Artificial Intelligence: getting around Moravec’s paradox?

Key take-aways

- Massive strides in computational power, data storage and algorithms have finally propelled us past the limitations of Moravec’s paradox.
- AI technologies are expected to have a massive economic impact, and while still in early stages, AI adoption presents unparalleled opportunities for countries to leap-frog ahead to position themselves for the future.
- Lack of a regulatory framework in AI and code of ethics for machines remains one of the greatest challenges and will be the focus in medium term.

Introduction

The concept of Artificial Intelligence (AI) i.e., machines exhibiting human-like cognition has been around for a few decades now. Interestingly, the main lesson of a long history of AI research has been that the hard problems were easy, and the easy problems were hard. While it was relatively easy to make computers successful at the hardest adult-level logical problems, the mental abilities of a child that we take for granted – recognizing a face, lifting a pencil, walking across a room, answering a question – were counterintuitively some of the hardest problems for a computer. This observation was known as Moravec’s paradox, after the Austrian scientist, Hans Moravec. He reasoned that the oldest human skills (motor, language) are largely unconscious after billions of years of evolution while abstract thought was more recently acquired, and hence easier to reverse-engineer. This limitation meant that AI applications for the most part of history, were concentrated to very niche domains. However, it’s only in the first decades of 21st century with massive strides in computation power, data generation/storage and machine learning technologies, we finally are at a pivotal point to enter into a true age of artificial intelligence.

Box

Ethics and morals in AI

In Europe, Middle East and Africa as well as in Asia Pacific this material is considered marketing material, but this is not the case in the U.S. No assurance can be given that any forecast or target can be achieved. Forecasts are based on assumptions, estimates, opinions and hypothetical models which may prove to be incorrect. Past performance is not indicative of future returns. Investments come with risk. The value of an investment can fall as well as rise and you might not get back the amount originally invested at any point in time. Your capital may be at risk.
What AI is, and what is not

All computer systems or machines that can continuously scan their environment, learn from it, and act in response to what they sense, as well as to human-defined objectives, constitutes AI. There are broadly three types of AI:

I. Basic AI or Artificial Narrow Intelligence (ANI): limited in scope and restricted to just one functional area.
II. Advanced AI or Artificial General Intelligence (AGI): is advanced and usually covers more than one field, such as power of reasoning, abstract thinking, or problem solving at par with human adults.
III. Autonomous AI or Artificial Super Intelligence (ASI): is the final stage of intelligence expansion in which AI surpasses human intelligence across all fields and/or becomes self-aware. This stage of AI, also called ‘AI singularity’, is not expected to be developed for several decades.

Today, we are somewhere between the ANI and AGI mark. The leap from basic machines to an advanced stage of ANI took a long time – more than 30 years – in line with Moravec’s constraint that it was easier to build AI for specific adult-level tasks that humans find complex but hard to replicate simple, sensorimotor skills that came instinctively to humans.

However, certain factors changed the equation in the 21st century. The sheer volume and diversity of data produced (Figure 1) – and more than 80% of it in unstructured format – for the first time started to comfortably surpass our ability to consume it manually. Combined with that, the massive strides in computing power reached a pivotal point and highly advanced algorithms came about. To help make sense of data in today’s ‘Zettabyte era’, while there were many advances in AI, other disruptive technologies also developed in parallel – like the field of Big Data, and several other related domains of Data Mining, Cloud Computing, Internet of Things (IoT), and Blockchain which have gained significance. They all however greatly differ from AI in the sense that while they utilize algorithms too, they lack the ability to learn and improve like AI. It is a similar case with many digital systems that use underlying AI technologies (AI-as-a-service, AlaaS) but are not intelligent themselves.

The development of Machine Learning (ML) and Deep Learning (DL) technologies has been primarily responsible for the current inroads into applications that lie in the uncharted realm of Moravec’s paradox. Structurally, while ML utilizes basic learning algorithms limited to one loop of learning, DL involves several learning loops organized like the structure of our brain. The core idea behind DL is to create a child-AI which learns and develops with experience (data). Both the technologies are well-equipped to analyze unstructured data and offer modern-day use cases such as face recognition technology (Computer Vision), smartphone assistants (Speech Recognition / Natural Language Processing), self-driving vehicles (Smart Mobility) or the personal robot that helps in chores (Smart Robots) (Figure 2).

These are all still examples of advanced ANI however — a result of brute force statistics, made possible by the quantity of data fed into the models and trained on specific datasets to accomplish one task. It’s only in the last few years that True AGI or human-level AI is beginning to be thought of as a real possibility but as of the writing of this report, true AGI still remains speculative.

