



Lenovo

# The Intelligent Transformation Index

Benchmarking global business adoption of big data, artificial intelligence and the internet of things

January 2023

Written by

**ECONOMIST  
IMPACT**

# Table of contents

<b>About this report</b> .....	3
<b>Executive summary</b> .....	4
<b>Section 1: Introduction</b> .....	6
<b>Section 2: The Intelligent Transformation Index</b> .....	8
Introducing the Intelligent Transformation Index .....	9
Intelligent transformation: the industry perspective .....	13
Technology diffusion and intelligent transformation .....	16
A novel survey of China's intelligent transformation .....	21
<b>Section 3: From digital transformation to intelligent transformation</b> .....	22
A framework for assessing digital transformation .....	23
Foundations of digital intelligence adoption .....	24
Benchmarking countries .....	27
Benchmarking China in digital transformation.....	29
China's digital intelligence divide .....	31
<b>Section 4: Where next for intelligent transformation?</b> .....	35
Intelligence as a service? .....	36
Going codeless .....	38
<b>Methodology</b> .....	42
Full indicator tables and data sources .....	42
Intelligent Transformation Index imputed data methodology .....	44
China survey methodology .....	46
Industry scope and definitions .....	47
<b>References</b> .....	49

# About this report

The Intelligent Transformation Index is a research programme from Economist Impact. An Economist Impact research team including Alexander van Kemenade, Michael Frank, Shreyansh Jain, Weisi Liu and Tom Nolan developed the Intelligent Transformation Index in February-August 2022, based on the OECD's ICT Access and Usage by Businesses dataset and a novel primary dataset derived from a survey of 511 China-based enterprises.

Lenovo is the sponsor of this research programme. The views expressed herein are those of Economist Impact and do not necessarily reflect Lenovo's perspective.

# Executive summary

Intelligent transformation has kicked off in earnest globally. Adoption rates of digital intelligence, defined in this report as the class of technologies that enable machines to learn and generate insights from data, rose strongly in 2021 in the world's major economies. For example, the EU saw the share of businesses using the internet of things (IoT) rise from 18% in 2020 to 29% in 2021.

This report explores the emerging landscape of digital intelligence usage by businesses across 33 countries (collectively representing 78% of global GDP), drawing on datasets published by the OECD and national governments. The Intelligent Transformation Index, constructed from adoption rates for big data analysis, artificial intelligence (AI) and IoT, provides a way to benchmark countries and industries. The study identifies emerging trends in adoption and explores the digital and organisational foundations of intelligent transformation.

As part of the study, a survey of businesses in China, which hitherto has been absent from the global data, was conducted to compare the world's second largest economy with its OECD peers.

Key findings of the report include:

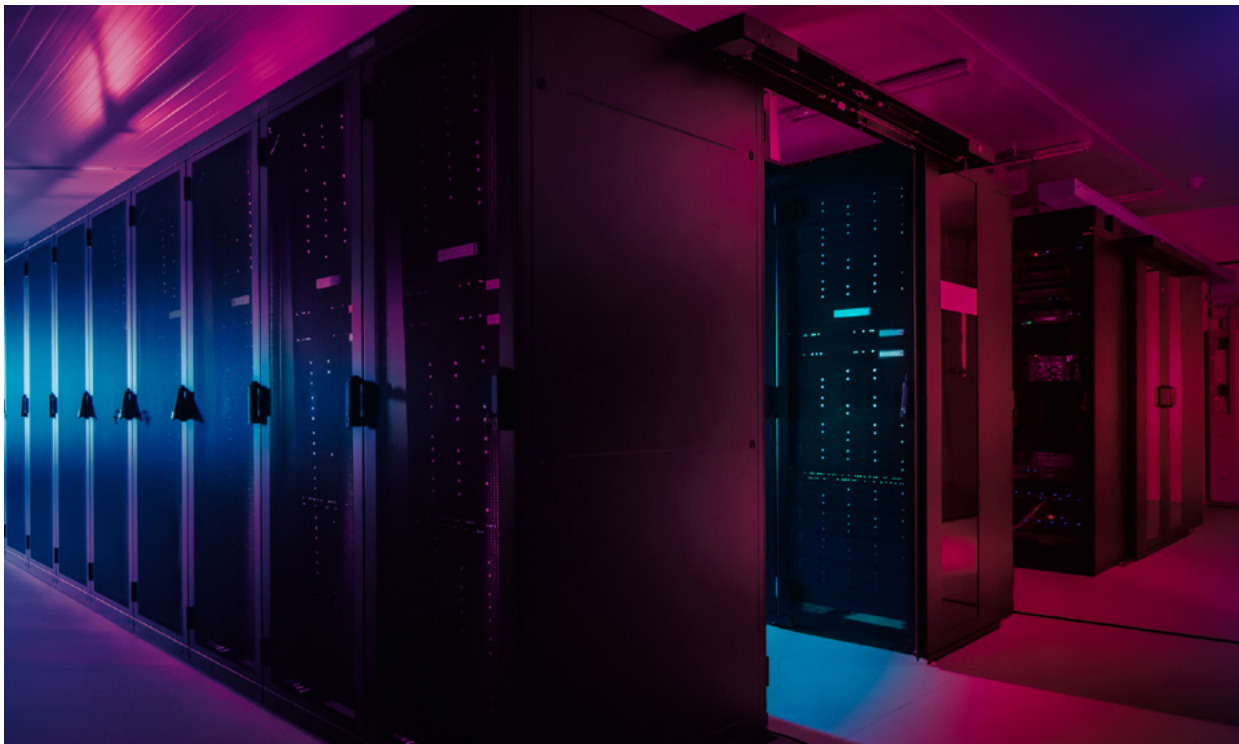
- Small, advanced and open economies, such as those in northern and western Europe, generally show higher rates of digital intelligence adoption. It is likely that forward-looking policies that aim to promote trust and transparency in data usage also play a role.
- The information and communications technology (ICT) services sector generally leads countries' digital intelligence adoption, but a high-performing ICT sector does not

automatically lead to a high level of adoption in non-ICT sectors. Ensuring adequate diffusion of technologies to non-ICT sectors should form part of national digitalisation strategies.

- Less digitalised sectors such as retail, accommodation, food service and construction account for the greatest cross-country differences in digital intelligence adoption. Differences in the average size of firms in these sectors play a key role, as larger firms have greater absorptive capacity for new technologies. For example, countries with a more consolidated retail sector tend to have higher adoption rates.



- Of the three technologies studied (big data, AI and IoT), AI shows the lowest level of adoption and the most variation across countries. IoT is the most adopted technology—it currently has the most general use cases that are deployable across a range of sectors. We observed a noticeable gap dividing high- and low-adoption countries in big data, but its causes remain mysterious.
- High-speed broadband, cloud computing infrastructure, ample supply of data and availability of skilled ICT workers are the key factors associated with countries with high levels of digital intelligence adoption.
- The increasing affordability and accessibility of digital intelligence is lowering barriers to adoption of digital intelligence. Businesses are increasingly outsourcing technology needs, and the emergence of “AI-as-a-service” and no-code software is reducing the need to recruit highly specialised ICT workers to implement rudimentary digital intelligence capabilities.
- Production automation through adopting digital intelligence does not necessarily lead to replacement of human workers. Many emerging applications of digital intelligence serve to augment rather than substitute the tasks of human workers. A key challenge of intelligent transformation for firms will be to find the right balance between task augmentation and full automation.
- Although small and medium-sized enterprises face the greatest challenges in intelligent transformation due to lack of scale, emerging models of collaboration and resource sharing may provide new ways for small firms to take advantage of larger repositories of data and computing capabilities.





**SECTION 1**

# Introduction

Since the advent of the personal computer, businesses have embarked on a process of integrating digital technology into nearly every aspect of an organisation’s functions. Commonly referred to as digital transformation, this process has undergone multiple waves. The emergence of new technologies, such as the internet and smartphones, can accelerate it, as can globally-significant events such as the covid-19 pandemic.

Since the advent of the personal computer, businesses have embarked on a process of integrating digital technology into nearly every aspect of an organisation’s functions. Commonly referred to as digital transformation, this process has undergone multiple waves. The emergence of new technologies, such as the internet and smartphones, can accelerate it, as can globally-significant events such as the covid-19 pandemic.

In early waves of digital transformation, personal computing changed the productivity of individuals with the widespread adoption of word processing and spreadsheets. The arrival of the internet then shifted the emphasis to connectivity, combining with smartphones

to revolutionise communications. Over the past decade, the confluence of vast amounts of data being generated and advances in computing hardware and software development has led to the rise of digital intelligence.

In this report, the term digital intelligence will be used to refer to the suite of technologies that enable machines to learn and generate insights from data. Specifically, these technologies are artificial intelligence (AI), big data analysis and the internet of things (IoT). The increasing number of business use cases for these technologies (see figure 1) is generating a new wave of digital transformation, which is referred to as intelligent transformation.

**Figure 1: Example applications represented in the Intelligent Transformation Index**

AI	Big data	IoT
Image recognition	Geospatial analysis	Smart energy management
Computer vision	Social-media analysis	Logistics management
Speech recognition	Recommendation engines	Smart premise security
Natural language processing/ generation	Fraud detection	Robotic manufacturing

This report firstly presents the Intelligent Transformation Index, which measures business adoption of intelligent technologies across countries and industries. The index draws heavily on data provided by the OECD. The report also includes a novel survey of technology adoption by businesses in China—widely believed to be an emerging leader in AI—with the aim of benchmarking China against OECD countries on intelligent transformation. The survey provides new insights into the uptake of emergent technologies across the entire Chinese economy.

Next, the report explores intelligent transformation and its foundations, namely the role of data, technology infrastructure, skills and policy. Commonalities and differences between countries and industries that exhibit high or low levels of intelligent transformation are explored with a view to understanding the factors that lead to successful technology adoption.

The analysis then turns to global trends in the provision of digital intelligence, notably the critical role of information and communications technology (ICT) talent and emerging alternatives. Do companies need their own ICT staff to engage in intelligent transformation? Or has the nature of digital technology accessibility changed so drastically that the IT department may soon become a remnant of the past?

This report is written with a broad, non-specialist readership in mind. It is the authors' hope that policymakers, ICT professionals, business executives or any person with an interest in technology will find the content engaging and come away with a new perspective on the role of digital technology in shaping the world. The team would like to thank the following experts for their time and insights:

- **Marco Bianchini**, OECD
- **Fraser Kelton**, OpenAI
- **Audrey Kindlon**, National Center for Science and Engineering Statistics, National Science Foundation
- **Sean Lawrence**, NTT Group
- **Yin Xi**, International Digital Economy Academy

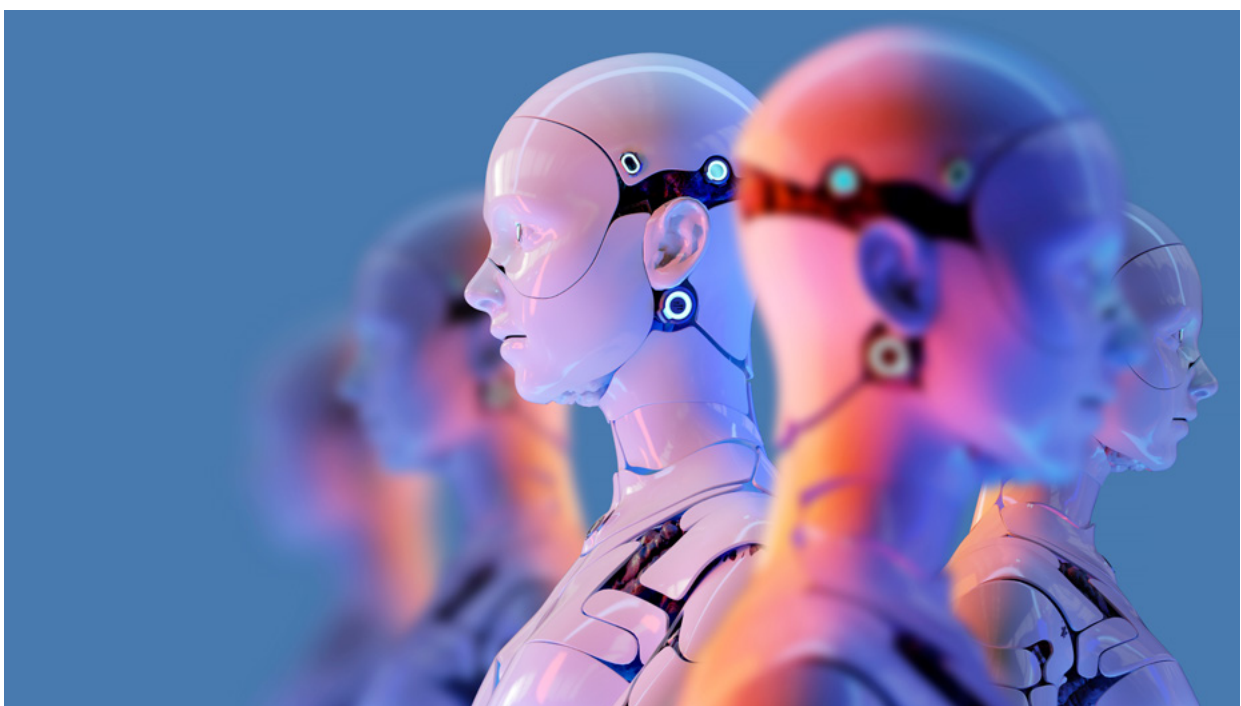
Finally, while adoption of digital intelligence is implicitly treated in this report as a force for bringing positive social and economic change, the authors would like to emphasise that it can also amplify existing limitations of human knowledge or be used to intrude on personal privacy and freedoms. All stakeholders in society have a role to play in ensuring that technology is deployed with a full view of ethical considerations.

**SECTION 2**

# The Intelligent Transformation Index

**Section summary**

- Countries with high levels of human and physical capital, such as those in northern and western Europe, generally show higher rates of digital intelligence adoption. It is likely that forward-looking policies that aim to promote trust and transparency in data usage also play a role.
- Of the three technologies studied (big data, AI and IoT), AI shows the lowest level of adoption and the most variation across countries. IoT is the most adopted technology—it currently has the most general use cases that are deployable across a range of sectors. We observe a noticeable gap dividing high- and low-adoption countries in big data is observed, but its causes remain mysterious.
- Less digitalised sectors such as retail, accommodation, food service and construction account for the greatest cross-country differences in digital intelligence adoption. Differences in the average size of firms in these sectors play a key role, as larger firms have greater absorptive capacity for new technologies.
- The ICT services sector generally leads countries' digital intelligence adoption, but a high-performing ICT sector does not automatically lead to a high level of adoption in non-ICT sectors. Ensuring adequate diffusion of technologies to non-ICT sectors should form part of national digitalisation strategies.





Although there is no standard definition of intelligent transformation, the notion itself is intuitive. If digital transformation refers to the integration of digital technologies into the functioning of an organisation, then intelligent transformation similarly describes the process of adopting digital intelligence. Pinning down the fast-moving boundaries of what constitutes digital intelligence remains a challenging task. Three decades ago, a computer mouse was considered an intelligent device, which today seems laughable.

Yet, starting in the early 2010s, a step change occurred in the ability of machines to perform human tasks. Algorithms began to recognise images and speech with a high degree of accuracy. Then came hair-raising stories of machines detecting patterns in consumer behaviour—for example, of a supermarket chain’s marketing department accurately predicting from a customer’s shopping receipts that she was pregnant. Computers started convincingly beating human champions at popular games like chess, Go and even science-fiction strategy game Starcraft. Machines became capable of learning from data and generating insights at a categorically higher level of sophistication.

Towards the end of the decade, digital intelligence had matured from a bleeding edge technology used by an elite segment of firms into one with a wide range of use cases and commercial applications. Tasks that mimic human cognitive functions, such as image recognition or speech generation, are generally considered to be a part of the AI movement. Since these tasks typically rely on processing large volumes of data and use of analytical techniques such as machine learning, there is significant overlap between AI and its little sister, big data. But not all big data analysis aims to develop AI. Plenty of big data analysis simply involves managing, organising and summarising the sheer volume of data involved. In the EU, for example, the top use case of big data is analysing geolocation data.

IoT also draws on AI and big data, but the pattern of uptake is markedly different.

The most popular uses of IoT in recent years have been in relatively “unintelligent” applications. In the EU, for example, the leading business application of IoT is in alarm systems that alert managers and authorities when an intruder or fire is detected. But IoT devices are getting smarter. Facial recognition technology, for example, is increasingly being built into internet-connected cameras, a technology that is being widely deployed for applications both benign (such as boarding an aeroplane) and sinister (such as intrusive surveillance). As time passes, devices will become more capable and prolific, and IoT will increasingly provide a critical sensory bridge between the physical and digital worlds.

As big data, AI and IoT pass from the initial stage of hype and curiosity into widespread use, data gathering by national governments has begun in earnest, led by OECD member countries. It is now possible to benchmark countries and industries on business usage of digital intelligence.

### **Introducing the Intelligent Transformation Index**

The Intelligent Transformation Index summarises country-level adoption of big data, AI and IoT. It draws heavily on data published by the OECD. Where comparable data for major economies such as the US and Japan is missing, Economist Impact has constructed estimates based on surveys performed by national governments and industry associations. To supplement data for China, Economist Impact commissioned a survey of 511 businesses. The survey was designed following the OECD’s model questionnaire, and every effort was made to replicate the OECD’s sampling methodology (see appendix for survey details).

The index is comprised of three indicators: the share of businesses in each country that are using each of the three technologies. Index scores represent the average of a normalised score for each indicator. The index is a composite measure of country-level adoption of digital intelligence by businesses. The results are shown in figure 2.

