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»» Artificial intelligence: high growth potential but low penetration in SMEs

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Artificial intelligence (AI) is seen as a future technology. It is deemed to have high growth potential and the qualities of a game changer in many sectors. Artificial intelligence also occupies a key position because it is closely linked to other digital technologies, and digital technologies are generally becoming increasingly important in many other fields of technology.

However, German SMEs have been very slow to take up artificial intelligence. Only 4% of SMEs use AI in their business. Most of these are companies that are working hard on digitalisation (12% of businesses with expenditure of EUR 15,000 and more on digitalisation each year), have a digitalisation strategy (13%), and conduct research and development (R&D) of their own (20%). This suggests that the use of artificial intelligence probably faces major obstacles in SMEs, the most prominent of which is the likely a shortage of skills.

Other countries have already developed broad expertise in AI, so it is unrealistic to expect Germany to catch up quickly on AI development. This needs to be viewed critically. Given the high growth potential and broad range of applications of AI, it appears to be particularly important for Germany to become internationally competitive, at least in its application.
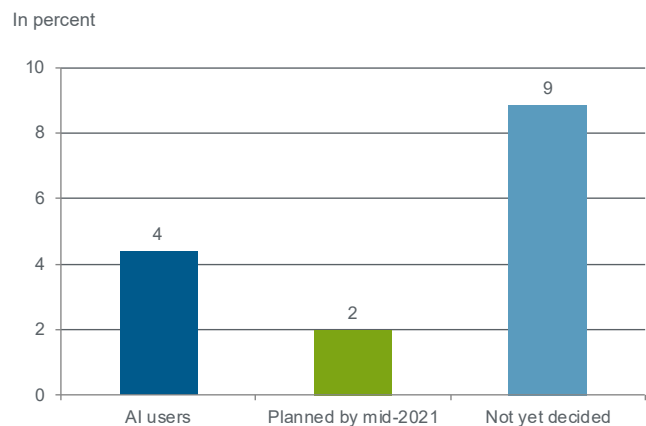
In addition to promoting the use of AI with funding, it is also necessary for businesses to gain expertise in its use. Key starting points are the activity of digital competence centres, basic and advanced training and advice from specialist service providers. Furthermore, making improvements to enabling conditions can promote the use of artificial intelligence. These include, for example, putting in place the legal framework, a standardised data infrastructure and an adequate internet connection.

The structural transition towards digitalisation is bringing about profound changes to the ways in which value is generated, how enterprises and trading structures evolve, and how we communicate and interact with each other. The importance of the digital transformation for business, the political sphere, science, civil society and culture can hardly be overestimated – irrespective of the sector. Artificial intelligence as a key technology of digitalisation plays a central role in this.

Thus far, however, there is no generally accepted definition of artificial intelligence.[1] The German Federal Government defines artificial intelligence as systems based on mathemat-

ical and information technology methods that have the ability to solve specific application problems and are capable of self-optimisation while emulating aspects of human intelligence.[2] The 'weak' artificial intelligence thus described aims to make predictions and recognise patterns. 'Strong' or general artificial intelligence is defined as systems that match or even surpass human abilities in a variety of tasks. An AI system of this type develops own problem situations and systematically looks for possible solutions. However, such systems are still in a very early stage of development. They are not expected to be ready for application in the coming decades.[3]

Figure 1: Use of artificial intelligence applications in the SME sector

In percent

Note: Figures extrapolated to the number of enterprises.

Source: KfW SME Panel 2019, own calculations

The term artificial intelligence is not a new one but goes back to the 1950s. Rapid improvements in data storage and processing technologies, however, have accelerated progress in development and opened up broader fields of application in the past years.