Status of modern AI

Unlike the last decade, AI is not a futuristic vision anymore, but rather something that is here today and being integrated and deployed into a variety of sectors. This includes fields such as finance, education, national security, health care, criminal justice, media, transportation, smart cities and more. While the scope of applications of AI is huge and evolving, they can be broadly divided into four areas as currently used by enterprises – 1) maintenance and quality control to optimize production, 2) enhancing user experience via virtual assistants, chatbots and marketing platforms, 3) research and development/predicting trends and finally 4) targeted sales and marketing. In 2020, as the pandemic raged on, the healthcare industry was overwhelmed with medical professionals at risk of being

In Europe, Middle East and Africa as well as in Asia Pacific this material is considered marketing material, but this is not the case in the U.S. No assurance can be given that any forecast or target can be achieved. Forecasts are based on assumptions, estimates, opinions and hypothetical models which may prove to be incorrect. Past performance is not indicative of future returns. Investments come with risk. The value of an investment can fall as well as rise and you might not get back the amount originally invested at any point in time. Your capital may be at risk.
In Europe, Middle East and Africa as well as in Asia Pacific this material is considered marketing material, but this is not the case in the U.S. No assurance can be given that any forecast or target can be achieved. Forecasts are based on assumptions, estimates, opinions and hypothetical models which may prove to be incorrect. Past performance is not indicative of future returns. Investments come with risk. The value of an investment can fall as well as rise and you might not get back the amount originally invested at any point in time. Your capital may be at risk.

04 Economic impact

One of the reasons for the growing attention to AI is the tremendous opportunities for economic development that it presents. A project undertaken by PricewaterhouseCoopers (PwC) estimated that “artificial intelligence technologies could increase global GDP by USD15.7tn in 2030” – a rise of 18.5%, from current levels in 2021. A major chunk of initial impact is expected to be driven by productivity gains from businesses automating processes, with capital-intensive sectors like manufacturing and transport witnessing the bulk of disruption.

Figure 5: Since Canada published the world’s first national AI strategy in 2017, more than 30 other countries and regions have published similar documents as of December 2020.

![Map of countries with and developing AI strategies]

Source: Stanford University, Deutsche Bank AG. Data as of 2021.

The next phase of GDP uplift will likely come from subsequent shifts in consumer demand and behavior and would soon have overtaken the productivity gains as consumers will mostly be attracted to higher quality and more personalized products and at the same time – have a chance to make better use of their freed-up time. There will indeed be some job displacements, especially with the adoption of ‘no-human-in-the-loop’ technologies but jumps in productivity, consumer demand and new technologies would also mean that new employment opportunities will arise. As per a survey by McKinsey & Company in 2020, High Tech / Telecom and Automotive industries are said to be most likely to deploy AI in business with Financial Services, Legal and Healthcare following in that order. While some sectors and businesses are indeed more advanced than others, AI is still in early stages of development overall. Thus, from a macroeconomic and regional point of view, AI adoption presents opportunities for emerging markets to
In the 19th century, many societies and economies were undergoing massive structural transformations as a result of the first industrial revolution. Discussions on socioeconomic issues, including equality, justice and economic progress were all pervasive as the world stood on the brink of reorganization. Fast forward to the 21st century, a new industrial revolution – this time led by digitalization – again dawns upon us. The changes that will ensue will be among the most important yet. Ethical and moral concerns in such times specifically again come to the forefront – time has always been a trigger for new thinking and reassessment of ethical fundamentals.

It is generally accepted in the scientific community that the development of increasingly intelligent and autonomous technologies will eventually lead to these systems having to face morally problematic situations. For example, who is accountable if an AI robot-surgeon commits an error? Is it the guiding doctor? The hospital management? The software company which designed it? The regulators who approved it? Or even the patient (user) who consented to it? In addition, there are also cases like Autonomous Cars where the affected not only include the users (passengers) but also third parties like pedestrians, cyclists or children who did not consent to it. What does one do then? The main problem is that autonomous systems can’t bear responsibility because they are not completely moral agents. But they can undermine efforts to ascribe responsibility. This is because it may be difficult to show that the holding agents responsible for their actions intended the consequences of actions or were at least able to foresee them, and that acted to control them. There may be situations in which a system acts “morally” although no human agent intended this, nobody was able to foresee it, and nobody was able to control the system once it was triggered.

