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WHITE PAPER

THE INTELLIGENT TANGIBLE WORLD

The Intelligent Tangible World

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Abstract

The multi-decade development of globalization is reversing, and the implications are broad and profound. In the following paper, we explore the implications from the point of view of the industrial economy:

1. **The massive shift in global production chains has ramifications for countries, companies, and emergence of new themes**
   To grasp this, one must first revisit the developments of the last 20 years to appreciate the magnitude of the reversal that we foresee. While this has been talked about for some time, the tectonic plates have started moving. There are tentative signs that the reversal of outsourcing to China is, in fact, happening. We examine labor data, company investment intentions, and the trend in actual corporate spending and note that last year was the first time we saw companies in our global strategy actually change long-term guidance based on the geopolitical changes we are expecting.

"There are tentative signs that the reversal of outsourcing to China is, in fact, happening."

2. **A new capex cycle driven by deglobalization and technology**
   We initially focus on the countries most affected by this trend. We will explore how the US, China, and Europe face quite divergent prospects from this trend. A particular focus will be on the US, the country we see as the net beneficiary of this transition. China, perhaps surprising to some – is also well-placed. Although we are less optimistic on Europe from a top-down perspective, paradoxically, many of the companies that will likely be winners of this shift are listed in Europe. While the country factor will be making a comeback, partly due to politics, what really matters is geographical revenue exposure.

3. **Intelligent Tangibles – the factory of the future**
   We discuss how manufacturing in the future will be different and the drivers behind this. Automation and energy efficiency are focal points for manufacturing investments we have explored in past white papers. We now introduce the concept of "Intelligent Tangibles" – the merging of the physical hardware needed in production with software as a new theme, but also the inevitable need for increased use of commodities to make the shift happen.

4. **Conclusion**
   We will combine the key takeaways from the thematic shifts with the best business models to highlight some key companies and themes that we believe will be the beneficiaries in this new era.

The tectonic plates have started moving

For three decades, from 1979 to 2009, the US and other industrial nations shifted manufacturing overseas to regions where labor was cheap, environmental rules were less restrictive, and other financial benefits helped overall profitability. While this made financial sense at the time, this arbitrage ended around a decade ago.

The international relationships that peaked around the Great Financial Crisis (GFC) have significantly deteriorated since. The euro debt crisis of 2011-12, the announcement of the industrial policy program "Made in China 2025" in 2015, and, more recently, China's push for import substitution are examples of government policies that are increasingly questioning the existing international system of economic and monetary cooperation. This drives more extensive government involvement and increasingly influences local and global economies and capital markets. The election of Donald Trump in 2016 and his later initiation of tariffs on Chinese imports signaled a shift in American policy towards China. Prior international cooperation in organizations like the GATT (General Agreement on Tariffs and Trade) and WTO (World Trade Organization) was discarded. It was determined that the price the US had paid for integrating the Chinese economy into the world trade system had been too excessive in the form of an unbalanced external trade balance, debt accumulation, and lost blue-collar jobs. Trade needed to be balanced to be fair. Furthermore, the US determined in the national defense strategy 2018 that China was now a strategic competitor. This sentiment was echoed in the ban on Huawei and other companies crucial to the Chinese state in 2019 and onwards.

The outbreak of Covid-19 in 2020 further highlighted the risks of relying on distant and fragile supply chains, as disruptions to global trade and transportation led to shortages of essential goods, and the excessive fiscal stimulus during the pandemic created the inflation we have been facing recently.

The Russian invasion of Ukraine in 2022, the associated disruptions to global commodity markets and especially energy, and the West's confiscation of Russia's foreign currency reserves further eroded international relations. The ban on selling advanced semiconductor technology to China in the same year also signaled the US's determination to keep its technological edge versus China.

"The outbreak of Covid-19 in 2020 further highlighted the risks of relying on distant and fragile supply chains."

While it certainly feels as if Europe continues to struggle with unaddressed political issues originating back to the GFC and earlier, handicapping its ability to react, major emerging market economies like India, Indonesia, and China are acting much more self-confidently and more independently from Western economies and politics. We are moving into a multipolar world – a world where governments, in contrast to free markets, are much more active and thereby influential in determining the outcomes, see also our White Paper "The Rise of Big Government".

"Reshoring and the fragmentation of supply chains is not a myth, it is now happening."

Reshoring and the fragmentation of supply chains is not a myth, it is now happening. The driving force is that the world has seen a significant geopolitical shift from free trade towards targeted industrial policies in major economic regions. Potentially as well, the beginning of a new industrial renaissance in the West.

We are in the early stages of a new investment cycle

As shown in Figure 1, see page 5, the last 20 years have seen some distinct phases for global capital expenditures. China's accession to the WTO in December 2001 was a critical moment for the global

capital cycle. This sparked a massive Chinese fixed asset boom from 2002, leading to the 2002 to 2013 mining and oil & gas capex supercycles. This was followed by a sustained period of industrial stagnation as some of that overinvestment unwound, with the backdrop of the European double-dip recession. Global capex hit a low in 2016 but has been rising since (pausing during the pandemic). The world has started a new capital cycle underpinned by the favourable secular themes of energy efficiency and security, digitalization, reshoring, government infrastructure spending plans, and strong corporates in a position to spend. As such, we believe that global capex will continue an upwards trajectory for much of this remaining decade, driven by the following:

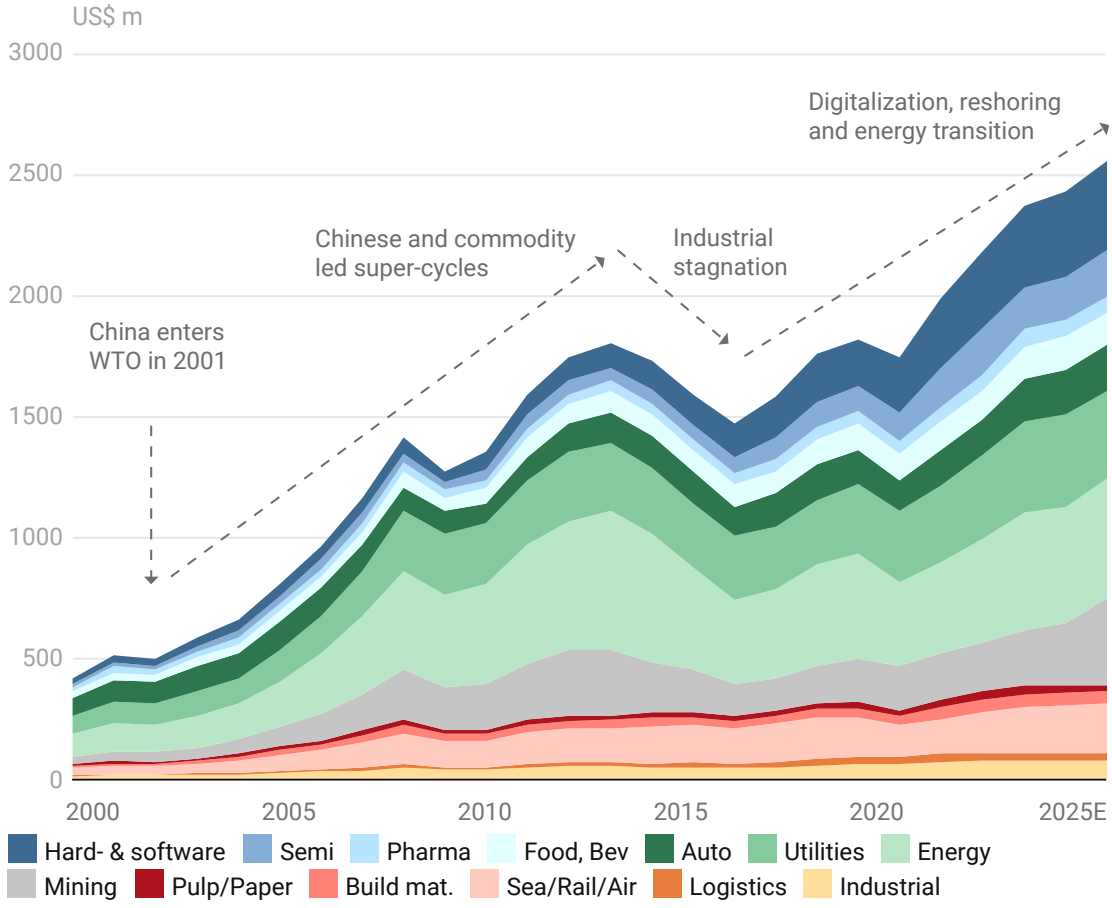
- The transition to renewable energy. This trend has accelerated with Russia's invasion of Ukraine, increasing focus on energy self-sufficiency as a sovereign must-have for Europe (e.g., REPowerEU).