Figure 2: The Intelligent Transformation Index results

Rank	Country	Adoption Rate (%)			Adoption rate (Rank)			Index
		Big data	AI	IoT	Big data	AI	IoT	
1	Denmark	27	24	20	2	1	25	100
2	Finland	22	16	40	8	3	3	94
3	United States	24**	15**	30**	4	4	10	88
4	Netherlands	27	13	21	1	7	24	82
5	Sweden	19	10	40	9	13	4	80
6	Ireland	23	8	34	6	16	6	77
7	Belgium	23	10	28	5	12	13	77
8	Germany	18	11	36	12	11	5	75
9	United Kingdom	27	4*	-	3	25	-	73
10	Slovenia	7	12	49	29	9	2	71
11	Austria	9	9	51	23	14	1	71
12	Luxembourg	19	13	22	11	8	20	70
13	Norway	19	11	24	10	10	17	68
14	Portugal	11	17	23	14	2	18	66
15	China	10 (S)	13 (S)	31 (S)	16	6	9	65
16	France	22	7	22	7	18	21	63
17	Japan	10**	14**	14*	17	5	28	51
18	Italy	9	6	32	25	20	7	51
19	Spain	9	8	27	21	17	14	50
20	Czech Republic	9	4	31	20	22	8	48
21	Lithuania	11	4	28	15	23	12	47
22	Greece	13	4	22	13	24	22	45
23	Latvia	9	4	28	26	26	11	43
24	South Korea	9*	8**	-	24	15	-	42
25	Slovak Republic	6	5	27	30	21	15	40
26	Brazil	10 (Ext)	6**	-	18	19	-	40
27	Turkey	9	3	21	22	33	23	36
28	Estonia	10	3	17	19	32	27	34
29	Hungary	7	3	22	28	30	19	34
30	Poland	8	3	19	27	31	26	33
31	Canada	2	3*	27*	32	29	16	30
32	Australia	-	3*	12*	-	28	29	24
33	Israel	5	4*	6*	31	27	30	19

Note: Unless indicated otherwise, data are taken from the OECD's ICT Access and Usage by Businesses database, covering all businesses with at least ten employees. The data periods for big data, AI and IoT are 2019, 2021 and 2021 respectively. More information about estimation methodologies is available in the appendix.

\*Economist Impact extrapolation based on the OECD's ICT Access and Usage by Businesses dataset

\*\*Economist Impact estimate based on OECD and non-OECD data sources

(S) Economist Impact China Survey

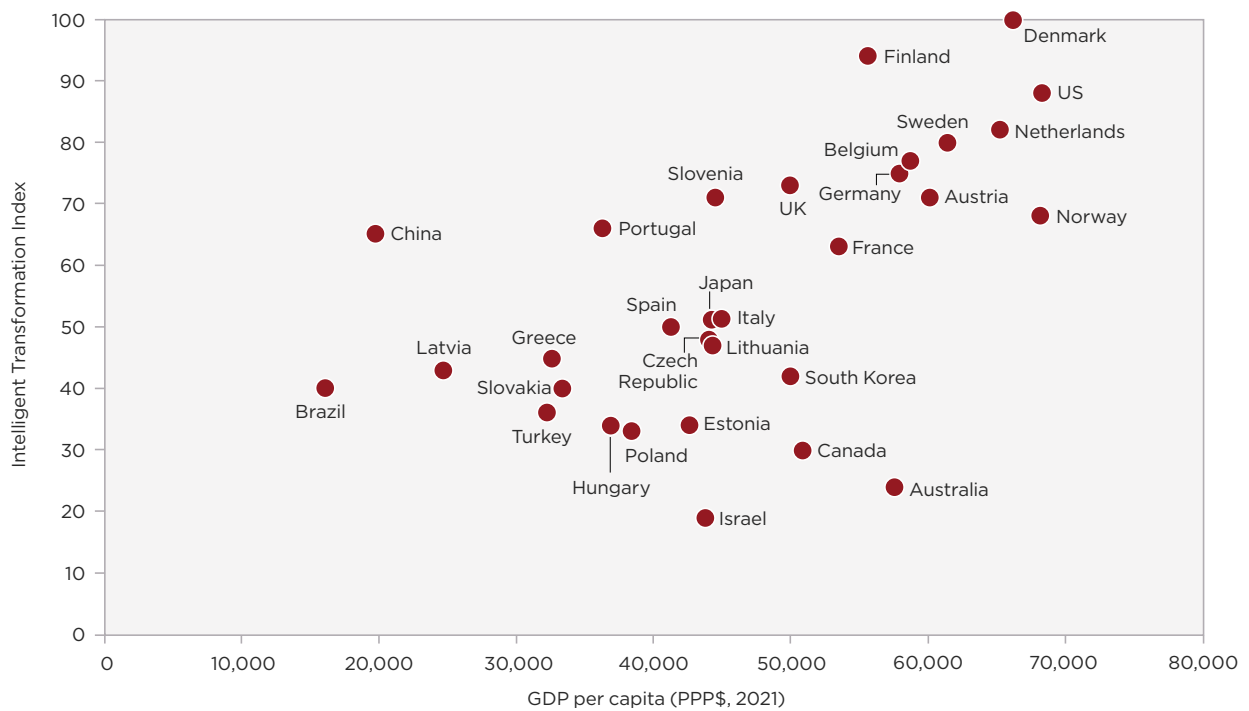
(Ext) External data source

Non-OECD data sources: United States: Annual Business Survey; Japan: Japan User Association of Information Systems; Brazil: Regional Centre for Studies on the Development of the Information Society; China: Economist Impact Survey.

Countries in Northern Europe, with advanced infrastructure, skilled labour forces and significant innovation, are furthest along with the deployment of big data, AI and IoT. In Denmark, the leader, 27% of its businesses already use big data, and 24% deploy AI—the highest take-up rates of these technologies. Finland, the Netherlands, Sweden and Ireland round out the top five, with relatively broad diffusion of intelligent applications across industries. There is one exception to the Nordic countries’ dominance: Norway, where businesses are slower to deploy AI than their peers elsewhere in the region.

Although the top five scoring countries all rank among the world’s highest in GDP per capita terms, it is far from the case that digital intelligence is exclusive to rich countries. Outside the small group of high performers, the correlation between GDP per capita and scoring on the Intelligent Transformation Index is weak (see figure 3). A number of high-income countries such as Canada and Australia score notably poorly. Conversely, China and Portugal are among the less-developed countries that perform remarkably well.

**Figure 3: Intelligent transformation is correlated with economic development but there are exceptions**



Sources: Economist Intelligence Unit, Economist Impact.



### SPOTLIGHT ON DENMARK

## Trust-based, future-focused policy

Denmark's top ranking in the Intelligent Transformation Index demonstrates the power of a set of factors common to its wealthy neighbourhood in Northern Europe. Along with the other Nordic countries and the Netherlands, broad adoption of digital technologies is paving the way for more intelligent applications. More than one in five businesses in Denmark are already using AI, big data and IoT. One partial explanation is a trust-based data policy.

One factor common to the top performers in the Intelligent Transformation Index is data governance. In addition to the robust protection of GDPR, Denmark's data governance promotes ethical practices through financial disclosure requirements. As of January 1st 2021, large companies in Denmark must publish their policy on data ethics or, if they do not have such a policy, explain why they do not. The legislation also provides guidelines for corporate policy with five key principles:

- Describe the types of data the company can access, how they are processed, and the purpose of collection and processing.
- Review company data collection and processing and assess benefits for all stakeholders.
- Develop requirements for third-party data sharing that engender customer trust.
- Review algorithmic bias and the consequences of automation (proactively, if the company does not currently deploy digital intelligence).
- Communicate data ethics guidelines widely throughout the company, including as a key part of onboarding and development.<sup>1</sup>

This culture of accountability and transparency helps to reinforce positive perceptions towards digital intelligence. Although there are rights-based regulations in these financial disclosure requirements, Denmark's approach to an ethical data culture also provides support on the positive, proactive steps that businesses can take to exceed the letter of the law and reinforce trust.

Other leading countries take a similar approach. The Norwegian Consumer Council, a government agency tasked with consumer protection, offers advice on rights but also on how to engage companies who may meet contractual requirements but fall short of living up to the principles of ethical engagement with technology platforms.<sup>2</sup> The Netherlands' Ministry of the Interior has taken a leadership role on data ethics within the OECD, helping to develop the Good Practice Principles for Data Ethics in the Public Sector, with ten recommendations that include publishing open data and source code and broadening users' control over their own data.<sup>3</sup>

Adopting a proactive policy to promote transparency and trust can help to avoid antagonistic relations developing between users and the organisations collecting their data. Data privacy breaches involving internet companies in the US, China and other jurisdictions in recent years create distrust and hamper the creation of an open data sharing environment that ultimately forms the fuel for driving intelligent technologies.

### Intelligent transformation: the industry perspective

The country adoption scores for each of the three indicators have been compiled through standardised surveys covering 10-11 economic sectors in each country. Understanding patterns of intelligent transformation across sectors is a good place to start. Figure 4 shows the global average adoption rate for each sector for each type of technology.

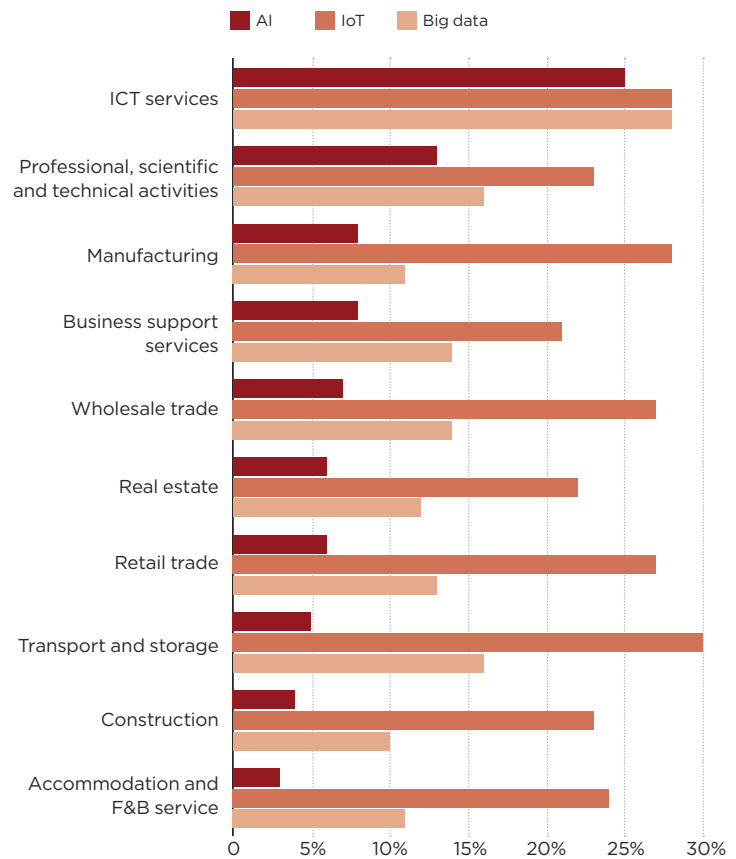
Unsurprisingly, the ICT services sector shows the highest adoption rates for digital intelligence—most tech firms are by nature highly-digitalised. Some sectors are more specialised in certain types of digital intelligence. Transport leads on the efficiency-driven intelligence of IoT. Professional, scientific and technical services represent a knowledge industry with more developed business use cases for AI and big data. The least “intelligent” sectors are accommodation, food service and construction. These sectors have a tendency to be dominated by small, often family-run firms, and digital technology is not a must-have feature of business operations.

Does this mean that the ICT services is the most important determinant of a country’s intelligent transformation score? Counterintuitively, the answer is the opposite. The tech sector is actually the least important. Why? ICT shows the least variation across countries when it comes to adoption of digital intelligence. In other words, adoption rates for the ICT sector are relatively similar when compared across countries.

One key explanation lies in the size of firms. In general, large businesses are more likely to deploy new technologies than small ones (see figure 5). Marco Bianchini, an economist and coordinator of the Digital for SME Global Initiative at OECD, points out that small businesses may have neither the necessity, resources nor incentives to deploy advanced technologies. “We have to be aware that many firms are small, family-run businesses that are motivated primarily by staying in the market and providing for their families,” says Mr Bianchini. “They aren’t trying to become something different than what they are.”

**Figure 4: ICT services leads in adoption of digital intelligence**

Share of firms by sector adopting technology, %

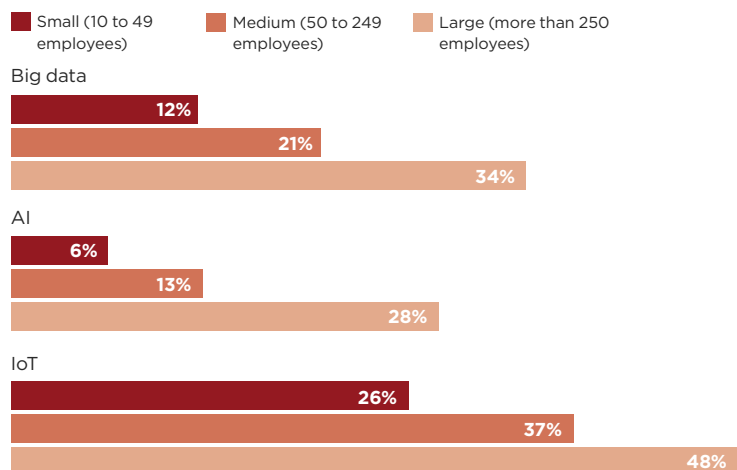


Sources: OECD, Economist Impact.

\*Adoption rates refer to the share of businesses using a type of technology. Data shown are the average for EU countries and China.

**Figure 5: Big firms are more likely to adopt digital intelligence**

Adoption rate by technology and size of firm



Source: OECD. Latest available year (2019 for big data, 2021 for AI and IoT).

Yet this may not be universally applicable for all sectors. A typical software firm in Brazil will have a similar technology profile compared with a peer in Denmark. No matter the size of the firm, it is likely to have engineers, servers, PCs, a broadband connection and a website. The same is not true of

firms in less digitalised sectors such as accommodation or retail. A retailer can take the form of a traditional mom-and-pop store that still uses paper-based accounting, or of a distribution behemoth like Walmart or Carrefour, which will have all the trappings of a digitally advanced organisation.



## SPOTLIGHT ON JAPAN

### A former superstar loses its edge

Japanese businesses raced ahead of many international peers in the 1980s with respect to the beginning of the computer era, and the country became known for its electronics and robotics industry. Yet today, the country is struggling to give momentum to the digital transformation of its businesses. Replacing legacy systems with next generation technology has been slow—the country’s dogged persistence in using obsolete technologies like fax machines is legendary. It ranks a middling 17th in the Intelligent Transformation Index, dragged down by its use of IoT, for which it ranks 28th.

Among the raft of hypotheses advanced to explain the nation’s self-diagnosed “digital defeat” is the seniority-based corporate culture of many of Japan’s leading large firms. IT engineers are already in short supply in Japan, but rules around seniority and compensation preclude firms from offering competitive salaries to younger talent. Of the

world’s top-four economies, Japan is the only one where IT engineers and data analysts earn less than the median wage.<sup>4</sup>

A risk-averse culture with respect to large investments, data privacy and cybersecurity also holds back many Japanese companies. An example from the medical field is particularly illuminating. While healthcare systems in other countries press ahead with cloud-based medical imaging, on-premises, closed networks dominate in Japan.<sup>5</sup> By comparison, the Czech Republic is already operating a nationwide cloud-based medical images network.<sup>6</sup>

Calling the covid-19 pandemic a digital “wake-up call” for the country, the Japanese government established a new agency in 2021, tasked with the objective of overhauling public services and coordinating efforts across government to boost digitalisation. One can only assume that the fax machines are also on its work plan.



The importance of firm size is evident from the disparity in technology adoption by business-size in figure 5, where large organisations outperform small and medium-sized firms across all intelligent applications. It is likely that countries with higher rates of consolidation in certain sectors—and therefore larger firms—also show higher rates of digital technology adoption.

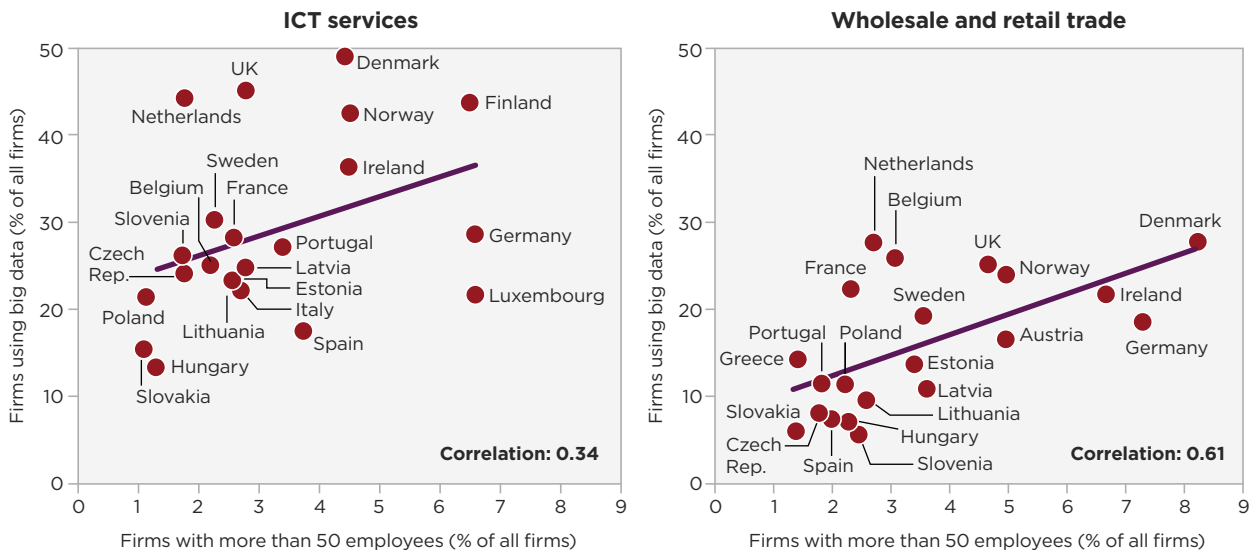
In Denmark, the top-ranking country in the Intelligent Transformation Index, 8.3% of retailers have more than 50 employees, the highest rate in the EU. Figure 6 shows the correlation between the share

of medium- and large-sized firms in a country and their big data adoption rates. The link is strong for the retail sector. It is less apparent for ICT services.

Formalising the logic above, the less a sector is digitalised, the higher the dispersion of adoption rates will be across countries. This can be seen in the strong negative correlation shown in figure 7. And since there is higher dispersion in less digitalised sectors, it follows that variation in these sectors helps to explain cross-country variation in intelligent transformation—more so than with highly-digitalised sectors.