The role of ethics and morals in an economy is therefore to, first of all, help us define a comprehensive framework within which humans and such intelligent systems can operate together and to make sure that it is based on and reflects underlying social values and beliefs. The state must add, in a reflective and reciprocal way, general conditions and limits so that individual actors do not have to consider in every situation whether their actions meet moral and ethical requirements. However, individual ethical behavior must also prevail where there is no legal obligation.

The pandemic has already given us a first taste of why social organizations need to be maintained regardless of immediate economic calculations. There is a mutual desire of all individuals to be treated fairly and respectfully, especially on their contribution to the greater good. Individuals need to find a place in the economy (even with AI-robots working in parallel) where they can perform best, based on their individual set of capabilities augmented by relevant skills. Equality of opportunity and contributive justice are the keys to a stable socio-economic development. Again, economy and morality are in fact two sides of the same coin.

The new AI and digital technology-led world thus challenges not only our existing ideas of work, but also how we live, trade and even define ownership. Hence, it’s imperative that we adopt a pre-emptive policy approach to ensure disruption is manageable and containable.

**Figure 6: Leading AI issues being flagged in media (frequency of topic appearance during 2013-2018)**

Key challenges and risks

AI promises to help deliver increased consumer benefits and great business value in the time to come. But as with every nascent technology, it has its associated risks and challenges. One of the often talked about challenges/risks is regarding the transformation of job requirements and disruption of traditional job functions as AI becomes pervasive. According to the World Economic Forum (2020), AI technologies are expected to replace more than 75 million jobs by 2022 globally. While job loss concerns have been a subject of much analysis, research and study, some experts believe the losses may not be as extreme as popularly thought. It is possible that greater AI-enabled productivity may generate jobs elsewhere with different skills – although with an unknown impact on wages. Indeed, in that sense re-skilling people and keeping them abreast with the rapidly changing technology landscape then becomes another challenge that will require a lot of investment from businesses and governments alike.

Another key challenge is regarding data privacy where we have seen several countries embark on a differentiated vision. For example, while EU has chosen to follow a strong data protection regime (GDPR), China and U.S. have a minimalist approach with greater focus on economic value. The different approaches become particularly problematic in cross-border business and data flow giving rise to many legal hurdles. Other challenges include developing a pre-emptive moral and ethical code to ensure accountability, transparency and security (discussed in the previous box) as we head towards the still-aspirational realms of AGI and potentially ASI.

However, in order to progress to these uncharted realms, there are also several developmental challenges which AI technologies are currently trying to overcome. These include enhanced man-to-machine communication – e.g., ability to interpret sarcasm, accents etc. as well as building multi-functional robots, among others, all of which can then help in truly achieving the true sense of AI.

Conclusion

Unlike the last decade, AI is not a futuristic vision anymore, but rather something that is here today and being integrated and deployed into a variety of sectors. The leap from basic machines to an advanced stage of ANI took a long time – more than 30 years – in line with Moravec’s constraint that it was easier to build AI for specific adult-level tasks that humans find complex but hard to replicate simpler skills that came instinctively to humans. In the 21st century, with massive strides in computing power, humungous volumes of data and new technologies finally helped us get around Moravec’s paradox.

In terms of funding, despite the COVID-19 pandemic, 2020 saw a higher growth rate than 2019 though the number of newly funded companies continued to decrease (more private investment in AI is being channeled into fewer start-ups). Majority of the fund flows in 2020 went into healthcare sector as was the need of the hour during the pandemic. Thus, AI as a theme has shown an adaptability to changing societal needs and functions as an enabler of other technologies.

For tracking investment performance of the AI theme, we prefer the STOXX AI Global Artificial Index which is comprised of 57 global companies (October 2021) that are positively exposed to AI technologies directly or as a service. As AI develops, these companies are positioned to take advantage of the long-term trend towards automation, which is expected to have a substantial impact on their revenue in the future. The relative performance of the STOXX AI index and the MSCI World since inception is shown in Figure 7.

In the short to medium term, we expect greater emphasis on regulatory landscape in AI with emphasis also on developing a robust code of ethics for machines. At the same time, more governments are expected to come out with national AI strategies, given the tremendous opportunities for economic development as well as to counter risks that AI presents.
In Europe, Middle East and Africa as well as in Asia Pacific this material is considered marketing material, but this is not the case in the U.S. No assurance can be given that any forecast or target can be achieved. Forecasts are based on assumptions, estimates, opinions and hypothetical models which may prove to be incorrect. Past performance is not indicative of future returns. Investments come with risk. The value of an investment can fall as well as rise and you might not get back the amount originally invested at any point in time. Your capital may be at risk.