- The transition to an electrified low-carbon economy has contributed to the launch of corporate and government initiatives that stand to spur investments in emission-free production and transportation systems. Government initiatives include the Inflation Reduction Act (IRA) of 2022 in the US, the Net Zero Industry Act (NZIA) in the EU, Japan's GX Green Transformation program, and similar initiatives in China and India.

Figure 1

Long Term Capex Cycle

Global Capex for end markets rolled-up



Source: Redburn, Bloomberg, January 2023

- Increasing nearshoring, digitization, and automated production: the Covid-19-related halt in global economies and the invasion of Ukraine caused significant disturbances in supply chains making companies increasingly focus on reducing supply chain risks. In addition, trade and geopolitical tensions between the US and China are driving investments in critical supplies of raw materials and components in the EU and the US (e.g., the Critical Raw Materials Act in the EU and the CHIPS Acts in the US and EU).

The IRA, CHIPS Act, and infrastructure packages in the US alone amount to nearly USD 2 trillion. Assuming European initiatives and countermeasures of 50-100% of this number suggests that USD 3-4 trillion in spending will be directed towards industrial and infrastructure capex in the coming decade. These public sector subsidies, however, are probably small compared to the amounts of private sector investments that can be activated in the decade to come.

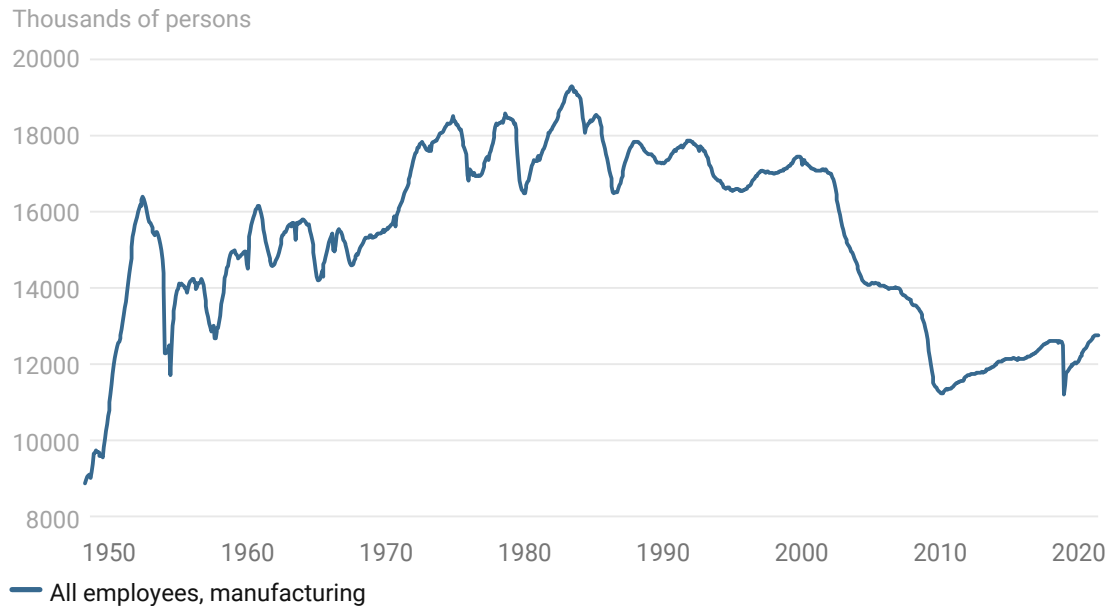
Reshoring and manufacturing renaissance in the West

As shown in Figure 2, below, over the last 50 years, there has been a significant reduction in manufacturing activity in the US. According to the US Bureau of Labor Statistics, US manufacturing jobs declined by just over eight million from the 19.6 million-peak in June 1979 to the 11.5 million low in December 2009, the largest reduction coming in the aftermath of China's entry into the WTO in 2001.

US manufacturing production as a percentage of global manufacturing fell from just below 30% to 16% in the same period. As shown in Figure 3, on page 7, the recent reversal of manufacturing jobs in the US has so far not had any meaningful effect on the aggregate industrial output of the US, as industrial production today is on par with production almost 20 years ago.

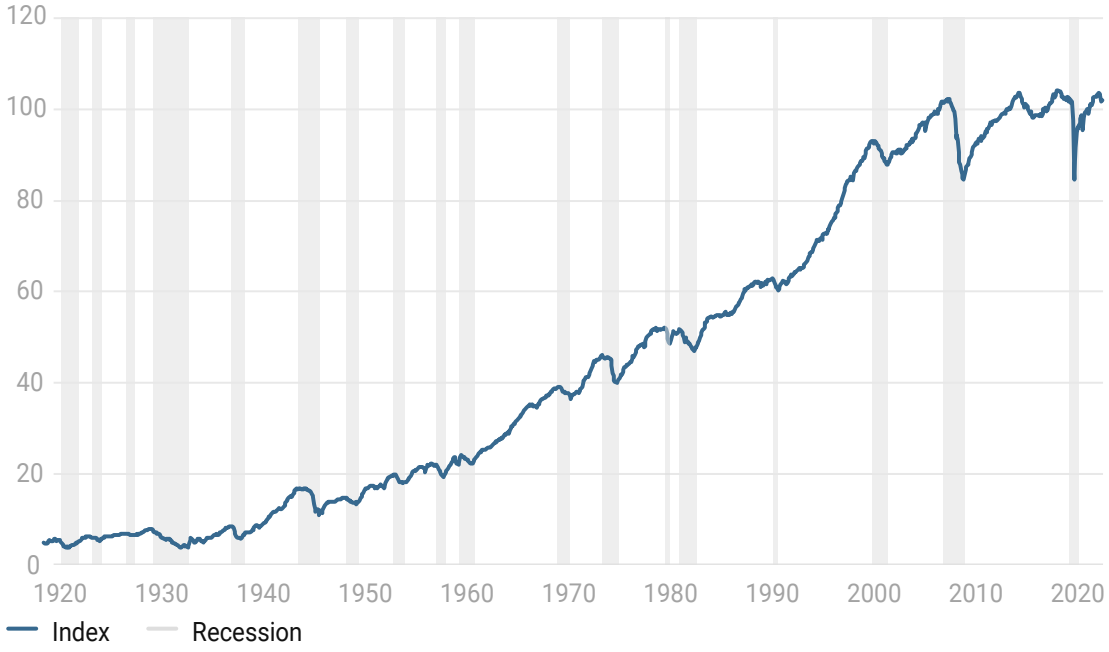
The reasons for reinvigoration of the manufacturing jobs market are many. The introduction of im-

Figure 2
Manufacturing Employment in the US



Source: US Bureau of Labor Statistics, March 2023

Figure 3
Stagnant US Industrial Production



Source: FRED, February 2023

"These investments will not be made offensively but for defensive reasons."

port tariffs, supply chain disruptions, and rising geopolitical tensions have taken center stage. Efficiency, just-in-time inventory, and profit maximization have been taken too far.

The investments required to tackle the above challenges will differ from historical corporate investments in that these investments will not be made offensively but for defensive reasons. These investments will not increase companies' sales potential but are made to protect them from future adverse outcomes. On top of that, governments are, via large subsidization schemes like the CHIPS Act and the IRA, tilting the scale in favor of domestic investment and production in a manner we have not seen for decades – if ever. The combined effect of this will likely be that investments will be less cyclical and more crucial for select industries and companies if they want to stay relevant for the longer term.