Artificial intelligence holds great potential

Numerous studies see artificial intelligence as having great potential to add value. A study by McKinsey[4] predicts a potential contribution of 1.2 percentage points to global GDP growth by 2030, while an Accenture study[5] forecasts an increase of 2 percentage points in annual global gross value added by the year 2035. The market value of artificial intelligence for German enterprises is estimated at EUR 1.5 billion for the year 2020. Significant growth in market value is being expected.[6]

Positive effects of using AI can also be identified at company level. Enterprises that use artificial intelligence are more likely to bring innovation to the market, generate higher returns and increase their workforce more strongly than others.[7]

Artificial intelligence offers a wide range of applications

Artificial intelligence can be used in radiological imaging, for example, to detect tumours which the human eye may overlook. Recommendation algorithms in online trade learn from internet users' consumption patterns and can generate purchase suggestions or even predict future purchases on the basis of past purchases or clicks on relevant websites. Artificial intelligence enables the smart automation of processes in production and logistics, such as learning (production) systems, predictive maintenance of plant and machinery and new forms of human-machine interaction in manufacturing. In product innovation it enables the development of intelligent products and services which promise additional service features and consumer benefits (e.g. tailor-made offerings) through the analysis of real-time user data, as well as completely new product features (e.g. driver assistance technology and autonomous driving). Finally, AI applications can be used to generate completely new business models such as digital platforms. Not least, the use of artificial intelligence can also be helpful in the fight against the coronavirus pandemic.[8]

However, artificial intelligence can also produce outcomes and be used for activities that must be viewed critically. Thus, AI models can generate racist or sexist outcomes or be used to surveil citizens, discriminate against or persecute minorities, or control autonomous weapons systems.[9] Germany and Europe can bring their values to bear in the development of artificial intelligence as a way of influencing how it will be developed further and how it will be used.

Artificial intelligence is a game changer

AI-based solutions can lead to fundamental realignments of traditional business models in many areas and set the course of future value creation processes. Digital platform markets are a good example of this.[10] The use of artificial intelligence enables the various offerings on a platform to be efficiently matched with users' preferences. This lies at the core of many digital platforms, and it is what makes them attractive in the first place. As the matching quality – based on the matching algorithm and the availability of large quantities of data – determines success, it also enables businesses unrelated to the industry to be very successful in platform markets.

Network effects that generate high user engagement are a further feature of such markets. The use of artificial intelligence generates additional self-reinforcing effects. A high number of users enables the artificial intelligence used to be better trained with the aid of the large available data quantities and to improve the matching, which makes the platform even more attractive for the users and makes it more difficult for competitors to enter the market. These winner-takes-all effects subsequently lead to a high concentration of few large enterprises in the relevant markets.[11]

The game changer qualities of artificial intelligence include the phenomenon known as digital technology convergence. This refers to the coming together of multiple technologies across industries. Developments in one technology stimulate and accelerate further development stages in other digital technologies. Progress in computing power and data availability, for example, facilitate the further development of artificial intelligence. AI itself is closely linked to technologies such as virtual reality, cyber security, internet of things and autonomous driving. This correlation is enhanced by the fact that digital technologies are also becoming increasingly important in other technological fields.[12]

Germany is not a leader in artificial intelligence

Policymakers have recognised the importance of artificial intelligence and made available EUR 3 billion in promotional funds up to the year 2025 under the German Federal Government's Artificial Intelligence Strategy, which was adopted in 2018 and has since been topped up by a further EUR 2 billion.

However, this should not hide the fact that Germany is lagging behind the US and China in artificial intelligence. Relatively few actors are developing artificial intelligence, mainly in the US and China. Thus, in the year 2018 alone, US companies submitted more than 2,700 transnational patent applications[13] in artificial intelligence. China's patent applications totalled just under 1,550. By comparison, German companies filed just over 400 transnational patent applications in the field of AI.[14] With the forerunner countries continuing to pursue ambitious AI strategies, there is reason to doubt that Germany will catch up with them in artificial intelligence in the near future.

Few small and medium-sized enterprises use artificial intelligence

Against this background, we examined the use of artificial intelligence by SMEs in Germany. In the period from 2016 to 2018, a mere 4% of SMEs used applications of artificial intelligence in their business (including a negligibly small portion of enterprises actively engaged in co-developing applications of artificial intelligence as providers).[15] Thus, a deep chasm exists in the use of artificial intelligence between SMEs and large enterprises, of which just under one third already use artificial intelligence, according to calculations by the Centre for European Economic Research (ZEW).[16] At the time of the survey, a further 2% of SMEs had plans to start using AI by mid-2021, and 9% were at least considering it (Figure 1).

