

GERMAN ENGINEERING 2025

What challenges German mechanical engineers need to address now





The COVID-19 pandemic hit the German mechanical engineering sector and key customer industries hard – nevertheless, it was already struggling with structural change and declining exports in 2019. Financial reserves and human capital are dwindling, making it difficult to invest in future technologies and the digitalization of products and production.



In order to leverage previously unused export potential in young growth markets, German manufacturers need to expand their portfolio as well as their production set-up in order to supply unit-cost-optimized machines priced in line with the market and to increase their competitiveness vis-à-vis international competitors.

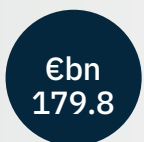


A differentiated strategy is required when dealing with „frenemies“: China is both the most important customer and the most important competitor for German mechanical engineering, while the tech giants from Silicon Valley are developing into important partners in terms of software, but are claiming the high-margin business with user data for themselves.

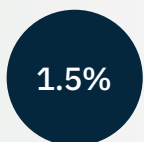


Long-term market success requires a forward-looking understanding of (changing) customer requirements that goes beyond the technical features of the machines and equipment: on the one hand, changing political framework conditions and regional shifts in demand must be considered in strategy development, and on the other hand, the sales potential of new business models must be explored.

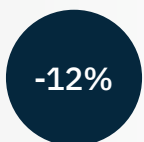
NUMBERS & FACTS



Export turnover 2019
(ratio: 80.3%)



Annual market growth before
COVID-19 (CAGR 2012-19)



Decrease in imports
2020 (% yoy)

CURRENT MARKET TRENDS



The international competition with low-cost and, in particular, digitally better positioned suppliers is intensifying; **Chinese investment activity** is often aimed at exerting political influence and acquiring key technologies.



Digitalization pressure requires the development of specific know-how and high-performance IT structures, including cloud applications, remote maintenance, etc. **Strategic alliances** enable the joint development of data standards and products.













Climate policy measures such as the European CO2 price are increasing the pressure to act across all sectors; manufacturers of energy-efficient machines stand to benefit from this trend.



Liquidity-preserving contract models: Increasing implementation of EaaS and leasing models in addition to the classic machine business, intensified by COVID-19-related liquidity bottlenecks of many customers.



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WHAT WAS EARLIER

In 2014, the fourth industrial revolution was still in its infancy in many places. As part of the first big data supported study, we evaluated the positioning of the German mechanical engineering industry, the potentials of digitalization and the acute needs for action to restore competitiveness in the changed global structure.

Study available at:
<http://bit.ly/Andersch-Maschinenbau>

In addition to the increased investment costs, the main challenges identified were increasing price pressure due to one-sided growth strategies and the emergence of international competitors. Location-related disadvantages such as the shortage of skilled labor, inadequate digital infrastructure and a lack of digitalization standards

hampered the development of German machine builders. All this took place against the background of solid overall market growth.

WHAT HAS HAPPENED SINCE

In the meantime, digitization projects are progressing across all industries - albeit at different speeds. The opportunities of the ongoing trend have been recognized in many places. However, the need for investment is now coming up against an economically challenging phase, against industry-wide slumps in orders and liquidity bottlenecks. The German economy grew by 0.6% in 2019, before the COVID-19 pandemic - the weakest in six years. Industrial production in the „industrial nation“ Germany, meanwhile accounts for only one fifth of total economic

output, not least due to the slump in the automotive industry and its suppliers, above all the German mechanical engineering industry. New competitors and network partners are no longer found only in Europe, but increasingly in Asia and Silicon Valley. This makes it all the more important to raise the necessary funds for the strategic development of a digital infrastructure and new business fields in order not to lose touch in the global innovation competition - especially in a „new reality“ shaped by COVID-19. Particularly now, it requires appropriate foresight to make innovation investments with a medium- to long-term return on investment.



MECHANICAL ENGINEERING IN TRANSITION

The dynamic environment will continue to challenge the German mechanical engineering industry in global competition in the future. Disruptive trends are shaping the industry at ever shorter intervals.

This brief study focuses on **short- and medium-term trends** depending on their relevance to sales as well as any need for action that may arise.

THE WORLD EXPORT CHAMPION - A TITLE DEFENDER?



HIGH EXPORT DEPENDENCY

Germany is the world's leading exporter of machinery - every sixth machine exported comes from Germany. Foreign trade is the most important source of revenue for the German mechanical engineering industry, accounting for three quarters (79%) of the sector's turnover.

However, the export strength is not only the driver of the German success model, it also has its downsides: the high dependency on global trade is directly reflected in the results when, as in 2019, trade conflicts, Brexit and a weakening of the economy reduce global demand. Even before COVID-19, the German Engineering Federation (VDMA) expected production to fall by 2% in 2020, mainly due to declining order volumes from abroad. German mechanical engineering companies already recorded a decline of around 2% in 2019.

NEW PLAYERS ON THE FIELD

The dangers of a high dependency on exports are exacerbated by the increasing success of foreign manufacturers: German mechanical engineering has been losing market share in international competition for years. The competitive pressure is largely driven by Chinese manufacturers - who recorded 16% growth in machinery exports in 2016-2017 alone. Still, the Chinese market is growing faster than domestic companies could meet the demand for high-quality machines. But in the foreseeable future, local market growth will only be realized through aggressive innovation and price competition. Chinese and US machinery manufacturers already account for more than 50% of global industry sales, with Germany in third place.

WINNERS AND LOSERS

The share of German mechanical engineering in world trade has fallen by around 3%-points over the last 10 years. Due to the extraordinarily high export quota, Germany was nevertheless recently in the lead in 15 of 31 specialist sectors of mechanical engineering (measured in terms of world trade share). However, not all special sectors are affected to the same extent by the economic developments. Structural upheavals in the target sectors also have an impact on mechanical

engineering: German manufacturers of industrial furnaces, printing and paper technology, packaging and textile machinery in particular have suffered losses in international competition; over the past ten years they have lost on average 8%-points of their world trade share. By contrast, companies in the measuring/testing technology sector in particular were able to gain market share (+1.1%-points); in this sector, German machinery accounts for just under one-third (31.9%) of world trade.

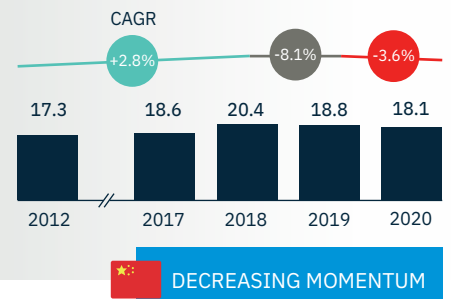
COOLING OF THE GLOBAL ECONOMY

Geopolitical conflicts, China's declining economic growth, UK's exit from the EU and the high debt levels of European member states increased the uncertainty of many decision-makers already in 2019, before the outbreak of the COVID 19 pandemic. Capital-intensive investments in particular in fixed assets such as machinery were delayed or even avoided. There were increasing prophecies of doom that the German mechanical engineering industry would find itself as one of the big losers between the new US and Chinese fronts in the coming years. The consequences of the COVID-19 pandemic and temporary lockdowns turned medium-term concerns into acute challenges: While orders could not be processed initially due to disruptions in the value chains, warehouses filled up with finished machines in part due to lack of incoming orders. Thus, the VDMA recently reported noticeable losses for half of its members, and even severe losses for around one third of the companies. In many of the VDMA's specialist sectors, recovery will take several years (see chart below). Despite the solid capital base of the traditionally medium-sized, often conservative German mechanical engineering sector, a reduction in personnel is now no longer ruled out in many places. More than half of the companies have imposed a hard hiring freeze, despite an acute shortage of skilled workers. The melting of financial reserves and human capital will weaken the position of German mechanical engineering in global competition in the medium term - because it is precisely now that investments in future technologies and skilled workers with specific digitalization know-how are urgently needed.