**Figure 6: Firm size matters more in some sectors than others**

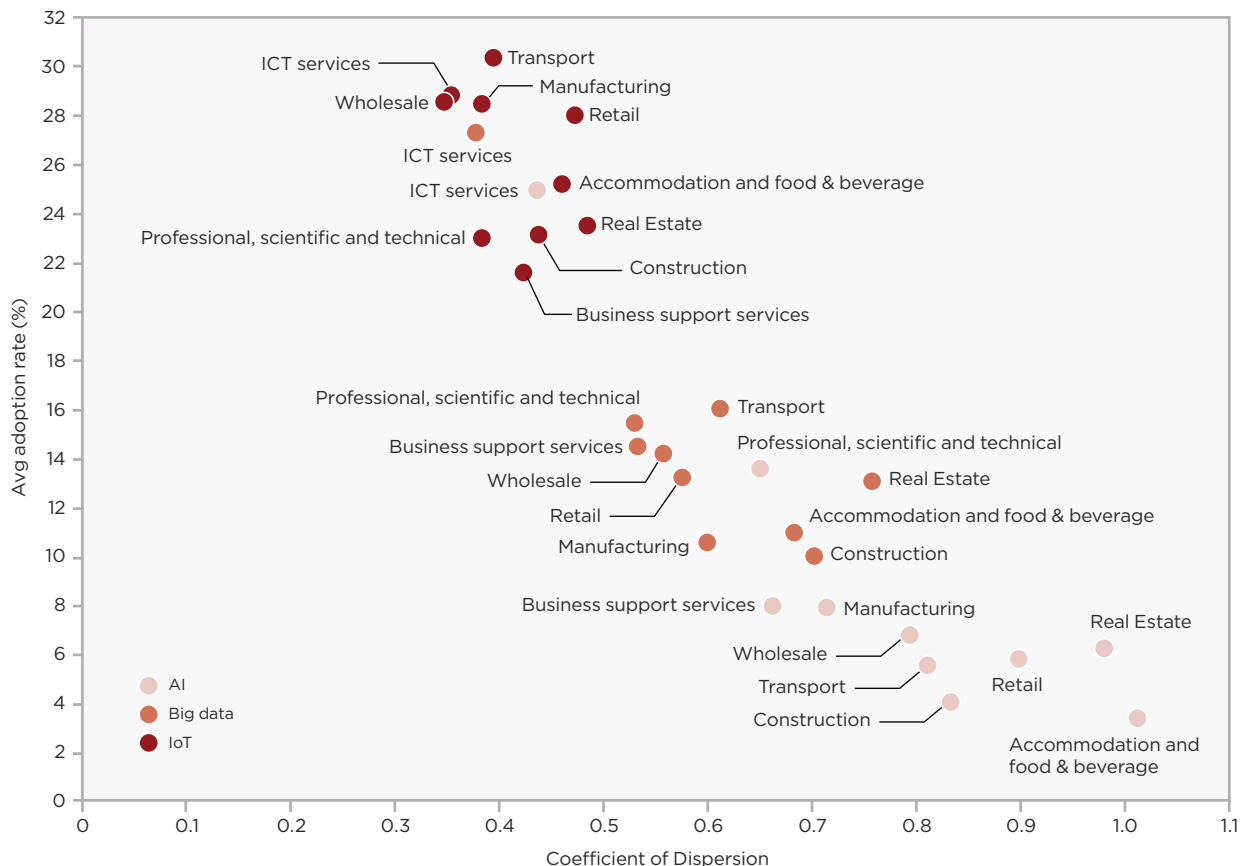
Share of firms by sector adopting technology, %



Source: Eurostat.

**Figure 7: Less digitalised sectors show more varied performance across countries**

Share of firms by sector adopting technology, %



Sources: OECD, Economist Impact.

The intuition of the above finding is straightforward: The digital diversity of businesses in less digitalised sectors is much greater than in highly digitalised ones. For a rudimentary impression of a country’s digital intelligence adoption, visiting local stores and restaurants would provide more accurate insight than visiting its tech companies.

**Technology diffusion and intelligent transformation**

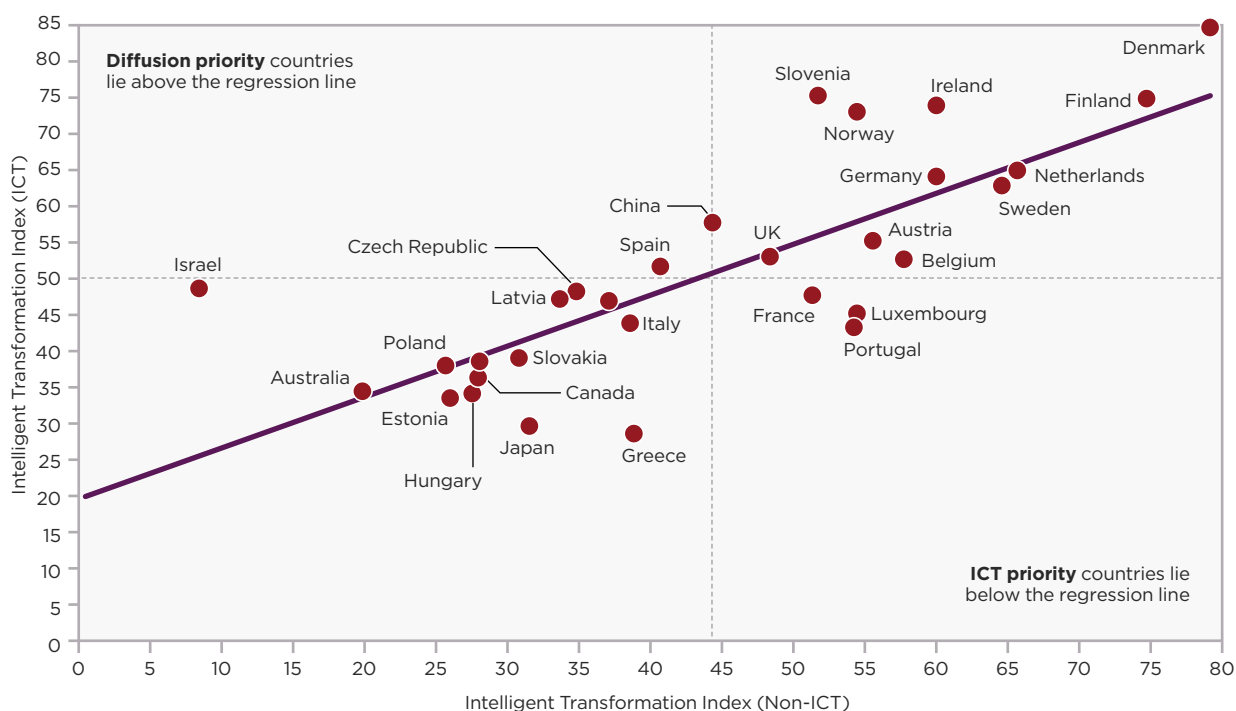
It is tempting to think of a country’s level of technological advancement as being reflected by the number of cutting-edge inventions it produces or the number of giant technology firms it is able to foster. News about tech unicorns dominates headlines, yet such coverage tends to be a poor indicator of broader

digital or even economic development because it focuses on the activities of an elite segment of firms rather than widespread adoption.

As described in the previous section, diversity in non-ICT firms’ technology adoption is one of the most important determinants of countries’ intelligent transformation. Technology diffusion is the adoption of digital intelligence by firms outside of the ICT sector.

To understand how countries perform on the spectrum of technology diffusion, the Intelligent Transformation Index, using adoption rates of AI, big data analysis and IoT, is calculated separately for the ICT and non-ICT sectors, with the results shown in figure 8.

**Figure 8: The state of technology diffusion highlights ICT development priorities for countries**



Sources: OECD, Economist Impact.

Intelligent transformation in the ICT and non-ICT sectors is highly correlated, although this does not mean that it is at the same level in both. For the three core indicators of big data, AI and IoT adoption, the non-ICT sector’s adoption rates are roughly only half the level of those in the ICT sector. Correlation simply implies that they move together. If a country has high adoption rates in the ICT sector, it is also likely to have high scores in the non-ICT sector. However, there are many exceptions to this rule. To highlight the diverse challenges that countries face in intelligent transformation, the following country groups may be discerned from figure 8:

- “Diffusion priority” countries are countries below the regression line. They have relatively poor economy-wide diffusion of digital intelligence, the use of which is concentrated in the ICT services sector. Israel and Slovenia stand out as notable countries in this group.
- “ICT priority” countries can be said to have relatively uncompetitive ICT sectors, with low levels of digital intelligence relative to non-ICT

sectors. Greece and Portugal fall into this category of countries.

There are several reasons why governments might seek to stimulate technology adoption in the non-ICT sectors. Firstly, non-ICT firms account for the bulk of employment and output in any economy. The share of GDP and employment of the ICT services sector in most economies is in the low single digits. Poor diffusion of digital intelligence in the broader economy means that the majority of firms and workers are unable to reap the productivity benefits of technology. GDP per capita is more tightly correlated with intelligent transformation in the non-ICT sector than in ICT.

Just as it is important to ensure that technological diffusion flows to non-ICT firms, having an underperforming ICT sector can also act as a drag on technology adoption in the broader economy. Although it is true that technology can be increasingly sourced from all corners of the globe, there is a limit on what economies can achieve without a strong local base of ICT talent and service providers.



**SPOTLIGHT ON ISRAEL**

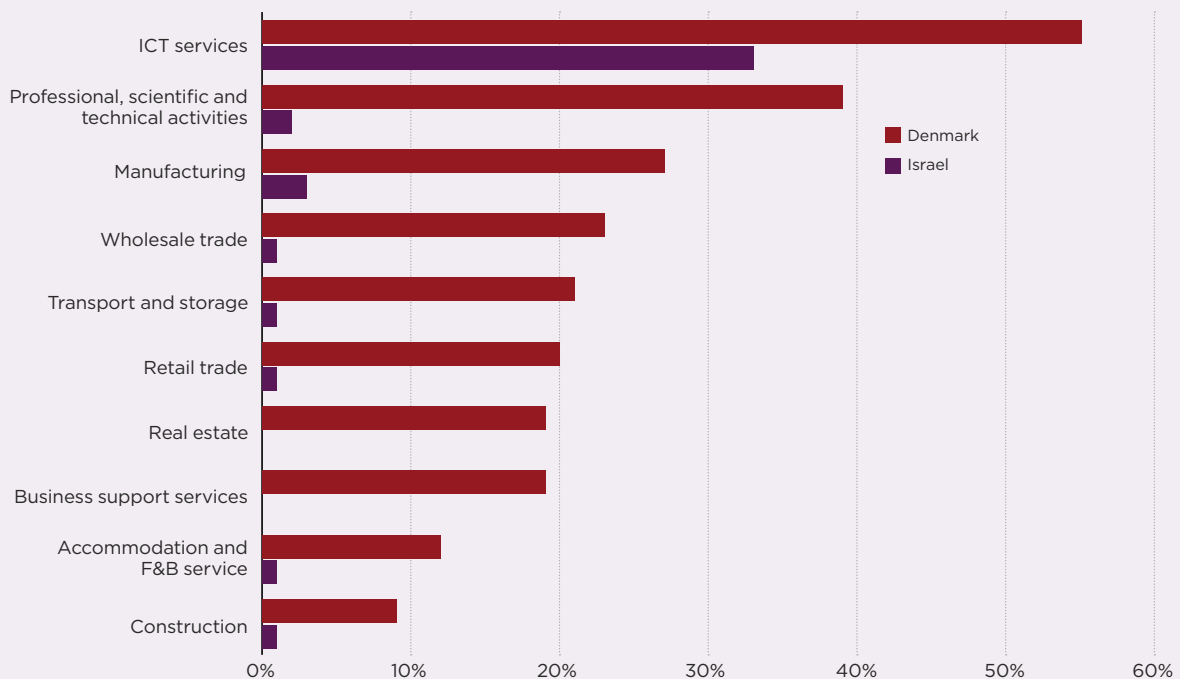
## A start-up oasis in a technology desert

Israel’s tech sector is world-class in digital intelligence adoption. The rest of its economy is not. The country’s outsized role in producing technology unicorns and renowned AI firms such as Mobileye has earned it a variety of nicknames including “Start-up Nation” and “Silicon Wadi” (wadi means valley in Hebrew). But this is where the country’s success in digital intelligence adoption stops.

While Israel’s ICT services sector ranks 6th in the world in business adoption of AI, its other sectors trail far behind. Figure 9 shows Israel’s sectoral AI adoption scores compared with those of Denmark, which is the world leader in AI adoption. The difference for non-ICT sectors is stark and explains why Israel ranks near the bottom of the Intelligent Transformation Index. It is a reminder that the vast majority of technology use lies outside of the excitable world of start-ups and venture capital. Translating innovation to wider transformation is not a given.

**Figure 9: AI usage has not spread outside of Israel’s ICT services sector**

Share of businesses using AI, %



Source: OECD.

Are there specific technologies in which countries can improve diffusion? Of the three digital intelligence technologies, IoT is the most diffuse, with the broadest adoption rates across industries. The next most diffuse is big data, followed by AI. Use of these technologies tends to be highly concentrated in the ICT services sector.

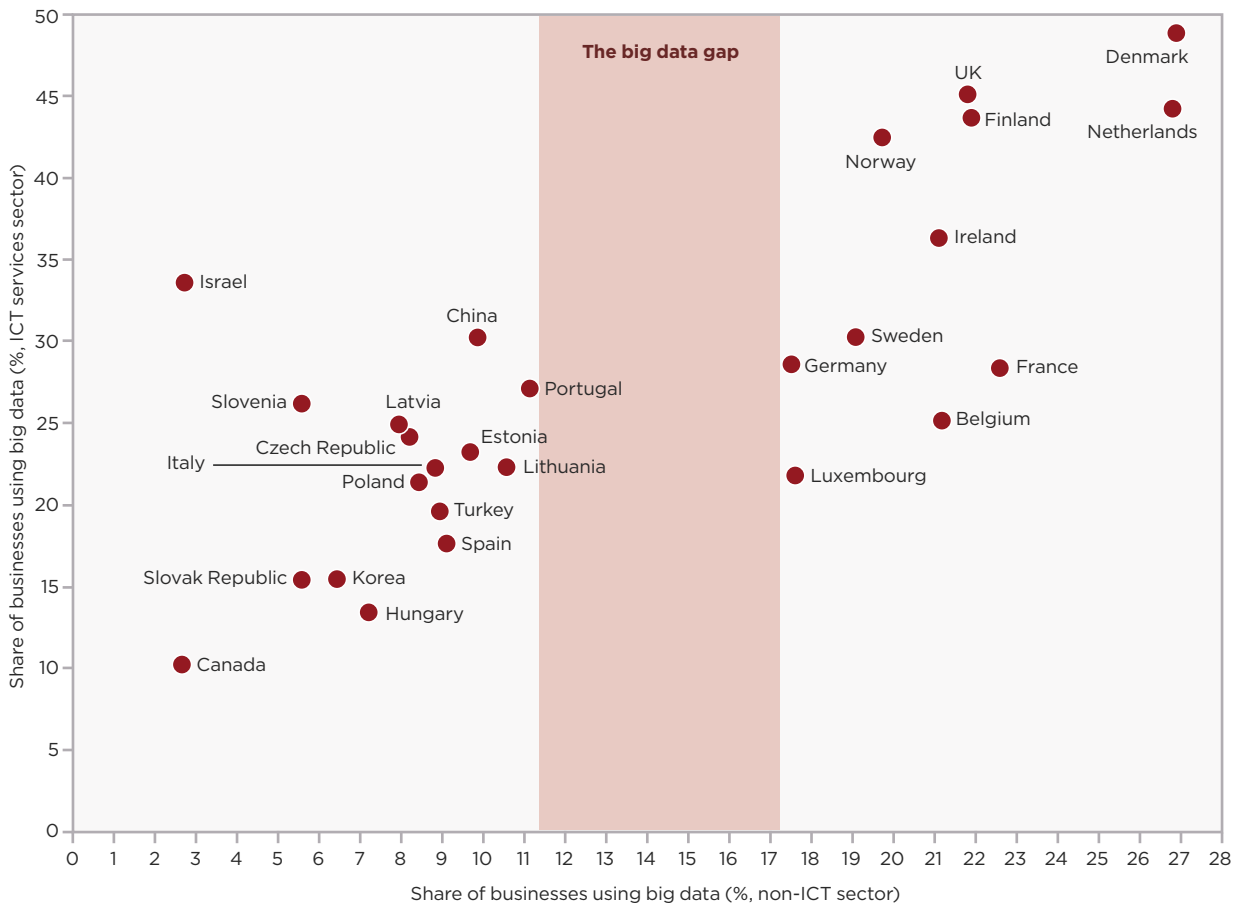
There is a peculiar pattern that can be observed in big data usage. For non-ICT sectors, there is a “gap” that divides low-adoption and high-adoption countries, the latter of which are exclusively in north-western Europe (see figure 10).<sup>7</sup> The gap is most noticeable in the retail, transport, and accommodation and food service sectors. The reasons behind the gap remain mysterious, but its existence is noteworthy.

There is a general set of policies identified by researchers that can support ICT

development in an economy, which are listed below. These relate to access to the following areas:

- Funding—Ensuring that firms have access to credit/capital
- Talent—Investing in ICT education/training, attracting skilled ICT migrant workers
- Infrastructure—Ensuring sufficient availability of high speed-broadband and data centres
- Institutions—Establishing organisations and governance mechanisms under which knowledge, technology and data is shared within and between government, academia and industry
- Market barriers—Removing traditional trade barriers or restrictions on data transfers and data processing

**Figure 10: A notable gap in big data adoption for non-ICT firms divides countries**



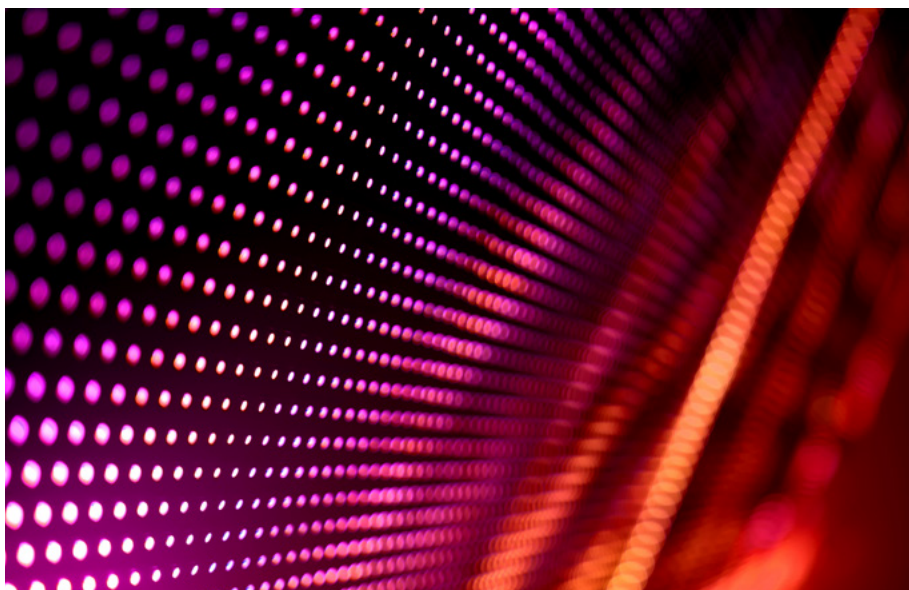
Sources: OECD, Economist Impact.