Thus, the use of artificial intelligence in the SME sector is limited to a small portion of companies. It is much lower than the use of digital platforms with 38%, for example.[17] This is probably due primarily to the fact that not all SMEs have identified possible uses of artificial intelligence and major obstacles to its use exist in the company.

Among other things, the use of artificial intelligence requires intensive engagement with the topic. This is evident from the fact that more than one third of employees who are engaged
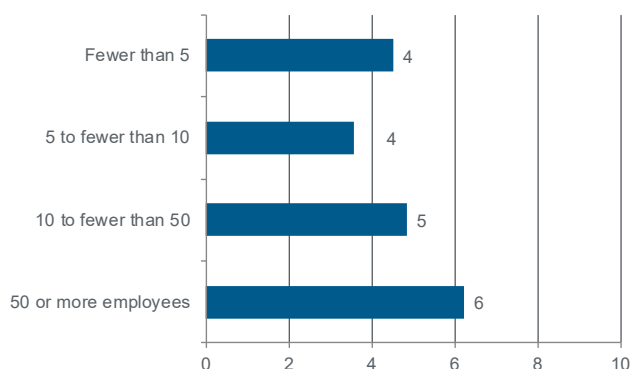
with the use of artificial intelligence devote most of their working hours to this topic.[18] Such intensive engagement overwhelms the available resources of small businesses in particular.

Even large SMEs use artificial intelligence only rarely
With only 6% of companies, even large SMEs with 50 and more employees make little use of artificial intelligence (Figure 2). This underscores the high barriers which even large SMEs face. So it is possible that insufficient economies of scale impede its use in small businesses. The slightly more frequent use of AI applications by large SMEs may also mask the often observed correlation that large enterprises are generally more active in digitalisation than small businesses.

Figure 2: Use of artificial intelligence by enterprise size

In per cent

Note: Figures extrapolated to the number of enterprises.

Source: KfW SME Panel 2019, own calculations

This is probably due in part to the fact that they are more likely to have uses for digital solutions given their broader activities and greater orientation to mass markets.[19] Not least, large SMEs are likely to be in a better position to employ specialists in artificial intelligence and therefore are more likely to possess the necessary expertise for its use.[20]
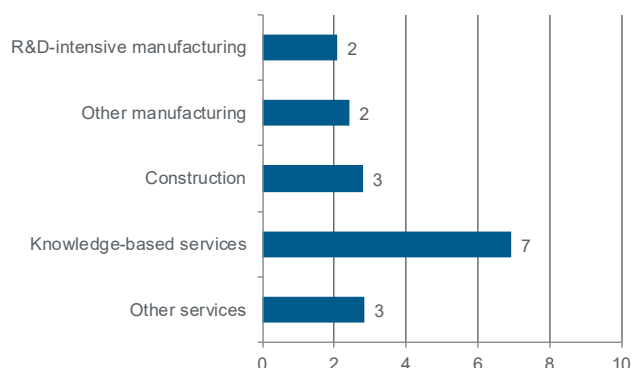
Knowledge-based service providers are forerunners
The sector comparison shows that companies in the knowledge-based services sector top the list with a share of users of 7% (Figure 3). These include, for example, media, IT and information services, law firms, tax consultancies and management consulting firms. Here, too, there are similarities to digitalisation activities as a whole. In this sector, the share of enterprises with completed digitalisation projects is also higher.[21]

By contrast, usage rates hardly differ between the other economic sectors thus far. This is a bit surprising with regards to R&D-intensive manufacturing, for example, which includes mechanical engineering, electronics and chemicals. These are typically more likely to be among the pioneers of digitalisation.[22] In any event, these sectors exhibit strong growth in adoption, which indicates that enterprises in these sectors in particular will at least catch up with or even surpass the forerunner sectors in the foreseeable future (Figure 8).

