



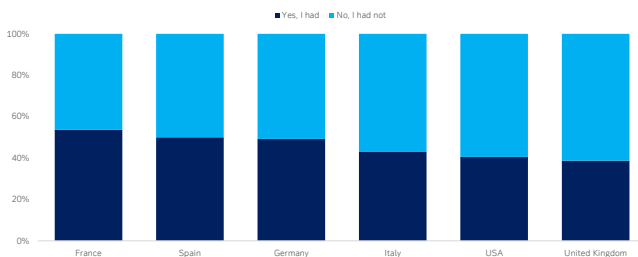
# AI in action: where is the smart money going?

- Artificial intelligence is an overnight success that has been many years in the making. To properly anticipate what AI innovation is to come next, we went back to the source, looking at patents and venture capital deal activity that will translate into the everyday AI applications of the future.
- We collected 175,072 published AI patent entries from 2012 to 2022 across 193 WIPO members, broken down into five broad categories. For venture capital investment, we used the OECD.AI database covering 24,310 deals across 92 economies from 2012 to 2022.
- In absolute terms, venture capital activity and patents in AI have surged since 2012. The number of venture capital deals multiplied over ten times to 3,884 and the value of deals in 2022 was almost 50 times higher than in 2012, at \$83bn. At the same time, the number of AI patents increased seven times to almost 37,000 in 2022.
- More than two thirds of AI innovation over the past decade, as captured by both venture capital deals and patents, has been concentrated in sectoral applications such as transportation, industrial and consumer uses.
- Looking at what’s next, we expect generative audio to arrive by 2024 at scale and disrupt industries like gaming and film production.

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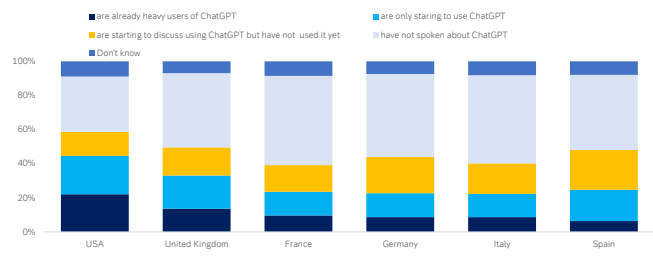
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Figure 1: Before today, had you heard of ChatGPT?



Source : Deutsche Bank, dbDIG.

Figure 2: My current place of employment...



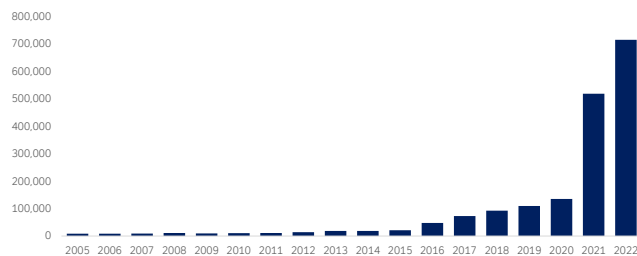
Source : Deutsche Bank, dbDIG.



## AI out of hibernation

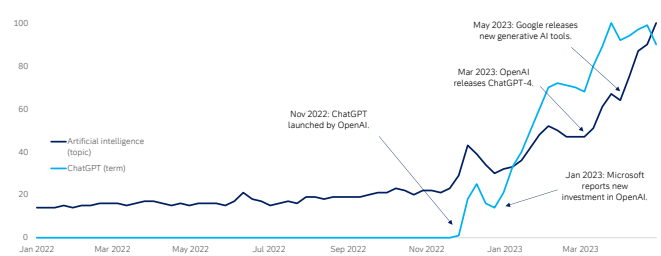
**With the release of OpenAI's ChatGPT in November 2022, interest in AI has exploded, not only for the everyday person, but corporates as well.** The number of mentions of "artificial intelligence" in corporate documents reached over 715,000 in 2022, compared to 135,000 in 2020.<sup>1</sup> And, according to our proprietary survey, 41% of Americans had already heard of ChatGPT by April 2023, whilst nearly 60% said their workplaces have in some form or another started to use ChatGPT.

Figure 3: Number of corporate documents mentioning artificial intelligence\*



Source : Deutsche Bank, AlphaSense. \*Artificial intelligence as defined by the OECD.AI.

Figure 4: Google Trends on artificial intelligence and ChatGPT



Source : Deutsche Bank, Google Trends.

Additionally, in recent news, [ChatGPT is now available on iPhone after launching its first app version on May 18 in the US App Store](#). [Google also announced on May 5 that it would begin rolling out generative AI tools integrated into its Google search product](#). Before going any further, a quick definition – AI is a machine-based system that can, for a given set of objectives typically defined by a human, make predictions, recommendations or even decisions that in turn may influence real or virtual environments.<sup>2</sup>

**These new developments in AI have been brewing for several years.** Venture capital deal activity and published patents related to AI have been quietly surging since 2012. For example, the number of VC deals has grown from 332 in 2012 to 3,884 in 2022. Deal value hit \$83bn in 2022, up from \$1.8bn in 2012. In the same vein, the number of patents published on artificial intelligence has increased seven times since 2012.

**Barriers to entry have been falling, spurring commercial innovation.** For example, the cost to train an image classification system has decreased by 64% since 2018, while training times have improved by 94%. A variety of new startups and VC recipients have also emerged on the scene, including OpenAI, Anthropic, Stability AI, A121 Labs, Midjourney and Cohere. [Anthropic has recently raised a reported \\$450mn in its Series C funding, with participation from Alphabet, Salesforce and Zoom](#). [Builder.ai, an AI company in London, raised a reported \\$250mn in its latest funding round](#).

**To properly anticipate what AI innovation is now arriving and soon to arrive in the metaphorical store front, we looked at patents and VC deal activity in this field.** We estimate that it takes firms receiving VC funding roughly two to three years after the

1 When using the OECD.AI's definition of AI.  
2 As defined by the OECD.



deal to have their product ready for market, or if the product is riding a longer-term trend or requires patent approval, then seven to ten years.<sup>3</sup> In terms of patents, after a firm secures its protection after patent publication, they will need to begin, marketing, selecting commercial partners, acquiring license agreements and product commercialisation.<sup>4</sup> This will roughly take one to three years.