Bibliography

1. MIT Sloan School of Business, “Tapping the power of unstructured data”, 2021
2. Stanford University, “Artificial Intelligence Index Report”, 2021
Retrieved from: https://hai.stanford.edu/research/ai-index-2021
3. OECD Digital Economy Papers, “Venture Capital Investments in Artificial Intelligence”, September 2021
8. DWIH New York, “An Interview With Dr. Catrin Misselhorn”, 2020
Retrieved from: https://www.mckinsey.com/~/media/mckinsey/industries/advanced%20electronics/our%20insights/how%20artificial%20intelligence%20can%20deliver%20real%20value%20to%20companies/mgi-artificial-intelligence-discussion-paper.ashx
10. Szczepański, M.; European Parliament Briefing, Economic impacts of artificial intelligence (AI), July 2019
Glossary

**AI-as-a-service (AIaaS)** is the third party offering of artificial intelligence (AI) outsourcing. AI as a service allows individuals and companies to experiment with AI for various purposes without large initial investment and with lower risk.

**Artificial Intelligence** is the theory and development of computer systems that can learn by themselves and are able to perform tasks normally requiring human intelligence.

**Blockchain** is a shared, immutable ledger that facilitates the process of recording transactions and tracking assets in a business network.

**Cloud Computing** is the practice of using a network of remote servers hosted on the internet to store, manage, and process data, rather than a local server or a personal computer.

**Computer Vision** is the process of pulling relevant information from an image or sets of images for advanced classification and analysis.

**Data Mining** is the practice of analysing large databases in order to generate new information.

**Deep Learning (DL)** is a type of machine learning based on artificial neural networks in which multiple layers of processing are used to extract progressively higher-level features from data.

**GDP (Gross Domestic Product)** is the most used measure for the size of an economy in terms of the goods and services it produces.

**Gesture Control** refers to the mathematical interpretation of human motions using a computing device.

**Internet of Things (IoT)** refers to the interconnection via the internet of computing devices embedded in everyday objects, enabling them to send and receive data.

**Machine Learning (ML)** is the use and development of computer systems that can learn and adapt without following explicit instructions, by using algorithms and statistical models to analyse and draw inferences from patterns in data.

**Natural Language Processing (NLP)** refers to the branch of artificial intelligence concerned with giving computers the ability to understand text and spoken words in much the same way human beings can.

**Smart mobility** is the connection of various elements of technology and mobility, a rethinking of the transportation infrastructure used in daily life and business to make transportation more efficient.

**Smart Robots** help in automation of repetitive tasks and common processes without the need to transform existing IT system maps.

**Speech Recognition** refers to a computer interpreting the words spoken by a person and converting them to a format that is understandable by a machine.

**Speech Translation** refers to digital tools that use advanced artificial intelligence to not only translate the words that are written or spoken, but also to translate the meaning (and sometimes sentiment) of the message.

**Venture capital (VC)** is a form of private equity and a type of financing that investors provide to startup companies and small businesses that are believed to have long-term growth potential.

**Video recognition** is the computer's ability to acquire, process, and analyze data coming from visual sources, i.e., videos.

**Virtual Assistants** also called AI assistant or digital assistant, is an application program that understands natural language voice commands and completes tasks for the user.

**Zetabyte** is a multiple of the unit byte that measures digital storage, and it is equivalent to 1,000,000,000,000,000,000,000 bytes.
Important information

General
This document may not be distributed in Canada or Japan. This document is intended for retail or professional clients only. This document is being circulated in good faith by Deutsche Bank AG, its branches (as permitted in any relevant jurisdiction), affiliated companies and its officers and employees (collectively, “Deutsche Bank”).

This material is for your information only and is not intended as an offer, or recommendation or solicitation of an offer to buy or sell any investment, security, financial instrument or other specific product, to conclude a transaction, or to provide any investment service or investment advice, or to provide any research, investment research or investment recommendation, in any jurisdiction. All materials in this communication are meant to be reviewed in their entirety.