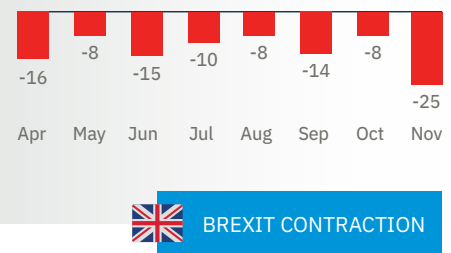


MOMENTUM ALREADY SLOWING BEFORE COVID-19:

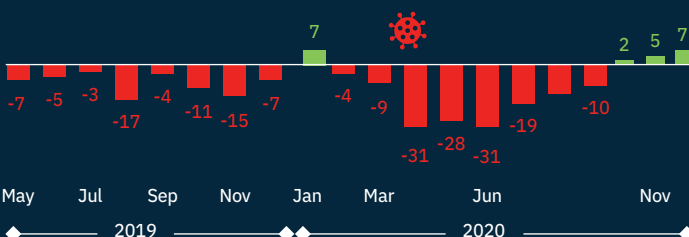
EXPORT OF GERMAN MACHINERY TO CHINA 2012-19 EXPORT VALUE (€BN)



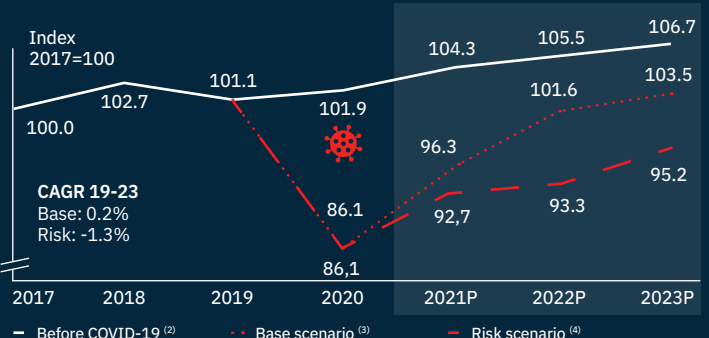
EXPORT OF GERMAN MACHINERY TO UK 2019 EXPORT VALUE, CHANGE TO PREVIOUS YEAR'S MONTH (%)



INCOMING ORDERS IN THE GERMAN MECHANICAL ENGINEERING SECTOR (% YOY)



COVID-19 IMPACT: FORECAST VALUE ADDED MACHINERY/PLANT ENGINEERING GERMANY (INDEX)⁽¹⁾



Sources: Oxford Economics; German Federal Statistical Office; VDMA; Financial Times; Stifterverband für die Deutsche Wissenschaft; FAZ; IFO Institute; Handelsblatt; FTI-Andersch analysis
 (1) Value-added output of the industry; (2) As of 03.12.2019; (3) Assumption: sustained Physical distancing further restricts production, but a new wave is avoided [As of 03.09.2020] (4) Assumption: further pandemic wave incl. return to lockdown in Q1 2021 leads to economic collapse with far-reaching consequences [As of 04.12.2020].

DOES „GERMAN“ MECHANICAL ENGINEERING STILL EXIST?



CHINA: CUSTOMER OR COMPETITOR?

In the past decade, China has become the second most important customer for German machinery and equipment. However, the years of unlimited growth in the flourishing Chinese market seem to be over for German manufacturers. On the one hand, the Chinese growth dynamic is slowing down considerably (also independently of COVID-19). On the other hand, domestic manufacturers are accounting for the lion's share of growth - partly supported by government economic subsidies, for example as part of the „Made in China 2025“ agenda. However, even though the growth rate of the Chinese economy was at its lowest level in 29 years at the end of 2019, the Chinese economy is today growing twice as fast in absolute terms. In addition, Chinese manufacturers have been able to significantly reduce the quality lead of German machinery through rapid development speed. German industrial companies should therefore follow China's further development closely.

CHINESE ON SHOPPING TOUR

Chinese suppliers no longer limit themselves to success at home: At the latest after the controversially discussed takeover of the German machine manufacturer Kuka by the Chinese Midea Group in 2016, the focus on respective advances has been sharpened. The last few years have been marked by a number of takeovers by Chinese companies, including the special machine manufacturer Krauss Maffei, waste incineration plants EEW or the cleaning division of Dürr.

PLATFORM FOR EXERTING INFLUENCE

It is striking that many Chinese investors are indirectly subordinate to state authorities or receive subsidies from them. On the one hand, these acquisitions entail the risk of losing future technologies to countries that subsequently take the lead in the development of high technology - and thus weaken domestic competitiveness. On the other hand, there is the risk that local companies and locations will be used as a means of exerting pressure to influence political decisions - as was suspected, for example, in 2017 in the context of the joint declaration by EU states on the human rights situation in China, which Greece

blocked. Also noteworthy: After the entry of the Chinese major shareholder Geely at Daimler future production of the electric Smart has been transferred to China.

ACQUISITION WAVE ABATES

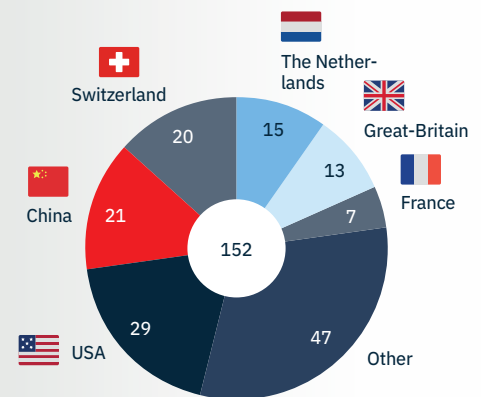
Acquisitions and investments by Chinese investors increased from 6 to 33 transactions between 2010 and 2018. The number even doubled in 2015/16 (increase from 24 to 44). The main drivers were China's Silk Road initiative and the „Made in China 2025“ strategic plan adopted in 2015, which aims to achieve leadership in ten key industries by 2025. China cannot achieve these goals through organic growth, which is why it is buying up companies with key technologies on a massive scale. The US trade dispute is shifting the focus to Europe, as Chinese investors in the USA are holding back or - as in the case of Huawei - are being strategically thwarted by the USA.

In 2018, the acquisition wave temporarily slowed down as a result of changes in the framework conditions: the Chinese economy grew more slowly and a tightening of regulations in Germany dampened activity. In addition, the Chinese government is attempting to limit excessive capital outflows through strict controls, which has led to a general shortage of available liquidity.

STRICTER RULES IN EUROPE

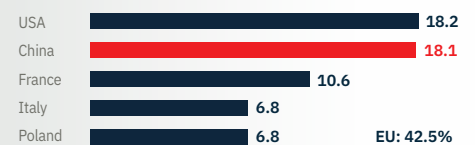
The German federal government, along with other European governments, has tightened the rules on takeovers by foreign companies. An amendment to the Foreign Trade and Payments Ordinance passed at the end of 2018 lowers the threshold for the federal government to examine the acquisition of shares in security-related industries to 10%. In the case of mechanical engineering company Leifeld, for example, a takeover was averted. When, in the wake of the COVID-19 pandemic, the market capitalization of many companies fell, in some cases considerably, (political) voices were once again raised calling for stronger safeguards against takeovers. The Federal Minister of Economics and Technology, Altmaier, had already sought an extension of the Foreign Trade and Payments Ordinance in order to protect further sectors from unwanted foreign takeovers. Meanwhile, the VDMA warns against placing foreign investors under general suspicion and calls for factually oriented individual examinations.

