clusters within the general Industrial Design industry:

Level I Clusters	**Level II Clusters**
Graphical User Interface	-
Industrial Design	Automobile & Transportation
	Building & Architecture
	Computer & Accessories
	Consumer Electronics
	Cosmetics & Personal Accessories
	Home Furnishing
	Machinery
	Medical/Laboratory Equipment
	Office Equipment
	Pet Products
	Power Generation & Distribution
	Sports Apparel
	Sports Equipment
	Textile & Clothing
	Tools/Hardware
	Toys
	Weapons

Taxonomies and expanded definitions of these clusters are included in appendix A.

Patent filings are on the rise in the Industrial Design industry



Our data was limited to design patents - the most prevalent type of patent being sought in the Industrial Design industry. Design patents have traditionally had several advantages over utility patents. First, there is a significantly higher allowance rate than for utility patents. Second, design patents are issued in 12-18 months, unlike utility patents, which typically take over three years or even longer in hot areas where finding qualified examiners would be difficult. Third, statutory law provides damages in the sum of total profits on an article of manufacture that infringes a protected design whereas infringement damages for utility patents are parsed to the smallest saleable unit or part that embodies the invention (making damages calculations highly complex).[69] The predictability of both the prosecution process for design patents and of the damages for infringement has created a favorable climate for design patent filings. And indeed, we see a rising number of design patent filings in the past decade.

While there has been considerable growth in patent filings in the Industrial Design industry in the past decade, there have also been a couple of dips. The first dip in patent filings occurred during the Great Recession of 2008, when many economic sectors experienced a difficult climate that led to reduced patenting activity. The second dip, in 2016, was likely created by an atmosphere of uncertainty in the wake of the Supreme Court's *Samsung v. Apple* decision, in which the Court held that an "article of manufacture" could refer to the finished product *or a component of the finished product*. This decision upended the long-held view that design patentees were always entitled to total profits from an infringing product.

Recent court decisions have adopted a four-factor test advocated by the Solicitor General in an amicus brief in *Samsung v. Apple*. The test considers the scope, design prominence, conceptual distinctness, and severability of the patented design and the infringing finished product. Under this test, it is still possible to obtain damages in the sum of total profits on the finished product, and at least one jury has awarded such damages since the *Samsung v. Apple* case.

The recent case law appears to have assuaged applicants' concerns regarding the value of design patents, and this renewed optimism is reflected in the number of patent filings that keeps increasing year over year.

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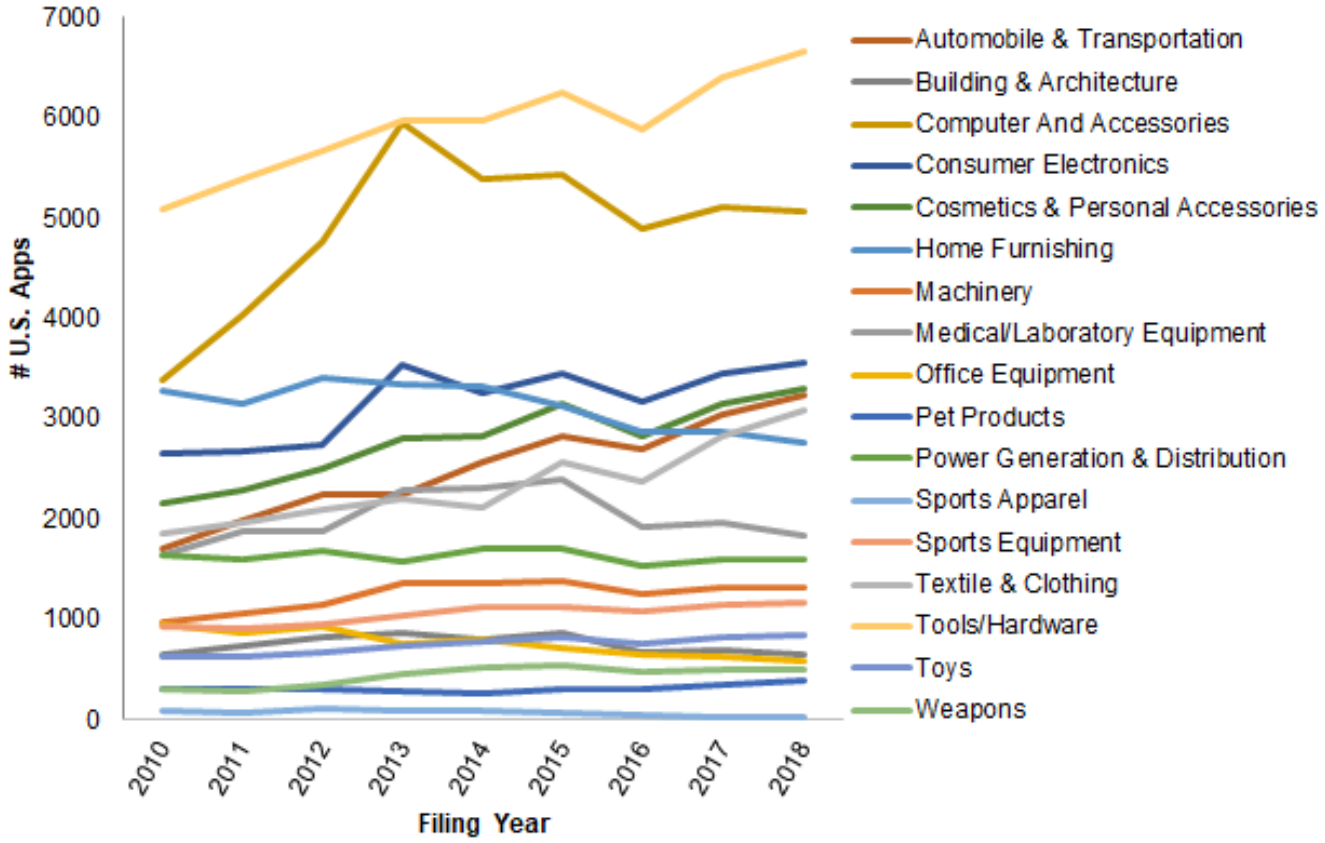
[69] https://www.jdsupra.com/legalnews/recent-developments-determining-design-36881/

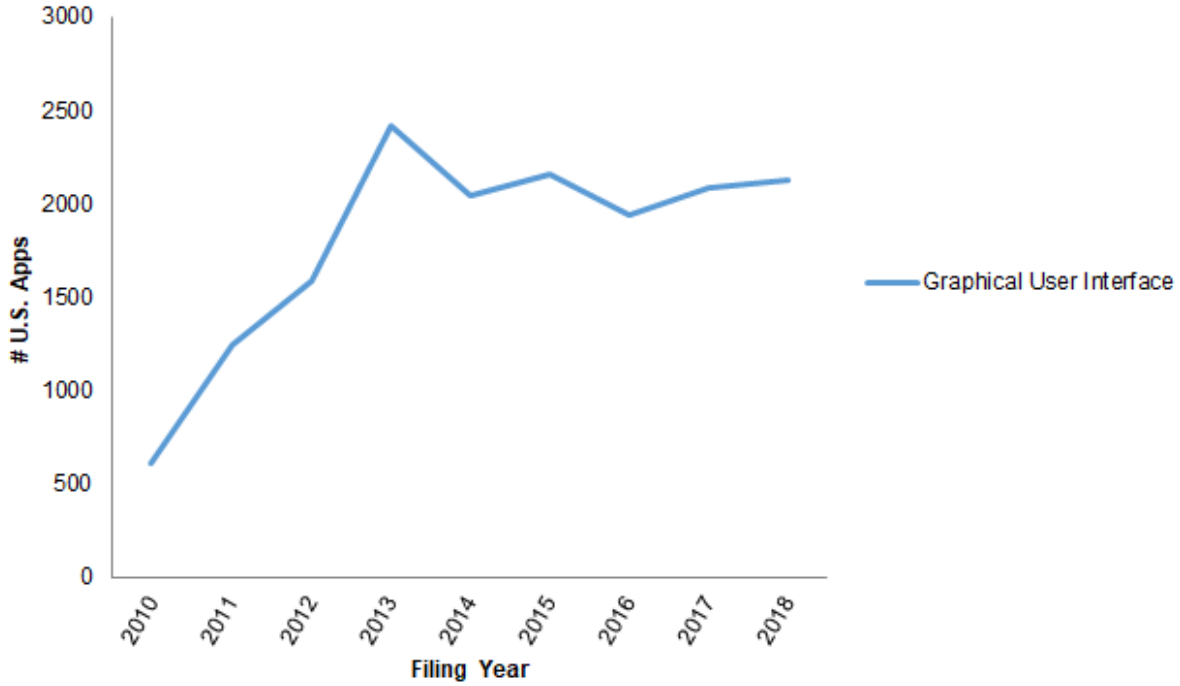
Patent filings are increasing across multiple technology clusters in the Industrial Design industry



Our study shows that there is a marked upward trend in a number of technology clusters within the Industrial Design industry. Automobile & Transportation, Computer And Accessories, Cosmetics & Personal Accessories, and Textile & Clothing are some of the clusters in which patent filings are growing most steeply.

In technology clusters where design patents are declining (such as Pet Products, Sports Equipment, and Medical/Laboratory Equipment), it is possible that innovators are choosing other methods of protecting their designs (such as trademark or trade dress protection) on products that are likely to be rapidly replaced by newer design versions. Further, innovators may alternatively or additionally only seek patents on breakthrough design innovations or on designs for less iterative product versions.

High tech innovators are protecting software innovations with design patents on graphical user interfaces ("GUIs")



GUIs are visual elements through which users can interact with electronic devices (*e.g.*, apps on smart devices or websites on computers). GUIs include icons, fonts, layout, logos, colors, animation/movement and framing/placement. GUIs are eligible for design patent protection on their ornamental features, so long as their design is not dictated solely by its function.

Between 2010 and 2013, a series of high-publicity lawsuits involving claims of infringement of GUI design patents, brought GUI design patents to the forefront of intellectual property trends. The appeal of these patents was enhanced by the high damages awards sought (and sometimes awarded) for the infringement of even a single GUI design patent.

In addition, GUI design patents offered a new approach to protecting software-related innovation just as the AIA was being implemented and the USPTO was changing its examination practices to make software-related utility patents harder to obtain. GUI design patents were especially attractive because these applications are granted with less prosecution and with higher yields while enjoying better damages in litigation.

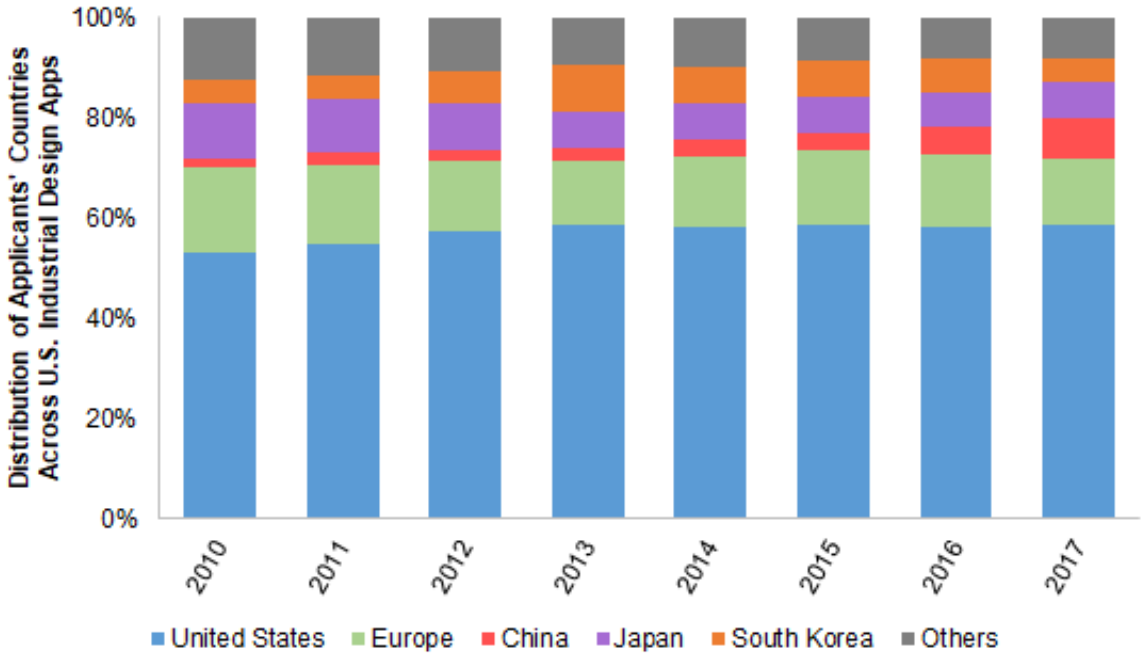
Even though the rise in GUI design patent filings has not been as steep in recent years as it had been between 2010 and 2013, the uptrend in these filings continues.

Numerous industry leaders are top filers in specific technology clusters within the Industrial Design industry

USING 2016 DATA:		
		Most Families Flied by
		(Applicants in alphabetical cinder)
Industrial Design		Delta Faucet Co, General Motors, LG, Nike, Samsung
Level I		
Graphical User Interface		Apple, Google, Jpp, Microsoft, Samsung
Industrial Design		Delta Faucet Co., General Motors, LG, Nike, Samsung
Level I	**Level II**	
Graphical User interface	-	
Industrial Design	Automobile & Transportation	Bridgestone Corp., Ford, General Motors, Goodyear, Honda
	Building & Architecture	Biotekt USA, Cambria Co., Chelsea Building Products, Clarkwestern Dietrich Building Systems, LG, Matthews International Corp., Clarkwestern Dietrich Building Systems
	Computer & Accessories	Apple, Google, LG, Microsoft, Samsung
	Consumer Electronics	
	Cosmetics & Personal Accessories	Air Cool Industrial Co., Cartier International, Citizen Watch Co, Hunter Fan Co., Youngo
	Home Furnishing	Bridgestone Corp., Mortarless Technologies, Okamura Corp., Philips, Steelcase
	Machinery	Caterpillar, Deka Products, Holley Performance Products, Mitsubishi, Samsung, Sintokogio
	Medics /Laboratory Equipment	3M, Beckton Dickinson And Co., Karl Storz, Siemens, Water Pik
	Office Equipment	Amsterdam Printing & Litho, Brother Industries, Hewlett-Packard, RPG Holdings, Seiko Epson Corp.
	Pet Products	Classic Brands, Doskocil Manufacturing Co., Hyper Pet, Petsmart Home Office, Shenzhen Xingrisheng Industrial Col
	Power Generation & Distribution	Guangdong Bestek E-Commerce Co., Japan Aviation Electronics Industry, LG, Molex, Wago Verwaltungsgesellschaft
	Sports Apparel	Acushnet Co., Brutus Park Creations,, Game Changer Goods, Plus Meditech Co., Sport Maska
	Sports Equipment	Acushnet Cp., Callaway Goff Co., Dunlop Sports Co., Karsten Manufacturing Corp., Microsoft, Nike
	Textile &Clothing	Cambria Co. Cole Haan, Converse, Nike, Under Armour, Sketchers U.S.A.
	Tools/Hardware	Den Faucet Co., Hansgrohe SE, Hunter Fan Co., LG, Spectrum Brands
	Toys	Anki, BMW, Daimler AG, Porsche, Sanrio Co., Tomy Co.
	Weapons	3M, Crimson Trace Corp., Ncstar, Vista Outdoor Operations, Whg Properties

As discussed, industrial design has been growing in importance for businesses in a growing number of industries. The broad applicability of industry design innovation is reflected in the wide variety of companies that are top filers in specific technology clusters and subclusters in our study.

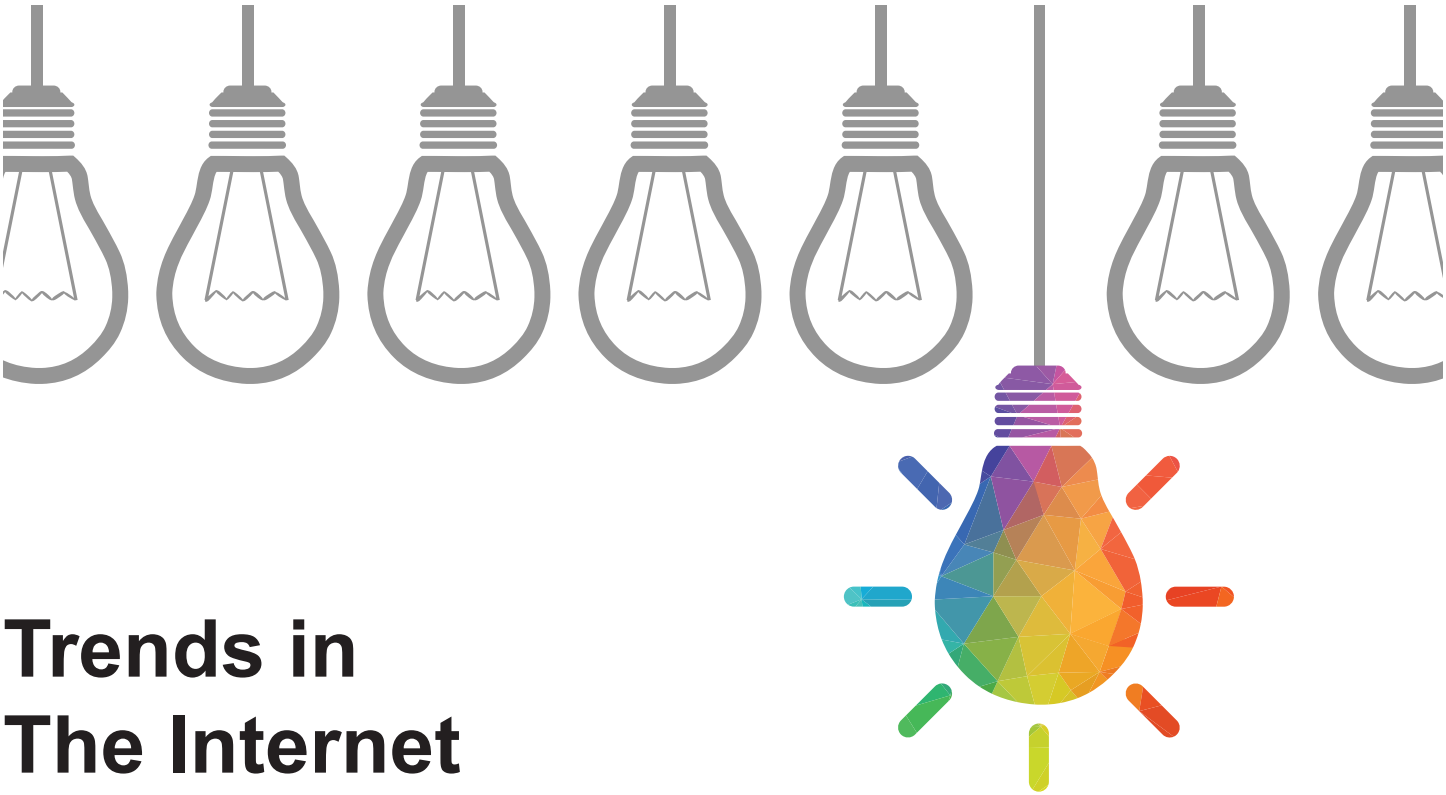
U.S.-based patent filings related to the Industrial Design industry are holding steady near 60%



The number of U.S.-based patent filings in the Industrial Design industry is growing. Even though the percentage of U.S.-based applications is holding steady, the overall number of patent filings is increasing, thereby increasing the number of U.S.-based applications, too. This trend is likely to continue as more and more businesses recognize the value of adding design patents to their intellectual property portfolios.

Also of note is the rapid rise in Chinese patent filings in the Industrial Design area. The rise in Chinese Applications corresponds with the adoption of the Hague Agreement Concerning the International Registration of Industrial Designs, which took effect in 2015. The Hague Agreement is an international registration system, which offers the possibility of obtaining protection for up to 100 industrial designs in member countries by filing a single international application in a single language.[70] The Hague Agreement has simplified international filing in a number of countries, and is likely to help grow the number of design patent filings even further by both U.S.-based and foreign entities.

