March/April 2018 iam
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Intellectual property and artificial intelligence: what does the future hold?

Artificial intelligence is creating a seismic shift in the way that people interact with technology. Research institutions and for-profit companies are moving to patent the commercial aspects of this new area in a land grab which could see rights holders reap future benefits

By Peter Cowan and Jim Hinton

Artificial intelligence (AI) has established itself as one of the next digital frontiers of innovation. Five years ago it supported only a $250 million market opportunity. However, with a compound annual growth rate (CAGR) of more than 50% since then, the market is now projected to reach between $35 and $50 billion by 2025. This growth has been attributed to value and adoption across many sectors, including healthcare, automotive, retail, education, industrial manufacturing, telecommunications, media and advertising, finance and security. McKinsey & Company's Global Institute notes that there is already a widening gap between the market successes of early adopters and industry laggards. The latter need to access the right data ecosystems and work aggressively to match this new technology to a business case.

This steep rise in technology adoption is creating patent filings that parallel the communications and internet boom of around 2000. Based on patent insights, one can create an IP strategy framework for AI adopters and market leaders to consider. This is vital for academic and corporate players looking to develop and take the lead in this growing global market, as well as for government funding programmes designed to support national research initiatives.

IP trends in AI

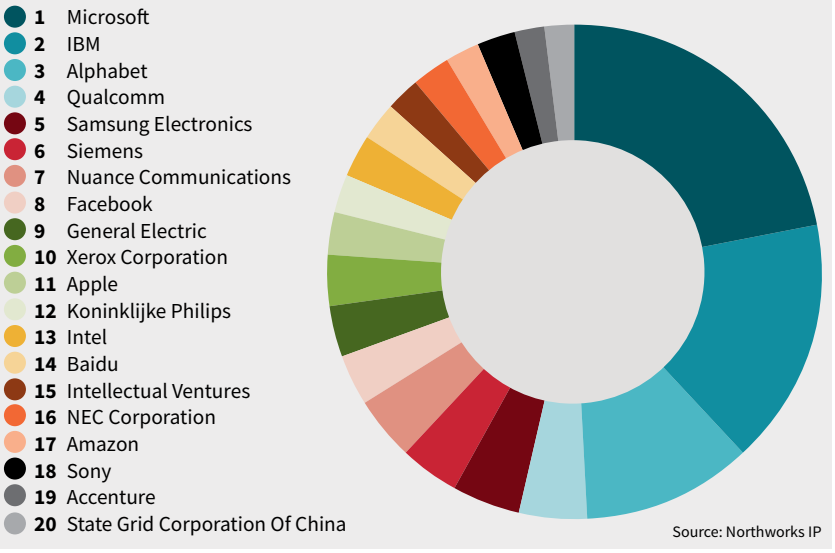
A patent landscape analysis in the AI space reveals that patent trends are mirroring investment and research trends, with high growth for the key research groups and ventures that are starting to emerge as technology leaders.

Looking at patent filings for the past 15 years, a list of the top assignees indicates where a significant volume of market-relevant R&D is being conducted. The majority of high-volume assignees are based in the United States (Microsoft, Alphabet, IBM, Facebook, Yahoo, Intel, Amazon, Apple and Qualcomm), followed by Japan (Sony, Fujifilm, NEC and Xerox), the European Union (Siemens and Philips) and finally Korea (Samsung). The taxonomy of AI technologies demonstrates a steady filing focus on natural language (speech and text processing and machine translation) and machine learning (predictive analytics, and supervised and unsupervised learning). Patents and research into neural networks (artificial, back propagation and convolutional networks, training samples and creation of tagging of datasets) has continued to grow at a consistent pace, although at a higher recent pace than other taxonomy groups.

A deeper dive into the data provides taxonomy insights by venture, indicating where AI-focused research is being developed. For example a large proportion of patents filed by IBM, Microsoft, Facebook and Apple (between 20% and 30%) reference natural language queries, whereas Siemens and General Electric remain more focused on the machine-learning aspects of AI. Across all groups, an AI landscape view illustrates that predictive analytics and neural processing is embedded in numerous patents across several different International Patent Cooperation categories. Specific market segments dealing with the control of industrial equipment related to energy (forecasting power distribution, wind power or engine loading) and image recognition implementation have also gathered pace when seen through market-specific AI patent coverage.