Figure 3: Use of artificial intelligence by economic sector

In per cent

Note: Figures extrapolated to the number of enterprises.
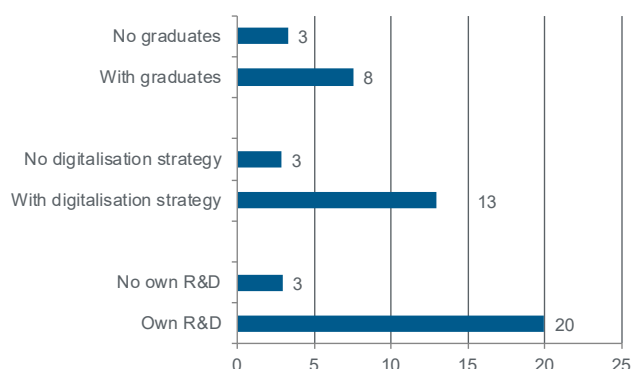
Source: KfW SME Panel 2019, own calculations

Employing graduates facilitates the use of artificial intelligence...
Figure 4 shows the use of artificial intelligence according to different indicators of the knowledge base existing in a business. In enterprises that employ university graduates the share of AI users is 8% – significantly higher than in enterprises that do not. This is probably because human capital is generally an important source of innovation. Having employees with a university degree is a strong driver for the implementation of such projects in enterprises.[23]

Particularly with respect to artificial intelligence, what is likely to be crucial is that in addition to programming skills, working with applications of artificial intelligence requires mathematic-statistical skills.[24] Importantly, there still tend to be few standards for AI applications and corresponding tools, which requires users to work out at least some adjustments individually for specific application cases. Tertiary graduates are also more likely to possess these skills.

Figure 4: Use of artificial intelligence by in-house knowledge basis

In per cent

Note: Figures extrapolated to the number of enterprises.

Source: KfW SME Panel 2019, own calculations

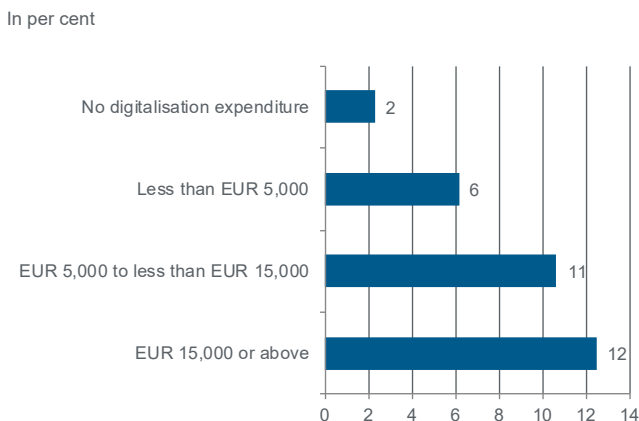## ... as does having a digitalisation strategy...

At 13%, the proportion of SMEs with a company-wide digitalisation strategy that use artificial intelligence is even higher. These enterprises use artificial intelligence over four times more often than enterprises that have no digitalisation strategy. Having a digitalisation strategy shows that the enterprise is closely examining the opportunities and challenges involved, is building expertise, and has derived conclusions from this for its further course of action. This is the process which the relevant enterprises are likely to have followed to identify the application cases for digital intelligence in their business.

... and, in particular, own R&D activities

In enterprises that conduct their own research and development (R&D), the share of AI users is even nearly 7 times higher, at 20%. Having own R&D activities is thus the key driver for companies to use artificial intelligence. It indicates that the company is systematically engaged in developing and implementing innovations using a scientific approach.[25] With respect to artificial intelligence, conducting R&D can be essential, as around two fifths of AI users indeed develop their applications at least partly themselves.[26]

Even in those businesses that do not develop AI applications themselves there is reason to suspect that scientific work promotes the development of expertise, structures and attitudes in the company that benefit the introduction and use of artificial intelligence. Examples include in-company input to the use of externally acquired AI applications and communicating the benefits of AI use in the company. Overall, these findings thus indirectly confirm the recognition that lack of expertise represents a crucial barrier to the use of artificial intelligence in many enterprises.[27]

Figure 5: Use of artificial intelligence according to how much an enterprise spends on digitalisation

In per cent

Note: Figures extrapolated to the number of enterprises.