**Using the World Intellectual Property Organisation's (WIPO) Patentscope tool, we collected 175,072 published AI patent entries from 2012 to 2022 across 193 WIPO members**, broken down into five broad categories: (i) sectoral applications; (ii) horizontal platforms; (iii) autonomous machines; (iv) semiconductors; (v) emerging tech.<sup>5</sup> **For VC and investment activity, we used the OECD.AI database covering 24,310 deals across 92 economies.**

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## 1. The AI landscape - bringing ideas to life

### 1.1 On the surface - how has the share market reacted

**Share prices surged for companies that quickly incorporated ChatGPT and other new AI capabilities.** For example, on 31 January 2023, C3.ai, an AI software company, announced its Generative AI Product Suite that integrates AI capabilities such as OpenAI, Google and academic research. On the same day, the share price rose nearly 22%, and prices are now up 143% since the beginning of the year. SoundHound, an AI audio and speech recognition software, has seen shares climb 66% year-to-date. And it is not just AI software companies, as the surge affects companies along the value chain. NVIDIA, a semiconductor company that produces computer chips powerful enough to run AI models, has seen its share price climb 110%. Meta has also strongly outperformed, [having announced it was looking to release a new LLM to researchers in government, civil society and academia on February 24](#) amid the AI race between Big Tech companies.<sup>6</sup> While share prices are surging, [global VC investment into AI](#) fell in Q1 2023, although AI investments in Silicon Valley rebounded.

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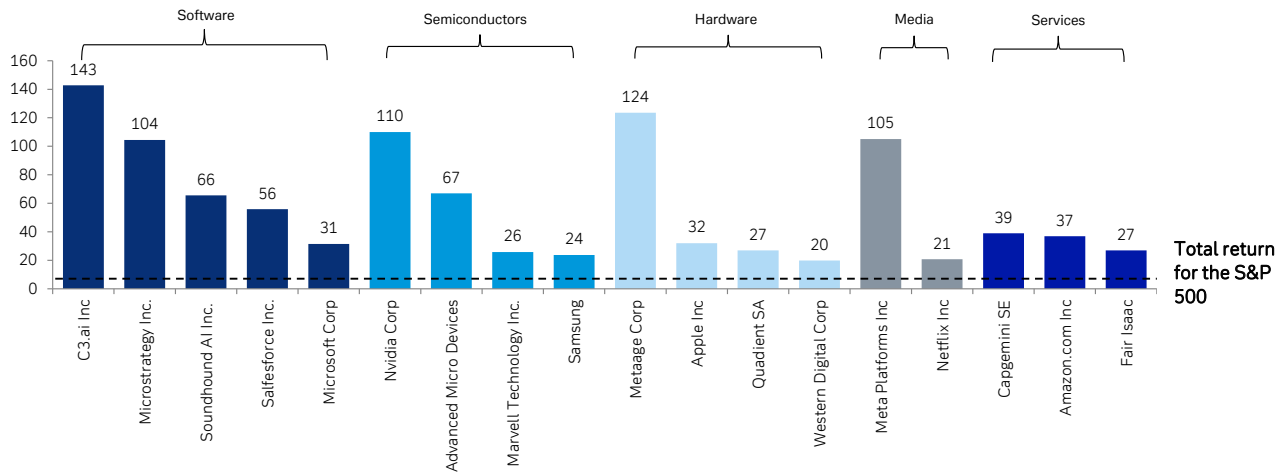
3 [As surveyed by PearVC](#). Approval for VC funding takes two to 20 weeks. However, securing the funding may take up to six months, depending on the industry. VCs typically want to see market size estimates five years after the deal is initially struck, unless the company's product is riding a longer-term trend or requires patent approval, then seven to ten years. This suggests that the recipient firm should generally have their product ready for market roughly two to three years after the deal but can be up to ten depending on the product.

4 According to the US Patent and Trademark Office it takes about 22 months to get approval and publication after filing for a patent. Although there is a one-year grace period to allow for market research after filing an initial application, full products stemming from the patent are typically not shipped at scale due to legal concerns.

5 Our search deliberately excludes the technique of 'machine learning'. Our patents database runs from



Figure 5: Returns\* for AI exposed top performing firms, 2023 YTD

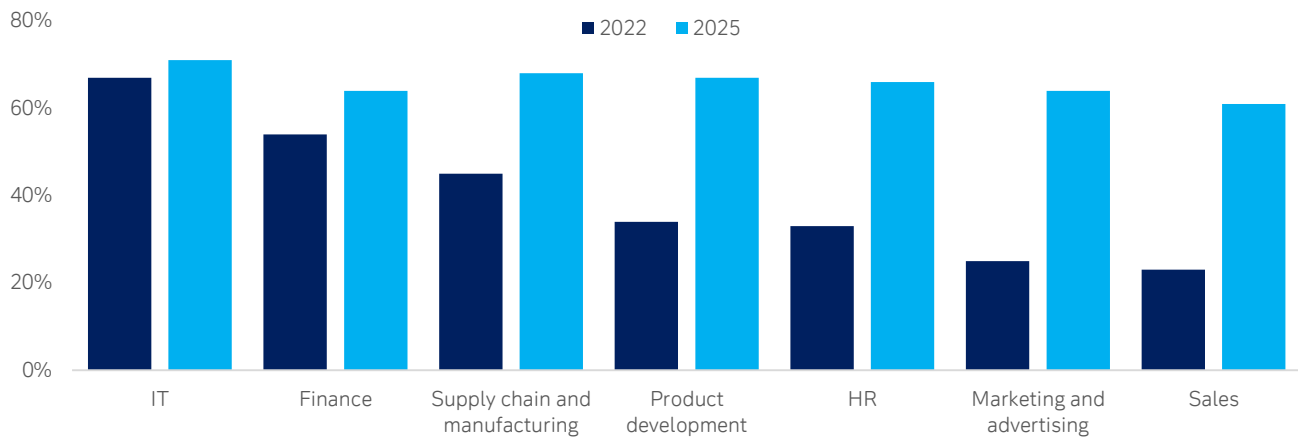


Source : Deutsche Bank, Bloomberg Finance LP. \*Total return accounts for both income (interest or dividends) and capital appreciation. \*Updated 23 May 2023.

