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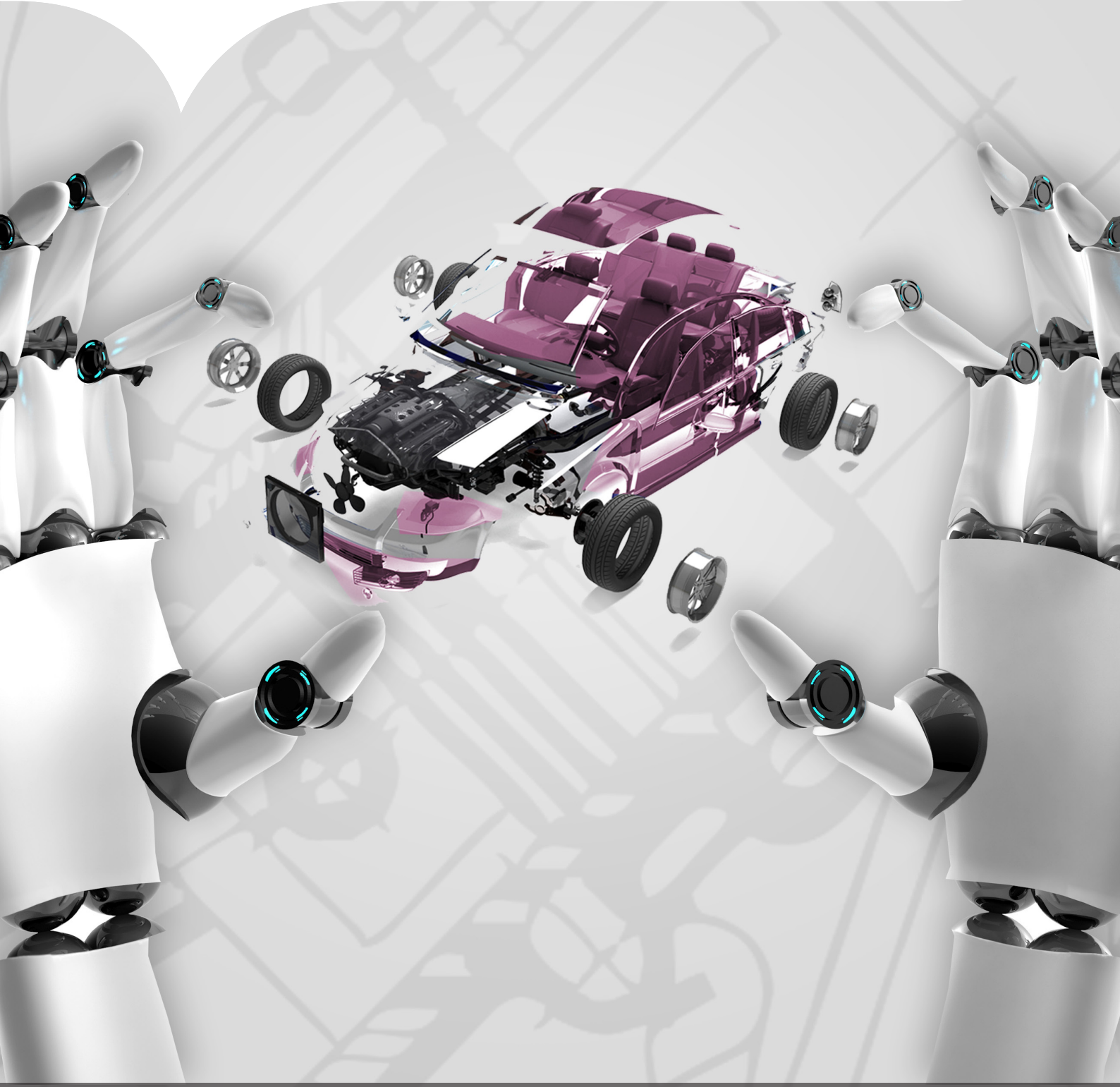
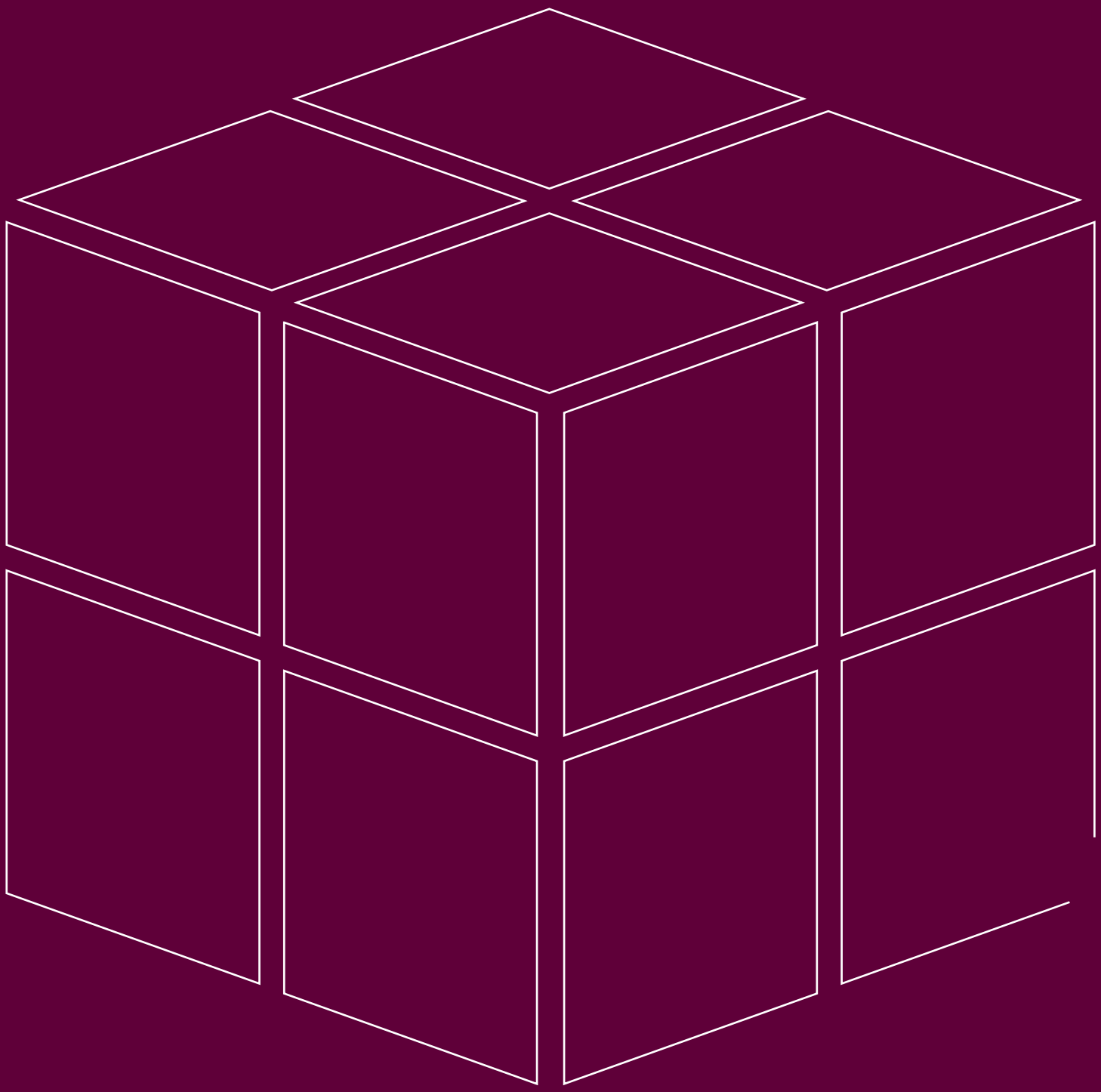


Next Generation Product Complexity Management

Are you ready to use digitisation to manage product variance?