If a court of competent jurisdiction deems any provision of this disclaimer unenforceable, the remaining provisions will remain in full force and effect. This document has been prepared as a general market commentary without consideration of the investment needs, objectives or financial circumstances of any investor. Investments are subject to generic market risks which derive from the instrument or are specific to the instrument or attached to the particular issuer. Should such risks materialise, investors may incur losses, including (without limitation) a total loss of the invested capital. The value of investments can fall as well as rise and you may not recover the amount originally invested at any point in time. This document does not identify all the risks (direct or indirect) or other considerations which may be material to an investor when making an investment decision. This document and all information included herein are provided “as is”, “as available” and no representation or warranty of any kind, express, implied or statutory, is made by Deutsche Bank regarding any statement or information contained herein or in conjunction with this document. All opinions, market prices, estimates, forward-looking statements, hypothetical statements, forecast returns or other opinions leading to financial conclusions contained herein reflect Deutsche Bank’s subjective judgment on the date of this report. Without limitation, Deutsche Bank does not warrant the accuracy, adequacy, completeness, reliability, timeliness or availability of this communication or any information in this document and expressly disclaims liability for errors or omissions herein. Forward looking statements involve significant elements of subjective judgments and analyses and changes thereto and/or consideration of different or additional factors could have a material impact on the results indicated. Therefore, actual results may vary, perhaps materially, from the results contained herein.

Deutsche Bank does not assume any obligation to either update the information contained in this document or inform investors about available updated information. The information contained in this document is subject to change without notice and based on a number of assumptions which may not prove valid, and may be different from conclusions expressed by other departments within Deutsche Bank. Although the information contained in this document has been diligently compiled by Deutsche Bank and derived from sources that Deutsche Bank considers trustworthy and reliable, Deutsche Bank does not guarantee or cannot make any guarantee about the completeness, fairness, or accuracy of the information and it should not be relied upon as such. This document may provide, for your convenience, references to websites and other external sources. Deutsche Bank takes no responsibility for their content and their content does not form any part of this document. Accessing such external sources is at your own risk.

Before making an investment decision, investors need to consider, with or without the assistance of an investment adviser, whether any investments and strategies described or provided by Deutsche Bank, are appropriate, in light of their particular investment needs, objectives, financial circumstances and instrument specifics. When making an investment decision, potential investors should not rely on this document but only on what is contained in the final offering documents relating to the investment. As a global financial services provider, Deutsche Bank from time to time faces actual and potential conflicts of interest. Deutsche Bank’s policy is to take all appropriate steps to maintain and operate effective organisational and administrative arrangements to identify and manage such conflicts. Senior management within Deutsche Bank are responsible for ensuring that Deutsche Bank’s systems, controls and procedures are adequate to identify and manage conflicts of interest.

Deutsche Bank does not give tax or legal advice, including in this document and nothing in this document should be interpreted as Deutsche Bank providing any person with any investment advice. Investors should seek advice from their own tax experts, lawyers and investment advisers in considering investments and strategies described by Deutsche Bank. Unless notified to the contrary in a particular case, investment instruments are not insured by any governmental entity, not subject to deposit protection schemes and not guaranteed, including by Deutsche Bank. This document may not be reproduced or circulated without Deutsche Bank’s express written authorisation. Deutsche Bank expressly prohibits the distribution and transfer of this material to third parties. Deutsche Bank accepts no liability whatsoever arising from the use or distribution of this material or for any action taken or decision made in respect of investments mentioned in this document the investor may have entered into or may enter in future. The manner of circulation and distribution of this document may be restricted by law or regulation in certain countries, including, without limitation, the United States. This document is not directed to, or intended for distribution to or use by, any person or entity who is a citizen or resident of or located in any locality, state, country or other jurisdiction, where such distribution, publication, availability or use would be contrary to law or regulation or which would subject Deutsche Bank to any registration or licensing requirement within such jurisdiction not currently met. Persons into whose possession this document may come are required to inform themselves of, and to observe, such restrictions. Past performance is no guarantee of future results; nothing contained herein shall constitute any representation, warranty or prediction as to future performance. Further information is available upon investor’s request.

Kingdom of Bahrain
For Residents of the Kingdom of Bahrain: This document does not constitute an offer for sale of, or participation in, securities, derivatives or funds marketed in Bahrain within the meaning of Bahrain Monetary Agency Regulations. All applications for investment should be received and any allotments should be made, in each case from outside of Bahrain. This document has been prepared for private information purposes of intended investors only who will be institutions. No invitation shall be made to the public in the Kingdom of Bahrain and this document will not be issued, passed to, or made available to the public generally. The Central Bank (CBB) has not reviewed, nor has it approved, this document other marketing of such securities, derivatives or funds in the Kingdom of Bahrain. Accordingly, the securities, derivatives or funds may not be offered or sold in Bahrain or to residents thereof except as permitted by Bahrain law. The CBB is not responsible for performance of the securities, derivatives or funds.