Source: KfW SME Panel 2019, own calculations

Use of artificial intelligence grows with rising digitalisation expenditure

Figure 5 shows the use of artificial intelligence by level of annual digitalisation expenditure. Its use rises with the level of expenditure from 2% in the group of enterprises that spend
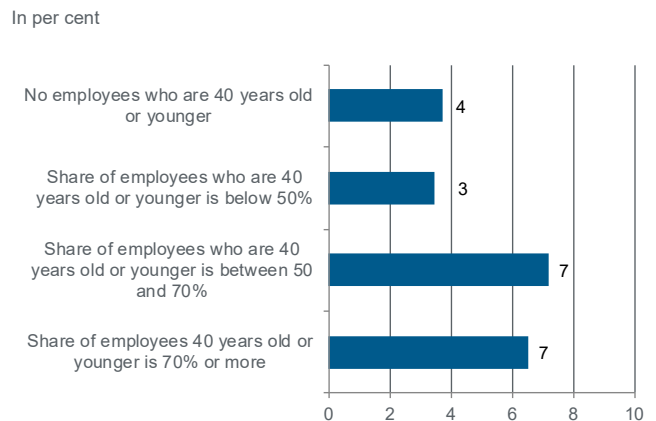
nothing on digitalisation to 12% in enterprises with the highest digitalisation expenditure (EUR 15,000 and more). Thus, the share of AI users in this group is six times higher than in enterprises that spent nothing on digitalisation in 2018. This increase underscores that the use of artificial intelligence is currently limited to enterprises that are intensively engaged with digitalisation. With a view to the two fifths of enterprises that co-develop their AI applications themselves, this presumably also reflects the high development costs of AI applications.[28]

Use of artificial intelligence also depends on the age of the workforce

Finally, the use of artificial intelligence is also determined by the age structure of a company's workforce. With respect to employee age, a clear trend is discernible (Figure 6). Businesses with a high share of young workers are nearly twice as likely to use artificial intelligence as companies with a lower share of young workers.

Studies have come to the conclusion that young people in particular use digital technologies sooner in their day-to-day work than older workers.[29] The broad dissemination of artificial intelligence in enterprises with young employees is likely due to the fact that younger people are more willing to embrace and more familiar with digital technologies. This finding corroborates the importance of digital natives for successful digitalisation, an aspect that is often emphasised in the public debate.
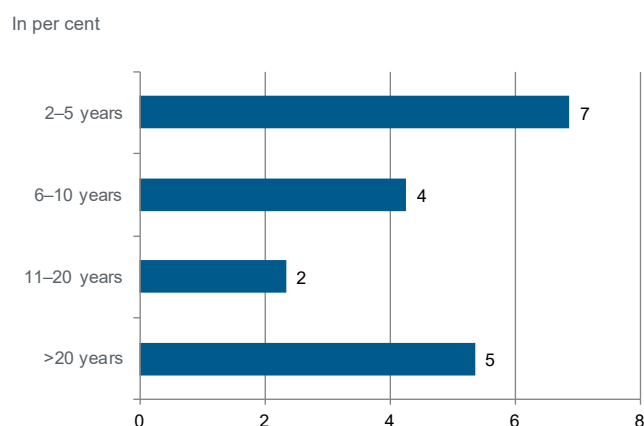
Figure 6: Use of artificial intelligence by age structure of workforce

In per cent

Note: Figures extrapolated to the number of enterprises.

Source: KfW SME Panel 2019, own calculations

Figure 7: Use of artificial intelligence by age of enterprise

In per cent

Note: Figures extrapolated to the number of enterprises.

Source: KfW SME Panel 2019, own calculations

By contrast, no clear link to company age is discernible for the use of artificial intelligence. Very young enterprises use artificial intelligence most often but so do enterprises in the highest age brackets (Figure 7).