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1. Executive summary

Product architecture and platform management are in many industries a proven way to reduce product complexity in an effective and efficient way. Particularly in automotive and manufacturing it is the core of the product strategy and therefore a critical capability.

Leveraging carry-over parts, analysing product data, managing the variants and restructuring the supply chain accordingly leads to a significant reduction of customer lead time as well as product and engineering cost. However, product complexity management today faces multiple disruptive changes along the value chain, such as global manufacturing networks, growing competitive pressure, diverse local customer demands, rapid technological innovations and new regulations. Customers expect personalised products quick and locally available at any time with the expected quality. Global organisations are often not able to fulfill all of the demands with the same degree maturity. One of the reasons is that product complexity is not managed agile enough to meet the mentioned business environment.

In our product complexity maturity study we focus on the dimensions of strategy, product, supply chain, production and technology. The key finding was that the existing IT tools and technologies are merely used for organising the product portfolio, but not for driving decision making in the field of product complexity management. In order to create significant business value with the increasing product data available, new approaches to optimise and manage product complexity are possible. Companies that are “Insight-driven complexity optimisers” have already understood how to manage an integrated product architecture that is operated with established processes and governance functions across the whole value chain. In addition they use analytical methods to optimise their existing product portfolio and new product developments in a structured and insights-driven way. By doing so, those organisations use PLM analytics tools to strive to perfection in product architecture and platform management.

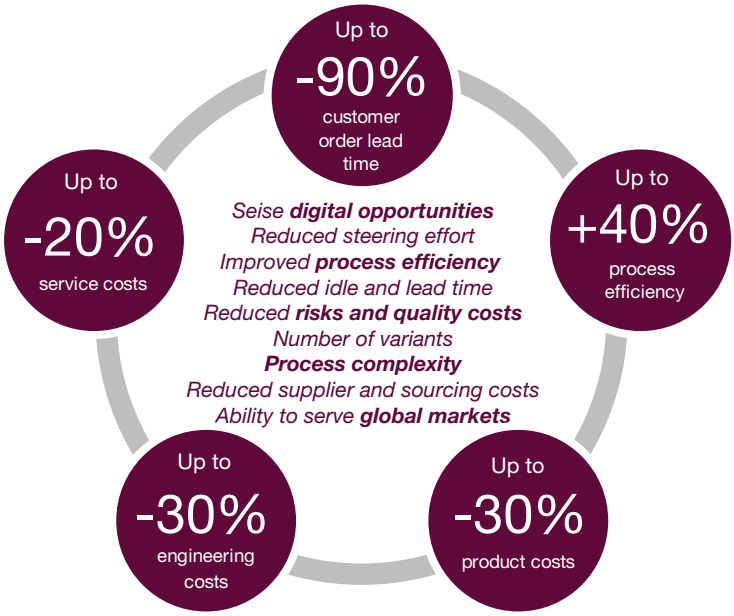
Within this point of view we want to outline the trends and challenges of manufacturing companies in this field and also give a viewpoint on the possible levers to address these and to optimise product complexity management. Our approach is easily understandable and addresses the key obstacles to overcome.

2. Benefits of complexity management in the new digital world

Organisations in every kind of industries are faced nowadays with an increasing individualisation of customer requirements. To fulfil this expanding demand, companies react by enlarging the number of product variants. This automatically leads to higher complexity, which the companies have to cope with. This becomes especially visible in the automotive and manufacturing sector, but also exists for example in energy and utilities. Thus, organisations need to learn, how to manage the balancing act between fulfilling the market needs regarding individual functionalities on the one hand and reducing internal complexity to save costs and time on the other hand.

Several companies already perform at a high level in the field of product complexity management, especially in the automotive industry. The modular transverse matrix platform of Volkswagen is only one quite popular example. But today's question is: to what extent do they consider current and upcoming industrial key challenges like sustainability, globally distributed value creation networks, market volatility and, most notably, the cross industry's digitalisation with its cyber-physical production systems? While conventional complexity management is able to manage product complexity locally quite well, a new approach is necessary to also address the growing complexity and digitalisation of the value network.

Global organisations could benefit tremendously through an integrated product architecture and platform management in the fields of service, production and engineering. Based on our experience, a world class product architecture and platform management is able to realise significant benefit effects.



3. Product complexity management has to involve the global value network

Product complexity management is a challenge, which affects the whole value chain and therefore needs a comprehensive solution approach. Companies continue to globalise and implement new variants of their products to spur growth. As a result, the global value network coordination, covering the idea generation, requirement specification, design, product series concept, sales, realisation and assembly and after all operations and maintenance, is more and more challenging and therefore drives product complexity.

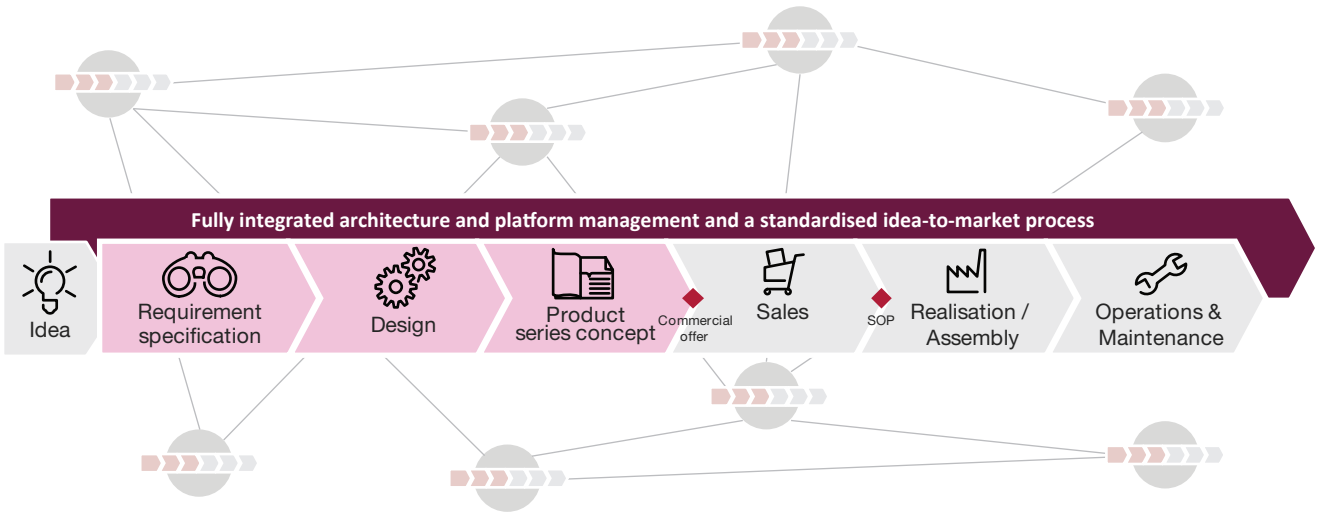
Within the **requirement specification** the large number of variants has led to an increased effort in material planning. The goal of complexity management here is to structure the product requirements and enforce a reuse of existing solutions.