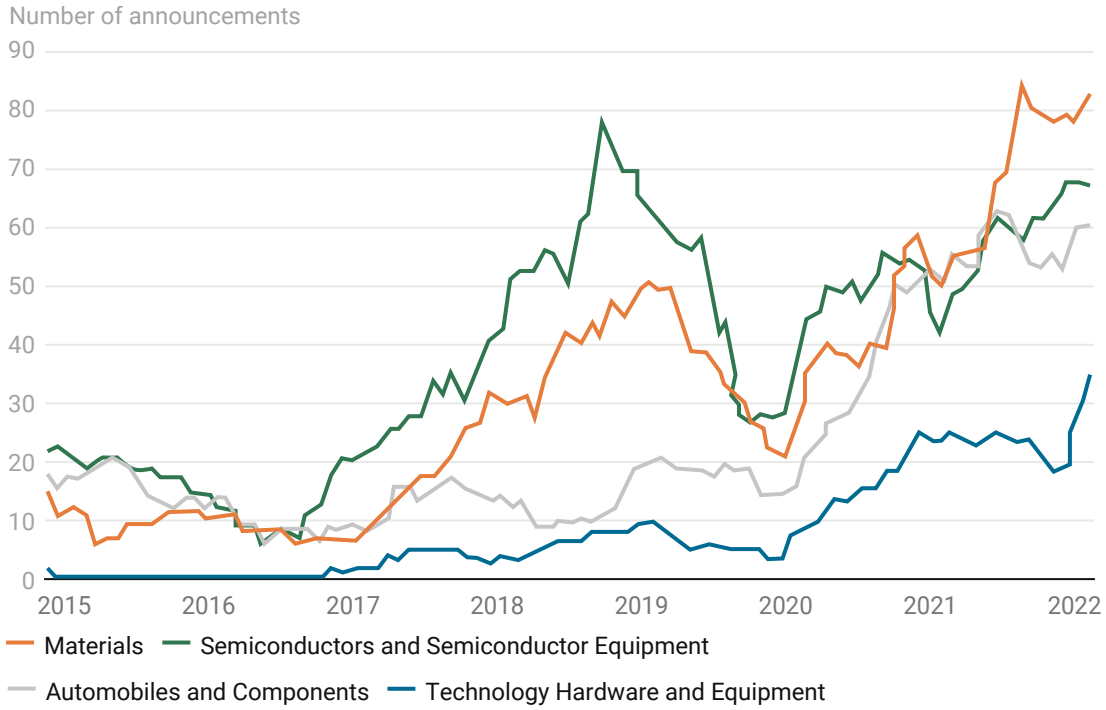
Figure 4, on page 8, shows the surge in US firms' intentions to re-shore. Today's key sectors re-shoring are tech hardware, semis, autos/ EVs, and materials. According to the US Semiconductor Industry Association, at the end of 2022, over $210 billion in private investments had been announced to increase domestic manufacturing capacity.

Despite significant interest rate rises over the recent quarters and high uncertainty about the immediate economic outlook, manufacturing construction activity is, at the time of writing, 50% above last year's level, see Figure 5, on page 8. The short-term outlook is, of course, uncertain because we stand in front of the most well-flagged

Figure 4

Supply Chain Movements to the US

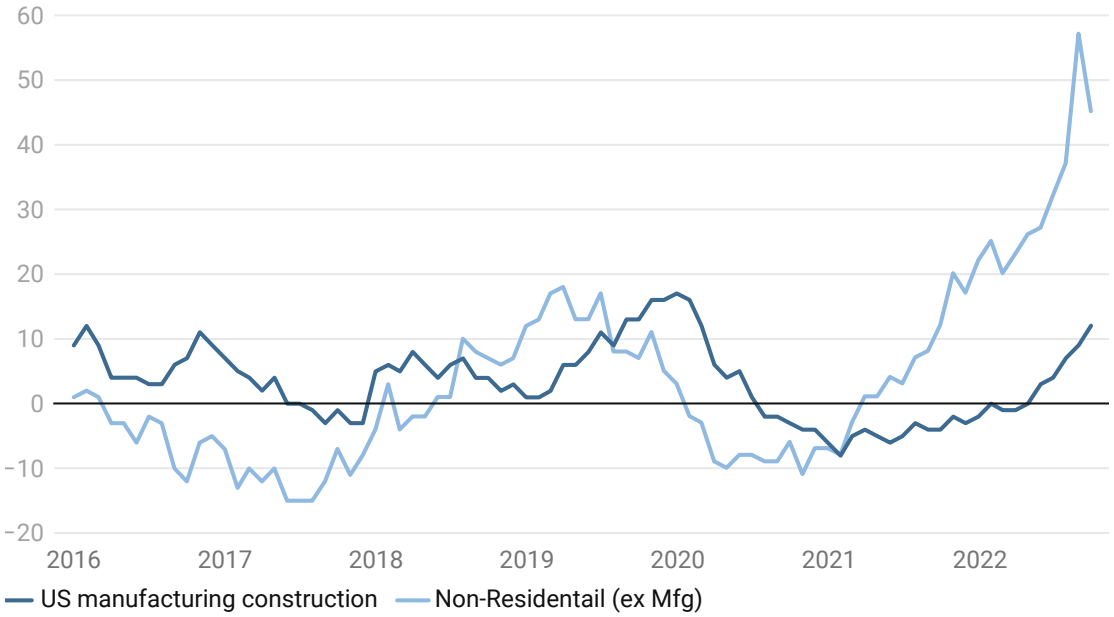
Announcements of supply chain movements to the US (12-months trailing sum)



Source: UBS Evidence Lab, March 2023

Figure 5

Construction Activity in the US (%)



Source: UBS, US Census Bureau, October 2022

US recession in living memory and because of the problems in the regional banking sector in the US since these banks are responsible for a significant share of the financing of commercial real estate in the US.

A new capex cycle driven by deglobalization and technology

Disregarding the uncertain short-term outlook, we have entered a new investment cycle. And for the reasons we will go through, the remaining part of the 2020s will likely be characterized by very high corporate investment levels. The rise of big government policies has reintroduced the country factor, and different geographies will be affected differently. While the pure country factor mostly relates to political risks like tariffs, export bans, and general local and regional intervention, a view on companies' geographical sales exposure will become more important. Hence a deeper understanding of the divegent paths of the three main economic regions, the US, China, and Europe is needed.

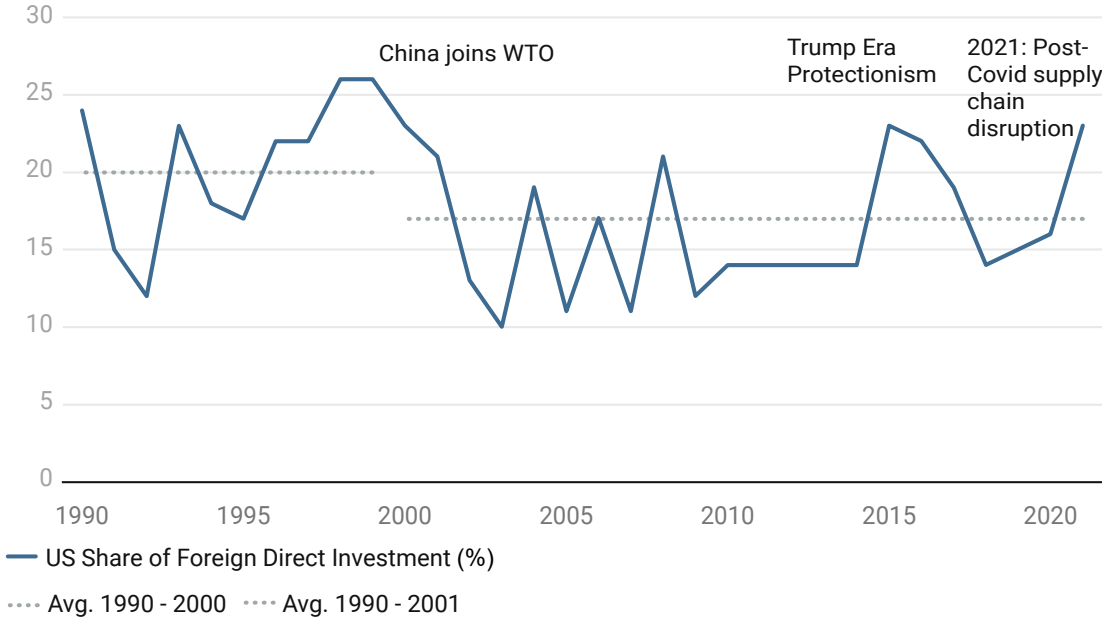
"The remaining part of the 2020s will likely be characterized by very high corporate investment levels."

USA – A material boost to manufacturing investments

We believe a material upside to US industrial investments will come from a potential reversal of meager US corporate investments over the last decades. On average, industrial investments grew 5.4% annually in the decades up to China's WTO accession. Since 2001, these investments have increased only 2.4% p.a., according to UBS. Assuming only a minor "normalization" in the growth rate of domestic corporate investments would lead to a significant upturn in domestic corporate investments.

Another boost could come from higher foreign direct investments in the US. In the period up to

Figure 6
US FDI Acceleration?



Source: UBS, US Census Bureau, October 2022

"We are more sanguine regarding whether Europe will receive its share of inbound investments."

China's WTO entry in 2001, the US, on average, received 20% of global FDI; this number has decreased to, on average, 16% since 2001, see Figure 6 above. Should these flows reverse back to the ratios before China's WTO accession, the impact on capital flows and investments into the US economy would be meaningful in the 100 billion US dollar per annum range. Factors underpinning the attractiveness of corporate investments in the US are a big domestic market, government support, and lower energy costs compared to most other parts of the world.

This juggling with numbers can't in any way give an exact total addressable market for capital expenditures in the decade to come. Still, the combination of approved public subsidy schemes and the 'defensive' investment requirements corporates face in the years ahead indicates that the decade ahead will see a very different overall investment level, specifically in the US.

According to the US Congressional Research Service[1], US business investments amount to approximately USD 3 trillion annually. In the years to come, this number could easily be boosted by half to one trillion dollars per annum from the combined effect of subsidy support, normalization of FDI flows into the US economy, and a modest increase in the growth rate of domestic business investments.

