

The future of German mechanical engineering

Operating successfully in a dynamic environment



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THE IMPORTANCE OF GERMAN MECHANICAL ENGINEERING IN FIGURES

GENERAL DATA (2013)

Around **40%** share of machinery turnover in Europe

Some **6,400** companies (2012)

Approx. **1 m** employees

Over **11%** of German R&D expenditure in
manufacturing industry (2012)

Over **EUR 35 bn** p.a. cumulative direct
investment overseas (2012)

11% of world machinery production

Over **EUR 200 bn** turnover p.a.

Almost **14%** of all German exports

Over **3%** of German gross value added (2012)

Some **16%** of global mechanical engineering
exports – no. 1 worldwide (2012)

RESULTS OF THE VDMA-McKINSEY STUDY

Average profitability over **6%**

Approx. **10%** global players,
some **60%** exporters, and
30% local players

Average annual
growth 2010 - 2012 approx. **10%**

Approx. **60%** see their offering in the
premium segment

97% innovation leaders or early
innovation adopters

Over **50%** are founder- or
successor-managed companies

WELCOME

German mechanical engineering – we shape the future!

German mechanical engineering has always been the backbone of the German economy. Even internationally, it stands for progress, performance, and reliability. In the past 20 years, it has been able to grow at 2.2 percent¹ p.a. and to generate an average EBIT margin of 3.9 percent.² Hardly any other industry is so diverse, and developing with so much rigor. Reason enough, then, for German mechanical engineers to confidently look toward the future.

At the same time, there are signs of change. There is pressure from foreign competitors with improving quality and lower-priced services even in industries traditionally dominated by German companies. The international integration of markets is increasing, which in turn increases volatility. The upcoming fourth industrial revolution ("Industrie 4.0"), the impact of digital technology on the value chain, and disruptive technologies such as 3D printing have the potential to change the very structure of business models.

As such, mechanical engineers must not rest on their laurels: as in the previous decades, companies can only ensure their international competitiveness if they actively shape industry trends and achieve continuous improvement.

And in doing so, the VDMA wants to provide the best possible support to its members. To this end, not only do we want German mechanical engineering to keep pace with international competition, but we want to underpin and further expand Germany's leading role even in the face of changing conditions.

Working with McKinsey & Company, the VDMA examined how this could be achieved. More than 330 companies were surveyed, and over 50 in-depth interviews were conducted with executives. The aim was to identify current success patterns and future industry trends, and to derive strategies based on these findings. The result: by implementing measures in six fields of action, German mechanical engineers can secure and expand future success:

- **Targeted and granular internationalization and growth strategy** to address the opportunities and challenges posed by internationalization with the appropriate business model
- **Expansion of aftersales/service segment through integrated, innovative solutions** to leverage profit in this increasingly important area

¹ Federal Statistical Office (turnover indices in manufacturing, WZ08-28, 1995 to 2013).
² Federal Statistical Office (calculated based on cost structure survey 1995 to 2011).

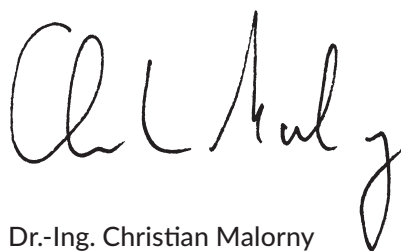
- **Standardization and modularization while ensuring customer-specific offerings and new business models** to efficiently address the increasing demand for customized system solutions
- **Continuous optimization of the product/portfolio value** to keep pace with competitors from emerging markets
- **Excellence, particularly in the domestic value chain**, e.g., using "Industrie 4.0" to realize the quality and productivity benefits of Germany as a place to do business
- **Stringent, risk-differentiated project management**, particularly in the solutions business to secure attractive margins.

This brochure highlights concrete approaches in these fields as the basis for further discussion. Depending on the respective starting situation, the approaches are weighted differently and should be shaped individually. Each company is invited to adopt the relevant courses of action that are applicable to their specific case.

Providing that German mechanical engineering continues to keep its finger on the pulse, it will continue to write its own success story.



Dr. Reinhold Festge
President of the VDMA
Frankfurt am Main



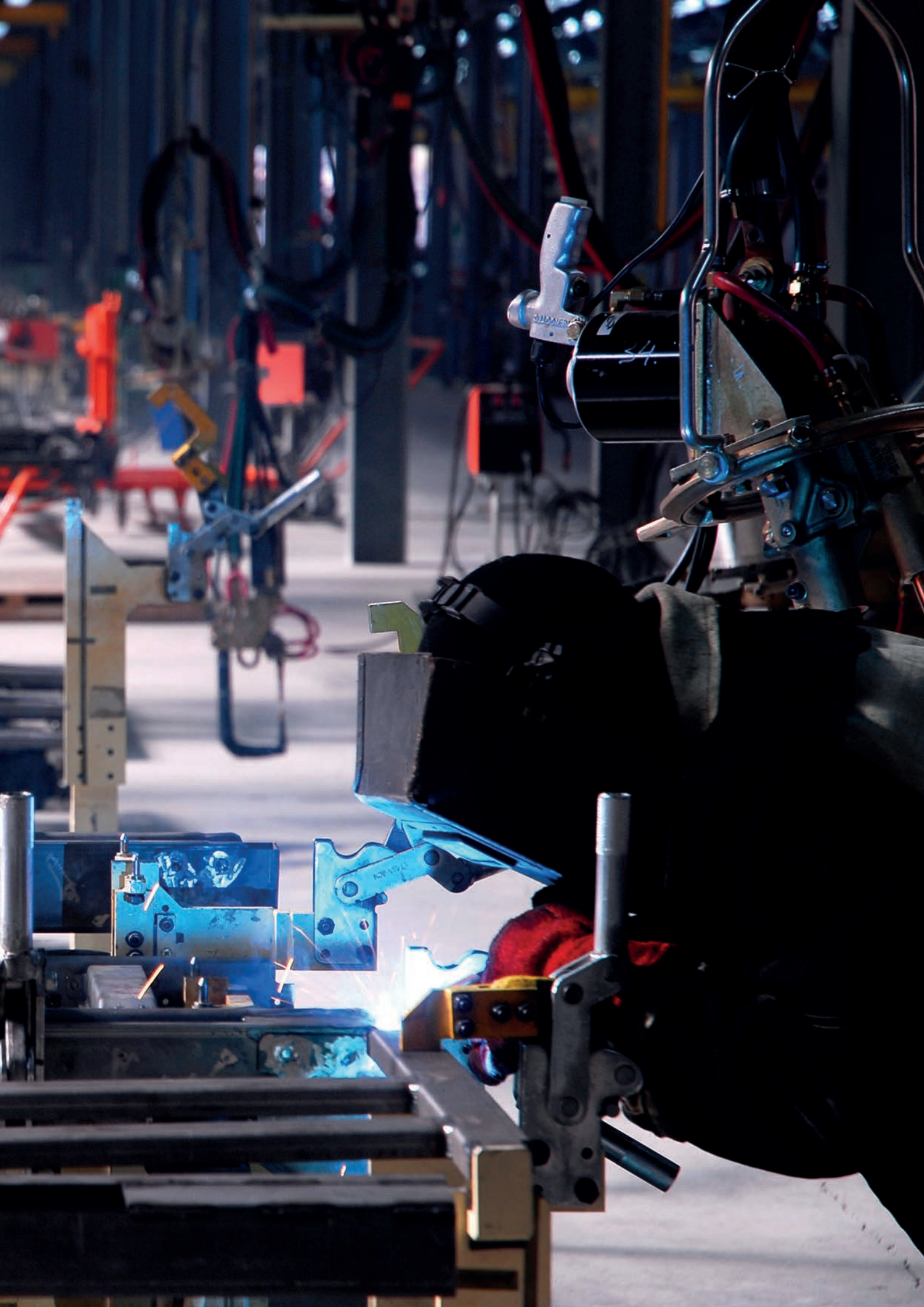
Dr.-Ing. Christian Malorny
Director McKinsey & Company
Berlin

BACKGROUND

MECHANICAL ENGINEERING AS THE BACKBONE OF THE GERMAN ECONOMY

Mechanical engineering is one of the most important industries in Germany: it makes up over 3 percent of gross value added. One in ten mechanical engineering products worldwide is produced in Germany – and thanks to the high export share, these products comprise 16 percent of global machinery exports. Around 1 million employees generate turnover of around EUR 200 billion a year. In terms of revenue, this makes Germany the world's third largest producer of machinery and plants after China and the United States. Furthermore, German mechanical engineering is very innovative: in the manufacturing industry, 11 percent of research and development (R&D) expenditure flows from this sector.





The mechanical engineering industry is in excellent shape. But ensuring growth and profitability is not a foregone conclusion

The enterprise landscape is highly diverse with over 6,000 companies – family-run businesses with less than 50 employees can be found next to large corporate groups with over 20,000 employees. The variety of German mechanical engineering is reflected in the 38 associations in which the members of the VDMA are organized according to their trade affiliation.

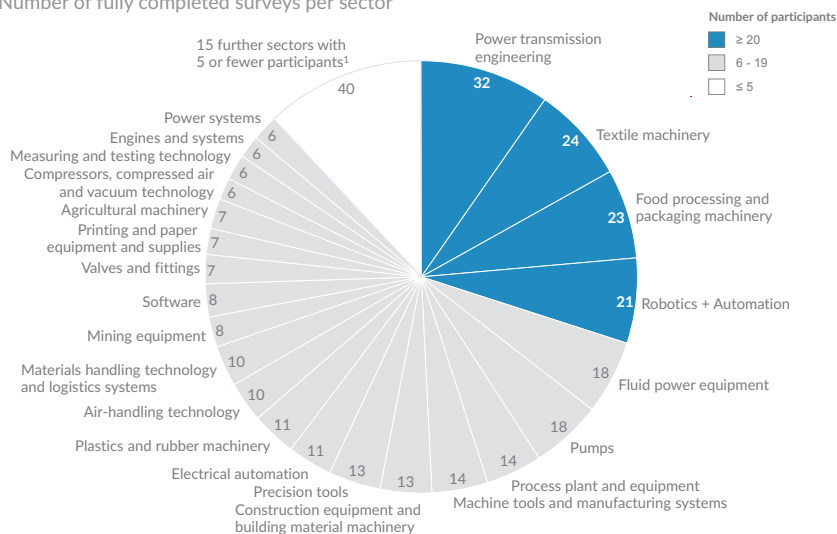
With an average EBIT margin of over 6 percent in 2012 and revenue growth of more than 2 percent p.a. since 1995 (due to recovery effects between 2010 and 2012 of almost 10 percent p.a.), mechanical engineering is a symbol of German economic power. But the competitive landscape is changing: markets outside Europe are becoming increasingly important, particularly Asia and China. But North America is also experiencing “reindustrialization.” The emergence of low-cost players with increasing quality is sharpening the competition in traditional industries in which the quality seal “Made in Germany” is still the standard, and is putting margins and existing success patterns under pressure. At the same time, customers are increasingly demanding customized system solutions, which puts new demands on the structure of supply and internal processes. Customers both home and abroad also increasingly expect a comprehensive aftersales/service offering. As such, many enterprises are still looking for a profitable business model, tailored to customer requirements. Production conditions are also changing: digitization and technological innovations such as “Industrie 4.0” and additive manufacturing (e.g., 3D printing) are revolutionizing production and traditional markets. Not least in Germany, well-trained engineers and specialists have become scarce in recent years. Above all, smaller enterprises or companies located outside urban areas have problems attracting and keeping skilled personnel and managers.

In view of these changes, mechanical engineers are tasked with ensuring growth and profitability, and therefore their long-term success. They face many questions:

- How can the large growth potential in new markets be effectively tapped?
- To what extent can exports from Germany ensure the necessary further growth?
- How can German mechanical engineering remain competitive in a highly dynamic international environment?
- What role does process excellence play in growth and profitability?
- How much does success depend on a clear focus in the business model?
- How can further standardization and customized system solutions be reconciled?
- What effects do emerging innovations have on productivity?
- How important will price premiums and the ability to innovate be in the future?
- How can the further potential in aftersales/service be developed in the best way?

A total of 333 companies have participated in the survey

Number of fully completed surveys per sector



¹ Incl. 3 participants without sector specification

SOURCE: VDMA-McKinsey Study 2014, "The future of German mechanical engineering"

EXHIBIT 1

This brochure, which has been compiled together by the VDMA and McKinsey & Company, attempts to offer some thought-provoking impulses and to outline the future prospects for German mechanical engineering. Chapter 2 first highlights drivers of growth and profitability and identifies cross-industry success patterns. Chapter 3 analyzes the most important industry trends of the coming years, and the associated opportunities and challenges. Building on these findings, Chapter 4 derives concrete measures in six central fields of action. The brochure concludes with a strategic outlook 2020 for German mechanical engineering.

In the study, 333 companies participated from all sectors of the mechanical engineering industry; over 150,000 data points were evaluated. Participants included companies of all sizes with different ownership and management structures, ensuring involvement of a broad cross-section of the industry. The survey covered key figures on the cost effectiveness and structure of the companies, while also appraising industrial trends and future opportunities and challenges. In addition, in-depth interviews with more than 50 executives from 27 industries were conducted. The interviews were supplemented with a range of external data, which helped validate the results and deepen the understanding of success patterns and trends.

To ensure the statistical validity and anonymity of participants for all evaluations, a minimum size of at least 20 participants was defined for the samples in each case. Four industries fulfill this criterion and were therefore evaluated separately: Power transmission engineering, Food processing and packaging machinery, Robotics + Automation, and Textile machinery. In order to offer as many participants as possible the opportunity of specific evaluation, similar industries were also summarized into four sector clusters respectively:

- **Mechanical appliances for process technology.** Compressors, compressed air and vacuum technology; Pumps; Valves and fittings; Air-handling technology; Process plant and equipment
- **Machines and components for automation technology.** Power transmission engineering, Fluid power equipment; Electrical automation; Measuring and testing technology; Software; Productronics; Microtechnology; Robotics + Automation
- **Machines mainly for mobile applications.** Construction equipment and building material machinery; Mining equipment; Agricultural machinery; Materials handling technology
- **Machines for certain manufacturing processes.** Machine tools and manufacturing systems; Precision tools; Textile machinery; Food processing and packaging machinery; Plastics and rubber machinery; Printing and paper equipment and supplies; Woodworking machinery; Garment and leather technology; Thermo process technology; Machinery for metallurgical plants and rolling mills; Foundry machinery.

Due to their minimal sample sizes and specific characteristics, the following industries were not assigned to any cluster: Waste and recycling systems; Security systems; Firefighting equipment; Automation and management for houses and buildings; Power systems; Engines and systems; Large plant construction.

Short description of the survey and the statistical evaluation

The survey drew on revenue growth and profitability (measured as EBIT in relation to revenue) as the key metrics. Sales development was measured for the period 2010 to 2012, and profitability was measured for 2012. Owing to the recovery effect after the 2008/09 crisis, average revenue growth is significantly higher in the years 2010 to 2012 at roughly 10 percent p.a. than over a longer period (a good 2 percent p.a. since 1995). However, the relative differences that were used in this study to assess success could be validated based on longer time series. For example, growth data and export volumes were compared with VDMA data,³ which revealed large agreement. Unless otherwise specified, all the following data relates to the survey and the periods used in the survey.

3 Comparison data for export share/turnover growth from VDMA incoming orders and turnover statistics (2010 to 2012).

SUCCESS PATTERNS

KNOWING WHAT MATTERS










What is success built on in German mechanical engineering? After analyzing the current status quo and selected structural and economic parameters, one thing is clear: there is no single formula for high profitability and growth. Overall, the findings of the survey point to ten success patterns in German mechanical engineering.





Companies find success in very different ways: for one company, success comes from size, innovative strength, and internationalization, but also from focusing on core business and operational excellence. Other companies benefit from their industry affiliation or management structure, the specific benefits of their solution or component business, a successful aftersales/service business, or a premium position. Overall, the findings of the survey point to ten success patterns in German mechanical engineering.