The same principle takes place in the **design** stage of the value creation. While product complexity causes increasing R&D costs and provokes development of new parts, product complexity management takes care of early definition of carry-over parts and establishes maturity concepts for components. Thereby, existing components can be easily identified and parts as well as subassemblies are prepared for reuse as much as possible in order to reduce reinvention costs.

During the **product series conception** rising complexity implies smaller and more expensive purchased parts. Besides, rising amount of components often leads to higher stocks and therefore rise in working capital. The vision of product complexity management in this phase is to develop common architecture components to facilitate an integrated portfolio management across all product families and brands.

A major negative effect of increasing product complexity in the **sales** phase is the rising complexity of demand forecast

Figure 1: Global distributed value creation network

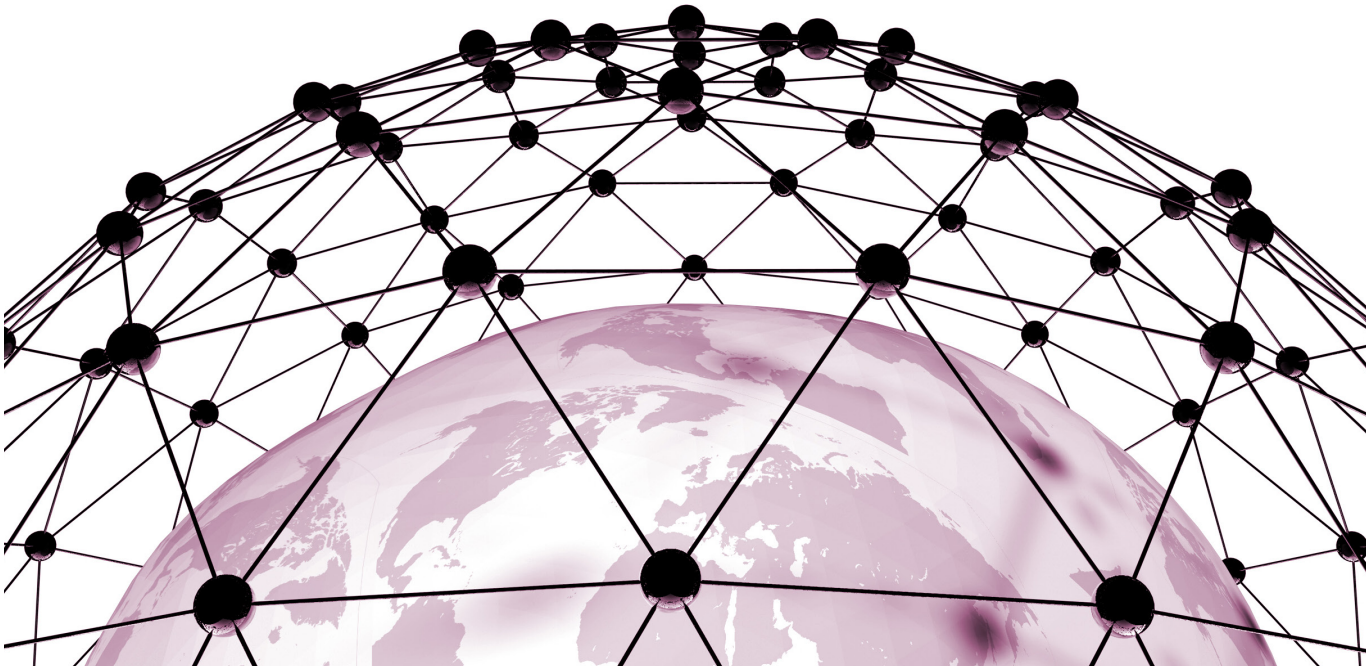


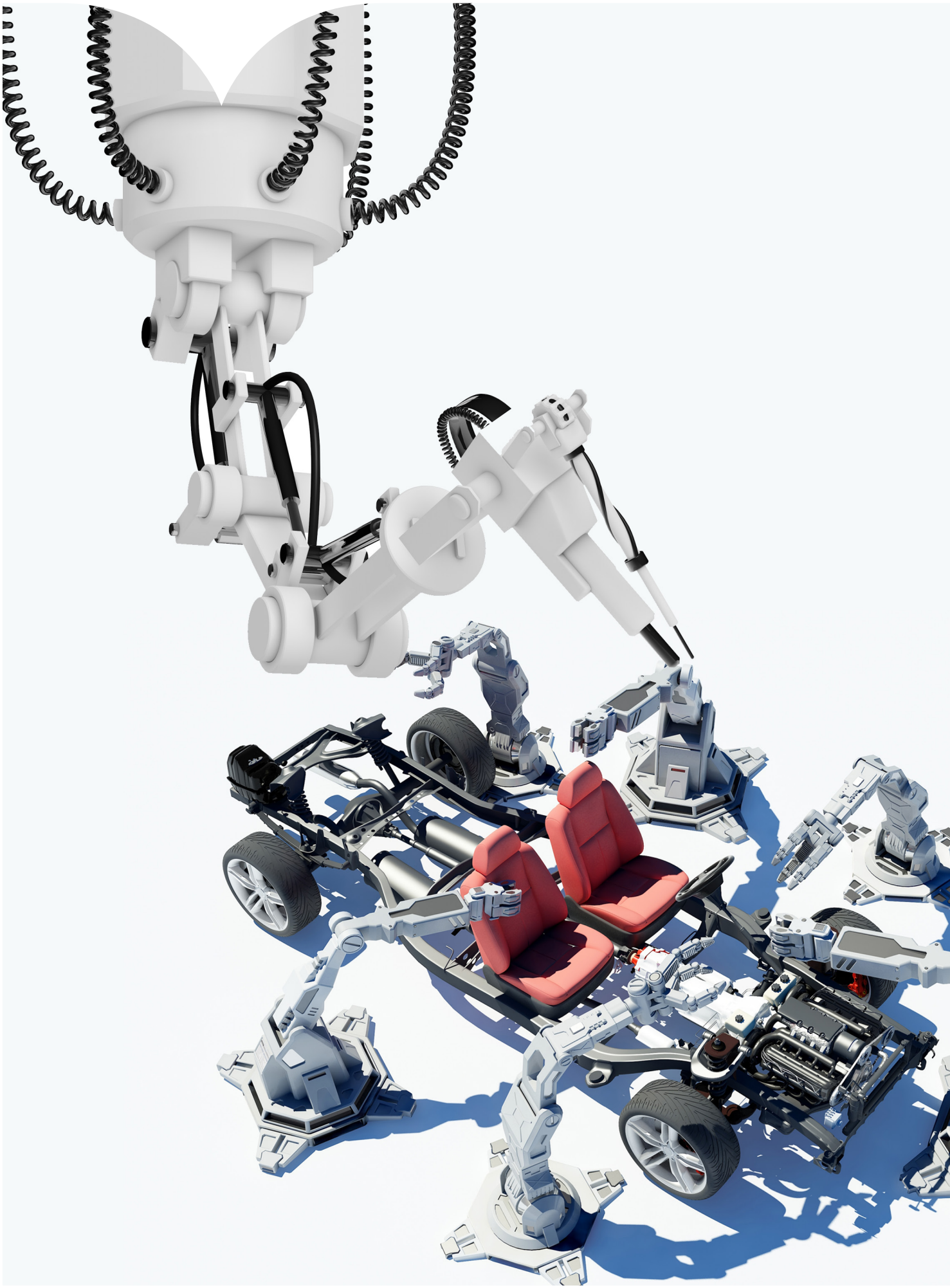
and cannibalisation of products and brands in the different markets. Managed product complexity should simplify demand forecast and could even ease the training needs of salesmen. With a managed central sales configurator the salesman and the engineering department has easy access to all data needed. They can use it to describe and manage the market offering internally and externally to significantly reduce interface problems as well as customer lead times.