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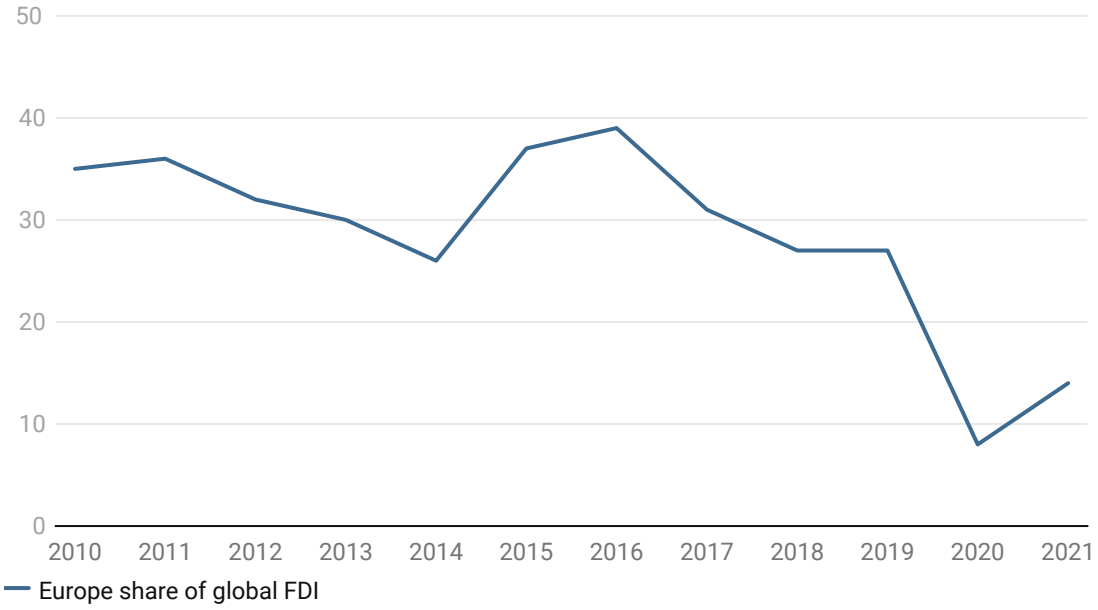
Figure 7
Europe less Relevant (%)



Source: UBS, US Census Bureau, October 2022

Europe – difficult top-down but strong bottom-up story

We are more sanguine regarding whether Europe will receive its share of inbound investments. From a top-down perspective, Europe faces structural challenges that impede long-term capital deployment. These span from low domestic demand growth due to aging demographics and a historical European business model of exporting to the world and running large external surpluses, something which is less likely in a fragmenting world economy. Furthermore, due to bureaucratic overreach and structurally high and uncompetitive energy prices on account of an ill-conceived energy transition policy, Europe runs the risk of seeing accelerated deindustrialization over the coming decade, as exemplified by the world's largest chemicals producer BASF's recent announcement to reduce capacity in Germany; "Europe's competitiveness is increasingly suffering from overregulation, slow and bureaucratic permitting processes, and in particular, high costs for most production input factors," said Martin Brudermüller, the BASF chief executive[2].

The result of these structural issues can be condensed down to looking at Europe's share of FDI, see above, see Figure 7 above. Europe is becoming less relevant as a manufacturing hub, and we are sceptical that Europe can reverse this trend via increased subsidization in competition with the US and China. As US firms operating in key industries receive large subsidies under the CHIPS and IRA and Chinese firms consolidate their dominance in sectors like solar, EV, and battery technology, European firms feel hemmed in on all sides. European governments are trying to formulate a coordinated response that puts them in the industrial policy game. The problem is that member states disagree on whether competition rules within the European Union's single market can be maintained. Furthermore, the unfinished business of building a fiscal

2 BASF to cut 2,600 jobs as energy crisis puts Germany on track for recession | Energy industry | The Guardian

overlay to the monetary union makes it impossible to disburse sufficient funds efficiently, which leaves individual member states to decide on subsidies, introducing an imbalance in competition between fiscally stronger and weaker countries.

The saving grace for Europe in the coming decade will not be the political and economic superstructure but the legacy positions of European capital goods companies, resulting in a bottom-up outlook that is completely different. In the future, the strong legacy positions in tangible physical structures and machinery that European companies have today will be leveraged by data and embedded intelligence, as described below. It is relevant to consider what legacy position, either the tangible phyical, or the intangible digital, will prevail as tangible and intangible merge in the "factory of the future".

"European capital goods companies in a strong position in their battle against the new entrants from the digital world."

We believe the existing suppliers of tangible physical capital goods will prevail in this fight, leaving the European capital goods companies in a strong position in their battle against the new entrants from the digital world. Companies like Siemens, Schneider, Alstom, Legrand, Atlas Copco, Assa Abloy, Hexagon, etc., the bedrock of the European capital goods industry, have strong global market positions in areas that will benefit strongly from the rise in global capex. Europe also has a strong foundation in materials sciences, chemicals, and optics – fundamental blocks for producing semiconductor equipment. Companies such as ASML, Infinion, STM and ASM are examples of the market leaders with the key technologies needed to merge the physical with the digital – The Intelligent Intangibles, what we will be exploring later.

China – on its path to the manufacturing automation super league

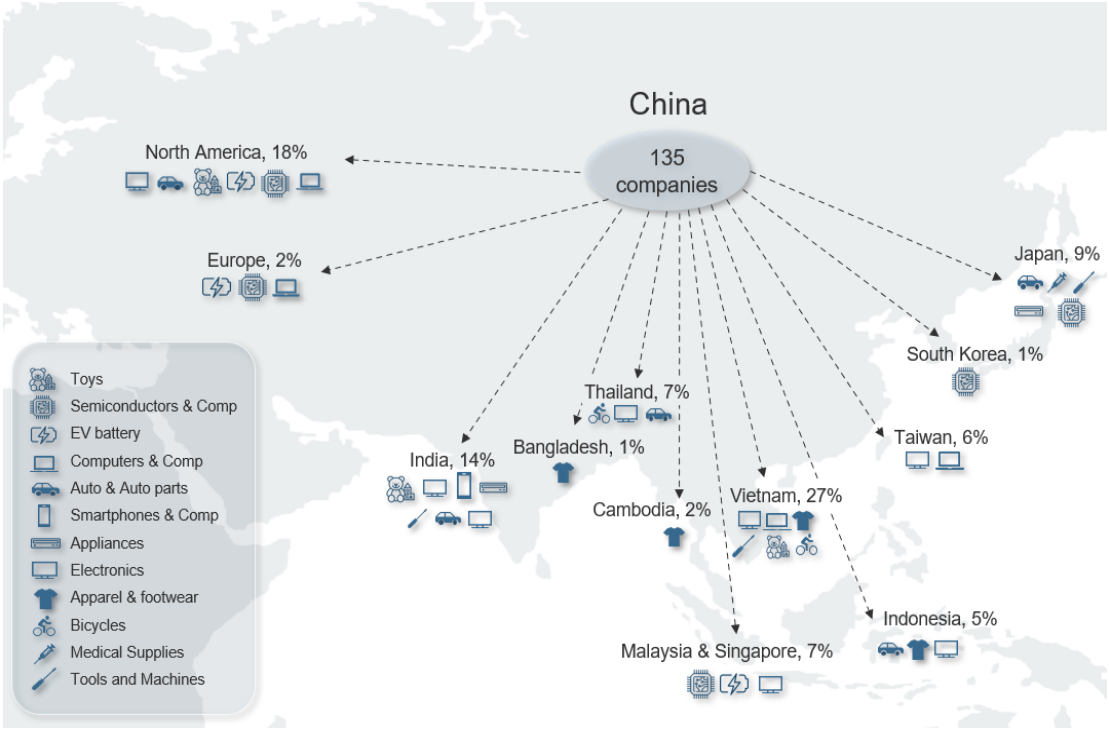
Sanford Bernstein makes a periodic survey of foreign companies' investments in China, the most recent survey covering a period of 18 months up until the end of 2022. 135 companies participated, and the survey covered 200 investment decisions. The significant finding of the survey is that companies are increasingly diversifying their supply chains under a headline called 'China + 1', i.e., most companies are not moving out of China, but the marginal investment dollar is going to other geographies to reduce supply chain risks.

"Companies are increasingly diversifying their supply chains under a headline called 'China + 1'"

Vietnam continues to be the largest recipient of outbound investments from China, but India is also starting to be a significant recipient; the prior survey from 2018 had India receiving zero outbound investments from China. An important driver of this is most likely Apple's decision to move up to 25% of smartphone manufacturing from China to India over the coming years. This has significant ripple effects on the whole iPhone supply chain system. Another notable finding was that 18% of the announcements were to the US, the US being the second most popular destination. Only 2% of the investments announced over this 18-month period were destined for Europe, see figure 8, on page 13.