### 1.2 But the money has been moving to AI for some time

**Worldwide venture capital investment in AI hit a peak of \$83bn in 2022, up from \$1.8bn in 2012.** Indeed, [Databricks and MIT](#) found most CFOs have begun widespread AI deployments. In their sample, the share of companies not using AI in 2022 was less than 6%.

Figure 6: CIO's current and expected rate of widespread AI usage by core business function



Source : Deutsche Bank, Databricks.

### 1.3 Companies are now set to benefit from the explosion of AI innovation

**Research is now being deployed in the commercial world after many years of being contained to academia.** Academia is the first mover: there is generally a 15-year lag from publication to patent.

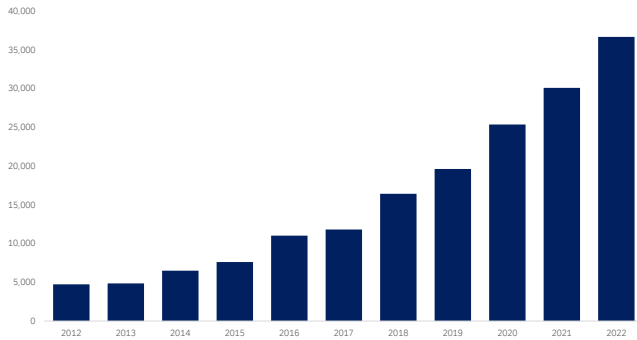
1990 to 2022, but we took from 2012 to harmonise with VC deals.

6 In its latest earnings report, Meta made it clear that it was shifting focus to artificial intelligence, with capital expenditures to build out AI capacity to be in the range of \$30 to \$33bn.



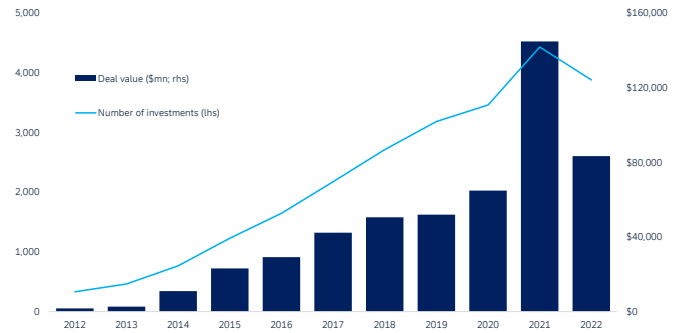
**However, it is becoming increasingly clear that the time is ripe for an explosion of AI innovation.** 49% of the VC deals from 2012 to 2022 were struck in the last three years. Similarly, 52% of AI-related patents in our database have been published in the three years. With the pipeline to market generally two to three years for VC and one to three years for patents, we are poised for the arrival of a wave of AI innovation.

Figure 7: Number of AI-related patents published by year



Source : Deutsche Bank, World Intellectual Property Organization.

Figure 8: Number of deals and deal value of AI-related VC investment



Source : Deutsche Bank, OECD.AI.

## 2. Applications: AI will now become mainstream throughout 2023

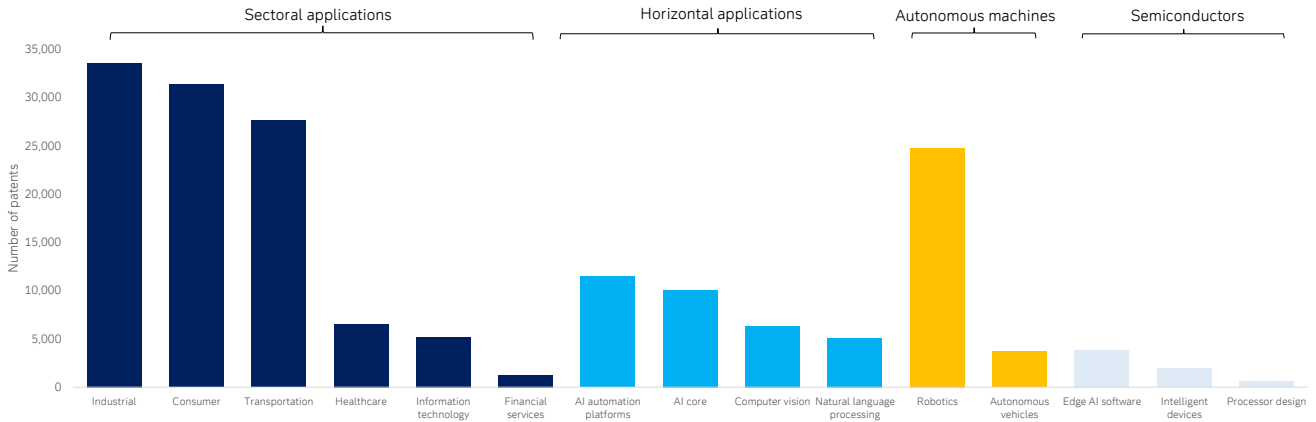
*“We are now solving problems with machine learning and artificial intelligence that were... in the realm of science fiction for the last several decades.”*

Jeff Bezos, Founder and Executive Chairman of Amazon.

Nearly four-fifths of AI-related VC deals made over the past decade have been in sectoral applications. A further 8% occurred in autonomous machines and vehicles, and the remaining 13% in the semiconductor space. The proportion for AI-related patents is similar. Just under two-thirds of patents in our database have been published under the umbrella of sectoral applications. A further 19% of patents were for technology solutions stretching horizontally across sectors, such as developer tools and computer vision; 16% for autonomous machines and vehicles; and the last 4% for semiconductors.

