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Investment Research

Automation and robotics - update

Longer Term Investments

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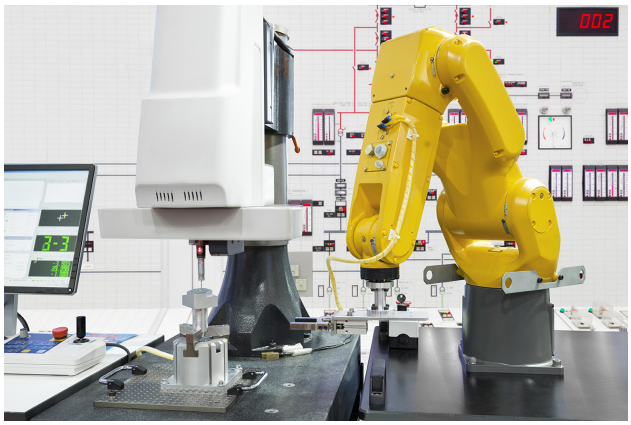
- We have updated our forecasts in this new report. We estimate the overall market size for automation and robotics to be USD 262bn in 2023, and expect it to grow to USD 346bn in 2025. The increasing digitalization and use of generative AI in the automation and robotics sectors is a key part of this investment theme.
- In this report, we introduce detailed AI estimates. One of the main business advantages of AI is its high scalability, which can result in significant cost savings. AI makes automation equipment more efficient and smarter—and, when combined with machine vision automation equipment, will be easier and faster to program, making it more accessible for users and an attractive option for more industries.



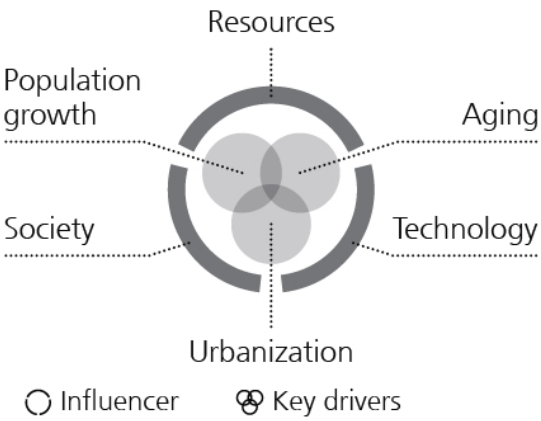
Source: gettyimages

Our view

The omnipresent topic of generative artificial intelligence (AI) plays an important role in the automation and robotics industry, offering a revenue opportunity through new products for customers and options for automation firms to optimize their cost base. The programming of robots will become much easier in the future, predictive maintenance will reach new levels, and the combination of AI and digital twins will optimize manufacturing processes even more, in our view. After a strong post-COVID 19 recovery in the hardware segment, we expect industrial software and increasingly also AI applications to drive the growth of the theme this year and the next. We expect highly automated manufacturing plants and techniques across sectors. More efficient production processes are also a key driver for green manufacturing, helping to reduce CO_2 emissions from the sector. In sum, we believe automation companies will be among the long-term winners from many structural drivers such as labor shortage, manufacturing reshoring, wage inflation, the drive for productivity gains, and rising digitalization.

The Longer Term Investments (LTI)

This series contains thematic investment ideas based on long-term structural developments, with investment opportunities influenced by the interplay of technological advancement, resource scarcity, and societal changes.



Growth drivers

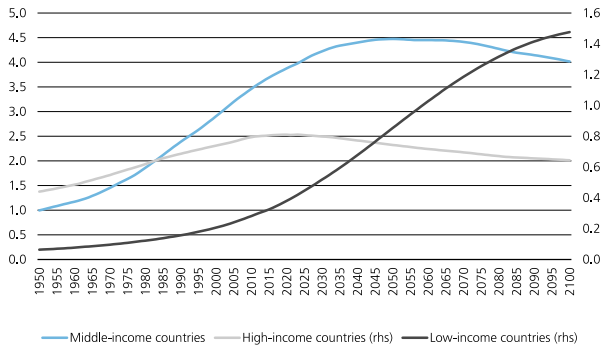
The manufacturing industry has a history of reinventing itself. Through steam power in the First Industrial Revolution, electricity in the Second, and computing and automation in the Third, industry has consistently found new ways to boost productivity. The Fourth Industrial Revolution (or Industry 4.0) is now underway and, in our view, will transform manufacturing once again—this time powered by smart automation. Industrial software is elevating the role of automation equipment beyond merely improving efficiency and accuracy, and automation is increasingly becoming a tool for total operational and asset management. Based on our definition, the automation market was worth USD 262bn in 2023. Following the post-pandemic rebound, we anticipate the smart automation industry will grow its average revenue at a double-digit rate in the teens in 2024–25. This should be supported by strong growth in new technologies such as AI and several structural drivers discussed in detail in this report for traditional automation end-markets. From an investment perspective, we believe smart automation will be one of the fastest-growing segments of the broader industrial and IT sectors over the next decade.

To understand the potential of this automation theme, it is important to identify the secular trends that could boost its rapid, sustainable growth over the next few years:

- We think emerging markets (EM) are one of the most promising growth areas for this theme. Many emerging markets are behind developed countries in terms of use of robotics, productivity gains, wage levels, and size of the manufacturing sector. Aging populations in emerging markets, as in developed markets, make these countries an attractive target for automation equipment (Fig. 1).
- The manufacturing sector is set to become more digital thanks to the adoption of industrial software and AI, resulting in increased automation investment in developed countries. The Industrial Internet of Things (IIoT) and the rollout of 5G enables communication along the entire value chain, improving productivity through the use of big data. Industrial software (i.e., smarter equipment) will likely increasingly also be a tool for asset optimization (e.g., remote monitoring, predictive maintenance). Other examples include robots, where embedded AI helps on several fronts—e.g., with generative AI, it is easier to install and adjust them for new applications with natural language, instead of needing specialized programming skills. Like other applications, robots will also have predictive maintenance to avoid downtimes, which is very important in mass-manufacturing. Based on estimates from the Information Technology & Innovation Foundation (ITIF), unplanned downtime in the automotive supply industry costs on average USD 1.3mn per hour. The embedded AI will also help robots to make autonomous decisions and interact more naturally in their area.
- The COVID-19 pandemic and geopolitical tensions between the US and China have revealed how interconnected the global economy is and how vulnerable global supply chains are when even small parameters change. As a result, firms now want to reshore some capacity. In particular, the semiconductor industry has seen the first evidence of companies planning to "reshore" (localize) some of their production, which should also support the automation and robotics theme. These developments represent a paradigm shift in manufacturing away from the "cost focus" of the last few decades, which favored concentrated manufacturing hubs. We expect new plants to have a higher level of automation than they did before given the many benefits automation provides companies, including protecting operations from labor disruptions and the cost savings accrued in relation to wage costs in developed countries.

Fig. 1: Demographic change: Shifting working age population

Size of population aged 15–64, in billions



Source: United Nations (World Population Prospects 2022), Online Edition, UBS, as of January 2023. Remark: rhs = right hand side

Automation market: an introduction

When people think about automation, most picture an industrial robot assembling a car. In reality, that is only one part of the automation value chain, which can be split into several categories, the most prominent being factory and process automation. Industrial software is also an important business driver in both segments. Factory (or discrete) automation generally describes assembly processes, such as automating robots in the automotive industry, as well as other processes in the general manufacturing space such as packaging and semiconductors. Process automation refers to continuous production processes that transform

raw materials into final products (e.g., the mixing of liquids in refining, or the distribution of electricity). The typical process automation end-markets are the oil and gas industry, refining, chemicals, and power generation. Between these sectors are several hybrid markets that use factory automation and process equipment alike (e.g., pulp and paper, or food and beverage). In addition to the traditional discrete and process automation markets, as well as the growing industrial software market, we also count several new applications in the automation market, such as 3D printing, artificial intelligence (AI), and drones. Although the new markets are still small, they are outperforming the overall automation market in terms of growth.