Further, increased product complexity causes small lot sizes and high tooling variety which complicates the **realisation and assembly** process. Therefore, product complexity management has to integrate the product view by all means from engineering through manufacturing to service in order to always have the right view of the product. Standardisation of production processes is a consequent benefit and eases the delivery of personalised products locally at a reasonable price.

Also **operations and maintenance** are affected by rising product complexity. If not managed well, effects can be higher installation times or space requirements than actually needed. In addition the service technician has to know each part details of a load of variants. For operations and maintenance the management of product complexity simplifies through standardisation of service processes and lowers the failure rate of parts, due to the reduced number of variants.

To address the requirements towards an integrated product complexity management while keeping the value network performance high, a comprehensive, but flexible and technology-based solution approach across all stages of the value chain is needed.





4. Leverage technology to control product complexity

The importance of the drivers for product complexity will intensify rapidly in the next years. Strong internal and external influences will force organisations to improve their product management substantially. It is necessary to identify the implications of these trends and to adjust the current view on product architecture and platform management proactively. The developments can be structured with the product complexity diamond, which contains five interdependent dimensions: competition, customer, globalisation, technology and regulations.

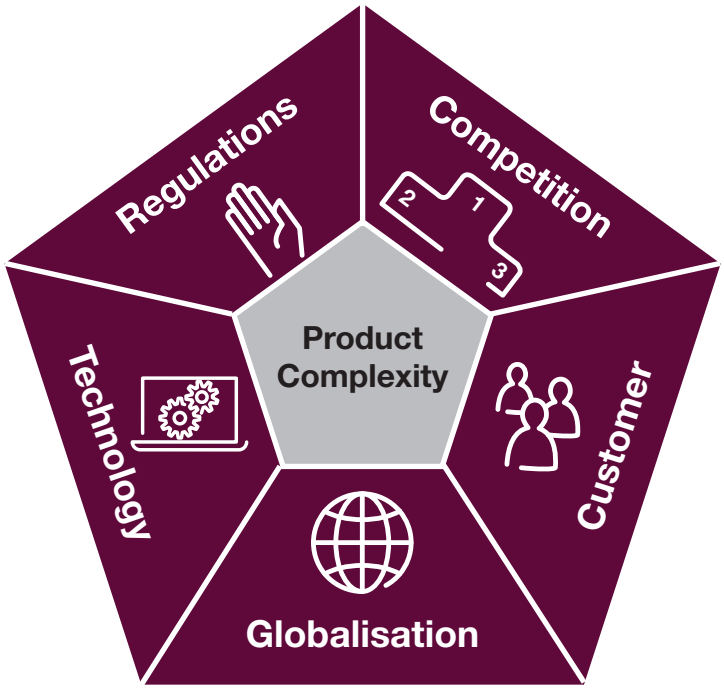
Today's **competitive** environment is characterised by increasing pressure and market volatility that affects the entire value chain and therefore also the requirements of products and services. Differentiation through quality and additional service has become a major competitive factor instead of the lowest price.

Also the **customer** demand for permanent product or service innovation and individuality is becoming increasingly important. Companies often answer individual customer requirements with an increasing number of variants. A German premium automotive OEM, for instance, has planned 10 to 15 new production ramp-ups within 2016[1]. Agile management of variants is crucial for these industries, right here and right now.

Globalisation leads to a globally distributed value creation network with new customers, especially from the emerging markets. As we all spoke about global markets a lot in the past, this has now become a reality, especially in Asia. Most of the European automotive players now operate production or even development sites from there. On the one hand this provides a large number of opportunities in sourcing, producing and delivering, but on the other hand also requires an increasingly complex and locally focused value creation.

Another trend affecting the complexity of products is the **technological** development in both, process and product technology. In the field of process technology the "Internet of Things" enables multiple

Figure 2: Product Complexity Diamond



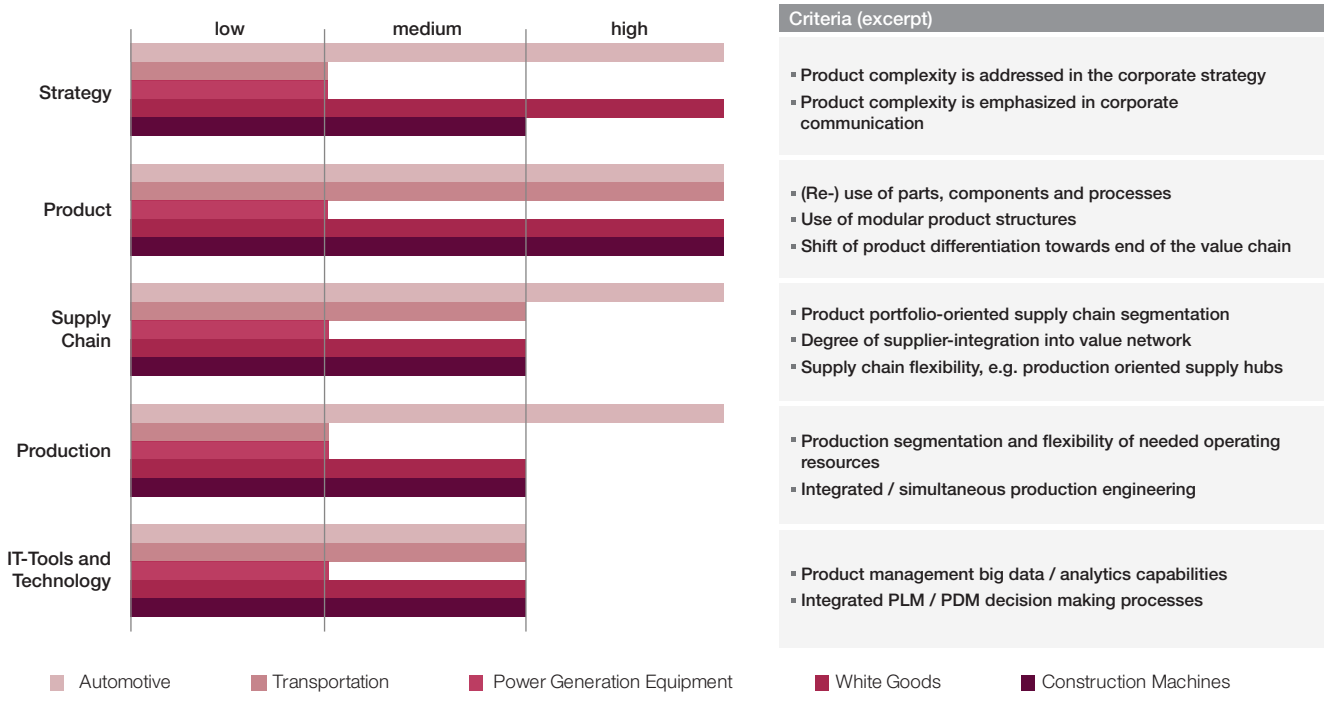
[1] http://www.automobil-produktion.de/2014/06/exklusivinterview-mit-norbert-reithofer-bmw-das-ist-ein-ziemlicher-kraftakt/

possibilities for autonomous demand planning or production through cyber-physical supply chain systems.[2] Also, the connection of the physical and digital world through sophisticated communication, identification and localisation technologies complicates the organisation but can also bring up new opportunities, if intelligently applied. Likewise, those new technologies are the basis for product innovations. Thus, attractive products are quite complex and have to fulfil multiple customer requirements towards "traditional" customers and the "young" tech-generation.