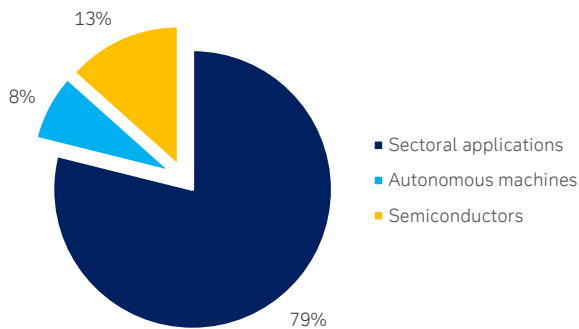


Figure 9: Total number of published patents by category



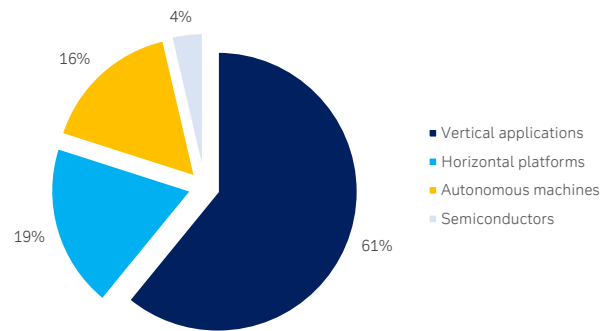
Source : Deutsche Bank, World Intellectual Property Organization.

Figure 10: Number of AI-related VC deals 2012-2022



Source : Deutsche Bank, OECD.AI.

Figure 11: AI-related patents published 2012-2022



Source : Deutsche Bank, World Intellectual Property Organization.

## 2.1 Sectoral applications: AI is not bound to one sector

Right now, 79% of VC deals and 61% of patents are occurring in what we consider ‘sectoral applications’. Under our definition, this includes (i) consumer; (ii) industrial; (iii) information technology; (iv) transportation; (v) healthcare; and (vi) financial services sectors.

From 2012 to 2022, the number of VC deals has increased from 270 to 3,006, more than a tenfold increase. In 2022, the total deal value hit \$62bn, up from \$1.3bn in 2012. And patents published within these sectors has also been booming. The number of patents being published under the sectoral applications umbrella has increased six-fold since 2012. Despite covering a broad range of applications, the companies holding the most patents are well-recognised technology incumbents, the likes of IBM, Samsung, Intel, LG Electronics and Qualcomm.

Allocation of VC investment and patent activity differed across these six sectors. Firstly, VC deals have been concentrated in AI in healthcare, information technology and financial services. The use of AI in healthcare involves improving



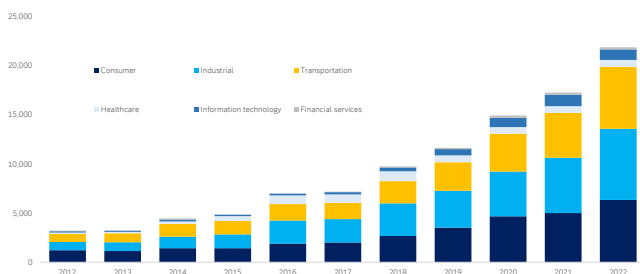
medicine and the provision of care.<sup>7</sup> This is to be leveraged across product categories that include AI-based drug discovery, clinical decision support, genetic analytics, healthcare administration, and personal health. In the EU, the European Commission estimated that smart health -- the use of AI in healthcare --- will have a cumulative impact [equivalent to €105bn by 2030](#).

AI in information technology (IT) includes enterprise software tools that optimise functions typically administered by IT departments.<sup>8</sup> In financial services, AI technologies are embedded into existing financial services via advanced analytics, process automation, robo-advisers and self-learning programs.<sup>9</sup>

**On the other hand, patent activity under the sectoral application umbrella has largely been occurring in the industrials, consumer, and transportation sectors.** The use of AI in the industrials sector typically involve technologies that automate industrial processes and unlock industrial data to find new efficiencies.<sup>10</sup> In the EU, the European Commission estimated that AI used in manufacturing and the industrial internet of things will [have a cumulative impact equivalent to €200bn by 2030](#). Next, consumer AI has affected business from their very business models to their individual product categories such as media, advertising, gaming, education.<sup>11</sup> It also has great relevance to what you see on the consumer side like intelligence price optimisation and e-commerce recommendation engines.

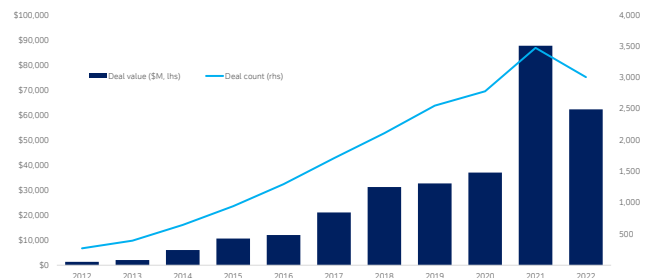
In transportation, AI can assist with logistics like intelligent fleet management.<sup>12</sup> We have already seen such products on the market, such as [WiseTech Global, which uses software automation to improve the efficiency of shipping logistics](#). It acquired Shipamax, which uses AI to convert unclean and unstructured data, such as in PDFs, into machine-readable formats. Automobiles have also employed AI assistance for the everyday driver for several years, such as parking assistance and cruise control.

Figure 12: Number of AI-related patents in sectoral applications



Source : Deutsche Bank, World Intellectual Property Organization.

Figure 13: Number of deals and deal value of AI-related VC investment in sectoral applications



Source : Deutsche Bank, OECD.AI.