"An important driver of this is most likely Apple's decision to move up to 25% of smartphone manufacturing from China to India over the coming years. This has significant ripple effects on the whole iPhone supply chain system."

Figure 8
China +1 Strategy



Source: Company data. Bernstein analysis, January 2023

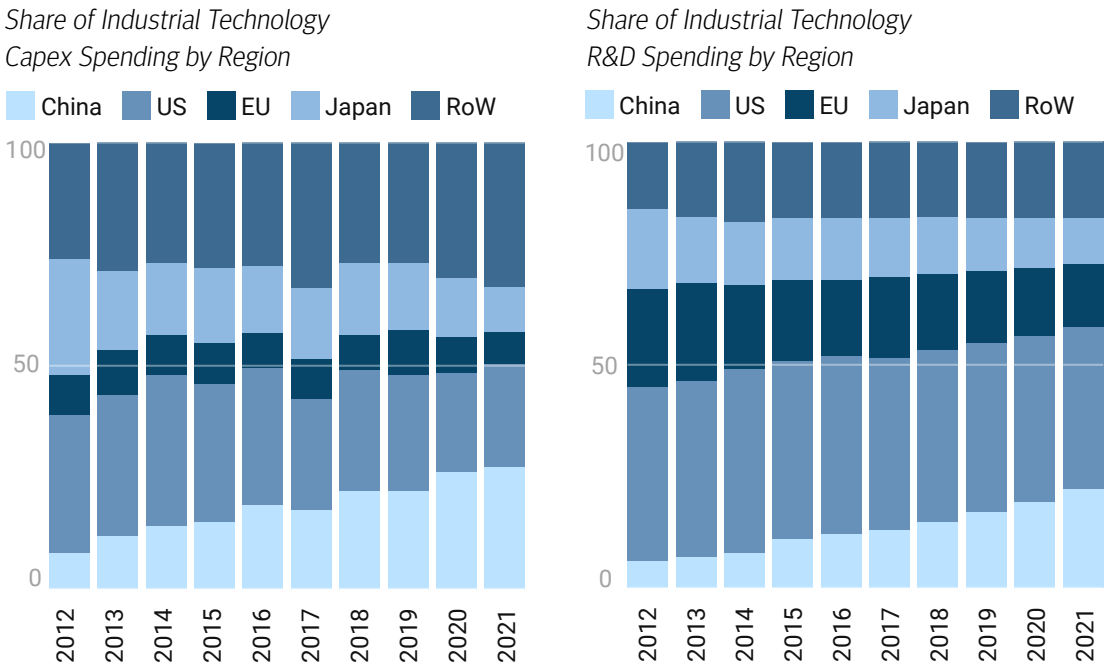
"China is the world's most competitive manufacturing economy, and that will continue to be the case going forward."

In China, supply chain migrations happen both ways. These two-way migrations result from China's strategic manufacturing upgrade focusing on import substitution and are very favorable for the demand for automation technology. Advanced manufacturing industries like automotive and industrial equipment are the backbones attracting foreign investment. The electronics sector shows an interesting, polarizing trend. While the assembly of computers and smartphones is migrating out of China, mainly to Vietnam and India, foreign investment at the more advanced components and device level is steadily growing. China continues to move up the value-added ladder.

China has a clear objective to drive technology upgrades in three priority areas: 1) green, digital, and smart manufacturing that drives modernization of a wide range of manufacturing verticals; 2) where China is already in the lead and hopes to incubate global champions (e.g., renewable energy, high-speed rail, artificial intelligence); and 3) supply chain bottlenecks where self-sufficiency, in the long run, is deemed critical (e.g., industrial/scientific instruments, semiconductor manufacturing, special materials, and industrial software).

China's industrial technology R&D spending relative to the world total has grown from 7% 10 years

Figure 9
Growing Dominance of US and China (%)



Source: European Commission, Bernstein analysis, December 2021

ago to 22% in 2021, and only the US has maintained its position. Over the same period, China's share of industrial technology capex has risen from 12% to 27%, taking share from all other regions, see Figure 9 above. This testifies to the strength of the Chinese manufacturing system, and we see no reason to expect this trend to reverse. There will be a reshuffling of global supply chains as some Western companies seek diversification through the China Plus One strategy. Alternative capacities are being built in, for example, Vietnam and India, or from reshoring/" friend-shoring" back to the US or Mexico[3] . But at the same time, China continues integrating its economy with other Southeast Asian economies and the 'Global South'. China is the world's most competitive manufacturing economy, and that will continue to be the case going forward.

Top priorities for governments and corporates today

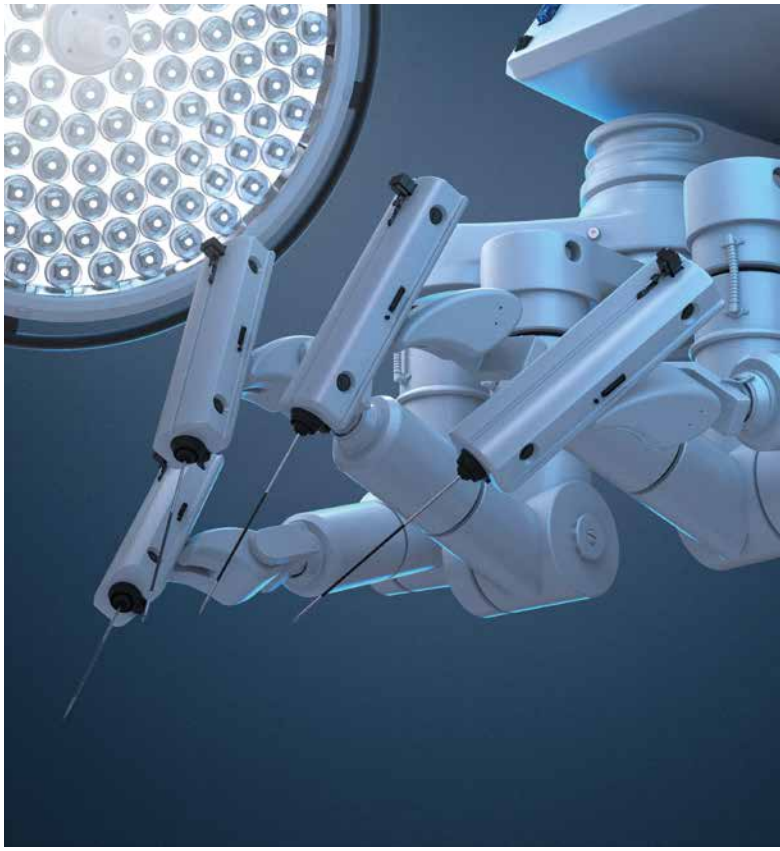
At the top of the global corporate agenda today, we believe, is decarbonization, mitigating supply chain and geopolitical risks, and finally, securing commodities and critical inputs. The world is moving from globalization towards regionalization, and companies and nations must prepare for this new reality.

We believe this creates some favorable secular investment themes, and we see two of our existing themes strengthened as a result:

Energy efficiency includes but is not limited to electrification, EV, battery, the increase in distributed energy sources, grid reinforcement investment, the move to autonomous

3 According to Schneider, as an example, Mexico has been growing 15-20% for two years for them led by the theme of nearshoring. To handle the growth, Schneider has expanded its Mexican capacity by 30% in the last few years and will expand by another 15% in 2023.

"The world is moving from globalization towards regionalization, and companies and nations must prepare for this new reality."



energy-efficient buildings, trains, LED lighting, heat pumps, and highly efficient motors & compressors.