State of Kuwait
This document has been sent to you at your own request. This presentation is not for general circulation to the public in Kuwait. The Interests have not been licensed for offering in Kuwait by the Kuwait Capital Markets Authority or any other relevant Kuwaiti government agency. The offering of
Important information

the Interests in Kuwait on the basis a private placement or public offering is, therefore, restricted in accordance with Decree Law No. 31 of 1990 and the implementing regulations there to (as amended) and Law No. 7 of 2010 and the bylaws there to (as amended). No private or public offering of the Interests is being made in Kuwait, and no agreement relating to the sale of the Interests will be concluded in Kuwait. No marketing or solicitation or inducement activities are being used to offer or market the Interests in Kuwait.

United Arab Emirates
Deutsche Bank AG in the Dubai International Financial Centre (registered no. 00045) is regulated by the Dubai Financial Services Authority. Deutsche Bank AG -DIFC Branch may only undertake the financial services activities that fall within the scope of its existing DFSA license. Principal place of business in the DIFC: Dubai International Financial Centre, The Gate Village, Building 5, PO Box 504902, Dubai, U.A.E. This information has been distributed by Deutsche Bank AG. Related financial products or services are only available to Professional Clients, as defined by the Dubai Financial Services Authority.

State of Qatar
Deutsche Bank AG in the Qatar Financial Centre (registered no. 00032) is regulated by the Qatar Financial Centre Regulatory Authority. Deutsche Bank AG -QFC Branch may only undertake the financial services activities that fall within the scope of its existing QFCRA license. Principal place of business in the QFC: Qatar Financial Centre, Tower, West Bay, Level 5, PO Box 14928, Doha, Qatar. This information has been distributed by Deutsche Bank AG. Related financial products or services are only available to Business Customers, as defined by the Qatar Financial Centre Regulatory Authority.

Kingdom of Belgium
This document has been distributed in Belgium by Deutsche Bank AG acting though its Brussels Branch. Deutsche Bank AG is a stock corporation ("Aktiengesellschaft") incorporated under the laws of the Federal Republic of Germany and licensed to carry on banking business and to provide financial services subject to the supervision and control of the European Central Bank ("ECB") and the German Federal Financial Supervisory Authority ("Bundesanstalt für Finanzdienstleistungsaufsicht" or "BaFin"). Deutsche Bank AG, Brussels Branch has its registered address at Marnixlaan 13-15, B-1000 Brussels, registered at the RPM Brussels, under the number VAT BE 0418.371.094. Further details are available on request or can be found at www.deutschebank.be.

Kingdom of Saudi Arabia
Deutsche Securities Saudi Arabia Company (registered no. 07073-37) is regulated by the Capital Market Authority. Deutsche Securities Saudi Arabia may only undertake the financial services activities that fall within the scope of its existing CMA license. Principal place of business in Saudi Arabia: King Fahad Road, Al Olaya District, P.O. Box 301809, Faisaliah Tower, 17th Floor, 11372 Riyadh, Saudi Arabia.

United Kingdom
In the United Kingdom ("UK"), this publication is considered a financial promotion and is approved by DB UK Bank Limited on behalf of all entities trading as Deutsche Bank Wealth Management in the UK. Deutsche Bank Wealth Management is a trading name of DB UK Bank Limited. Registered in England & Wales (No. 00315841). Registered Office: 23 Great Winchester Street, London EC2P 2AX. DB UK Bank Limited is authorised and regulated by the Financial Conduct Authority and its Financial Services Registration Number is 140848. Deutsche Bank reserves the right to distribute this publication through any of its UK subsidiaries, and in any such case, this publication is considered a financial promotion and is approved by such subsidiary where it is authorised by the appropriate UK regulator (if such subsidiary is not so authorised, then this publication is approved by another UK member of the Deutsche Bank Wealth Management group that has the requisite authorisation to provide such approval).