## 2.2 Horizontal platforms: the AI toolkit

**We have seen the number of patents in the category of horizontal platforms rise**

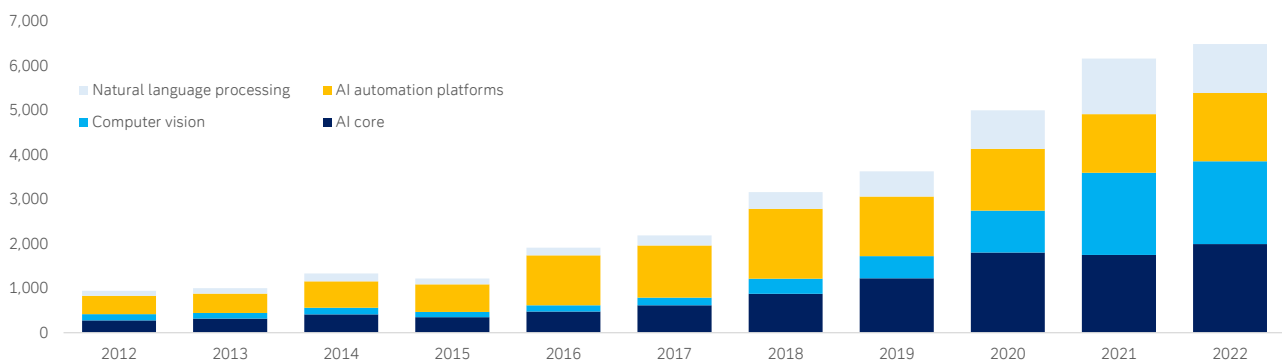
7 Within the sectoral applications category, healthcare makes up 28% of VC deals.  
 8 Within the sectoral applications category, information technology makes up 36% of VC deals.  
 9 Within the sectoral applications category, financial services make up 15% of VC deals.  
 10 Within the sectoral applications category, industrial makes up 32% of patents.  
 11 Within the sectoral applications category, consumer makes up 30% of patents  
 12 Within the sectoral applications category, transportation makes up 26% of patents.



**nearly six-fold since 2012.** <sup>13</sup> Horizontal platforms, representing nearly a fifth of total AI-related patents in our database, includes (i) AI core; (ii) natural language technology; (iii) AI automation platforms; and (iv) computer vision software. Horizontal applications are the building blocks of AI development and deployment, needed to build and deploy AI models. In effect, developments in these fields enhance the AI toolkit for firms across all sectors. Key companies holding patents in this category include AT&T, IBM, LG Electronics, Baidu as well as the technology-sector incumbents.

AI core can be considered the foundations of AI deployments and includes the developer tools needed to build and deploy models to production. AI automation is the software and services that enable firms to leverage AI to automate their critical business processes. This technology is the one that the average employee will more likely interact with day to day, and is focused on low-order, repetitive tasks.

Figure 14: Number of AI-related patents in horizontal applications



Source : Deutsche Bank, World Intellectual Property Organization.

Natural language processing is an AI tool used in the large-language models (LLMs) that have become popular with the advent of ChatGPT. This technique uses computational linguistic techniques to ‘learn’ from communications data, both written and oral, and make predictions about the structure and content of language. Some examples of natural language processing include translation, autocorrect, automatic text summarising, chatbots and, in finance, processes such as requests for information.

Computer vision involves the use of AI to analyse visual data and make meaningful predictions about the physical world and digital images. It is not solely generative but utilises visual data to make inferences upon which it can build. Examples include facial recognition, geospatial analysis and visual data labelling software. Microsoft’s Inner Eye technology has helped detect tumours and abnormal cells. In their latest research, [Microsoft demonstrated how its technology has enabled clinicians to perform radiotherapy planning 13 times faster](#). Two of the five companies with the greatest number of computer vision patents are Chinese: Baidu and Huawei.

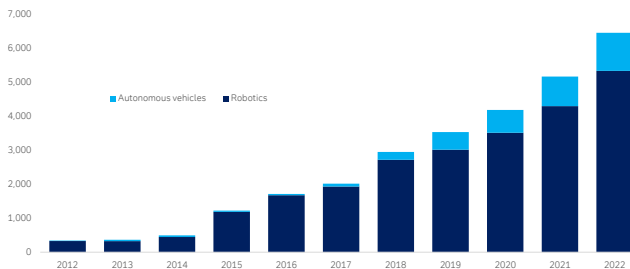
<sup>13</sup> The proportion is similar for VC deal count, but this data is not available for publication.





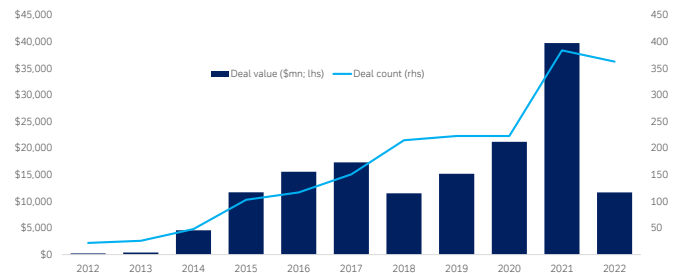
### 2.3 Who even needs a driver's licence anymore? Autonomous machines have arrived

Figure 15: Number of AI-related patents published in autonomous machines



Source : Deutsche Bank, World Intellectual Property Organization.

Figure 16: Number of deals and deal value of AI-related VC investment in autonomous machines



Source : Deutsche Bank, OECD.AI. Note: For VC investment, we took the 'Mobility and autonomous vehicles' as defined by the OECD.AI.

**8% of VC deals and 16% of patents in the last decade have occurred in 'autonomous machines'.** This category of technology covers two key areas: (i) autonomous vehicles; and (ii) intelligent robots. This sector has received a lot of attention over the last decade. Much of this coincided with the success of Tesla, which has been experimenting on autonomous vehicle systems, [creating Autopilot and Self-Driving features that rely on highly advanced cameras and neural net processing](#).<sup>14</sup>

**From 2012 to 2022, the number of VC deals in autonomous machines increased from 22 to 363. In 2022, the total deal value hit \$11.7bn, up from \$0.2bn in 2012. Similarly, the number of patents being published has surged seventeen-fold since 2012.**

Intelligent robotics falls within this category. These are the robots that are able to operate to an extent without the need for human intervention and input. AI is typically used to assist in the training and adaption of robots. It also includes software, such as operating systems for autonomous robots. Companies like Samsung, LG Electronics, Intel, and Chinese companies SZ DJI and Beijing Didi Infinity Tech have a strong foothold with robotics patents. Autonomous vehicles have also been a point of discussion for several years, and it is likely that this steep increase in both VC and patents comes as other companies, aside from Tesla expand their research and investment into the technology necessary for self-driving cars.