Each country has unique circumstances in tackling its ICT development challenges. It is not within the scope of this report to issue specific recommendations to countries. However, some of these policies may be more suitable for certain countries in the context of the above distinction drawn between “diffusion priority” and “ICT priority” countries. As Mr Bianchini puts it, one of the policy implications is “pushing the boundaries of productivity for the rest of the system.”

Diffusion-oriented policies should generally aim at lowering the costs of adoption for non-ICT firms, including both monetary costs but also those associated with learning and implementing new technologies. Some countries already provide financial support for businesses deploying intelligent technologies, such as South Korea, although subsidies can be a crude form of policy support. Having a competitive industry of ICT service providers can help to keep costs manageable, as can lowering trade and investment barriers for global ICT goods and services. Depending on the country, there may also be basic infrastructure obstacles to address, such as a lack of fibreoptic networks outside of key commercial hubs that precludes wider adoption.

Policy targeting the ICT sector inherently concentrates public resources in ways diffusion-oriented policy does not. However, ICT has economy-wide benefits that ostensibly justify government support, either directly through fiscal measures or indirectly through ICT-oriented education and immigration policies that promote development of the talent base. Countries with robust ICT foundations but a dearth of AI-specific expertise may also resort to re-training programs for software developers to develop new skills.

In an OECD survey of 30 countries, all but three (Italy, the UK and the US) reported having policies in place to promote business adoption of digital technology, covering both financial and non-financial support.<sup>9</sup> The OECD also notes that as of



**Diffusion-oriented policies should generally aim at lowering the costs of adoption for non-ICT firms, including both monetary costs but also those associated with learning and implementing new technologies**

2020, 60 countries in the world had rolled out national strategies for AI development, many of which were only promulgated in the past couple of years. Healthcare and transport were the most targeted sectors in national AI strategies. Amid this explosion of new policy development and implementation, it is too early to determine what form of support works best.

Perhaps most critically, for digital intelligence to proliferate, businesses will require the steady supply of vast datasets on which to train the algorithms underpinning their products or operations. Many AI-based businesses will naturally build their own proprietary datasets, but governments are accelerating the move to make rich sources of public data accessible. In countries such as the UK, the move to open data sharing has extended to the private sector with initiatives such as Open Banking, whereby banking transaction data is made available under mechanisms that safeguard user privacy and data security.





## A novel survey of China's intelligent transformation

A notable entrant in the Intelligent Transformation Index is China, made possible by a novel survey from Economist Impact that sought responses from businesses consistent with the aforementioned OECD methodology. There are a good number of reasons to be interested in the development of digital intelligence in China. It is the leading country globally in AI-related scientific publications.<sup>9</sup> It boasts a number of world-leading companies in AI hardware and software, notably AI chips and facial recognition technology. It has one of the most digitalised consumer economies in the world, measured by the share of e-commerce in retail sales and the use of mobile payments.

China's achievements in AI-related scientific output and research and development are impressive, especially for an economy that still ranks 75th in the world in GDP per capita. But leading in research output should not be equated to leading in adoption. In fact, as readers will discover, the two can be very different. China ranks 15th in the

Intelligent Transformation Index, led by its relatively high adoption rate of AI.

This report constitutes the first attempt to measure and compare adoption of digital intelligence by businesses in China with other countries. To compile data, Economist Impact conducted an online survey of 511 large, medium and small businesses across 11 industries. To enable cross-country comparison using standardised indicators, in China Economist Impact deployed a modified version of the OECD's Model Survey on ICT Usage by Businesses. A full description of the survey methodology can be found in the appendix.

Governments around the world are betting on digital intelligence to drive the next wave of economic growth. Business adoption has just begun to take off. There are some emerging leaders as documented in this report section, but it is far too early to predict who the winners will be. However, the historical context of digital transformation offers insight.

Governments around the world are betting on digital intelligence to drive the next wave of economic growth. Business adoption has just begun to take off. There are some emerging leaders,

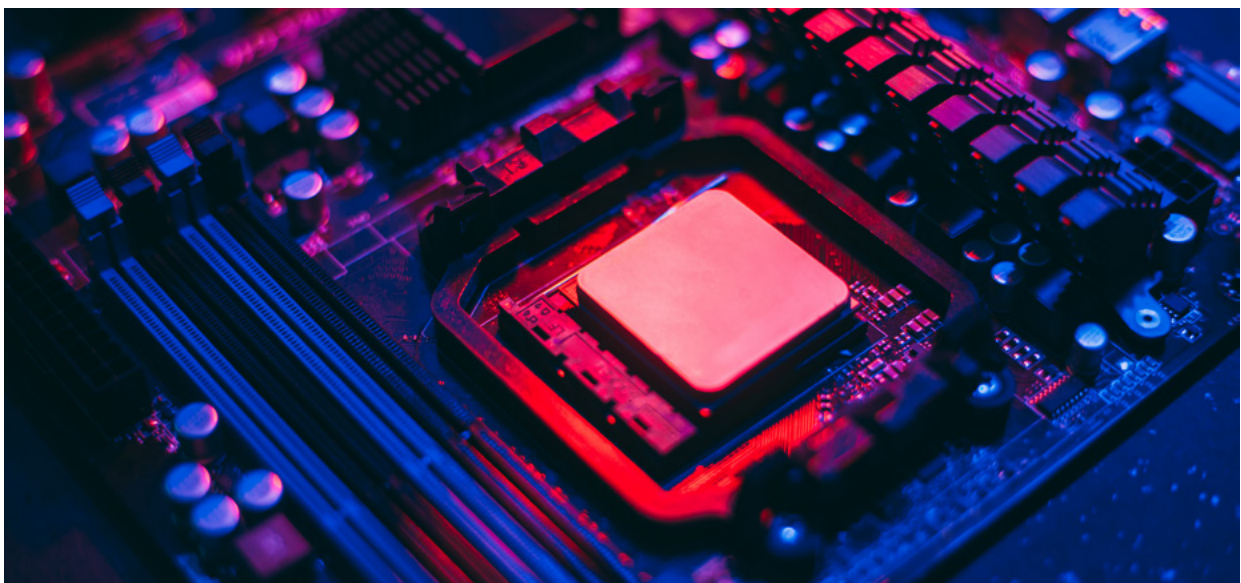
as documented in this report section, but it is far too early to predict who the winners will be. However, the historical context of digital transformation offers insight.

**SECTION 3**

# From digital transformation to intelligent transformation

**Section summary**

- Evidence from European and Chinese industry and company-level data consistently support the finding that infrastructure, data and talent are the core features of digitally intelligent firms.
  - » Infrastructure such as high-speed broadband and cloud usage, notably for application development, are key features of firms that have adopted digital intelligence.
  - » Customer relationship management (CRM) usage, notably on the cloud, is highly correlated with digital intelligence adoption as it provides an important customer dataset upon which many firms perform predictive analytics.
  - » Firms adopting digital intelligence are much more likely to employ ICT staff in house, even though most firms outsource digital intelligence work.
- Although small and medium-sized enterprises face the greatest challenges in intelligent transformation owing to lack of scale, emerging models of collaboration and resource sharing may provide new ways for small firms to take advantage of larger repositories of data and computing capabilities.



The focus of the report to this point is digital intelligence. But digital intelligence does not exist in a vacuum. Organisations active in big data, AI or IoT typically will have extensive digital foundations, ranging from basic infrastructure such as high-speed broadband to more advanced cloud-based data processing capabilities. They typically have higher rates of digital literacy and employ specialists to build and maintain systems.

This section of the report seeks to understand intelligent transformation in the broader context of digital transformation. We propose a framework that captures the various stages of digital transformation, as well as exploring the relationship between various technologies in an aim to understand the path to intelligent transformation.

The term “transformation” implies a process of change over time—this is the

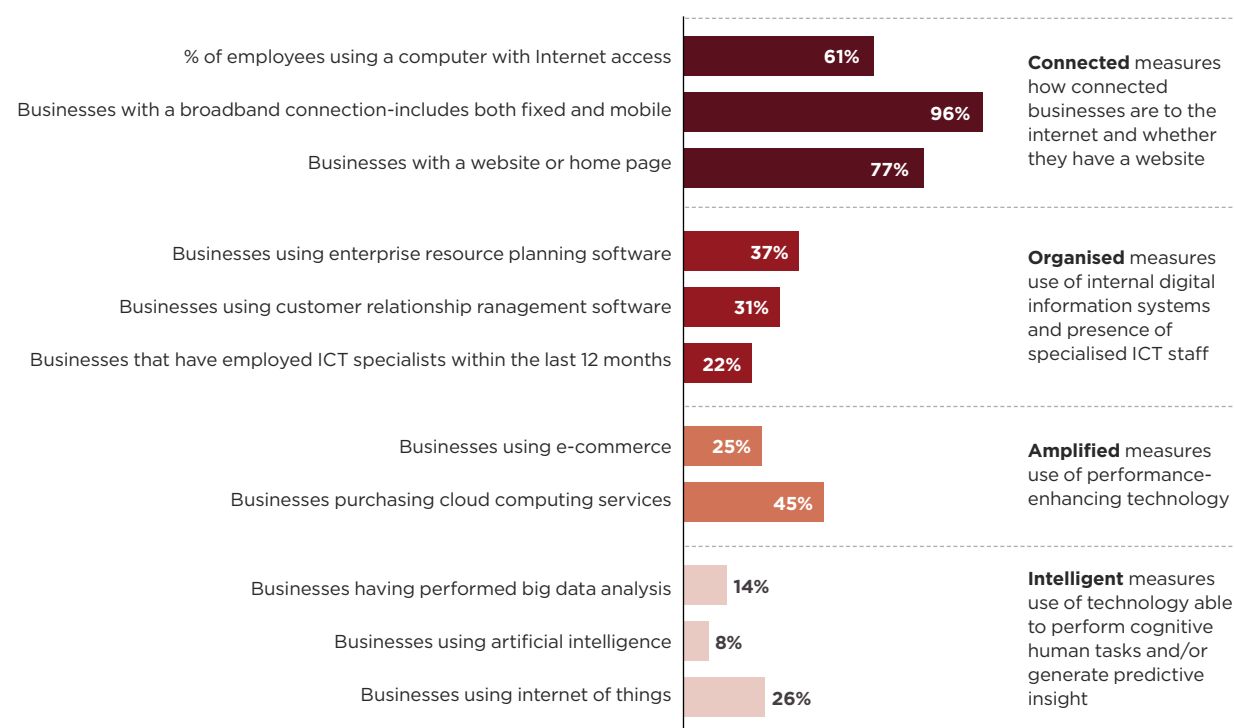
case for long-established organisations. However, a technology start-up is typically founded with most of the digital features that it needs. For the purposes of this section, we use the term “digital transformation” to describe the adoption of a range of common technologies that typically feature in the digital landscape of an organisation regardless of whether they are adopted sequentially or simultaneously.

### A framework for assessing digital transformation

To understand the link between digital intelligence and earlier stages of digital transformation, 11 indicators, including the three indicators of the Intelligent Transformation Index, were selected for benchmarking countries’ performance. The average score for all countries is shown in figure 11. The indicators are then classified into four pillars: connected, organised, amplified and intelligent.

**Figure 11: The digital transformation assessment framework contains 11 indicators structured according to four pillars**

Share of firms by sector adopting technology, %



Source: OECD.

The four pillars of the framework follow a logical progression. *Connected* measures the online presence of a company, measured through its internet infrastructure, the digitalisation of its workforce and whether or not it has a website. This pillar generally shows the highest prevalence, given the importance of the internet to most businesses. The covid-19 pandemic accelerated adoption for lagging sectors such as food and beverage and retail. The share of employees with access to the internet surged in 2021 as remote working became widespread (see figure 12).

The “organised” pillar captures the first wave of software that companies began adopting in the 1980s and 1990s, as well as the presence of ICT staff in companies to support activities ranging from network administration to cybersecurity and software development. The adoption of these technologies appears to have plateaued over the past decade (see figure 12).

The “amplified” pillar contains more recent technological developments—e-commerce (receiving orders online) and cloud computing. These innovations represent new ways to sell to customers or store and process data. Uptake of these technologies, especially cloud, is rising rapidly.

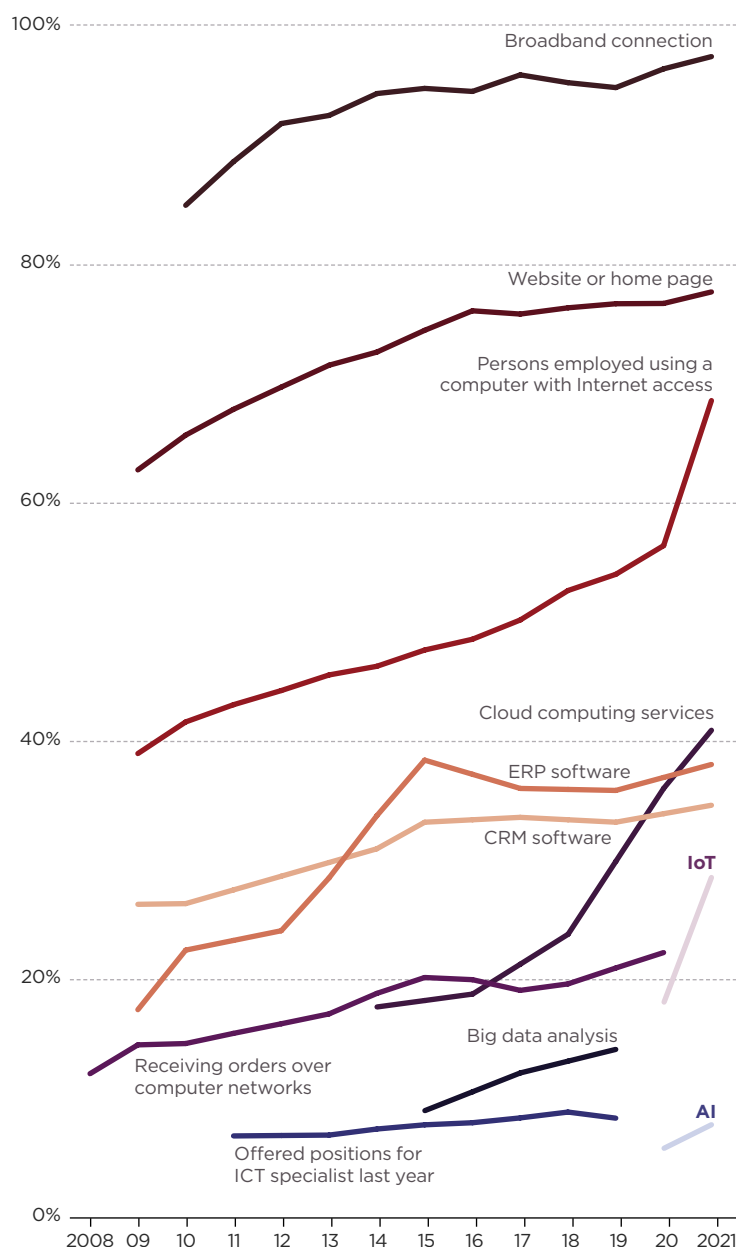
The “intelligent” pillar is the Intelligent Transformation Index, discussed extensively in section 2. Although adoption rates of big data, AI and IoT are relatively low compared with technologies in the other pillars, they have surged in recent years.

### Foundations of digital intelligence adoption

This analysis considers how the “connected”, “organised” and “amplified” pillars relate to “intelligent”. Two sources help to illuminate the factors that facilitate intelligent transformation. The first uses data from the survey conducted by Economist Impact in China for this study. The second relies on Eurostat country- and industry-level data.

**Figure 12: Cloud computing and digital intelligence adoption are growing rapidly**

Adoption rates by technology, EU27 (%)

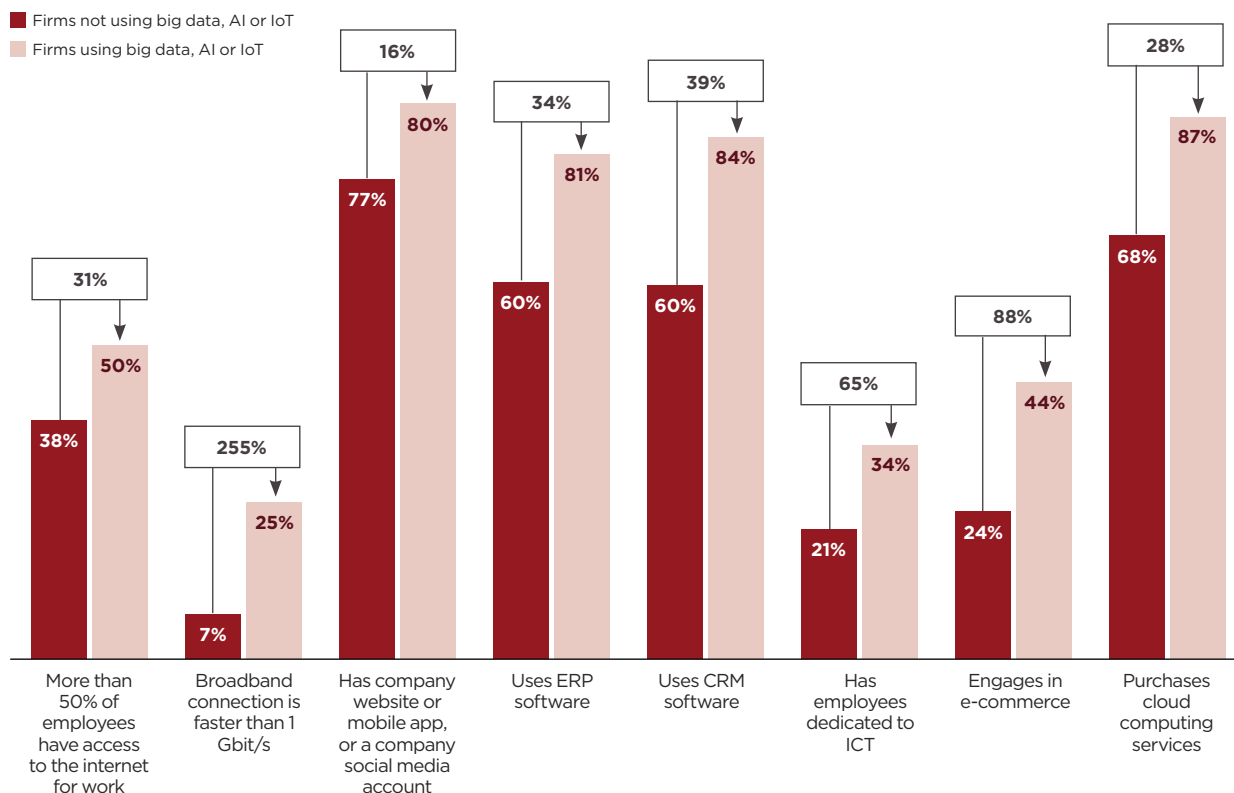


Source: OECD.