Hong Kong
This document and its contents are provided for information only. Nothing in this document is intended to be an offer of any investment or a solicitation or recommendation to buy or to sell an investment and should not be interpreted or construed as an offer, solicitation or recommendation. To the extent that this document makes reference to any specific investment opportunity, its contents have not been reviewed. The contents of this document have not been reviewed by any regulatory authority in Hong Kong. You are advised to exercise caution in relation to the investments contained herein. If you are in any doubt about any of the contents of this document, you should obtain independent professional advice. This document has not been approved by the Securities and Futures Commission in Hong Kong nor has a copy of this document been registered by the Registrar of Companies in Hong Kong and, accordingly, (a) the investments (except for investments which are a "structured product", as defined in the Securities and Futures Ordinance (Cap. 571 of the Laws of Hong Kong) (the "SFO") may not be offered or sold in Hong Kong by means of this document or any other document other than to "professional investors" within the meaning of the SFO and any rules made thereunder, or in other circumstances which do not result in the document being a "prospectus" as defined in the Companies (Winding Up and Miscellaneous Provisions) Ordinance (Cap. 32 of the Laws of Hong Kong) ("CO") or which do not constitute an offer to the public within the meaning of the CO and (b) no person shall issue or possess for the purposes of issue, whether in Hong Kong or elsewhere, any advertisement, invitation or document relating to the investments which is directed at, or the contents of which are likely to be accessed or read by, the public in Hong Kong (except if permitted to do so under the securities laws of Hong Kong) other than with respect to the investments which are or are intended to be disposed of only to persons outside Hong Kong or only to "professional investors" within the meaning of the SFO and any rules made thereunder.

Singapore
The contents of this document have not been reviewed by the Monetary Authority of Singapore ("MAS"). The investments mentioned herein are not allowed to be made to the public or any members of the public in Singapore other than (i) to an institutional investor under Section 274 or 304 of the Securities and Futures Act (Cap 289) ("SFA"), as the case may be (as any such Section of the SFA may be amended, supplemented and/or replaced from time to time), (ii) to a relevant person (which includes an Accredited Investor) pursuant to Section 275 or 305 and in accordance with other

In Europe, Middle East and Africa as well as in Asia Pacific this material is considered marketing material, but this is not the case in the U.S. No assurance can be given that any forecast or target can be achieved. Forecasts are based on assumptions, estimates, opinions and hypothetical models which may prove to be incorrect. Past performance is not indicative of future returns. Investments come with risk. The value of an investment can fall as well as rise and you might not get back the amount originally invested at any point in time. Your capital may be at risk.
Important information

conditions specified in Section 275 or 305 respectively of the SFA, as the case may be (as any such Section of the SFA may be amended, supplemented and/or replaced from time to time), (iii) to an institutional investor, an accredited investor, expert investor or overseas investor (each as defined under the Financial Advisers Regulations) (“FAR”) (as any such definition may be amended, supplemented and/or replaced from time to time) or (iv) otherwise pursuant to, and in accordance with the conditions of, any other applicable provision of the SFA or the FAR (as the same may be amended, supplemented and/or replaced from time to time).

United States
In the United States, brokerage services are offered through Deutsche Bank Securities Inc., a broker-dealer and registered investment adviser, which conducts securities activities in the United States. Deutsche Bank Securities Inc. is a member of FINRA, NYSE and SIPC. Banking and lending services are offered through Deutsche Bank Trust Company Americas, member FDIC, and other members of the Deutsche Bank Group. In respect of the United States, see earlier statements made in this document. Deutsche Bank makes no representations or warranties that the information contained herein is appropriate or available for use in countries outside of the United States, or that services discussed in this document are available or appropriate for sale or use in all jurisdictions, or by all counterparties. Unless registered, licensed as otherwise may be permissible in accordance with applicable law, none of Deutsche Bank or its affiliates is offering any services in the United States or that are designed to attract US persons (as such term is defined under Regulation S of the United States Securities Act of 1933, as amended). This United States-specific disclaimer will be governed by and construed in accordance with the laws of the State of Delaware, without regard to any conflicts of law provisions that would mandate the application of the law of another jurisdiction.

Germany
This document has been created by Deutsche Bank Wealth Management, acting through Deutsche Bank AG and has neither been presented to nor approved by the German Federal Financial Supervisory Authority (Bundesanstalt für Finanzdienstleistungsaufsicht). For certain of the investments referred to in this document, prospectuses have been approved by competent authorities and published. Investors are required to base their investment decision on such approved prospectuses including possible supplements. Further, this document does not constitute financial analysis within the meaning of the German Securities Trading Act (Wertpapierhandelsgesetz) and, thus, does not have to comply with the statutory requirements for financial analysis. Deutsche Bank AG is a stock corporation (“Aktiengesellschaft”) incorporated under the laws of the Federal Republic of Germany with principal office in Frankfurt am Main. It is registered with the district court (“Amtsgericht”) in Frankfurt am Main under No HRB 30,000 and licensed to carry on banking business and to provide financial services. Supervisory authorities: The European Central Bank (“ECB”), Sonnenmannstrasse 22, 60314 Frankfurt am Main, Germany and the German Federal Financial Supervisory Authority (“Bundesanstalt für Finanzdienstleistungsaufsicht” or “BaFin”), Graurheindorfer Strasse 108, 53117 Bonn and Marie-Curie-Strasse 24-28, 60439 Frankfurt am Main, Germany.