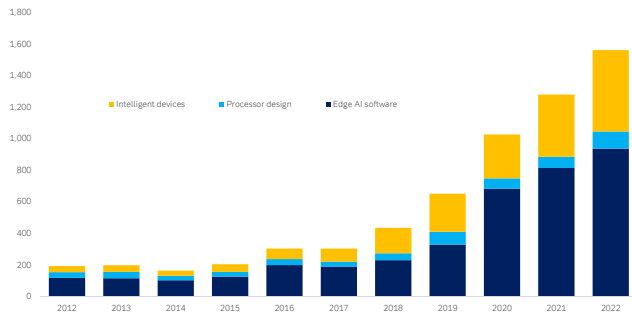
### 2.4 Counting up the semiconductor chips

*"It's very clear that AI is going to impact every industry. I think that every nation needs to make sure that AI is a part of their national strategy. Every country will be impacted."* Jensen Huang, CEO of Nvidia.

<sup>14</sup> [Tesla have postponed their release of self-driving cars several times, with the most recent being from 2022 to 2023.](#)

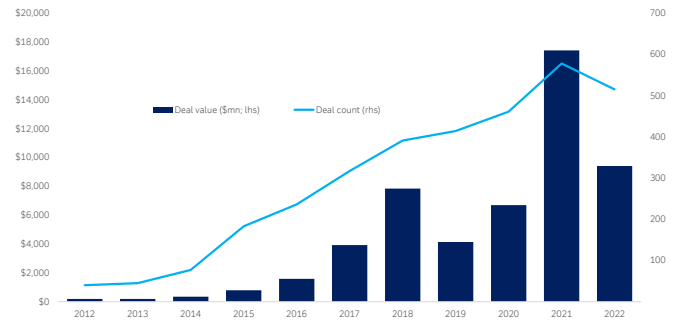


Figure 17: Number of AI-related patents published in semiconductors



Source : Deutsche Bank, World Intellectual Property Organization.

Figure 18: Number of deals and deal value of AI-related VC investment in semiconductors



Source : Deutsche Bank, OECD.AI. Note: For VC investment, we took the 'Robots, sensors and IT hardware category' as defined by the OECD.AI.

**Semiconductors represent 13% of AI-related VC deals and 4% of published patents.** We divided the semiconductors category further into the subcategories of (i) processor design; (ii) edge AI software; and (iii) intelligent sensors & devices.

**From 2012 to 2022, the number of VC deals in semiconductors increased from 40 to 515. In 2022, the total deal value hit \$9.4bn, up from \$0.2bn in 2012. Similarly, the number of patents being published has rose seven-fold from 2012 to 2022.**

As we explain in *US-China on semiconductor chips: 10 slides on an unprecedented situation* ([link](#)), chips have seen rapid innovation since the 1970s, with performance doubling every few years in line with Moore's law. Producers must keep up with the pace of advancement, or will be at risk of being left behind, and as technology becomes more sophisticated, new tools are necessary. This is where AI can come in to play.

The use of AI in the creation of computer chips, otherwise known as processor design, assist in generating efficiency and speed. Innovations in this sub-category have included low-precision calculations to reduce transistor count. As we discussed ([link](#)), much of the upstream design segment of the supply chain is done in the US. In contrast, China dominates assembly, packaging, and testing. It has made little headway in processor design, the higher value-added segment of the supply chain.

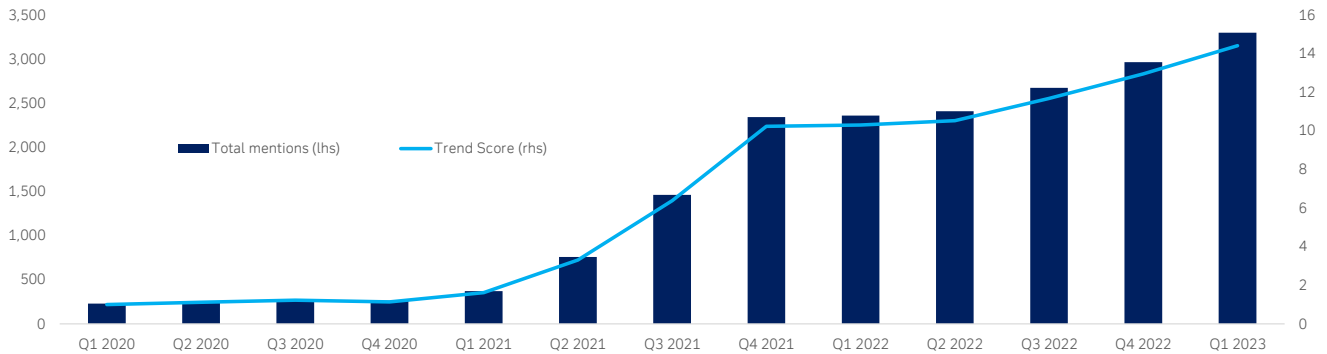
Edge AI technology uses compression algorithms that optimise AI models to be deployed in semiconductor environments and edge devices. A final subcategory in this segment is intelligent sensors & devices. These are the devices we see most often in our day-to-day lives, such as smart thermometers and alarms. They often measure specific parameters in real-world conditions such as environmental conditions, motion, images, and chemical levels.



### 3. Emerging opportunities: 2024 and beyond

#### 3.1 Listen closely - generative audio may be the next big hit

Figure 19: Number of corporate documents mentioning 'generative audio'



Source : Deutsche Bank, AlphaSense.

**Thanks to generative audio, AI is now able to create a human's voice and synthetic audio based on a text input, in different languages, accents and dialects.** It uses the generative AI that became popular with ChatGPT. Some examples of recently published patents include the recreation of the sound quality of an audience location in a performance space, and the dynamic generation and modulation of music based on the reaction of players in a game. From Q1 2020 to Q4 2022, the number of corporate documents mentioning 'generative audio' increased over thirteen-fold.