Figure 13 shows adoption rates for two groups of firms in China: those that use big data, AI or IoT, or those that do not. As one might expect, firms using the most advanced technologies have stronger digital foundations, but some characteristics stand out.

**Figure 13: Firms using digital intelligence are more digitally sophisticated**

Adoption rates for using and non-using firms by technology, China (%)



Source: Economist Impact China Intelligent Transformation 2022 survey.

The first is that internet speed matters. Firms using intelligent technologies are 2.6 times more likely to have a broadband connection of at least 1 Gbit/second than firms that haven't yet deployed those technologies. Using firms are also 65% more likely to have dedicated ICT staff, which is unsurprising given the specialised nature of digital intelligence.

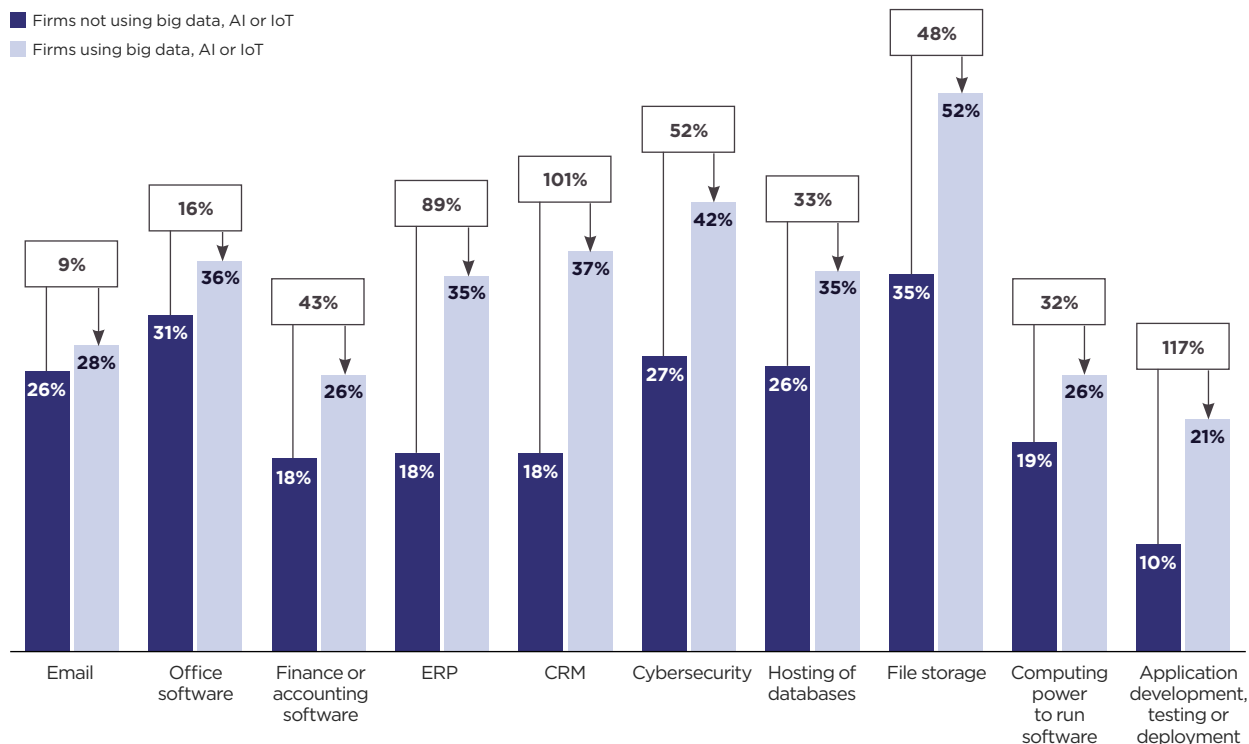
E-commerce and CRM are interesting, as neither are considered critical for development of digitally intelligent systems. A plausible interpretation is that many firms will use their CRM database for running big data analysis in order to understand their customers and conduct more effective marketing campaigns. Likewise, firms engaging in e-commerce are likely to be compiling data on online customer transactions and browsing histories (either themselves or through third-party e-commerce platforms) and performing marketing analysis.

The low increases associated with cloud computing are puzzling, as any organisation seeking to store and process vast amounts of data is likely to require cloud infrastructure. However, the puzzle is resolved when one considers the diverse range of software services provided through the cloud, ranging from email to virtual computing environments. Figure 14 shows a similar chart to the one above but for specific use cases of cloud services.

The leading use cases of cloud in China are file storage and office software used for productivity. These use cases are common across all types of firms. Cloud for application development and in CRM usage is a unique juxtaposition. Although the likelihood of using these technologies doubles for firms using big data, AI or IoT, their adoption level remains low. Only 21% of firms using intelligent technologies employ cloud for application development, suggesting that many of the digital intelligence applications in use may be provided by third parties.

**Figure 14: Firms using digital intelligence have more unique use cases for cloud**

Adoption rates for using and non-using firms by cloud use case, China (%)



Source: Economist Impact China Intelligent Transformation 2022 survey.

**Figure 15: Patterns in the EU closely match those in China**

		Independent variable								
		Connected			Organised			Amplified		
		% of employees using a computer with Internet access	% of businesses with a broadband connection	% of businesses with a website	% of businesses using CRM	% of businesses using ERP	% of businesses employing ICT specialists	% of businesses purchasing cloud computing services	% of businesses using e-commerce	
Dependent variable	% of businesses using AI	+++			++		+++		+++	
	% of businesses using big data analysis				++		+++		+++	
	% of businesses using IoT						+++		+++	

+++ Very high significance level (p<0.01) ++ High significance level (p<0.05)

Source: Economist Impact analysis, Eurostat data.



The analysis of data from the EU confirms a similar pattern of technology use. For the EU, the analyst team regressed the adoption rate of each “intelligent” technology (AI, big data and IoT) on each of the variables in the framework above using detailed industry-level data across all EU countries.<sup>10</sup> Figure 15 shows the strength of the correlations for each regression.

Mirroring the China analysis, “intelligent” is correlated with cloud computing, the employment of ICT talent and CRM usage. There are numerous sub-indicators that also help to explain intelligent transformation. For example, while “percentage of enterprises with broadband connection” is not a good predictor of digital intelligence, “percentage of enterprises with a broadband connection of at least 100 Mbit/second” has strong explanatory power.

The analysis broadly points to three factors that are critical for effective intelligent transformation: data (embodied in CRM), infrastructure (high data transfer speeds, powerful computing and storage) and talent. These are by no means exhaustive but provide a good general indication of the critical inputs required for successful transformation.

The conclusion is not that any firm that adopts these technologies will successfully achieve intelligent transformation. But governments aiming to realise their AI ambitions ought to be interested in the ample supply of these inputs if their firms are to succeed.

### Benchmarking countries

Finally, it is instructive to benchmark countries’ performance on the four pillars to understand areas in which they perform well. Figure 16 shows the rankings based on the composite score of indicators within each pillar. The order of countries is based on their ranking in the Intelligent Transformation Index (the final pillar, “intelligent”).

“Connected” is the most basic foundation for transformation. There are only five

countries where fewer than 90% of businesses have broadband access. Nearly 80% of businesses had websites by 2021. For example, in the EU a majority of employees now have access to the internet. The advanced economies of northern Europe dominate top echelons of the “connected” ranking. All firms in Denmark and Finland are connected via broadband and more than 90% of them have a website. Over 80% of staff in Finland, Norway and Sweden have internet access for their work. Japan is the most connected country in Asia (6th overall), on par with Norway. The other relatively advanced economies in western Europe and North America are in the middle bracket.

Central, southern and eastern Europe generally have lower scores. Greece sits at the bottom of the ranking; only 82% of its businesses have broadband access. The country also has low high-speed broadband penetration and below-average internet connectivity among EU countries.<sup>11</sup>



**Figure 16: Benchmarking countries in digital transformation**

Rank of countries based on composite score for each pillar

Country	Connected	Organised	Amplified	Intelligent
Denmark	3	3	3	1
Finland	1	5	4	2
Netherlands	4	4	6	3
Sweden	2	18	1	4
Ireland	16	11	5	5
Belgium	9	1	8	6
Germany	11	10	19	7
United Kingdom	12	15	9	8
Slovenia	13	25	17	9
Austria	8	6	16	10
Luxembourg	15	8	31	11
Norway	5	14	7	12
Portugal	30	12	25	13
China	22	2	10	14
France	18	16	27	15
Japan	6	7	12	16
Italy	23	26	13	17
Spain	20	9	20	18
Czech Republic	21	24	18	19
Lithuania	14	19	14	20
Greece	32	22	30	21
Latvia	28	23	29	22
Korea	19	13	23	23
Slovakia	26	27	24	24
Brazil	27	21	15	25
Turkey	31	31	32	26
Estonia	17	30	11	27
Hungary	29	28	26	28
Poland	25	17	28	29
Canada	10	32	22	30
Australia	7	20	2	31
Israel	24	29	21	32

Sources: OECD, various national sources—see methodology note for full annotation.

Moving into the “organised” pillar, northern Europe again tops the index. Talent is a differentiator; notably, a high proportion of firms hiring ICT talent explains Belgium’s strong ranking in this phase. China’s second-place ranking is explained by high adoption rates of CRM and enterprise resource planning (ERP; see section 4 for detail). Sweden’s relatively lower rank is due

to the low proportion of firms employing ICT specialists—possibly a consequence of persistent shortages of local ICT specialists, even though the labour force is among the most digitally skilled in the EU.<sup>12</sup>

The top two countries in the “amplified” ranking, Sweden and Australia, respectively represent the two key components of

the pillar: cloud and e-commerce. In Sweden, 75% of businesses are purchasing cloud services. In Australia, nearly half of firms take orders online. There are some surprising laggards, however. Germany (19th) has a relatively smaller proportion of companies engaging in e-commerce compared to its peers. This gap is partially a consequence of industrial structure. Despite a large consumer-facing e-commerce sector, the country's dominant industries, in particular automotive and heavy manufacturing, are less likely to sell products on online channels.

In general, each of the pillars are correlated, which is unsurprising given how various technologies tend to build on one another. For example, broadband facilitates faster cloud connections, which can then support digital intelligence work. Therefore, countries performing well in one pillar will generally perform well in others.

However, there are exceptions, which provide for the most interesting cases. For example, while Ireland ranks in the top five in the "intelligent" ranking, it ranks only 16th in "connected" owing to rather average levels of broadband and website adoption. This may reflect the fact that while Ireland has emerged as a European hub for many technology firms owing to favourable tax conditions, it has a low rate of diffusion of digital intelligence for non-ICT firms when compared with the other top-five countries.

At the other end of the ranking, there are a few countries that score poorly in "intelligent" but well in other pillars. Canada and Australia respectively rank 31st and 32nd in "intelligent" but rank 10th and 7th place in "connected". Australia ranks 2nd globally in "amplified" owing to high e-commerce and cloud adoption. Scoring well in more basic areas of digital transformation is no guarantee of success in digital intelligence.

### Benchmarking China in digital transformation

Adoption rates for businesses in China are shown for the 11 indicators in the digital transformation framework (discussed in section 3) in figure 17. As a general heuristic it is useful to remember that of the 33 countries benchmarked, China ranked second last (before Brazil) in GDP per capita (US\$ PPP) in 2021. Given that digitalisation tends to go hand in hand with economic development, one might expect China to rank at roughly the same level for the 11 indicators.

This is far from the case. On most indicators, China performs above its level of economic development. This is especially true for indicators involving deployment of third-party software. China ranks in the top three for CRM, ERP and cloud usage, with 66%, 63% and 75% of businesses reporting use of each technology, respectively.

**Figure 17: China performs well in use of third-party business software and cloud services**

Pillar	Indicator	Adoption rate (%)	Rank (of 33 countries)
Connected	% of employees using a computer with internet access	46.4	29
	% of businesses with a broadband connection	100.0*	1*
	% of businesses with a website or social media account	78.6	19
Organised	% of businesses using CRM	65.5	1
	% of businesses using ERP	62.6	3
	% of businesses employing ICT specialists	20.4	21
Amplified	% of businesses purchasing cloud computing services	75.1	3
	% of businesses using e-commerce	27.1	18
Intelligent	% of businesses using big data analysis	10.8	16
	% of businesses using AI	12.5	6
	% of businesses using IoT	28.1	9

\*Broadband adoption rate is 100% by default since the survey was conducted online

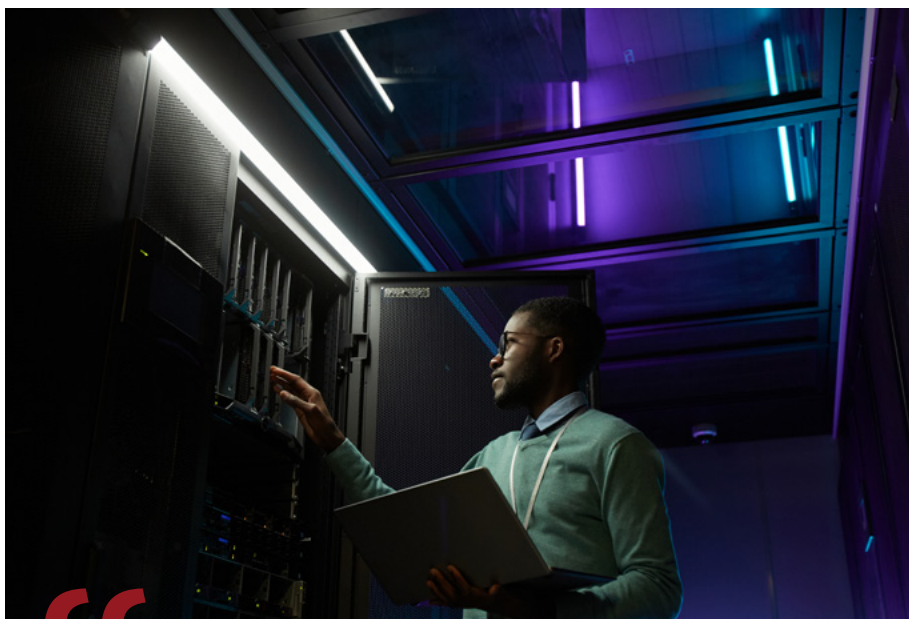
Source: Economist Impact

It is worth noting significant differences in the internet landscape between China and other countries that may affect the interpretation of China's scores, notably for CRM. Firstly, China's internet users primarily engage in online activities and media consumption with their mobile devices—much more so than in other countries. Secondly, social media apps, notably WeChat, are heavily integrated into e-commerce and online marketing. Many firms may not have a website but communicate to potential customers through their official WeChat account. A CRM application in China may thus consist simply of an interface that allows a business to manage and interact with followers of its WeChat account.

Thirdly, China's e-commerce giants have been investing heavily in offline retail. This can include establishing their own brick-and-mortar stores, as firms like Alibaba have done, or partnering with existing store owners, who can “plug in” to the e-commerce firm's orders system in exchange for shelf or warehousing space (see case study in next section). This allows small business owners to essentially hyper-digitalise their operations.

The unique nature of China's internet development has led to the country's businesses following a different trajectory of digitalisation—one that lends itself to use by small and medium-sized businesses and leverages the scale of its internet giants' capabilities and user base. “The partnership between SMEs and internet giants is a key part of China's success in intelligent transformation,” says Yin Xi, a neurolinguistic programming algorithm expert in the AI Platform Technology Research Center at the International Digital Economy Academy, a China-based technology think-tank. “Once you merge with a big partner, you share the data, and data is the most important asset [for intelligent transformation].”

Where China performs less well is on indicators relating to digitalisation of the workforce. Only 46.4% of employees in Chinese firms have access to an internet



### The partnership between SMEs and internet giants is a key part of China's success in intelligent transformation.

**Yin Xi**, a neurolinguistic programming algorithm expert in the AI Platform Technology Research Center at the International Digital Economy Academy

connection for work, putting China in 29th place on this indicator. This suggests that a high proportion of Chinese workers are not engaged in tasks requiring a personal computer or internet access. The share of businesses that employ specialised ICT workers is also relatively low, at 20%.

Another surprise is China's e-commerce ranking. The country's share of e-commerce in total retail sales stood at 32% in 2021, the highest rate in the world, yet only 27% of businesses in the survey reported using e-commerce. Here, it is useful to remember that e-commerce usage tends to be concentrated in firms engaged in the sale of consumer goods. If the survey focused on manufacturing and retail firms, China's e-commerce adoption ranking would be much higher. Given the broad sectoral coverage of the survey, which include non-consumer sectors such as ICT services and construction, China's e-commerce ranking is only average.

## China's AI-using mom-and-pop stores

In many countries, the local family-run grocers tend not to be plugged into the analytics engine of a multibillion-dollar tech giant. Yet that is exactly what is happening under the JD.com Convenience Store programme. JD.com is the country's second largest e-commerce platform. Under a partnership programme launched in 2017, virtually any convenience store can convert itself into an e-commerce delivery hub.

The arrangement is simple. The store owner maintains ownership over the store and operating costs. The store is either wholly or partially supplied by JD.com, which handles logistics and deliveries to customers. JD.com installs the digital infrastructure required for inventory management, purchasing and receiving orders and provides training to the store staff.

Effectively, this transforms the store overnight from a traditional brick-and-mortar retailer into a hybrid shop/e-commerce logistics hub. Any order placed on JD.com could potentially be fulfilled from the partner store. In exchange, JD.com is able to deepen its penetration in offline markets while at the same time securing valuable storage space for the goods it handles. JD.com's main rival, Alibaba, has also announced a similar programme but is less ambitious in its expansion plans.

A similar phenomenon is occurring among restaurants. While food delivery apps have been around for years, China's tech giants are taking them to the next level. An increasing number of restaurants in China have now done away with in-person ordering, instead opting to place a QR code on each table that diners can scan and order from. This may not suit all customers, but it certainly saves on staff costs and creates a powerful customer transaction database that is ripe for data analytics.

### China's digital intelligence divide

As a first step to understanding adoption of digital intelligence in China, a sectoral comparison is helpful. Using the same methodology and indicators in section 2, a Sectoral Intelligent Transformation Index is calculated for ten industries across 31 countries. Figure 18 shows China's sectoral scores compared with the OECD average and China's ranking.