The study reveals 10 success patterns

			Impact on ...	
			Profit-ability	Growth
1		Company size as an opportunity: larger companies are gradually more profitable (Ø 2 - 3 PP) due to professionalization and internationalization	✓	—
2		Internationalization as key growth driver (vs. diversification) – global players Ø 2 PP more profitable than exporters	✓	✓
3		Operational excellence as basic prerequisite – operational champions 2 PP more profitable and grow 5 PP faster, particularly in the solutions business	✓	✓
4		Consistency in the business model indispensable – companies focused on core business Ø 1 - 2 PP more profitable and grow Ø 3 - 4 PP faster	✓	✓
5		Innovation as criterion for competitiveness – 97% of German mechanical engineering companies are innovation leaders or fast followers	✓	✓
6		Premium companies with higher growth, but no significant profitability advantage – higher profitability only in combination with international operations (> 50%)	—	✓
7		Single machine/component business more profitable (Ø 2 PP) than solution providers, but solution providers grow faster	✓	✓
8		Aftersales/service with growth potential – opportunity to compensate lower profitability in traditional business	(✓)	—
9		Industry affiliation sets the pace: average profitability varies from 3 to 9% – profitable industries with intense competition	✓	✓
10		Management structure determines strategy – externally managed companies slightly more profitable, family-run companies grow faster	✓	✓

SOURCE: VDMA-McKinsey Study 2014, "The future of German mechanical engineering"

EXHIBIT 2

The ten identified success patterns have different parameter values in a profitability-growth matrix.

Revenue growth and profitability driven by various factors

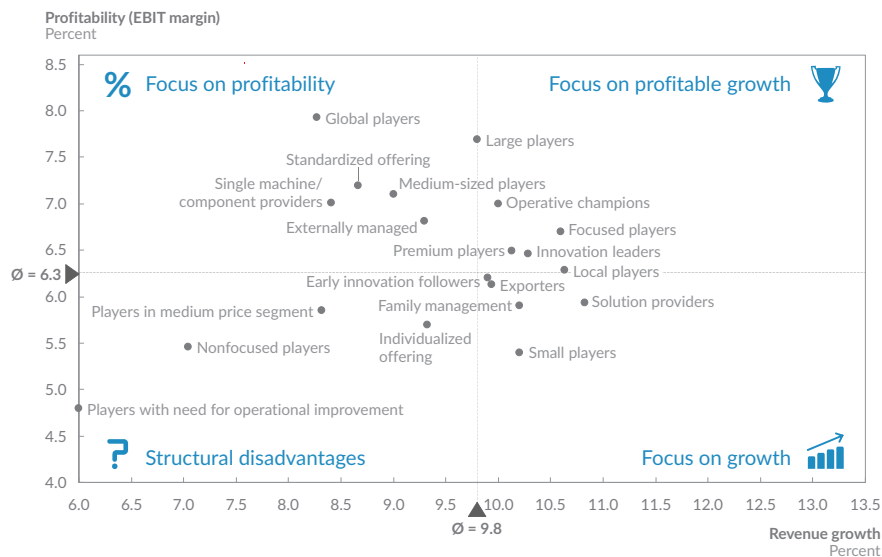


EXHIBIT 3

1 Company size as an opportunity

On average, larger companies show greater profitability. Companies with over EUR 300 million revenue on average perform 2 to 3 percentage points better than smaller companies with up to EUR 50 million revenue. At the same time, there is a wide range of "small champions" (small but very profitable companies), who prove that while size is an advantage, it is by no means the only key to success.

Size opens up more possibilities. Larger companies can achieve greater profitability through professionalization and internationalization

Small champions

Although small champions generate less than EUR 50 million revenue, they show an average profitability of more than 7 percent with growth of more than 14 percent – far more than other companies of their size (average EBIT margin of 5 percent and growth of 10 percent). All small champions operate in the premium segment and are characterized by a minimum of standardization, a strong focus on their core business, and operational excellence. Their success does not depend on the industry – the 20 small champions in the sample are spread across 11 different industries.

Profitability tends to develop over several stages; the thresholds calculated by arithmetic means may be higher or lower depending on the individual industry.

Higher profitability driven by professionalization, internationalization, and scale effects

Percent

Revenue EUR m	Profitability (EBIT margin)		Sales growth	Share of inter- national sales	Share of international production	Share of family-man- aged business	Share of innovation leaders	Share of top 3 customers
> 1,000	7.7	Global players: highly internationalized, attractive for employees, have economies of scale	9.5	76.0	50.0	28.0	83.0	18.0
> 300 - 1,000	7.7	Export champions: strong growth, demand for talent	10.1	81.0	40.0	31.0	76.0	19.0
> 100 - 300	6.5	Companies in internationalization phase (profitability decline)	7.2	72.0	44.0	50.0	92.0	23.0
> 50 - 100	7.4	Highly professionalized, innovative companies with an increasingly broad customer base	9.7	68.0	27.0	43.0	82.0	19.0
10 - 50	5.5	Fast-growing companies that are increasingly externally managed	10.9	58.0	16.0	63.0	65.0	30.0
< 10	5.2	Local family businesses	9.0	48.0	7.0	83.0	62.0	35.0
Total	6.3		9.8	63.0	23.0	55.0	73.0	26.0

EXHIBIT 4

SOURCE: VDMA-McKinsey Study 2014, "The future of German mechanical engineering"

Smaller enterprises (revenue typically up to EUR 50 million) – professionalization of processes. On average, small enterprises have an EBIT margin of a good 5 percent. If they exceed the revenue threshold of approximately EUR 50 million, profitability rises by 1 to 2 percentage points. Four factors in particular play a role in this:

- Increasing professionalization of processes: delivery reliability stabilizes at 85 percent, and the customer complaint rate typically declines.
- Increased innovation: the number of innovative leaders across companies rises from 65 percent to 82 percent.
- Increased internationalization and therefore the accompanying economies of scale: the revenue share outside Germany rises from 58 percent to 68 percent.
- Improved negotiating positions with suppliers and customers, and a broadening of the customer base: the percentage of top three customers declines from 30 percent to 19 percent.

Medium-sized enterprises (revenue usually about EUR 100 to 300 million) – establishing global cost structures. Profitability does not increase continuously. If companies continue to increase their revenue, they initially experience a small profitability decline. This is because further growth typically now demands substantial investment in the internationalization of production, purchasing, and the sales and aftersales/service network. As such, medium-

“When our revenues were below EUR 50 million, our profitability was significantly lower.”

[Food processing and packaging machinery]

sized enterprises see their percentage of overseas production rise from, e.g., 27 percent to 44 percent. Local recruiting and training of employees,

e.g., in new markets such as China, Brazil, and India, also presents a challenge. Thus, productivity losses can barely be avoided during these phases, meaning, on average, reduced profitability of around 1 percentage point among the survey respondents.

Larger enterprises (typically with revenue of EUR 300 million and higher) – standardization and economies of scale. With further growth, the investments pay off. With revenues of EUR 300 million, profitability clearly rises again, achieving an average level of around 8 percent. Economies of scale play a particular role on the cost side: savings are achieved in purchasing, e.g., as a result of the better negotiating position with suppliers due to the increased purchasing volumes and amount of identical components. Furthermore, fixed costs in production, sales, and in administration can be better allocated and additional cost benefits can be realized thanks to the lower transport and customs costs per unit. Delivery times can be further reduced. For larger enterprises, greater standardization also pays off – the percentage of standardized offerings doubles from 10 to 15 percent to 20 to 30 percent, which allows additional cost savings. Companies in this phase also benefit from the stronger market position. As a result of international operations, the share of overall revenue comprised by machines and plants sold abroad increases from 72 percent to over 80 percent. The greater financial power also allows further investment in the expansion of sales and service capacities in new markets, investment in new business models (e.g., financing), and investment in product and process innovations.

Of course, size alone is no guarantee of profitability. The in-depth interviews show that in many cases, smaller enterprises react more flexibly and faster, and that their relative financial weakness is offset by cooperation agreements and equity and borrowed capital investment. In addition, larger enterprises also often need to improve their processes. As such, growth in revenue to over EUR 1 billion no longer substantially increases profitability: the rising complexity resulting from a combination of numerous markets on the one hand and a number of different business fields on the other overlays further economies of scale. Other indices become more important than size, e.g., operational excellence or consistency in the respective business models (see Success Patterns 3 and 4).

Internationalization contributes more to growth than diversification – global players are on average 2 percentage points more profitable than exporters

2 Internationalization as key growth driver

In general, companies have two ways in which to grow: first of all, organically through market growth and market share gains over competitors, and secondly inorganically through acquisitions.

The average growth of around 10 percent p.a. (2010 to 2012) in German mechanical engineering tends to be organically driven. Especially, companies with more than EUR 50 million in revenue grow not only with the respective user markets, but also from market share gains: they were able to increase their global market share on average by 3 to 4 percentage points.

9 percent of smaller enterprises (less than EUR 100 million revenue) and 15 percent of medium-sized and larger enterprises (over EUR 100 million) are planning acquisitions to sustain technical revolutions, 17 percent and 23 percent respectively want to use this strategy to diversify their portfolio.⁴ In actual fact, however, with only 2 to 4 acquisitions in every 1,000 companies per year in German mechanical engineering, growth from acquisitions plays a similarly limited role as in other industries.⁵ The in-depth interviews show that many mechanical engineering companies are afraid of possible acquisition risks, such as cultural differences, or are unwilling to take on the complex task of integrating and leveraging synergies.

The study also shows that internationalization of existing business sectors has a greater effect on growth than diversification of the portfolio. Small enterprises with less than EUR 10 million revenue sell 50 percent of their products abroad, and enterprises with a revenue of EUR 10 to 50 million sell 57 percent abroad. Enterprises with over EUR 100 million revenue, however, on average sell 72 percent of their products abroad,

“Internationalization is by far our most important driver of growth.”

[Plastics and rubber machinery]

and for enterprises with revenues of over EUR 300 million, this figure is over 80 percent. Their growth, then, is primarily based on internationalization. In contrast, the share of revenue generated

by diversification – that is, outside the core business – is only 14 to 19 percent for all size categories – without any recognizable increase in growing companies.

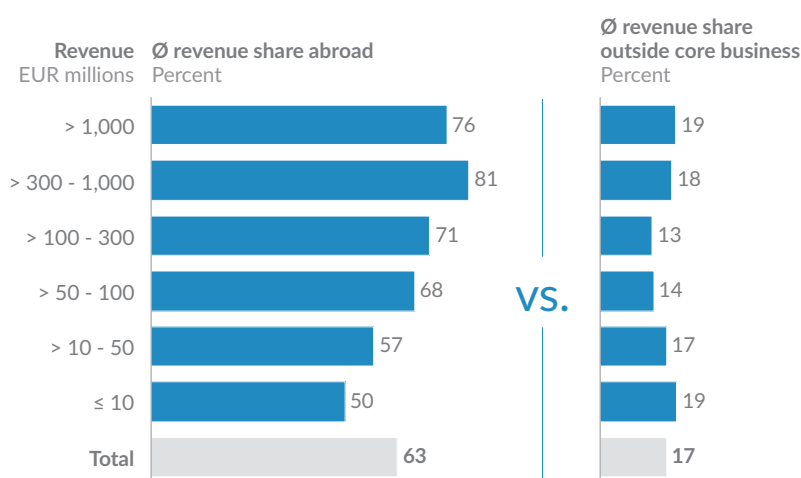
The in-depth interviews offer an explanation: the benefits realized by R&D expenditure and product-specific investment are achieved faster through international growth. At the same time, the risk of failure decreases: products that were sold successfully in the German market are generally also in demand in new markets – especially if mechanical engineers follow their global customers into new markets.

Internationalization is generally achieved via a typical growth path: from the local provider with primarily domestic production (30 percent of respondents) through to exporters with primarily international customers and predominantly local production (58 percent), up to global players with a worldwide production network (12 percent).

⁴ Individual major takeovers such as Jiangsu JinFangYuan by Trumpf (2013) can already be observed.

⁵ Combination of chemicals, automotive, aerospace, and energy industries.

Internationalization more important growth driver than diversification



SOURCE: VDMA-McKinsey Study 2014, "The future of German mechanical engineering"

EXHIBIT 5

Local players have an average revenue of approximately EUR 50 million and achieve profitability of approximately 6 percent. Close cooperation with suppliers and customers as well as access to skilled employees are important success drivers.

Exporters are larger on average (approximately EUR 400 million revenue). They take a share of international revenue potential without having to establish capital-intensive international production sites. However, owing to additional costs such as customs, logistics expenditure, margins for distributors, and disadvantages with regard to local cost structures, any size benefits are not reflected in profitability, which is on average around 6 percent, as with local players.

With revenues of over EUR 800 million, global players are on average far bigger than exporters. Although they grow less strongly (8 percent vs. around 10 percent for exporters and nearly 11 percent for local players), they have margins of up to 2 percentage points higher than local players and exporters. Their cost benefits are based primarily on international production. In particular, they benefit from their proximity to customers with lower logistics costs and stronger economies of scale thanks to higher local sales – in addition to the more cost-effective local wage and salary structures. Local purchasing combined with the willingness of local customers to pay more for shorter delivery times and local service also contributes toward better results. In addition, there are fewer

"We have not sold any low-cost machines in China for a long time now, but are instead successfully focusing on top quality."

[Textile machinery]

"outliers" among these companies in terms of profitability: compared to local players and exporters, the standard deviation of EBIT margin is more than one-third lower.

A consistent process organization and systematic project management are particularly important when it comes to offering customer-specific solutions. Whereas operationally excellent component providers are barely 1 percentage point more profitable, solution providers with operational excellence achieve well over 2 percentage points higher margins – in each case, compared to players with a need for operational improvement. Solution providers with a need for operational improvement also often have a lower standardization level.

4 Consistency in the business model indispensable

Companies that concentrate on their core business perform better in terms of profitability and growth. When core business comprises less than 40 percent of the gross revenue, companies achieve profitability of around 5 percent and sales growth of 7.5 percent, whereas companies that focus more on their core business achieve an EBIT margin of 6 to 7 percent, and grow by more than 10 percent p.a.

Companies focused on core business are on average 1 to 2 percentage points more profitable and grow by 3 to 4 percentage points faster

“Shoemaker, stick to your last.”

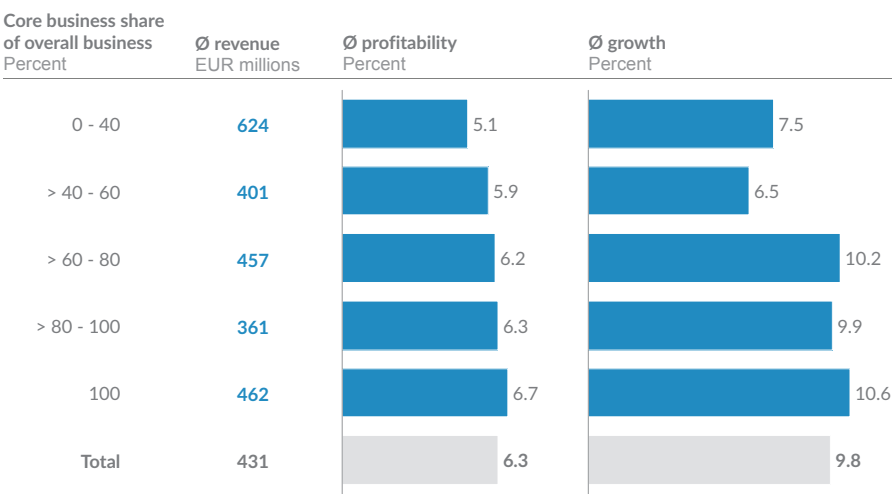
[Power transmission engineering]

The most important strategy is to firmly focus structures and processes on the core business – regardless of the respective type of business model. A rigorous approach can manifest itself in various dimensions: in the offer itself, but also in processes. Companies that focus on their core competencies can deliberately expand and refine them, and they can also bundle their innovative strength. This makes it easier to develop technologically leading offers.

Finally, focusing on core business allows cost benefits to be realized from modularization and standardization, and to achieve higher productivity. Concentrating on core business allows the steepest learning curve. Elements of products and offerings that are not part of the company's core competencies are outsourced to suppliers or manufactured as part of cooperation agreements. As such, growth is achieved more from integrating additional elements of the value chain rather than from products outside the area of core competency.