With those developments, it is obvious, that on the one hand new technologies, global value creation, strong competition and higher customer requirements need adjusted **regulations**, e.g. to enable entering new markets. On the other hand market-specific conditions affect product regulations, such as country specific legal restrictions for product security reasons or product data protection which leads to different variant types for different regions or even countries.

All in all we see these drivers currently getting more and more intensified and relevant for global organisations, especially in automotive and manufacturing industries. With this observation, we wanted to find out how successful companies address those challenges and how they handle product complexity management today. Therefore, we compared the maturity in five industries: construction machinery, white goods, power generation equipment, transportation and automotive in a research study to get a clear picture of the as-is situation.[3] We analysed several companies of each industry regarding their usage of product complexity management levers such as **strategy, product, supply chain, production and IT tools and technology**.

Figure 3: Degree of product complexity management maturity in covered fields by industry



[2] Holler et al.: From Machine-to-Machine to the Internet of Things, 2014

[3] Capgemini Consulting Research 2015

Anchoring the topic in the corporate **strategy** is important for external and internal recognition and emphasising importance. However, according to this field study, the integration of product complexity management into the organisation's strategy is just partly done in the construction machines industry, whereas most of the white goods companies coupled their position clearly with product complexity reduction targets. Also power generation equipment companies integrate product complexity management clearly into their strategy – in comparison to transportation providers who nearly do not consider this at all. The highest maturity of strategic consideration of product complexity management was stated in the automotive sector making it a clear forerunner.

Naturally, **products** are the most important lever for influencing product complexity, i.e. construction of carry-over parts, modular product structures, postponement of product differentiation to the value chain's end or using platforms as a communal part structure. The construction machine industry shows intentions of modularisation only in the subareas of product design whereas white goods manufacturers are carrying out modularisation and platform architecture initiatives as a standard. More than half of the power generation equipment companies and a major part of the transportation equipment firms also show clear modularisation and product architecture concepts. However, the automotive industry has implemented the highest maturity of complexity management within the product design using product architectures and platforms including cross-product family and cross-unit collaboration.

In order to manage product complexity it is important to apply a product specific **supply chain** and integrate data flows across company borders. The construction machine as well as white goods industries show just a few relevant initiatives like flexible stockings. Even fewer intentions of supply chain integration and segmentation were identified with power generation equipment manufacturers, while transportation companies show at least partial supply chain integration and segmentation initiatives to manage product complexity as part of their nature. Automotive firms have already mostly aligned their supply chain with their product complexity management and use it as a strategic asset to fully involve suppliers in the early phase of product development itself into their product architecture and platform processes.

Parallelisation of production process activities, segmentation of production lines and more flexibility by using operating material are levers to support product complexity management within the **production** processes. Construction machines manufacturers intensively consider these levers and tend to make production processes more flexible, whereas a slightly lower degree of maturity in this field is realised by white goods organisations. Power generation and transportation equipment firms are not yet integrating production processes and product development processes in terms of product complexity alignment. The automotive industry is again the top player in this field and stands out by applying complexity principles accordingly in production.

What we have seen across all focused industries is that **IT tools and technology** are barely used to support product complexity management. Neither the deep integration into PLM and PDM software is a standard nor the use of analytics. White goods manufacturers and transportation providers at least have implemented telematics services extensively, but don't leverage big data or analytics. In this field also the automotive sector does not take much advantage out of the structured use of IT tools and analytical technology as a lever for product complexity management. This field is most immature overall.

Although we find multiple examples, where companies already use digital technology in a product complexity context (**see digital best practice solutions**), we also see a tenor of fear towards using it as a standard in a structured way to support objective decisions in a governed way. It is also obvious that while the automotive industry is again a pioneer and paves way, other manufacturing sectors lag behind. But the use of technology is the key success factor for the future and is already a differentiating factor on the way to becoming a world class market leader. Everyday data is created, attached and changed. Data insights through technology bring new impetus in this exciting topic, where not everything has been settled yet. Where and how to use technology naturally depends on the specific situation, but it definitely brings new and unexpected benefits. So get rid of technology pessimism and find out how the future can look like.

Digital best practice solutions

Design Solution Finder

A digital solution finder helps to manage product complexity within the design stage by searching existing component-solutions easily through an engine-based keyword-search across the whole company and partners. With the solution finder, the degree of re-use of e.g. engineering documents, CAD files or prototypes, can be supported and incremental product innovations are facilitated.

A global premium automotive OEM uses a solution finder during the product development process to find and re-use 3D-constructions of similar constructions. In this way, the company reduces developing lead time and costs, minimises redundant work and reaches a faster time-to-market. In addition, it is able to eliminate unique parts already at the design stage leading to a higher degree of standardisation.

Sales and Service Release Configurator

To tackle the sales complexity the gross of companies have implemented a sales and service release configurator. It enables sales representatives to define a scope of a requested or anticipated business and customer activity by selecting and configuring variants, work packages, parts and service releases. Additionally it is useful to plan sales and service release offerings as well as specific variant related service offers.

With this tool a crane manufacturer implemented a modern, service oriented sales process. Improved conversion rates, shorter lead time and an additional self service configuration have been leveraged as benefits. This led to additional revenue in the field of service offers, improved product performance, minimised maintenance costs and optimised service deployment.

Communal Parts Analyser

In order to visualise interdependencies between components or product families, a communal parts analyser helps to make similarities or even communalities transparent. By this, the latest product component data is consolidated in one consistent graph database to create a typed attributed graph, which can be analysed by common patterns, such as attributes, structures, dependencies, etc.

A tool manufacturer used this intelligent method to identify redundant parts and to optimise the existing product structure. The visualisation of the product variant components in a “network-format” facilitated the compilation of a standardised toolbox reducing the amount of required components. Today the tool is used in daily business to assess the suitability and conformity of new products and components for the existing product range and decreased the redundancy level significantly.