Jurisdictional trends based on annual growth also vary by country, with filings in China and the United States providing interesting insights for both ventures and governments. While US patent grants and filings have been rising consistently in past years with a CAGR of between 15% and 20% since 2010, there was a dramatic drop of grants in 2014 (likely attributed to the 2014 US Supreme Court *Alice* decision). Filings in China may have begun slowly but since 2010 they have exploded, with a CAGR in excess of 50%, surpassing US filings in 2013. This pace by Chinese filers means that by 2016 there were three times as many filings related to AI in China as there were in the United States. In comparison, filings in other jurisdictions (eg, Europe, South Korea and Japan) do not even measure up, making patent protection essentially a two-country race. This may leave China as the leading choice for future AI investments from a purely strategic view: it has the combination of patent filings for protection, R&D expertise and talent, manufacturing capabilities and large market size. Such a situation creates an opportunity for other ventures – provided that strong IP filings in all jurisdictions increase – as it will ensure that high-volume R&D investments coming out of China can still be subject to rents by R&D firms as the technology expands internationally – presuming that there is overlap from an infringement point of view. However, with weakening software patent protection in the United States, an increased focus on software in China and almost no filings by

FIGURE 1. Top assignees by patent volume



Source: Northworks IP

volume relative to China or the United States in other jurisdictions by ventures involved in AI, Chinese firms and research organisations are still set to become the *de facto* hub of both technology development and future licence income recipients. Governments and ventures must act swiftly to increase funding for patent generation and consider robust patent protection policies.

While patent growth provides data trends at a high level, analysing the detailed patent data results in intelligence that both companies and investors can utilise on two fronts:

- Where is AI-based intellectual property coming from?
- How is the AI-based IP ecosystem developing?

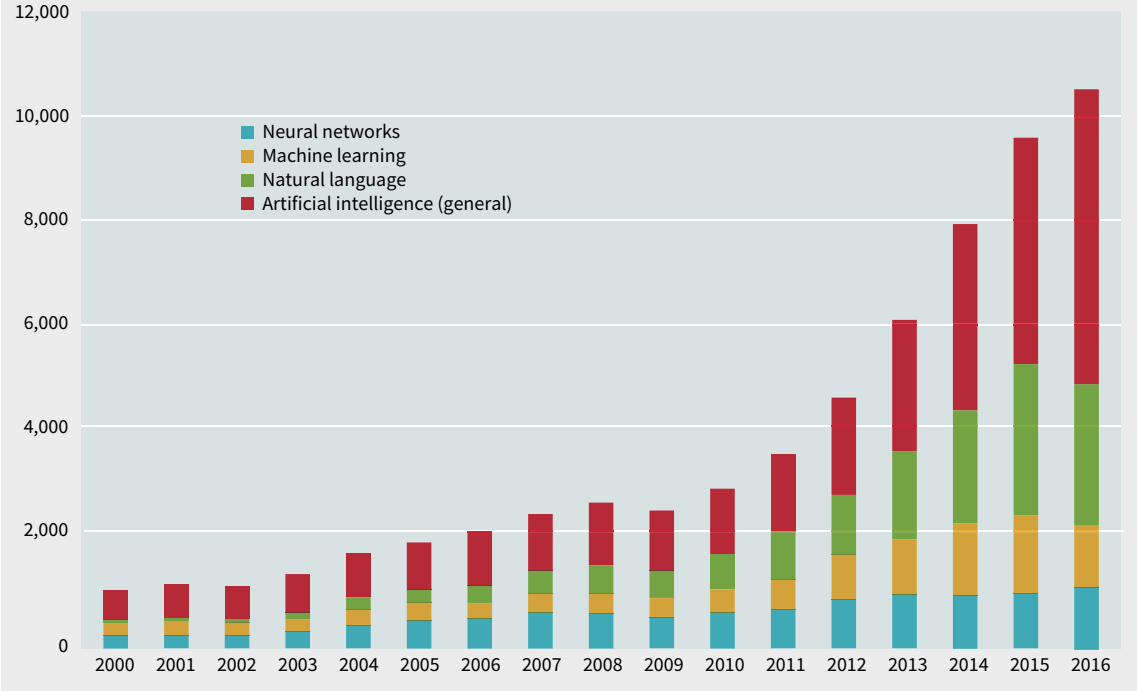
With these insights, companies and investors of all sizes can better focus their IP-based programmes to leverage AI opportunities.