Rigorously focusing on the core business, however, also means establishing clear limits when accepting orders to be able to invest resources into the most promising projects. Numerous in-depth interviews show that undifferentiated order acceptance harbors the risk of partly investing resources inefficiently in incidental activities, which can lead to profitability losses. One example often given in the in-depth interviews is providers that develop from single machines and components toward the solutions business – with the associated problems if the solutions business is not managed as a separate business model with its own processes, resources, and skills.

Companies focused on core business more profitable and growing faster than diversified players



SOURCE: VDMA-McKinsey Study 2014, "The future of German mechanical engineering"

EXHIBIT 7

As of a certain company size, dedicated focus on core business becomes even more important: if the market is exhausted with the previous business field – even international markets – it can become necessary to realize growth opportunities by moving into new business fields. To ensure that the benefits of a focused core business are not lost, separate business models with specific structures and processes are advisable.

A stringent focus on core business, however, can lead to strong fluctuations in incoming orders, production, and revenue, particularly in volatile markets. According to the in-depth interviews, in order to stabilize the business, a second supporting leg – clearly delineated in the business model – is just as advisable as a solid aftersales/service business.

5 Innovation as a criterion for competitiveness

Innovation is a further prerequisite for success in German mechanical engineering. It often supports clear market positioning, and therefore differentiation among domestic and foreign competitors. This in turn allows a price premium and can lead to higher margins.

The in-depth interviews provide evidence of significant profitability and growth advantages for innovation leaders compared to late innovation followers: leading companies even from high-innovation industries report that, over time, only few of their competitors are able to keep pace. However, there are only marginal differences between innovation leaders and

early innovation followers: innovation leaders are only slightly more profitable and grow only marginally faster.

*"No future without innovation."
[Foundry machinery]*

Innovation makes for competitiveness: of the companies surveyed, 74 percent see themselves as innovation leaders and 23 percent as early innovation adopters

"It's very difficult in Germany for late innovation followers."

[Plastics and rubber machinery]

The advantages for innovation leaders and early innovation followers are mainly due to location factors. German innovations benefit from established innovation processes, e.g., between companies and research establishments, well-trained specialists, and a strong cooperation network. However, German companies that position themselves with low prices rather than innovative offerings face cost disadvantages compared to providers from new markets.

Innovation is not only found in products and technologies, but also in processes and applications – particularly in mechanical engineering. In the in-depth interviews, companies emphasize how important process innovations are in order to reduce costs, respond to customer requests faster, and increase quality. Furthermore, application innovations in a specialized field allow new customer groups to be targeted without the cost-intensive changing of the product. With the fourth industrial revolution ("Industrie 4.0"), the cost and revenue benefits for innovative leaders will show an increasing trend in this area.

Whether product, process, or application innovations dominate depends on the industry and specifics of the offering. The length of the product life cycle plays an important role: it ranges from less than 5 years, e.g., for manufacturers of electronic components for mechanical engineering, to more than 35 years. Companies with longer product life cycles are barely 1 percentage point more profitable than those with short cycles, but grow by 1 to 2 percentage points more slowly.

There are also different drivers for innovation – which determine where innovations are triggered in the value chain. For example, innovations in the automation of production are normally triggered by the user industry; other offerings change based on the new technologies. In well-established industries such as drive technology, the pressure of international competition often necessitates process and application innovations. In highly innovative, profitable, and fast-growing industries – such as Robotics + Automation – the benefit of innovative leadership is lowest owing to the high risk of failures. Innovation followers with well-established technology can be just as profitable and grow just as quickly in this area as innovation leaders.

Many innovations are currently still developed in Germany, the focus being on product innovations. However, some companies indicate they also have to respond to the increasing international dynamic of the markets with innovations abroad, and increasingly with innovations in processes and in the business model. In this regard, the value proposition, and the nature in which this value proposition is fulfilled, have to be challenged time and again.

"Process and business model innovations are just as important for us as product innovations."

[Food processing and packaging machinery]

6 Premium is more profitable only in combination with international operations

Where there is distinct internationalized value creation, premium leads to disproportionately high profitability

With 99 percent, nearly all companies surveyed regard themselves as premium providers or as operating in the medium price segment. Only around 1 percent operates in the low price segment. Of the 99 percent, 64 percent see themselves as purely premium providers, 22 percent as operating in the medium price segment, and 13 percent as operating both in the premium and medium price segments. Large enterprises with over EUR 300 million revenue are particularly well represented in the premium segment: 71 percent target the premium segment alone, while 20 percent target a mixture of the premium and the medium price segments.

Interestingly, premium providers grow faster than companies in the medium price segment but are on average only less than 1 percentage point more profitable.⁶ In the face of increasing competition, charging premium prices becomes more difficult. Although premium providers can generally charge a slight price surcharge, customers in turn expect additional services, e.g., particularly high quality, innovative solutions, customized solutions, short delivery times, or a broad service offering. The majority of the price surcharge compensates for these costs.

Clear profitability differences only become apparent once the degree of internationalization is used as the second dimension: with an EBIT margin of 6 percent, premium providers that manufacture almost exclusively in Germany barely fare better than providers in the medium price segment (almost 6 percent). Premium providers with a high proportion of overseas manufacturing on the other hand have an EBIT margin of almost 9 percent and

Premium with significant profitability advantage only in combination with international operations

Average profitability in percent

		Production share in Germany			
		> 75 - 100%	> 50 - 75%	≤ 50%	Ø
Provider type	Premium segment	6.1	6.5	8.7	6.5
	Both	6.0	7.1	7.3	6.6
	Medium price segment	5.8	5.8	6.6	5.9
		"Made in Germany"		"Made abroad"	
		Ø	6.0	6.5	7.8

SOURCE: VDMA-McKinsey Study 2014, "The future of German mechanical engineering"

EXHIBIT 8

⁶ There may be exceptions to these observed averages – the premium segment classification is based on the self-assessment by participants.

"Premium only works if you can standardize to a high degree and produce good quality economically."

[Power transmission engineering]

are clearly more profitable than providers in the medium price segment (below 7 percent). The bottom line: the surcharge levied for the "Made in Germany" badge is often not enough to absorb possible negative effects in the cost structure. If a premium provider is able to leverage more effective cost structures abroad, however, this permits a disproportionately high margin. It remains to be seen how sustainable this advantage will be in the face of new competitors in foreign markets.

7 Single machine/component business more profitable, but solution providers grow faster

While single machines and components are elements of larger machines and plants, providers of end-to-end solutions sell closed systems that are usually tailored individually to the customer. Providers of single machines and components are on average around 1 percentage point more profitable than providers of end-to-end solutions (7 percent vs. almost 6 percent), but grow around 3 percentage points more slowly (8 percent vs. 11 percent). When the degree of standardization is also taken into account, the gap becomes larger: providers of single machines and components that have a high degree of standardization are approximately 2 percentage points more profitable than providers of customized end-to-end solutions (more than 7 percent vs. 5 percent).

Providers of single machines and components are 1 to 2 percentage points more profitable than providers of customized solutions, but do not grow as fast

The higher profitability of single machine and component manufacturers with high standardization has several reasons:

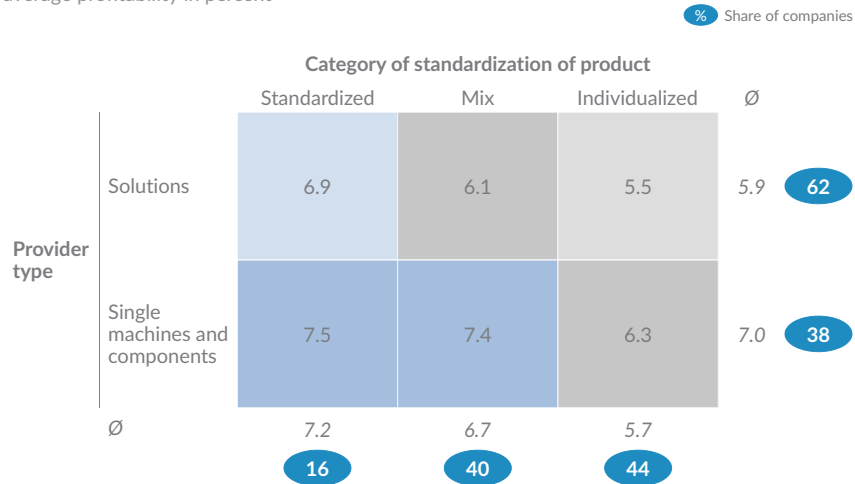
- **Economies of scale and efficiency benefits.** Standardized companies are almost 2 percentage points more profitable than customized providers. Economies of scale in R&D and efficiency benefits across the entire process chain have positive effects. Despite this potential, only 16 percent of companies surveyed standardize the majority or all of their manufacturing, and 40 percent focus on partly standardized and customized manufacturing. The remaining 44 percent are exclusively customized.
- **Structural differences in the business model.** It is easier for manufacturers of single machines and components to achieve a high standardization level than for solution providers – meaning savings in production and process costs. Change and request management is also easier for manufacturers of single machines and components. On the other hand, the very fact that standardization in the solutions business is associated with greater challenges can in fact represent a possible competitive advantage: in the solutions business, a high level of standardization allows an almost 2 percentage points increase in profitability compared to the average (almost 7 percent vs. slightly over 5 percent). For manufacturers of

"Focused standardization means we can earn more money."

[Air-handling technology]

Low standardization level overall – despite some profitability advantages

Distribution of companies across provider type and standardization category;
average profitability in percent



SOURCE: VDMA-McKinsey Study 2014, "The future of German mechanical engineering"

EXHIBIT 9

single machines and components, the profitability advantage is only 1 percentage point (a good 7 percent vs. slightly more than 6 percent).

- **Focus on core competencies.** It is easier for manufacturers of single machines and components to focus on their core competencies. Customers often expect solution providers to also offer components that are outside their core competencies, and to integrate these into the complete plant, or to fulfill specific demands and changes at no extra charge. The suitable technical components sometimes have to be sourced externally and integrated as part of a costly and complex process. This means liability and warranty risks. The challenges faced in project management and a sometimes inadequate requirements management structure mean that the costs from these risks are borne by the systems engineer.

In terms of growth potential, however, solution providers are ahead thanks to rapidly growing demand for customized system solutions. The demand for high-quality end-to-end solutions is increasing strongly, particularly in new markets. Providers of end-to-end solutions who cited China, India, and Brazil as their new prioritized target markets

"As a provider of end-to-end solutions, we lose most of our money when customers force us to add extras to our products that are not in our core competency."

[Air-handling technology]

in the survey grow by almost 11 percent p.a. compared to the corresponding single machine and component providers at only 6 percent. Customers in these countries can often source standardized single machines and components locally, whereas for their solution demands, they rely on the

traditionally strong mechanical engineering companies with well-known names. Despite the increasing demand, scaling the solutions business remains difficult:

- Customers too often demand their own specifications rather than standardized plants without paying a price premium for it. A contributory factor is that small to medium-sized enterprises in the German mechanical engineering industry often compete with large enterprises and their corresponding purchasing and negotiating power.
- The engineers required in the solutions business need to be well trained and highly skilled. The lack of engineers and specialists is particularly apparent here.
- Collapses in demand mean significant risks, particularly for solution providers with short delivery and lead times. High volatility can stump growth.

To strengthen their profitability, the most profitable solution providers modularize their offering and value chain: they standardize their portfolio and processes internally, but are still able to offer customers tailored solutions thanks to a sophisticated modularity.

8 Aftersales/service with growth potential

With a revenue share of 15 percent, the aftersales/service business plays only a minor role in German mechanical engineering compared to other industries.⁷ There are no major differences between providers of single machines and components (average 12 percent) and solution providers (16 percent). Also the size of the company does not influence the share. The aftersales/service share is only significantly higher for very large enterprises (more than EUR 1 billion revenue) in the solutions business with an average of 25 percent.

In many industries, aftersales/service is an opportunity to offset lower margins in traditional business. On average, however, a higher aftersales share does not necessarily mean higher overall profitability

It is even more surprising that companies with higher aftersales/service shares are not more profitable in this field despite the greater margins:⁸ both companies with an aftersales/service share of less than 10 percent and those with a share of more than 30 percent have an EBIT margin of on average 6.4 percent. Again, there are no substantial differences between single machine and component providers and solution providers or between smaller and larger enterprises.

Overall, a large majority of the industry sees aftersales/service purely as a sales argument. 88 percent of companies believe the segment has a strong or very strong influence on the purchase decision. However, it is seldom used as a separate business model: only 37 percent regard service as a stand-alone competitive instrument. The VDMA benchmarks⁹ show that most companies do not manage aftersales/services as a separate business: 28 percent

"For us, service is only a courtesy so that we can sell our highly profitable machines faster."
[Agricultural machinery]

do not distinguish it from their hardware business, while 22 percent only regard it as a cost center. Only 42 percent of companies manage aftersales/service as profit centers.

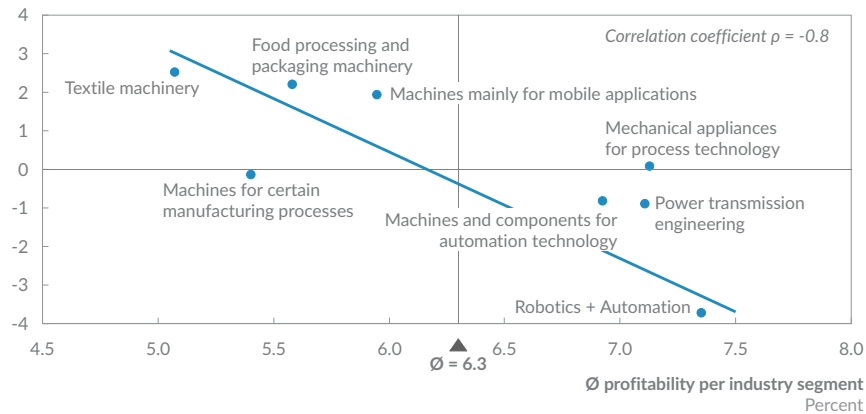
⁷ By comparison, see the VDMA-Kennzahlen BwZ 79 Kundenservice 2012, sample N = 158; these indicate a revenue share of 19.6 percent for aftersales/service in mechanical engineering.

⁸ VDMA-Kennzahlen BwZ 79 Kundendienst 2012, sample N = 99; the time series conducted by the VDMA shows that the contribution margin in the aftersales/service business rose from about 40 percent in 1999 to 47 percent in 2012.

⁹ VDMA-Kennzahlen BwZ 79 Kundendienst 2012, sample N = 167.

Industries with lower profitability from traditional businesses profit from higher shares of aftersales/service

Profitability difference between high and low share of aftersales/service¹
Percentage points



¹ The difference in profitability between companies per sector cluster with an aftersales share of greater than or less than 10% of revenue; for Food processing and packaging machinery, it is a difference of greater than or less than 20% of revenue

SOURCE: VDMA-McKinsey Study 2014, "The future of German mechanical engineering"

EXHIBIT 10

The result is surprising: it seems that aftersales/service is currently not regarded as a successful separate business model in German mechanical engineering. The 47 percent contribution margin of the aftersales/service business cited in the VDMA benchmarks¹⁰ indicates a yet almost untapped potential. To date, German mechanical engineering companies have tended to concentrate on classic aftersales/service models: the services offered by two-thirds of companies focus on the maintenance and repair of machines

already sold. As such, the most important offerings are spare parts, maintenance, customer training, and assembly, which are also seen to reflect the best growth perspectives. Only a few companies also optimize the operating costs of existing customers, e.g., by providing customer

"We aim to build machines with low maintenance requirements that run for 20 years and more – aftersales/service is therefore not a business model for us."
[Machine tools and manufacturing systems]

training and consultation. Almost no companies use the acquired customer data for continuous improvement of the offering, which could be translated into software offerings or operator models, for example.

The potential of aftersales/service depends on the industry: companies that are very profitable in their hardware sales – like Robotics + Automation – have free or inexpensive aftersales/service offerings in order to increase their product revenue. As such, a higher aftersales/service revenue share in these industries can even lead to a lower EBIT margin for the entire company of 1 to 4 percentage points. On the other hand, companies with lower profitability in the

"Innovating our entire business model to focus more on service has put us back on the track to success."