Market estimates

We discuss all end-markets in more detail further on in this report. In the first section, we focus on the discrete (factory), robotics, and process automation end-markets, as all three are crucial for industrial automation companies. In the second section, we focus on automation software and the emerging 3D printing market, artificial intelligence, and drones. We estimate that the combined market value was USD 262bn in 2023. In this update, we include detailed estimates for relevant AI applications for the automation and robotics theme. That has resulted in lower market estimates for 2023 (new USD 262bn vs. the previous forecast of USD 299bn), since our last update lacked a detailed breakdown and outlined broader AI market estimates. We now have enough data for a more detailed breakdown as the monetization of AI has become more visible and projectable over the last 12 months. We include only AI software assistants and AI cloud & models in our estimates for automation and robotics. The AI infrastructure market is primarily related to our Enabling technologies longer-term investment theme, published on 8 March 2024. More details can be found lower down in this report.

To estimate the market size, for discrete and process automation, we used a bottom-up approach and aggregated the automation sales of the most important market participants. As the basis for our 2023 robotics estimates, we used the market size estimated in the "World Robotics 2020" publication (IFR, as of 24 September 2020) and applied the market growth forecast for the following years, also from IFR, and price assumptions based on UBS estimates. Our estimate for the industrial software market is based on Emerson/Aspentech estimates (as of October 2021) and our own UBS estimates based on forecasts from industrial software firms in the automation sector. For our estimates on the 3D printing market, artificial intelligence, and drones, please see detailed sources in the section "New long-term trends."

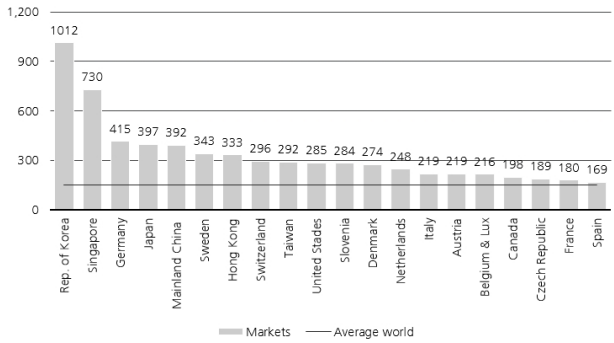
We estimate that 14% of the market size in 2023 was made up of discrete automation (USD 36.8bn), 8% of robotics (USD 20.7bn), 33% of process automation (USD 86.5bn), 27% of industrial software (USD 70bn), 4% of artificial intelligence that we count to the automation market (USD 10bn), 7% of 3D printing (USD 19.2bn), and 7% of drones (USD 19bn). After demand rebounded sharply in recent years, we forecast low- to mid-single-digit revenue growth in traditional automation end-markets (discrete and factory automation equipment), high-single-digit sales growth for industrial software and robotics, and mid- to high-teens growth in emerging technologies drones and 3D printing. We expect the artificial intelligence (AI) market to grow by about 250% year-over-year in 2024 and 60% year-over-year in 2025. In sum, we expect a compound annual growth rate (CAGR) of about 15% for the overall automation market in 2024 and 2025, mainly driven by AI and industrials software, while the hardware segment in discrete and process automation is expected to grow in the low- to mid-single digits.

Factory (discrete) automation

Typical products in factory automation include programmable logical controllers (PLCs), electric motors, sensors, robots, and of course, manufacturing software. The market is mainly controlled by European and Japanese companies and a few US and Chinese vendors. Over the longer term, we think the robotics subsegment is exciting given the structural trends we outline in the "Growth drivers" section. In particular, robot penetration in many emerging markets is still much lower than in developed countries. Mainland China is a case in point—robot density in the country moved from 25th in 2015 (density of 49 units) to fifth in 2022 (density of 392 units), according to the IFR World Robotics (Fig. 2). In the past few years, domestic firms gained market share in China in the smaller robots segments, for larger robots the foreign brands are still leading.

Fig. 2: Robot density

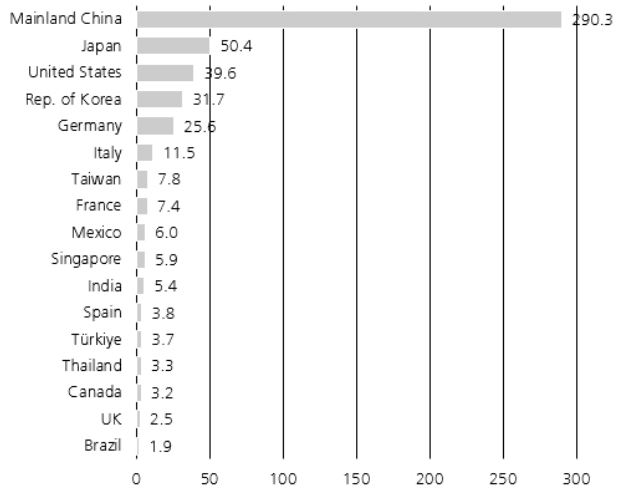
Robots per 10,000 employees in manufacturing (all industries) by market or region, 2022



Source: International Federation of Robotics, "World Robotics 2023"; UBS

Big gaps also exist in the leading, manufacturing-heavy industrialized countries, illustrating the market's growth potential globally. According to IFR, most robots installed in 2022 (the latest available data) were in Mainland China, followed by Japan, the US, Republic of Korea, and Germany (Fig. 3).

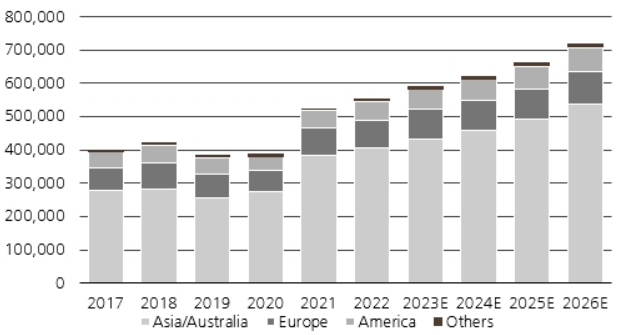
Fig. 3: New industrial robot installations in 2022
Top 17 markets (in thousands)



Source: International Federation of Robotics, "World Robotics 2023"; UBS

For 2024, IFR expects a slightly lower volume growth of 5.4%, which is in-line with our thinking of a slower macroeconomic environment in 2024. For the following years IFR expects an acceleration with 6.4% in 2025 and 8.5% in 2026 (Fig. 4). Taking into account price inflation, we expect high-single-digit sales growth for the robot market in the next three years. All major regions are investing heavily in robots to build more expertise in this sector and to support the broad range of end-markets that are using them.