Use of artificial intelligence is expected to grow strongly
Asked about their plans for the next two years, a considerable number of enterprises responded in the first half of 2019 that they were planning to start using artificial intelligence in the next two years, or at least considering it. If all businesses put these ideas into practice, significant increases in usage to as much as around one third of enterprises are likely, particularly among large SMEs. At sector level, the usage rate in R&D-intensive manufacturing in particular would increase many times over. Besides, the group of users among enterprises with a digitalisation strategy would grow to just under two fifths, and to almost half of those enterprises that conduct R&D (Figure 8).

Not least as a result of the coronavirus crisis, obviously not all enterprises can be expected to implement their plans and decide to introduce the use of artificial intelligence.[30] Even if only a portion of them begins to use artificial intelligence, a significant spread of the usage rates among the business characteristics examined here can be expected. In any case, these rates reflect the interest which many small and medium-sized enterprises have in this new technology.
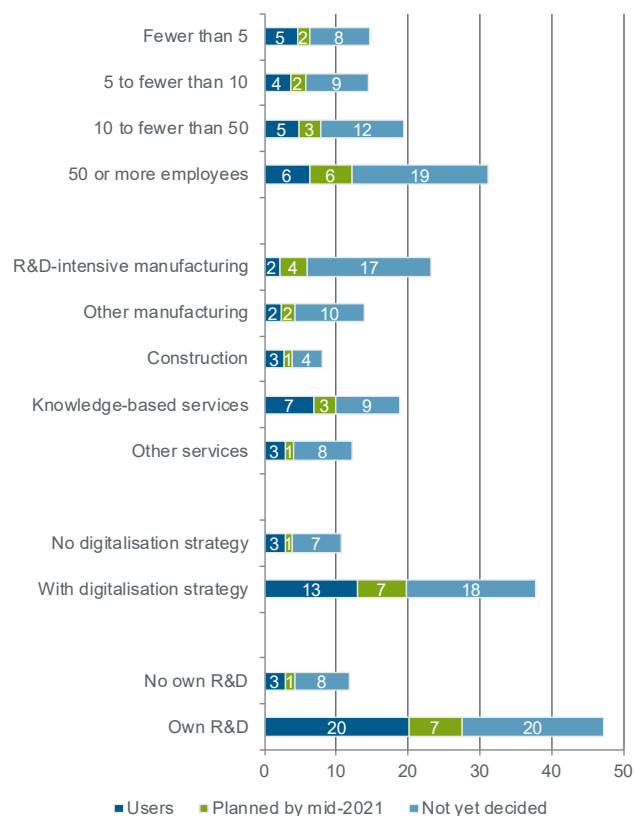
Conclusion
Artificial intelligence is a future technology that is believed to have strong growth potential. This potential results from the range of possible applications and their potential to become a game changer in many industries. Another reason artificial intelligence plays a key role is that it is closely intertwined with other digital technologies, and that digital technologies in general are gaining importance in many technological fields.

Artificial intelligence – like other digital technologies – is not one of Germany's traditional strengths, however. Nor is it being widely used in Germany's SME sector thus far. Its use

is concentrated in a small number of enterprises. These are mainly enterprises that are heavily involved in digitalisation, have a digitalisation strategy and conduct their own R&D. This probably reflects the fact that lack of expertise in particular hampers growth in the use of artificial intelligence in SMEs.

Figure 8: Plans for the use of artificial intelligence

Note: Figures extrapolated to the number of enterprises.

Source: KfW SME Panel 2019, own calculations

Other countries have already developed strong technological competence in artificial intelligence, and it appears rather unlikely that Germany will be able to catch up with them within just a few years. So in the interest of a 'fast follower strategy', which has been deemed to be successful for Germany in some technological fields in the past[31], it appears to make sense to aspire to become internationally competitive in the application of artificial intelligence without at the same time neglecting efforts in the field of AI research.

Besides promoting the application of this technology with finance, there appears to be a need for businesses to develop skills in its use. The digital competence centres that were established in the past years play an important role here, as does increased workforce training and professional development. This includes expanding relevant courses at schools, universities of applied sciences and universities. Specialised service providers can also play an important role in advising existing and potential AI users.