**We will likely see an explosion of new competitors as music and sound development becomes democratised.** Anyone will soon be able to input text or an image to generate the audio content for their gaming product without needing an audio specialist or a computer scientist. Critically, these new technologies are not resource constrained in the same way that voice actors and musicians are.

This will likely impact a range of sectors like gaming, communications, music, news, and healthcare. Companies holding the greatest number of patents related to generative audio include Sony, Amazon, Huawei, Bytedance, Adobe, Apple and Tencent.

#### 3.2 Going deep on generative audio - what audio is even being generated?

**Generative audio comes in four main categories: (i) synthetic voice; (ii) speech interaction; (iii) music generation; and (iv) audio editing.** Firstly, using deep learning, an AI can synthesise a real human voice, all its pitches, tones and pace, at high quality. [Microsoft can already replicate anyone else's voice from a three-second clip.](#) [Google produces 380 different human voices in over 50 languages and variants through its machine learning technology.](#) In a similar way, speech interaction utilises technology like a virtual assistant, for example Apple's Siri and Amazon's Alexa. As technology develops, it is likely that there will be increasingly 'natural' interactions with AI.

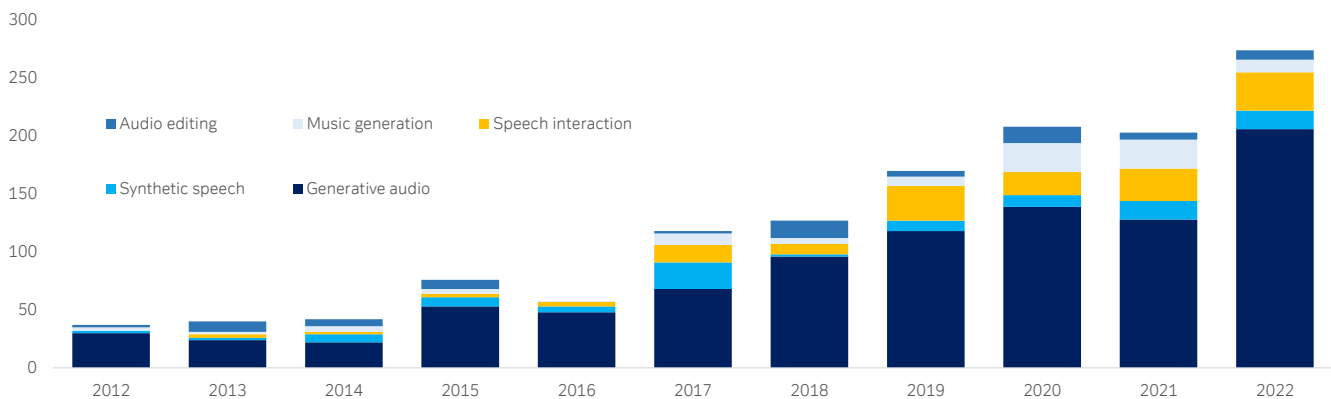
Music generation technology can already create new music of significant variety, whether that be instrumental or rudimentary singing, with ease. Examples include Spotify's DJ and Aimi Studio. AI-generated music has already challenged the music industry. [Spotify reportedly removed 7% of the songs uploaded by AI startup](#)



[Boomy due to suspicions of 'artificial streaming', whereby online bots inflate listens for certain songs](#). In contrast, [Universal Music Group NV announced on May 23 it would partner with AI startup Endel to design AI-generated soundscapes](#), relying on Universals' current catalogue of music, as reported by Bloomberg.

Finally, audio editing uses AI to improve audio recording quality. For example, the use of AI to enhance audio quality during low-quality connection conditions. [Adobe Podcast has already put this technology into practice](#), whereby its Enhance Speech capabilities sharpen voice frequencies to sound as if they were recorded in a podcasting studio.

Figure 20: Number of AI-related patents published in generative audio



Source : Deutsche Bank, World Intellectual Property Organization.

## The machine thinking method is here

*"Once the machine thinking method had started, it would not take long to outstrip our feeble powers. At some stage therefore we should have to expect the machines to take control."* Alan Turing 1951, founding father of modern artificial intelligence.

**AI is here, and new innovation is on our doorsteps. Innovation in artificial intelligence, measured by the leading indicators of patents and venture capital investment, has exploded over the past decade.** The number of VC deals, which usually have a two to three-year lead time to production, rose more than tenfold to 3,884 in 2022, reaching a cumulative 24,310 over the decade. The value of those deals soared from almost \$1.8bn in 2012 to \$83bn in 2022. Published patents, which tend to roughly have a one to three years lead-time to production, grew seven-fold, from 4,316 in 2012 to 32,800 in 2022. More than two thirds of AI innovation over the past decade, as captured by both VC activity and patents, has been concentrated in sectoral applications such as transportation, industrial and consumer uses. This is followed by horizontal applications, autonomous machines, and then semiconductors.

**Beyond 2023, we anticipate an upswell in generative audio innovation.** We have already seen generative text and images catch the attention of the world with the arrival of ChatGPT and DALL-E. Together, these technologies will transform industries like gaming and film production.

**However, there must be a careful consideration of the potential challenges.** The incredible amount of computational power needed to train a LLM may see market



share concentrated in the hands of a few large technology players. The computational capabilities required to train modern machine learning systems has multiplied hundreds of thousands of times despite algorithmic and software improvements. It can cost \$100mn in energy to train nodes on the scale of OpenAI's LLMs. The cost barriers will prevent all but the likes of Microsoft, Google and Facebook from creating the most significant LLMs. Consequently, inaccurate data and a lack of transparency may cascade across companies that use the APIs.

**Most countries have yet to impose significant regulation on AI, exposing firms to regulatory risk.** The work is underway in some, like the EU, which has been working on harmonised rules since 2021. Final approval for the AI Act is expected by the end of the year or early 2024. Some countries have already reacted to the launch of ChatGPT, [with Italy banning it in April, citing privacy concerns](#). In the US, regulation has not yet been drafted, but [the Biden administration has begun seeking public comments on accountability measures](#).<sup>15</sup> Key technology industry leaders, including Elon Musk and Steve Wozniak, [signed an open letter with the Future of Life Institute](#) calling for a pause in the development of AI more powerful than ChatGPT to ensure AI innovation is ethical.