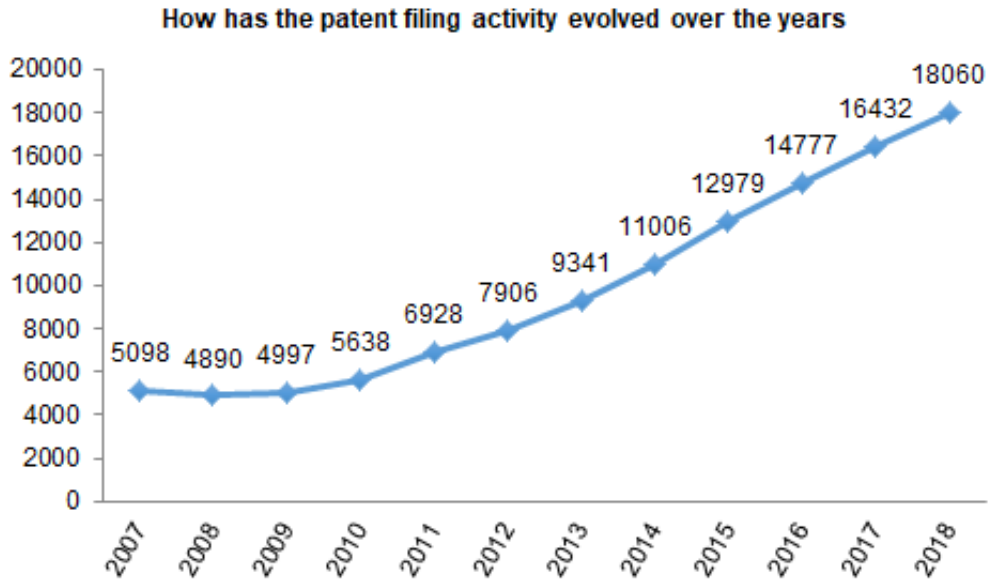
[70] https://www.uspto.gov/patent/initiatives/hague-agreement-concerning-international-registration-industrial-designs



Trends in The Internet of Things (IoT)

The high volume of patent filings relating to applications of IoT is a strong indicator of an ever-increasing role for this technology in the economy.

Patent filings relating to the Internet of Things ("IoT") are skyrocketing. A rapidly increasing number of patent filings is consistent with the fact that IoT is one of the most innovative and competitive industries right now and that it is likely to continue to innovate for years to come.



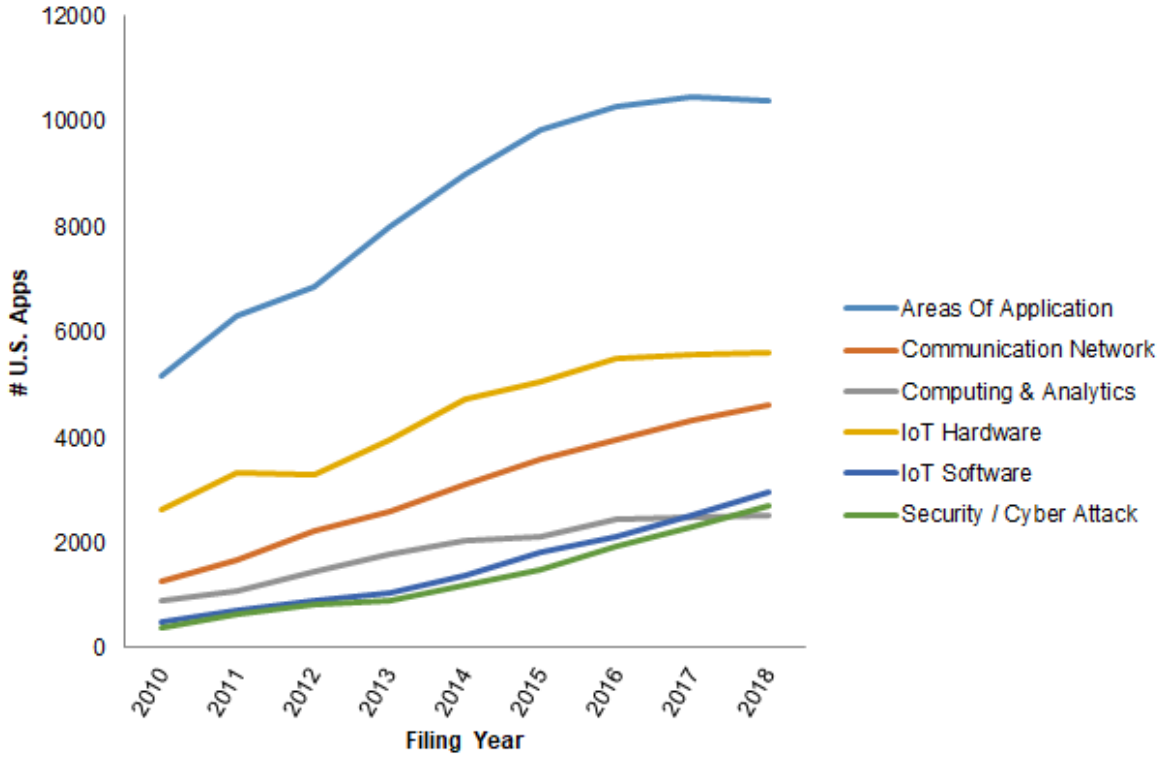
IoT is impacting and changing a wide range of industries, while also still developing as a technology itself. Indeed, the total size of the IoT market is predicted to grow to between $1.4 and $3.7 trillion by next year.[71] As it becomes integrated into more and more aspects of our lives and businesses, IoT also must address a number of concerns, including security, privacy, and compatibility. To delve deeper into the trends of patenting IoT innovation, we have defined the following technology clusters within the general industry of IoT:

Taxonomies and expanded definitions of these clusters are included in appendix A.

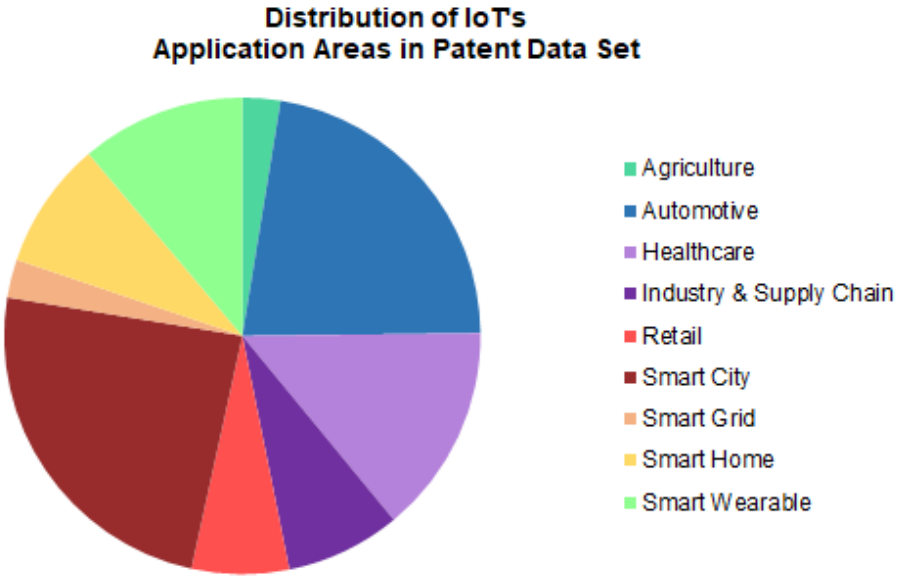
IoT-Level I Clusters	Level II Clusters
Application Area	Agriculture
	Automotive
	Healthcare
	Industry & Supply Chain
	Retail
	Smart City
	Smart Grid
	Smart Home
	Smart Wearable
Application Software	
Backbone Network (Network Infra	
Cloud Computing And Analytics	
Communication Network	Communication Techniques
	Mesh Networking
	Wireless Protocols
Edge Computing And Analytics	
Gateway Equipment	
Operating Systems	
Security/Cyber Attack	
Sensors And Actuators	
Storage & Servers	

[71] https://www.forbes.com/sites/louiscolumbus/2018/06/06/10-charts-that-will-challenge-your-perspective-of-iots-growth/#659607643ecc; https://www.forbes.com/sites/louiscolumbus/2018/06/06/10-charts-that-will-challenge-your-perspective-of-iots-growth/#7a6fdea63ecc

The majority of patent filings relate to the applications of IoT, with heavy emphasis on smart cities, automotive, and healthcare



Virtually every industry could be made more efficient and productive by incorporating IoT capabilities into its operations, and virtually every industry has taken notice of this technology and is spending heavily on IoT integration.[72] The high volume of patent filings relating to applications of IoT is a strong indicator of an ever-increasing role for this technology in the economy.



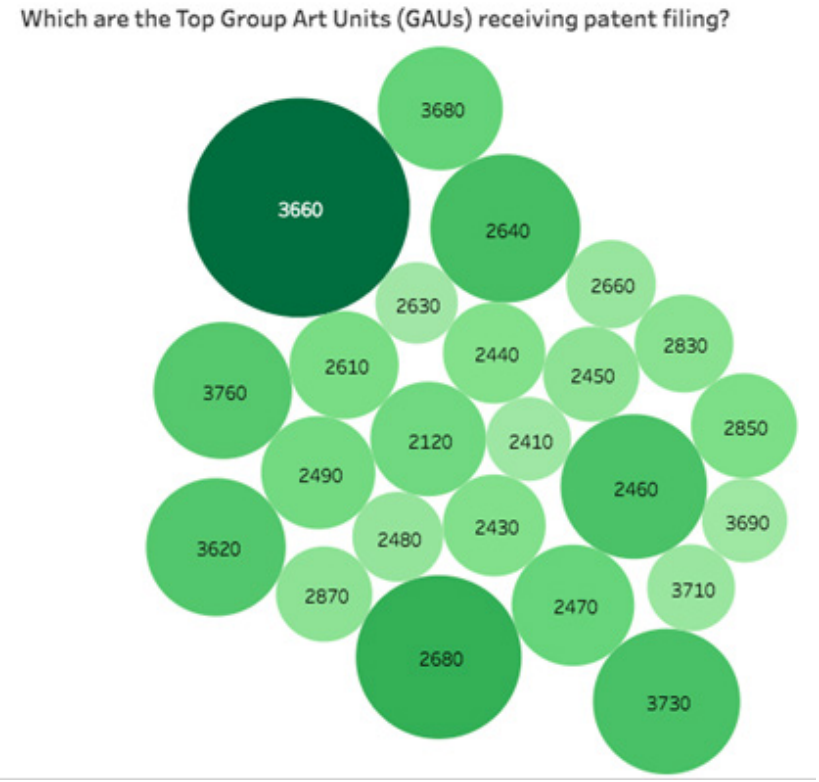
[72] https://innovationatwork.ieee.org/industry-iot-growth-trends/

Smart City IoT has the highest number of patent filings. This finding may be due both to the wide range of activities (from public safety to traffic regulation to air quality) in which the deployment of IoT would be beneficial in an urban setting and to the growing adoption of IoT projects by local governments.[73]

In the United States, there is also a strong emphasis on IoT innovation in the healthcare and automotive industries.[74] In healthcare, the majority of IoT applications relate to patient monitoring, energy metering, and imaging devices.[75] In automotive, IoT has gained acceptance throughout the lifecycle of the vehicle - from the design stage, to manufacturing, to making the driving experience easier, safer, and more enjoyable.[76]

The technical diversity in IoT innovation is evidenced by the large number of Art Units examining IoT applications

As noted above, the applications of IoT span many technological areas. Thus, it is perhaps not surprising that IoT patent applications are assigned to a wide variety of Art Units at the patent office. In fact, the applications are broadly dispersed across multiple different technology centers (each of which relates to a high-level type of technology). Given that different Art Units are associated with different allowance rates, applicants in the IoT space are likely to encounter a broad distribution of allowance prospects.



[73] https://www.mckinsey.com/~/media/mckinsey/industries/capital%20projects%20and%20infrastructure/our%20insights/smart%20cities%20digital%20solutions%20for%20a%20more%20livable%20future/mgi-smart-cities-full-report.ashx
[74] https://iot-analytics.com/top-10-iot-segments-2018-real-iot-projects/
[75] https://healthtechmagazine.net/article/2018/08/why-healthcare-iot-rise-infographic
[76] https://www2.deloitte.com/insights/us/en/focus/internet-of-things/iot-in-automotive-industry.html

USING 2016 DATA:				
		# Apps Filed in this Year assigned to Art Unit w:		
		Most Industry Apps	**2nd Most Industry Apps**	**3rd Most Industry Apps**
		Art Unit	Art Unit	Art Unit
IoT		3667	3663	3762
Level I		3667	3663	3762
Areas of Application		2412	2471	2646 | 2462
Communication Network		3667	2122	2859
Computing & Analytics		3762	375	3736
IoT Hardware		3664	2179	3667
IoT Software		2497	2436	2435
Security/Cyber Attack				
Level I	**Level II**			
Areas Of Application	Agriculture	3671	2836 | 2887	2436
	Automotive	3667	3663	2668
	Healthcare	3762	3735	3763
	Industry & Supply Chain	3625	3628	3627
	Retail	3625	2687	2859
	Smart City	3667	2663	3661
	Smart Grid	2836	2859	2842
	Smart Home	2844	2121 | 2127	2126
	Smart Wearable	3762	2872	2859
Communication Network	Communication Techniques	2471	2412	2915
	Mesh Networking	2887	2685 | 2844	2412 | 2464
	Wireless Protocols	2645	2646	3715
Computing & Analytics	Cloud Computing And Analytics	3667	2859	2456
	Edge Computing And Analytics	2122	2457	2456
IoT Hardware	Backbone Network (Network Infrastructure)	2645	2649	2685
	Gateway Equipment	3625	2457	2645
	Sensors And Actuators	3762	3735	3736
	Storage & Servers	3664 | 2421	2136	2424
IoT Software	Application Software	3664	2179	3667
	Operating Systems	2497	2195	2116

Cellular phone, cloud-based service, and artificial intelligence leaders are filing large numbers of patent applications related to IoT

IoT is dependent on high-speed wireless networks, cloud-based computing and APIs that enable greater and faster integration between the IoT component and the existing network.[77] In addition, the use of A.I. is growing in IoT. For example, as IoT sensor and monitors generate data (*e.g.*, temperature, humidity, or vibrations), A.I. can be used to detect anomalies and particular types of events much faster and with greater accuracy.[78]

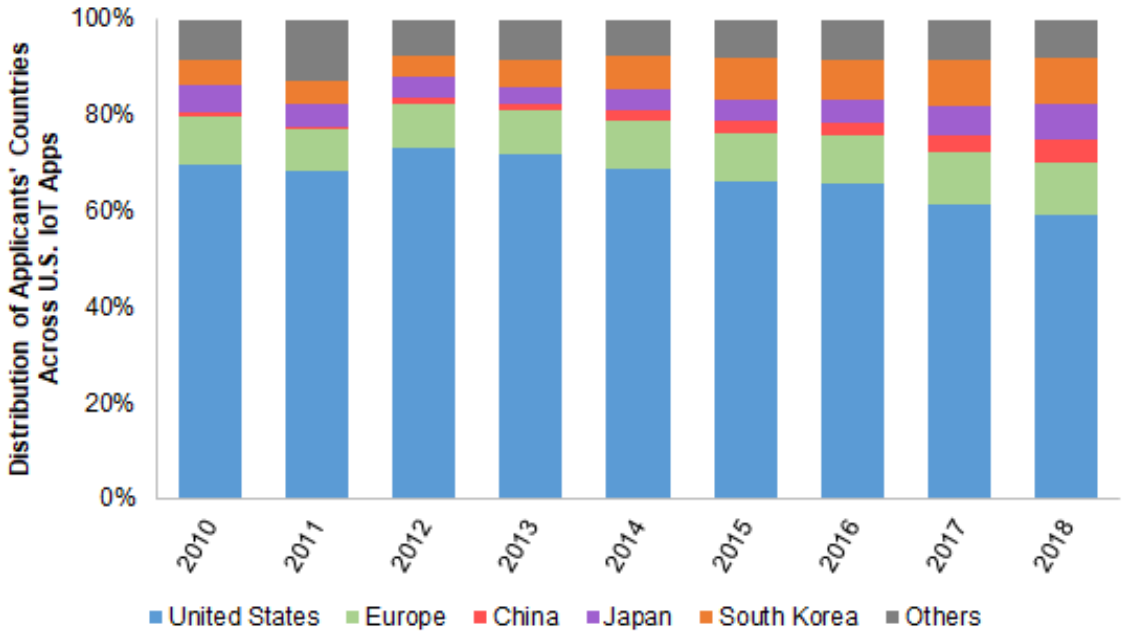
The technology leaders who are filing the most patents in IoT are major players in these fields. Companies with expertise in high-speed wireless networks – like Qualcomm, LG, Cisco, and Intel – are vying for leadership in the IoT space, alongside leaders in cloud-based services and A.I. – like IBM and Microsoft.

USING 2016 DATA:		
		Most Families Flied by
		(Applicants listed in alphabetical order)
IoT		Ford, IBM, Intel, Qualcomm Samsung
Level I		
Areas Of Application		Ford, General Motors, IBM, Samsung, Toyota
Communication Network		AT&T, Ericsson, IBM, Intel, Samsung
Computing & Analytics		Cisco, IBM, Intel, Microsoft, Qualcomm
IoT Hardware		Ford, IBM, Intel, Qualcomm, Samsung
IoT Software		General Electric, IBM, Microsoft, Samsung SAP SE
Security / Cyber Attack		Cisco, IBM, Intel, Qualcomm, Samsung
Level I	**Level II**	
Areas Of Application	Agriculture	Cnh Industrial America, Deere And Co., IBM, King Fahd University Of Petroleum And Minerals, The Climate Corp.
	Automotive	Ford, General Motors, Hyundai, Samsung, Toyota
	Healthcare	Cardiac Pacemakers, General Electric, IBM, Samsung, Tosense
	Industry& Supply Chain	Blackberry, Beneral Motors, IBM, Intel, Kyland Technology Ca, Walmart
	Retail	Century Link Intellectual Property, IBM, Microsoft, Samsung, Walmart
	Smart City	Ford, Honeywell, IBM, Samsung, Toyota
	Smart Grid	ETRI, General Electric, IBM, Kyland Technology Co., LG, Qualcomm
	Smart Home	Echostar Technologies International Corp., Google, Honeywell, Johnson Controls Technology Co., Samsung, Siemens
	Smart Wearable	Apple, IBM, Intel, Micmac$ Qualcomm, Samsung
Communication Network	Communication Techniques	

[77] https://www.forbes.com/sites/louiscolumbus/2018/06/06/10-charts-that-will-challenge-your-perspective-of-iots-growth/#659607643ecc
[78] https://www.wired.com/brandlab/2018/05/bringing-power-ai-internet-things/

	Mesh Networking	AT&T, IBM, Intel, Quo Silergy Semiconductor Technology (Hanzhou)
	Wireless Protocols	AT&T, Ericsson, Intel, Qualcomm, Samsung
Computing & Analytics	Claud Computing And Analytics	General Electric, IBM, Intel, Microsoft, Qualcomm
	Edge Computing And Analytics	AT&T, Cisco, IBM, Intel, Microsoft
IoT Hardware	Backbone Network (Network Infrastructure)	AT&T, Intel, Qualcomm Samsung, Veniam
	Gateway Equipment	AT&T, Cisco, Hyundai, Intel, Qualcomm, Verizon Patent And Licensing
	Sensors And Actuators	Ford, IBM, Intel, Qualcomm, Samsung
	Storage & Servers	Capital One Services, Ford, IBM, Intel, Microsoft, Qualcomm, Samsung
IoT Software	Application Software	General Electric, IBM, Microsoft, Swing, SAP SE
	Operating Systems	General Electric, IBM, Intel, Microsoft, NXP, Samsung

The percentage of patent applications relating to IoT filed by U.S.-based applicants is falling



The percentage of U.S. patent applications originating in China, Japan, and Korea has grown dramatically over the last five years and has contributed to U.S.-based application accounting for less than 60% of filings last year. This trend may represent a rise in IoT innovations originating from these countries and/or an increased emphasis on globalization and international patent protection. For example, it is possible that the relative rate of IoT innovation across countries has remained stable over the past decade, whereas the observed trend is explained by a change in foreign entities' prioritization of securing patent protection in the U.S. for their technologies.