[Plastics and rubber machinery]

¹⁰ VDMA-Kennzahlen BwZ 79 Kundendienst 2012, sample N = 99.

hardware sales – such as textile machines – seem to have professionalized their aftersales/service more, and benefit from a high share and higher margins. A higher aftersales/service revenue share is associated with a 2 to 3 percentage points higher profitability in the overall business in these industries.

Owing to its generally high profitability, a stand-alone aftersales/service segment therefore has a stabilizing effect on volatile or declining hardware business. It can also help to promote

"A customer wanted a spare part for an 18-year-old machine as a goodwill gesture."

[Machine tools and manufacturing systems]

profitable hardware sales. In an ideal scenario, aftersales/service is used for both purposes. In the in-depth interviews, this was regarded as promising across all industries.

So despite all this, why is aftersales/service not established as a separate business model across the board? Apart from the expenses that are associated with setting up a profit center with its own organizational unit, the in-depth interviews revealed further reasons:

- Some customers are unwilling to pay for the service – partly because they do not see the added value and partly because aftersales/service (in particular, maintenance) are an integral part of hardware sales.
- In many companies there is a lack of infrastructure and qualification for the sales of aftersales/services. Two key challenges are keeping response times to a minimum and offering comprehensive service also in new markets. To install such a global network is very difficult, particularly for smaller companies.
- In new markets in particular, the machinery in operation is still young and customers do not always see the need for service offerings. In addition, some customers tend to refuse business models such as remote maintenance.
- Third-party suppliers for spare parts make things more difficult.
- Some user industries prefer their own maintenance and repairs – e.g., for cost reasons, to ensure quicker response, or to protect company secrets.

Chapter 4 discusses how the opportunities in the aftersales/service segment can be better utilized than previously, despite the difficult conditions.

9 Industry affiliation sets the pace

The average profitability of industries varies between 3 and 9 percent – profitable industries are more competition-intensive. However, a higher margin can be achieved with corresponding performance in every industry

Industries with high revenue growth tend to be more profitable: with growth rates of 11 to 14 percent p.a., profitability is highest (7 to 8 percent), with sales growth of 5 to 9 percent, profitability is lowest (5 to 6 percent). However, the profitability of an industry does not seem to be driven either by the growth of the user industry or by the company's own innovative strength. Also, profitability is not immediately linked to the traditional strength of German industries in a certain industry: the variance of industry-specific EBIT margins cannot be explained by the number of German companies that are active in the industry.

The differing profitability of the industries is related to the other success patterns. The industry determines the market opportunities that result from demand growth and the general price elasticity of the user industries (e.g., the degree of the market saturation and maturity). Where there is high cost pressure, this also drives the internationalization of operations. Some industries can build on technological developments or a good image, whereas for others, new technologies revolutionize the entire business model such as in Robotics + Automation. Regional or other specific market requirements such as the need for public tenders, regulations, and standards are further heterogeneous influencing factors, particularly for safety-relevant machines. Last but not least, the product features also play an important role: for example, more complex offerings require specially qualified engineers in Sales and during installation, which drives up costs.

"The condition of an industry has a strong (...) effect on own performance."

[Air-handling technology]

The particular characteristics of the market also affect the competitive landscape. Industries with several competitors are on average 2 to 3 percentage points more profitable than less competitive industries.

The in-depth interviews demonstrate possible reasons for this:

- **Market development.** Larger and recently developing profit pools attract more competitors into the market. Several competitors would be an indicator that many companies still see an opportunity to achieve above-average profitability. By contrast, companies exit the market faster in the case of less profitable industries.
- **Airbus-Boeing phenomenon.** In markets with few competitors, e.g., an oligopoly, there is typically a fight for market share and awards of large-scale projects that are driven by price. One of the most well-known examples is the competition between Airbus and Boeing: despite dominating the market, both use price deductions to fight for customers and have experienced comparably low profitability for years at 3 to 6 percent.
- **Competition invigorates the market.** More competition tends to mean that additional applications are found for existing technologies in new and highly profitable markets. If there are several competitors, companies prioritize the more worthwhile orders.

Companies also attempt to differentiate themselves, e.g., with service offers or innovative processes and applications. Competition also forces optimization, for example, of administrative costs in order to increase competitiveness.

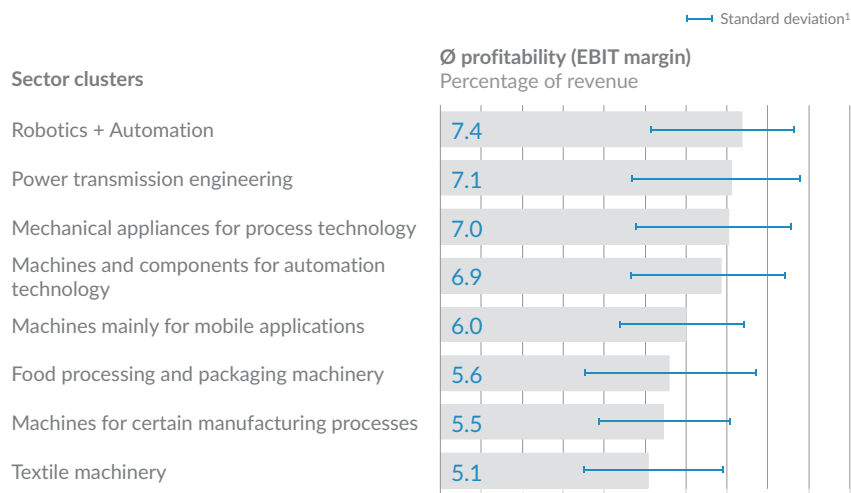
But there are exceptions: of course, a world market leader can still have above-average profitability in a specific segment even with a very small number of competitors.

"In a 100-meter race, you run faster if you have a lot of opponents."

[Power transmission engineering]

However, there is always the danger of new market entrants. A detailed observation of the market (e.g., the development of substitutes) and a fast response to changes can help maintain the lucrative position in the long term.

Industries differ in profitability, but high margins possible in all industries through top performance



¹ Standard deviation describes half the range scope by the average value within which around 68% of all values lie assuming standard distribution
SOURCE: VDMA-McKinsey Study 2014, "The future of German mechanical engineering"

EXHIBIT 11

Although the industry determines the pace, companies have some degree of flexibility when it comes to shaping their success regardless of industry affiliation. The highly variable profitability within the sector clusters shows that superior company performance is generally possible in every industry – regardless of the number of competitors.

10 Management structure determines strategy

Externally managed companies are slightly more profitable, while family-run companies grow faster

One in two mechanical engineering companies is family-run – either by the founder or a successor. Compared to companies that are managed by hired management, i.e., “externally managed,” family-run businesses exhibit growth that is around 1 percentage

“If we were a family-run business, we would have made different decisions in some situations.”

[Fluid power equipment]

point stronger. However, their margin is around 1 percentage point lower. Interestingly, there is no recognizable link between the management and the ownership structure. Around two-thirds of the companies surveyed are companies with limited liability – this

is equally valid for externally managed companies or those run by the founder or a successor; only some 20 percent are stock corporations and approximately 13 percent are partnerships. Stock corporations are around 1 percentage point more profitable than partnerships and companies with limited liability, but grow around 2 percentage points more slowly.

Externally managed companies focus more on medium- to short-term profits for two reasons: contracts for external managers often include short-term incentives and are designed for shorter periods; this makes the pressure to achieve quick profits seem higher.

“We see our investors as customers.”

[Robotics + Automation]

Family-run companies on the other hand grow faster because for many founders and their successors, the survival and expansion of their company is more

important to guarantee their future. That often means greater investment. The fact that externally managed companies are around twice as willing to consider acquisitions does not change much because the number of acquisitions in the mechanical engineering industry is low anyway.

Although neither one management structure nor the other shows clear benefits, the associated characteristics of each can influence the long-term strategic direction of a company. According to the in-depth interviews, many founders or successors have recognized the importance of an outside perspective for profitability and have therefore sought advice or external investors.

INDUSTRY TRENDS

DYNAMIC CHANGE OF COMPETITIVE CONDITIONS

The figures are clear: on the whole, German mechanical engineering is currently doing well. The in-depth interviews also reveal a generally self-confident reflection of this industry. But the underlying conditions are changing.





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				Libellen
				Übersicht

WKS	Position	Restweg	Motorspindel	S1
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			Vorgewähltes Werkzeug	30
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Red emergency stop button

Yellow start button

Function keys: +C+Z, -X+X, -Z-C

Rotary dials: 0-100, 0-100

Buttons: 0-9, 0.001, 0.01, 0.1, 1, 10, 100, 1000

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Buttons: R0, R1, R2, R3, R4, R5, R6, R7, R8, R9

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Buttons: H0, H1, H2, H3, H4, H5, H6, H7, H8, H9

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Buttons: B0, B1, B2, B3, B4, B5, B6, B7, B8, B9

Buttons: C0, C1, C2, C3, C4, C5, C6, C7, C8, C9

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During the study, the participating companies were asked which emerging industrial trends they felt were the most important, which were associated with risks and opportunities, and how they are preparing for these trends. 74 percent of all respondents see the rising demand for customized system/integration solutions as one of the top trends, closely followed by the shift of demand to countries outside Europe (70 percent). The increasing importance of aftersales/service (60 percent), the increasing competition from new market players (47 percent), and the increasingly important competitiveness of Germany as a place to do business (45 percent) were less in focus, but still highly relevant nevertheless. Trends such as stricter environmental requirements, increasing energy costs, volatile raw material costs, and a threatened shortage of engineers and specialists were less important. Overall, external changes are rated as being more important than internal challenges such as rising costs.

Customized system solutions and demand shifts are two of the top trends

Trend	Relevance Percent	Opportunity or risk?		How well prepared is your company for the trend?	
		Risk	Opportunity	Rather not	Rather well
a Increasing demand for customized system and integration solutions	74				
b Shift of demand to countries outside Europe	70				
c Increasing relevance of aftersales/service	60				
d Increased competition due to new market participants	47				
e Growing importance of the competitiveness of Germany as a location	45				
f Disruptive technology innovations revolutionizing products or production processes	41				
g Increasingly modular product development	37				
h Increasing environmental aspirations and requirements at both process and product levels	31				
i Shortage of engineers/skilled labor in Germany	29				
j Globally synchronized economic cycles	22				
k Rising energy costs in Germany (vs. other countries)	17				
l Rising and more volatile raw material costs	14				
m Increasing importance of trade policy and legal/regulatory framework	13				

SOURCE: VDMA-McKinsey Study 2014, "The future of German mechanical engineering"

EXHIBIT 12

Most companies see upcoming trends as opportunities and feel well prepared for them

Generally, German mechanical engineering is optimistic about the future, as the ranking of the trends shows. Trends that are perceived as opportunities have a higher relevance than those primarily associated with risk; the only exception is the trend "increasing competition from international market players." Even risks frequently discussed in the media such as a lack of skilled labor and rising energy costs only appear in the lower third of the list. On average, the companies also see themselves well prepared to deal with the most important trends: there is no trend for which the majority indicates they are badly prepared.

The five most important trends and their possible effect on profitability and growth in the industry are described in more detail below.

a Increasing demand for customized system and integration solutions

Companies see two key challenges associated with customized system solutions: establishing internal expertise (cited by 72 percent of companies that see this trend as one of the five most important) and close cooperation with the customer (68 percent). In view of the international direction of the industry and the heterogeneous customer requirements, these goals are a complex undertaking. According to the in-depth interviews, many companies have therefore focused on a small number of customers that they know well.

On the one hand, the further development of the offering in new markets contributes toward the increasing demand for customized system solutions. Since local providers

"Close cooperation with the customer even at the development stage is a central trend in German mechanical engineering."

[Security systems]

can increasingly manufacture products of lower complexity locally, the innovation and technology gap becomes even more of a positive differentiator of German companies. On the other hand, end customers in the user industries demand

increasingly specific and diverse product ranges, which requires special machines and therefore makes the ability of German mechanical engineers to specialize even more of a competitive advantage.

Over 77 percent of companies want to strongly or very strongly adjust their portfolio toward customized system solutions and cite three prerequisites:

- **Proactive customer dialog** to ensure joint development of new products. Involvement in product development now seems to be fairly common. In the in-depth interviews, managers state that such involvement should even be a firm part of standard processes – what is needed above all is a culture in which various departments, particularly Sales as well as R&D, work closely together from the outset.
- **Greater modularization of production to ensure** that profitability does not suffer as a result of customized solutions – standardization, focus, and operational excellence are imperative.
- **Stringent project management for customer orders** in which all key functions collaborate in a structured system. Amongst other things, this should prevent excessive development hours for integration activities and ensure an active requirements management including an engineering change management.

Growing demand for customized system solutions necessitates a further development of the offering

b Shift of demand to countries outside Europe

German mechanical engineering has long had an international customer base. Currently, some 40 percent of demand comes from Germany and Western Europe – but with clear differences between industries. Whereas around 53 percent of machines and components for automation technology are sold in Germany and Western Europe, the figure for textile machines is only 16 percent.

Increasing demand, particularly from China and North America expected – many companies therefore want to position themselves more internationally

In many international markets such as China and India, customers of German companies are increasingly demanding high-quality premium products combined with an excellent service network. The resulting internationalization of the value chain made necessary by this development represents a major challenge for many German mechanical engineers; however, it seems largely unavoidable in order to offer market-specific products, quick delivery times, and a reliable local service. Precise monitoring of interface costs and management costs is vital. Some enterprises have already followed this path and shifted development and production sites abroad. In some cases, over 95 percent of the workforce, including management, already comes from the respective countries.

“Our product portfolio is focused more on demand in Asia than in Germany.”

[Printing and paper equipment and supplies]

70 percent of companies surveyed assume that this trend will intensify, and the number of customers from countries outside Europe will increase. This is validated by external data:¹¹ in 2017, 43 percent of sales in the global mechanical engineering industry will be generated in BRIC¹² countries. It is currently only 39 percent, and in 2002 it was as low as 20 percent.

For 81 percent of the companies, China continues to be by far the most important market in terms of demand shift, followed by North America with 53 percent and Russia with 46 percent. India and Brazil follow with 40 and 35 percent. While the importance of China is clear with the growth of local user industries, the “reindustrialization” of North America can be regarded as a new phenomenon. Low energy costs and comparably low labor costs allow competitive production again.

In Brazil, the underlying macroeconomic conditions and high import duties prevent an even bigger market. Russia, on the other hand, is expected to open up more to foreign investors owing to the significant demand for modernization. However, as of spring 2014, political developments pose a risk here. In Africa, German mechanical engineers have already addressed the potential in some industries – despite the increasing prosperity and penetration of Chinese competitors.

Two in three companies surveyed intend to further internationalize large parts of their operations. About 70 percent state that they intend to internationalize the areas of purchasing, production, sales/marketing, and aftersales/service, whereas only 23 percent of the participants plan to internationalize R&D. At present, only 7 percent of R&D expenditure is invested abroad. The in-depth interviews identify various challenges related to shifting R&D functions abroad such as a lower education level, the lower quality of suppliers,

¹¹ IHS data, December 2013.

¹² Brazil, Russia, India, China.

"We have noticed that the US is recovering massively – the 'reindustrialization' is creating new jobs and increasing user demand."

[Plastics and rubber machinery]

the lack of security of intellectual property, challenges in communication (language, time difference, culture), and efficiency losses caused by several small R&D sites rather than one large site. Smaller and medium-sized enterprises in particular show an inherent

skepticism toward the underlying prerequisites of R&D locations outside Europe. Limited capital and expertise also makes it difficult for small companies to ensure high quality and to overcome cultural differences. Several companies, however – above all larger enterprises – stress that an internationally focused R&D function offers the possibility of improving market understanding, being closer to foreign customers, and not least leveraging local cost advantages.

c Increasing relevance of aftersales/service

At an industry average, the aftersales/service segment still has little impact on profitability, even though there are substantial differences between the industries (see above). The companies cite insufficient resources as substantial obstacles – manifested in long response times (81 percent), lack of expertise in sales of services (53 percent), insufficient availability of spare parts (44 percent), and an insufficiently established sales/service network (42 percent).