Furthermore, making improvements to enabling conditions can accelerate the use of artificial intelligence. Among them would be steps to make legal provisions more international in order to counteract the fragmentation of markets and create legal security. This would also mean generating a standardised data infrastructure, as is being attempted under the Gaia-X initiative, for example. Finally, an adequate infrastructure in the form of fast broadband or mobile internet is necessary in order to better exploit the potential.

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[1] Cf. Van de Gevel, A. J. W. and Noussair, C. N. (2013): The Nexus between Artificial Intelligence and Economics, Springer, Heidelberg, and Tegmark, M. (2017): Life 3.0: Being Human in the Age of Artificial Intelligence, New York, Knopf Doubleday Publishing Group.

[2] Cf. German Federal Government (2018): Strategie Künstliche Intelligenz der Bundesregierung (*Artificial intelligence strategy of the German Federal Government* – our title translation, in German only) status November 2018.

[3] Cf. Hecker, D. et al. (2017): Zukunftsmarkt Künstliche Intelligenz. Potenziale und Anwendungen (*Artificial intelligence as a future market. Potentials and applications* – our title translation, in German only), Fraunhofer-Allianz Big Data.

[4] Cf. McKinsey Global Institute (2018): Notes from the frontier: Modeling the Impact of AI on the World Economy, Discussion Paper, September 2018.

[5] Cf. Purdy, M. and P. Daugherty (2017): How AI Boosts Industry Profits and Innovation, AI Research; Accenture.

[6] Cf. Schmoch, U. et al. (2021): Identifizierung und Bewertung von Zukunftstechnologien für Deutschland (*Identifying and assessing future technologies for Germany* – our title translation, in German only). Final report for KfW, Fraunhofer ISI, December 2020, forthcoming.

[7] Cf. Rammer, C. (2020): Auf Künstliche Intelligenz kommt es an – Beitrag von KI zur Innovationsleistung und Performance der deutschen Wirtschaft (*Artificial intelligence makes the difference – contribution of AI to innovation output and performance of German industry* – our title translation, in German only), German Federal Ministry for Economic Affairs and Energy, Berlin.

[8] Cf. Naudé, W. (2020): Intelligente Eindämmungsstrategien gegen Covid-19: Die Rolle von Künstlicher Intelligenz und Big Data (*Intelligent containment strategies against Covid-19: the role of artificial intelligence and big data* – our title translation, in German only), Perspektiven der Wirtschaftspolitik 21(3), p. 311–322.

[9] Vgl. http://github.com/daviddao/awful-ai. Last retrieved on 27 January 2021.

[10] Cf. Lee, J. et al. (2019): Emerging Technology and Business Model Innovation: The Case of Artificial Intelligence. Journal of Open Innovation: Technology, Market, and Complexity 5, 44.

[11] Cf. Farboodi, M. et al (2019): Big Data and Firm Dynamics, NBER Working Paper 25515.

[12] Cf. Schmoch, U. et al. (2021): Identifizierung und Bewertung von Zukunftstechnologien für Deutschland (*Identifying and assessing future technologies for Germany* – our title translation, in German only). Final report for KfW, Fraunhofer ISI, December 2020, forthcoming.

[13] Transnational patent applications are applications in patent families, with at least one application filed with the World Intellectual Property Organization (WIPO) via the PCT process or an application with the European Patent Office. Cf. Neuhäusler, P. and O. Rothengatter (2020): Patent Applications – Structures, Trends and Recent Developments 2019, Studien zum deutschen Innovationssystem 4-2020.

[14] Cf. Schmoch, U. et al. (2021): Identifizierung und Bewertung von Zukunftstechnologien für Deutschland (*Identifying and assessing future technologies for Germany* – our title translation, in German only). Final report for KfW, Fraunhofer ISI, December 2020, forthcoming.

[15] The question was worded as follows: 'Did you use or develop digital platforms yourself in your company in the years 2016–2018?'