Security is a critical issue for IoT

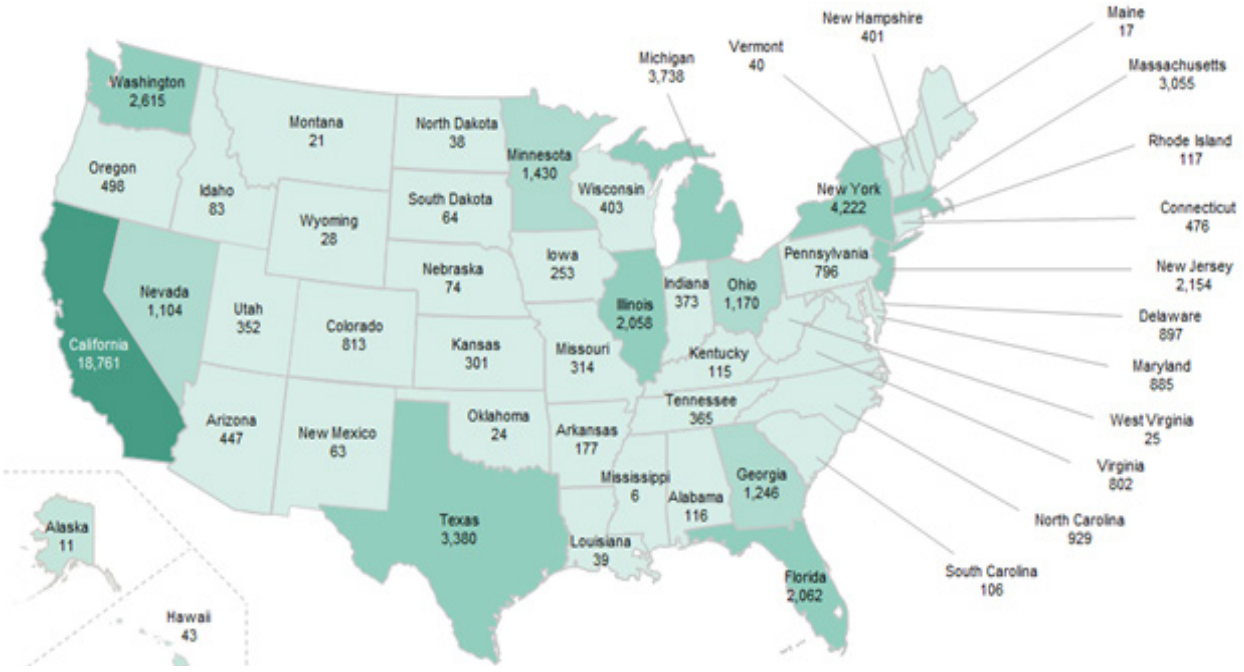
As IoT is adopted by more and more sectors of the economy, its vulnerability to cyberattacks and other malicious interference is becoming a more pressing threat. To date, there have already been documented attacks on IoT in building infrastructure, communications, and industrial infrastructure.[79]

Our study finds that security-related IoT patent filings have been steeply increasing year over year, although the overall percentage of patent applications in this space remains small. As the urgency of creating better security for IoT mounts, however, and as companies innovate to make their IoT assets less vulnerable,[80] we anticipate this technology cluster to increase in patenting activity.

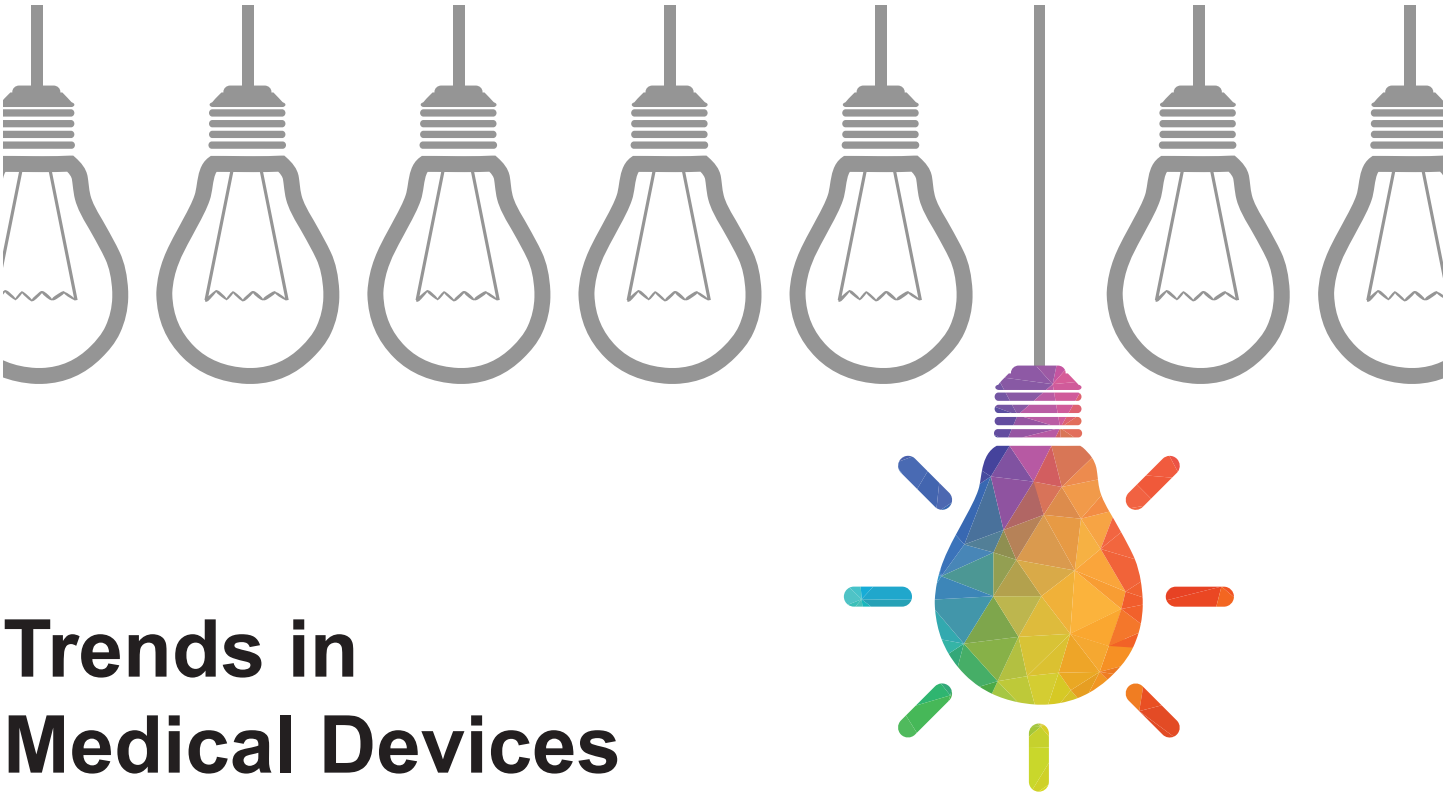
IoT-related innovation is distributed across the United States

IoT innovation is taking place not only in diverse industries but also in diverse geographies. While the majority of IoT-related patent activity is concentrated in California, residents of many other states have filed a significant number of patent applications in this technology area. Residents from each of the following states have filed at least 1000 applications: Florida, Georgia, Illinois, Massachusetts, Minnesota, New Jersey, New York, and Texas.

Distribution of filings across states for the IoT industry



[79] https://www2.deloitte.com/content/dam/Deloitte/ch/Documents/innovation/ch-en-innovation-IoT-defense-policy-and-the-internet-of-things.pdf
[80] https://www.csoonline.com/article/3289392/staying-secure-as-the-iot-tsunami-hits.html



Trends in Medical Devices

While there is a significant number of startups in the Medical Devices industry, patent applications are still being filed largely by the established players in this market.

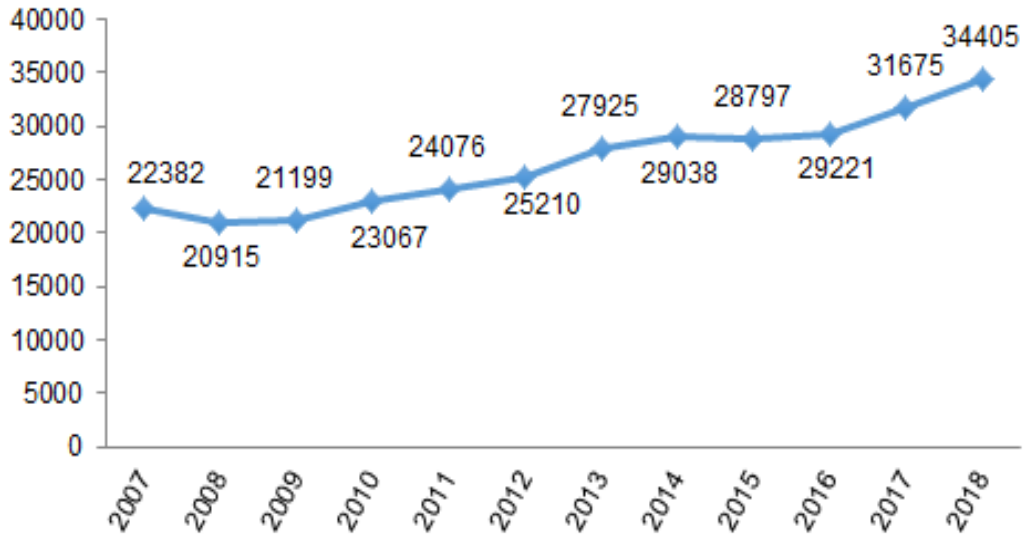
Innovation and patent filings are on the rise in the Medical Devices industry. The increase in patenting activity is seen across multiple technologies in this industry.

To delve deeper into the trends of patenting medical device innovation, we have defined the following technology clusters within the general Medical Devices industry:

Taxonomies and expanded definitions of these clusters are included in appendix A.

Level I Clusters	**Level II Clusters**
Assistive Care Devices	Durable Medical Equipment
	Feeding Equipment
Infant Care	
	Measuring Devices (Meters) Mobility Aids
	Orthopaedic Devices
Prosthetic Devices	
	Respiratory Equipment
Sensory Aids	
	Telehealth Equipment
	Treatment Equipment
	Voiding Equipment
Consumables And Disposables	-
Diagnosis & Imaging Devices	Endoscopic Devices
	Monitoring & Tracking Devices
Drug Deliver/ Devices	Implantable Drug Delivery Deice
	Infusion Pumps
Inhalers	
	Syringes
Transdermal Patches	
Surgical Devices	Electrosurgical Devices
Handheld Surgical Devices	
	Next-Generation Surgical Devices
Sutures & Staples	
Wearable Medical Devices	-

Patent filings are on a significant uptrend

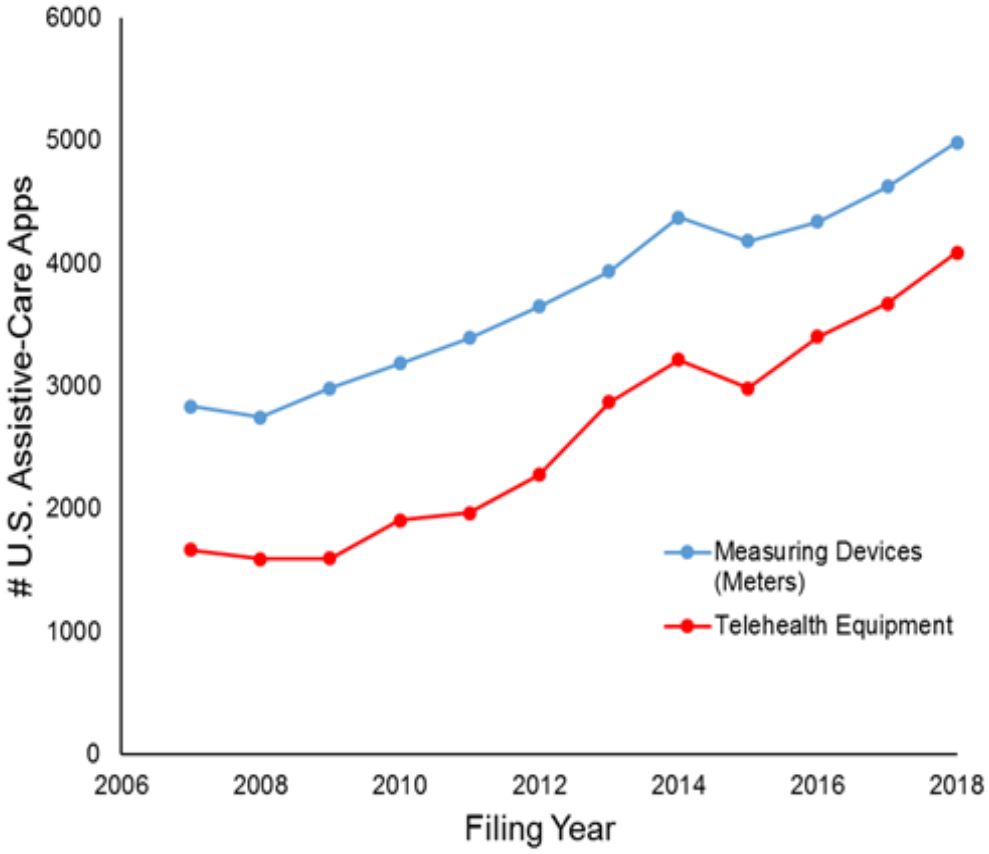


After a slight dip during the Great Recession in 2008, patent filings in the Medical Devices industry have recovered and have been on a continuing uptrend since.

Several trends are converging to make the Medical Devices industry a hotbed of innovation and patenting activity. First, the increasingly aging populations of first-world countries and the higher physical activity level of older people in these countries create a growing market for innovative medical devices.[81] Second, the rise of A.I. and robotics in medical settings, including surgery and diagnostics, have opened up new opportunities for innovation and patenting.[82] Third, the personalization and decentralization of medical care - including the growing acceptance of health-related mobile apps - may lower the barrier to entry into the medical device market for new entrants.[83] All three of these trends are forecast to continue growing in upcoming years, fueling the increasing pace of innovation and patenting in the Medical Devices industry.

[81] https://mercercapital.com/assets/5-Trends-to-Watch-Med-Dev-Industry-2018.pdf
[82] https://www.pwc.com/gx/en/industries/healthcare/publications/ai-robotics-new-health/transforming-healthcare.html
[83] https://health2con.com/news-iteam/8992/

Innovation and patent filings are high in Measuring Devices and Telehealth Equipment



While patent filings are on the rise in the majority of the technology clusters in our study, filings in Assistive Care Devices are both significantly higher and rising more steeply than in any other cluster. Within Assistive Care Devices, two subclusters are particularly noteworthy in their uptrends: Patent filings in both Measuring Devices and Telehealth Equipment are rising sharply, suggesting that both of these subclusters are going through a significant innovation boom.

Measuring devices, including sensors for a variety of stimuli, are becoming more sensitive, accurate, and sophisticated. They are used to monitor conditions such as diabetes, cardiovascular disease, and respiratory disease, all of which are on the rise in countries with aging populations. Measuring devices are also being integrated into medical equipment to make that equipment both more effective and safer.

The increasing capabilities of measuring devices are also a significant factor in telehealth innovation, which depends on data from remote sensors to provide both medical care and patient monitoring. Research shows that the use of telehealth services is on the rise and that it is expected to continue to grow.[84] As acceptance of telehealth grows among healthcare providers and patients, it will open the door to more innovation in both the Telehealth and the Measuring Devices technologies.

[84] https://mhealthintelligence.com/news/research-shows-telehealth-service-use-availability-on-the-rise

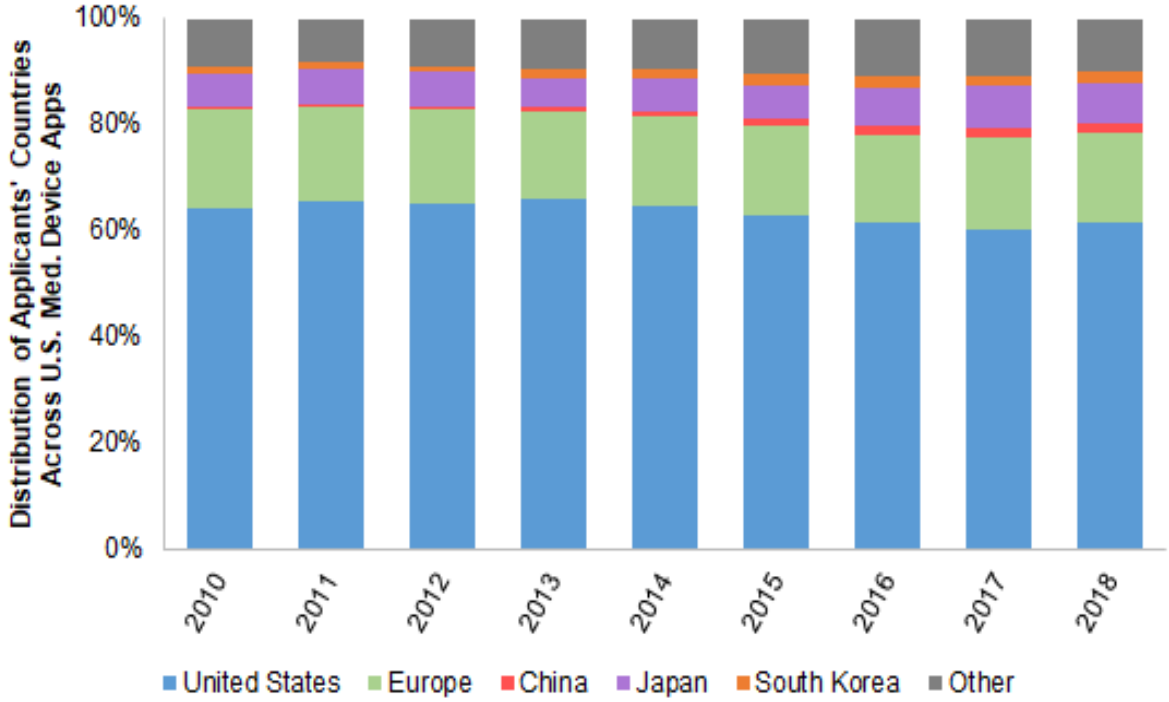
Well-known medical-device companies are the leaders in patent filings

While there is a significant number of startups in the Medical Devices industry, patent applications are still being filed largely by the established players in this market. While these companies innovate in-house, they are also partnering with high-tech companies for consumer-facing offerings, and they are licensing more technologies from universities, which serve as incubators for innovation in the Medical Devices industry.[85] It is possible, therefore, that the large medical-device companies have rights to even more technology than our study shows.