At the same time, nearly two-thirds of the companies surveyed work on the assumption that the aftersales/service segment will grow in importance. Aftersales/service could also help to level the increasing revenue volatility by synchronizing economic cycles – particularly in the growing solutions business.

Aftersales/service will become more important, but presents many companies with challenges

Although the expansion of the aftersales/service segment is a high priority in German mechanical engineering, not all companies appear to have found the optimum strategy yet. Companies have responded very differently: 70 percent want to expand their

"Expanding our aftersales/service activities is the top priority for us."

[Air-handling technology]

sales network in the next three to five years, 69 percent want to increase the qualifications of their service employees, and 68 percent want to expand their service offerings. Another 48 percent

want to optimize their spare parts logistics – e.g., by introducing local hubs to increase availability. 34 percent plan to introduce online services to increase their accessibility. In the face of this wide range of challenges, many companies are wondering how this industrial trend can be leveraged profitably.

d Increased competition due to new market participants

Between 1995 and 2012, the share of locally produced machines and plants in Germany fell from 59 percent of total sales to 51 percent.¹³ With 71 percent, most imports came from Europe, e.g., Italy (10 percent) and France (8 percent). Imports from China, Japan, and the USA amounted to 7 percent each. The increase in imports is related to a long-term declining price level: at approximately 1 to 2 percent p.a., the price rise for machines in the past 15 years has been below the rate of inflation of around 2 to 3 percent p.a.¹⁴

Global competition will in future increase even in specialized industries

Almost one in two companies expects global competition, and therefore competition in Germany, to increase as a result of new market players – not only mechanical engineers, but also suppliers. Previous trends appear to confirm this: imported goods to Germany from China rose by over 17 percent p.a. from 1995 to 2012 and by 12 percent from the Czech Republic. On the other hand, imported goods from other European markets rose only by 3 to 5 percent p.a.¹⁵ 81 percent of companies surveyed expect prices to fall further. 45 percent expect declining market shares, particularly in industries with lower entry barriers or pronounced international sales such as food processing and packaging machines. However, 38 percent of companies believe that the rising competition will mean increased dynamics in innovation.

“China has long been able to build highly complex and high-quality machinery.”

[Printing and paper equipment and supplies]

The in-depth interviews show that foreign competitors are increasingly positioning themselves in the market with high-quality products. This means they are now also targeting specialized industries that were traditionally dominated by German mechanical engineering.

To counter this risk, companies appear to be prioritizing sales and service measures as opposed to product measures: 81 percent would like to strengthen their service offering, and 64 percent are planning to invest more in sales and marketing. By contrast, only 53 percent want to broaden their product portfolio with self-developed products and reduce costs through process innovation and by avoiding overcapacities.

e Growing importance of the competitiveness of Germany as a location

The badge “Made in Germany” promises quality, innovation, and reliability. German mechanical engineering companies benefit from systematic advantages based on a

¹³ VDMA calculations based on “Statistisches Handbuch für den Maschinenbau,” edition 1999 and 2013, p. 43 respectively, VDMA Verlag.

¹⁴ Federal Statistical Office (Index of Producer Prices for Industrial Products, WZ08-28, 1995 - 2013).

¹⁵ VDMA list for leading import countries (2013) was applied to data from the Federal Statistical Office for the overall machine sector (GP 2009 - 2028).

combination of good reputation, established value chains, strong legal security, good infrastructure (e.g., qualified personnel), as well as established innovation networks and clusters. In the more well-developed industries, the low national intensity of competition and high domestic demand have a positive effect. However, 90 percent of the surveyed companies see the comparably high tax burden and the above-average location costs such as energy costs as a challenge. 84 percent also cite the high wage and salary levels as a negative factor. The price increase justified by the “Made in Germany” badge is largely consumed by these effects.

Almost one in two companies believes that both the advantages and disadvantages of Germany as a location will affect the profitability and growth of mechanical engineers

“The expertise and quality of employees in Germany are more important than the disadvantages associated with production costs.”

[Air-handling technology]

even more in future. Energy costs are expected to rise further as a result of the turnaround in energy policy, which will clearly increase location costs particularly for energy-intensive industries. Despite this, only 19 percent of companies are planning to shift production locations abroad. In addition to the proximity to German customers, reasons

for staying include the risks associated with a relocation, e.g., managing processes and recruiting well-qualified experts and managers. Instead, companies are planning to intensify the level of automation of production, process innovations, and integrated solutions, namely “Industrie 4.0,” in order to remain competitive globally even while based in Germany.

In the face of increasing competition, it will become even more important for German mechanical engineers to fully leverage the benefits of Germany as a location. This applies above all to German innovative strength, e.g., establishing further innovation networks could provide the stimulus for further growth.

The location advantages of Germany will become even more important to safeguard the competitive edge

Further trends

In terms of the less frequently cited industry trends, the companies see the following changes occurring.

- **A revolution in product and production processes triggered by technological innovation** is seen as a top trend by 41 percent of companies. Most regard product and process innovations as equally relevant. They plan to counter this trend primarily by expanding their R&D departments, networking with core customers, and observing the market more closely. The most important topics are progressive materials with superior characteristics, human-machine interaction, as well as “Industrie 4.0” and extensive digitization.
- **Modular product development** is regarded as highly relevant by 37 percent of companies. The vast majority of them wants to follow this strategy to lower costs, to better meet customer requirements, and simplify development processes. Possible approaches include expanding the product range, standardizing production processes, and closer integration of suppliers and customers.

- **Increasing environmental requirements** are seen as among the most important changes by 31 percent of companies. For many companies, this affects both products and processes. At the same time, most of those companies surveyed also see the increasing requirements as an opportunity to differentiate or to improve their image, focusing mainly on changes to product design, energy consumption, and production.
- **A shortage of engineers and specialists** is seen as a top trend by only 29 percent despite demographic change. Most companies expect higher recruiting costs in Germany and see the shortage as a hindrance to growth. In terms of international competition, most companies believe this change will cause problems in managing export operations and foreign locations. The most important measures are further training, university marketing, and the use of online recruitment.
- **Increasingly synchronized global economic cycles** are seen as particularly relevant by 22 percent. Effects include the decreasing reliability of forecasts and budgets and need to adapt production capacities. Most companies cite diversification and more flexible organization of production as countermeasures.
- **The rising energy costs in Germany in international comparisons** are regarded as significant and as a risk for 17 percent of those surveyed. Suppliers and customers are also strongly affected by this. Optimizing energy consumption in production processes is regarded as the primary method to improve.
- **The rising/volatile costs of raw materials and other materials** are seen as highly relevant by 14 percent of companies. Around half of these companies see both cost increases and increasing volatility as major challenges. Countermeasures include more efficient production, optimization of material costs even in the development stage, and the reduction of purchasing costs.
- **Political and legal frameworks** play an ever more important role for 13 percent of companies. Above all, they cite import duties as the most important influencing factor, followed by demands for minimum shares of local creation and bureaucratic hurdles.

FIELDS OF ACTION

LAY THE TRACKS FOR FURTHER SUCCESS

By following a course of continuous improvement in recent decades, German mechanical engineering has established a strong position: it is profitable, growing – not least thanks to the recovery effects following the financial and economic crisis – and has an excellent reputation. Most companies, particularly the most profitable, see the emerging industry trends as positive and feel well prepared for them.





The current strong position means future challenges could be underestimated

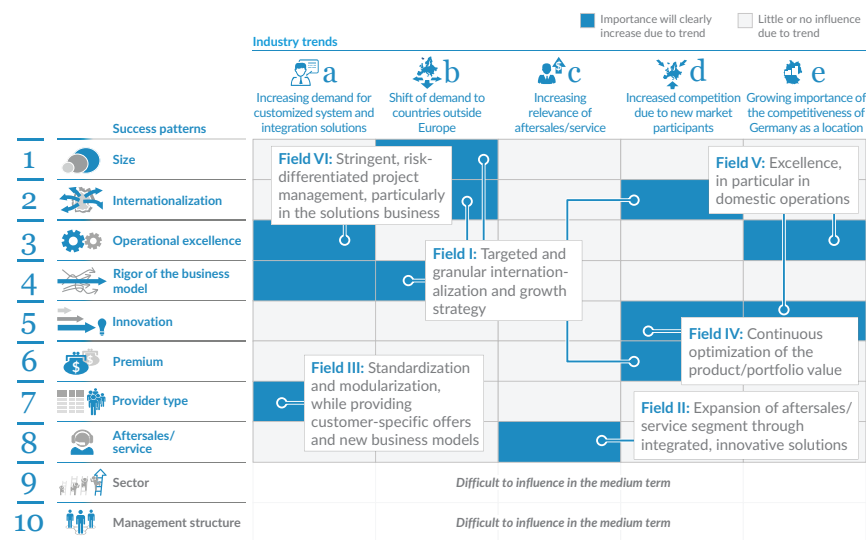
However, ensuring future competitiveness must not be taken for granted. Today's strong position means that emerging challenges could be underestimated. The survey offers some indications: although aftersales/service is an important topic for 60 percent of companies surveyed, only a few companies have so far succeeded in leveraging the profitability opportunities presented by it. A higher revenue share of this segment does not go hand in hand with higher overall profitability. To take another example: the perceived premium position of German mechanical engineers is hardly reflected in higher EBIT margins. The competition from low-cost providers from new markets is increasing. Not only this, but 74 percent of the companies see the increasing demand for customized solutions as a top trend – however, challenges in project management in particular continue to squeeze the profitability of many solution providers.

The success patterns and trends reveal six central fields of action

It is clear that opportunities are not being translated into growth and profitability in all cases. Today's success patterns are not identical with those of tomorrow in every case – the emerging industry trends influence their importance for the market. Superimposing the success patterns over the industry trends reveals six central fields of action for mechanical engineering – the priorities may vary depending on the company and its strategic direction.

The details of these six fields of action and how they can be implemented will be described below. These ideas serve primarily to offer some initial food for thought.

The top trends influence the importance of the 10 success patterns and reveal important fields of action



SOURCE: VDMA-McKinsey Study 2014, "The future of German mechanical engineering"

Potential impact of fields of action on the profit and loss (P&L) statement of a mechanical engineering company

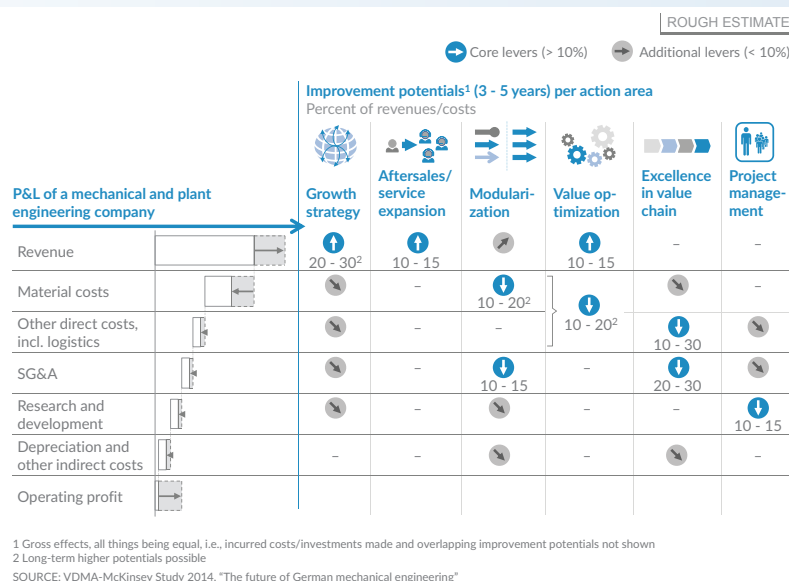


EXHIBIT 14

I Targeted and granular internationalization and growth strategy

Internationalization is one of the main sources of growth potential (see Chapter 2). In the course of gradual internationalization, companies are faced with three central tasks: prioritization of the expansion markets, employing the optimum market penetration strategy, and adapting the global value chain to local requirements.

Gradual internationalization. To become a successful international enterprise, gradual development that depends on the company size and significance of the market is recommended. At a simplified level, international markets are penetrated in six stages: following the first stage of pure exports, the second step involves supporting sales representatives or resellers. To strengthen the respective markets, sales and service offices are established in the third step. With local assembly shops, proximity to the customer can then be improved in the fourth step, and tariff and non-tariff trade barriers can be avoided. Subsequently, production is established locally, and development follows in the final step. This is how proximity to the customer can be further increased with market-specific products. But how should companies proceed in detail, and which markets offer the greatest potential?

Prioritization of expansion markets. Growth options are often realized selectively. Often, the crucial element is not the market in which the largest growth potential can be leveraged or where the best return on investment can be gained, but, for example, what

Internationalization is gradual and follows systematic market selection

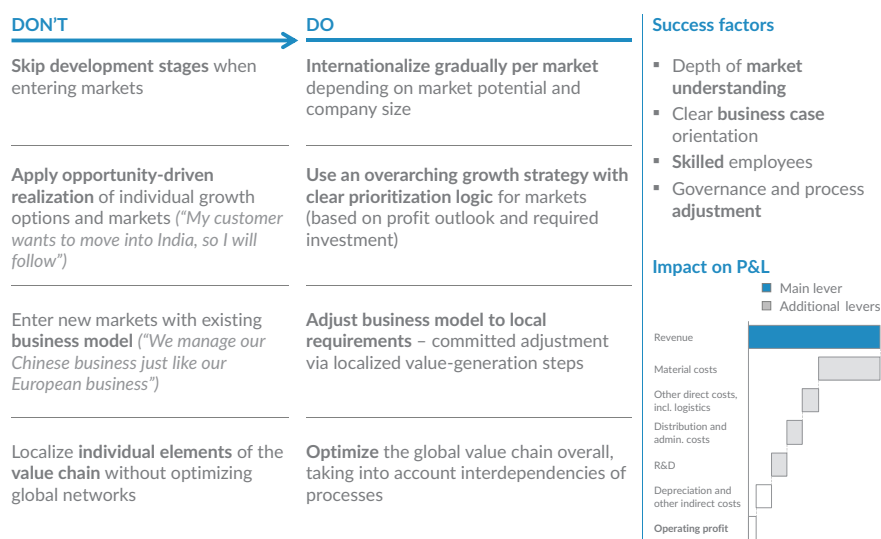
competitors are doing, what global customers demand, or where the company – sometimes by chance – has found a good marketing partner. Ideally, however, internationalization should be an integral component of a targeted growth strategy, which first selects the markets and then the entry strategy.

Archetype “international player”¹⁶

The most successful international companies are characterized by the following:

- They have a broad product portfolio that allows them to better meet international demand, enabling them to target a broader customer base. However, this also means a more competitive environment.
- They tend to have smaller customers, which improves their negotiating position. This includes more favorable contract conditions and lower contractual penalties, e.g., governing late deliveries. These benefits are relative, however, because the delivery reliability of these companies is generally high anyway, and there are few customer complaints.
- Successful component providers benefit from the fact that they can also market and sell their products without extensive customer-specific process knowledge, which means they require fewer international employees.

Targeted and granular internationalization and growth strategy



SOURCE: VDMA-McKinsey Study 2014, “The future of German mechanical engineering”

EXHIBIT 15

¹⁶ In a sample of companies with over 50 percent international sales, the study investigated how structural and economic parameters differ between very profitable and unprofitable companies.

To facilitate this, the markets should be split into various groups. The most important criteria are the importance of the market (expected share of the local revenue or profits) and the extent of the entry barriers (e.g., necessary investments in local production, technological product adjustments, or a local sales/service network). Qualitative aspects such as legal framework conditions, trade barriers, and political stability also play a role. An appropriate market penetration strategy is then developed for each group. The strategy is implemented in waves so that the acquired know-how can be transferred to the next market in each case.

Optimum market penetration. The in-depth interviews show that in some cases the entry strategy into new markets is not rigorous or differentiated enough. Ideally, the company will define which stage of the gradual internationalization should be achieved in the target scenario for each of the initially defined country groups.