This will push green capex much higher in the coming years, which will be a powerful driver of demand for certain metals in the future. The rise in strategic industrial competition between China, Europe, and the US, as each race to attract clean-tech capital, is boosting green capex growth. Incentives like tax credits in the IRA, representing 30% of green capex costs for a project, are accelerating investments in the US and attracting investments that previously would have been made in Europe. Therefore, the IRA has incentivized European policymakers to launch the NZIA, further boosting demand for "green commodities" like copper, nickel, and cobalt. According to Bank of America, rising clean energy incentives through the IRA and the NZIA combined could trigger an estimated USD 6 trillion of capital mobilization over the next ten years

Digitalization of manufacturing: continued customer desire to speed up design innovation cycles, reduce costs, improve agility and flexibility, the shift from "make-to-stock" to "assemble-to-order", and move to mass customization / batch-size-one will continue to drive accelerated production replacement cycles and lift the penetration of connected products, industrial software, digital twins, edge devices, 5G and advanced AI-led automation. We call this Intelligent Tangibles

Early stages of a commodity supercycle

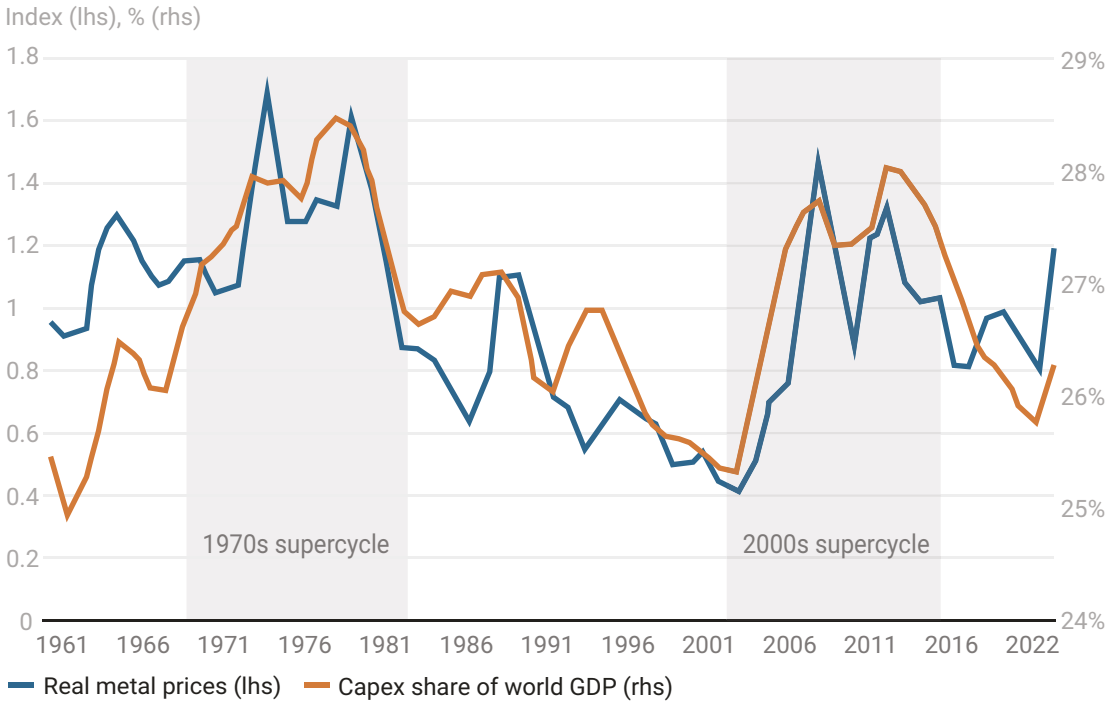
We believe we are in the early stages of a commodity supercycle, where physical constraints on growth create physical pricing pressures – thereby creating the price signal to expand capacity. It is no coincidence that the last two supercycles corresponded nearly precisely to the two most significant global capex cycles in the previous 70 years, see Figure 10, on page 16.

Commodities are cyclical, and we expect the decade ahead will show large swings in commodity prices but also that, on average, prices will rise overall. Our preferred company exposures are the "picks and shovels" ahead of the direct commodity producer exposure. We find that the capital goods providers have better business models, often operate in duopolistic market structures with more pricing power, and generally have higher returns on capital over the cycle compared to the commodity producers. Furthermore, mining companies also have significant political risk from nationalization, changed taxation regimes, etc., something the equipment suppliers don't have. On top of that, mining is increasingly being done underground, meaning more drilling and digging,

Figure 10

Commodity and Capex Supercycles

Commodity supercycles correspond to large capex cycles



Source: Goldman Sachs Global Investment Research, December 2021

leading to more demand for equipment for a given production level. This is also the case because, as ore grades decline, more rock is excavated for the same amount of mineral. Demand for mining equipment will likely outstrip the demand for metals. On top of that, the mining industry is facing its own technological transformation, with the growth of autonomous, electrified mining practices, which promises an improved work environment, much better energy efficiency, lower CO_2 emissions, and higher productivity. We believe this technology transformation will increase mining equipment suppliers' overall growth and profitability over the coming decade.

While we believe that there are opportunities to invest in the companies that provide the picks-and-shovels to the actual extraction or production of what one traditionally has meant by tangible assets – metals, oil, and physical goods, we believe an even bigger opportunity has emerged where the companies enjoying the tailwind from deglobalization also exhibit the pricing power, high margins and recurring revenues that we as quality investors typically look for – the companies exposed to Intelligent Tangibles.

Intelligent Tangibles – physical assets with embedded intelligence

Traditionally, assets have been seen as tangible, i.e., physical, or intangible, such as goodwill or intellectual property like a brand or software. This distinction will become increasingly blurred going forward, as we will see the fusion of traditional tangible and intangible assets into what we call Intelligent Tangibles. By this, we mean physical

assets with embedded intelligence. The confluence of low-cost sensors, embedded computers, always-on communication, and advances in artificial intelligence/machine learning enables new levels of intelligence and autonomy for an expanding class of products.

"We expect the next few years to show a solid trend for highly automated and robotized factories with hardly any blue-collar workers."

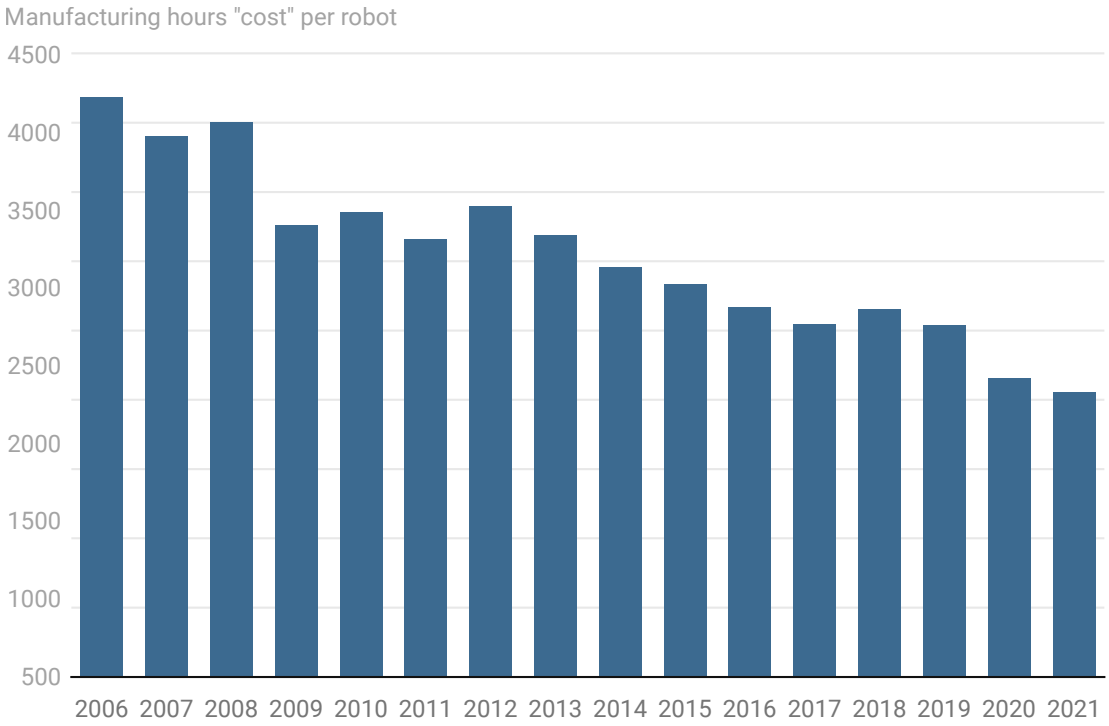
This technology theme is strengthened by reshoring, nearshoring, and political decoupling. These technologies are critical in higher-cost economies in the West and also in supporting the continued advancement of China's manufacturing capabilities. As technology continues to drive down costs, this addresses, to a certain extent, the problem of moving production back to high-cost economies with mostly very tight labor markets. Given the shortages of skilled labor worldwide, we expect the next few years to show a solid trend for highly automated and robotized factories with hardly any blue-collar workers.

Figure 11, below, is a case in point; according to Bank of America, the price of robots has declined by 2% per annum over the last 15 years or around 35%. Over the same period, the labor costs in the West have gone up so that while the price of one robot back in 2006 would cost the equivalent of 4000 hours of labor cost, or approximately two employees per year, that cost had decreased by

Figure 11

Robots Substituting Labour

In 2006: Pick a robot or two workers. In 2021: Pick a robot or one worker.