USING 2016 DATA:	
	Most Families Flied by
	(Applicants In alphabetical order)
Medical Devices	Boston Scientific, Covidien, Ethicon, Medtronic, Olympus Corp.
Level I	
Assistive Care Devices	Boston Scientific, Cardiac Pacemakers, Medtronic, Samsung, Siemens
Consumables And Disposables	Boston Scientific, Covidien, Ethicon, Fenwal, Katalyst Surgical, Procter &Gamble
Diagnose &Imaging Devices	Boston Scientific, Cardiac Pacemakers, Covidien, General Electric, IBM, Olympus Corp.
Drug Delivery Devices	Becton Dickinson And Co., Boston Scientific, Fenwal, Medtronic, Terumo
Surgical Devices	Biosense Webster (Israel), Boston Scientific, Covidien, Ethicon, Olympus Corp.
Wearable Medical Devices	Apple, IBM, Intel, Samsung, Seiko Epson Corp., Tosense

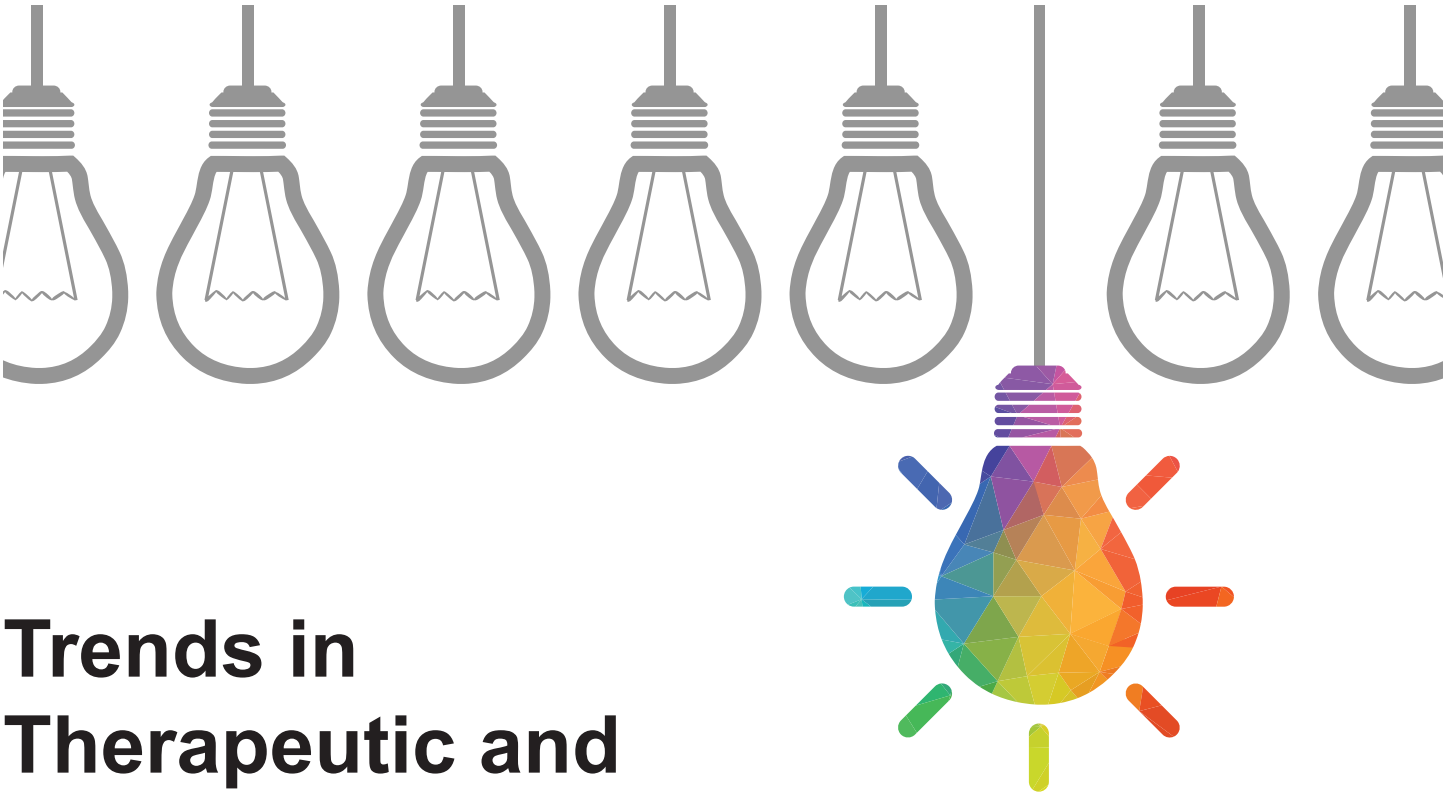
[85] https://www.medicaldesignandoutsourcing.com/here-are-5-medtech-industry-trends-you-need-to-know/

U.S.-based patent filings are increasing



The percentage of U.S.-based patent filings has been stable over the past several years, hovering near 60%. This trend is in contrast with several other industries where our study shows a decreasing percentage of U.S.-based patent filings. Because the percentage of filings is steady but the overall number of filings continues to rise sharply, the overall number of patents filings from the United States is increasing at a high rate.

Our study also shows that while China and Korea are still contributing very small percentages to the overall number of patent filings in the USPTO, those percentages are growing. For China, it is likely that both its rising prosperity - which allows it to invest more in medical device research - and its recent state emphasis on more patent protection are responsible for the rising trend in patenting activity. For Korea, the increasing importance of mobile technology in medical devices has created an opportunity for its high tech companies to participate in the medical device markets.



Trends in Therapeutic and Diagnostic Molecules

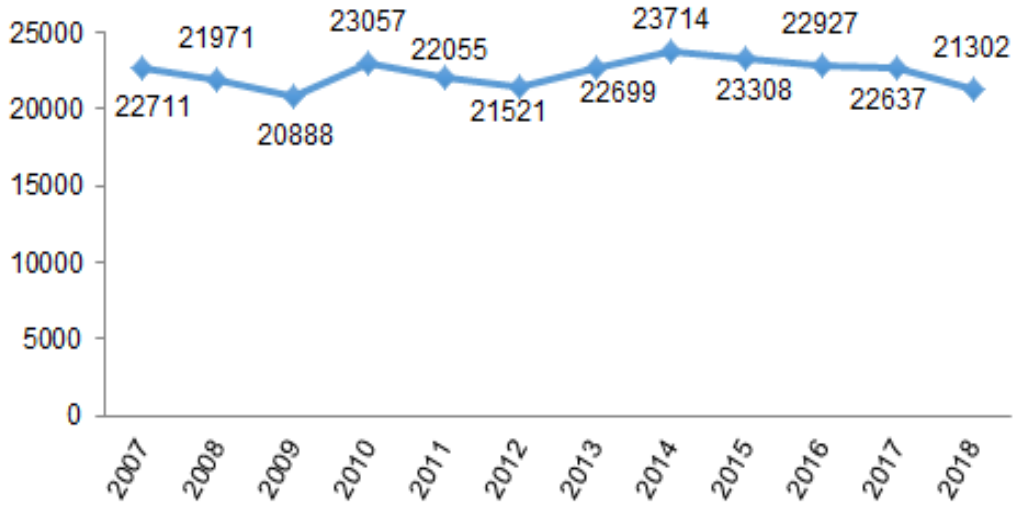
Although large molecules (*e.g.*, antibody-drug conjugates, recombinant DNA, and fusion proteins) hold a great deal of promise and are capturing increasing attention, the research into small molecules is not drying up.

The Therapeutic and Diagnostic Molecules industry generates a consistent stream of breakthroughs and innovations that hold the promise of eradicating disease and improving health outcomes. Patent filings in this industry can provide a glimpse into the future of medicine. To delve deeper into the trends of patenting innovation in therapeutic and diagnostic molecules innovation, we have defined the following technology clusters within the general Therapeutic and Diagnostic Molecules industry:

Large Molecules	**Used As**	
Diagnostic Agent	-	
	Used As	
Therapeutic Agent	Biological Sources Of Large Molecule	
		Fermentation Technique For Manufacturing Large Molecule
		Large Molecule Delivery System
		Molecular Structure/Sequence Of Large Molecule
		Purification Process Of Large Molecule
		Therapeutic Indications Of Large Molecule
Small Molecules	Synthesis Of	
Small molecule	Semi-Synthetic/Biologically Synthesized	
	Used As	
Diagnostic Agent	Synthetic	
-		
	Used As	
Therapeutic Agent	Chemical Structure Of Small Molecule	
		Combination With Other Small/Large Molecules
Composition Containing Small Molecule		
		Dosage Regimen
Drug Delivery System		
		Formulation/Dosage Form
		Production Process
Route Of Administration		
		Therapeutic Indications Of Small Molecule

Taxonomies and expanded definitions of these clusters are included in appendix A.

Patent filings are steady



Patent filings have been steady over the past decade despite rising R&D spending in the Therapeutic and Diagnostic Molecules industry.[86] This trend is notable both because there is a high and consistent need for new products in this industry and because patent filings in other industries are on the rise. One possible explanation is that R&D budgets have increased to keep up with rising expenses rather than to expand R&D programs.

This flat number of patent filings when looking across the board may be masking increasing filings in certain areas (*e.g.*, compositions) and decreasing filings in others. In particular, in view of the uncertainty in patent law with respect to patent eligibility for diagnostic methods, there may be fewer filings to protect therapeutic drugs tied to diagnostic methods.

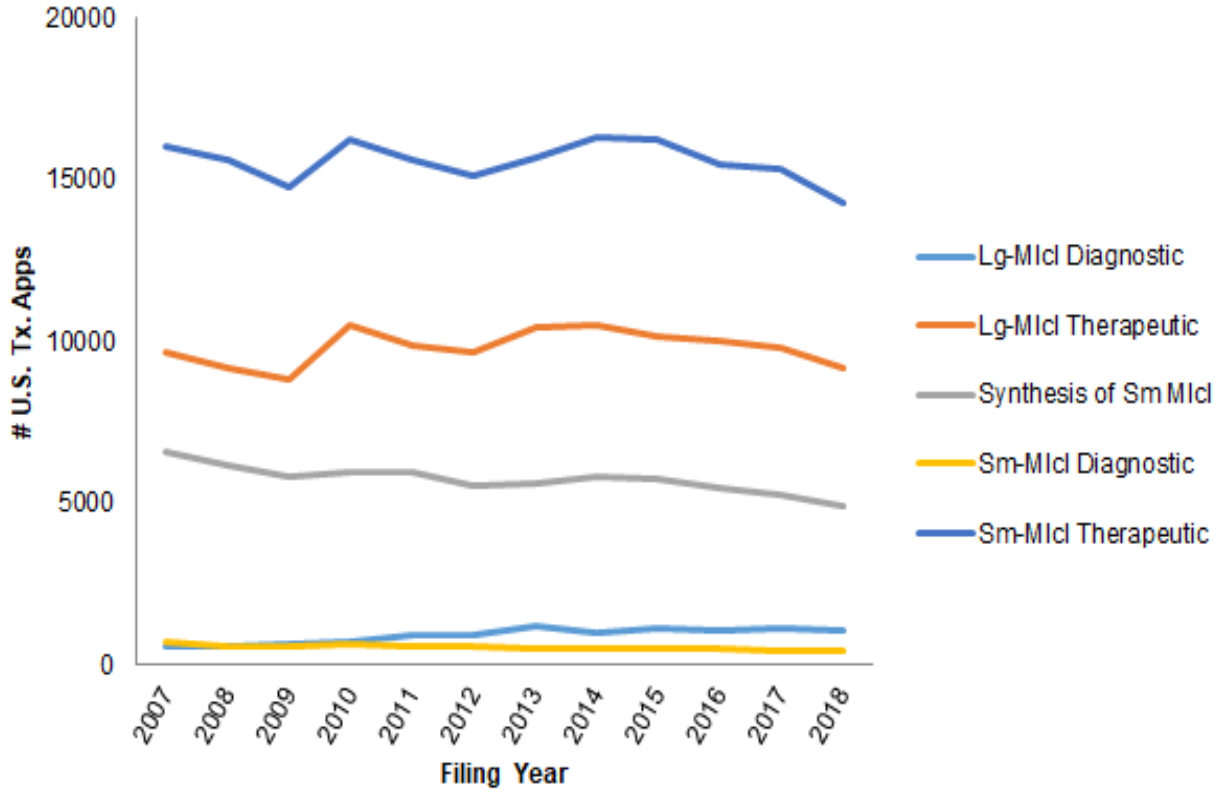
An additional possible explanation for this trend may be the climate of political uncertainty surrounding U.S. pharmaceutical patents in the last few years. Pharmaceutical patents have come under fire from some lawmakers, activists, and pundits as being responsible for the high prices of medications in the United States.[87]

Another factor that may play a role in keeping the number of patent filings from rising is the availability of the *inter partes* review (IPR) proceeding in the USPTO since 2011, which has made challenging patents easier and cheaper. While generic pharmaceutical companies have a limited interest in challenging patents through the IPR proceeding because it provides no opportunity to gain market exclusivity, this proceeding became a vehicle for patent challenges from outside the pharmaceutical industry, including as an arbitrage strategy by hedge funds. In view of the risk posed by IPRs, it is possible that pharmaceutical companies have become more conservative in their patenting strategies.

Finally, this trend may also be due in part to the difficult economic conditions in Europe, which has traditionally been a major contributor of innovation and patent activity in this industry.

[86] https://www.abpi.org.uk/facts-and-figures/science-and-innovation/phrma-members-rd-expenditure-in-total-and-in-the-us-only/
[87] https://khn.org/news/in-the-battle-to-control-drug-costs-old-patent-laws-get-new-life/

The majority of patent filings are for small molecules used as a therapeutic agent



The number of patent filings for small molecules used as a therapeutic agent is significantly higher than for any other technology cluster in the Therapeutic and Diagnostic Molecules industry. This trend is reflective of the traditional emphasis in the pharmaceutical industry on small molecule research. Although large molecules (*e.g.*, antibody-drug conjugates, recombinant DNA, and fusion proteins) hold a great deal of promise and are capturing increasing attention, the research into small molecules is not drying up. For example, the majority of startups looking to harness A.I. for drug discovery are focused on small molecules.[88] Moreover, small molecules are continuing to be the significant majority of new molecular entities approved by the FDA. The percentage of FDA approvals for NMEs that were small molecule has held steady at approximately 76% between 2010 and 2018.[89]

Another possible reason the disparity between the number of patent filings on large molecules versus small molecules may be due to the difference between how these classes of molecules can be claimed. While small-molecule patent claims can encompass large groups of chemical compounds and identify the claimed compounds by chemical and functional features, it is practically impossible to define and claim large molecules with similar breadth. Therefore, applicants may be more selective about which large molecules they choose to patent.

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[88] https://www.biopharmatrend.com/post/67-will-small-molecules-sustain-pharmaceutical-race-with-biologics/
[89] https://www.biopharmatrend.com/post/67-will-small-molecules-sustain-pharmaceutical-race-with-biologics/; https://www.dcatvci.org/5828-new-drug-approvals-which-drugs-made-the-mark-in-2018

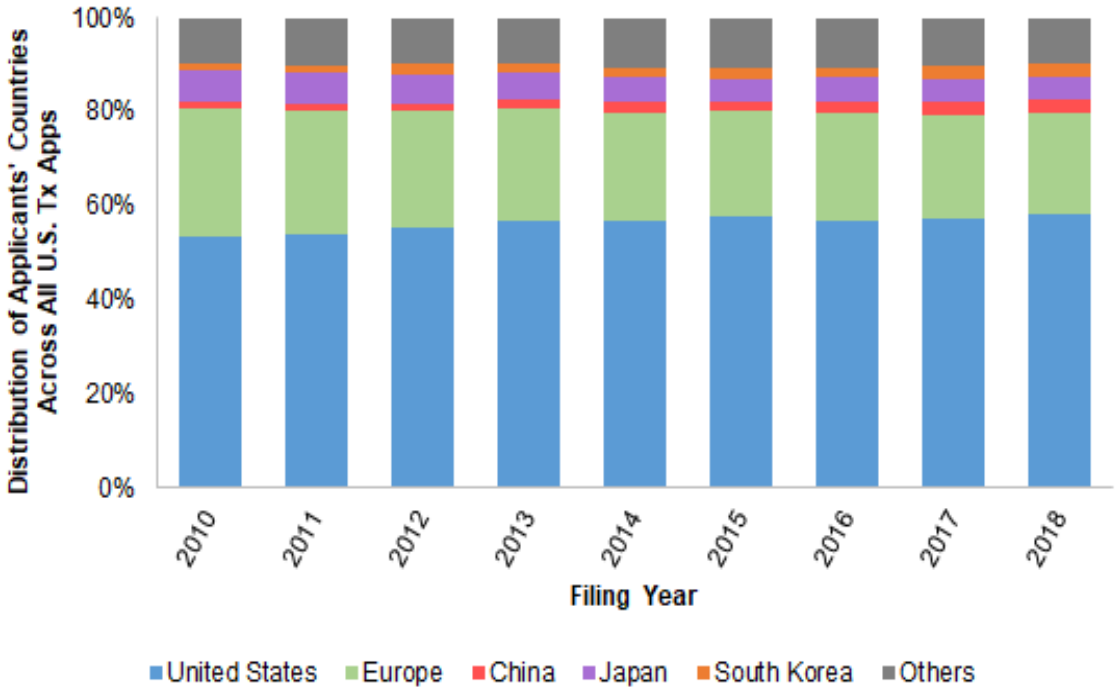
The leaders in patent filings are well-known pharmaceutical companies and academic institutions

USING 2016 DATA:		
		More Families Flied by
		(Applicants in alphabetical order)
Small-Large Molecules		Gilead Sciences, Johnson & Johnson, Regeneron Pharmaceuticals, University of California, University of Texas, Wisconsin Alumni Research Foundation
Level I		
Large Molecules		Invades Biotechnologies, Johnson &Johnson, Regeneren Pharmaceuticals, Stanford University, University of California
Small Molecules		Gilead Sciences, Johnson &Johnson, King Saud University, Merck, Wisconsin Alumni Research Foundation
Level I	**Level II**	
Large Molecules	Used As Diagnostic Agent	Abbott Laboratories, Euroimmun Medizinische Labordiagnostika, Insight Instruments, Johnson & Johnson, Kite Pharma, Korea Institute Of Science And Technology, Northwestern University, Parsagen Diagnostics, Roche, Sysmex Corp., United Arab Emirates University
	Used As Therapeutic Agent	Immatics Biotechnologies, Johnson & Johnson, Regeneron Pharmaceuticals, Stanford University, University Of California
Small Molecules	Synthesis Of Small Molecule	Gilead Sciences, Hong Kong Baptist University, Johnson & Johnson, King Saud University, Korea Institute Of Science And Technology, Macau University Of Science And Technology, Massachusetts Institute Of Technology, Merck, Northwestern University
	Used As Diagnostic Agent	Academia Sinica, Massachusetts Institute Of Technology, Samsung, Stanford University, University of California
	Used As Therapeutic Agent	Ceigene Corp., Gilead Sciences, Incyte, Johnson & Johnson, King Saud University, Merck, University of Texas, Wisonsin Alumni Research Foundation

Despite the large number of startups in the Therapeutic and Diagnostic Molecules industry, the leaders in patenting activity are established pharmaceutical companies and academic institutions.

The Therapeutic and Diagnostic Molecules industry favors established players because there is a high barrier to entry into the industry. Pharmaceutical research is extraordinarily costly because (1) a very small percentage of molecules are found to be safe and effective; and (2) clinical trials and the FDA-approval process are protracted and expensive. Thus, startups are often not in a position to take a drug to market.

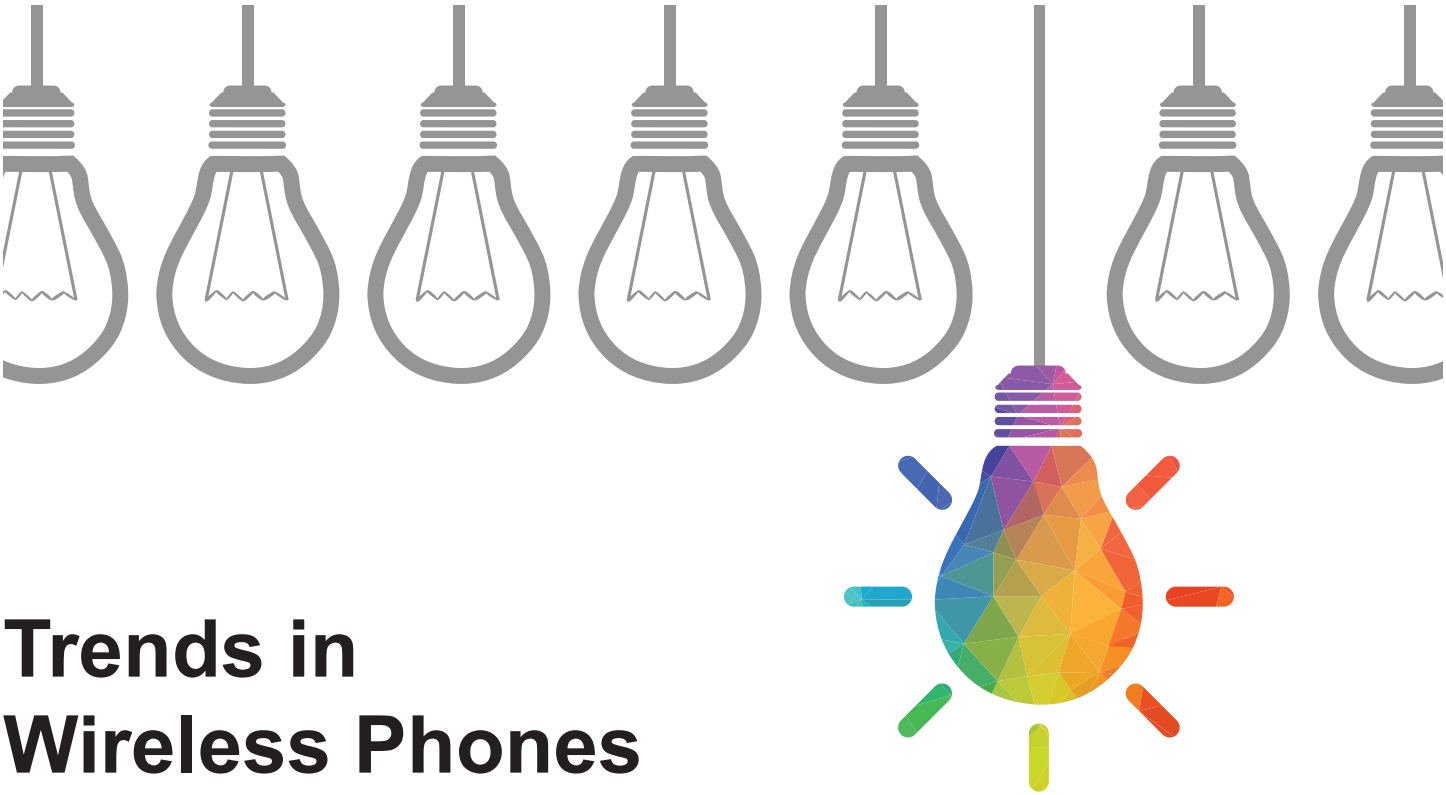
U.S.-based patent filings are continuing to account for approximately 50% of the overall patent filings