FOREIGN ACQUISITIONS OF GERMAN INDUSTRIAL COMPANIES (NUMBER OF TRANSACTIONS JAN-NOV 2019)



„German companies are not only in competition for the best products, but increasingly in competition with economic systems which heavily rely on governmental interventions and protectionist market foreclosure put. This is an unequal battle that more and more of our companies are losing.“
Economics Minister Peter Altmaier, quoted in Die Zeit, available online at: <https://bit.ly/2rh3Hco>

REGIONAL SHARE OF GERMAN MACHINE EXPORT ((%, BASIS: EXPORT VALUE (€) JAN-NOV 2019)

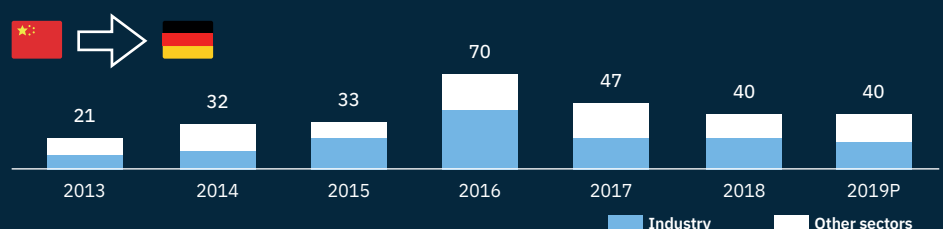


„China can roll over us. China's strategic industrial policy requires to take a closer look. (...) One must set a narrower framework under which conditions we want to allow takeovers of German companies by Chinese.“
Mikko Huotari, Deputy Director Mercator Institute for China Studies, in the WirtschaftsWoche interview, online available at: <https://bit.ly/35GIs2x>

DEVELOPMENT OF CHINESE TAKEOVERS/INVESTMENTS

Chinese investors have acquired shares in around 180 German companies since 2014; according to the Bertelsmann Foundation, one third of them can be assigned to the ten most important key technologies.

CHINESE TAKEOVERS AND INVESTMENTS IN GERMAN (INDUSTRIAL) COMPANIES (NUMBER OF TRANSACTIONS INCL. PRIVATE EQUITY)



Sources: Federal Statistical Office; IMF; Mergermarket; Handelsblatt; Capital; WirtschaftsWoche; Die Zeit; Bertelsmann Foundation; VDMA; FTI-Andersch analysis



OPPORTUNITIES IN YOUNG MARKETS

In addition to the USA and China as the main customers for German machinery, manufacturers generate around 57% of their foreign sales in Europe - the already strongly developed markets continue to drive most of the sector's growth. Exports to younger regions such as the MIST countries are stagnating and lagging behind local economic growth. In the course of the global economic crisis, this had temporarily changed, emerging countries were of high importance for German exports. Since 2015/16, however, the development has returned to the pre-crisis level - while the young markets would be more receptive to German machinery in economic terms (see charts).

ROOM FOR IMPROVEMENT

Current export quotas prove that the marketing of German machines in emerging markets is not a sure-fire success. In addition to the time- and capital-intensive establishment of a local presence, the cause lies in a different requirement profile of the local customers: instead of highly flexible, high-precision systems, they primarily demand cost-effective machines that deliver high batch sizes at low unit costs.

At present, however, the technically mature machines from Germany are primarily geared to globally producing companies with a highly differentiated product range and cater to trends such as increasing individualization.

COSTS DECIDE

For a less differentiated program, machines with high output are needed that require little or no retooling. It is true that customers from emerging markets are also increasingly demanding low maintenance intensity and the lowest possible downtime. But these requirements are increasingly being met by low-cost machines from third countries. And while in the West, based on many years of learning curves, an increasing consideration of the lifetime costs for the acquisition of a new machine has become established, in which repair and failure costs are taken into account (total cost of ownership), in emerging countries the original acquisition costs are often still considered.

In this context, German mechanical engineering companies should focus on the attractiveness of

their offer for third countries: According to an analysis by the VDMA global demand for machinery will largely shift to non-European countries over the next two decades. It is important to actively avoid ostensibly price-related order losses, which are based on the demand for simpler, unit-cost-optimized machines.

WAY FORWARD

Asian, especially Chinese, machine builders are on a race to catch up and are increasingly self-confident in the international market. However, their quality standards do not yet reach the German level - the value of the „Made in Germany“ brand is regarded as a promise of quality and stands internationally for precision and reliability. In order to increase export opportunities in the new - very price sensitive - markets, it is important to be able to offer machines at prices in line with the market without diluting one's own quality standards too much.

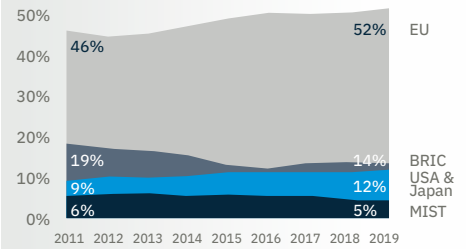
THE RIGHT TIME

So-called design-to-cost or fit-for-purpose approaches are a first step towards increasing price competitiveness. They steer traditional engineering thinking in research/development (what machines are possible?) towards a market-driven approach (what prices are possible?). The question of when customers should be involved in the R&D process, for example, plays a central role here. At the same time, there is the question of the production location, which in the case of local production, for example, could enable offers that are less distorted by wage costs, energy prices or the strong Euro.

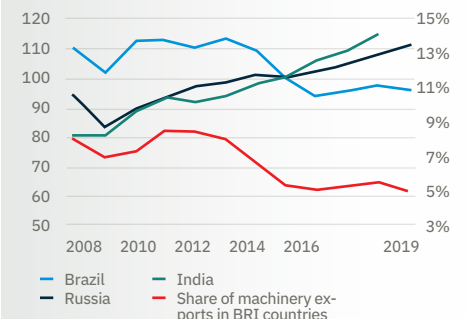
And last but not least, the advancing degree of local development could increase the prospects of success for German mechanical engineering companies: At present, with their „hardware“ alone, they are still in direct price competition with other suppliers in developing countries. In the course of time, however, topics such as system integration, consulting and service - areas in which the German mechanical engineering industry is well positioned - will become more relevant and enable a price premium. At the same time, it is important not to lose touch with competitors in these markets, especially now.