Fig. 4: Each of the following years is expected to bring a new all-time-high in new installations - Asia will be the main driver for demand
Annual installations of industrial robots



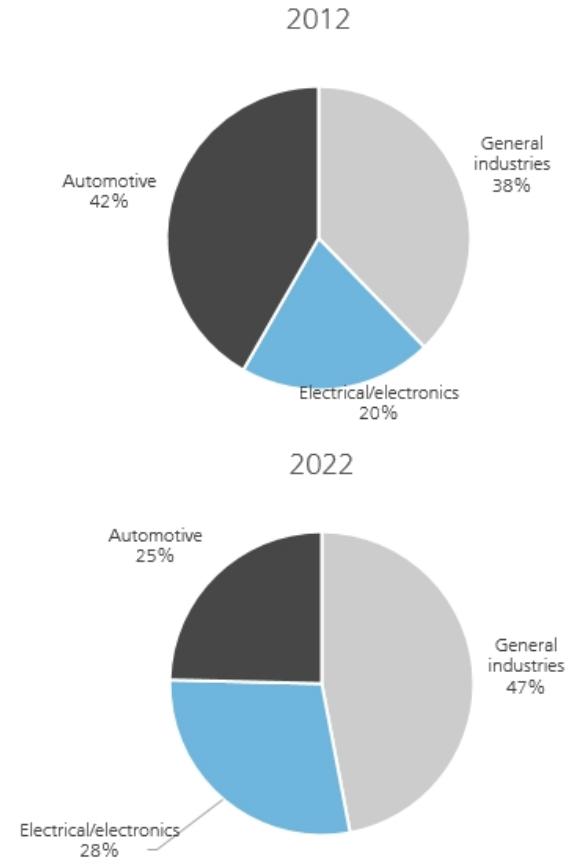
Source: International Federation of Robotics (World Robotics 2023), UBS

New capacity expansions used to be the key driver of demand, but industry upgrades will be another important driver, in our view. Automation equipment is increasingly being used outside the automotive industry, which provides a growth opportunity for automation equipment manufacturers. In particular, industry upgrades in the low- to middle-end manufacturing sectors—due to rising labor costs, labor shortages, and an aging and better educated population that doesn't want to work in factories—are bolstering demand. In 2020, for the first time, and again in 2021 and 2022, the automotive sector wasn't the largest end-market anymore, confirming our conclusions (Fig. 5). In 2012, the automotive sector represented a large part of demand with 42%, which has fallen to only a quarter 10 years later.

Wages have risen significantly in emerging markets, and like many developed countries, some emerging markets also have aging societies. A prominent example is China, where the population shrank by around 2.08 million in 2023, after a decline of 0.85 million in 2022, marking the second year of decline. The last two years marked the first drop in the population in six decades. On top of this, rising education levels have resulted in fewer workers willing to take lower-pay factory jobs. While the demographic challenge is a long-term issue, rising labor costs are an important short-term driver, as higher wages shorten the payback period for robots. Efficiency and depending on the task also the quality is also much higher with robots, and the best example can be found in the automotive industry.

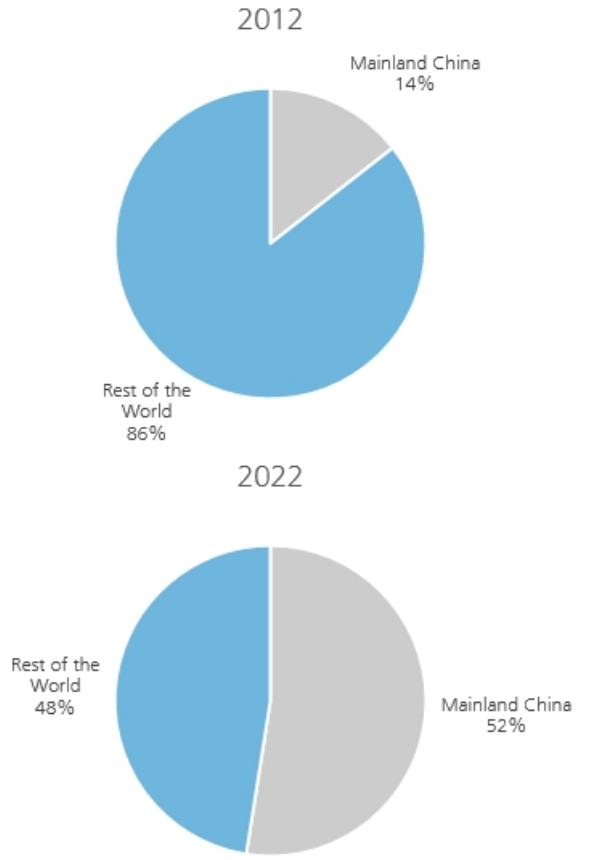
Fig. 5: The automotive market is not the largest end-market anymore

Demand for robots split among industries



Source: International Federation of Robotics, "World Robotics 2023"; UBS

Fig. 6: China gained massive market share in new global installations



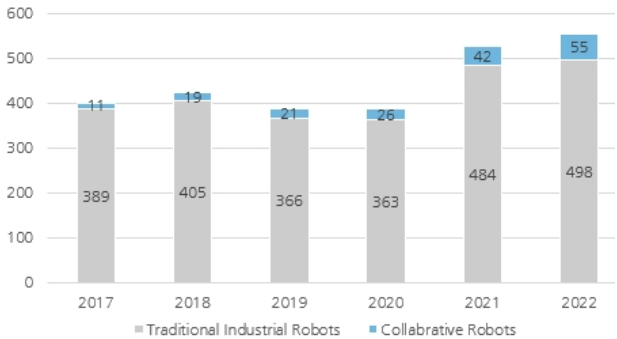
Source: International Federation of Robotics, "World Robotics 2023"; UBS

The strong focus in China over the last 10 years can also be seen in robots installations compared to total installations worldwide. While mainland China represented only 14% of global demand in 2012, the share grew to 52% in 2022 (see Fig. 6).

Another growth opportunity and increasing trend is the implementation of so-called cobots (collaborative robots). These are robots that work together with humans and help them perform their tasks. They can range from small robots on a table to larger robots that lift things or perform other tasks. The cobot growth rate is higher than for traditional industrial robots—e.g., in 2022, the growth rate was 31% y/y for cobots (see Fig. 7). Cobots represented 10%, or 55,000, of newly installed robots in 2022, up from only 2.5% of newly installed robots in 2017 (11,000 installed cobots).

Fig 7: Annual new installed robots – collaborative robots gain market share

Collaborative and traditional industrial robots



Source: International Federation of Robotics, "World Robotics 2023"; UBS

Aside from cobots, another area of interest is the development of humanoid robots. Several firms and universities across the world are working on prototypes or have already presented robots that are out in the real world. China is very committed to this technology. Based on targets from the Chinese Ministry of Industry and Information Technology (MIIT), China aims to launch mass-production of these robots by 2025. One of the advantages of humanoid robots is that due to their design (human-like with arms and legs), they can act in areas/rooms made for humans.

Process automation

As mentioned earlier, process automation involves the continuous flow of raw materials (e.g., in the oil and gas or the chemical industries), where a high degree of measurement, timing, and precision is important. The most important part is a Distributed Control System (DCS)—essentially a central computer that processes inputs from sensors and intelligent devices, and coordinates groups of pumps and valves to run the process smoothly. Systems have become increasingly sophisticated, measuring not just temperatures and pressures, but also fine details such as corrosion or gas leakage.

Without process automation systems, plant operators must physically track all the parameters during production, assess the quality of the output, and calculate process changes required to achieve the required product. In addition, maintenance is performed at regular intervals, rather than only when necessary. All this makes it challenging for plant operators to achieve optimal performance compared with an automated plant that uses sensors and computers to analyze thousands of signals and respond quickly. Inefficiencies in production processes and suboptimal maintenance intervals make operations more costly. Like factory automation, this market is also mainly controlled by European, Japanese, and US companies.

During the post-COVID-19 recovery, process automation firms benefited from rising commodity prices, which supported the P&L of their customers in the various commodity-exposed end-markets (e.g., oil & gas, mining industry, electric utilities). Market demand has normalized, therefore we expect in 2024 and 2025 mid-single-digit growth on average. Capital expenditure on traditional energy and chemical plants remains robust globally, supporting new project work as well as high-margin recurring maintenance, repair, and overhaul work. Sustainability-related end-markets, such as biofuels, hydrogen, and carbon capture, represent a rapidly-growing addressable opportunity as well.