For small and medium-sized enterprises, the focus will first be on the establishment of sales and service branches. There needs to be a clear distribution of responsibilities between the headquarters, sales representatives/resellers, and sales/service branches: Who assumes the coordination of advertising measures and trade exhibition activities? Which service activities should be provided by the sales partners? Close management and support by the head office are crucial.

Larger companies must first decide which parts of their operations should be run locally based on price and cost structures: How is demand distributed across the premium, medium-price, and low-price segments? Under which cost structures do local companies operate? How developed is the local value chain of other international players? Which regulatory provisions must be observed? The optimum business model can then be determined depending on the market.

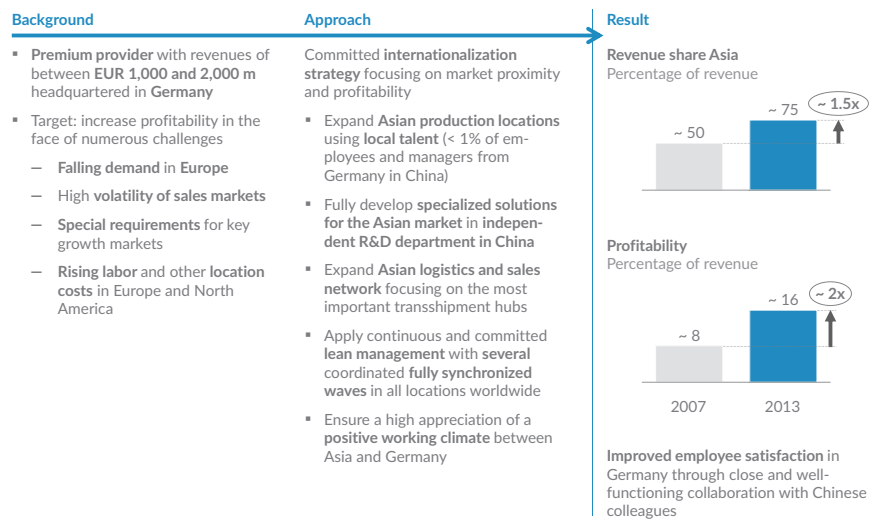
For Western Europe, for example – where the premium- and medium-price segments account for a high share of offerings, and with average cost structures and low import restrictions – an export strategy that focuses solely on investment in local sales and service networks is probably recommendable. In large markets such as Russia and Brazil with different price, quality, and product requirements than Europe and a high level of regulatory hurdles, it makes sense to localize purchasing, production, and ancillary functions. The in-depth interviews show that the sale of machines and plants that are successful in Europe – even those that have been technically adapted – only captures potential in part in new markets like China and India. As such, the market size and customer requirements possibly also justify localizing development in order to offer cost-effective products suitable for the market.

Many companies fear that a simultaneous offering in the low-price segment could damage their image. Some companies already mitigate such risks by adopting a multibrand strategy. They use their traditional name in Germany and other premium markets, and use the secondary brand for new markets. This allows the different business models to be clearly separated in the eyes of customers. However, this strategy also poses a risk of market cannibalization and is therefore not without its critics.

Market penetration and business model selected based on company and market characteristics

International market penetration may be facilitated through the acquisition of a suitable local provider. This does not necessarily have to be a mechanical engineer – even the acquisition of a reseller or a service provider could help accelerate the establishment of international sales and customer structures. However, there are also risks with this strategy: due to cultural differences, integrating the acquisition target is not always simple.

Case study: a premium provider doubled its EBIT margin by increasing proximity to Asian markets and implementing lean management



SOURCE: VDMA-McKinsey Study 2014, "The future of German mechanical engineering"

EXHIBIT 16

Adjustment of the global value chain to local requirements. If the growth strategy aims to penetrate several markets, possible synergies should be checked. Approaches may include the development of globally deployable platforms/modules, a more globalized purchasing strategy, or the bundling of production for individual regions – e.g., in China also for ASEAN, in Mexico for South and North America, in Eastern Europe also for Russia.

II Expansion of aftersales/service segment through integrated, innovative solutions

The aftersales/service segment offers attractive growth potential. This can be further leveraged if the offering is systematically communicated and tailored to customer requirements, thereby generating demand, adapted to product properties and company skill sets, and if the necessary resources are provided.

Archetype “aftersales player”

The companies with an above-average aftersales/service share include some that are particularly profitable. They have the following characteristics:

- Company size – with several locations, a certain network density is ensured through natural means.
- Production with a slightly more international focus that allows duty costs and delivery costs as well as delivery times to be reduced.
- A trend toward smaller customers with a high interest in services.
- Fewer customer complaints, which suggests a high service quality as well as a close relationship with the customer and a strong customer focus, e.g., with proactive preventive maintenance offers.

To professionalize the aftersales/service segment, a systematic approach is useful; medium-sized businesses in particular can increase revenue and profitability in this way.

Customized, modular offering. The first thing that is needed is a clear understanding of customer needs. Criteria for successful customer segmentation may include, for example, the relevance of machine reliability (e.g., costs if a machine fails, safety risks), value of the machines, complexity of the offer, and size and global presence of the customer. Whether the customer is a basic customer or a premium customer can also play a role. The requirements of the aftersales/service offering can be derived based on these criteria, e.g., international availability, fast response times, a competitive price, or a high-quality offering. While aspects such as supply guarantees may be particularly important in one segment, customers in other segments may value operator trainings or a worldwide service available 24/7. Taking these considerations into account means that a suitable service package can be put together for each customer segment. However, the survey and the in-depth interviews show that the aftersales/service business is still very narrow in most cases – focusing on spare parts, repair, and maintenance. If it does not already exist, a business model with clear objectives, responsibilities, and processes should first also be established for these products.

A tailored, modular aftersales/service model with transparent pricing is important

Expansion of aftersales/service segment through integrated, innovative solutions

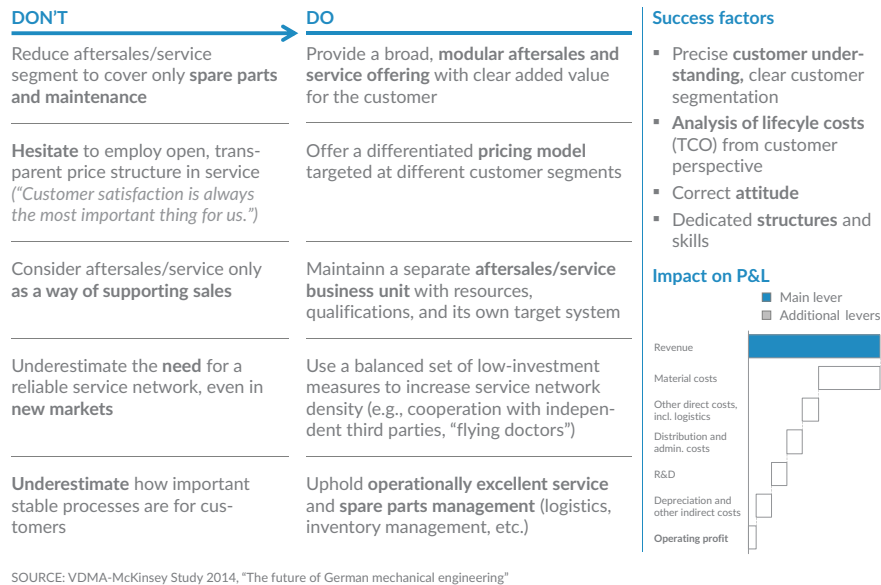


EXHIBIT 17

There is further potential in more comprehensive aftersales/service models that optimize the yield of a machine or plant for the customer over its lifetime, e.g., by reducing downtimes or maintenance costs. By deploying software and analyzing machine/plant data, the product value for the user can be increased – an aftersales/service segment that will continue to grow in importance, particularly in relation to "Industrie 4.0." The in-depth interviews showed that many customers are still very skeptical about concepts such as remote maintenance in which machine data is accessed remotely. To tap this market potential, customer trust must be established in the medium and long term.

Customers' benefit. In some German mechanical engineering companies, aftersales/service is a part of hardware sales. However, a successful aftersales/service business requires attractive offerings based on customer needs. Clearly communicating its customer benefit increases the probability of success. For example, the lifecycle costs of a machine or component can be a powerful argument, as these costs can be optimized through targeted service measures. Certain customer groups might also be reached through alternative business models like performance-related remuneration, subscriptions, or operator models.

Resources/organization. In many companies, the aftersales/service segment is contained within Sales and is often not considered as a separate entity. The aftersales/service potential can be harvested by professionalizing respective processes. Professionalizing the segment requires corresponding organizational reinforcement: trained specialists are required (who have not just been trained in the technology, but also in communication skills), separate processes, and a separate target and KPI cockpit that focuses, for example, on customer orientation (e.g., service availability, delivery reliability), operational performance (e.g., extent of utilization, safety, stock turnover speed), and financial results (e.g., gross margin, administration costs), and which offers incentives for employees.

A close coordination between the hardware sales and aftersales/service offers is crucial. Ideally, an aftersales/service agreement should be offered automatically with each hardware sale. In turn, aftersales/service employees should identify further potential leads for hardware sales with existing customers.

As the face of the company, the service employee plays a key role in the brand message and can strengthen customer loyalty. Regular contact with the customer is crucial, not just at a marketing level. Service employees can also gain contact to decision makers outside purchasing, who can advocate additional business. At the same time, the service employee is an important source of information for sales, product development, and service management.

Service network density and cooperations. For many mechanical engineers, the success in aftersales/service can be sustained by establishing the prerequisites that are still lacking internally for an attractive service offering. This includes developing an international network, for example, which represents a major challenge for smaller companies in particular. These companies need to determine how and to what extent the service requirements can be covered – including international markets – with as minimal cost and investment as possible. In the models specified in the in-depth interviews, service partnerships with other mechanical engineers, cooperations with specialized service providers, or mobile service stations (“flying doctors”) should be established in addition to the resellers and sales representatives. It should be noted that international customers will expect service offers that they are familiar with from one market in other markets, too. The systematic selection and further development of partners based on the internationalization and growth strategy is the basis for successful cooperation.

Separate internal structures, a sufficient service network, and systematic spare parts management are the key to success

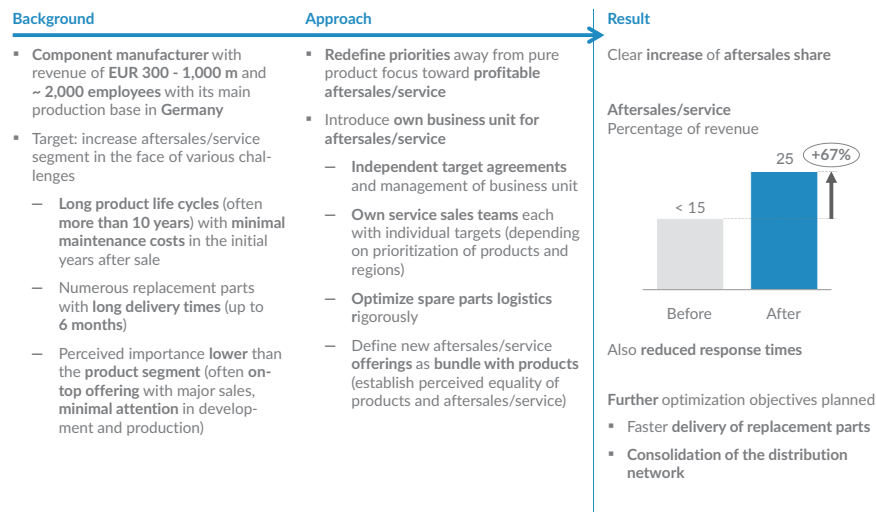
Spare parts management. Long-term high levels of customer satisfaction require trouble-free spare parts management – no small task, particularly for smaller and for highly internationalized companies. Many companies already categorize spare parts based on volume and predictability of demand: high-volume parts with predictable demand are fed into regular production and continuously dispatched. The aim is to minimize stock on hand. A similar process is followed for low-volume parts with good predictability. Minimum stocks are held in the warehouse for low-volume parts that are difficult to predict, while high-value parts are created on demand (assemble-to-order). Furthermore, with a higher number of identical parts, product modularization can be a contributing factor in increasing volumes and stabilizing sales. An alternative is to outsource those parts from outside the company’s core competency to specialized providers, who oversee the supply of spare parts in the name of the company. In future, 3D printing may also play a role.

Gray markets and third-party providers in the spare parts business in particular is not an insurmountable problem. Constructive solutions or the destandardization of strategic parts are possible answers.¹⁷ Offering cheaper spare parts under a second brand name is also feasible:¹⁸ in some in-depth interviews, for example, establishing a premium and low-cost sales operation in parallel was cited as a possible means of serving all customers while clearly differentiating the premium benefits from the basic offering.

¹⁷ In this case, destandardization means the targeted move away from industry standards, but without contravening the internal standardization/modularization strategy (see following chapter).

¹⁸ For the challenges relating to a multibrand strategy, see “Targeted internationalization and growth strategy.”

Case study: a component manufacturer was able to increase its aftersales/service segment to a revenue share of 25%



SOURCE: VDMA-McKinsey Study 2014, "The future of German mechanical engineering"

EXHIBIT 18

3D printing

3D printing is an additive manufacturing technique that creates objects based on digital models by applying material layer by layer. Plastic, metal, ceramics, glass, and paper may be used and sometimes combined. In some cases, even moving connected parts such as hinges and mesh webs can be manufactured in a single printing order. 3D printing therefore allows the production of components with new characteristics and shapes, a high degree of individualization, and faster production of prototypes, tools, and spare parts. As a result, manufacturing methods can be simplified, warehouse stocks reduced, and dispatch costs saved.

III Standardization and modularization, while providing customer-specific offers and new business models

The aim of standardization and modularization is a less complex portfolio with lower variance and cost levels, while retaining the breadth and individuality of the offer. The number of identical components and parts is increased, modularization is applied across the entire value chain, and standard packages are developed with individually priced variants.

Archetype “successful standardizer”

Successful companies with a high level of standardization are characterized by the following:

- Above-average size, which allows a standardization strategy to be translated into greater profitability faster
- Higher revenue growth, which can be supported by a standardized/modularized offering or which necessitates standardization/modularization; also encouraged by a presence in fast-growing markets
- Higher R&D quotas, offering an additional competitive advantage thanks to high-frequency and targeted process and product innovations.

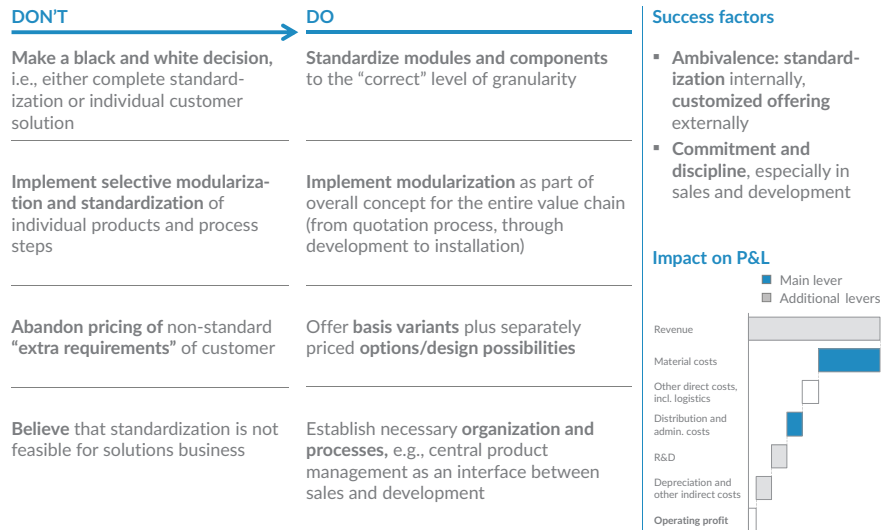
Providers of single machines and components are particularly successful in this respect – thanks to the lower complexity in modularizing individual parts and their greater economies of scale.

However, an individually tailored modularization strategy can help any company, as the following chapter shows.