Sources: Quest Trendmagazin; VDMA; Federal Statistical Office; OECD; FTI-Andersch analysis

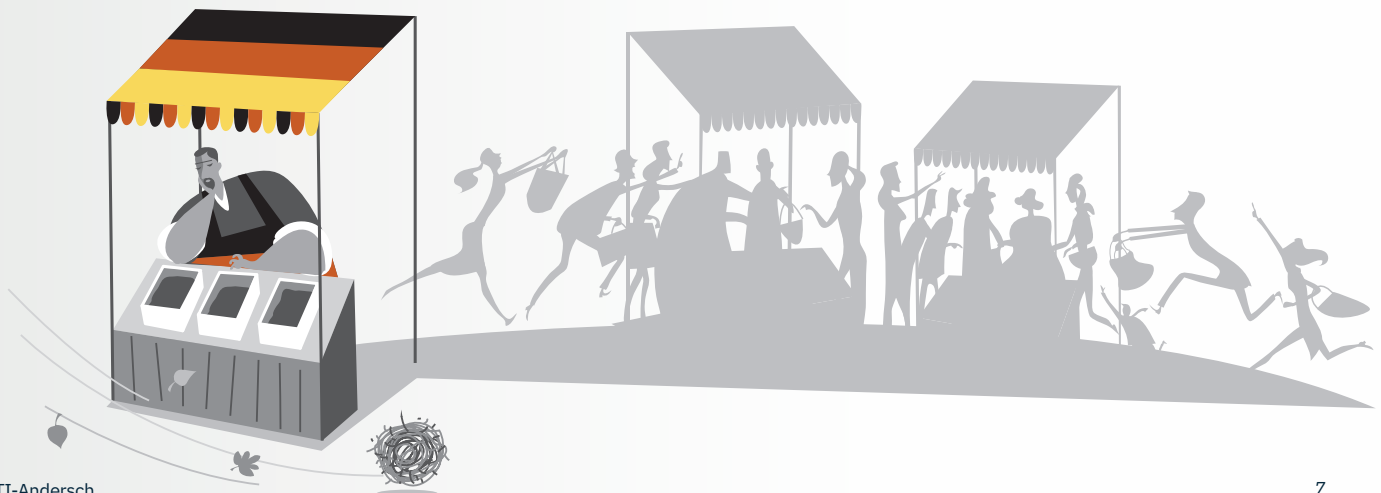
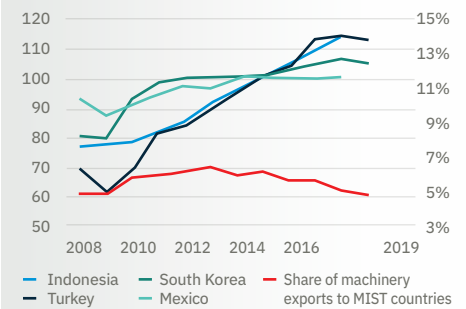
SHARE OF MACHINERY EXPORTS BY REGION (SHARE OF MAIN REGIONS, BASIS: EXPORT VALUE IN USD)



GERMAN MACHINERY EXPORTS VS. INDUSTRIAL PRODUCTION BRI COUNTRIES (SHARE BRI-COUNTRIES IN GERMAN EXPORTS (%); PRODUCTION BRI INDEXED, 2015 = 100)



GERMAN MACHINERY EXPORTS VS. INDUSTRY PRODUCTION MIST COUNTRIES (SHARE OF MIST COUNTRIES IN GERMAN EXPORTS (%); PRODUCTION MIST INDEXED, 2015 = 100)





SALES AND SAVINGS POTENTIALS

The networking of machines/systems and the Internet of Things, the so-called machine-to-machine communication, generate data volumes that exceed the volume of almost any other industry. The data that can be used in industry have new potential for increasing sales and efficiency. Experts expect increases in production efficiency of up to 10% through big data analysis, a reduction in operating costs of up to 20%, and savings in maintenance of up to 50%. The latter are primarily driven by core components of Industry 4.0, including, for example, predictive maintenance, a forward-looking approach to machine/plant maintenance that essentially serves to minimize downtime. However, the implementation of these concepts requires a high-performance digital infrastructure, which is still lacking in many places, especially in rural areas.

CHANGING REQUIREMENTS

In principle, the German mechanical engineering sector is well positioned in terms of products and know-how in global competition, which is illustrated not least by the positioning of many mid-size companies among the global hidden champions or the number and quality of German patents. In order to be able to maintain this position in the medium to long term, software competence of employees is playing an increasingly important role in the course of Industry 4.0, in addition to hardware competence. In recent years, the requirements profile for employees has changed massively - this is reflected not least by the recent mass redundancies (e.g. Heidelberger Druckmaschinen is planning to cut 5,000 of the total of 20,000 jobs, along with others such as Gildemeister, Gea, Demag Cranes and Schuler) - while at the same time an acute shortage of skilled workers is being complained about throughout the industry. This current mismatch between the number of employees already available and the number needed represents an obstacle to growth.

GROUNDWORK

In addition to the question of data security and responsibility, a central challenge lies in the visualization and presentation of results of large heterogeneous data volumes, especially since not every data user is also a data scientist/data specialist. In order to cope with the change brought

by digitalization, investments in young talents are indispensable. The VDMA and leading members such as Siemens therefore also see an acute need for modernization on the part of universities. Their demand: computer science and data analytics should become compulsory components of engineering basic studies, graduates should also be equipped for the future beyond pure technology. Basic knowledge of relevant programming languages or the targeted protection of data is indispensable. In the next five years, skills in the „new disciplines“ (digital product development, production control, working with „digital twins“) will also become essential as a basis for increasing competition. Similarly, in addition to the development of new specialists, existing skilled workers must also be sufficiently qualified for Industry 4.0 in order to actively counteract the shortage of skilled workers.

MID-SIZE COMPANIES AT A CROSSROADS

In recent years, however, SMEs in particular have often been faced with the problem that, in addition to a lack of skilled workers and an inadequate digital infrastructure, there was often too little time to deal with the issue alongside day-to-day business. This was not least due to the time advantage that innovation drivers such as Bosch had already gained in this area. In addition, managers in SMEs lacked digital skills, which is why necessary investments in digitization fell by the wayside due to low prioritization. And finally, despite the current low interest rates, many SMEs, which used to be frequent drivers of innovation, are asking themselves whether and how they can afford comprehensive networking projects at all. Even larger SMEs shy away from such capital expenditure and generally do not have sufficient IT specialists or structures at their disposal. This is also one of the reasons why not even one in ten mechanical engineering companies has so far systematically recorded, analysed and used the data it collects. But they need to make these investments now in order not to lose out. In complex areas that combine several disciplines and in which they cannot do this alone, cooperation and mergers will be increasingly observed.

„[When] Chinese people visited the production halls of German companies like Siemens ten years ago, they couldn't get out of their amazement. Now many German factories look old compared to Chinese ones.“

Fang Weizhong, Managing Director Easitech, in a DW interview. Online available at: <https://bit.ly/2v6TpWN>

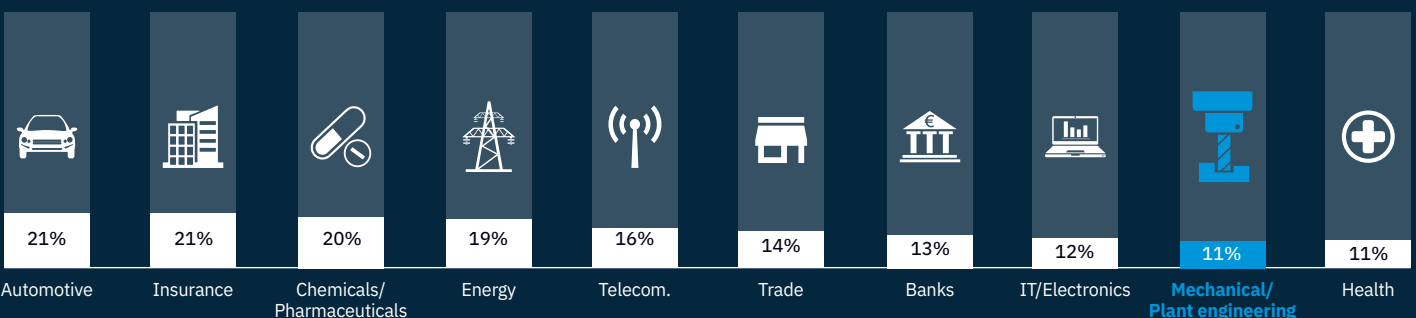
REALISING THE POTENTIAL FOR DATA MONETIZATION REQUIRES TARGETED ACQUISITION OF DIGITAL SKILLS