In the near future, we expect DCS providers to advance software to elevate insights and controls from the plant level to the enterprise level. In doing so, customers would be able to evaluate and optimize asset portfolio performance from a single pane of glass.

Hybrid automation

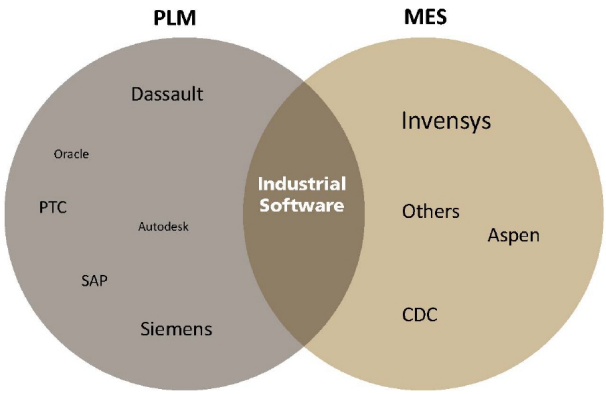
As the name implies, this category integrates characteristics of both continuous process and batch-specific production. This includes categories such as food & beverage, pharmaceuticals & life sciences, personal care, rubber/tire and waste management.

Industrial software

The growth outlook for industrial software remains solid, in our view, as more companies are leveraging the benefits of digitalization in product manufacturing. The rising trend has become more apparent, as many manufacturing companies have started to carve out separate internal teams called "digital factories" to take advantage of software in manufacturing. Despite a mixed outlook for overall enterprise IT spending, we think the outlook for the software industry remains solid, with high-single-digit growth anticipated in industrial software in the next two years.

The two major sub-industries within the industrial software segment are product life cycle management (PLM) and manufacturing execution systems (MES) (Fig. 8).

Fig. 8: Industrial software landscape
PLM = product life cycle management;
MES = manufacturing execution system



Source: Company reports, UBS

PLM is generally considered an enterprise-level software system, whereas MES is a plant-level system. The major difference is that PLM is used in development and corresponding production processes, while MES is used to optimize the production process. An example of PLM is a computer-aided design (CAD) software program for designing products on the computer; an example of MES is operation management software. Key vendors in PLM include Dassault, Autodesk, PTC, and Siemens, while the top vendors in MES include Invensys, CDC Software, and

Aspen (Fig. 8). Increasingly, IT service companies like IBM and Accenture have begun to invest more in industrial software and services to take advantage of the industry's healthy growth outlook. In our view, growth in industrial software will continue to depend on the following:

1. Solving design complexity: Industrial software helps manufacturing companies reduce design complexity, which is often a key bottleneck. For example, Renault's Formula One team leverages industrial software by using state-of-the-art simulation technologies for a broad range of applications, including engine combustion, intake and exhaust, thermal cooling, batteries, electric motors, and turbochargers, thus enhancing its race competitiveness. Despite the rising usage of industrial software, we still see significant growth potential for design-based software, particularly from emerging markets where penetration remains low.
2. Improved time to market: By solving design complexity and improving production efficiency through integrated tools, industrial software can significantly improve time to market. In this regard, in addition to the advancements in 3D printing and additive manufacturing, drones are fast emerging as a key IT tool for the growth of industrial automation.

Digital twins

In our previous report, we defined a "digital twin" using the description from Siemens: A virtual representation of a product, production process, or performance. Modern factories no longer exist just in the physical world. As the consumer industry experienced with the launch of smartphones, the industrial sector is undergoing a fundamental IoT-driven structural change (Box 1), and the COVID-19 crisis should accelerate this shift. Industrial equipment is becoming increasingly interconnected, enabling people to collaborate better and firms to enhance productivity. Amid this digital transformation, companies will need to sense, analyze, and act based on data. So major industrial companies are in the process of expanding their software offerings or acquiring specialist IT companies that not only provide new product optimization opportunities for their customers, but also create new incremental revenue opportunities for themselves. Like IT companies, industrial firms have also started to transform their software divisions into a software-as-a-service (SaaS) business model. This business model offers companies, for instance, the opportunity to broaden their offering to smaller firms that couldn't afford the service before due to high additional costs (e.g., IT infrastructure, etc.). With the SaaS offering, the total cost of ownership is lower for the user.

One key enabler of digital twins is IIoT, which describes a network of connected devices. Modern robots, warehouse equipment, devices that automate refineries, heating and cooling systems in buildings, and even modern airplane engines all generate data. IIoT enables the owner of the assets to operate them much more efficiently. IIoT technology and the related industrial software are also becoming a tool for asset optimization (cost savings) through remote monitoring and predictive maintenance. Among other applications, IIoT involves the use of sensor data, machine-to-machine communication, and big data technology (cloud-based platforms) to better monitor equipment and analyze data. Digital twins and IIoT technology eliminate inefficiencies and save time and money through better management of production processes and predictive maintenance. New technologies, particularly the 5G network, will accelerate the adoption of IIoT. We have seen countries that have used the fiscal stimulus from the coronavirus crisis to increase spending on their 5G networks.

Box 1: Internet of Things vs. Industrial Internet of Things

The Internet of Things (IoT) refers to a network of connected, everyday devices that constantly send and receive data. A combination of connected chips (Bluetooth, wifi, or cellular) and sensors or low-power processors linked to a remote hub is making regular objects like refrigerators, cars, and public lighting "intelligent."

The Industrial Internet of Things (IIoT) describes the IoT in the manufacturing world. It includes, among other applications, the use of sensor data, machine-to-machine communication and big data technology (cloud-based platforms) to better monitor equipment and analyze data. IIoT technology optimizes inefficiencies and saves time and money through better management of the production process and predictive maintenance.

New long-term trends

AI is at the center of the Fourth Industrial Revolution

Artificial intelligence (AI)—which we refer to as a set of tools and programs that make software smarter such that an outside observer would think the output was generated by a human—is set to be a significant driver in the automation space, as it will have far-reaching implications for many industries. In the most simplistic terms, AI leverages self-learning systems by using multiple tools like data mining, pattern recognition, and natural language processing. It operates as a human would when conducting routine tasks such as common sense reasoning, forming an opinion, or social behavior. That said, AI is an umbrella term that covers a confluence of multiple technologies, such as machine learning (which includes deep learning), cognitive computing, natural language processing, and neural networks (see Fig. 14).

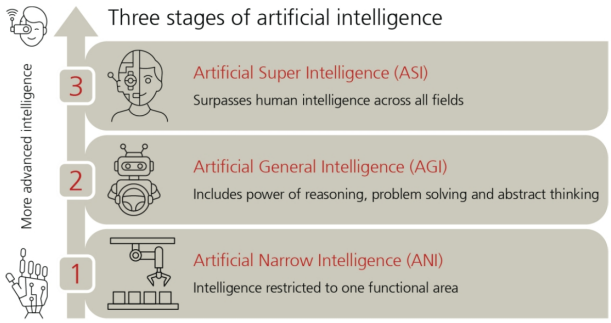
The main business advantages of AI over human intelligence are the former's high scalability, resulting in significant cost savings. Other benefits include AI's consistency and rules-based programs, which eventually reduce errors (both omission and commission), along with its longevity, continuous improvement, and ability to document processes.