The percentage of U.S.-based patent filings in the Therapeutic and Diagnostic Molecules industry has been slightly increasing, but Europe's percentage of patent filings has been slightly decreasing. Europe's decreasing contribution is possibly due to the effects of the austerity measures implemented by many European governments since 2010.[90]

Our study also sees an increasing percentage of patent filings from both China and Korea, although both are still minor contributors to the overall number of filings. These increased percentages may be the result of some pharmaceutical R&D resources shifting away from the United States and Europe due to cost and regulatory considerations.[91]

[90] https://www.ihealthcareanalyst.com/european-pharmaceutical-industry-recent-trends-statistics/
[91] https://www.sciencedirect.com/science/article/pii/S1359644615003797



Trends in Wireless Phones

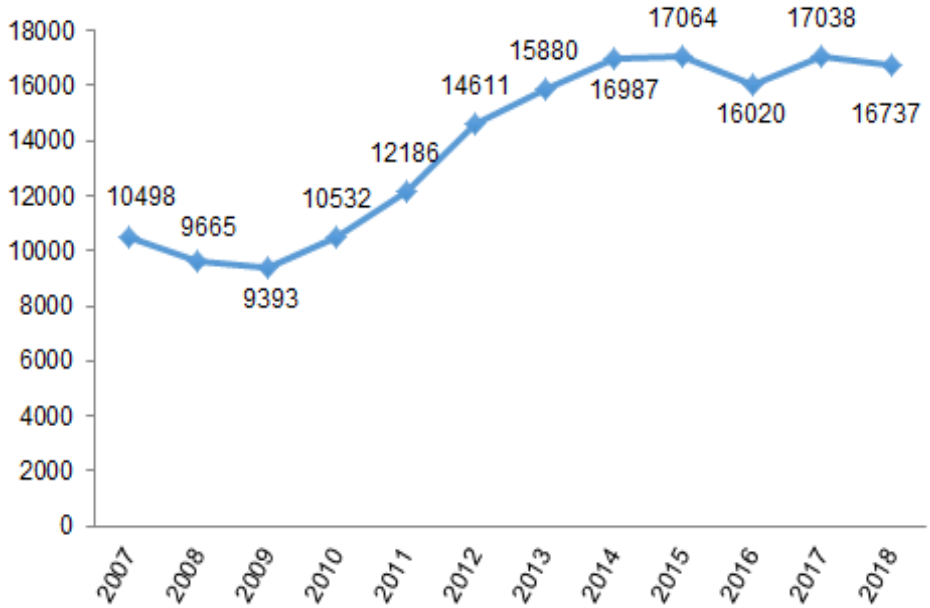
The number of patent filings relating to software is on a downtrend, likely signifying that most phone platforms have reached maturity. Explosive growth in app development earlier this decade has resulted in quick saturation and bloat of the app marketplaces.

The Wireless Phones industry is a maturing industry that has seen a number of competitors leave the market in recent years. However, while overall patenting activity has slowed down significantly, some technologies within this industry are continuing to experience an innovation and patenting uptrend. To delve deeper into the trends of patenting wireless phones innovation, we have defined the following technology clusters within the general Wireless Phones industry:

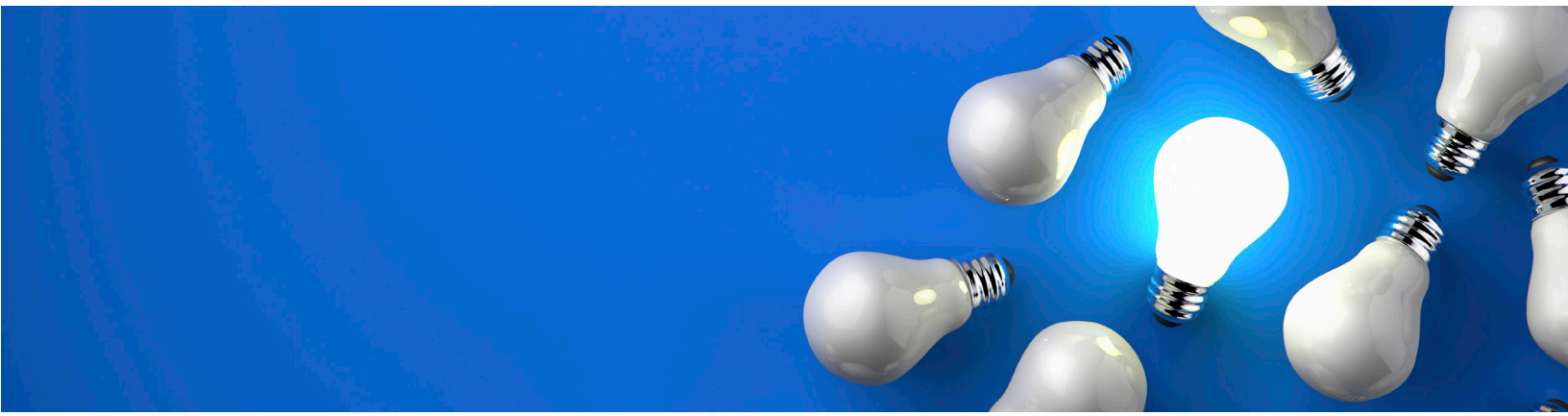
Taxonomies and expanded definitions of these clusters are included in appendix A.

Wireless Phones - Level I Clusters	**Level II Clusters**
Hardware Components	Antenna
	Battery Module
	Camera
	Charging Accessories
	Display
	Speakers & Microphones
	System On Chip (Soc)
Security/Authentication	-
Software Components	Mobile Applications
	Operating System
	User Interface (Ui/Ux)
Wireless Technology S:ardards	3G
	4G/Lte
	5G

The overall number of patent filings in the Wireless Phones industry has been plateauing

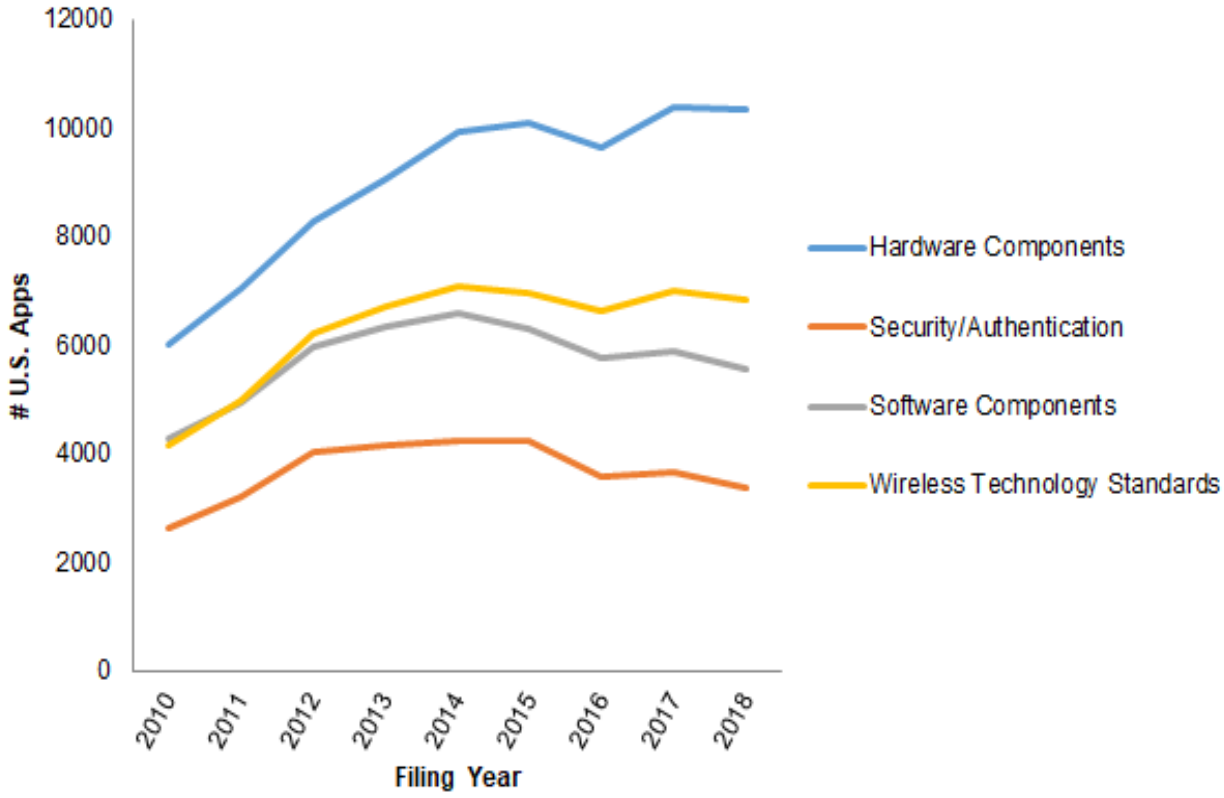


After rapidly rising between 2009 and 2014, the number of patent filings in the Wireless Phones industry has begun to drop off, with a notable uptick in 2017, which is likely due to the recent wave of 5G innovation. In part, the slowing trend in patenting may be due to market saturation (*e.g.*, by 2013, 91% of U.S. adults had a cell phone).[92] Another reason for the flattening trend in patent filings may be the refocusing of early innovators like Nokia (sold its handset division to Microsoft in 2013),[93] Motorola (Google sold its Mobility subsidiary to Lenovo in 2014),[94] Blackberry (stopped making handsets in 2016),[95] and ZTE (banned from U.S. market in 2018).[96]

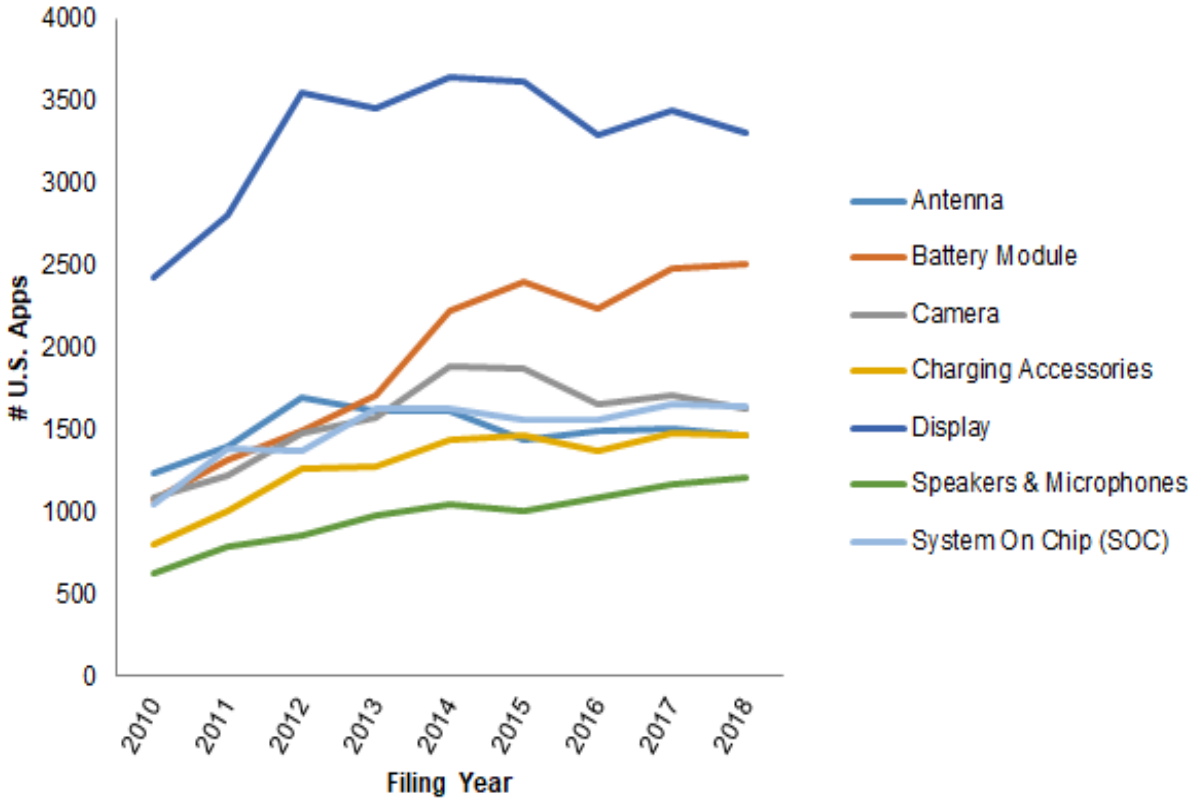


[92] http://www.pewresearch.org/fact-tank/2013/06/06/cell-phone-ownership-hits-91-of-adults/
[93] https://www.theatlantic.com/business/archive/2013/09/why-nokia-died-nobody-buys-phones-anymore/279337/
[94] https://qz.com/172207/why-google-just-sold-motorola-to-lenovo-for-3-billion/
[95] https://www.businessinsider.com/blackberry-stops-making-own-phones-quarterly-results-q2-2017-2016-9?r=UK
[96] https://www.engadget.com/2018/05/09/zte-phones-us-ban-qualcomm/

Patent filings in the Hardware Components technology cluster dominate the patent trends in the Mobile Phones industry

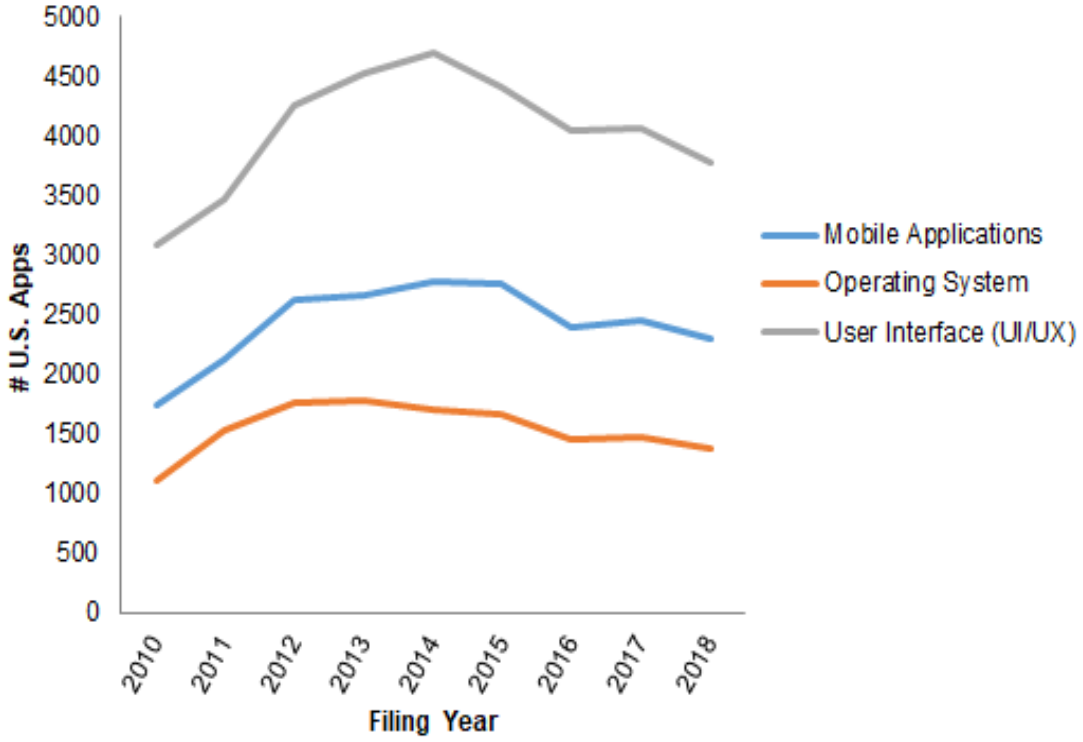


The largest number of patent filings in the Mobile Phones industry relates to the Hardware Components technology cluster. The subclusters comprising the Components technology cluster, however, show marked differences in patenting activity.



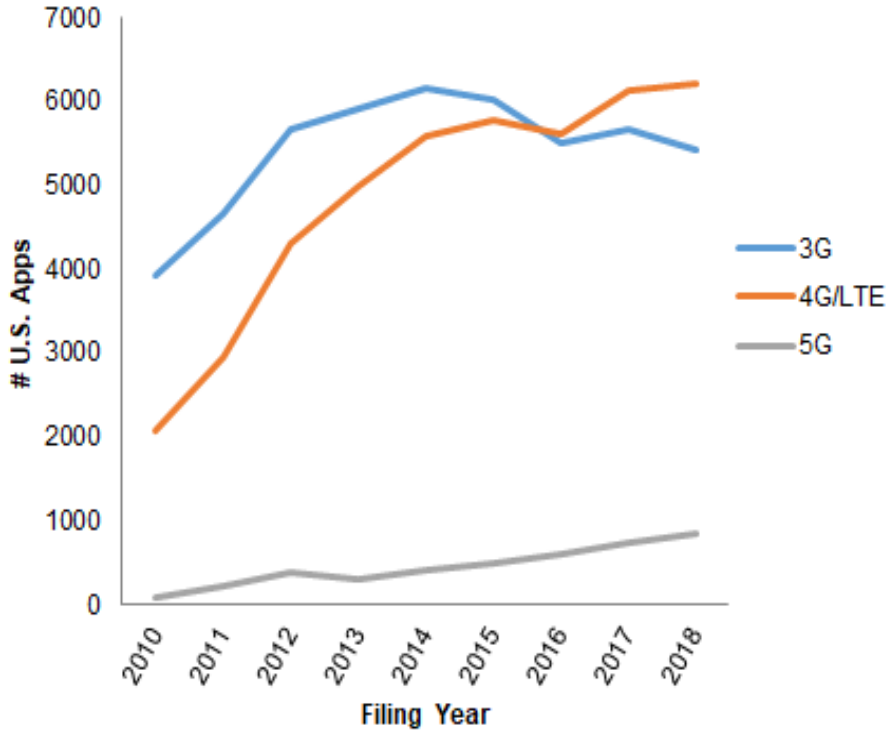
Patent filings related to Battery Modules and to Speakers & Microphones continue to rise, likely because they are the areas that still offer significant opportunity for improvement. Other component clusters, however, show a slowing trend in patent filings, suggesting that an uptrend in patent filings relating to these components will remain stagnant until there are significant new technological breakthroughs.

The number of Software patent filings appears to have peaked



The number of patent filings relating to software is on a downtrend, likely signifying that most phone platforms have reached maturity. Explosive growth in app development resulted in quick saturation and bloat of the app marketplaces.

5G innovation is starting to take off



In 2015, 98% of the U.S. population had access to 4G networks and, currently,[97] the vast majority of new wireless phones sold in the United States are 4G-enabled. The ubiquity of access to 4G corresponds to a drop in patent filings related to 3G as that standard matured and the continuing rise in 4G/LTE-related filings. It is also of note that, while smartphone sales are slowing, the sales of 4G low end phones are expected to skyrocket in the coming years,[98] suggesting that there may be continuing innovation and patent filings in the 4G standard technology cluster. Also, IoT has brought persistent data to many more devices using LTE data.

The steady rise in 5G-related patent filings is following the pattern of the previous generations of wireless phone standards. Therefore, with the first 5G phones expected to go on sale later in 2019,[99] it is likely that 5G-related patenting activity will continue to rise in the future.