Source: BofAML, St. Louis FED, FRED Database, December 2021

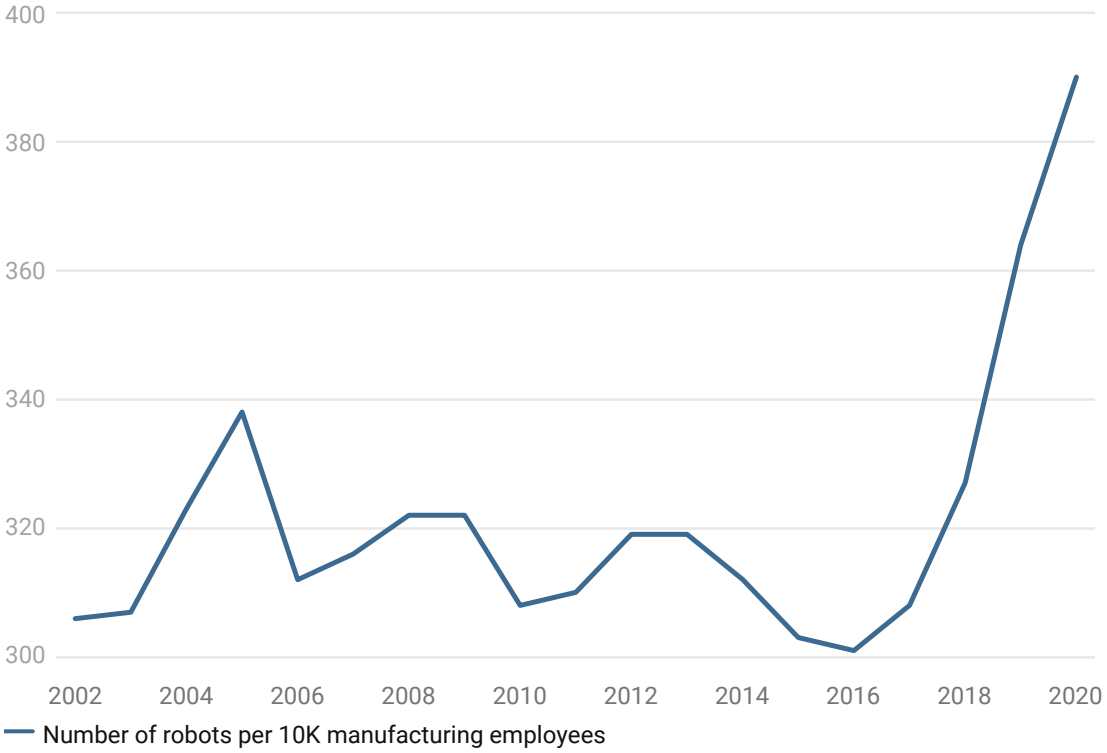
half to 2000 hours or one employee by 2021. Technology will continue to be deflationary, while wages will most likely continue to rise over the years. This analysis also leaves out the large productivity increases per robot, as they have transitioned to having more axes, being able to carry much more weight, and also being able to cooperate with humans, often negating the need for sealed areas for robots. Therefore, increasingly robots and other automation technology will outcompete the need for human capital in advanced manufacturing.

Japan, due to its historical leadership in using robots, shows a very important trend in automation. In the world's most mature robotic market, robot density increased by 30% in just four years after staying flat between 2002 and 2017, see Figure 12, below. This new wave of accelerating robot adoption is driven by the most traditional industries adopting the most advanced automation technologies.

Over the past decade in Japan, "robot shipment intensity", defined as annual robot shipment per employee in the end-industry, jumped 350% in machinery, 150% in electronics, and 100% in metal products, which all outgrew the manufacturing industry average of 60%. Conversely, the historical leader in robotics, the automobile sector, was the laggard and stayed flat, see Figure 13, on page 19.

The growth areas are not necessarily new industries like EV batteries or semiconductors. In traditional industries, the required robotic technologies are far from traditional. Much of the adoption in machinery, electronics, and metal products are

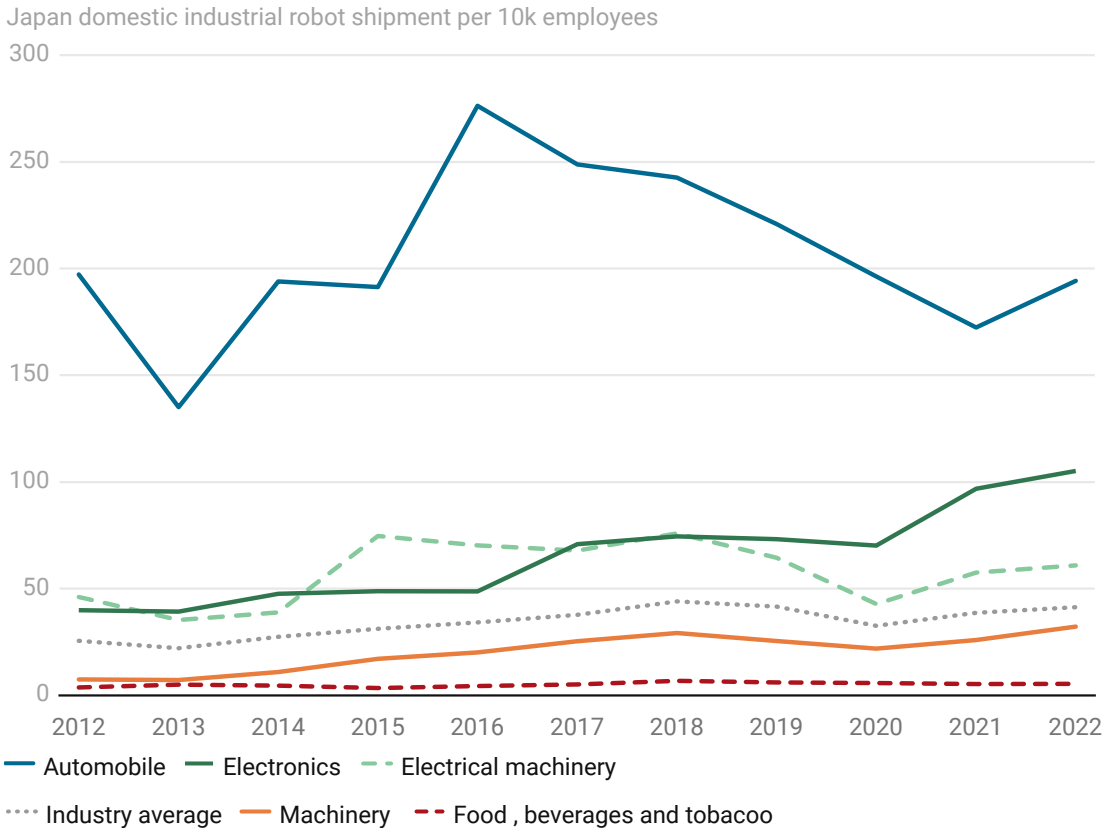
Figure 12
Japan Robot Density Accelerating



Source: Bernstein analysis, January 2023

Figure 13

Robots Proliferating Selectively



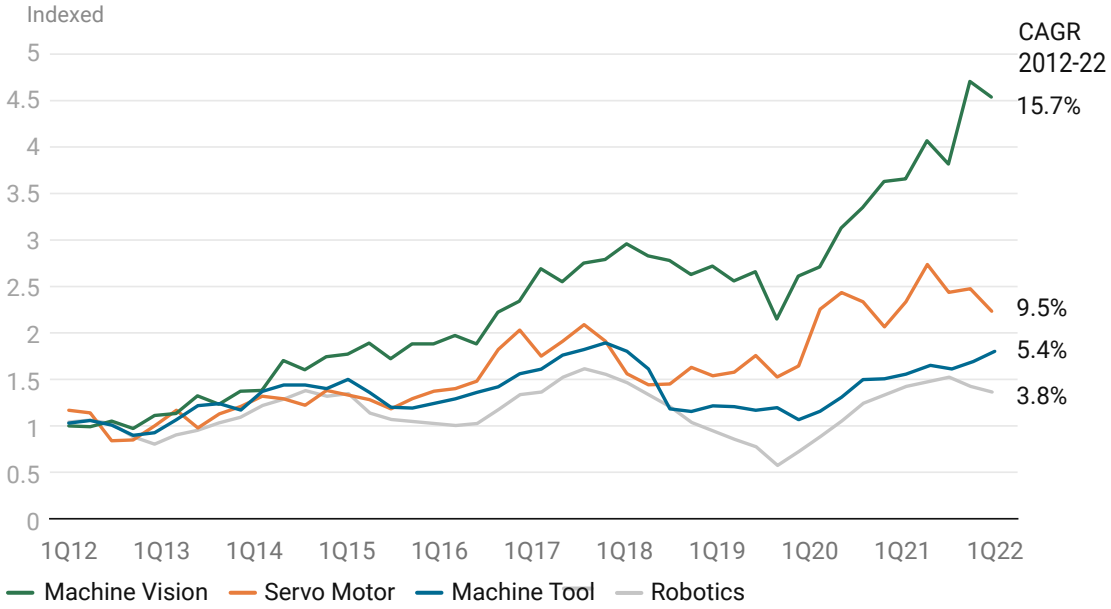
Source: Bernstein estimates and analysis, December 2022

only happening now because it requires very advanced robotic functions like adaptive welding, machine tending, assisted assembly, and bin picking, which are enabled by advanced technologies, including machine vision and AI. These applications generally require autonomous robotic control and are technically more challenging than robotic spot welding, as seen in the automotive sector, and which is pre-programmed.