5. Become world class with product analytics

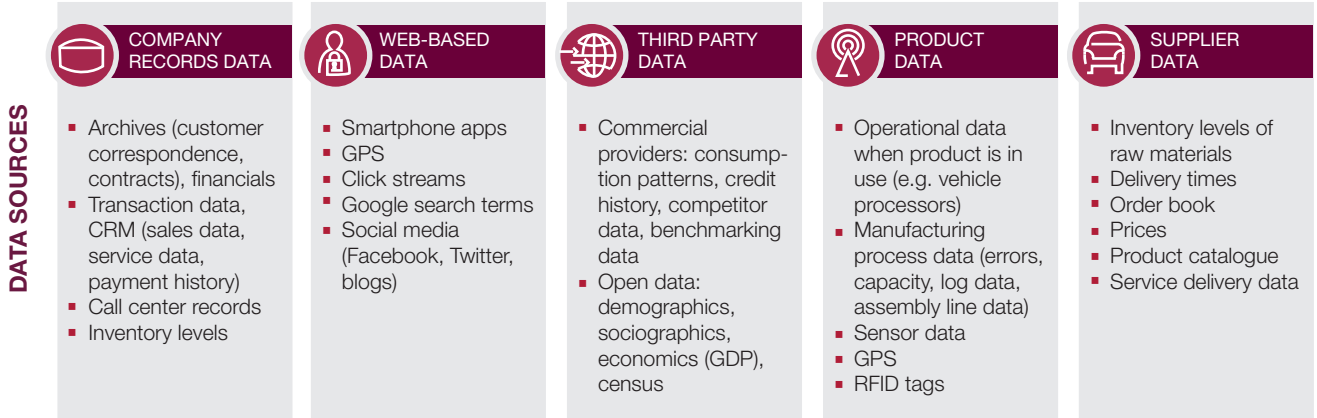
Just a few companies have integrated big data and analytics in their information and technology environment in order to support product complexity management. However, the exploding amount of information generated through clients, products and processes and the need for agility make it inevitable to consider the implementation of analytical tools.

These tools collect their data input from different sources, such as company records data (transaction data, CRM, inventory levels,...), web-based data (GPS, social media, smart phone apps,…), third party data (credit card history, demographic data,…), product data (manufacturing process data, sensor data,…) or supplier data (delivery times, prices,…).

Depending on the solution the analytics tool carries out a consolidation, validation and cleansing of the collected information, before generating analytical predictions like a demand analysis for instance. The findings are visualised in interactive tables and appealing charts, making it easy to get insights, support decisions and deduct further actions in product complexity optimisation. With the help of such a solution, elimination, addition or modification of the whole product and service family including all attributes can be applied systematically. It can also function as a decision tool for preparing objective groundwork for decisions concerning the product architecture or platform.

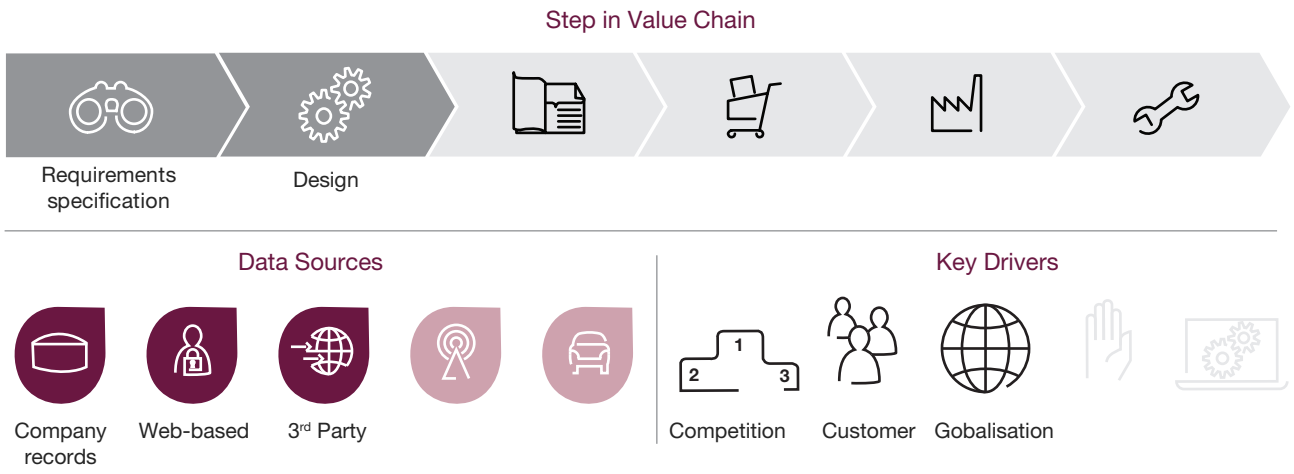
Analytics can be applied across the whole value chain. To concretise the approach within product complexity management, we would like to provide a selection of potential use cases.

Figure 4: Data sources for Big Data Analytics



Customer needs analysis and design

Figure 5: Customer needs analysis and design



One of the problems that organisations have to tackle on the customer side is that customer requirements are often fuzzy and unstructured or even just not known. That can result in product offerings that do not suit the market. It is also one reason for product cannibalisation due to inaccurate differentiation and increased production costs due to unnecessary work or missed use of equal tools.

Thus, the challenge is to specify customer needs concerning desired variants exactly in accurate product offerings without creating cannibalising products. With a detailed customer needs analysis, profitable product variants or even features can be identified and offered for decision taking. The combination of internal (e.g. historical CAD, CAE, PLM and CRM data or social media data) and external information sources (e.g. sales data from sales platforms, search engine research or demographic trends data) serves as input for a sentiment analysis or predictive modelling to identify patterns that makes it easier to draw conclusions with direct affect on parts and model variants. For example, criteria-based rules for the design stage can be defined so that new features, such as e.g. colour or measures can be automatically denied for new designs.

The benefit of this approach is the elimination of unnecessary differentiation resulting in fewer product variants (or more specific variants) and hence, reduced complexity in the sales, production and sourcing process. In addition, it comes with some implementation barriers such as availability and applicability of data, missing decision criteria or insufficient data series. But in order to use market insights for product design decisions the customer need analysis is a valid and intuitive tool to use analytics in this context.

Communal parts optimisation

Figure 6: Communal parts optimisation

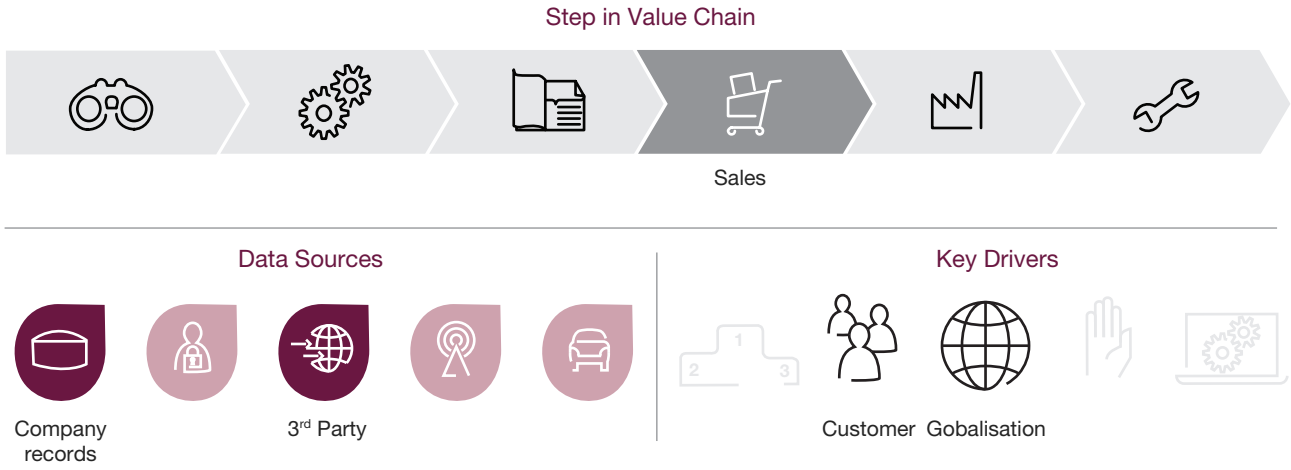
Another key challenge during the product creation process is that many product variants lead to high diversity of parts. Naturally there is nobody in the organisation who knows every product in detail and can find communal parts systematically to identify those that are not needed anymore. Additionally, in most of the cases, the features are so complex that inter-dependencies and commonalities between the individual components cannot be easily recognised. Visualising product components in a network can help to remove parts redundancies through the identification of commonalities.