External			Internal	
Data as commodity	Knowledge as commodity	Products supported by data analysis	Sales increase	Cost reduction
<ul style="list-style-type: none"> Raw data Processed data 	<ul style="list-style-type: none"> Analysis results Forecasts Consulting 	<ul style="list-style-type: none"> Better or new products and services 	<ul style="list-style-type: none"> Increase sales success Improve customer loyalty 	<ul style="list-style-type: none"> Increase productivity Reduce scrap and consumption
Direct			Indirect	

Sources: Handelsblatt; VDMA; Deutsche Welle (DW); Tableau; mi-connect; Produktion; Bitkom



USE OF BIG DATA BY INDUSTRY (% OF COMPANIES USING ADVANCED DATA ANALYTICS)



Although high potentials could be achieved especially in mechanical engineering, the degree of penetration of big data is currently still very low in a cross-industry comparison.



KARLSRUHER INSTITUTE OF TECHNOLOGY (KIT),
WBK INSTITUTE OF PRODUCTION SCIENCE

GLOBAL PRODUCTION NETWORKS IN TRANSITION

Global production networks for machine tools have changed in many ways due to international outsourcing as well as digitalization and flexibilization of supply chains. In the past, German machine manufacturers were able to adorn themselves with the ‚Made in Germany‘ seal - an international recognition of the outstanding quality of their products. With an increasing focus on delivery time and price sensitivity, driven by Asian and American competitors, German machine builders were forced to decentralize. The opening up of new markets and the regionalization of products as lever for the top line and later the use of labor cost advantages to optimize the bottom line have led to the international competitiveness of German mechanical engineers. The structure of production networks changed from German global factories to a hub-and-spoke model in which the core technologies continue to be manufactured in Germany, but the assembly and production of simple, non-knowledge-intensive components take place in the local markets.

GLOBAL MARKETS OPEN UP NEW CHALLENGES

While German mechanical engineering companies had to react primarily to changing market requirements and new competitors around the turn of the millennium, they are now facing a new group of challenges. The increasing complexity, both in terms of products and production networks, as well as the fast pace and volatility of globally distributed sales markets, political conditions and technological developments require agility and adaptability of production networks. At the same time, a focus on sustainable products and production is becoming increasingly important for machine manufacturers, so that new, environmentally friendly manufacturing processes, circular value chains to increase resource efficiency and transparency with regard to environmental impacts are coming more into focus.

DIGITIZATION AS AN OPPORTUNITY

The effective use of digital applications is a decisive building block for mastering the current challenges. The continuous collection of product-related data is considered a decisive enabler for the digital transformation of many machine builders. A far-reaching database serves to control production processes more effectively and to develop forward-looking applications and intelligent service offerings. This is made possible by established technologies and standards such as RFID, UBW or the GS-1 standard. Disruptive technologies such as 5G for improving connectivity and blockchain for securing and verifying process and product data form the basis for continuous changes in the market. A best practice for the successful use of blockchain technology within production networks for quality-related process tracking is the IOTA Tangle-based tracing system from Pickert. IOTA Tangle - a platform for the international exchange and documentation of information as well as digital assets - enables industrial companies to create tamper-proof ‚digital twins‘. However, the cross-industry digitization of production networks is currently hampered by the lack of standardization of data protocols. A standardized digital basis structure would accelerate the establishment of new business models, such as „Production-as-a-Service“, even if a timely introduction is unlikely due to the high implementation costs and the lack of consensus among companies. Production-as-a-Service is currently being promoted by the machine tool manufacturer Trumpf in partnership with Munich Re. With this business model, capital-intensive production technologies can be used by smaller, less solvent customers. This change is crucial for German mechanical engineering companies, as they differentiate themselves from competitors primarily through product individualization and a high level of service. In addition, new tools for their own agile production management can be built on the continuous data basis. These include live reporting and monitoring platforms, but also decision support tools such as simulation, optimization and artificial intelligence. By means of increased use of digital tools complex networks can be designed and managed

more effectively while expanding digital features for customers. The focus of future network developments must be much more strongly linked to strategic goals. For example, site role concepts can be aligned with the product portfolio and order fulfilment organization to create a more productive and flexible network. In addition to the classic cost calculation, softer factors such as the local level of education, culture fit and political factors are increasingly being taken into account in network design and site selection. The location of Tesla’s Gigafactory in Germany is a clear sign of the significance of local know-how.

FOCUS ON RESILIENT PRODUCTION NETWORKS

In increasingly volatile times, production networks must become more adaptable so that network disruptions can be resolved more quickly. Especially the current COVID-19 crisis, which is dramatically affecting both markets and supply chains, highlights the need for resilient production networks. Such resilient networks are characterized by the anchoring of strategic redundancies and the rapid, demand-related shifting of competencies. Agile location concepts, which enable the rapid establishment of standardized factories, promote the transformation from historically grown production networks to strategically adapted, fluid networks. For example, VW’s new factory concepts - so-called slim-flex movers - have a high degree of standardization, so that they can be set up within a very short time to offer local products. The change towards adaptable networks is supported by the further modularization of the machine tools, some of which are highly complex, in order to combine economies of scale, a high number of variants and fast delivery times. By means of agile management concepts and strategic diversification, companies can better protect themselves against extreme events such as the COVID-19 crisis, market fluctuations and trade barriers. This resilience can be further strengthened by intelligently integrating different partners and promoting digital collaboration.

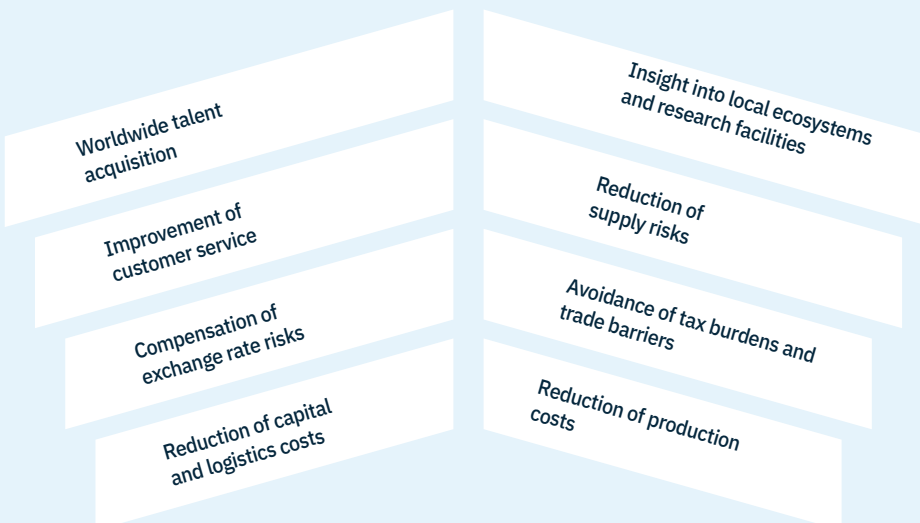


Figure 1: Objectives for global production - increasing focus on „soft“ factors

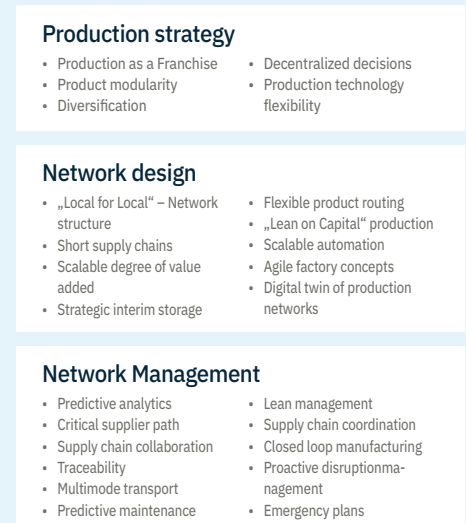


Figure 2: Opportunities for increasing the resilience of production networks at three levels