Outside Japan, the same proliferation trend drives growth in robotics. Traditional industries are adapting to automation through advanced and more autonomous robots. The proliferation of robots in many more industries is healthier and less cyclical than growth driven by explosive capacity buildup in a few emerging industries. Proliferation provides substantial long-term upside. Despite the multi-fold increases, in absolute terms, robot shipment intensities in machinery and metal products are still just a fraction of that in the automobile sector today.

The ongoing "Robot Renaissance" is enabled by falling costs and an array of industrial technology fusion trends where robots are combined with advanced vision technology, mobile platforms, and A.I. making possible automated inspection, pick & place, bin picking, autonomous path planning, predictive maintenance, and multi-robot collaboration.

Figure 14
Vision Strongest Growing Automation Technology



Source: Bernstein estimates and analysis, December 2022

We are in the early stages of AI deployment in manufacturing

In manufacturing, AI strengthens, rather than substitutes for, the underlying robot and vision technologies and expands the boundary of their applications. Most notably, AI enables complex defect inspection by machine vision and ushers robot adoption into unstructured environments that require autonomous (as opposed to pre-programmed) trajectory planning. Only in the last 2-3 years have AI technologies progressed to square off the unique challenges in manufacturing. We expect that combining these different technology verticals will strongly expand the total addressable market for the different verticals in the years ahead. Technology allows traditional industries to automate in a manner impossible until now. One area that will most likely benefit the most is vision sensors, which are at the center of the proliferation of automation. In recent years robots have seen strong growth, but machine vision has outgrown robots by a factor of almost 2, as seen on Figure 14.

The intelligence in Intelligent Tangibles

While we have explored the subject of Semiconductors in-depth in several of our previous white papers ("Leading Edge; Pushing the Boundaries and the Future of Compute"), and we refer our readers to these white papers for more detail, one should not forget that the Intelligence in Intelligent Tangibles ultimately has to come from a chip. Companies that either produce chips or provide the equipment to make them, companies such as Atlas Copco, with its vacuum technique or ASML in Lithography and ASM in deposition, have started to bring up the subject of Technological Sovereignty as a driver of revenue growth. ASML, with its monopoly position in extreme ultraviolet lithography even raised its long-term guidance late last year explicitly on geopolitical concerns. Atlas Copco, a key supplier of vacuum equipment to the semiconductor industry, also pointed to duplication of supply chains, with increased investments in the U.S. as a revenue tailwind, at its 2022 Capital Markets Day.

Conclusion

- Supply chain security is a critical concern in the post-pandemic world. Moving from 'just-in-time' to 'just-in-case' and executing either a reshoring or a China Plus One strategy will lead to global supply chains that are more fragmented and complex, closer to end demand, and more robust but less capex efficient.

- The combination of approved public subsidy schemes and the 'defensive' investment requirements corporates face in the coming years indicate that the decade ahead will see a very different overall investment level, especially in the US.

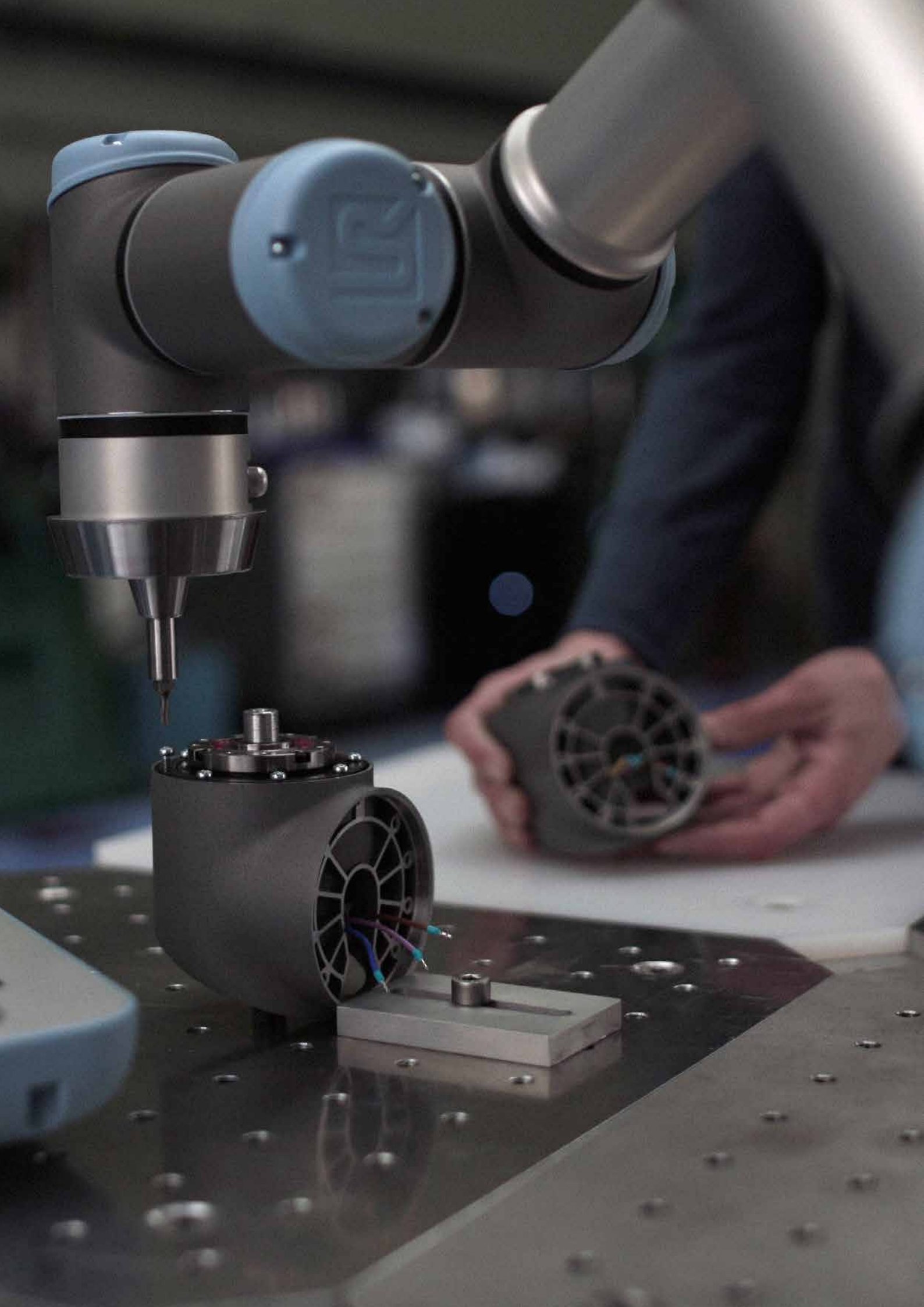
- In China, supply chain migrations happen both ways. These two-way migrations result from China's strategic manufacturing upgrade focusing on import substitution and the shedding of lower value-added manufacturing. China will continue to be the world's most competitive manufacturing economy as the country continues to move up the value-added ladder.

- Companies benefitting from this will be the critical technology and capital equipment providers supplying the automation technologies. At the same time, the costs will be borne by companies operating less efficient production systems and potentially the end customers through higher prices and taxpayers through subsidies.

- We will see the fusion of traditional physical, tangible assets, and intangible intelligence into what we call Intelligent Tangibles. The confluence of low-cost sensors, embedded computers, always-on communication, and advances in artificial intelligence/machine learning enables new levels of intelligence and autonomy for an expanding class of products.

- Machine vision and AI enable the proliferation of robots and other automation technologies. Traditional industries are adapting to automation through advanced and more autonomous robots. The proliferation of robots in many more industries will generally lift the structural growth rate of automation technologies . What is clear is that recent technological advancement will allow traditional industries to automate in a manner impossible until now.

- The winners of this transition will be the companies that combine a large geographical exposure to regions we believe will be the net winners in a deglobalizing world – the US and China with business models of supplying critical components into the modernized production systems. Companies such as Epiroc, with a dominant position in hard rock drilling, needed to provide the world with necessary raw materials; Keyence, with its lead in machine vision; Siemens, with its digital industries and innovative infrastructure divisions; Atlas Copco supplying both the general industry, the transition to LNG, and the semiconductor industry with vacuum stand out. Finally, one should not forget the data explosion resulting from this transformation of our production systems. This explosion drives demand for computing power and data storage, giving exposure to the advantages of companies like TSMC, ASML, and cloud computing providers.



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