**As we become increasingly reliant on digital systems, we must keep up with the development of hacker technology.** There are two main types of AI attack: (i) an input attack, which manipulates what is fed into the AI; and (ii) poisoning attacks, which involves corrupting the process through which the AI is created. In the same vein, cyberattacks will likely increasingly involve the use of AI, overwhelming existing system capacity. [81% of respondents to the WEF's survey on cybersecurity](#) stated that "staying ahead of attackers is a constant battle and the cost unsustainable," up from 69% in 2020. As mentioned above, technologies already exist, such as Microsoft's, that can replicate anyone's voice very effectively just from a 3 second clip, increasing the risk of identity theft and fraud. With these concerns mounting, [US President Biden met key stakeholders in the development of AI on May 4](#). \$140mn was set aside for a new National AI Research Institute to advance AI R&D in cybersecurity.<sup>16</sup>

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15 In the near-term, there will likely be growing concern of the peculiar legality surrounding AIs inventing by themselves. [This year, the US supreme court ruled that only "natural persons" and not an artificial intelligence system, can be awarded patents](#). Yet as AI becomes increasingly sophisticated, there is a possibility no single person can claim to have 'complete conception'.

16 As well as climate, agriculture, energy, public health and education.



## Appendix

Figure 21: Definition of sectoral applications

| Sectoral applications  | Definitions   | Number of Published Patents (Change from 2012 to 2022) | VC Deal Value (\$mns, 2012-2022) | VC Deal Count |
|------------------------|---|--|----------------------------------|---------------|
| Financial services     | The embedding of AI technologies into existing financial services such as the use of advanced analytics, process automation and robo-advisors.  | 1272<br>(231%)   | 304,278                          | 19,178        |
| Healthcare             | Includes technologies that leverage AI to improve medicine and health care provision. Product categories range from AI-based drug discovery, clinical decision support, genetic analytics, healthcare administration, and personal health.  | 6532<br>(386%)   |                                  |               |
| Consumer               | Technologies that enhance business-to-consumer models that range from media & entertainment, advertising technology, gaming, e-commerce recommendation engines, education technology and intelligent price optimisation.  | 31355<br>(419%)  |                                  |               |
| Industrial             | The use of AI to automate industrial processes and utilise industrial data to find new efficiencies such as crop maximisation, energy grid automation, geospatial analysis, heavy industry automation, and supply chain optimisation.   | 33570<br>(755%)  |                                  |               |
| Information technology | AI used to optimize specific functions typically administered by IT departments, both back-end and front-end use cases. Product categories include human resource automation, IT infrastructure management, legal automation, property technology and software development tools. | 5185<br>(702%)   |                                  |               |
| Transportation         | This can include the management of an intelligent fleet as well as driver assistance. The category does exclude autonomous vehicles.  | 27620<br>(682%)  |                                  |               |

Source : Deutsche Bank, World Intellectual Property Organization, OCED.AI.

Figure 22: Definition of horizontal applications

| Horizontal applications     | Definitions  | Number of Published Patents (Change from 2012 to 2022) | VC Deal Value (\$mns, 2012-2022) | VC Deal Count |
|-----------------------------|--|--|----------------------------------|---------------|
| AI core                     | The building blocks for the deployment of AI, and it includes the developer tools that are needed to build and deploy AI models to end production.   | 10076<br>(622%)  | NA                               | NA            |
| Computer vision             | Use of visual data to make meaningful predictions about both the physical world and digital images, and can include AI-enabled augmented reality, facial recognition, geospatial analysis, and visual data labeling software.      | 6340<br>(1237%)  |                                  |               |
| Natural language processing | This involves the use of computational linguistic techniques to learn from written data and make predictions about the structure and content of language, such as conversational AI like chatbots and natural language generation. | 5100<br>(862%)   |                                  |               |
| AI automation platforms     | Software and services that enable enterprises across all verticals to leverage AI to automate critical business processes via predictive analytics.  | 11486<br>(273%)  |                                  |               |

Source : Deutsche Bank, World Intellectual Property Organization, OCED.AI.

Figure 23: Definition of autonomous machines

| Autonomous machines | Definition   | Number of Published Patents (Change from 2012 to 2022) | VC Deal Value (\$mns, 2012-2022) | VC Deal Count |
|---------------------|--|--|----------------------------------|---------------|
| Autonomous vehicle  | This includes the software and hardware to enable self-driving or driver assistance capabilities.  | 3670<br>(1531%)  | 149,254                          | 1,875         |
| Robotics            | Robotic systems and uncrewed aerial vehicles that can operate without human input. AI can be used for the learning, control, and adaptation of robots. | 24762<br>(7367%)                                       |                                  |               |

Source : Deutsche Bank, World Intellectual Property Organization, OCED.AI.

Figure 24: Definition of semiconductor applications

| Semiconductors      | Definition  | Number of Published Patents (Change from 2012 to 2022) | VC Deal Value (\$mns, 2012-2022) | VC Deal Count |
|---------------------|---|--|----------------------------------|---------------|
| Intelligent devices | This covers: (i) Devices that measure specific parameters in real-world conditions (ii) Sensor systems (Assemblages of sensors and chipsets that empower specific IoT use cases such as smart buildings, industrial IoT, and connected vehicles). | 1901<br>(1221%)  | 52,531                           | 3,257         |
| Processor design    | Design of chips that attain high efficiency and speed for AI-specific calculations such as through parallel calculations and low-precision calculations to reduce transistor count.   | 574<br>(203%)  |                                  |               |
| Edge AI software    | Compression algorithms that optimise AI models for deployment within various semiconductor environments and edge devices.   | 3843<br>(693%)   |                                  |               |

Source : Deutsche Bank, World Intellectual Property Organization, OCED.AI.



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