KARLSRUHER INSTITUTE OF TECHNOLOGY (KIT),
WBK INSTITUTE OF PRODUCTION SCIENCE

THE PATH TO INDUSTRY 4.0 IN MECHANICAL AND PLANT ENGINEERING:

The German mechanical and plant engineering industry is characterized by complex production processes, driven by high levels of individualization and the resulting production times. In recent years, German manufacturers have experienced more fluctuating and individualized customer demand. Industry 4.0 therefore represents a promising opportunity to control the complexity of production systems and to remain competitive with international competitors. As user and supplier of Industry 4.0, mechanical and plant engineering can benefit from the potential in two ways.

METHOD AND STRATEGY AS SUCCESS FACTORS

Industry 4.0 enables manufacturers to respond to changing product requirements, optimize price and quality, and increase resource efficiency through the digitalization of production processes. The implementation of an Industry 4.0 strategy is mostly capital and time intensive, which is why the use of a toolbox for operational implementation is indispensable. The INTRO 4.0 research project has identified so-called basic methods: enablers for the transformation of production, and potential methods, levers for financial effects in production. The design of the methods must be individual for each company and depends on the digital maturity of the company (<https://digitalisierung.andersch-ag.de/de>). Based on the maturity level, an individualized Industry 4.0 strategy can be defined by means of a workshop concept with process experts and production managers. Special consideration is given to the established production system as well as the development of the market and customer needs. Combined with an analysis of the company's goals, product-oriented target factors are weighted: A premium manufacturer with poka yoke strategy (zero-defect production) prioritizes other target factors than a supplier in the low-price segment.

Methods can be derived from the formulated strategy and transferred to an operational roadmap. A selection of the most important fields of action of the Industry 4.0 toolbox is shown in Figure 1. In the case of a Swiss plant manufacturer offering premium precision equipment, Industry 4.0 potential methods were prioritized that ensure high product quality (e.g. digital twin, digital poka yoke) and high flexibility (intelligent workforce scheduling, worker assistance system) in production. For a supplier of modular, standardized production systems with medium quantities, the target factors of time and cost were optimized. For customers with production systems that have a large proportion of automated process steps, methods of self-organization and decentralization come to the fore.

DECENTRALIZED IMPLEMENTATION AND CONCRETE DESIGN OF METHODS

Once the methods to be implemented have been determined, Industry 4.0 teams can be formed, similar to the CIP teams of lean management, which jointly develop and implement new Industry 4.0 tools and technologies in the company. Due to their process knowledge, these teams represent an important source of ideas for further possible applications of Industry 4.0 in the production process. The Industry 4.0 teams combine process knowledge and digital competencies in order to implement the measures operationally and are in constant exchange with the project management. By actively involving employees in the implementation, acceptance problems can be prevented and Industry 4.0 becomes a success in the company.

NEW BUSINESS MODELS AND SERVICES AS SUPPLIER-SIDE INDUSTRY 4.0 POTENTIALS

As a supplier of machinery and production equipment, Industry 4.0 gives mechanical and plant engineering a top-line lever by expanding existing

sales markets and building new business models. The strategic question for management at this point must be to what extent digitization should expand the product range and to what extent new business models should be developed. On the product side, the VDMA's Industry 4.0 toolbox clearly shows that the integration of sensor technology, communication interfaces and data storage systems are a basic prerequisite, as these form the basis for the implementation of decentralized and self-organized production systems. The integration of these Industry 4.0 technologies in production plants additionally offers the mechanical and plant engineering industry the possibility of new visionary business models. Another example besides the above-mentioned approach of Trumpf shows how a new leasing model for production plants can be realized with the help of Industry 4.0 technology: Here, the leasing rate is determined according to the availability and quality of the equipment. The systems are equipped with the latest sensor technology and therefore enable in-process quality assurance with decentralized control for adjusting the tool parameters. The customer of the production plant is therefore guaranteed a high quality rate and plant availability by the plant manufacturer, which is taken into account in the calculation of the leasing rate to be paid. In return, the manufacturer receives all machine tool and production environment data, which he can then use to sustainably optimize his production equipment. At the same time, field data from the production plant offers the possibility for manufacturer services such as remote diagnostics and predictive maintenance services to ensure the highest possible plant availability. Since plant availability is a limiting factor for the efficiency of production systems in many production facilities today, many plant engineering customers are also willing to pay for such services and business models. Interesting use cases arise in particular in globally distributed production networks.

Industry 4.0 - methods collection

Industry 4.0 potentials (promise concrete improvement possibilities)

Assistance systems and visualization

- Order visualization
- Digital maintenance information via AR
- Leading through the process
- Integrated change process

Networking and transparency

- Demand-oriented supply of production plants
- Digital remote diagnosis of production plants
- Digital communication between employees
- Digital layout planning and digital factory model

Self-organization and decentralization

- Automatic planning and optimization of production
- Autonomous transport vehicles
- Flexibilization of production systems
- Intelligent workforce management

Industry 4.0 basics (create conditions for implementation of potentials)

Enabler

- Unique and secure proof of identity for products, processes and machines
- Use of cyber-physical systems
- Acquisition of process data (among others) by machines and tools

Data

- Requirements-based information through filtering
- Cybersecurity of stored data respectively organizational and communicative IT security
- Data security of equipment/systems

Human

- Education and training
- Change management
- Digital skill matrix and digital employee assignment
- Development of competence profiles

Figure 1 Excerpt from the method toolbox of the INTRO 4.0 project



EXPAND INNOVATION

Shorter innovation cycles and increasing price and competitive pressure on international markets have led to an increasing convergence of hardware in mechanical engineering. Innovative strength has become the most important core discipline alongside efficiency in value creation. At ever shorter intervals, the question arises as to where new customer benefits and competitive advantages over price breakers can lie. However, innovative strength should not end with the hardware: product-related services such as consulting (e.g. conceptual design of fully networked plant layouts) and maintenance offer an opportunity to differentiate. They are therefore already offered integrated as part of a complete package in many cases.