Starting with research institutions, it is evident that China is investing heavily in AI-based research. China accounts for 15 of the top 20 research institutions filing AI patents, while the United States accounts for the other five. This insight bears out the alarm sounded by Eric Schmidt of Alphabet in late 2017 at a technical summit, organised by a national security think tank. Schmidt predicted that China would overtake the United States in AI research by 2025. Layering the patent statistics on top of Schmidt's prediction, it is clear that the Chinese will have not only technology leadership but also patent leadership.

Moving past research into inventor-based data, a second view emerges. Machine-learning patents see top inventor counts (by patent volume) coming from Microsoft, Siemens, Cisco, Xidian University, Qualcomm, IBM, Ricoh Innovations and Intellectual Ventures. This aligns with information published by each organisation on how AI is an important component of their ventures or that they each have a dedicated research team focused on this area. A broader view of AI sees top inventors add in patents from Fotonation Limited and additional research universities from China (ie, Southeast University and Xidian University). Intellectual Ventures may even be expanding machine-learning work beyond traditional licensing, as it has partnered with several firms and research groups in the healthcare sector to develop tools such as an AI-powered microscope, which could be used to accelerate the diagnosis of malaria.

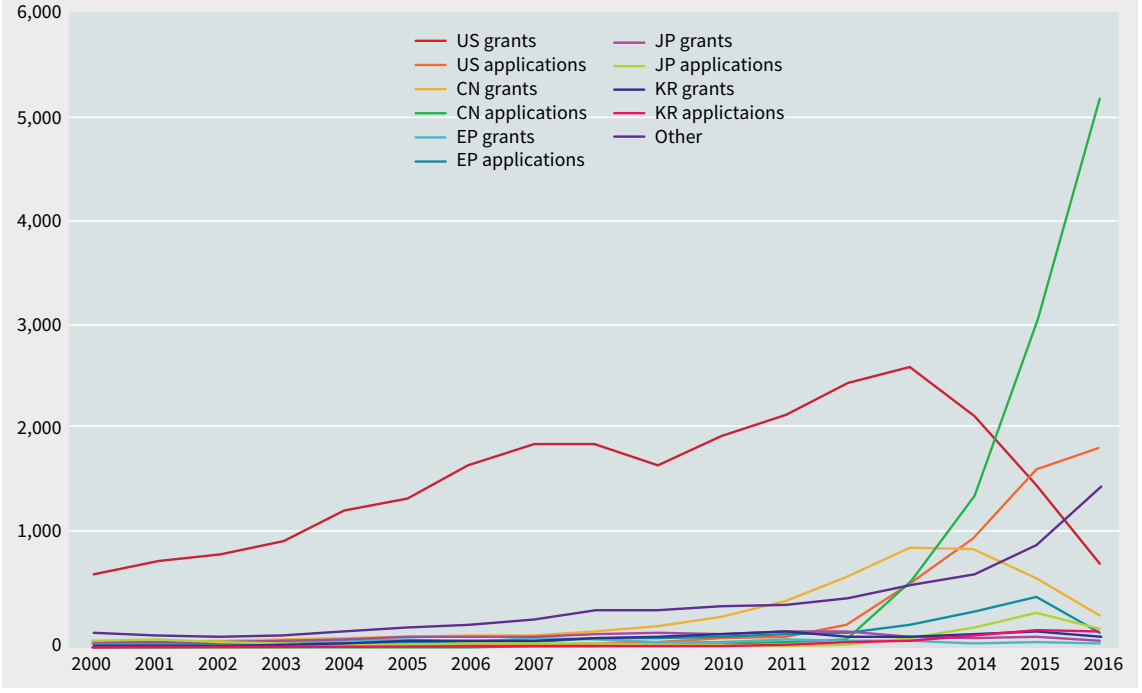
Overall, the top 20 inventors in the field collectively contribute over 2,500 active patents, providing core