We believe AI can be divided broadly into three stages (Fig. 9): artificial narrow intelligence (ANI), artificial general intelligence (AGI), and artificial superintelligence (ASI). The use cases for AI are diverse, as AI-based software will push the limits of automation. Like a brain, AI powers the traditional sources of automation and robotics and drives the progress of sectors like autonomous vehicles and drones. But as a standalone industry, AI-based software can create significant business opportunities. Some examples include virtual assistants or chatbots providing expert assistance; smart or robot advisors in the fields of finance, insurance, legal, media, and journalism; and expert healthcare systems that provide medical diagnosis and assistance. Other benefits include significantly improving efficiencies in R&D projects by reducing time to market, optimizing transport and supply chain networks, and improving governance through better decision-making processes.

However, for AI to be capable of capturing these unique opportunities, it will require significant human guidance in terms of designing, implementing, and directing component systems. Symbolic learning systems use data based on human-readable/understandable problems, essentially trying to replicate human reason and intuition. This branch of AI was the focus of most research and development efforts in the 1990s. But the rapid decline in the cost of computing power and the explosion of data have resulted in a surge of machine learning. Machine learning can be thought of as the ability of an AI system to automatically learn and improve a solution without being explicitly programmed to do so. To "learn automatically" is not the same as to "learn autonomously," as most machine learning systems require some human direction regarding data and desired outcome.

The transition from the first (artificial narrow intelligence, ANI) to the second (artificial general intelligence, AGI) phase has taken a long time, but when we fast-forward six years since our primer, the exponential growth in computing power, the rise of sophisticated algorithms, and the evolution of large language models (LLM) and generative AI (coupled with billions of dollars of investments) give us the confidence to say that we are closer to the AGI stage. While not every aspect of AGI can be deployed across software applications or automated devices overnight—including integrating softer attributes like emotions or empathy—the recent progress of AGI projects at leading firms like OpenAI (Project Q* with reinforcement learning) and other major tech platforms leads us to believe that AGI is coming soon. But predicting an exact timeline is extremely difficult, given the many complexities at hand—e.g., processing power, access to chips, regulations, governance, costs, to name a few. That said, with advanced GPUs expected to further narrow the gap with human intelligence, and with a pipeline of strong products in the next few years, we should see an explosion of AI use cases within the automation space in this decade as AGI eventually becomes a reality.

Fig. 9: Development of Artificial Intelligence



Source: UBS, as of 2024

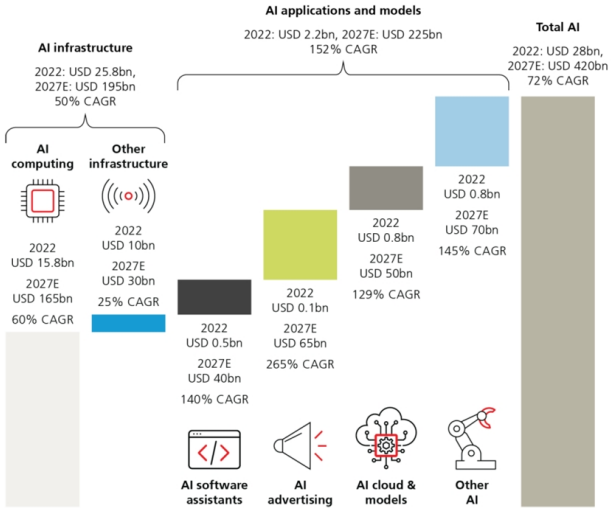
We are optimistic about the growth prospects of the AI industry. The exponential growth in computing power and the solid cloud and smart device ecosystem that are already in place, coupled with favorable supply factors like low computing and storage costs, advanced algorithms, and the increased availability of AI-based talent, are all supportive factors.

How big is the opportunity and spotlight on generative AI

We expect AI industry revenues to grow 15x between 2022 and 2027, expanding from USD 28bn in 2022 to USD 420bn in 2027—a 72% CAGR (see Fig. 10). This will likely make AI one of the fastest-growing and largest segments within global tech, and arguably the "tech theme of the decade," as we don't see similar growth profiles elsewhere in the sector. This comes against a backdrop of improving visibility for AI infrastructure spending that should extend beyond the initial training and inferencing boom, and amid broadening demand for AI applications and models. In our automation and robotics market estimates, we use only AI software assistants, and AI cloud & models. AI infrastructure falls primarily under our Enabling technologies longer-term investment theme, published on 8 March 2024. In particular, AI software assistants and AI clouds & models should grow from USD 3bn in 2023 to USD 16.5bn in 2025.

Fig. 10: Semiconductors and software are best positioned to ride the AI wave

15x growth expected in AI demand from 2022–27E based on our revised estimates, in USD bn

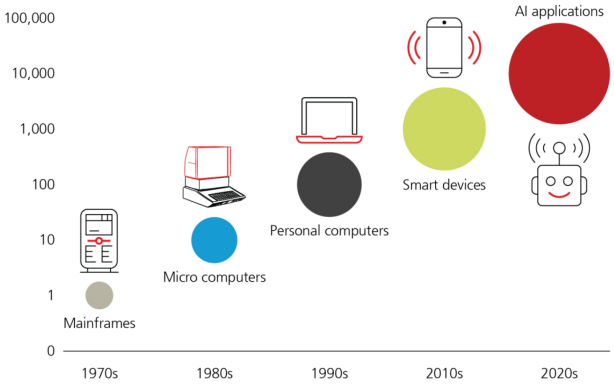


Source: Bloomberg Intelligence, UBS estimates, as of December 2023

The strong upward revision in our revenue estimate is consistent with our playbook on the computing cycle, where investors have rewarded every cycle with strong returns thanks to solid growth prospects. The computing cycle has evolved in such a way that each one has lasted for at least 10–15 years, with a significant 10x or so expansion in annual shipments. Annual shipments for mainframes were only about 1mn units until the 1980s, when they ballooned to around 10mn as microcomputers became mainstream computing devices (see Fig. 11). This was followed by a sharp increase during the PC era, when annual PC shipments shot up to more than 100mn units, with PC shipments eventually reaching an annual run-rate of nearly 300mn. Smart devices, which include smartphones and tablet PCs, crossed 1bn shipments during the mid- 2010s. Currently, annual shipments are close to 1.5bn units. With AI, we expect this 10x growth trend to continue, with annual AI chatbots and applications potentially crossing 10bn units.

Fig. 11: We are in the early innings of the AI growth cycle

Evolution of computing devices and size of annual addressable markets, in millions



Source: UBS, as of December 2023

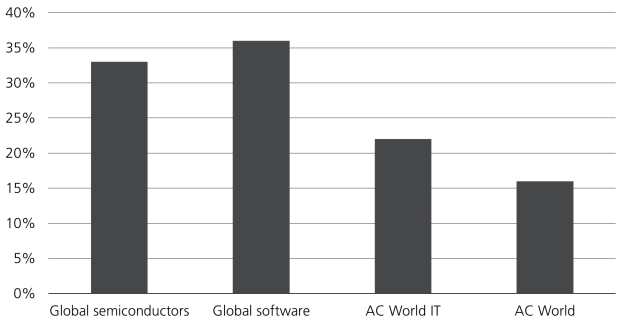
We believe the majority of near-term spending in generative AI computing will focus on data center investments—which are GPU-intensive—end-device AI chips, and AI edge-computing that can provide low latency and personalized generative AI services. For instance, some basic image generation and translation services may not need a model with trillions of parameters and may require training only a few billion parameters. Today, there are many smaller, dedicated AI chipsets that can perform these kinds of tasks and can be easily integrated inside end-devices like smartphones and PCs and other segments like autos and Internet of Things (IoT) devices. We believe the ability to process data locally without getting exposed to external data security risks could force many consumer electronics companies to explore such opportunities, as they can still participate in the generative AI opportunity through integrating AI edge-computing chips in end-devices. In certain situations, the ability of edge devices to offload some basic computation from the GPU-intensive, cloud-based computation can come in handy. Likewise, we see the potential of such technological devices to integrate within the automation space, extending productivity growth and enhancing innovation.