SERVICE AS A PRODUCT

Service in particular offers an average margin potential that is twice as high as the pure hardware business. However, the view of services as stand-alone products, which benefits could be marketed separately and reimbursed adequately, is often still underdeveloped in the German mechanical engineering industry. The goal: customers should not take value-added services for granted. To ensure that their use is not uncompensated in the context of active customer loyalty, the services must be positioned as stand-alone products:

- Clear definition of the range of services, standardization of the services and quality standards (in particular for (external) service technicians for later scaling).
- Management of customer expectations
- Increase in willingness to pay
- Successive addition of digital services such as online real-time maintenance

ENRICHED CORE BUSINESS

The offer of turnkey, customized complete solutions, comprehensive control technology and system integration is already part of the basic package for many machine builders in sales discussions. Increasingly, new business models such as equipment-as-a-service are also gaining ground. The operator model offers customers potential for cost savings in the short term; machine builders can generate higher revenues in the long term, but also bear a higher economic risk. In the course of

increasing price pressure worldwide, predictive maintenance solutions in particular are becoming more relevant: Not only in original equipment, but also in the classic spare parts business, machine builders are increasingly confronted with price-driving third-party suppliers. Since it simultaneously minimizes unplanned downtimes on the customer side and counteracts the company's own erosion of the spare parts business as a revenue driver, predictive maintenance is considered a new growth segment: networked machines report ideal maintenance times and replacement requirements early on, and automated spare parts orders can be triggered via platform and direct interface to the machine supplier.

PRODUCT INNOVATION

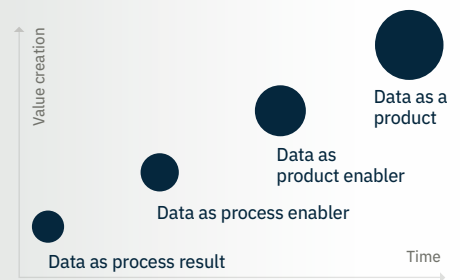
Offering additional digital services requires a high degree of digitization on the part of the customer and technical know-how on the part of the machine manufacturer. Strict data protection requirements and customer reservations about cross-company data exchange are often cited as further hurdles to the widespread use of technology. However, beyond these reservations, technical possibilities and marketing potential are growing steadily: General Electric, for example, offers a standardized possibility to develop industrial applications in the cloud with its IoT platform Predix. Users can transform real-time data into relevant insights and decision-making bases by connecting machines and data with the entire company. At the same time, the machines networked via the Internet of Things can be directly controlled by the machine manufacturer - for example, when setting up or adjusting an entire production line - which enables stronger customer penetration and loyalty, while the customer can focus on its actual value creation. In purchasing and materials management, which account for a significant portion of working capital, comprehensive networking also offers significant potential for optimization, which can be controlled with even greater precision in the future using smart data analyses. Both customers and machine builders themselves can benefit from this. Overall, mechanical engineering in particular is considered one of the main beneficiaries of comprehensive digitalization.

Sources: Handelsblatt; VDMA; Bitkom; Tableau; mi-connect; Produktion; Commerzbank; own analysis

„Tomorrow, we will master batch size 1 with data and thus be able to implement customer wishes flexibly, economically and at short notice.“

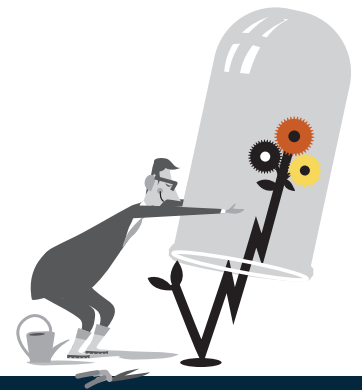
Patrick Hantschel, Head of Digitalization Center Wittenstein SE. Interview available online at: <https://bit.ly/2va5VeZ>

FROM PROCESS DATA TO DATA PRODUCT USABILITY OF BIG DATA (LIFE-CYCLE VIEW)



Graphic: Fraunhofer-Institute for Production Technology IPT

The classic product life cycle begins with the idea and construction of a product – also data pass through a life cycle, which starts in the selection and targeted collection of data. Potentials of data usage can be found in all areas along the life cycle: big data client as basis for make-or-buy decisions, customer demand analyses and -prognoses, predictive maintenance of machines, enrichment of products – until they can finally be marketed on their stand-alone.



DATA USE AND MONETIZATION

Physical

Smart factory

Sensors create increased transparency and an enhanced planning capability
→ *Augmented Reality, RFID & AutoID, CPS*

Smart products

The product thinks along and is in contact with the manufacturer even after sale
→ *digital product life cycle (RFID), communication and interface standards*

Industrial leadership

Industry 4.0

Big Data

Expansion of the range of services

Virtual

Smart operations

Networked production enables flexible production planning and control
→ *CPPS, Concurrent Engineering, M2M, Cybernetic Production*

Smart service

The networking of product and manufacturer opens up new markets for services
→ *Product service systems, hybrid products, service engineering, service platform*



DIFFICULT HOME GAME

Framework conditions for the German mechanical engineering industry will be determined in the coming years by climate protection regulations, structural changes in key customer industries and politically driven location promotion. In many cases, these are primarily European challenges that make competitiveness in the global market more difficult. For these reasons, the VDMA is calling for, among other things, simpler and less bureaucratic tax legislation, internationally competitive tax rates and faster depreciation options. Greater leeway would boost private investment and strengthen the competitive position, according to the VDMA.

CLIMATE CONSEQUENCES

Awareness of climate protection is increasing worldwide - the World Economic Forum recently described climate change as an „overshadowing global risk“. The effects of climate policy measures are also having an impact on the machine engineering industry. On the one hand, the European CO2 price is leading to rising energy costs, which are hitting German mechanical engineering companies (in the wake of the EEG reallocation) harder than foreign competitors. Many customer industries would also feel setbacks due to considerable cost increases for steel and chemical products. Some even fear a migration of energy-intensive industries to countries with lower energy costs and rising emissions in these countries. Frans Timmermans, Vice-President of the EU Commission, is therefore calling for a CO2 border tax to minimize the economic disadvantages of the EU's „Green Deal“ for domestic suppliers in the European market. The German Minister of Economics, Peter Altmaier, also hints at possible measures to offset rising energy supply costs. On the other hand, the domestic mechanical engineering sector will benefit from strict EU climate policy, as the tight regulatory framework will force industrial companies to purchase more efficient machines. In addition, German mechanical engineering companies are in a „pole position“ with regard to these new requirements in comparison with their international competitors, as they not only have sufficient relationships with all stakeholders involved, but also a technological edge.

FIT FOR THE FUTURE

A trend that is gaining in relevance - also from a sustainability perspective - is the increasing retrofit. It aims at the technical upgrade of a technologically backward machine/systems. The trend originated in large-scale plant construction, where amortisation times and capital commitment are correspondingly higher. In the course of the increased need to make machines fit for Industry 4.0 via sensors and software updates, among other things, the trend is gaining further relevance. The integration of technology leaps (e.g. an upgrade of outdated photovoltaic lines to the new PERC technology) is also possible. In the case of particularly durable machines/systems, retrofitting can also be carried out several times. Flexibility in the use of components and materials is an essential prerequisite. It can be

promoted through modular design and standardization. While on the one hand this trend reduces the potential for new business, it also opens up new market opportunities in times of increased investment restraint.

SILICON VALLEY & BEYOND

The formation of a monopoly by the tech giants Google, Amazon, Facebook and Apple (GAFA) from Silicon Valley is perceived with concern by German SMEs, but according to recent surveys only 15% of machine builders see GAFA as direct competition. Although they are attacking the entire industry head-on with their platform solutions, they clearly lack the necessary hardware expertise. Nevertheless, machine builders can learn a lot from the tech giants when it comes to product and process innovation: from an expert's point of view, partnerships rather than competitive situations between machine building and tech companies will arise in the future; GAFA is not currently thought to be planning its own production of machines. The high capital commitment combined with significant risk does not fit GAFA's business model, as past sales activities of Google also show. The machine builders will continue to be positioned at the interface to the customer and therefore have the necessary detailed knowledge and customer confidence. A partnership that involves the tech giants as software service providers and data owners in machine sales to complement industrial production with modern information and communication technology is a likely future scenario. Machine builders should therefore examine the benefits of cross-industry cooperation with software and data houses as early as possible.