As confirmed by the in-depth interviews, standardization and modularization do not preclude customized offerings. This means benefits can be achieved even in low-volume mechanical engineering – even or especially when demand for customized system solutions increases. There are four success factors:

Right level of standardization. The decision for or against standardization does not have to be made across the board for the entire portfolio. It is better to choose the suitable standardization level for each component, which strikes the optimum balance between cost-saving standardization and flexibility for customers. This can be achieved using a platform strategy: offerings with a large number of identical parts form a “platform,” which allows individual design of the product despite the extensive standardization. The benefit of this is that the common parts – whether used for solutions, single machines, or components – generate synergies in purchasing, production, development, and in tool use. Product quality and response times also improve.

Standardization and modularization, while providing customer-specific offers and new business models



SOURCE: VDMA-McKinsey Study 2014, "The future of German mechanical engineering"

EXHIBIT 19

A manufacturer of warehousing technology deliberately defines a technology platform for industrialized countries and a platform for BRIC countries. Both differ significantly in the architectural concept and the selected technical solutions. While the company was only able to achieve around 20 percent identical parts between the platforms, the products are planned together within one platform and therefore achieve identical part rates of up to 80 percent.

Standardization is defined at module level, and applied throughout the value chain

A module structure should also be defined with a suitable level of standardization so that individual modules can be frequently reused regardless of machine or plant. As such, they apply to individual, differentiated components or systems within a machine or plant.

An industrial machine manufacturer follows a common strategy for operating panels across all product lines; instead of the more than 20 previous variants, there are now 5 standard panels with a uniform operating concept. The standard panels have the same LCD display and operate with a common, parameterized software. Similar approaches are conceivable, e.g., for machine-to-machine communication in the context of "Industrie 4.0."

Holistic concept across the entire value chain. Often, only individual pilot offerings or process steps are standardized. However, the modularization only realizes the full cost effect of these steps when implemented across the entire value chain. The number of customized variants that can be manufactured within a reasonable budget is reduced to the same extent as their development time and sales process requirements. Development benefits from shorter cycles and greater reliability as a result of learning curve effects

on the platform. In addition, cross-function modularization allows economies of scale in purchasing, simplified production, lower warehouse stocks, increased quality, and faster service processes.

A provider of technical equipment for oil and gas production has standardized dimensions and specifications for certain modules in such a way that body modules can be premanufactured to a larger scale. The customized design is performed only in the final steps of the value chain. This allows far more homogeneous utilization and better planning for large parts of the value generation process.

Pricing approach for nonstandardized solutions. Companies often feel impelled to accept all solution and change requests of their customers. This leads to a large number of variants, which means substantial developing costs in manufacturing. The resulting profitability losses can be stemmed using standard modules: most individual variants can be offered with minimal additional developing costs by standardizing interfaces. The cost of further modules and options are then more transparent. Such a system has no disadvantages for the user: the basic offer is tried and tested, the prices are more transparent, and the basic price is also lower because companies do not have to calculate risk premiums for expected amendments.

By following this strategy, a manufacturer of transport equipment was able to revise its product list and transparently invoice for customized special requirements. Owing to a lack of a defined standard, it previously had to tacitly accept customer requests as part of the normal order process. Thanks to the increased transparency, customized engineering costs fell by 20 percent.

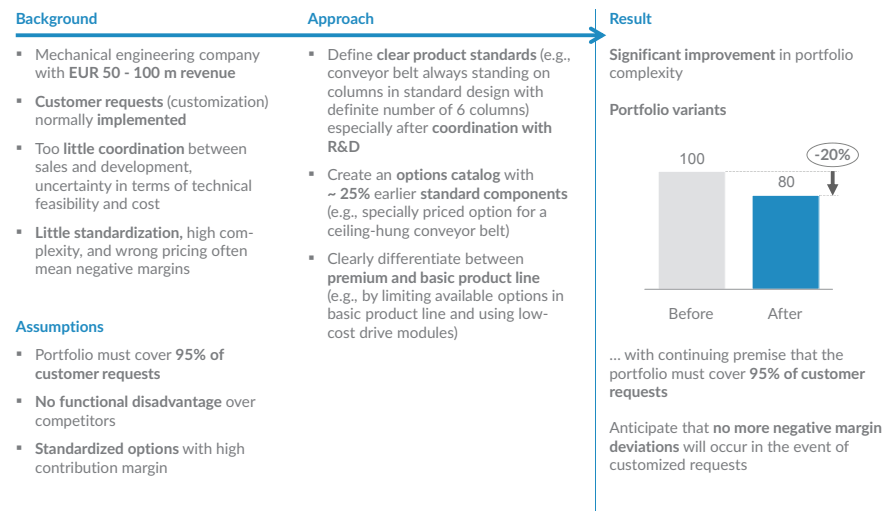
Structures and processes. Standardization supports a customer-focused organizational culture – if it is institutionalized. With new positions such as Module or Platform Leads, organic structures are established that offer the necessary incentives to both reduce costs while also focusing equally on individual customer requests. It is important to anchor this philosophy firmly in all processes and in project management. With the right training, Sales can highlight the strong customer orientation in its communications with customers. Internally, processes for orders that are generated within the platform should be differentiated from those that require additional engineering effort.

A modular offering prices "extra requirements" of the customer transparently and fairly

Case studies show: the rigorous implementation of such a standardization strategy¹⁹ can reduce lead times by up to 70 percent, lower the number of nonidentical parts by up to 75 percent or more, and thereby lower project costs by up to more than 35 percent; material costs alone fall by 6 to 7 percent. Reduced assembly times, lower stock of incomplete products, and shorter development times are further positive effects of this strategy.

19 Anonymized McKinsey case studies from 2011 to 2013.

Case study: the number of variants could be reduced with similar customer benefit by standardizing the portfolio



SOURCE: VDMA-McKinsey Study 2014, "The future of German mechanical engineering"

ABBILDUNG 20

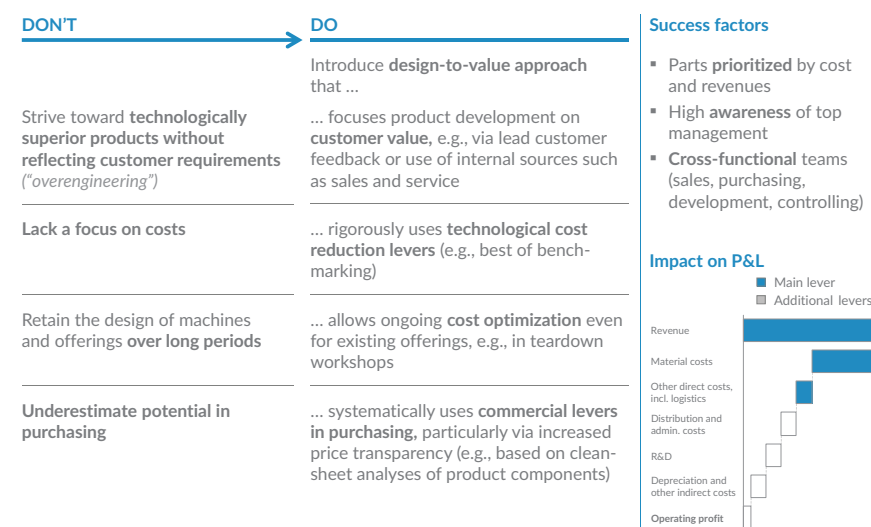
IV Continuous optimization of the product/portfolio value

German mechanical engineering relies on its innovative strength as central differentiator (see Success Pattern 5). Design to value helps to preserve this innovative strength and avoid overengineering. The continuous optimization of product value is made even more transparent by following a modularization strategy – even with low volumes.

Although innovation is today seen as a success factor, it is not always linked to the willingness to pay on the part of the customer. Design to value – also called value-focused design or even "good enough strategy" – establishes the link between product development and cost optimization in the course of a product life cycle.

Focus on customer value. Today's product development often focuses on technology leadership, which is not always immediately geared toward the value of the technology for the customer. In order to change this, customers should be closely involved in the development process so that the value for the customer is always the priority in the case of new product features. By closely integrating sales and service into the retrieval of information (e.g., to determine the customer value of options and machines), it is possible to ensure that the additional willingness to pay on the part of the customer is greater than the additional costs of the product features. It helps to first involve customers in the development of product adaptations and the development of market-specific products before they are later selectively involved in more complex technology development projects. In the in-depth interviews, regular technology and product days in which

Continuous optimization of the product/portfolio value



SOURCE: VDMA-McKinsey Study 2014, "The future of German mechanical engineering"

EXHIBIT 21

products are discussed with core customers have been cited as particularly promising. In addition, they result in the development of new processes, the identification of new application areas, the generation of orders, and the mutual sharing of benefits and risks of development by all stakeholders. This includes, e.g., joint specification sets, joint construction of prototypes, and a clear allocation of intellectual property. The customer becomes the tester and multiplier of the specialized machines. This applies in particular to foreign customers – owing to the specific regional guidelines and product requirements, direct involvement locally is usually worth it.

"We call the days on which customers visit us one-million-dollar days."
[Agricultural machinery]

Development focused mainly on the paid customer value

A neutral position between market and technology, e.g., a product management or strategic marketing, helps to translate the market requirements into technical specifications cost efficiently and precisely, and avoids overengineering.

Committed and ongoing cost optimization (technical levers). A usefulness analysis in the design to value program assists in the systematic cost optimization over the lifetime of the machines – which is useful within the context of rising cost pressure. The machines on offer are broken down into individual components in order of their value and their material costs (e.g., in teardown workshops), and ideas are put forward as to how the same functionality of a part can be achieved with less or cheaper material, changed designs, or lower production costs. Purchasing also takes on a strategic role here because it can already identify cost potential when the product specifications are defined. In individual cases, suppliers are also directly involved in the development of new, cost-optimized product solutions, because they understand the production costs of various construction alternatives. Once the machine or component has been produced, the costs of the design

can be optimized further. To ensure the success of the program, the measures should be coordinated by the highest management level, sufficient resources made available, and suitable incentives set. Many companies establish dedicated teams in which product costs are bundled and which drive forward continuous product cost optimization.

In a three-day teardown workshop for three modules of a mechanical engineering plant (supply systems, ejection system, and frames), technical and commercial measures were identified with a cost reduction potential of 22 percent overall. For example, machine basics were integrated into a connecting wall, a steel frame was thinned from 4 mm to 3 mm, and welded small parts were removed from the connecting wall.

Strategic purchasing and systematic cost reduction ensure margins

Strengthening the negotiating position for Purchasing (commercial levers). The lack of price transparency of suppliers weakens the company's own negotiating position in purchasing. In order to establish the necessary fact base for negotiations, clean-sheet analyses are recommended: the supplied components are broken down into their constituent parts right down to their screws, and the respective prices are calculated as precisely as possible by simulating the production steps and manufacturing processes (with accurate costing). The total price is based on the total production costs of the individual components plus an appropriate margin. The resulting transparency combined with extensive information about comparable offers helps Purchasing achieve a much stronger fact-based negotiating position with its suppliers. As such, Purchasing not only ensures demand coverage, but also plays a strategic role in the lowering of product costs.

Such programs therefore realize their full effect when there is an organizational disconnect between strategic and operational purchasing. This also strengthens the negotiating position with suppliers. Furthermore, strategic purchasing has the necessary flexibility to oversee long-term, systematic supplier development.

A clean-sheet analysis of a chain guide system reveals a gap of 27 percent between the aggregated production costs and actual price. The invoice included raw materials and purchased parts, but also smaller cost drivers such as defective goods, labor costs, transport, and warranty, as well as a 10 percent profit for the supplier. New negotiations could be entered into based on these figures.

By rigorously applying the design to value concept, one of the world's largest manufacturers of industrial handling machines achieved cost reductions of 25 percent. Upscaling the results is always crucial to the success of such a program: ideas for a component should be transferred to all similar type components and implemented across all locations. This requires cross-functional teams from Sales, Purchasing, Production, and Development that work full-time on the design to value concept.

V Excellence, in particular in domestic operations

The study shows that well-structured companies are more profitable and grow far faster (Chapter 2). In order to meet the intensifying competition from new markets, the strengths of domestic operations (Chapter 3) must be utilized even better in future, and top values must be achieved in costs, quality, and delivery times. This applies in particular to small and medium-sized enterprises with limited options for international production.

Archetype “companies with excellent domestic operations”

The most successful companies with a production share of over 75 percent in Germany:

- Have fewer “key accounts” (the share of orders comprised by the three most important customers is lower), which minimizes their order book risk
- Profit from the profitability benefits of greater standardization and positioning as a premium provider
- Are active in faster growing markets that attract a higher number of competitors due to their attractiveness.

Excellence, in particular in domestic operations

DON'T

Allow **waste, variability, and inflexibility** in the value chain and auxiliary processes

Underestimate possible **disruptive changes** in production processes (“Industrie 4.0”) (“Google is not a competitor”)

Pay for **high logistics costs**, especially in global export

DO

Apply **lean transformation** across the entire value chain to **increase productivity** and reduce complexity

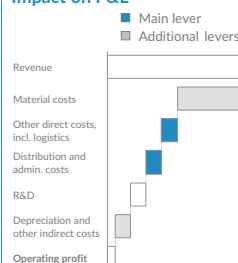
Take a strategic approach to “Industrie 4.0” (e.g., focus areas, partnerships)

Reduce costs systematically in the delivery chain by applying structural, technical, and commercial levers

Success factors

- Committed alignment of **company culture**
- Stringent **process orientation**
- Establishment of corresponding **skills**

Impact on P&L



SOURCE: VDMA-McKinsey Study 2014, “The future of German mechanical engineering”

The survey respondents essentially see the location of Germany as an advantage – but with some cost disadvantages. Competitive advantages may be won by reducing delivery times and increasing process and product quality. To do so, location benefits such as infrastructure, know-how, and employee qualifications should be intelligently utilized. On the other hand, the German wage levels and energy costs cannot compete with countries such as China or India. Logistics costs are also playing an increasingly greater role with the shift in demand to new markets. In order to offset these negative effects, companies must at least increase their productivity in proportion to the cost rises.

The benefits are expanded and the negative effects mitigated by the following 3 approaches:

Lean principles reduce waste, variability, and inflexibility in production and administration

Use of lean principles. Productivity can be further increased even in a well-established industrial location such as Germany by the committed use of lean principles, with the key focus on costs, quality, and lead times. A holistic approach includes the operational system, management, as well as the attitudes, conduct, and abilities of the employees in equal measure. Even though the following information primarily relates to production, the full effect of the lean principle is only realized when applied to the entire workflow.

The aim of lean is to reduce the waste, variability, and inflexibility caused by focusing on customer benefit. Waste includes all activities that generate costs, but do not add value – e.g., overproduction, waiting times, transport, overprocessing, warehouse stocks, reworking. Variability refers to deviations from the standard process that leads to additional controls, reworking, and reprocessing. Inflexibility in turn drives up costs and increases delivery times as a result of meeting unexpected customer requirements, deliveries, or product demands.

There are a large number of instruments that can reduce such costs and effort: the introduction of the pull principle (mapping customer cycles in the company's own production), self-governing, decentralized control loops (e.g., Kanban systems), cycle and flow production, and a sustained reduction of setup times (e.g., by Single-Minute Exchange of Die (SMED) – tool changeovers within the single-digit minute range). Further elements of lean management include a regular performance dialog with employees and controlled regular communication at employee level (shop floor management), the introduction of systematic work processes, and smoothing production with smaller lots (one-piece flow). A continuous improvement process (CIP) should be introduced to secure and further develop processes. All instruments can be transferred to administrative processes, particularly for repetitive processes such as accounting.