FIGURE 2. Patent filings by taxonomy



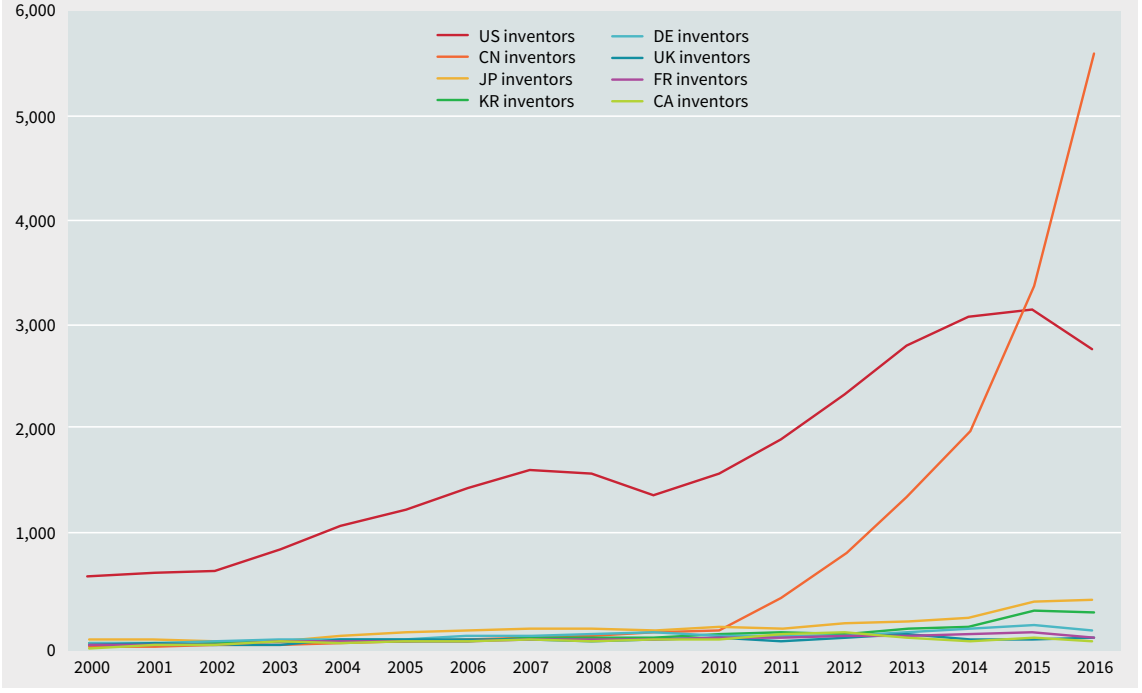
Source: Northworks IP

FIGURE 3. AI global filing trends



Source: Northworks IP

FIGURE 4. AI-related patent volume by inventor nationality



Source: Northworks IP

research around machine-learning techniques and models, mobile device behaviours and user interfaces, medical imaging, natural language and predictive models. This shows a pattern of top-heavy patent generation, indicating that those that have captured value continue to do so to the detriment of new market entrants. Instead, new players must work doubly hard to realise the same value as those leading innovators. Investors and government funding initiatives need not only realise this asymmetry but also ensure that any investments made in AI include a comprehensive IP strategy.

Filtering this insight by the inventor's country provides yet another key view into where research is being conducted and which ventures are reaping the R&D benefits. In the United States, inventors at Microsoft, Alphabet, IBM, Facebook, Qualcomm,

TABLE 1. Top 20 university assignees for AI-related technologies

Beihang University
Beijing University of Technology
Columbia University
Hohai University
Huazhong University of Science and Technology
Jiangsu University
Johns Hopkins University
Nanjing University of Posts and Telecommunications
Peking University
Shanghai Jiaotong University
South China University of Technology
Southeast University
Stanford University
State University System of Florida
Tianjin University
Tsinghua University
University of California
University of Electronic Science and Technology of China
Xidian University
Zhejiang University

Source: Northworks IP

TABLE 2. Inventor nationality and assignee focus

CN inventor patents
Eight universities combined
Baidu
State Grid Corporation of China
Microsoft
Zhejiang University

SK (South Korea) inventor patents
Samsung Electronics
Four institutions / universities combined
Chemessen Inc
Hyundai Motor Company
LG Chem Ltd

JP inventor patents
Fanuc
Sony
FUJIFILM Holdings
NEC Corporation
Canon

UK inventor patents
Microsoft
Alphabet
BT Group
IBM
BAE Systems

US inventor patents
Microsoft
Alphabet
IBM
Qualcomm
General Electric

DE inventor patents
Siemens
SAP
Robert Bosch
Fraunhofer
Porsche

FR inventor patents
Xerox
CEA
Airbus
Sanfran
Cisco

CA inventor patents
Blackberry / QNX
IBM
Google
Primal Fusion
Microsoft

Patent scale:	0	30	40	45	75	125	185	250	350	700	1,500	2,750

Source: Northworks IP

Yahoo! and Amazon are leading the way. The position is the same in several other countries, where almost all inventors have assigned patents owned by national firms: in Japan, the market is headed by Fanuc, Fujifilm, Sony, NEC and Canon, while in Germany Siemens and Bosch rule, and in South Korea Samsung and various research institutions take the lead. Baidu might not be in the top 20 patent owners by volume in China but it is generating the most AI IP-based inventions, followed by Microsoft, Alibaba and several Chinese universities. Chinese-based innovators are a mix of multinationals, local firms and Chinese-based research groups. Interestingly, eight Chinese-based universities have over 1,300 active patent assets, which makes them collectively a top five global patent asset holder.