MECHANICAL ENGINEERING AS PLAYER IN CLIMATE POLICY

Push	Pull
<ul style="list-style-type: none"> • Customer expectations driven in particular by rising electricity prices (energy efficiency partly specified in specification sheets) • Restrained investment behaviour • Low service sales over lifecycle • Competitive pressure from international competitors with less efficient but cheaper machines 	<ul style="list-style-type: none"> • Increased willingness to invest in efficient machines or retrofit services despite economical and political situation • Growth prospects in the environmental technology market (up to 7% CAGR) • Pole position vs. international competitors in the field of GreenTec through expertise and relationships with relevant stakeholders

„The Annual Economic Report 2020 generally does not give a all-clear signal. Business location Germany remains under pressure, not just because of global trade conflicts. Many problems are homemade. These include, above all, the fiscal framework conditions, which have long since ceased to be internationally competitive.“

Dr. Ralph Wiechers, Chief Economist of the VDMA, online available at: <https://bit.ly/2ShXlme>

Sources: VDMA; Handelsblatt; FAZ; FTI-Andersch analysis





ACT - BUT HOW?

The challenges outlined in this white paper place increasing pressure on decision-makers to make decisions and take action. Due to the complexity, prioritization is required. Those who reduce complexity with the right analysis approach and act in a targeted manner will gain competitive advantage.

FOCUS THROUGH POSITION ASSESSMENT

Our experience shows that the focus of resources must first and foremost be placed stringently on the most important needs for action. This requires a targeted assessment of the strategic orientation of key value creation processes and, due to the general pent-up demand for digital networking, also the determination of the level of digital maturity. The position assessment shows in which areas the necessary transformation is already being successfully carried out and where is still a need to catch up. The potential and need for action derived from this must be prioritized along the target dimensions. Today, modern approaches make this possible by means of software-supported tools for recording the company's internal state of knowledge and benchmarking against competitor data. In many cases, the question then also arises as to whether and how the investments, often associated with innovation and growth targets, can be financed.

FINANCIAL RESOURCES

The financing of important transformation projects can be provided via external financing contributions (external financing) or liquidity reserves and earnings potential (internal financing). The influence of the currently prevailing pandemic is causing financial institutes to exercise a certain degree of restraint and at the same time requires the company to have a stable asset structure (including equity resources). If the effects of the pandemic are already visible on the earnings and liquidity side, as is the case in many companies in the German mechanical engineering sector, internal financing may be the only option. Optimizing working capital is a key approach to solving this problem.

WORKING CAPITAL OPTIMIZATION

Studies show that German machinery manufacturers have considerable unused resources in the form of liquidity potential in current assets. Even though active working capital management is often of high priority on the agenda of decision-makers, there are regularly difficulties in its implementation. Significant liquidity potentials remain unused as a result. In connection with deficits in the context of digital maturity, analyses are often based on high level key figures (e.g. reach of receivables, DSO) and implementation is based on lagged control parameters.

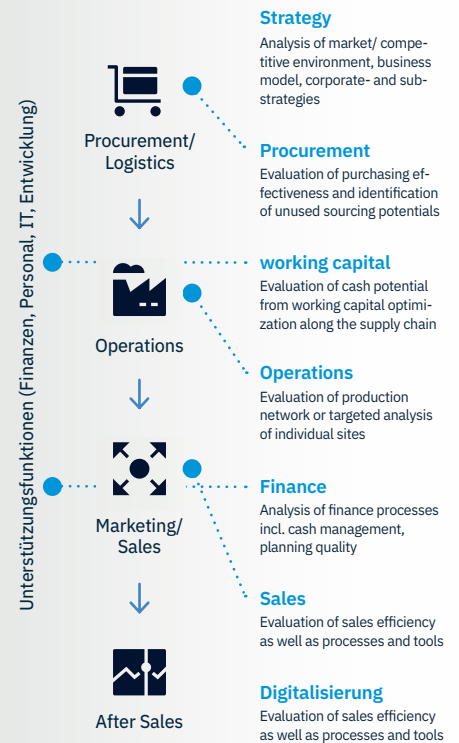
ANALYSIS OF MASS DATA

Sustainable optimization in working capital requires a high level of competence in the digital disciplines of extracting and processing very large volumes of data. Sustainable liquidity potentials are optimally identified and formulated for implementation through analyses at a very granular level. The collection of movement and assessment data for receivables, liabilities and inventories is possible at the individual document level using modern technologies and algorithms, regardless of the size of the company. In this way, the right adjustment screws can be identified in a targeted manner and yo-yo effects can be avoided.

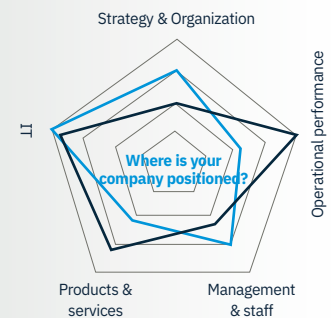
MASTERING CONFLICTING GOALS

The optimization of working capital management is characterized by numerous conflicting goals. For example, the ability to deliver can suffer if inventories are reduced across the board, and thus for the wrong items. System-based simulations of efficiency and effects of possible measures help to identify interdependencies and to minimize the risk of unintended side effects. This form of analysis, deriving measures bottom-up from non-compacted system and mass data, enables new approaches to the optimization of working capital: tailor-made individual measures replace general empirical values.

DIMENSIONS FOR TARGETED POSITION ASSESSMENT



ALIGNMENT OF NEEDS FOR ACTION WITH COMPANY'S OBJECTIVES



INTERNAL FINANCING THROUGH SUSTAINABLE WORKING CAPITAL OPTIMIZATION

TRADITIONAL APPROACHES

Approach	Working Capital		Frequent one-off effects
Analytics and visualization	<ul style="list-style-type: none"> Rough analysis based on balance sheet data (DSO, DPO, CCC), partly with limited comparability Traditional (static) preparation in the form of reports 		
Optimization	<ul style="list-style-type: none"> General optimization approaches, e.g. aggressive enforcement of payment terms with suppliers, damaging the business relationship Reactive approach (One-off) effects mainly for the duration of the project 		

UP-TO-DATE WORKING CAPITAL ANALYTICS

Approach	Working Capital		Focus on Stabilization of effects
Analytics and visualization	<ul style="list-style-type: none"> Differentiated analysis and standardized KPIs based on mass data (-> Data Science) Visualization of KPIs and impact correlations via interactive dashboards 		
Optimization	<ul style="list-style-type: none"> Targeted optimization of customer/segment-related individual topics with knowledge of exact interdependencies of effects Modelling and use of forecasts Stabilization of effects by providing continuous analysis tools („dashboards“) and adapting processes 		



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FTI-Andersch is the leading restructuring consultancy in the German-speaking region.

FTI-Andersch supports clients in the development and implementation of sustainable future/performance and restructuring concepts. FTI-Andersch becomes active in situations in which companies have to deal with operational or financial challenges - or well before, in order to align the business model, organization and processes for the future at an early stage. A particular focus is on the preparation of independent decision-making bases for targeted (re-) financings.

Clients include medium-sized companies and corporations that operate internationally. FTI-Andersch is part of the global FTI Consulting Group (NYSE: FCN) with more than 5,500 employees.

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