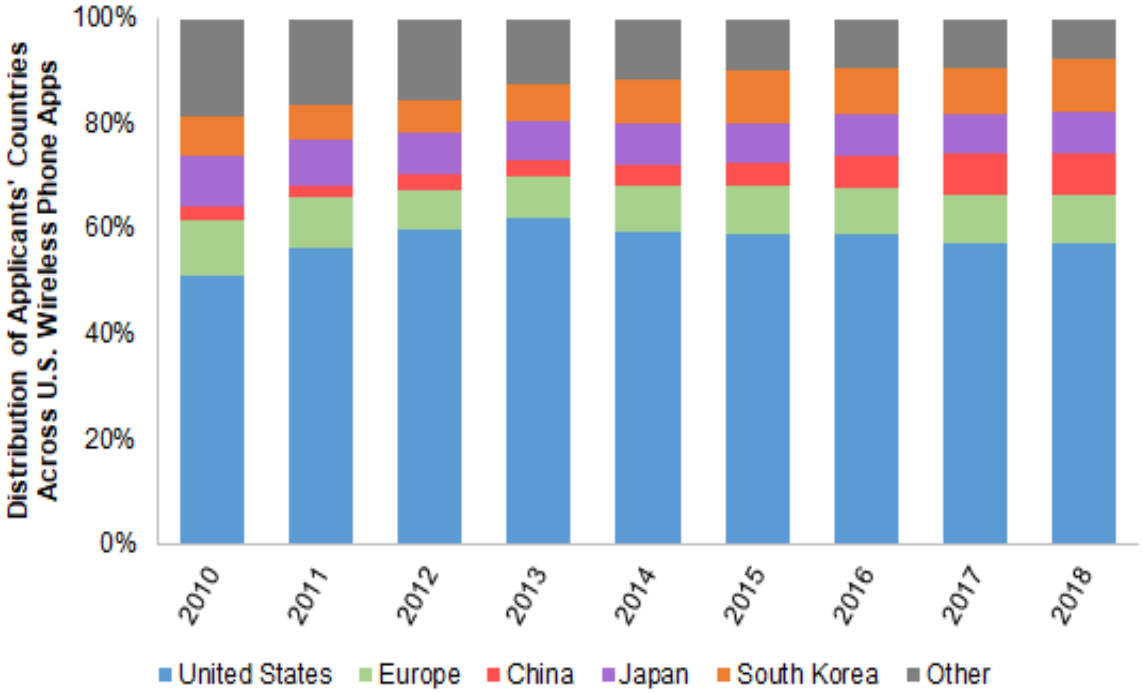
[97] https://bgr.com/2015/03/23/lte-coverage-map-united-states/
[98] https://www.cnbc.com/2017/03/22/4g-feature-phones-emerging-markets-apple-iphone-samsung.html
[99] https://www.digitaltrends.com/mobile/5g-capable-phones/

Leaders in wireless technology continue to grow their patent portfolios

USING 2016 DATA:		
		Most Families Filed by
		(Applicants in alphabetical order)
Wireless Phones		Apple, IBM, Intel, Qualcomm, Samsung
Level I		
Hardware Components		Apple, Intel, LG, Qualcomm, Samsung
Security/Authentication		IBM, Mastercard, Qualcomm, T-Mobile U.S.A., Samsung
Software Components		Google, IBM, LG, Microsoft Samsung
Wireless Technology Standards		Apple, Intel, LG, Qualcomm, Samsung
Level I	**Level II**	
Hardware Components	Antenna	Apple, Guang Dong Oppo Mobile Telecommunications Corp., LG, Qualcomm, Samsung
	Battery Module	Apple, IBM, LG, Qualcomm, Samsung
	Camera	IBM, LC, Microsoft, Qualcomm, Samsung
	Charging Accessories	Ford, IBM, Intel, Qualcomm Samsung
	Display	Apple, Goggle, IBM, LG, Samsung
	Speakers & Microphone	AAC Technologies Pte., Apple, Bragi Gmbh, Cirrus Logic International Semiconductor, Samsung
	System On Chip (SOC)	Apple, Intel, Qualcomm, Samsung, Universal Display Corp.
Software Components	Mobile Applications	Apple, Belling Xiaomi Mobile Software Co., IBM, Kyocera, LG, Microsoft
	Operating System	Apple, Google, IBM, LG, Microsoft, Qualcomm
	User Interface (UI/UX)	Google, IBM, LG, Microsoft, Samsung
Wireless Technology Standards	3G	Apple, Intel, LG, Qualcomm, Samsung
	4G/LTE	Apple, Intel, LG, Qualcomm, Samsung
	5G	AT&T, Ericsson, Intel, Qualcomm, Samsung

Leaders in the Wireless Phone industry continue to patent broadly, with patent filings across multiple technology clusters. In addition, leaders in software, like IBM, are continuing to innovate and file patent applications in this industry as well.

Patent filings originating in the United States account for approximately 60% of the overall number of filings in the Wireless Phone industry



The percentage of U.S.-based patent filings in the Wireless Phone industry peaked in 2013 but has been drifting down since then. In contrast, China has been increasing its share of patent filings in this industry, and the trend is likely to continue, in part because of the growing Chinese consumer base and its adoption of mobile technology along with pursuit of different technology standards.[100]

[100] https://www.ozy.com/acumen/the-biggest-mobile-market-in-the-world-hint-its-not-the-us/88904

KILPATRICK TOWNSEND

About KT

We help leaders create, expand, and protect the value of their businesses and most prized assets. Our attorneys bring a balance of business savvy, technical skills, and creative thinking to the opportunities and issues our clients face daily. From the most complex challenges to the routine, we work together to make businesses better, smarter, more protected, and more successful.

GREYB SERVICES

About GreyB Services

GreyB is global consulting firm committed to improving decisions. We are a community of researchers, who are combining technology with human intelligence to read patent data patterns. From helping attorneys win high stake patent litigations to advancing the use of patent data for business decisions, GreyB sources information (prior art, evidence of use, clustering etc.) about technology through research. In our work, we saved millions of dollars in licensing fees by killing troublesome patents for fast growing companies.

Appendix

Artificial Intelligence

Industrial Design

Building Materials

IoT

Wireless Phones

Bioinformatics

Small & Large Molecule

Medical Devices

Automotive

Blockchain

Clean-Green Tech

FinTech

Disclaimer

Artificial Intelligence Systems

Level I Clusters	Level II Clusters	Level III Clusters	Scope/Definition
Artificial Intelligence Systems			This refers to systems that use intelligent processes in machines/computers so as to make them behave like humans. These processes include learning - acquisition of information and rules for using the information; reasoning - using the rules to reach to an approximate or definite conclusions, and self correction.
	Machine Learning Systems		Machine learning is a sub-category of artificial intelligence (AI) that provides systems with the ability to automatically learn and improve from experience without being explicitly coded. Systems that use machine learning algorithms — whether supervised, semi-supervised, unsupervised or reinforced — are included under this node.
		Utilizing Predictive Analysis	Predictive analytics encompasses a variety of statistical modelling, machine learning techniques and uses statistics (both historical and current) to estimate or predict future outcomes. These models can be trained over time to respond to new data or values, delivering the results.
		Utilizing Neural Networks	Artificial Neural Networks (ANNs) are statistical models directly inspired by and partially modelled on biological neural networks, which are capable of modelling and processing non-linear relationships between inputs and outputs in parallel. These work on a set of algorithms built around a model of artificial neurons spread across three or more layers.
		Utilizing Support Vector Machines	Support Vector Machines (SVM) is a supervised machine learning algorithm used for data classification based on the concept of decision planes that define decision boundaries. The goal of the SVM is to train a model that assigns new unseen objects into a particular category. It achieves this by creating a linear partition of the feature space into two categories.
		Utilizing Pattern Recognition	Pattern recognition is a branch of machine learning that observes patterns and regularities in data for the purpose of learning. Pattern recognition can be either “supervised,” where previously known patterns can be found in a given data, or “unsupervised,” where entirely new patterns are discovered. The objective behind pattern recognition algorithms is to provide a reasonable answer for all possible data and to classify input data into objects or classes based on certain features. Some examples of pattern recognition are Instrument Classification, Automatic Improvisation, Gesture Recognition, Feature Extraction, etc.

Level I Clusters	Level II Clusters	Level III Clusters	Scope/Definition
		Utilizing Classifiers	Machine Learning uses classification algorithms in which the computer program learns from the data input given to it and then uses this learning to classify a new observation. Some examples of classification algorithms used in Machine Learning are Logistic Regression, Naive Bayes Classifier, Decision Trees, Boosted Trees, Random Forest, Nearest Neighbor, etc.
		Utilizing Clustering	Clustering is the process of grouping similar entities together. The goal of this unsupervised machine learning technique is to find similarities in the data point and group similar data points together. Four widely used clustering algorithms are K-Means, Fuzzy K-Means, Hierarchical Clustering & Mixture of Gausians.
	Knowledge Based Systems		Knowledge-based systems are a major branch of artificial intelligence. They are capable of making decisions based on the knowledge residing in them, and can understand the context of the data that is being processed. These systems broadly consist of an interface engine and knowledge base where the interface engine acts as the search engine and the knowledge base acts as the knowledge repository. Knowledge-based systems can aid in expert decision making and allow users to work at a higher level of expertise and promote productivity and consistency. This node includes Expert systems, Intelligent DA, Intelligent DSS, Intelligent Agents, etc.
Application Areas/ Industry			Artificial intelligence in the past decade has affected numerous industries in a positive way leading them towards automation and reducing human effort/ involvement. Under this node, trends would depict the velocity of research and implementation of artificial intelligence in such areas.
	Robotics		Robotics is a branch of AI, which is composed of Electrical Engineering, Mechanical Engineering, and Computer Science for designing, construction, and application of robots. Robots are devices that can move and react to sensory input, aiming to reduce human intervention. Robots are now widely used in factories to perform high-precision jobs such as welding and riveting. They are also used in special situations that would be dangerous for humans — for example, in cleaning toxic wastes or defusing bombs.

Level I Clusters	Level II Clusters	Level III Clusters	Scope/Definition
	Natural Language Processing		Natural Language Processing (NLP) is a fundamental element of artificial intelligence for communicating with intelligent systems using natural language. NLP helps computers read and respond by simulating the human ability to understand the everyday language that people use to communicate.
	Computer Vision		Computer Vision is a field of computer science & artificial Intelligence that works on enabling computers to see, identify and process images in the same way that human vision does, and then provides appropriate output. The goal of Computer Vision is to emulate human vision using digital images through these three main processing components executed one after the other — Image acquisition, Image processing, and Image analysis/ understanding.
	Cognitive Security		Cognitive security is the application of AI technologies patterned on human thought processes to detect threats and protect physical and digital systems. Self-learning security systems use data mining, pattern recognition and natural language processing to simulate the human brain, albeit in a high-powered computer model. Cognitive Systems use machine learning algorithms to constantly mine data for significant information and acquire knowledge through advanced analytics so that they can anticipate threats and generate proactive solutions.
	Healthcare		The adoption of Artificial Intelligence in healthcare is on the rise and is being used for solving a variety of problems. AI has brought a revolution in Healthcare industry via the introduction of systems for Robot assisted surgery, virtual nursing assistants, administrative workflow, preliminary diagnosis, medication management, drug creation, health monitoring, etc.
	Automotive		Artificial Intelligence is transforming automotive industry by integrating machine learning algorithms into vehicles.
	FinTech		The FinTech sector is starting to use artificial intelligence in several ways. This include integration of AI with financial industry to provide advanced customer service such as chatbots, enhanced investment analysis, automated techniques for expenditure analytics, claims management, Automated Virtual Financial Assistants, Wealth Management, etc.
	Education		Artificial Intelligence techniques to facilitate teaching and learning. For example, these technologies can be used to identify curriculum, adaptive tests, student-customized assignments, interactive learning interfaces, etc.

Level I Clusters	Level II Clusters	Level III Clusters	Scope/Definition
	Digital Marketing		Marketers have developed tools to automate their work and reduce manual effort for a while. With the use of AI in digital marketing, it's going to be much easier to predict buyer behavior, buyer persona, search cycles and provide the ease of customer service because chatbots can solve issues at a much faster rate. Also, AI-based Digital Marketing makes reaching out to the best target audience easier, as AI helps in finding people based on their interests, focus, demography, and other aspects and decides which people would be the best-suited audience for the brand.
	Augmented/Virtual Reality		Augmented Reality refers to the technology that layers computer-generated enhancements atop an existing reality in order to make it more meaningful by providing the ability to interact with it. A good example would be the way AR enables users to try out furniture in different colors and styles to see how the items fit with their living rooms.
	Entertainment		AI is reshaping the entertainment industry by using machine learning algorithms and computer vision technologies to build complex and holographic scenes within a pair of goggles.

Industrial Design

Level I Clusters	Level II Clusters	Scope/Definition
Industrial Design		Industrial design refers to the ornamental or aesthetic aspect of an article. It may consist the three-dimensional features, such as shape of an article, or two-dimensional features, such as patterns, lines or colors.
	Consumer Electronics	Consumer electronics includes devices meant for individual or household purposes such as cameras, washing machines, refrigerators, etc. Design patents related to these equipment will be considered under this cluster.
	Computer And Accessories	Computer and accessories entails equipment used for communicating and processing data, along with the peripherals required to support those equipment. This would include designs of equipment like PCs, mobile phones and computer modems.
	Office Equipment	Office equipment include the materials required for teaching or office purposes. The office equipment consists of photocopying and printing apparatus, amongst other equipment. Design patents related to these will be considered under this cluster.
	Cosmetics & Personal Accessories	Cosmetics and personal accessories include products used for personal grooming and comfort. This covers products ranging from handbags to hair wigs. Design patents related to these will be considered under this cluster.
	Textile & Clothing	Textile industry covers apparels, production equipment utilized for manufacturing them and the raw materials utilized in the process. Design patents related to apparels, production equipment, etc. used in textile industry will be considered under this cluster.
	Home Furnishing	Home furnishing is the domain catering to the furniture and other décor items. This covers design patents related to everything a home might require for its décor from carpets to furniture to clocks.
	Sports Equipment	Sports equipment cover articles utilized for sports activities such as gymnastic apparatuses, gaming equipment etc. Design patents related to these will be considered under this cluster.
	Sports Apparel	Design patents related to aspect of sports clothing/apparel will be considered under this cluster.
	Toys	Toys cover articles utilized for amusement and fun-filled activities e.g. games, toy cars, dolls etc. Design patents related to these will be considered under this cluster.
	Automobile & Transportation	Automobile industry caters to designing and manufacturing of automobiles for transportation of people and goods. The design patents related to vehicles (all type of vehicles from aircrafts to animal-driven vehicles), their components (such as engines, wheels, tires etc.) & transportation equipment (such as conveyor belts, forklifts, etc.) would be clustered under this node.
	Pet Products	Pet products can include objects like pet toys, chewing products, food crates, leashes & collars etc. All design patents related to these products will fall under this category.
	Machinery	Every industry requires a specific set of equipment for its operation. For instance, equipment utilized in agriculture and construction for various tasks. Design patents related to such Machineries will be considered under this cluster.

Level I Clusters	Level II Clusters	Scope/Definition
	Tools/Hardware	The designs of equipment, articles or tools used for testing, signaling and other tasks along with other hardware such as metal fittings and locking devices will be covered here.
	Weapons	The designs of different types of weapons and ammunition will be covered under this node.
	Medical/ Laboratory Equipment	A medical kit consists of all the possible equipment that may be required for handling a medical emergency. This node will have the clusters of patents containing such equipment like syringes or prosthetics and other pharmaceutical products. In addition to these, laboratory equipment such as test tubes, beakers, flask, etc. will also be considered under this cluster.
	Power Generation & Distribution	Power generation & distribution entails equipment such as transformers, motors or generators utilized to generate, control and distribute power. Design of equipment involved in power generation & distribution will be considered under this cluster.
	Building & Architecture	Building & architecture entails the construction and designs of buildings. The aspects associated with buildings and their construction such as building material or pre-assembled parts are also covered here.
Graphical User Interface		This would include the user interface design employed in electronic devices. The user interfaces allow users to interact with the electronic devices via widgets, icons and digital buttons.

Building Materials

Level I Clusters	Level II Clusters	Scope/Definition
Binding Materials		A binder or binding agent is any material or substance that holds or draws other materials together to form a cohesive whole mechanically, chemically, by adhesion or cohesion. For example in building construction, concrete uses cement as a binder.
	Cement	Cement is a key binding element and is a prime part of two main mixtures utilized for construction, i.e. mortar and concrete. Various types of cement include hydraulic cement, Portland cement, cement clinkers, white Portland, aluminous cement, fibre cement.
	Pozzolanic Materials	Pozzolana is a globally popular word and mostly used in construction industries nowadays. Pozzolanic materials include metakaolin, silica fume, fly ash, slag, VCAS, calcined clay, etc. Pozzolans contains siliceous and aluminous mineral substance, which in itself possesses little or no cementitious properties. Typically, pozzolans are used as cement replacements rather than cement additions. Adding pozzolans to an existing concrete mix without removing an equivalent amount of cement increases the paste content and decreases the water/cement ratio.
	Polymeric Materials	Polymers are very long molecules typically made up of many thousands of repeat units. They include plastics, PVC, rubbers, thermoplastic elastomers, adhesives, foams, paints and sealants. Polymer concrete (PC) is a composite material in which the binder consists entirely of a synthetic organic polymer. It is variously known as synthetic resin concrete, plastic resin concrete or simply resin concrete. Because the use of a polymer instead of Portland cement represents a substantial increase in cost, polymers should be used only in applications in which the higher cost can be justified by superior properties, low labor cost or low energy requirements during processing and handling.
Concrete/Mortar/ Artificial Stone		Aggregates are building materials used in construction, including sand, gravel, crushed stone, and recycled concrete. Aggregate is used as a filler material in concrete to provide volume, strength, wear, and erosion resistance to the finished product. End markets for aggregates include private residential construction, commercial construction, and publicly-funded infrastructure projects, with the latter consuming the most aggregates, usually for use in highway and road construction.
Precast Concrete Products		A precast concrete product is a factory-made piece manufactured with concrete and which, later, together with other pieces, will become part of a larger structure. Precast concrete elements are prepared, cast and hardened at specially equipped plants with a permanent location. This includes concrete bricks, concrete masonry unit, concrete blocks, concrete pavers, concrete wall blocks, etc.
Reinforcing Components and Supporting Structures		These refer to Metallic & Polymeric Products used in the building and construction sector. Their application areas include structures, reinforcements, cladding, roofing, window frames, plumbing, etc. For example - Steel bars, resin-based lumber alternatives, frames, etc.
Protective & Decorative Materials		These refer to materials and items used to improve the service and decorative quality of buildings and structures, as well as to protect structural members from atmospheric and other effects such as paints, vapor barriers & polish. They are also called “Finishing Materials”.

Level I Clusters	Level II Clusters	Scope/Definition
Green Building Materials		Green materials such as wood, timber, stone, straw, etc. are materials which pose minimum load on the environment and produce minimal or no harm to human health - be it the process of raw material procurement, product manufacturing, application or the cycle of regeneration and reuse. Favorable initiatives have been/are being made by several governments to encourage use of green building materials such as Leadership in Energy and Environmental Design (LEED) in the United States. This has caused a rampant shift in its usage and consequently the market is progressing swiftly.
Smart Building Materials		Smart materials used in built environment can be defined as those offering specific functional and adaptable properties in response to thermal, optical, structural, and environmental stimuli. These materials not only enhance the overall performances of new building construction, but also promise safer structures, longer durability of building elements, more building energy savings, greater environmental sustainability, and even higher indoor user comfort. These will include smart nanostructures and nanomaterial for thermal insulation, chromic materials used in smart glazing systems, self-healing building materials, smart materials for shallow geothermal systems, etc.

IoT

Level I Clusters	Level II Clusters	Scope/Definition
IoT Hardware		Different hardware/equipment is utilized in implementing IOT technology for e.g. sensors, servers etc. Patent applications talking about such hardware would fall under this category.
	Sensors And Actuators	Patent applications related to sensors, sensing modules and actuators deployed in IoT will be kept under this node.
	Gateway Equipment	Patent applications related to gateway equipment in the field of IoT technology will fall under this node. In computer networking and telecommunications, network gateway joins two networks so the devices on one network can communicate with the devices on another network.
	Backbone Network (Network Infrastructure)	Backbone network, as the name suggests, is the underlying frame of an IoT network that interconnects various elements of network, providing a path for the transmission and exchange of information. Backbone network can also tie diverse networks, for instance connecting networks of different buildings in a campus.
	Storage & Servers	An IoT network generates a large amount & variety of data that needs to be stored and managed properly. Storage & servers solutions are meant specifically for managing the data and network connections.
IoT Software		Different type of software and operating systems are utilized in implementing an IOT infrastructure. Patent applications talking about such software aspects would fall under this category.
	Application Software	Patent applications that describe a software/applications for managing industrial assets in a network will be kept under this node. This would include apps, applications, user interfaces, software/program interface/visualization, etc.
	Operating Systems	Patent applications relating to operating systems for different types of nodes involved in IoT infrastructure will be considered under this node.
Computing & Analytics		Patent applications talking about different computing and analysis aspects such as cloud computing, edge computing etc. would fall under this category.
	Cloud Computing And Analytics	Cloud Computing & Analytics refers to the analysis performed on the data extracted from a shared logical pool. In IoT environment, cloud computing enables data computation from a server remote to the IoT devices that generate data.
	Edge Computing And Analytics	Patent applications related to facilitating edge-level data computation will be kept under this node. Edge computing refers to data processing power at the edge of a network, i.e. near the source of data. In an IoT environment, edge computing enables data computation near the IoT devices that generate the data.
Security / Cyber Attack		Patent applications that detail on the aspects of maintaining or enhancing security, protection from cyber attacks, etc. in an IoT network will be kept under this node.
Communication Network		This would include patents focusing on communication related aspects within IoT. It would include techniques used for communication, communication protocols, topologies, etc.
	Communication Techniques	Patent applications that relate to various communication techniques used in an IoT network will fall under this node. This would include multiplexing techniques, topology, routing algorithm, resource management, interoperability, time synchronization, communication scheduling, etc.