Research coming out of the United Kingdom, Canada and France tells a different story, with few local companies generating any substantial volume of AI patents. Almost all patented AI R&D invented in these countries is outsourced or owned by global firms such as IBM, Alphabet, Dell, Xerox, Cisco or Microsoft. This provides an interesting paradox, at least for Canada: the country is investing heavily in AI-based research, well over $250 million (a sizeable sum for Canada) in 2017 alone in government-based AI research grants and projects, yet there is little or no patented protection for this work held by Canadian firms which means that the resulting economic benefit is leaking out of the country. Until policy makers in Canada, the United Kingdom and France move to stop this IP leakage, strong international players will continue to exploit these wealthy foreign governments to help them fund their research and drive their bottom line.

This analysis clearly shows that the patent landscape – as a proxy for the AI IP ecosystem – is fragmented in terms of patent owners, geographies protected, key research institutions and how firms are investing R&D resources. As market opportunities emerge, leaders with a strong cache of AI-based patents will become necessary licensors for future new entrants.

It is clear that both US and China-based ventures and research universities are using the so-called 'own the field' concept when it comes to AI patents. To be a true leader in the commercialisation of AI, other companies and countries will need to own or be prepared to license a significant volume of patents in the AI space.

Beyond patents: data

Given this patent landscape, what do companies and countries involved with AI do? First, an AI IP strategy should not be considered in a vacuum. A fundamental component of implementing AI is data. As oil is to an engine, so is data the fuel of AI technologies. Like oil, data is often found in a crude and unrefined state coming from a number of sources (eg, existing public health records, user data and environmental parameters). This crude data cannot simply be input; it must be refined and curated before it can be fed into an AI system.

Why is data so fundamental in the IP conversation? According to the McKinsey Global Institute 2017 discussion paper "Artificial Intelligence. The Next Digital Frontier?" there is a direct link between AI's successful deployment and the dependent source of unique data. Successful AI programmes require the right data ecosystem, along with seamless data access. The top AI patent owners may have created their own data to help

successfully enable their technology in the market, yet there are likely more quality data owners who hold no formal patents than those that do. This provides a unique opportunity for data creators, curators and owners to engage successfully in the AI space without initially holding or filing any patents. It provides an exciting new opportunity for government institutions – which might be the creators of such large datasets – to participate in the AI ecosystem, an opportunity that did not exist in the previous communications and IP internet boom.

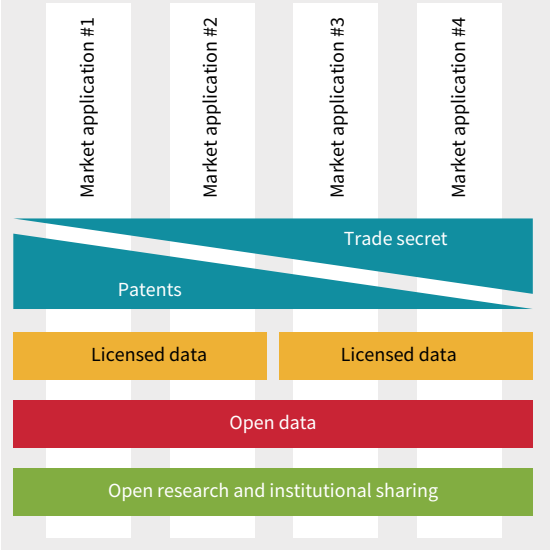
Capturing economic benefit from AI innovation assets requires a mix of patents and trade secrets. Companies extract value from refined data by preventing or limiting access to it and making it available to be monetised and leveraged. However, relying on technology protection alone is insufficient, as aspects of the data may be compromised or reverse-engineered, thus eroding the data's value. As the figures illustrate, ventures are generating patents for the refinement and use of strategically important data in specific market applications, such as voice analysis, vision automation, and intelligent and automated information processing.