There is considerable variation in China's sectoral performance. There are three sectors where China performs well: manufacturing; construction; and professional, scientific and technical activities, for which the country ranks 3rd, 4th and 3rd respectively. China's ICT services sector also performs better than average, but only marginally. For the remaining six sectors, notably transport and storage, and the accommodation and food and beverage industries, China's performance trails behind. "In China, those sectors are more conventional [than the leading sectors]," says Mr Yin. "They

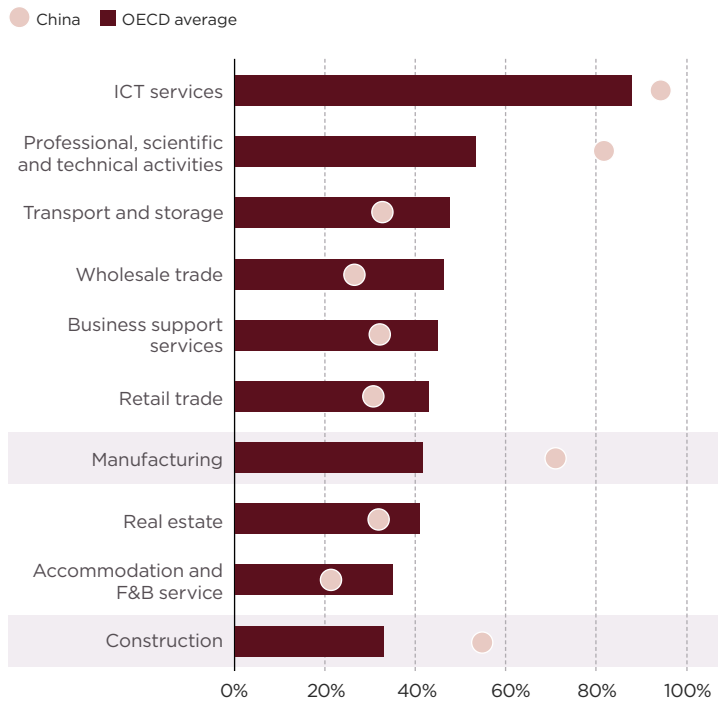
generally don't have the full infrastructure to support intelligent transformation," meaning foundational elements such as high-speed internet and cloud.

In fact, considering the size of this "gap" between leading and lagging industries compared with other countries, China stands out as having the highest variation in industry performance (see figure 19), pointing to significant imbalances in digital intelligence adoption across sectors.

**China stands out as having the highest variation in industry performance, pointing to significant imbalances in digital intelligence adoption across sectors.**

**Figure 18: China performs exceptionally well in manufacturing and construction but lags in many other sectors**

Average adoption rate of big data, AI and IoT

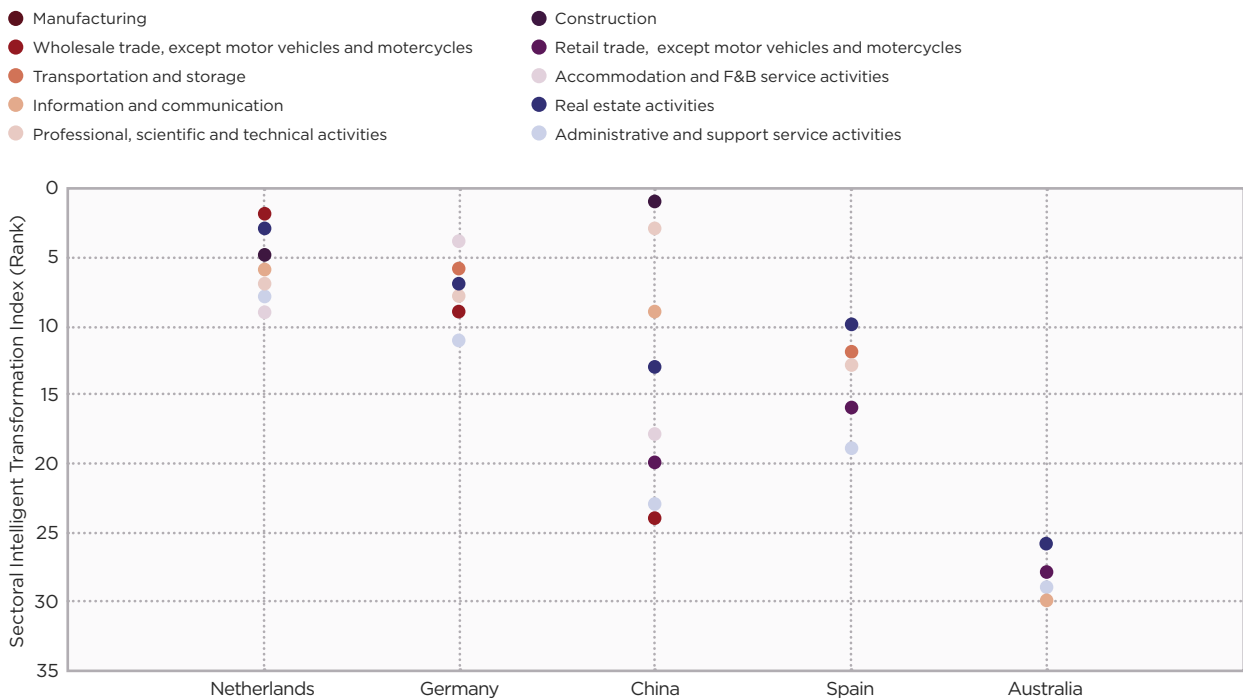


China's sectoral Intelligent Transformation Index ranking

Sector	Rank (out of 31 countries)
Manufacturing	3
Professional, scientific and technical activities	3
Construction	4
ICT services	14
Real estate	17
Retail trade	22
Business support activities	23
Wholesale trade	25
Accommodation and F&B service	25
Transport and storage	26

**Figure 19: China has the highest variation in sectoral performance**

Sectoral Intelligent Transformation Index, select economies



Sources: Economist Impact China Intelligent Transformation 2022 survey, OECD.



While imbalances can indicate the presence of market failures or market-distorting policies, there are good reasons why this case can be benign. It is worth considering whether the imbalance is due more to higher performance of China's manufacturing and construction sectors, or to the poor performance of its transport, accommodation and F&B, and wholesale sectors. As described above, China's overall performance in the Intelligent Transformation Index is well above its level of economic development. While certain sectors in China are underperforming in relative terms compared with other sectors in China and with other OECD countries, they are nonetheless still performing at an appropriate level in absolute terms when taking China's GDP per capita into account.

A more interesting question, then, is how China's manufacturing and construction sectors came to be in such a leading global position? In 2021 China was the world's largest manufacturing economy. Manufacturing in China is highly globalised. It is the top production hub for multinationals in the manufacturing sector, which have transferred technology to their operations in China for the better part of four decades. Today, it is not just subsidiaries and joint ventures of multinationals but also domestic firms that are making use of advanced manufacturing capabilities, and the technological sophistication of manufacturers in China is world-beating in all but a few highly specialised sectors.

With much of the country's manufacturing capacity established in the past two decades, China has been able to incorporate the latest technologies into its manufacturing without having to grapple with legacy equipment and systems. This contrasts with other manufacturing-oriented economies such as Japan, which experienced its boom in the 70s and 80s. China's construction industry has witnessed a different type of boom. China's construction sector is comparatively less globalised. It is dominated by domestic firms. But like manufacturing it has been a critical driver of the country's

economic growth since the early 2000s. The establishment of China's private housing market in the late 1990s and a wave of government-led investment in transport and telecommunications infrastructure combined to create a construction boom on a scale that the world had never seen before.

**Manufacturing and construction have long held a favoured position in China's development model, which may help to explain why these sectors show such high rates of adoption of digital intelligence. This has created a "digital intelligence divide" between the two leading sectors and other parts of the economy.**

China's government has promoted the growth of these sectors, often to the consternation of trade partners and competitors. Government incentives to promote foreign investment, exports and technological upgrading in manufacturing have contributed to the sector's phenomenal growth in recent decades. At the same time, significant government allocation of capital to infrastructure, as well as favourable tax conditions for the property sector, has turbo-charged the country's construction industry. In 2021 52.7% of the country's GDP came from industry, the third-highest ratio in the world, behind energy-rich Saudi Arabia and Azerbaijan.<sup>13</sup>

Manufacturing and construction have long held a favoured position in China's development model, which may help to explain why these sectors show such high rates of adoption of digital intelligence. This has created a "digital intelligence divide" between the two leading sectors and other parts of the economy. The divide may be benign, given that the lagging sectors still perform on par with China's level of economic development, and it may resolve over time as government development priorities shift to the services sector. But as with all economic imbalances, it is worth keeping an eye on.

## Use cases of digital intelligence in manufacturing

China’s manufacturing sector ranks 3rd among the 31 countries studied, led by high adoption rates of AI and IoT. In figure 20, the main use cases of AI and IoT are shown for the manufacturing sector in four countries/regions for comparison: China, Germany (Europe’s leading manufacturing economy), the EU and the leading countries in the adoption of AI and IoT. In the case of manufacturing sectors, these are Denmark and Austria respectively.

Bearing in mind that the use cases are non-exhaustive, there are some notable differences between China and European countries. Starting with AI, China has significantly higher adoption of AI for replicating human cognitive functions such as image or speech recognition and natural language processing. But it trails Denmark, the leading country, when it comes to “automating workflows and assisting in decision-making”. This may suggest that while companies in China have adopted task-specific intelligent technologies, they have yet to integrate their use into more complete automated systems that can make autonomous decisions based on diverse sources of data.

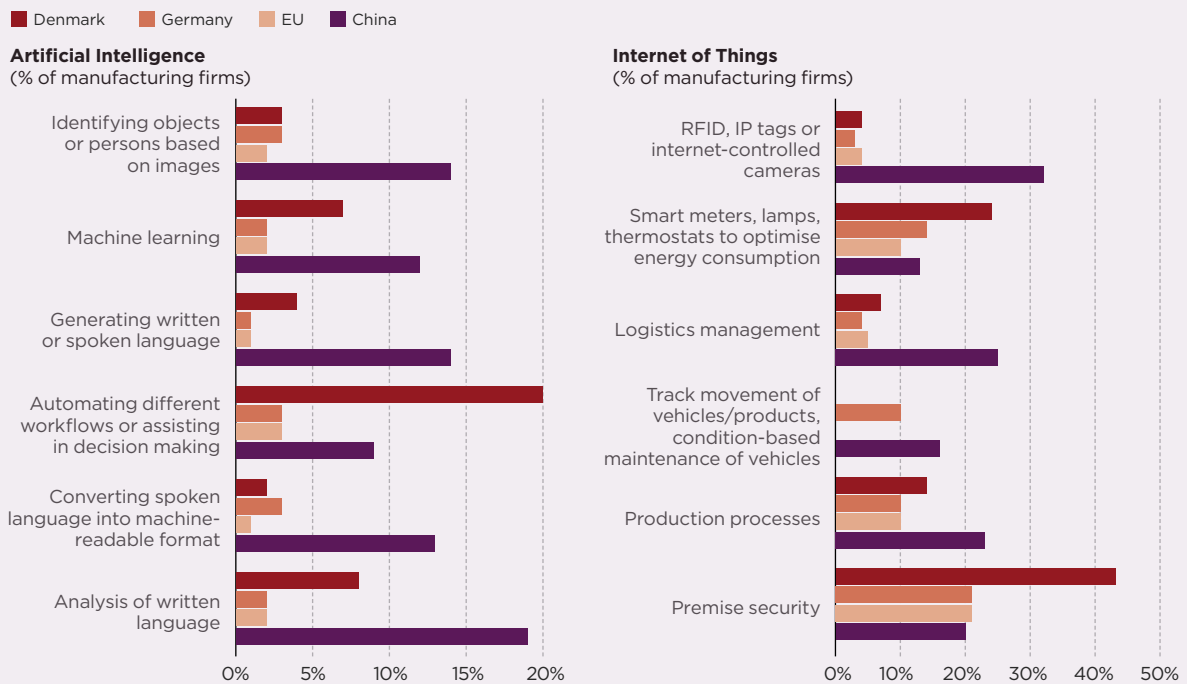
In IoT, China’s use cases appear to be focused

on management of logistics and production. In particular, China also has extraordinarily high deployment of cameras, which can be used for a variety of purposes, ranging from vehicle tracking to quality control or surveillance. By contrast, the leading use cases in Austria (which leads in manufacturing IoT use) and the wider EU appear to be in two areas—premises security (alarms, sensors and so on) and energy consumption management.

It is not yet clear what drives different use case patterns across countries. One plausible explanation for the most widespread use of energy management devices in European countries is the higher cost of energy (which is subsidised in China), driving the need for more efficient energy use. Higher crime rates may also explain more rigorous use of smart alarm systems in some countries. Smart logistics may be more critical in sub-sectors that rely on complex supply chains and just-in-time inventory management such as manufacturing of electronic devices.

The production- and logistics-oriented use of IoT in China is unsurprising given the country’s role as a global manufacturing hub.

**Figure 20: China’s use cases of digital intelligence differ from European countries**



Sources: Economist Impact China Intelligent Transformation 2022 survey, Eurostat.

**SECTION 4**

# Where next for intelligent transformation?

**Section summary**

- Although more ICT workers are entering the workforce, the share of firms employing ICT staff has remained flat, most likely due to a limited number of technology firms absorbing much of the talent.
- Large and medium-sized firms are increasingly outsourcing technology needs to external vendors to overcome the ICT talent crunch, but the trend is less clear for small firms.
- The emergence of AI-as-a-service and increasingly accessible methods to implement machine-learning methods will lower the expertise and cost barrier for small firms to adopt digital intelligence, although other barriers such as lack of data still need to be overcome.
- Production automation through adopting digital intelligence does not necessarily lead to replacement of human workers. Many emerging applications of digital intelligence serve to augment rather than substitute the tasks of human workers. A key challenge of intelligent transformation for firms will be to find the right balance between task augmentation and full automation.



As this report documents, the digital intelligence boom is still in its infancy. Significant gaps in adoption remain across sectors and countries, but digital intelligence is being deployed on a wide scale. The transformation will not happen overnight. Building digital infrastructure can be a relatively quick process, but the process of equipping the workforce with the necessary skills and waiting for organisations to adapt to an increasingly data-driven and automated way of doing things may take decades.

Yet, the forces of economics and technology have a way of unpredictably accelerating change when it comes to things that society values. In the mid 1970s American technology executives were still debating whether there was any point in making computers for home use. Even if you could make them small and cheaply enough, no one would have any purpose for these unwieldy machines or the specialised knowledge to be able to use them, sceptics argued.<sup>14</sup>

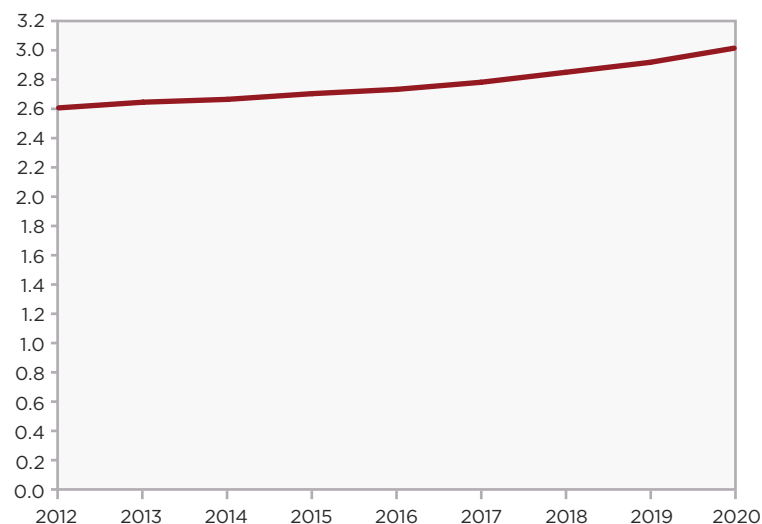
Just as innovations like the graphical user interface shifted computer navigation away from typed text commands to clicking on icons and using touchscreens, making computing accessible for billions of people, there are scores of initiatives underway to make big data analysis and AI available to non-specialists. This section explores how emerging trends are changing the way that adopting firms are engaging in digital intelligence.

### Intelligence as a service?

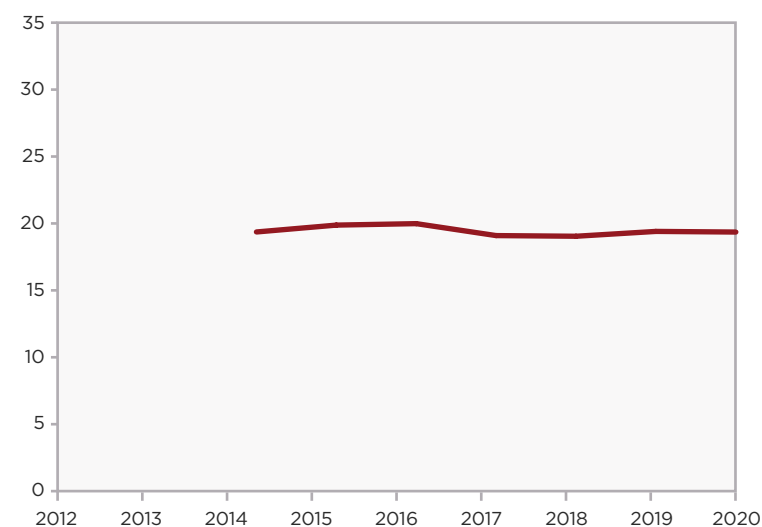
One of the most significant barriers to increasing adoption of new digital technologies is the difficulty in recruiting ICT professionals.<sup>15</sup> Fifty-five percent of companies in the EU reported difficulty in filling ICT vacancies in 2021, and the share of companies that employ ICT talent has remained flat for much of the past decade (see figure 21). The trend stands in contrast with the prevalence of ICT workers in the labour force, which is steadily increasing. The likely conclusion from these two trends is that a limited number of firms are doing most of the hiring of technology workers.

**Figure 21: The share of ICT workers in the workforce is increasing but the share of firms hiring them is not**

**Share of ICT employees in total employees %**  
(EU Aggregate)



**Enterprises employing ICT talent %**  
(EU Aggregate)



Source: Eurostat.

The critical question for policymakers is how much of a problem this poses. On the one hand, the inability to hire ICT staff suggests that companies will be unable to meet their own digital transformation demands. On the other, the adoption of technologies such as AI, big data and IoT have all risen despite the talent shortage. There are generally far more companies using technology such as CRM, ERP, e-commerce and cloud than there are companies that employ ICT staff.