Low value chain efficiency also leads to a noncompetitive cost structure. The following measures are particularly helpful:

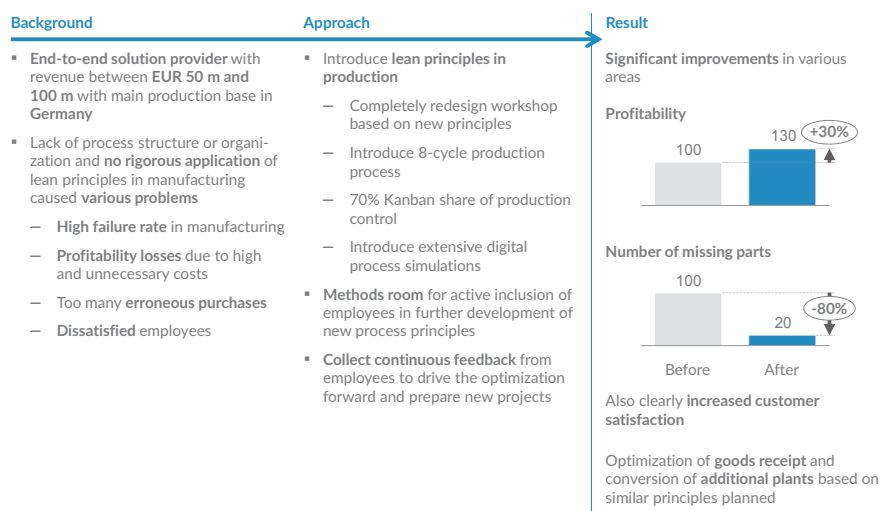
- Improved arrangement of parts on the line. This includes aspects such as optimized packaging sizes in order to minimize waste, variability, and inflexibility on the assembly line. Order and cleanliness at the work station are vital (5S).
- Optimizing the material flow from the warehouse to the point of use (focus on the value stream). This can be achieved, e.g., by standardizing replenishment routes and signals, and by sequence control and kitting.

- Improving goods receipt with standardized processes. This includes segmentation of storage locations, smoothing the workload, and ceasing activities that do not generate value.

Strategy for “Industrie 4.0.” Digitizing the value chain will mean disruptive change to the mechanical engineering industry. Companies should respond early to this trend by connecting with research networks, reviewing partnerships, and recruiting employees with the right skills.

Intelligent and globally networked machines have the long-term potential to fundamentally change value generation processes

Case study: provider of end-to-end solutions significantly increased profitability through lean production



SOURCE: VDMA-McKinsey Study 2014, “The future of German mechanical engineering”

EXHIBIT 23

“Industrie 4.0” – the factory of the future

The world is on the brink of another industrial revolution. The invention of the steam engine triggered the first industrial revolution – mechanical equipment took on the work of previously manual tasks on a large scale. Thanks to electricity, assembly line production then ensured a huge leap in productivity and high volumes. Thirdly, computers, robotics, and automation made their way into factories.

Now the fourth industrial revolution is set on digitizing factories: “Industrie 4.0” means the technical integration of cyber-physical systems (CPS) in production and logistics and the use of the Internet in industrial processes – for instance, by locating, tracking, coordinating, and controlling physical objects via the Internet. This has far-reaching consequences for aspects such as value generation, business models, and the organization of labor.²⁰

²⁰ Source: “Deutschlands Zukunft als Produktionsstandort sichern – Umsetzungsempfehlungen für das Zukunftsprojekt Industrie 4.0 – Abschlussbericht des Arbeitskreises Industrie 4.0,” Bundesministerium für Bildung und Forschung, April 2013.

The potential of “Industrie 4.0” is immense: the worldwide networking of machines, warehouse systems, and operating equipment as CPS will mean new smart factories: intelligent machines will exchange information on their own initiative and be self-optimizing. Production processes and supply chains will become more efficient, with advances in productivity and huge savings in material and energy. In future, it will even be easier to manufacture smaller batch sizes and to meet individual customer requests.

Successful implementation of “Industrie 4.0” requires extensive effort in R&D and the necessary framework conditions: this includes, e.g., the definition of standards and a reference architecture, or the provision of a nationwide broadband infrastructure for the industry. However, issues such as the (data) security of production systems and the future structure of the working organization must also be reviewed. There is also a high demand for specialists to construct and maintain these new factories. Employees will increasingly have to master a combination of classic mechanical engineering and IT – the training programs must be adapted accordingly.

Such a transformation does not happen over night. The realization of “Industrie 4.0” is a long process that requires cooperation between various industries, companies, and politicians. Germany therefore benefits from the perfect prerequisites: a high concentration of IT competence and extensive expertise in embedded systems and automation technology. By 2025, this development in Germany could lead to an additional GDP of over EUR 200 billion – and has the potential to catapult Germany into the world’s elite in terms of digitization, where currently US companies still set the pace.²¹

“Industrie 4.0” therefore offers German mechanical engineering the opportunity to expand international competitiveness even further. However, there is also the risk that software companies could steamroll the market with intuitive control technology for mechanical engineering in the same way that Apple once succeeded with smartphones.

Systematic reduction of logistics costs. For many mechanical engineers, logistics costs are so high because they do not design packaging that is suitable for logistics, they do not negotiate transport conditions rigorously enough, and some transport networks are inefficient. These challenges can be tackled by applying technical levers (e.g., packaging that is suitable for logistics), structural levers (optimized transport networks), and commercial levers (strengthening the purchasing position by, e.g., ensuring greater cost transparency).

21 Source: McKinsey – 15 Technologien, die die deutsche Wirtschaft verändern, published in WirtschaftsWoche no. 20, May 12, 2014.

VI Stringent, risk-differentiated project management, particularly in the solutions business

Although the demand for customized solutions is increasing, the solutions business is less profitable than the standard business. This is partly due to deficiencies in project management. By ensuring the focused prioritization of projects, efficient project planning and controlling, and consistent requirements management, margins can be increased in the solutions business.

Stringent, risk-differentiated project management, particularly in the solutions business

DON'T

Handle all projects equally

Distribute resources "randomly"

Coordinate projects on an "on call" basis

Let the "operational business" fall off the top management agenda

Make unreasonable, uncosted concessions to change requests of customers

DO

Prioritize projects by (technical) complexity and relevance for the business

Assign project managers according to skill sets and weighting of the project

Standardize processes with clear responsibilities, interfaces, and milestones

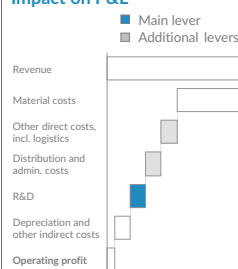
Hold regular review meetings with top management: transparency of project progress and costs; clear rules for escalation and conflicts

Apply rigorous engineering change management by defining ("freeze") milestones and forgoing subsequent customer requirements

Success factors

- Clear project structures, e.g., stringent processes
- Clear KPI cockpits per project
- Regular reviews of all projects (multiproject management)

Impact on P&L



SOURCE: VDMA-McKinsey Study 2014, "The future of German mechanical engineering"

EXHIBIT 24

Prioritization of projects. In many cases, all projects are treated the same, and processed using the same processes after order acceptance. This means that resources are often tied to small, less complex projects and are therefore not available for the processing of complex large-scale projects. Instead, projects and the corresponding resource requirements should be prioritized, e.g., according to technical complexity and relevance and/or risk for the business. The more complex and relevant the project, the more it should be prioritized, monitored, and assigned to experienced project managers. More and more companies employ project managers who do not handle sales or development work, but only coordinate project execution.

Standardization of processes. Responsibilities and interfaces between the functions and persons involved must be clearly defined. Coordination between development and sales and precise deadlines for design and purchasing processes are crucial. Subprocesses must therefore be assigned clear responsibilities, milestones must have clear criteria ("quality gate"), and the interfaces from one function to the next must be cleanly detailed.

With increasing customized demand, the prioritization of projects and standardization of processes is of strategic importance

Involvement of top management. Project managers generally have a good overview of their projects. The key to successful multiproject management is the optimum allocation of resources, but this means it must be possible to compare resources across the entire portfolio. The top management level must be continuously informed about the progress of important projects by way of, e.g., regular control groups or standardized reporting. This allows target achievement to be monitored for each function, solutions to be discussed, and resources reassigned to critical projects if necessary.

Consistent requirements management. Often, late change requests by the customer are fulfilled without renegotiation. It is almost impossible to say “no” for fear of angering the customer. However, the resulting additional costs are clear: fixed dates, when change demands cannot be considered anymore (freezing points) should be defined at the start of the project together with the customer, and additional changes that occur after these dates should be invoiced (requirements or claim management). These amendments may include volumes, delays, cancellations, technical adaptations, and much more. A regular requirements committee can be a helpful tool in initiating the appropriate measures early.

Not least, successful project management requires a clear project structure, for which there are two options: in the first variant, the project manager only controls the process, while the individual departments monitor their respective goals autonomously. In the alternative option, a project manager is responsible for all project targets and commits the individual departments to achieving these.

Example of the successful introduction of project management

A German mechanical engineering company was able to substantially increase its profitability by classifying projects according to three categories and specifying a standard process in each case. In addition to standard timelines, this included all milestones comprising final products, recipients, responsibilities, and quality criteria. The project progress was recorded using a standardized system and presented by the project manager in regular management meetings. The project manager's performance was also monitored and further developed in training courses. Delivery reliability and quality as well as coordination in the management team improved considerably.

FUTURE PERSPECTIVES

STRATEGIC OUTLOOK 2020

What makes German mechanical engineering so successful as a whole? The preceding chapters examined in detail the success patterns on which companies rely to remain successful – but these may not still apply in 2020. Which strategic perspectives will be beneficial to German mechanical engineering overall when compared to international competition?





Essentially, three competitive strategies appear promising: building better machines than the competition, building cheaper machines, or occupying a product niche. German mechanical engineering is currently playing a leading role in nearly all markets, built on technically superior products that are successfully positioned in the premium segment: since more than 70 percent of companies focus their production on Germany, local strengths can be leveraged to full effect – the strong innovative force of companies, efficient innovation networks, closed value chains, and excellently trained employees. This also means that niches can be successfully occupied. Cost leadership, however, can only be achieved in certain areas, and a competitive advantage cannot be realized across the board.

German mechanical engineering will maintain its competitive advantage through to 2020 by rigorously leveraging local advantages

However, premium positioning cannot be taken for granted through to 2020. Although the “Made in Germany” badge still allows German mechanical engineering to charge a premium, the advantage decreases as international competitors continue to increase their quality with lower costs. This is confirmed by this study, which shows that premium providers that manufacture primarily in Germany show only marginal profitability advantages compared to companies in the medium-price segment.

To maintain and further expand the current competitive edge in the product offering, companies must on the one hand continue to focus strongly on innovation – both for existing products and new developments. The trend toward networked production processes within the context of “Industrie 4.0” offers an outstanding opportunity to secure the competitiveness of German mechanical engineering on a long-term basis. This is generally easier for large and focused enterprises. On the other hand, outstanding service, superior product quality, and design and image can also contribute toward securing the premium positioning. Finally, limiting the cost disadvantages compared to the competition is crucial in further expanding competitiveness.

This brochure shows a variety of possible activities concerning many of these success factors: the further expansion of a profitable aftersales/service segment underpins premium positioning with outstanding service. Increasing productivity through operational excellence, leveraging economies of scale through internationalization, and modularization all help to reduce the cost disadvantages. Not least, improving project management also has a double effect: there is a greater focus on projects regarded as core competencies, and application, technology, and process innovations can be better systemized. Local mechanical engineers must consciously draw on the benefits of Germany as a location at all times, and there must be no easing in such efforts in the future.

Not all action plans are equally relevant to all companies. Moreover, their implementation requires time because in some respects, they demand a fundamental change to processes. However, these approaches remain true to the success recipe of progress, performance, and reliability. As such, they equip German mechanical engineering with the best tools for the future.

And this is exactly what the first sentence of this brochure states. The future is in the hands of German mechanical engineering.

German mechanical engineering – we shape the future!

Glossary

5S	Workplace organization method that, as a part of lean management, aims at increasing efficiency, quality, orderliness, cleanliness, and safety
Additive manufacturing	Process for fast and cost-effective production of models, samples, prototypes, tools, and end products, e.g., 3D printing. Also known as generative manufacturing
Aftersales/service	Services and products offered to the customer to encourage loyalty following a sale
Archetype	Typical form or structure
Batch size	Quantity of products for a production order in batch manufacturing
BRIC countries	Abbreviation for the country group of Brazil, Russia, India, and China
Cannibalization	Rival marketing of similar products at different prices by the same company
CIP	Continuous improvement process
Claim management	Management of claims, i.e., monitoring deviations from an agreement, assessing their economic consequences for the purposes of determining and enforcing claims
Clean-sheet analysis	In the context of design to value: analysis of product costs by disassembling a product and estimating the costs of the individual parts and assembly
Company with limited liability	Limited liability corporation according to German law, e.g., GmbH (Ltd.)
Components	Company that only offers parts of a system, e.g., a machine provider
Continuous improvement process	Ongoing effort to improve products, services, or processes step by step
Core business	Most important business field of a company

Core competency	Area that a company masters particularly well in comparison to other companies, and where it offers a competitive edge
Cycle production	Type of flow production, in which work stations are chronologically linked, but not spatially
CPS	Abbreviation for cyber-physical system, a group of technical software components with mechanical and electronic parts. CPS is highly significant for "Industrie 4.0"
Delivery reliability	Maintenance of the delivery deadline promised in the order
Design to value	Customer-centric approach starting from product development with the aim of increasing either the customer benefit of a product or reducing product costs without impacting customer benefit
Diversification	Expansion of the range to new products
EBIT	Earnings before interest and tax, also termed operational profit
Economy of scale	Size advantage or reduction of unit costs when the manufactured volume grows with a given production technology and current fixed costs
Emerging markets	New markets, particularly developing countries with high development potential
End-to-end solution	Product that offers all required system components and their integration to solve a problem or meet a customer need
Fixed costs	Costs that remain constant even when a reference factor is changed (e.g., revenue or production volume) in a certain period
Freeze point	Instrument of requirements management. Point at which no further change requests may be accepted in a project, generally so as not to jeopardize the completion date or project costs
Identical part	Component that can be used unchanged in different products, but is not a standard part

Industrie 4.0	Technical integration of Internet-related hard- and software in industrial processes through cyber-physical systems that aim at making these industrial processes more versatile, flexible, resource efficient, and ergonomic
Inorganic growth	Growth of a company triggered not by its own business activities but from acquisitions
Kanban	Scheduling system for production processes that controls the logistical chain from a production point of view
KPI	Key performance indicator
KPI cockpit	Information summary for managers in order to support decision making
Lead time	Time that an object requires to pass through a process
Lean management	Incorporates all of the philosophies, methods, and procedures for the efficient organization of the entire value chain, aims to fulfill customer demand without wasting resources
LCD	Liquid crystal display, a screen technology
Modularization	Splitting the whole into parts, which are called modules. Modules can be joined together, or they can interact via interfaces
Organic growth	Growth of a company triggered by its own business activities
Operational excellence	Superior processes and workflows that lead to comparable results with lower costs in relation to other companies or better results with comparable costs
P&L	Initialism for profit and loss statement, one of the financial statements of a company that shows the company's revenues and expenses during a particular period
Partnership	Combination of at least two natural and/or legal entities to realize a specific purpose
Platform	Technical basis for several products that have different outward appearances
Premium provider	Company that operates in the premium segment

Premium segment	Upper price segment of a comparison group of goods in a certain market
Profitability	Ratio of success to capital input
Proof of concept	Feasibility study
R&D	Research and development
Requirements management	Organization and processing of change requests (e.g., from customers) during a project
Return on investment	Key figure for measuring the yield of a company activity based on the profit in relation to the assigned capital
RFID	Radio-frequency identification; technology for identifying and locating objects
Scaling	Expansion, e.g., by increasing the number of items. In the context of business models: transferring a successful business model in a smaller framework to larger volumes
SG&A	Initialism used in accounting to refer to selling, general and administrative expenses, i.e., expenses incurred for selling products that cannot be assigned to individual items
Single-Minute Exchange of Die	Method in lean management for reducing waste of time in a manufacturing process, which provides a rapid and efficient changeover within the single-digit minute range
Smart factory	Industrial production in which the production equipment achieves optimized production thanks to constant, immediate, and extensive exchange of information
SMED	Single-Minute Exchange of Die
Solution provider	Company that sells end-to-end solutions
Standard deviation	Dispersion measure in statistics
Standardization	Standardization of dimensions, types, processes, etc.
System/integration solutions	See “end-to-end solution”

Teardown workshop	Breaking down of a product as part of the design to value approach (e.g., for the purpose of identifying target costs)
SG&A costs ratio	SG&A costs as percent of revenue
Value added	Income from goods generated by a given entity (e.g., a company) minus the externally provided services
Value chain	Entirety of process steps to generate value

Thank you

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