India
The investments mentioned in this document are not being offered to the Indian public for sale or subscription. This document is not registered and/or approved by the Securities and Exchange Board of India, the Reserve Bank of India or any other governmental/regulatory authority in India. This document is not and should not be deemed to be a “prospectus” as defined under the provisions of the Companies Act, 2013 (18 of 2013) and the same shall not be filed with any regulatory authority in India. Pursuant to the Foreign Exchange Management Act, 1999 and the regulations issued there under, any investor resident in India may be required to obtain prior special permission of the Reserve Bank of India before making investments outside of India including any investments mentioned in this document.

Italy
This report is distributed in Italy by Deutsche Bank S.p.A., a bank incorporated and registered under Italian law subject to the supervision and control of Banca d’Italia and CONSOB.

Luxembourg
This report is distributed in Luxembourg by Deutsche Bank Luxembourg S.A., a bank incorporated and registered under Luxembourg law subject to the supervision and control of the Commission de Surveillance du Secteur Financier.

Spain
Deutsche Bank, Sociedad Anónima Española is a credit institution regulated by the Bank of Spain and the CNMV, and registered in their respective Official Registries under the Code 019. Deutsche Bank, Sociedad Anónima Española may only undertake the financial services and banking activities that fall within the scope of its existing license. The principal place of business in Spain is located in Paseo de la Castellana number 18, 28046 - Madrid. This information has been distributed by Deutsche Bank, Sociedad Anónima Española.

Portugal
Deutsche Bank AG, Portugal Branch is a credit institution regulated by the Bank of Portugal and the Portuguese Securities Commission (“CMVM”), registered with numbers 43 and 349, respectively and with commercial registry number 980459079. Deutsche Bank AG, Portugal Branch may only undertake the financial services and banking activities that fall within the scope of its existing license. The registered address is Rua Castilho, 20, 1250-069 Lisbon, Portugal. This information has been distributed by Deutsche Bank AG, Portugal Branch.

In Europe, Middle East and Africa as well as in Asia Pacific this material is considered marketing material, but this is not the case in the U.S. No assurance can be given that any forecast or target can be achieved. Forecasts are based on assumptions, estimates, opinions and hypothetical models which may prove to be incorrect. Past performance is not indicative of future returns. Investments come with risk. The value of an investment can fall as well as rise and you might not get back the amount originally invested at any point in time. Your capital may be at risk.
Important information

Austria
This document is distributed by Deutsche Bank AG Vienna Branch, registered in the commercial register of the Vienna Commercial Court under number FN 140266z. Deutsche Bank AG is a public company incorporated under German law and authorized to conduct banking business and provide financial services. It is supervised by the European Central Bank (ECB), Sonnemannstraße 22, 60314 Frankfurt am Main, Germany and by the Federal Financial Supervisory Authority (BaFin), Graurheindorfer Straße 108, 53117 Bonn, Germany and Marie-Curie-Strasse 24-28, 60439 Frankfurt am Main, Germany. The Vienna branch is also supervised by the Austrian Financial Market Authority (FMA), Otto-Wagner Platz 5, 1090 Vienna. This document has neither been submitted to nor approved by the aforementioned supervisory authorities. Prospectuses may have been published for certain of the investments mentioned in this document. In such a case, investment decisions should be made solely on the basis of the published prospectuses, including any annexes. Only these documents are binding. This document constitutes marketing material for informational and promotional purposes only and is not the result of any financial analysis or research.

The Netherlands
This document is distributed by Deutsche Bank AG, Amsterdam Branch, with registered address at De entree 195 (1101 HE) in Amsterdam, the Netherlands, and registered in the Netherlands trade register under number 33304583 and in the register within the meaning of Section 1:107 of the Netherlands Financial Supervision Act (Wet op het financieel toezicht). This register can be consulted through www.dnb.nl.

050542 110221

In Europe, Middle East and Africa as well as in Asia Pacific this material is considered marketing material, but this is not the case in the U.S. No assurance can be given that any forecast or target can be achieved. Forecasts are based on assumptions, estimates, opinions and hypothetical models which may prove to be incorrect. Past performance is not indicative of future returns. Investments come with risk. The value of an investment can fall as well as rise and you might not get back the amount originally invested at any point in time. Your capital may be at risk.