Level I Clusters	Level II Clusters	Scope/Definition
	Wireless Protocols	Patent applications related to wireless protocols (e.g. Wi-Fi, ZigBee, BLE, Cellular Communication, RFID) employed in IoT network will be kept under this node.
	Mesh Networking	Patent applications relating to mesh networking in an internet of things environment will be considered under this node.
Areas Of Application		IOT has its application in different industries/areas such as homes, wearable, automotive etc. All such areas would fall under this category.
	Smart Home	IoT enables home automation and allows our homes to be smart. Smart homes allow the user to control various aspects associated with the home such as home appliances, computers, security camera etc. Patent applications related to smart home will be kept under this node.
	Smart City	Smart cities came into picture with IoT which makes it possible to remotely monitor & control equipment based on real time-data input from sensors deployed all over the city and connected over a network. Patent applications related to smart city will be kept under this node.
	Smart Grid	An electric grid deployed with sensors to detect the local electricity usage changes and the ability to adjust accordingly forms a smart grid. The grid utilizes digital communication for these adjustments and thus, ensures efficient energy usage. Patent applications related to smart grid will be kept under this node.
	Smart Wearable	Wearable devices such as wristwatches, smart glasses, fitness bands etc. utilize a network of sensors to monitor a certain set of specified parameters to take intelligent decisions. For instance, smart wearable clothing helps in monitoring the performance of athletes. Patent applications related to smart wearable will be kept under this node.
	Industry & Supply Chain	With the emergence of IoT, the entire domain industrial domain and supply chain can be connected over a network, simplifying the monitoring & control at every step. Patent applications related to implementation of IoT in industrial domain will be kept under this node.
	Automotive	With the advancement in IoT technology, automobiles are becoming more independent and provide automatic-driver-assistance systems. Apart from this, IoT has also stepped in helping the automakers to improve the driving experience of their customers. Patent applications dealing with implementation of IoT in automotive sector will be kept under this node.
	Healthcare	In healthcare, IoT enables medical officials to monitor patients, enhance surgeries and doctor-patient engagement. Patent applications talking about implementation of IoT in healthcare domain will be kept under this node.
	Retail	Retail environments have greatly benefitted from IoT as it elucidates predictive equipment maintenance and creates an ecosystem for connected consumer, Allowing consumers to check-in into stores and scan the pricings at their fingertips via their mobile phones. Patent applications describing implementation of IoT in retail sector will be kept under this node.
	Agriculture	IoT offers smart farming solutions and allows farmers to monitor soil profile, crop health and control machinery with extreme precision via a distributed sensor network. Patents focusing on implementation of IoT in agriculture sector will be kept under this node.

Wireless Phones

Level I Clusters	Level II Clusters	Scope/Definition
Hardware Components		Mobile hardware is the collection of physical parts or components of a smartphone. This includes the screen, antenna, battery, camera, SoC etc.
	System on Chip (SoC)	System on Chip (SoC) refers to an Integrated Circuit (“IC” or “chip”) that integrates all components of a wireless phone. It includes a Processor, Memory element, Input/output ports, secondary storage - all on a single substrate. Recently, the focus in the smartphone SoC market has shifted away from the number of processor cores to the integration of newer technologies driving newer experiences.
	Battery Module	Battery is one of the most important parts of a mobile phone or a tablet as this is what keeps the device mobile. Patent applications discussing about power management in wireless phones, cell phone batteries, charging & discharging processes would fall under this node.
	Display	A mobile display is an output surface and projecting mechanism that shows text and often graphic images to the mobile user. Patent applications talking about enhancement in touch screens, impedance detection, optical detection, screen resolution etc. would be categorized under this node.
	Camera	Smart Phones are employed with camera to make it capable of capturing photographs & recording videos. Various advancements has been made in the mobile cameras such as increased megapixels, optical zoom, red eye features, capability to record high definition video, panorama view, live photos, and many more.
	Speakers & Microphones	A speaker is a small sound driver fitted within a phone to produce sounds. Microphone is embedded in the phone for transmitting the voice electronically through the call and voice recordings. Patent applications that relate to the improvement in functionality of speakers & microphones would fall under this node.
	Antenna	Mobile Phones contain at least one radio antenna in order to transmit or receive radio signals. An antenna converts an electric signal to the radio wave (transmitter) and vice versa (receiver). Some cell phones use one antenna as the transmitter and receiver; while others, such as the iPhone 5, have multiple transmitting or receiving antennas. Many modern smart phones also contain more than one type of antenna. In addition to the cellular antenna, they may also have Wi-Fi, Bluetooth and/or GPS antennas.
	Charging Accessories	Charging accessories refer to the components that are being utilized for power management of a smartphone. Patent applications discussing about power adapters, charging cables & wireless charging pads would be categorized under this node.
Software Components		Software Content refers to a collection of data or instructions that tell the smartphone how to work, in contrast to the physical hardware from which the system is built, that actually performs the work. This includes the Operating System & various mobile applications.
	Operating System	An Operating System (OS) is an interface between a mobile phone user and mobile phone hardware and controls the execution of all kinds of programs. Examples of Operating Systems are Windows, Android, Symbian, IOS, Blackberry OS. Patent applications talking about developments related to operating systems would fall under this node.

Level I Clusters	Level II Clusters	Scope/Definition
	User Interface (UI/ UX)	The User Interface, or UI, of a device is the look and feel of the on-screen menu system. User Interface allows the user to interact with the device's apps, features, content and functions. Patent applications that discuss any modifications in features of the UI would be categorized under this node.
	Mobile Applications	A mobile application, most commonly referred to as an app, is a type of application software designed to run on the mobile device. Apps are generally small, individual software units with limited function such as a game, calculator or mobile web browsing etc.
Wireless Technology Standards		This would cover enhancement related to 3G, 4G & 5G technology and technology-enabled handsets.
	3G	3G (Third Generation) is a mobile communication standard that allows mobile phones, computers, and other portable electronic devices to access the Internet wirelessly. Patent applications discussing about enhancements related to 3G technology & 3G-enabled smartphones would fall under this node.
	4G/LTE	4G (IEEE 802.11n) stands for fourth generation of data technology currently being utilized for broadband mobile capabilities. It succeeds 3G and is also called "IMT-Advanced" or "International Mobile Telecommunications Advanced". 4G provides improved download/upload speeds and reduced latency than 3G. Patent applications discussing enhancements related to 4G technology & 4G-enabled smartphones would fall under this node.
	5G	Fifth generation wireless (5G) is a wireless networking architecture built on the 802.11ac IEEE wireless networking standard, which aims to increase data communication speeds by up to three times compared to its predecessor 4G. Patent applications discussing the enhancements related to 5G technology & 5G-enabled smartphones would fall under this node.
Security/ Authentication		Mobile device security means the security measures designed to protect sensitive information stored on and transmitted by smartphones. Mobile device security spans the scope from user authentication measures to mobile security best practices for protecting against compromised data in the event of unauthorized access or accidental loss of the mobile device to combat malware, spyware and other mobile security threats that can expose a mobile device's data to hackers.

Bioinformatics

Level I Clusters	Level II Clusters	Scope/Definition
Sequence Analysis		In bioinformatics, sequence analysis is the process of subjecting a DNA, RNA or peptide sequence to any of a wide range of analytical methods to understand its features, function, structure, or evolution. It includes the comparison of sequences in order to find similarity (homologous sequences), identification of active sites, point mutations and single nucleotide polymorphism (SNP) present in sequences, exploring the evolution of organisms and also includes identification of protein structure/ function from gene sequence.
	Sequence Identification	Sequence identification is the process of determining the precise order of a) nucleotides within a DNA molecule or b) amino-acids in a protein molecule. It includes any method/algorithms or technology that is used to determine the order of the respective monomers of these macromolecules.
	Sequence Alignment/ Comparison	In bioinformatics, a sequence alignment is a way of arranging the sequences of DNA, RNA, or protein to identify regions of similarity between the two or more sequences (homologous sequences). Usually, in this case, the sequence of the known DNA, RNA, or protein are stored in databases, and later compared to the newly discovered genes/proteins for identifying them.
	Sequence Assembly	Sequence assembly refers to reconstruction of the original sequence through merging of small DNA fragments.
	Genome Annotation	DNA annotation or genome annotation is the process of identifying all of the coding regions in a genome. Previously, gene annotation was conducted through various techniques like microarray, metabolomics, and proteomic experiments. But now, several bioinformatics databases for sequence, genome, gene function, protein, and protein interaction databases, are available to be used in performing faster annotation with high accuracy.
	Computational Evolutionary Biology	In evolutionary bioinformatics, the origin of species is predicted by bioinformatics tools on the basis of data related to change in DNA rather than by conventional data (physical taxonomy or physiological observations).
	Genetics Of Disease/ Mutations Responsible For Disease	Analysis of sequences to pinpoint the mutations (e.g. point mutation, single nucleotide polymorphism (SNP), etc.) responsible for complex diseases such as diabetes, cancer or Alzheimer's Disease.
	Pharmacogenomics	Pharmacogenomics provides data of individual genetic variations, such as single nucleotide polymorphism (SNP) which impacts drug response. Bioinformatics tools are used to perform SNP analysis for personalizing the medication programme.

Level I Clusters	Level II Clusters	Scope/Definition
	Functional Genomics/ Proteomics	This category relates to detecting and assessing gene and protein functions and interactions. Functional genomics focuses on gene transcription, translation, regulation of gene expression and protein-protein interactions. It usually involves methods like microarrays, expressed cDNA sequence tag (EST) sequencing, serial analysis of gene expression (SAGE) tag sequencing, massively parallel signature sequencing (MPSS), or various applications of multiplexed in-situ hybridization, etc. These techniques produce a huge data, which can be processed to produce meaningful patterns via mathematical techniques like data clustering, machine learning, artificial neural networks, etc.
Structural Bioinformatics		Structural bioinformatics describes the 3-dimensional structure of proteins encoded by a genome. With the help of bioinformatics tools, data from different methods of structure determination is analyzed by a combination of experimental and modeling approaches to determine the protein structure.
Analysis Of Gene Expression		Gene expression is the process by which protein-coding genes are transcribed into proteins, and non-protein coding genes (e.g. transfer RNA i.e. tRNA or small nuclear RNA, also referred as snRNA) lead to formation of functional RNA. Basically, in this type of analysis, a collection of information on gene sequences obtained via various experiments (tilting arrays, microarrays, SNP chips) is analyzed by bioinformatics tools.
Computational Neuroscience		Computational neuroscience uses computational techniques (e.g., modelling, big-data analyses, and data transformations) to understand the function and anatomy of part or all of a nervous system.
Computational Biomodeling		Computational biomodeling describes the use of computer simulations of biological systems to analyze and visualize the complex connections of the cellular processes. Further, these processes include networks of metabolites and enzymes being used in metabolism, signal transduction pathways, and gene regulatory networks, etc.
Protein Analysis		Analysis on a) protein synthesis b) its function c) its regulation via various experiments (two-dimensional electrophoresis, madly MS, protein chip, etc.) is called Protein Expression Analysis in general sense. It helps in understanding the structure, function, interactions and regulation of a protein.
Patient Data Analysis		Patient Data Analysis includes particular types of computational processing used to analyze patient data. The analysis may facilitate diagnosis, treatment selection, prognosis assessment, etc. This category also includes High Throughput Screens technology, where a large number of experimental samples are tested under given conditions.

Small & Large Molecule

Level I Clusters	Level II Clusters	Level III Clusters	Scope/Definition
Small Molecules			A small molecule is a low molecular weight (< 900 daltons) organic compound that may regulate a biological process. Most drugs are small molecules. These small molecules can be processed into easily ingestible dosage form (e.g. tablet). The tablet dissolves in the gastrointestinal tract, the dissolved active substance is absorbed into the bloodstream via the intestinal wall. From there, the small molecules can reach almost any desired destination in the body because of their tiny size.
	Synthesis Of Small Molecule		Small molecules can be synthesized from various routes. We can simply isolate them from biological sources (e.g. penicillin). These molecules can also be semi-synthesized, starting from some biological raw material (e.g. vincristine). However, most of the small molecules are manufactured in laboratories, and are completely synthetic in origin.
		Synthetic	Synthetic small molecules are produced using man-made chemicals rather than natural ingredients e.g. acetylsalicylic acid.
		Semi-Synthetic/ Biologically Synthesized	Semi-synthetic small molecules are formed through the chemical reaction of a naturally occurring molecule to form a new product e.g. anticancer drug (vincristine) is a derivative of vinca alkaloids extracted from Catharanthus roseus. Here, we would also include small molecules that are biologically synthesized i.e. obtained from biological sources such as bacteria (e.g. penicillin).
	Used As Diagnostic Agent		Small molecules can be used to examine the body in order to detect any therapeutic condition or impairment of its normal functions. E.g. to check gall bladder function, few small molecules like Iocetamic acid, Iodipamide, Tyropanoate sodium can be used. Similarly to check liver function, Indocyanine green can be used.
	Used As Therapeutic Agent		Small molecules can be used to provide treatment in a disease state. These molecules can be inhaled, injected, absorbed via a patch on the skin.
		Chemical Structure Of Small Molecule	Patent applications which are talking about the chemical structure of a small molecule. They disclose chemical structure in a way so that it indicates a group of related chemical compounds as well.
		Composition Containing Small Molecule	Patent applications in which other ingredients are listed along with the active substance (small molecule). The active component is responsible for therapeutic effect for particular disease or condition, whereas inactive substance or excipients have no therapeutic effect but is helpful to make stable drug in particular dosage forms like tablets, capsules, syrup.
		Production Process	Production process of small molecules includes a series of unit operations, such as milling, granulation, coating, tablet pressing, and others.
		Formulation/ Dosage Form	Dosage forms are the means (or the form) by which drug molecules are delivered to sites of action within the body. These dosage forms can be solid, semisolid, gaseous or liquid in nature.

Level I Clusters	Level II Clusters	Level III Clusters	Scope/Definition
		Dosage Regimen	Dosage regimen is defined as the manner in which the drug is taken. For some drugs like analgesics single dose is efficient for optimal therapeutic effect but in other disease conditions, drugs are required to be taken on a repetitive bases over a period of time depending upon the nature of illness. Dosage regimen is the one in which the drug is administered in suitable doses with sufficient frequency that ensures maintenance of plasma conc. within the therapeutic window for entire duration of therapy.
		Route Of Administration	The route of administration is the path by which a small molecule is taken into the body. Routes of administration are generally classified by the location through which substance is inserted inside the body. Common examples include oral and intravenous administration.
		Combination With Other Small/Large Molecules	Small molecules can also be used in combination with other active pharmaceutical ingredients (APIs); sometimes, the combination provides synergistic effect or it lowers down the side effects.
		Drug Delivery System	Drug delivery is the method or process for transporting a pharmaceutical compound safely (without getting deteriorated in the path) in the body to achieve a therapeutic effect in humans or animals. E.g. prodrug formation, entric coating.
		Therapeutic Indications Of Small Molecule	Patent applications disclosing therapeutic usage of the small molecules for diseases such as cancer, pain etc., would be classified here.
Large Molecules			Large molecules can be composed of proteins that have a therapeutic effect. Biologics are isolated from a variety of natural sources - human, animal, or microorganism - and may be produced by biotechnology methods.
	Used As Diagnostic Agent		Large molecules can be used to examine the body in order to detect any therapeutic condition or impairment of its normal functions. E.g. enzyme-linked immunosorbent assay (ELISA) is conducted which uses antibodies to identify viral infections.
	Used As Therapeutic Agent		Large molecules can be used to provide treatment in a disease state. These molecules can be injected through vaccination.
		Molecular Structure/ Sequence Of Large Molecule	Patent applications which are talking about the molecule structure/ sequence of a large molecule would be classified here.

Level I Clusters	Level II Clusters	Level III Clusters	Scope/Definition
		Biological Sources Of Large Molecule	Microorganisms — bacteria and yeast — have been widely used for the production of genetically engineered (recombinant) biopharmaceuticals. Typical examples include the prokaryotic bacteria Escherichia coli (E. coli) and the eukaryotic yeasts Saccharomyces cerevisiae, Hansenula polymorpha, and Pichia pastoris (P. pastoris). Recombinant technology is used on these microbes to produce large quantities of desired substances, including peptides, proteins, and nucleic acids. Patent applications disclosing about such genetically modified organisms will come under this category.
		Fermentation Techniques For Manufacturing Large Molecule	In fermentation, micro-organisms break down the glucose molecules in the absence of the oxygen. E.g. fermentation of Clostridium botulinum produces botulinum toxin type B vaccine which is used in overactive muscle movement.
		Purification Process Of Large Molecule	Large molecules are purified by different processes like free flow electrophoresis, centrifugation, ion exchange chromatography etc.
		Large Molecule Delivery System	Different types of device like vaccine, Infusion, transdermal patches, Insulin pen are used to administer the large molecules to the patients.
		Therapeutic Indications Of Large Molecule	Large molecules can be used therapeutically such as monoclonal antibodies used in different types of cancer.

Medical Devices

Level I Clusters	Level II Clusters	Scope/Definition
Diagnosis & Imaging Devices		Diagnostic devices are used to identify the nature or cause of a medical condition. Examples of diagnostic devices are miniature retinal scanners, CT scanners, MRI machine, ultrasound machine, electrocardiograph, fetal monitor, DNA nanobots, thread based diagnostic devices, eye imaging visual system, EEG and X-ray machines etc.
	Endoscopic Devices	Endoscopic devices are used to examine the interior of a body organ. Endoscopes are inserted directly into the organ. These devices transmit light to allow direct visualization of body systems.
	Monitoring & Tracking Devices	Patient monitoring devices are used to observe conditions of a disease, or several other medical parameters. These devices continuously measure certain parameters such as vital signs (e.g. bedside monitor), and/or perform medical tests (such as blood glucose monitoring with a glucose meter in diabetic patients). Usually in case of such devices, sensors are deployed, from which data is collected, then processed and displayed either locally or remotely.
Wearable Medical Devices		Devices that can be worn by the patients/users themselves so as to provide real-time access to their health records, which in turn leads to quicker diagnosis and treatment of any emergency condition. These devices also sometimes provide remote monitoring of users.
Drug Delivery Devices		Drug delivery devices are specialized tools for the delivery of a drug or therapeutic agent via a specific route of administration. Such devices might include smart inhalers, biostamps, infusion pump, contact lens eye glass combination, nano-diamond based drug delivery system, etc.
	Infusion Pumps	An infusion pump is a medical device used to deliver fluids into a patient's body in a controlled manner. These devices deliver fluids in large or small amounts, and may be used to deliver nutrients or medications – such as insulin or other hormones, antibiotics, chemotherapy drugs, and pain relievers.
	Inhalers	An inhaler (puffer or pump) is a medical device used for delivering medication into the body via the lungs.
	Syringes	Hypodermic syringes are used to inject drugs, fluids into the bloodstream.
	Transdermal Patches	Transdermal patch is a medicated adhesive patch that is placed on the skin to deliver a specific dose of medication through the skin and into the bloodstream.
	Implantable Drug Delivery Devices	Implantable drug-delivery devices release drugs to the bloodstream continuously without even hospitalizing the patients.
Assistive Care Devices		Any device that is designed, or adapted to assist a physician/patients to perform a particular task is called an assistive care device. For examples, dental drills, dental chairs, defibrillator, ventilators, ultrasound therapy, vital signs monitor, advanced bionic eyes, smart contact lenses, virtual reality visual devices, bio-hybrid kidney, neuroprosthetics, deep brain stimulators, prosthetics, etc. all are assistive devices.
	Mobility Aids	The devices used to assist patients in walking e.g. wheelchairs, walkers, canes, crutches.
	Sensory Aids	Any instrument which is used by a disabled or elderly person to compensate the inability like hard of hearing or visibility e.g. glasses, hearing aids.
	Prosthetic Devices	Prosthetic device is an artificial device that replaces a missing body part, to support a body part or function of a body part e.g. artificial arms or legs.