How to invest in AI?

We believe the semiconductor and software industries (with a combined market cap of more than USD 10tr) are the best ways to play the strong and improving visibility for AI. Semiconductors, while cyclical, are well positioned to benefit from solid near-term demand for AI infrastructure. Meanwhile, software, with broadening AI demand trends from applications and models, is a defensive trade, thanks to its strong recurring revenue base. We expect both industries to post strong operating margins—33% for semiconductors and 36% for software—significantly above the global IT average of 22% and global average of 16%, respectively, (see Fig. 12).

Fig. 12: Semiconductors and software should post one of the best operating margins across global industries in 2024

2024E operating margins



Source: Factset, Bloomberg, UBS estimates, as of December 2023

Additionally, semiconductors should benefit from strong pricing tailwinds in 2024, which we think should translate into 25% revenue growth and more than 50% operating profit growth. Within semiconductors, we believe logic, semiconductor capital equipment, foundries, and memory companies are the four sub-industries that are best-positioned to ride the AI wave. For software, we expect mid- to high-teen percentage revenue growth in 2024, which would be a solid outcome, thanks to strong AI and cloud tailwinds, as well as resilient margins. Within software, industry leaders exposed to office productivity, cloud, models, and other software segments are relatively better positioned to benefit from rising AI contributions. Eventually, we also believe the internet industry should benefit from AI as demand broadens, but we believe semiconductors and software offer the most compelling risk-reward in the near term. This is also supported by strong pricing power and margin leadership in 2024.

The rise of commercial drones

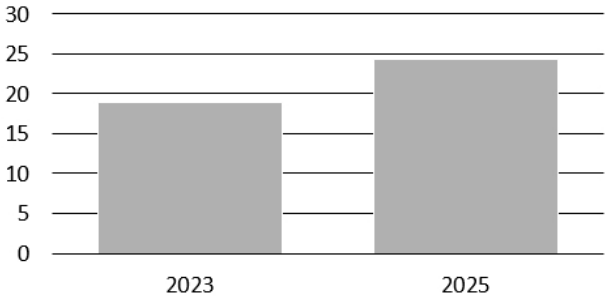
Drones, which were initially restricted to military use for their tactical reconnaissance capabilities, have slowly expanded to personal use and are now literally taking off for commercial purposes. In recent years, drones have increasingly been used during search and rescue missions to provide immediate aerial vision support or to deliver critical medical supplies, such as insulin and EpiPens, to rescue sites. Also known as unmanned aerial vehicles (UAVs), drones are operated remotely or autonomously and generally carry a video camera to monitor flight. Although drones are still in their infancy, they are being used across industries like manufacturing, utilities, agriculture, film, and government organizations at a fraction of the cost of a manned aircraft.

E-commerce and logistics companies are also beginning to experiment with drone technology. Amazon, the global e-commerce leader, anticipates a future where unmanned aircraft flights will exceed general air traffic, which currently totals 85,000 flights a day. Throughout the COVID-19 pandemic, countries like Singapore have used drones to manage social distancing. Thanks to their autonomous feature, drones could be a new tool for industrial automation. For industrial companies, they could aid in aerial inspection surveying, particularly in the oil, gas, and mineral exploration and production industries. They could also be used for short cargo transport within the factory line, resulting in significant cost savings.

Agriculture is another promising industry where drones can be widely used, for example to survey crops and spot irrigation problems. Based on new forecasts released last year from the US Federal Aviation Administration, we now expect the global drone market to grow from USD 19bn in 2023 to USD 24bn in 2025 (Fig. 13). The growth will be driven not only by consumer drones, but also by commercial ones, as demand continues to be strong across industries. Despite the advantages of the drone market, we believe safety and other regulatory issues need to be addressed before we can estimate the industry's long-term growth rate. Many governments across the world are in the process of setting up regulations on safety and privacy.

Fig. 13: Increasing demand both for commercial and consumer drones globally

Rapid growth in global drone market fuelled by advancing drone technology. Global drone market in billion USD.



Source: US Federal Aviation Administration, UBS estimates, as of 2024

3D printing remains a long-term opportunity

Widely known as additive manufacturing, the 3D printing process uses significantly less raw material and fewer manufacturing steps to construct objects as compared with conventional manufacturing methods. Its high energy efficiency helps to reduce industry energy consumption and provide opportunities to lower manufacturing output costs in the long term. Figure 15 shows the various 3D printing techniques available in the market today. The COVID-19 health crisis has highlighted how a global pandemic can significantly disrupt far-flung supply chains, underscoring the need for more localized ones. 3D printing processes helped a few countries navigate short-term supply shortages for key products like face masks and shields, bolstering the business case for 3D printing, at least in the initial stages or during prototype creation. That said, beyond a few current applications, any dramatic benefits are only

expected to materialize over the longer term. In the near term, rather than using 3D printers for mass production, we see opportunities for them in businesses requiring rapid prototyping and high customization with small production quantities. Based on Bloomberg Intelligence data, we expect the industry's revenues to grow from around USD 20.3bn in 2023 to around USD 26.8bn in 2025.

Automation and robotics and the SDGs

We see automation and robotics as an important area of development that could support sustainable development through productivity gains. Specifically, we see potential contribution to SDG 9: Industry, Innovation and Infrastructure, which aims to promote inclusive and sustainable industrialization and foster innovation. In particular, target 9.4 focuses on upgrading infrastructure to make industries more sustainable and resource-efficient, and on greater adoption of environmentally sound technologies and industrial processes. Target 9.5 aims to enhance scientific research and upgrade the technological capabilities of industries in all countries.

The target of resource efficiency and improving industrial and technological capabilities is at the heart of our theme around automation and robotics, both of which aim to deliver not only cost benefits, but also sustainability benefits, even where improved sustainability is not the primary goal of automation. Industrial software, precision machinery, and more sophisticated sensors and monitoring systems in manufacturing, mining, and agriculture can lead to more efficient water, energy, and raw material use and the reduction of waste. In the area of robotics, some companies are using robot technology to tackle explicit sustainability challenges. For example, major industrial companies are already using robots to aid them in their recycling processes by picking out reusable pieces for other products, while robots have also been developed to clear trash and pollution from waterways, and to plant trees at a much faster rate than humans can. Robots can enhance safety by taking over dangerous tasks such as handling hazardous materials, or by improving accuracy in critical areas such as in pharmaceutical or surgical uses.

In the area of research, artificial intelligence is changing the way humans solve problems and analyze data, and AI has already been put to work on some the most challenging sustainability problems. AI can collect and analyze data to enable more effective targeting of intervention, waste reduction, and pollution and air quality monitoring. The benefits are felt not only in the environmental field, but also in the social field, among others. AI can promote efficiency in healthcare systems by enabling self-monitoring and allowing early diagnosis of medical conditions. Machine learning can further extend the availability of quality medical care to remote regions through automated diagnosis. AI also has a use in sustainable investing, in our view, as the data hungry field of environmental, social, and governance (ESG) analysis has started to adopt tools like data mining, pattern recognition, and natural language processing to give better insights into corporate sustainability risks and opportunities.

However, while automation and robotics may be relevant to SDGs, investors should still be conscious of sustainability risks, such as the social impact of automation, which can reduce the availability of jobs for low-skilled workers who are unable to retrain, particularly in cases where the transition of a sector or large company may have a significant impact on whole communities.