An analytical parts visualisation tool consolidates the latest product component data in one consistent attributed graph. Repetitive tasks are formalised in rule sets enabling the user to perform an attribute-, structure- and pattern-based analysis. In this way, components for each product variant are displayed in form of a network and links between parts as well as redundancies can be visually identified. With filtering functions the views can be tailored easily to certain topics and use cases.

The complexity management profits from this visualisation of product variant components as a network facilitates the compilation of a standardised toolbox while reducing the amount of required components. Transparency concerning the dependencies within the product portfolio seems to be the key to success. Thanks to the communal parts visualisation, companies are able to speed up the processes of data collection, processing and visualisation by substituting manual work. Linking different components to each other becomes more flexible, interactive and better maintainable. Thus, the visualisation serves as an intuitive decision support for an optimisation of the existing product portfolio as well as an input for decisions concerning new products and components.

Customer lifetime value optimisation

Figure 7: Customer lifetime value optimisation



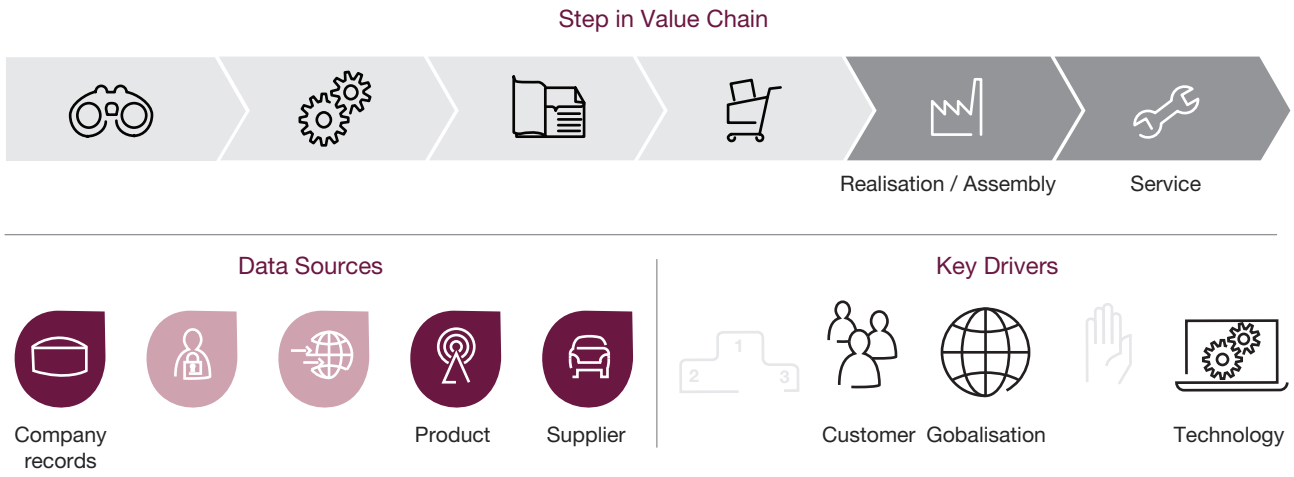
On the sales side it is obvious, that current and future customers create more and more data as the digitalisation of the sales channel is standard today. The challenge is, that customer groups are not easy to segment and also relationships and interdependencies of customer requirements are hard to identify and capture. Since some customer groups generate significantly more revenues than others, the evaluation of customer relationships is crucial. The measure "Customer Lifetime Value" is used to conduct customer segmentation and to manage marketing-related measures. Present and future revenue streams and costs (e.g. customer-specific advertising costs), payment behaviour, shopping frequency, external credit ratings are integrated in the calculation.

For product complexity management this means that this measure can be used as a valuable input for decisions related to grouping and differentiation of products, brands and local variants. Potentially unprofitable product variants or features can be identified, discussed and prioritised accordingly. Key for this use case is the combination of data from outside and inside the organisation. To get meaningful insights the variables have to be selected intelligently and combined based on one common goal, which can be for example the elimination of unprofitable components or the identification of parts that run the best and for making them available also for other products from other product families or brands.

The extent of the decision making impact and value the information brings into the decision process highly depends on the input data available. If applied intelligently, benefits of this use case are generated in the fields of cost optimisation in customer service and offerings, increased customer loyalty among most profitable customers and higher customer satisfaction through supply and service optimisation.

Production process complexity optimisation

Figure 8: Production process complexity optimisation



Along with an increasing number of variants comes a demand for increasing flexibility of the production sites in terms of process agility. The vision to be able to produce every product in all production sites in the world is not within reach under the circumstance of having an increasing number of product variants. But in order to enable standardisation of the production programme data from the site can be used and combined to give insights towards the product complexity.

With the digitalisation of the factory, real-time data from sensors becomes more accessible and can be collected to monitor machines and control operations. This allows ubiquitous process control and optimisation to identify conspicuous defective parts and problematic or non-profitable product variants. Moreover, actual site-specific production programme data across all product variants and features can be generated in order to compare production variants to recognise patterns. Those patterns can be used directly to optimise production variants, in order to minimise variety and complexity that comes along with each product category.

As a majority of costs is hidden in design errors that result in production inefficiencies this is a promising method to optimise by a specific but beneficial lever. The approach leads to products that are more aligned with the given and future production capabilities. Moreover, it gives the opportunity to detect product defects and can boost product quality, if fed back to product development.

As good as all this sounds to a product manager's ears, as equally important are also the recommended parameters for using product analytics methods for product complexity management.

High quality data

As a foundation for further analytics, external and internal data that is used has to be of good quality: consistent, error-free, available and relevant to be integrated adequately.

Analytics software

The appropriate choice of analytics software should be tailored to business requirements and embedded in the strategic business context.

Support infrastructure

Sufficient storage capacity to store ever increasing amounts of data has to be ensured and investments into databases and solutions planned early on.

Smart network

To ensure collaboration and sharing customer and product data the analytics solution has to be embedded into an incentivised smart network of business partners.