What has enabled this talentless digital revolution? Faced with high costs of employing in-house ICT staff, many companies have begun to rely on or include external service providers in their operations. The trend is especially prominent for large companies. Figure 22 shows data for firms that employ ICT staff and the evolving split of work done by internal and external ICT teams. Between 2015 and 2018 the share of large firms reporting that their ICT functions were mainly being performed in house fell from 41% to 36%, while those relying on external suppliers increased from 13% to 15%.

Working with external technology suppliers can take many forms. In some cases, companies may work with large teams of consultants who develop systems from scratch. These solutions tend to be costly and generally used when a high degree of customisation and support is required. A lower-cost alternative is to enter the rapidly emerging landscape of out-of-the-box solutions delivered via the cloud that can be deployed with little or no customisation.

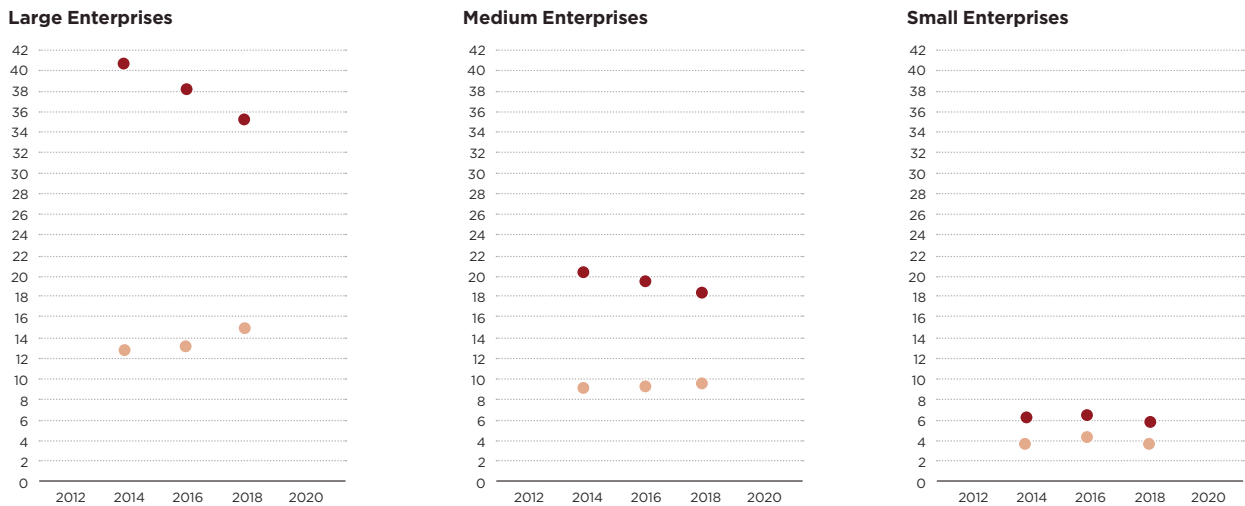
The “servicisation” of ICT functions is a phenomenon neatly encapsulated in the term “everything as a service”, or XaaS. Essentially, ICT functions ranging from

software applications to infrastructure are increasingly being outsourced, obviating the need for in-house ICT staff. Today, nearly all large tech companies, from Microsoft to Salesforce are offering some form of technology as a service.

Perhaps unsurprisingly, the term “AI-as-a-service” (AlaaS) has already begun to enter common usage. However, the current range of AlaaS solutions is not for the technologically faint of heart. These typically include interfaces or environments that allow programmers to draw on a more powerful machine-learning or big-data back end, such as a sentiment analysis algorithm to understand what customers are saying about their company’s products. In 2019 6.6% of companies in the EU said that they were using big data techniques to analyse social media. Another emerging example of AlaaS is chatbots, predominantly used to respond to customer service inquiries. Although generally considered to be inferior to an actual person, they can be a first line of response for the most common queries received or can triage queries to the right customer service agent. Some 1.1% of businesses in the EU reported using AI to generate written or spoken language in 2021. The same figure for China in 2022 was 6.3%.

**Figure 22: Large and medium-sized firms are increasingly relying on external suppliers for ICT**

- Employ ICT specialists and ICT functions are mainly performed by external suppliers (EU Aggregate)
- Employ ICT specialists and ICT functions are mainly performed by own employees (EU Aggregate)



Source: Eurostat.

With time, the range of AlaaS solutions and the number of firms adopting them are likely to expand dramatically. Future use cases for small businesses could include complex tasks such as financial planning and inventory management, which for now are generally the domain of the world’s largest and most sophisticated firms.

**Going codeless**

Although computer scientists that develop core machine-learning algorithms remain an elite group, a bigger group of analysts using higher level programming languages, such as R and Python, are able to deploy intelligent solutions without knowing the inner workings of the code. Many of the most transformative intelligent applications are now available for free from open-source libraries. Figure 23 shows how usage of machine-learning packages in R has ramped up in recent years. Many of today’s university students studying a quantitative discipline will encounter these languages in their studies.

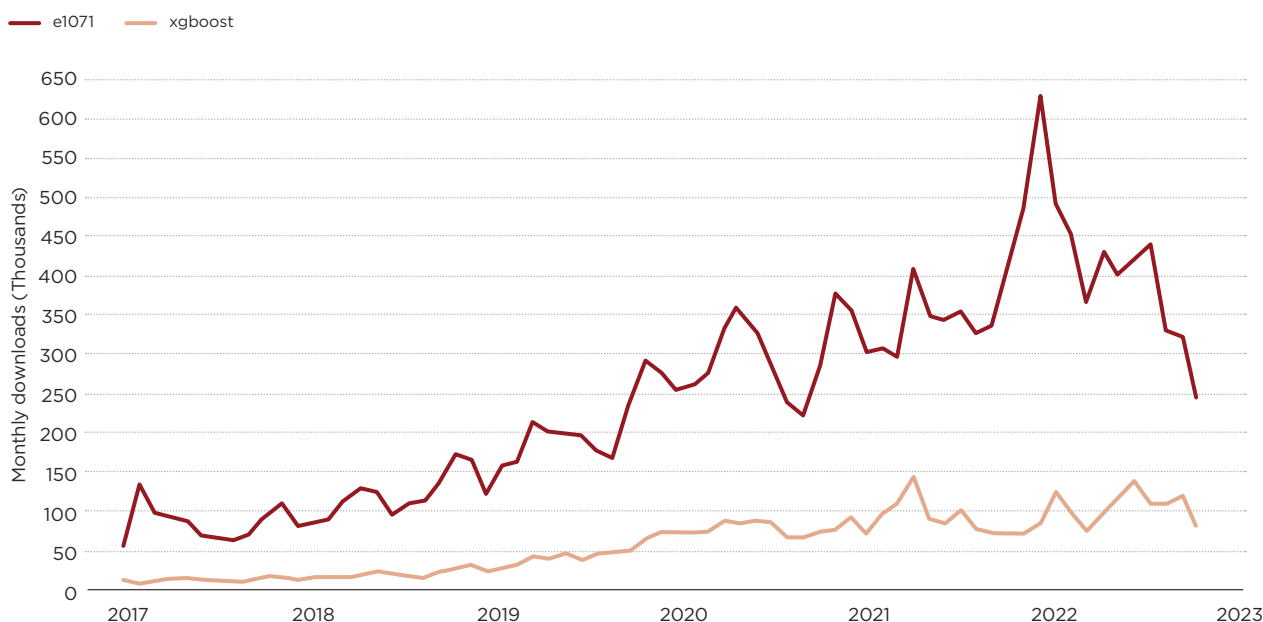
There are many emerging workarounds available to surpass the need for core coding acumen, ranging from “low-code” to “no-code” options. In the case of low-code,

the most complex steps of building machine learning models are pre-coded and readily available for use through downloadable packages, although a minimal degree of code is still required to make everything work.

The “no-code” movement is breeding a new generation of software that allows users to train algorithms to recognise visual objects or audio and deploy chatbots without needing to write any code at all. Start-ups like DataRobot, obviously.ai and Pecan offer an intuitive user interface to allow users to build a machine learning model and generate predictions with the user’s own data. OpenAI’s GPT-3 even helps to translate instructions from plain English into code.

The natural language revolution, which has seen large leaps in computers’ ability to interact with users in human tongues, not only makes AI accessible, but affordable. The salaries of top machine-learning engineers can easily start above US\$1m—far too expensive for all but a small subset of elite internet firms and financial institutions. Conversely, the best available neurolinguistic programming and natural language generation models are available for US\$100 or less per million words.

**Figure 23: Monthly downloads of machine-learning packages in R**



Source: Eurostat.



Readers may recall when, in 2011, Watson, a supercomputer developed by IBM, made headlines by winning Jeopardy, a popular US TV gameshow. Today’s models, some available for public use, would not flinch at completing the same challenge. One such model is GPT-3, which answers the question “Can you explain why intelligent transformation is important for small businesses?” below.

“The research breakthroughs have led to these large improvements in capabilities of the models,” says Fraser Kelton, who leads the API team at OpenAI, the research institute behind GPT-3. “I think many people haven’t yet fully digested that the increase in capabilities has come with an equivalent increase in accessibility.”

Whether no-code, low-code or AlaaS is the future of widespread AI adoption remains to be seen. Emerging start-ups in AI services have demonstrated that specific tasks with a wide range of applications such as image, video and audio or speech recognition are well within reach—and affordably so—of non-expert users.

There are also more specialised industry offerings in place. For example, financial services firms have long used machine learning to analyse movements in asset prices or evaluate the risk of loan default or fraudulent transactions. These too, are beginning to be offered in AlaaS form, providing a level of accessibility and affordability hitherto out of reach for many firms.

**Figure 24: An AI language model (GPT-3) explains intelligent transformation**

Prompt	GPT-3 answer
<p>Can you explain why intelligent transformation is important for small businesses?</p>	<p>There are a few key reasons why intelligent transformation is important for small businesses:</p> <ol style="list-style-type: none"> <li>1. Technology has become more democratised, meaning that small businesses have access to the same types of tools and platforms as larger businesses. This level playing field gives them the opportunity to compete in new and innovative ways.</li> <li>2. The global economy is becoming more interconnected, and small businesses need to be able to operate in this environment. Intelligent transformation can help them do this by automating processes, improving communication and collaboration, and providing access to new markets.</li> <li>3. Intelligent transformation can help small businesses improve their efficiency and productivity, which can lead to increased profits. Additionally, it can help them better manage their resources and better understand their customers.</li> </ol>

## Human-in-the-loop: augmentation over automation

Some of the most exciting transformation is taking place through applications where a programmer and algorithm trade tasks back-and-forth as part of a larger effort. “The case where we’re seeing consistently great results from companies is when the AI is augmenting a human experience, but a human remains in the loop,” says Fraser Kelton, head of the API team at OpenAI. Rather than displacing humans, an algorithm is augmenting creativity and efficiency. One advantage of that approach is that a human can identify shortcomings in a machine-learning model that may not be obvious until real-world deployment.<sup>16</sup> In this sense, not only is human-in-the-loop machine learning more effective, it also mitigates the risk that an algorithm will take any unethical turns based on its input.

The complementarity between humans and algorithms will come as welcome news to those concerned about mass redundancies stemming from increased automation. Rather than being replaced by algorithms, it is more likely in the short term that humans will find their work being increasingly assisted by intelligent applications. According to Bjorn Brynjolfsson, the director of the Digital Economy Lab at Stanford University, “a common fallacy is to assume that all or most productivity-enhancing innovations belong [to] automation ... augmentation has been far more important throughout most of the past two centuries.”<sup>17</sup>

As algorithms become smarter, humans will inevitably be taken “out of the loop” for an increasing number of tasks. It would be naive to forecast when that moment will arrive, but it is still important to resist the urge to latch onto the most sensational forecasts about digital intelligence and human labour. Digital intelligence can improve labour productivity, and with it, increase incomes and living standards, says Mr Brynjolfsson.

The caveat to this positive outlook is that those increases are likely to be unevenly distributed even if the aggregate effect is beneficial.<sup>18</sup> The largest gains will go to those developing and maintaining the technologies discussed. Those with jobs that require the performance of repeated tasks are likely to experience the brunt of job displacement. Jobs requiring empathy or complex judgement are likely to remain—for the time being.

Yet, although sophisticated technology is becoming accessible to anyone with the inclination to use it, there remains a missing piece of the puzzle that the AI industry has yet to solve. The predictions generated by models, no matter how sophisticated, are only as good as the data fed to them. Most small business owners do not possess vast datasets on their finances, operations and customers. If digital intelligence is truly to proliferate among small businesses, the prerequisite is that these firms are able to

build data gathering and management systems.

This may be too much to ask of the proverbial mom-and-pop corner grocer. Mr Bianchini points out that SMEs are “a bit overwhelmed by the software offering. It is difficult for them to navigate and make an investment in these solutions.” But there may be a third way. China’s e-commerce giants have been partnering with small brick-and-mortar retailers to merge their

physical store space with the digital nerve centre of firms like Alibaba and JD.com (see case study in section 4). Partnering with larger, digitally native firms may be one approach for SMEs to tap into a vast network of digital intelligence overnight. But it also raises new questions. If a store is not managing its own CRM or inventory, is the store still the same store? How much autonomy will the store owner still exercise versus a machine? These are the questions that businesses will need to grapple with in the age of digital intelligence.

All of this evidence points to an inevitable disruption as a consequence of intelligent transformation. In the context of today's economy, such a prospect may prompt concern about vast dislocation. However, waves of technological change have a tendency to create more jobs in the long term than they destroy. Organisations that are able to adjust to a new equilibrium that capitalises on the complementarities of emerging technologies and their workforce will be well-placed to weather the disruption.

# Methodology

Full indicator tables and data sources

**Figure A: Digital transformation full indicator table**

	Persons employed using a computer with Internet access (%)	Businesses with a broadband connection -includes both fixed and mobile (%)	Businesses with a website or home page (%)	Businesses using ERP (Enterprise Resource Planning) software (%)	Businesses using CRM (Customer Relationship Management) software (%)	Businesses which employ ICT specialists, within the last 12 months (%)	Businesses receiving orders over computer networks (%)	Businesses purchasing cloud computing services (%)	Businesses having performed Big data analysis (%)	Businesses using Artificial Intelligence (AI) (%)	Businesses using Internet of Things (IoT) (%)
Denmark	76	100	94	50	42	30	38	65	27	24	20
Finland	85	100	96	48	46	26	29	75	22	16	40
United States	65	94	66	65	56	30	11	52	24	15	30
Netherlands	73	99	92	43	52	25	28	65	27	13	21
Sweden	83	99	90	35	38	18	36	75	19	10	40
Ireland	61	95	79	24	32	32	40	59	23	8	34
Belgium	66	98	87	57	54	28	31	53	23	10	28
Germany	60	95	88	38	45	19	22	42	18	11	36
United Kingdom	63	95	84	28	31	27	29	56	27	4	-
Slovenia	58	99	83	36	22	18	27	43	7	12	49
Austria	64	98	89	45	46	20	30	40	9	9	51
Luxembourg	54	98	84	40	35	25	12	33	19	13	22
Norway	83	96	78	39	39	19	26	64	19	11	24
Portugal	44	98	59	52	25	21	17	35	11	17	23
China	45	100	78	58	58	18	22	74	10	13	31
France	63	96	72	45	32	17	18	29	22	7	22
Japan	71	96	92	38	38	27	25	65	10	14	14
Italy	54	94	72	32	27	16	18	60	9	6	32
Spain	58	96	76	49	40	17	28	31	9	8	27
Czech Republic	50	97	83	38	18	20	25	44	9	4	31
Lithuania	59	100	80	45	32	15	36	34	11	4	28
Greece	45	82	59	35	20	22	21	22	13	4	22
Latvia	52	88	64	39	18	20	17	29	9	4	28
Korea	63	100	67	62	19	-	22	30	9	8	-
Slovak Republic	50	92	73	31	22	18	17	36	6	5	27
Brazil	54	97	53	28	22	26	22	54	10	6	-
Turkey	48	95	52	28	11	14	12	11	9	3	21
Estonia	55	98	81	23	23	15	23	58	10	3	17
Hungary	53	87	62	21	15	26	20	26	7	3	22
Poland	53	96	70	32	32	23	18	29	8	3	19
Canada	-	89	82	9	19	12	28	25	2	3	27
Australia	-	99	80	15	30	29	50	55	-	3	12
Israel	-	90	62	30	25	15	15	51	5	4	6

The Intelligent Transformation Index is calculated as the average of the normalised scores (100 = best) of only the following three indicators:

- Businesses having performed big data analysis (%)
- Businesses using artificial intelligence (AI) (%)
- Businesses using the internet of things (IoT) (%)

Figure B: Composite score detailed methodological annotation

	Persons employed using a computer with Internet access (%)	Businesses with a broadband connection -includes both fixed and mobile (%)	Businesses with a website or home page (%)	Businesses using ERP (Enterprise Resource Planning) software (%)	Businesses using CRM (Customer Relationship Management) software (%)	Businesses which employ ICT specialists, within the last 12 months (%)	Businesses receiving orders over computer networks (%)	Businesses purchasing cloud computing services (%)	Businesses having performed Big data analysis (%)	Businesses using Artificial Intelligence (AI) (%)	Businesses using Internet of Things (IoT) (%)
Denmark	A	A	A	A	A	A	A	A	A	A	A
Finland	A	A	*	A	A	A	A	A	A	A	A
United States	***	***	(Ext)	(Ext)	(Ext)	**	(Ext)	A	***	***	***
Netherlands	A	A	A	A	A	A	A	A	A	A	A
Sweden	A	A	A	A	A	A	A	A	A	A	A
Ireland	A	A	A	A	A	A	A	A	A	A	A
Belgium	A	A	A	A	A	A	A	A	A	A	A
Germany	A	A	A	A	A	A	A	A	A	A	A
United Kingdom	*	A	A	*	*	A	*	*	A	*	-
Slovenia	A	A	A	A	A	A	A	A	A	A	A
Austria	*	A	A	A	A	A	A	A	A	A	A
Luxembourg	A	A	A	A	A	A	A	A	A	A	A
Norway	A	A	A	A	A	A	A	A	A	A	A
Portugal	A	A	A	A	A	A	A	A	A	A	A
China	(S)	(S)	(S)	(S)	(S)	(S)	(S)	(S)	(S)	(S)	(S)
France	A	A	A	A	A	A	A	A	A	A	A
Japan	**	A	A	**	**	**	*	*	***	***	*
Italy	A	A	A	A	A	A	A	A	A	A	A
Spain	A	A	A	A	A	A	A	A	A	A	A
Czech Republic	A	A	A	A	A	A	A	A	A	A	A
Lithuania	A	A	A	A	A	A	A	A	A	A	A
Greece	A	A	A	A	A	A	A	A	A	A	A
Latvia	A	A	A	A	A	A	A	A	A	A	A
Korea	*	A	A	*	*	-	*	*	*	**	-
Slovak Republic	A	A	A	A	A	A	A	A	A	A	A
Brazil	*	A	A	*	*	(Ext)	*	*	(Ext)	**	-
Turkey	A	A	A	A	A	A	A	A	A	A	A
Estonia	A	A	A	A	A	A	A	A	A	A	A
Hungary	A	A	A	A	A	A	A	A	A	A	A
Poland	A	A	A	A	A	A	A	A	A	A	A
Canada	-	A	A	*	*	A	*	*	A	*	*
Australia	-	A	A	*	*	-	(Ext)	(Ext)	-	*	*
Israel	-	*	*	*	*	*	A	*	*	*	*

Annotation	Estimation method	Data source
A	Actual data reported for index year	OECD ICT Access and Usage by Businesses
*	Imputed from time series trend extrapolation	OECD ICT Access and Usage by Businesses
**	Imputed from cross section model	OECD ICT Access and Usage by Businesses
***	Imputed from cross section model	Annual Business Survey, multiple years—United States Japan User Association of Information Systems, multiple years—Japan
(Ext)	External data source	Information in supplementary table below
(S)	Survey data	Economist Impact survey
-	Missing data	

**External data supplementary table:**

Country	Variable	Source
United States	Businesses with a website or home page (%)	Clutch.co "Small Business Websites in 2018" <sup>19</sup>
United States	Businesses using enterprise resource planning software (%)	US Census Bureau. 2018. "2018 Annual Business Survey." data reference year 2017 <sup>20</sup>
United States	Businesses using customer relationship management software (%)	US Census Bureau. 2018. "2018 Annual Business Survey." Data reference year 2017
United States	Businesses receiving orders over computer networks (%)	US Census Bureau, E-Commerce Retail Sales as a Percent of Total Sales [ECOMPCTSA], retrieved from the Federal Reserve Bank of St Louis <sup>21</sup>
Brazil	Businesses that offered positions for ICT specialist, within the last 12 months (%)	Cetic.br <sup>22</sup>
Brazil	Businesses having performed big data analysis (%)	Cetic.br
Australia	Businesses receiving orders over computer networks (%)	Australian Bureau of Statistics <sup>23</sup>
Australia	Businesses purchasing cloud computing services (%)	Australian Bureau of Statistics

**Intelligent Transformation Index imputed data methodology**

The index is based on enterprise adoption rates of AI, big data and IoT. The main source is the OECD's ICT Access and Usage dataset, except in the case of missing values, where the analyst team used two approaches to produce estimates.<sup>24</sup> The first approach is deployed in cases where an indicator is missing for the index year (2019 for big data, 2021 for AI and IoT) in the OECD's dataset but reported for some of the preceding years. The second approach is deployed where the indicator does not appear for any year in the OECD ICT Access and Usage dataset.