[16] Cf. Rammer, C. (2020): Auf Künstliche Intelligenz kommt es an – Beitrag von KI zur Innovationsleistung und Performance der deutschen Wirtschaft (*Artificial intelligence makes the difference – contribution of AI to innovation output and performance of German industry* – our title translation, in German only), German Federal Ministry for Economic Affairs and Energy, Berlin.

[17] Cf. Zimmermann, V. (2020): **Which SMEs use digital platforms?** Focus on Economics No. 303, KfW Research.

[18] Cf. Rammer, C. et al. (2020): Einsatz von Künstlicher Intelligenz in der Deutschen Wirtschaft (*The use of artificial intelligence in German business* – our title translation, in German only), German Federal Ministry for Economic Affairs and Energy, Berlin.

[19] Cf. Zimmermann, V. (2020): **KfW SME Digitalisation Report 2019. Digitalisation projects are gaining traction in the SME sector but digitalisation expenditure has remained low for years**, KfW Research.

[20] Cf. Rammer, C. (2020): Auf Künstliche Intelligenz kommt es an – Beitrag von KI zur Innovationsleistung und Performance der deutschen Wirtschaft (*Artificial intelligence makes the difference – contribution of AI to innovation output and performance of German industry* – our title translation, in German only), German Federal Ministry for Economic Affairs and Energy, Berlin.

[21] Cf. Zimmermann, V. (2020): **KfW SME Digitalisation Report 2019. Digitalisation projects are gaining traction in the SME sector but digitalisation expenditure has remained low for years**, KfW Research.

[22] Cf. Zimmermann, V. (2020): **KfW SME Digitalisation Report 2019. Digitalisation projects are gaining traction in the SME sector but digitalisation expenditure has remained low for years**, KfW Research and Zimmermann, V. (2020): **Which SMEs use digital platforms? Focus on Economics No. 303**, KfW Research.

[23] Cf. Hottenrott, H and Peters, B. (2012): Innovative capability and financing constraints for innovation – more money, more innovation? Review of Economics and Statistics 94(4), p. 1126–1142 and Zimmermann, V. (2018): **Determinants of digitalisation and innovation behaviour in the SME sector**, Focus on Economics No. 236, KfW Research.

[24] Cf. Rammer, C. et al. (2020): Einsatz von Künstlicher Intelligenz in der Deutschen Wirtschaft (*The use of artificial intelligence in German business* – our title translation, in German only), German Federal Ministry for Economic Affairs and Energy, Berlin.

[25] Cf. OECD (2015) (publisher), Frascati Manual 2015. Guidelines for collecting and reporting data on research and experimental development.

[26] Cf. Rammer, C. et al. (2020): Einsatz von Künstlicher Intelligenz in der Deutschen Wirtschaft (*The use of artificial intelligence in German business* – our title translation, in German only), German Federal Ministry for Economic Affairs and Energy, Berlin.

[27] Cf. Begleitforschung Mittelstand-Digital WIK GmbH (Hrsg.) (2019): Künstliche Intelligenz im Mittelstand. Relevanz, Anwendungen, Transfer (*Artificial intelligence in SMEs. Relevance, applications, transfer* – our title translation, in German only).

[28] Cf. Rammer, C. (2020): Auf Künstliche Intelligenz kommt es an – Beitrag von KI zur Innovationsleistung und Performance der deutschen Wirtschaft (*Artificial intelligence makes the differ-*

ence – contribution of AI to innovation output and performance of German industry – our title translation, in German only), German Federal Ministry for Economic Affairs and Energy, Berlin.

[29] Cf. Meyer, J. (2011): Workforce age and technology adoption in small and medium-sized service firms, Small Business Economics 37(3), p. 305–324 or Weinberg, P. (2004): Experience and technology adoption, IZA Discussion Paper 1051.

[30] Cf. Zimmermann, V. (2020): **Coronavirus crisis is hampering innovation, digitalisation sees mixed trend**, Focus on Economics No. 312, KfW Research

[31] Cf. Legler, H. et al (2000): Germany's Technological Performance: A Study on Behalf of the German Federal Ministry of Education and Research, ZEW Economic Studies 8.