Level I Clusters	Level II Clusters	Scope/Definition
	Orthopaedic Devices	Orthopaedic devices are intended to treat or reconstruct skeletal tissues i.e. it is a piece of equipment that is used for preventing and treating deformities and injuries of the musculoskeletal system in man.
	Durable Medical Equipment	Medical devices which are used to support performance of basic activities of daily living, such as beds, lifts, and toileting equipment e.g. hospital bed, specialized mattress, chair (e.g., geri-chair or lift chair), lift equipment, commode, urinal, bed pan.
	Measuring Devices (Meters)	These devices includes a wide range of devices for determining health status or managing disease conditions, either one time or on an ongoing intermittent basis e.g. thermometer, stethoscope, blood glucose meter, blood coagulation (PT/INR) meter, pulse oximeter, weight scale, blood pressure monitor, apnea monitor, electrocardiogram monitor, fetal monitor.
	Treatment Equipment	These equipment are used to administer various medical therapies e.g. IV equipment, infusion pumps, dialysis machines, transcutaneous electrical nerve stimulation systems.
	Respiratory Equipment	Respiratory equipment is used to treat respiration-related conditions e.g. ventilator, continuous positive airway pressure, bi-level positive airway pressure, and demand positive airway pressure equipment, oxygen cylinder, oxygen concentrator, nebulizer, masks and canulas, respiratory supplies, cough assist machine, suction machine, manual resuscitation bags.
	Feeding Equipment	Feeding devices are used for feeding the patients e.g. feeding tubes (nasogastric, gastrostomy, jejunostomy), enteral pump
	Voiding Equipment	Voiding equipment devices are used for releasing urine or feces from the body e.g. Catheter, Colostomy bags.
	Infant Care	Infant care devices include machines used to monitor and treat infants e.g. incubator, radiant warmer, bilirubin lights, phototherapy, apnea monitor.
	Telehealth Equipment	Telehealth equipment are used to collect data from remote location and transmit the data to monitoring site e.g. cameras, sensors data collection and communication equipment (e.g., computer).
Surgical Devices		A surgical instrument is a specially designed tool for performing specific actions during a surgery or operation, such as modifying biological tissue, or to provide access for viewing it. Such devices might include balloon catheters, surgical robots, 3D printed surgical planning models, piXL, virtual reality assisted surgeries, etc.
	Sutures & Staples	Sutures, stitches and staples are used to close wounds or surgical incisions.
	Handheld Surgical Devices	Handheld surgical devices are designed to be held in hand during surgery. These handheld surgical devices are used for various purposes such as to cut and fulgurate body tissues. Different types of handheld surgical devices include forceps and spatulas, retractors (dilators, graspers), auxiliary instruments (clamps, cannulas, closure devices), cutters (trocars, lancets, scissors), suction tubes, rasps, dissectors, and needle holders, etc.
	Electrosurgical Devices	Electrosurgery devices apply electrical current to biological tissues provide incision at the site of surgery. Electrosurgical devices are frequently used during surgical operations helping to prevent blood loss.

Level I Clusters	Level II Clusters	Scope/Definition
	Next-Generation Surgical Devices	Patent applications disclosing latest surgical devices that have been developed using new technologies and would probably replace an existing device. E.g. surgical robots, 3D printed surgical planning models, piXL, virtual reality assisted surgeries, etc.
Consumables And Disposables		These are the devices that are intended to be consumed and are designed for a single use. They can be recycled or disposed after usage. Such devices might include disposable plastic syringes, blood bags, IV fluid sets, wound management products, etc.

Automotive

Level I Clusters	Level II Clusters	Scope/Definition
Electric/Hybrid Vehicles		Electric Vehicles also known as EV are propelled using electric or traction motors. The sub-categories include battery-based, fuel cell-based and hybrid vehicles.
	Battery Electric Vehicles	This category will include patents focusing on battery-based electric vehicles. Battery electric vehicles are the ones in which the main propulsion system is electric motor.
	Fuel Cell Based Vehicles	This category will include patents focusing on fuel cell-based electric vehicles. Fuel Cell Vehicles or FCVs employ fuel cell to convert chemical energy from a fuel to electricity. The electricity so generated is used to run the vehicle.
	Hybrid Electric Vehicles	Hybrid Electric Vehicles or HEVs employ a conventional internal combustion engine (ICE) along with an electric propulsion system.
AI Integrated Vehicles		Vehicles enabled with emerging technologies such as artificial intelligence or big data to perform specialized functions such as automatic driving would be clubbed here.
	Autonomous Vehicles	Autonomous vehicles, also known as self-driving or driverless vehicles, are capable of taking their own decisions with respect to driving like lane maintenance and adapting anti-collisions routes.
	Connected Vehicles	Connected vehicles are capable of communicating with their surroundings over a network. This would include ‘vehicle to vehicle’, ‘vehicle to cloud’, ‘vehicle to infrastructure’ and ‘vehicle to everything’ communications.
Vehicle Propulsion System		Propulsion system of automobile produce thrust to push automobiles forward. Propulsion system of automobiles includes multiple subparts such as electric motors, battery and electric motor.
	Internal Combustion Engine (ICE)	Internal combustion engine refers to an engine capable of generating motive power by burning fuel with air and then using the gases so produced for performing work or driving piston. This would also include auxiliary systems and components that assist the working of the engine such as ignition system, induction system, lubrication system etc.
	Electric Motor	An electric motor is a device for converting electrical energy into mechanical energy. This category will include patents disclosing about different electric motors used in propulsion system of automobiles.
Battery		This category will include patents focusing on different aspects related to batteries that are used in propulsion system of automobiles. These includes battery management systems, battery packs, and types of batteries.
	Lead Based Batteries	This category will include patents focusing on different aspects related to lead-based batteries that are used in propulsion system of automobiles. These includes battery management systems, battery packs, and types of batteries.
	Lithium Based Batteries	This category will include patents focusing on different aspects related to lithium-based batteries that are used in propulsion system of automobiles. These includes battery management systems, battery packs, and types of batteries.
	Other Aspects (Battery Management System/Packs)	This category will include patents focusing on other aspects of batteries (apart from whether it is lead acid or lithium-based battery). These aspects include battery management systems, battery packs, etc.

Level I Clusters	Level II Clusters	Scope/Definition
Vehicle Controlling System		Vehicle control system entails speed control, steering control, and power train. Power Train (also known as powerplant) refers to the mechanism that generates the power and delivers it to vehicle's axle.
Vehicle Navigation System		This category will include patents disclosing about navigation systems in automobiles and use of geo-location services for the same.
Vehicle Safety System		This category will include patents disclosing about different safety mechanisms in automobiles. It will cover aspects like electronic stability of vehicles, suspension system, traction control system, anti-lock braking system and other systems for failure control in automobiles.
Ancillary Vehicle Systems		Ancillary vehicle systems include systems that support the functioning of vehicles and comfort associated with them. This would include emission control systems, lighting system, sound system, horns, wipers etc.
Vehicle Design		This category will include patents disclosing about structure and aesthetics of automobiles. This category will also include patents focusing on doors of automobiles, chassis of automobiles.

Blockchain

Level I Clusters	Level II Clusters	Scope/Definition
Type of Blockchain		This section is dedicated to cater inventions that focus on a specific type of blockchain, be it public blockchain, or private blockchain or federated/ consortium blockchain.
	Public Blockchain	Patent applications relating to implementation of Public Blockchain will be considered under this node. A public blockchain, as its name suggests, is the blockchain of the public, meaning a kind of blockchain which is 'for the people, by the people and of the people'. Here no one is in charge and anyone can participate in reading/writing/auditing the blockchain. Example: Bitcoin, Litecoin etc.
	Private Blockchain	Patent applications related to Private Blockchain will be considered under this node. Private blockchain, as its name suggests, is a private property of an individual or an organization. Unlike public blockchain, private blockchain has an in charge who looks after important things such as read/write or whom to selectively give access to read or vice versa. Here, the consensus is achieved on the whims of the central in charge who can give mining rights to anyone or not give at all. Example: Bankchain
	Federated/ Consortium Blockchain	Federated/Consortium Blockchain tries to remove the sole autonomy that gets vested in just one entity by using a private blockchain. Therefore, a federated blockchain has more than one entities in charge. Basically, it has a group of companies or representative individuals coming together and making decisions for the best benefit of the whole network. Such groups are also called consortiums or a federation, hence the name consortium or federated blockchain.
Blockchain Computation		Blockchain computation relates to computational processes that use blockchain data and/or structure.
	Block Generation	Patent applications related to techniques used in the construction of a block for blockchain will be bucketed under this node. These technologies will include processes involved in creation/storage/addition/sidechaining of blocks on a blockchain.
	Block Hashing	Patent applications that are related to the various hashing functions or encryption algorithms in play in order to link records in Blockchain technology will be bucketed under this node. Hashing refers to the concept of taking an arbitrary amount of input data, applying some algorithm to it, and generating a fixed-size output data called the hash. This node will cater patents about algorithms of hashing and encryption, such as the MD5 algorithm, SHA algorithm, digital signatures, encryption, elliptic curve cryptography.
	Block Mining	Patent applications related to methods regarding the validation or verification of a data block in a Blockchain network through a defined algorithm (e.g. Proof of Work, Mining, Proof of Stake, comparing Hashes/Signatures, etc.) will be kept under this node. For confirming that a transaction is legit, a particular method of agreement or validation is performed by all the participating nodes. Only after this validation is the transaction allowed and the corresponding block is added to the blockchain.
	Block Sharing	Patent applications that explain the methods for sharing a transaction or data block among the participating nodes in a Blockchain network will be bucketed under this node. Also, the patents that explain the methods related to retrieving a transaction data in a Blockchain network will be bucketed under this node.

Level I Clusters	Level II Clusters	Scope/Definition
Data Structure (Merkle Tree)		Patent applications related to the various data structures used in Blockchain technology will be bucketed under this node. For example - Merkle Tree and Key-Value Directory. Merkle trees are hash-based data structures in which the leaf nodes contain hash of a block of data, and the non-leaf nodes contain hash of its child nodes. It is implemented in Blockchain for efficient data verification, for they use hashes instead of full files. Key-value databases are generally used to search the immediate previous transaction to maintain consistency in the network.
Security		Patent applications that relate to techniques implemented to prevent, thwart or mitigate attacks or to address vulnerabilities and exposures (for example, for tampering or corrupting the data) in the Blockchain network will be bucketed under this node. On similar lines, the patents regarding protection of infrastructure, nodes, code, wallets, etc. will come under this node.
Network Arrangements		Patent applications in this cluster relate to a design and/or architecture of a blockchain network. The arrangement may relate to which networked components are configured for communication, operational principles and/or communication protocols.
	Peer-to-Peer Networking	Patent applications that relate to techniques focused on a peer-to-peer (P2P) data distribution system and the nodes involved in a Blockchain network will be bucketed under this node.
	Decentralized Database/Ledger	Patent applications that relate to implementations or manipulations of a distributed or decentralized database in a Blockchain network will be bucketed under this node.
Application Areas		Patent applications related to methodologies and implementations based on Blockchain technology.
	FinTech (Cryptocurrency)	Patent applications that relate to Cryptocurrencies will be bucketed under this node.
	FinTech (Other Aspects)	Patent applications that relate to other aspects of FinTech, specifically related to banking and securing transactions will be bucketed under this node.
	Gaming	Patent applications that relate to implementation of Blockchain technology or the related Cryptocurrencies in a gaming environment will be bucketed under this node.
	Digital Media	Patent applications that relate to processing or authentication of digital content/ digital media through Blockchain technology will be bucketed under this node.
	Supply Chain/ Logistics/E-Commerce	Patent applications that relate to Blockchain for recording information related to particular supply chains, logistics and e-commerce will be bucketed under this node.
	Energy Distribution/Smart Grids	Patent applications that relate to Blockchain in smart grids and energy distribution systems will be bucketed under this node.
	Healthcare	Patent applications that relate to Blockchain in healthcare services, medicines, genomics, etc. will be bucketed under this node.
	Internet of Things	Patent applications that relate to Blockchain for internet of things will be bucketed under this node.

Clean-Green Tech

Level I Clusters	Level II Clusters	Scope/Definition
Clean Energy Harvesting		Clean energy harvesting refers to the process by which clean energy is derived from renewable sources. This covers all forms of renewable and zero emission energy sources.
	Solar Energy	Solar energy is a source of renewable energy obtained from sun which is utilized to produce heat, cause chemical reactions, or generate electricity. Solar energy is a sustainable energy source because it is plentiful & pollution free.
	Wind Energy	Wind energy is a clean, free, highly abundant and readily available renewable energy source. Wind Mills or Wind Turbines are used to convert Wind Energy into useful form to generate electricity.
	Hydro Energy	Hydro energy is the renewable energy obtained from the power of moving water. The kinetic energy produced by the moving water is converted into either mechanical energy to perform some work or directly into electrical energy by means of an electrical generator. This will cover Tidal energy, Wave energy, Run-of-river hydroelectricity, Ocean thermal energy & other techniques providing hydroelectricity.
	Nuclear Energy	Nuclear energy comes from splitting atoms in a reactor to heat water into steam, turn a turbine and generate electricity.
	Geothermal Energy	Geothermal energy is another source of renewable energy which comes from the heat contained inside the earth. Resources of geothermal energy include shallow ground, hot water, hot rock and molten rock - magma. The conversion of geothermal energy into electricity occurs through a geothermal power plant.
	Bioenergy	Biomass or Biofuels come from things that once lived: wood products, dried vegetation, crop residues, aquatic plants and even garbage. The energy trapped in them is converted into biomass energy by burning them. Biomass energy is usually used for heating & cooking due to its low cost & indigenous nature.
	Fuel Cells	A fuel cell undergoes hydrogen combustion to convert chemical energy into electrical energy. The fuel cell will produce electricity as long as fuel (hydrogen) is supplied, never losing its charge. Renewable energy sources, like the sun and wind, can’t produce energy all the time. But they could, for example, produce electric energy and hydrogen, which can be stored until it’s needed. In the future, hydrogen could also join electricity as an important energy carrier.
Energy Efficient Systems		Energy-efficient systems refer to the systems that manage and restrain growth in energy consumption. A system is more energy efficient if it delivers more services for the same energy input, or the same services for less energy input.
	Smart Grids	Smart grid is an electric grid encompassing a collection of technologies such as smart meters, renewable energy and energy-efficient sources that supply electricity to consumers via two-way digital communication. This system allows for monitoring, analysis, control and communication within the supply chain to help improve efficiency, reduce energy consumption and cost, and maximize the transparency and reliability of the energy supply chain. Many government institutions around the world have been encouraging the use of smart grids for their potential to control and deal with global warming, emergency resilience and energy independence scenarios. This will cover power distribution automation, demand management/response management, advanced metering infrastructure (AMI) & smart meters, self repairing technologies and power conservation.

Level I Clusters	Level II Clusters	Scope/Definition
	Smart/Green Homes	Smart homes employ home automation technologies that use resources to create high quality, healthier, convenient, secure and more energy-efficient homes. This encompass efficient use of energy, water & other resources, use of renewable energy sources, enabling of reuse & recycling, use of non-toxic materials, daylight harvesting, green roofs, use of solid state lighting.
	Electric Vehicles	Patent applications related to vehicles that are driven by an electric motor which draws its current either from storage batteries or from overhead cables and emit the usage of fuel would be categorized under this node. This includes battery electric vehicles, hybrid electric vehicles, plug-in hybrid electric vehicles, and fuel-cell electric vehicles. The government of the US is also facilitating the growth of the electric vehicles market by taking several initiatives with regards to construction of electric vehicle charging facilities.
Environment Protection		Environment protection encompasses all the technologies & substantial steps aimed at conserving the natural resources, preserving the current state of natural environment and, where possible, reversing its degradation. Patent applications discussing about preservation of biodiversity, prevention & control of environmental pollution along with emission of carbon dioxide, carbon monoxide, nitrogen oxides, unburned hydrocarbons, volatile organic compounds (vocs) & particulate matter would be categorized under this node.
	Air Pollution	Air pollution means the presence of chemicals or compounds in the air that are usually not present and that lower the quality of the air or cause detrimental changes to the quality of life such as Ozone depletion, Global warming, emission of greenhouse gases. This node covers the patents that talk about preventing & controlling air pollution which encompass carbon capture & sequestration, emissions control etc.
	Soil Pollution	Soil pollution is the contamination of soil with harmful substances that can adversely affect the quality of the soil and the health of environment, living organisms and plants. Patent applications discussing about techniques for prevention & control of soil pollution would be categorized under this node.
	Water Pollution	Water pollution is any change in the physical, chemical or biological properties of water that will have a detrimental consequence on any living organism. Patent applications related to prevention & control of water pollution would fall under this category. This would also include wastewater treatment & disposal.
	Waste Treatment & Recycling	Waste treatment & recycling refers to the processes of treating solid wastes and offers variety of solutions for recycling items that don't belong to trash. Waste treatment and disposal methods are selected and used based on the form, composition, and quantity of waste materials. This includes Landfills, Incineration, Recovery/Recycling, Gasification, Composting, converting waste to energy, Bioremediation etc.
	Sustainable Materials	Sustainable materials refer to the material innovation being employed in the domain of Clean Tech/Green Tech. This include Bio-based Materials, Nano-Materials, Glass Materials, Chemical Materials, Building Materials, Ceramics, Polymers & Biodegradable Materials.

FinTech

Level I Clusters	Scope/Definition
Electronic/Mobile Payments	Digital or mobile payments refer to a range of different instruments used for making financial transactions, not involving use of physical cash/currency. Generally, these type of instruments are used to make financial transactions over online channels or via instruments carrying coded instructions.
Capital Markets & Investing	Capital markets are trading places where long-term debts or equity backed securities are bought and sold. This aspect of FinTech includes wealth management (for corporates) as well as solutions which facilitate investment into various assets, stocks and shares. Integrating technology in this sector of finance creates opportunities such as robo-advisors which use artificial intelligence to recommend assets for investment, match buyer/sellers, etc.
Core Banking System/ Processes	Core Banking is one of the sectors of finance industry most heavily affected by integration of technology. Technology has affected various aspects of banking such as sales & marketing (via artificial intelligence), improved delivery channels (such as mobile apps), enhanced clearing and settlement processes and so on. Even core operations of banking such as reconciliation, account analysis, etc. has also been improved as a result of FinTech evolution.
Lending/Financing & Crowdfunding	Lending refers to the process of money being loaned from an individual(s) or an entity to another individual(s)/entity. Crowdfunding is basically a version of lending where money is raised from a large number of people. Now, with the integration of technology, both these sectors have immensely improved - there have been developments in the platforms being used for lending/crowdfunding, unknown borrowers and lenders can be matched taking factors such as credit score into consideration and so on.
Insurance	Insurance (also referred as Insurtech) is another sector of finance that has been impacted by emergence of FinTech. Various aspects of insurance such as rating, underwriting, policy administration, claims processing, etc. have been immensely improved/automated via integration of technologies.
Personal Finance Management	The cluster relates to technologies that help customers in managing their financial activities. This would cover expense tracking and analytics, financial advisory, etc. A financial advisor is a professional who suggests and renders financial services to clients based on their financial situation. In FinTech, these include the systems that provide suggestions automatically to customers for their wealth management on the basis of various analysis techniques. Expense analytics is another area in which a lot of FinTech start-ups have started showing interest recently.
Financial Security	Security is a vital aspect when it comes to banks/financial institutions. There are three main concepts around which security revolves - maintaining confidentiality, maintaining data integrity and network availability. Data confidentiality refers to preventing access of unauthorized users to confidential data/information. Data integrity refers to maintain the data intact i.e. preventing any kind of data tampering or manipulation. Network availability refers to the aspect of making financial networks available for transactions and at the same time secure from attacks such as DDOS.
Cryptocurrency	A cryptocurrency (or crypto currency) is a digital asset designed to work as a medium of exchange that uses strong cryptography to secure financial transactions, control the creation of additional units, and verify the transfer of assets. Cryptocurrency is a kind of digital currency, virtual currency or alternative currency. Cryptocurrencies use decentralized control as opposed to centralized electronic money and central banking systems. The decentralized control of each cryptocurrency works through distributed ledger technology, typically a blockchain, that serves as a public financial transaction database.

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