From a long-term strategy view, data is key. Although US and Chinese ventures are leading in terms of patent ownership, all AI ventures will need access to quality data. This positions data access and control as one of the levelling fields for the have nots of ventures and companies coming late to AI patent protection.

However, few patent assets deal with the creation of data required for the markets, only the curation and manipulation of data. As mentioned earlier, the top 20 inventors in the space account for over 2,500 patents and of those patents a high proportion reference manipulation of data for a market application or learning process.

While open data is a viable strategy to drive adoption, the ways in which the data will be utilised need to be contemplated. In particular, government and research institutions often hold a swath of public data, and make it available to advance the public good. Government-held data can be considered a national innovation asset, which can be leveraged to drive economic growth for the country. Countries that have large volumes of unique data but are not patent holders must be shrewd when it comes to open data or licensed data initiatives; otherwise they may be out-manoeuvred by stronger players and cede potential economic returns to existing foreign patent holders. Ultimately, without a sophisticated strategy, an open-source strategy may result in limited future potential for the original data owner.

FIGURE 5. Building an AI or data-driven IP strategy



"This analysis clearly shows that the patent landscape is fragmented in terms of patent owners, geographies protected, key research institutions and how firms are investing R&D resources"

A shrewd strategy will capture downstream economic growth from the use of the data via strategic patenting and data-access terms. For example, open source providers should consider generating their own patent protection or requiring technology users to provide licences to downstream patents for the use of their data. Otherwise, those that develop technology and capture intellectual property from it may lock them out from the economic benefit derived from their own data. Thus, for a venture that is using the data, it may be open to take but not free to build AI systems in specific verticals.

Strategies for governments, research institutions and new businesses

The AI-based patent filings indicate a relatively high volume by proportion of both US and Chinese-based research institutions. This national influence on the future of AI IP positions cannot be understated: national research firms and government entities may have lower volumes of patent filings but they still have the ability to influence the ultimate ownership of a strong IP position. Not only do they own the research being generated, but they have access to valuable and unique datasets coming out of this research. In other words, the new crude oil is being generated by nationally funded researchers in parallel with well-known venture entities.

With this in mind one should consider a strategy that takes into account the data, the type of intellectual property (ie, patent, trade secret or open source) and also the market application (eg, healthcare, automotive, speech, vision, security and financial technology). This is critical because different market applications may require a different mix and will be specific to a venture's ultimate goals for the market.

For research institutions generating data and AI research, there should be a deliberate mix of open source and patents. Open source may be free to use but it is not necessarily free to build on for key research segments identified by the institution – these may prove valuable for spin-offs and national interests.

The strategy for new entrants to the space will differ from established players. New ventures must prepare for freedom to operate challenges. In particular, they should try to generate patents over new commercial aspects of AI that the holders of the fundamental intellectual property will ultimately have to license for strategic leverage and

Action plan

AI innovation assets include intellectual property and data as AI technology moves from fundamental machine-learning algorithms to commercial applications. Now that some of the fundamental questions have been addressed there is a land grab for the new commercial use of AI and the patents that go with it:

- Much of the foundational intellectual property is already taken and has 10 to 15 years remaining.
- To protect for the future, innovators need to ensure that a data strategy is built into their IP strategy.
- For research institutes, mix open source with patents to capture economic benefit for key research segments. Consider data sharing and transfer strategies in order to ensure ownership or access to future AI intellectual property, as required.
- For companies, generate patents in new commercial aspects of AI that the holders of foundational intellectual property will ultimately want to have or to license. Consider partnerships with key research universities in the United States and China, which are moving to ensure protection for work generated.
- For governments, increase freedom to operate via sector-focused patent collectives or IP assistance via sovereign based IP funds, or else attach strong IP strategy requirements to AI innovation funding initiatives.

cross-licensing opportunities. New ventures can also reduce their exposure via patent clearing and licensing mechanisms (eg, the License on Transfer Network).

Countries that are not leaders in AI ownership (eg, Canada, France and the United Kingdom) need well-crafted and cohesive strategies that consider the country's position in the international landscape. Countries with weak AI ownership should resist IP leakage and work collaboratively to provide mechanisms such as patent collectives to increase freedom to operate, or provide sector-focused sovereign patent funds as either standalone investments or those attached to key innovation funding initiatives. In either case, any investment in AI should be carried out with a thorough understanding of the IP ecosystem that has become well established in the United States and even more so in China. iam

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