In the first instance, if there is insufficient historical data to construct a reliable trendline, the value of the most recent year available is imputed as appropriate. Figure C below shows the observations for which the latest available data point has been imputed as the value for the index year.

**FIGURE C: Summary of imputed data points in Intelligent Transformation Index, for which reference year data are not available**

Country	Indicator	Latest available year
Australia	AI, IoT	2020
Canada	AI, IoT	2019
Israel	AI, big data, IoT	2020
Japan	IoT	2019
United Kingdom	AI	2020

The second case, where some indicator values are not reported at all in the OECD database, presents a more complex set of challenges. The countries falling into this category are Australia, Brazil, Japan, South Korea, the UK and the US. In the case of the latter three countries, publicly available survey datasets provide reasonably close approximations for most of the OECD indicators to ensure comparability with the OECD indicators.

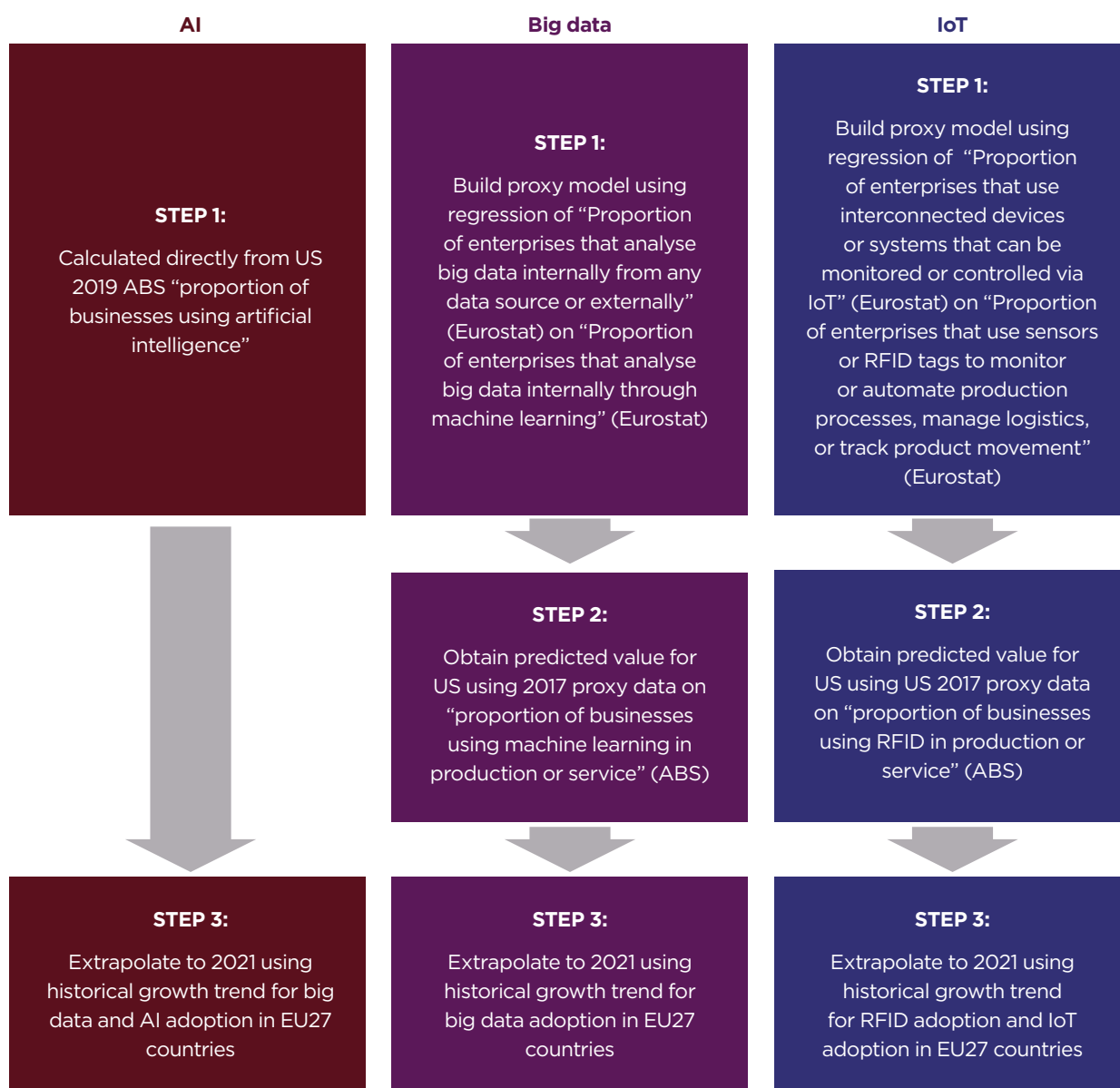
For cases such as Australia, Brazil, South Korea and the UK, where data were completely missing for one of the three indicators, the team computed the Intelligent Transformation Index score on the basis of two out of three available indicators.

Constructing estimates for the US proved to be the most challenging. The US has a far greater reporting lag than most of the other countries in the Index. Given the rapid growth of digital intelligence, the analyst team came to the conclusion that a modelled estimate would be far superior to using five-year old data—and the alternative of omitting the world's largest economy from the Index was unpalatable.

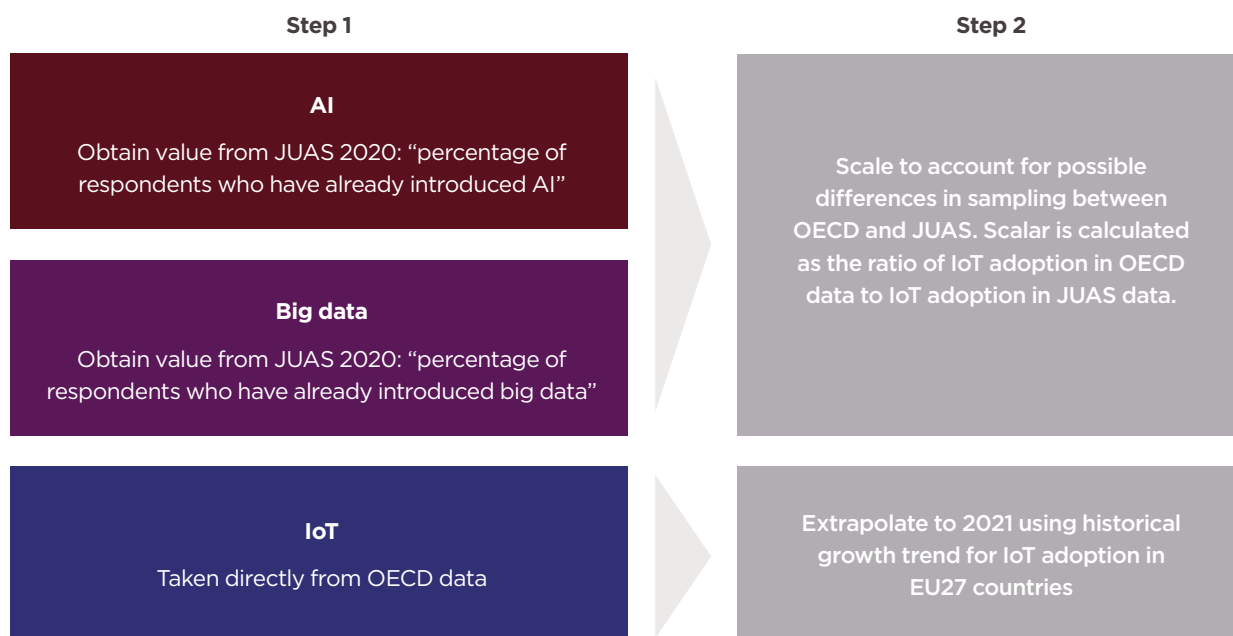


The US Annual Business Survey (ABS) includes virtually all non-farm employer businesses. Survey questions include intelligent technology use. For AI, the ABS survey question is nearly identical to the OECD Model Survey on ICT Usage by Businesses questionnaire. However, for big data and IoT the analyst team selected relevant proxy questions from the ABS as a starting point for analysis (see figure D). For Japan, as IoT adoption was the only comparable data point between the OECD and Japan User Association of Information Systems (JUAS) surveys, we used the ratio between the two as a proxy adjustment factor to derive estimates for both AI and big data.

**FIGURE D: Methodology for estimating missing Intelligent Transformation values for the US**



**FIGURE E: Methodology for estimating missing Intelligent Transformation values for Japan**



**China survey methodology**

Economist Impact commissioned a survey of 511 businesses in China to create a novel dataset that could be used to construct China estimates for the OECD indicators. The survey questionnaire was designed to follow the OECD Model Survey on ICT Usage by Businesses questionnaire to ensure comparability of results.

The online survey targeted mid- and senior-level executives who are either decision-makers or provide inputs or exercise influence over key ICT decisions. A minimum quota of n=40 was set for each sector, with the exception of manufacturing, which was set a minimum quota of 60 to reflect manufacturing’s larger actual share of firms in China.

To calculate the final values for the Intelligent Transformation Index and other indicators shown for China in this report, each observation was weighted according to the firm’s size and sectoral combination, taken from the China economic census.

As for the distribution across firm sizes, a deliberate skew was introduced towards small and medium-sized firms, to mimic the composition of businesses in China. Firm-size segments of the China survey are consistent with the OECD’s definition of small (10-49 employees), medium (50-249 employees), and large (250 or more employees) enterprises.

**FIGURE F: China survey sampling breakdown**

Country	Total	Firm size		
		Small	Medium	Large
Manufacturing	64	45	12	7
Construction	40	25	10	5
Wholesale trade, except of motor vehicles and motorcycles	40	25	10	5
Retail trade, except of motor vehicles and motorcycles	41	25	11	5
Transportation and storage	44	26	12	6
Accommodation and F&B service activities	40	25	10	5
Information and communication	40	25	10	5
Financial and insurance activities	40	20	10	10
Real-estate activities	41	26	10	5
Professional, scientific and technical activities	40	25	10	5
Business support services	41	25	11	5
Education	40	25	10	5

**Small enterprises:** 10-49 employees

**Medium enterprises:** 50-249 employees

**Large enterprises:** 250 or more employees

## Industry scope and definitions

Short name	Industry definition from NACE <sup>25</sup>
Accommodation and food & beverage	This category includes the provision of short-stay accommodation for visitors and self-service or dine in restaurants.
Business support services	This category includes a variety of activities that support general business operations.
Construction	This category includes general and specialised construction activities for buildings and civil engineering works. It also includes new work, repair, additions and alterations.
Education <sup>26</sup>	This category comprises establishments such as schools, colleges and universities that provide instruction and training in a wide variety of subjects.
Finance	This category includes financial service activities, including insurance, reinsurance and pension funding activities, and activities to support financial services.
ICT services	This category includes the production and distribution of information and cultural products, the provision of the means to transmit or distribute these products, as well as data or communications, information technology activities, and the processing of data and other information service activities.
Manufacturing	This category includes the physical or chemical transformation of materials, substances, or components into new products.
Professional, scientific and technical	This category includes professions and activities that require a high degree of training and make specialised knowledge and skills available to users.

Short name	Industry definition from NACE <sup>25</sup>
Real estate	This category involves selling, buying or renting real estate, providing other real-estate services such as appraising real estate or acting as real estate escrow agents.
Retail	This category includes the resale (sale without transformation) of new and used goods mainly to the general public for personal or household consumption or utilisation.
Transport	This category includes the provision of passenger or freight transport by rail, pipeline, road, water or air, and associated activities such as terminal and parking facilities, cargo handling and storage.
Wholesale	This category includes the resale (sale without transformation) of new and used goods to retailers, mostly business-to-business trade.

\*Industry names follow the Statistical Classification of Economic Activities in the European Community (NACE).

# References

1. "Policies," Velkommen til EKF, accessed August 24, 2022, <https://www.ekf.dk/en/about-ekf/esg-at-ekf/policies>.
2. "Digitale Tjenester (Digital Services)," Forbrukerrådet, June 12, 2021, <https://www.forbrukerradet.no/forside/digitalt/>.
3. "Good Practice Principles for Data Ethics in the Public Sector," OECD, accessed September 2022, <https://www.oecd.org/digital/digital-government/good-practice-principles-for-data-ethics-in-the-public-sector.htm>.
4. Motokazu Matsui, "Low IT Pay Stifles Japan's Digital Transformation," Nikkei Asia (Nikkei Asia, June 12, 2022), <https://asia.nikkei.com/Spotlight/Datawatch/Low-IT-pay-stifles-Japan-s-digital-transformation>.
5. "Ambra Health Partners with MC Healthcare to Launch Cloud Medical Imaging Platform in Japan," PR Newswire, accessed August 8, 2022, <https://markets.businessinsider.com/news/stocks/ambra-health-partners-with-mc-healthcare-to-launch-cloud-medical-imaging-platform-in-japan-1021295184>.
6. Jan Bruthans, "The Successful Usage of the DICOM Images Exchange System (Epacs) in the Czech Republic," Applied clinical informatics (Georg Thieme Verlag KG, January 2020), <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7002168/>.
7. A sectoral breakdown was not possible to obtain for US data, but given high overall big data adoption in the US, it would likely feature on the "right" side of the gap.
8. OECD Digital Economy Outlook 2020.
9. The Artificial Intelligence Index Report 2022, Stanford University.
10. Separate regressions were run for each of the three technologies in the Intelligent phase of the index: AI, big data and IoT. The basic unit of the regressions were sector-country combinations, totalling 426 observations. Controls for sector and country were included in the regressions.
11. European Commission. 2021. "Digital Economy and Society Index (DESI) 2021, Greece."
12. European Commission. 2021. "Digital Economy and Society Index (DESI) 2021, Sweden." <https://digital-strategy.ec.europa.eu/en/policies/desi-sweden>.
13. Industry includes manufacturing, construction and mining/quarrying. Data source: The Economist Intelligence Unit estimates
14. In 1977, Ken Olsen, founder and CEO of Digital Equipment Corporation, famously said "There is no reason for any individual to have a computer in his home".
15. "2021-2023 Emerging Technology Roadmap for Large Enterprises", Gartner.
16. John E Tomaszewski, "Human-in-the-Loop - an Overview" (Artificial Intelligence and Deep Learning in Pathology, 2021), <https://www.sciencedirect.com/topics/computer-science/human-in-the-loop>.
17. Erik Brynjolfsson, "The Turing Trap: The Promise and Peril of Human-like Artificial Intelligence," Stanford Digital Economy Lab, April 22, 2022, <https://digitaleconomy.stanford.edu/news/the-turing-trap-the-promise-peril-of-human-like-artificial-intelligence/>.
18. Ibid.
19. "Small Business Websites in 2018 | Clutch.Co," n.d., accessed September, 2022, <https://clutch.co/website-builders/resources/small-business-websites-2018>.
20. "ABS - Digital Technology Module 2018 Tables," n.d., accessed September, 2022, <https://www.census.gov/data/tables/2018/econ/abs/2018-abs-digital-technology-module.html>.
21. "E-Commerce Retail Sales As a Percent of Total Sales (ECOMPCTSA)," n.d., accessed September 2022, <https://fred.stlouisfed.org/series/ECOMPCTSA>.
22. "TIC Empresas- Cetic.Br," n.d., accessed September, 2022, <https://cetic.br/pt/pesquisa/empresas/publicacoes/>.

23. "Characteristics of Australian Business, 2019-20 Financial Year", <https://www.abs.gov.au/statistics/industry/technology-and-innovation/characteristics-australian-business/latest-release>.
24. "The OECD Model Survey on ICT Usage by Businesses." Accessed September 2022. <https://www.oecd.org/sti/ieconomy/ICT-Model-Survey-Usage-Businesses.pdf>.
25. "NACE-Rev-2-Eurostat", <https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF>
26. "Industries at a Glance: Educational Services: NAICS 61," n.d., accessed September, 2022, <https://www.bls.gov/iag/tgs/iag61.htm>.