When selecting corporate instruments for exposure to this theme, sustainable investors may wish to consider the companies' management of ESG issues for a more holistic assessment of long-term investment alignment. For example, manufacturers of automation equipment that demonstrate superior performance in managing environmental and social risks within their supply chain and procurement standards may be more resilient as regulatory and consumer standards shift. Please see our *Sustainable investing topics* for an overview on the UBS framework for analyzing financially material ESG issues.
Stephanie Choi, Sustainable Investing Strategist

Conclusion

We think the current industrial revolution will turn today's manufacturing plants into tomorrow's smart factories over the next decade. The smart automation industry's total annual revenues stand at around USD 262bn in 2023. We expect the sector to grow around 15% annually in 2024 and 2025, with AI being the outperformer and traditional factory hardware and process automation to grow in the low- to mid-single digits after the COVID-19-related rebound in the previous year (normalization of demand and some inventory de-stocking). We anticipate hardware companies with sizable software exposure will grow their automation businesses over the longer term by mid-single-digit rates and pure-play software companies by high-single-digit rates.

We already mentioned in our previous reports that industrial software will be a differentiator for companies and investors, but now the rollout of generative AI will make it an even more important offering for firms to have. We expect the industrial software market to grow by a high-single-digit rate on average and exhibit high margins. Software and AI are at the center of this revolution, but there is also tremendous demand for automation hardware, such as robots, from emerging markets and several sectors, which should lead to sustainable growth. One obvious example is the rising trend of multiple IT devices per individual (compared with just one PC in the past). Coupled with

shorter product cycles (six months to one year), these dynamics are leading to a surge in device manufacturing and increasing complexity. Against this backdrop, the rising trend of automation by IT vendors is evidence of the recent robust demand for industrial robots. Other supportive long-term drivers are demographic challenges in key countries like China and, in general, increasing wages in emerging markets, but in recent years also developed markets after a period of globally high inflation.

Last but not least, rising trade concerns and the experience of supply chain issues after the COVID-19 crisis have bolstered the localization efforts of manufacturing companies. Reshoring has been an evolving theme over the last few years, one that was sparked by the rapid increase of wages in China. As a result, some companies have started to shift operations to other countries around the globe. Focus on this theme has intensified further in the past several years, starting with the trade frictions between the US and China, and attracting even more attention in the last years in the wake of COVID-19's impact on supply chains and logistic costs. Thus, we expect companies to continue to explore shifting some operations back to North America or Europe, which should result in more automation equipment investments. Also, the better energy efficiency of new automation equipment should support demand on the back of higher commodity prices and the back of the Ukraine war.

In sum, we expect all these forces to lead to above-average earnings growth for industrial companies with automation exposure. We think investors have the opportunity to benefit from the automation and robotics trend over the next few years. Investors with a particular interest in sustainability may choose to focus on the companies that are using robotic technology or AI to tackle explicit SDG challenges.

We have compiled a reference list of automation and robotics companies at the end of this report (Tables 1 and 2). Please note that this list is only for reference and is not a recommendation list.

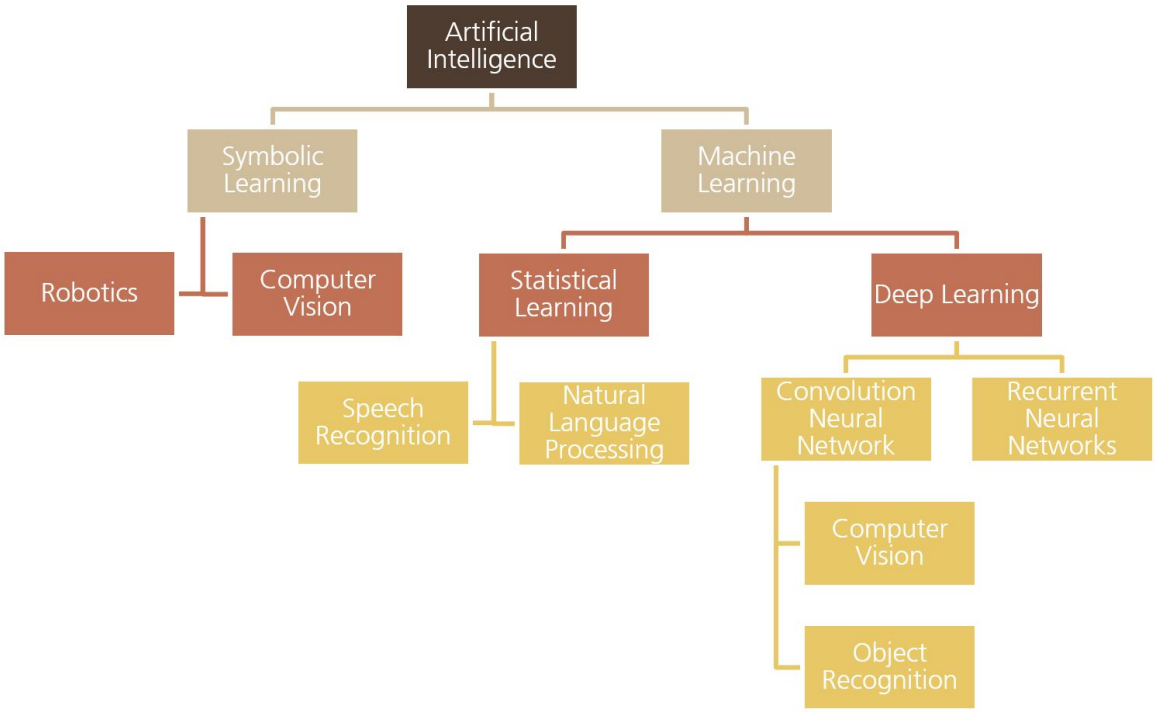
Risks

We see a global industrial recession as the main risk that could negatively impact automation investments given the cyclical nature of some industrial end-markets. Weakness in commodity prices (oil, metals) could hinder or delay investments across the process automation value chain. Increased competition from Chinese firms could negatively impact sales and earnings of established automation firms. With the increasing connectivity of automation equipment and remote control (Industrial Internet of Things), cyber-attacks also represent a potential risk.

Reference list

In the following we describe our screening process. To select the stocks in this list, we used the FactSet business classification system (RBICS), which uses a bottom-up approach to classify companies according to the products and services they provide. Out of more than 1,500 subsectors in the FactSet RBICS classification, 20 are in the scope of our investment theme. We filtered the 20 subsectors for stocks that have at least 25% sales exposure (calculated as the sum of individual sales exposures across all 20 subsectors, equal to or exceeding 25%). We excluded stocks with a market capitalization of less than USD 1.5 bn. Please note that this list is only for reference and is not a recommendation list. Twenty FactSet sub-sectors: 3D Modeling/Rapid Prototyping Automation Providers, Assembly Equipment Manufacturing, Automotive Industry Software, Autonomous Drone Manufacturers, Autonomous Drone Parts Manufacturers, Business Planning and Control ERP Software, Computer Aided Design (CAD) Software, Customer Service Software, General Factory Automation Makers, Household Robot Makers, Industrial Robots and Robotic Assembly Line Makers, Machine Vision and Quality Control Manufacturing, Manufacturing Industry Software, Monitoring and Control Sensor/Instrument Products, Motion Control and Precision Motors Manufacturing, Other Automation Support Product Manufacturing, Other Design and Engineering Software, Other Industrial Electrical Products Manufacturing, Sales Force Automation (SFA) Software, Paper and Textile Automation Providers.