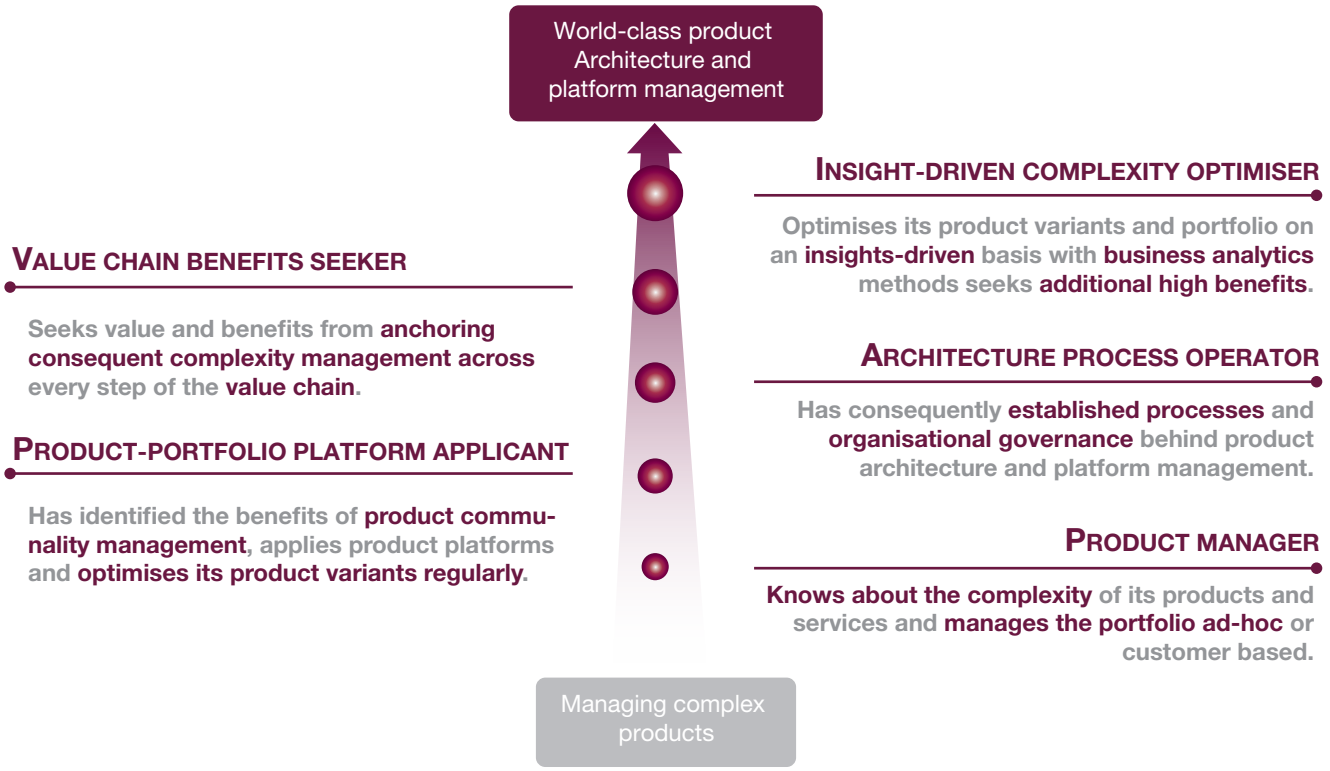
All in all, big data analytics offers multiple opportunities to provide insights in order to optimise product complexity.

Solutions are quite individual and the business impact largely depends on the data situation available and used in this context. But the possible benefits show that becoming world class in product complexity management means to be capable of using the existing analytics tools for the company's competitive advantage.

6. Start today!

Product architecture and platform management is surrounded by exciting developments, such as "Industry 4.0" or the fact that globalisation has become a reality. These trends and challenges, however, bear an extreme potential for product complexity management, if addressed properly. Moreover, leveraging the increasing amount of data over the whole value chain and across locations is the key to dominate product complexity. Sensors, machine to machine communication and data flows from clients through connected supply chains are only a few examples of information sources. The intelligent analysis and smart combination can provide valuable business insights and action proposals for reducing product complexity. Nevertheless, product analytics is really the jumping point to become world class. Where to start the journey truly depends on the organisational maturity in product architecture and platform management. We identified five stages in which companies can be classified.

Figure 9: Journey to world-class product architecture and platform management



In the first stage, the organisation knows about the complexity of its products and services, but their ability to manage its complexity is narrowed, we call them **product manager**. They manage their product portfolio ad-hoc or customer-based, but are not able to plan upfront. An easy to implement tool those companies use is a basic sales and service variant configurator that serves as an interface to the customer to show complex individuality without shaping complete new requirements.

In the second stage, the **product-portfolio platform applicant** already has identified the benefits of product communality management, applies product platforms and optimises its product variants on a regular basis. A common and proven solution element is a continuous and rule-based product portfolio and variant planning as a basis for quick reaction to short term disruptions.

The **architecture process operator** in the third maturity stage has consequently established processes and organisational governance behind product architecture and platform management. An integrated product architecture process is used in parallel to the product development process to bring stability in the complexity of decision making along with a clear product architecture ownership with dedicated responsibility. Decisions influencing the product architecture are made on an objective basis using clear KPIs and the qualitative knowledge from former projects and key product manager.

The fourth stage represents the **value chain benefits seeker**. Those companies manage complexity by anchoring consequent complexity management across every step of the value chain and make decisions and impacts transparent for each step. A crucial solution element to get into that stage is an integrated SCM demand planning and forecasting with a clear link to product architecture and platform management.

The highest maturity in product architecture and platform management is gained by companies that manage complexity as an **insight-driven complexity optimiser**. In doing so, they optimise their product variants and portfolio with business analytics methods and seek additional benefits. Thus, becoming world class in product architecture and platform management is strongly connected to the digitalisation of the organisation and data structures surrounding it.

As stated before, it depends on the company's individual maturity, what range of measures and tools should be used for a transformation. Once the maturity is screened, the targets and priorities for the future product architecture and platform management are derived through an 8-step approach.

1. Analyse existing product portfolio and set architecture strategy
2. Structure existing product portfolio
3. Analyse communalities across products
4. Define architecture structure and governance
5. Develop and align the product architecture process
6. Define requirements towards tools and systems
7. Optimise product variants and configurations
8. Operationalise variant and platform management

For a successful transformation of product complexity management towards world class, it is essential to engage people's minds and hearts - this is what Capgemini Consulting approaches with digitally enabled change management. Proven measures and new technologies are combined in a change approach tailored to the needs of our clients to balance the rational and emotional side of change and fully integrate change management activities in the transformation.

The integrated approach of product architecture and platform management by Capgemini Consulting offers multiple possibilities to professionalise your product complexity management. It is essential to assess the maturity of your own capabilities to make deficits and possibilities transparent. Additionally you should think about solutions that best suit your products, services and customer environment and equip you for the challenges of the future. So open up your mind to the possibilities of "Industry 4.0" and start your journey now!

Success factors for your journey to Next Generation Product Complexity Management:

- Product complexity management is a **strategic topic and needs support from top management**, otherwise the measures are not sustainable and it leads to a one-off effect.
- Decisions around the product portfolio are **not single decisions** but have to be controlled and steered professionally for all local markets globally.
- **Mature data management is the basis** for rational complexity decisions and therefore extremely important.
- Product architecture and platform management is not only a technical topic, but always has to **involve the people and skills side** to effectively steer decisions.
- To gain the benefits along the whole value chain, organisations need to have **high process maturity**.
- **Ownership and responsibility have to be defined** and anchored to guarantee that the decisions are made collaboratively and fact-based.

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About Capgemini

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