Fig. 14: Artificial intelligence is an umbrella term for many technologies



Source: UBS, as of 2023

Fig. 15: Multiple 3D printing techniques in the market today

Process name	Description
Binder jetting	A liquid bonding agent is selectively deposited to join powder materials
Directed energy deposition	Focused thermal energy, such as a laser, is used to fuse materials to form an object by melting the materials as they are being deposited
Material extrusion	Materials are heated and selectively dispensed through a nozzle or orifice
Material jetting	Materials, such as photopolymers or wax, are selectively deposited
Powder bed fusion	Thermal energy selectively fuses regions of a powder bed
Vat photopolymerization	Certain types of light, such as lasers, are used to selectively solidify liquid photopolymers
Sheet lamination	Sheets of materials are bonded to form an object

Source: US Government Accountability Office, Bloomberg Intelligence, UBS

Table 1 - Automation and robotics companies reference list
This not a list of recommendations. The following companies meet UBS SI definitions to be considered as a company with ESG Thematic attributes, and most relevant to sustainable investing solutions:

Company name	Market	Market value (USD mn)
Salesforce, Inc.	UNITED STATES	290,631
Siemens Aktiengesellschaft	GERMANY	150,016
Schneider Electric SE	FRANCE	128,651
ABB Ltd.	SWITZERLAND	87,506
Emerson Electric Co.	UNITED STATES	65,220
Dassault Systemes SA	FRANCE	57,212
AMETEK, Inc.	UNITED STATES	41,525
Mitsubishi Electric Corp.	JAPAN	35,230
Rockwell Automation, Inc.	UNITED STATES	32,322
Hexagon AB Class B	SWEDEN	29,876
ANSYS, Inc.	UNITED STATES	29,542
Mettler-Toledo International Inc.	UNITED STATES	27,921
Delta Electronics, Inc.	TAIWAN	26,617
Nidec Corporation	JAPAN	24,325
PTC Inc.	UNITED STATES	21,749
Shenzhen Inovance Technology Co., Ltd Class A	CHINA MAINLAND	18,693
NICE Ltd.	ISRAEL	15,208
Bentley Systems, Incorporated Class B	UNITED STATES	14,241
Yaskawa Electric Corporation	JAPAN	11,522
Halma plc	UNITED KINGDOM	10,867
Nemetschek SE	GERMANY	10,657
Fuji Electric Co., Ltd.	JAPAN	10,169
MKS Instruments, Inc.	UNITED STATES	8,338
OMRON Corporation	JAPAN	7,147
Yokogawa Electric Corp.	JAPAN	6,128
Novanta Inc	UNITED STATES	5,874
AutoStore Holdings Ltd.	NORWAY	5,763
SPX Technologies, Inc.	UNITED STATES	5,598
Horiba , Ltd.	JAPAN	4,349
Azbil Corporation	JAPAN	4,022
COMET Holding AG	SWITZERLAND	2,592
SIASUN Robot & Automation CO., Ltd. Class A	CHINA MAINLAND	2,215
Verint Systems Inc.	UNITED STATES	1,947
Durr AG	GERMANY	1,700

Source: Factset, UBS, as of 10 April 2024. For more details about the screening process please see our reference list methodology.

Table 2 - Automation and robotics companies reference list

This is not a list of recommendations. The following companies meet our screen's criteria for inclusion on the reference list, but either do not qualify or do not report the necessary data to meet the additional SI criteria outlined above.

Company name	Market	Market value (USD mn)
Honeywell International Inc.	UNITED STATES	127,599
Keyence Corporation	JAPAN	103,435
Autodesk, Inc.	UNITED STATES	51,128
Fortive Corp.	UNITED STATES	29,245
Fanuc Corporation	JAPAN	28,563
Aspen Technology, Inc.	UNITED STATES	13,343
BE Semiconductor Industries N.V.	NETHERLANDS	12,758
UiPath, Inc. Class A	UNITED STATES	10,417
monday.com Ltd.	UNITED STATES	9,780
Shanghai Baosight Software Co., Ltd. Class A	CHINA MAINLAND	9,308
MSA Safety, Inc.	UNITED STATES	7,558
Cognex Corporation	UNITED STATES	7,069
ZoomInfo Technologies Inc	UNITED STATES	5,958
Beijing Roborock Technology Co. Ltd. Class A	CHINA MAINLAND	6,108
Shanghai BOCHU Electronic Technology Corporation Limited Class A	CHINA MAINLAND	5,878
Altium	AUSTRALIA	5,628
Smartsheet, Inc. Class A	UNITED STATES	5,276
Shinko Electric Industries Co., Ltd.	JAPAN	4,960
Altair Engineering Inc. Class A	UNITED STATES	4,582
Five9, Inc.	UNITED STATES	4,541
Huagong Tech Co., Ltd. Class A	CHINA MAINLAND	4,384
Spectris plc	UNITED KINGDOM	4,075
AAC Technologies Holdings Inc.	HONG KONG	3,886
Jentech Precision Industrial Co., Ltd	TAIWAN	3,986
INFICON Holding AG	SWITZERLAND	3,336
ATS Corporation	CANADA	3,112
Braze, Inc. Class A	UNITED STATES	3,078
HIWIN Technologies Corp.	TAIWAN	2,896
Kulicke & Soffa Industries, Inc.	UNITED STATES	2,695
Ecovacs Robotics Co., Ltd. Class A	CHINA MAINLAND	2,683
LS Corp.	SOUTH KOREA	2,662
Harmonic Drive Systems Inc.	JAPAN	2,557
Mirion Technologies, Inc. Class A	UNITED STATES	2,407
Harbin Boshi Automation Co., Ltd. Class A	CHINA MAINLAND	2,173
PagerDuty, Inc.	UNITED STATES	2,071
LEM Holding SA	SWITZERLAND	2,110
Asana, Inc. Class A	UNITED STATES	2,047
Mitsui High-Tec, Inc.	JAPAN	1,972
Shenzhen Kstar Science and Technology Co., Ltd. Class A	CHINA MAINLAND	1,772
PROS Holdings, Inc.	UNITED STATES	1,694
Furukawa Electric Co., Ltd.	JAPAN	1,552
SUPCON Technology Co., Ltd. Class A	CHINA MAINLAND	4,783
Symbotic, Inc. Class A	UNITED STATES	4,257
Doosan Robotics Inc.	SOUTH KOREA	3,493
Zhonghang Electronic Measuring Instruments Co. Ltd. Class A	CHINA MAINLAND	3,283
UBTECH ROBOTICS CORP LTD Class H	HONG KONG	2,905
Rainbow Robotics, Inc.	SOUTH KOREA	2,552
Wuhan Jingce Electronic Group Co., Ltd. Class A	CHINA MAINLAND	2,307
Estun Automation Co. Ltd. Class A	CHINA MAINLAND	2,122
China Marine Information Electronics Co., Ltd. Class A	CHINA MAINLAND	2,037
Xi'an Bright Laser Technologies Co. Ltd. Class A	CHINA MAINLAND	2,002
Jiangxi Lianchuang Optoelectronic Science & Tech Co., Ltd. Class A	CHINA MAINLAND	1,762
Shenzhen Urban Transport Planning Center Co. Ltd. Class A	CHINA MAINLAND	1,977
Robotechnik Intelligent Technology Co., Ltd. Class A	CHINA MAINLAND	1,665
Beijing Dahao Technology Corp., Ltd. Class A	CHINA MAINLAND	1,694
Hollysys Automation Technologies Ltd.	CHINA MAINLAND	1,593
Chongqing Chuanyi Automation Co., Ltd. Class A	CHINA MAINLAND	1,483

Source: Factset, UBS, as of 10 April 2024. For more details about the screening process please see our reference list methodology.

Appendix

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