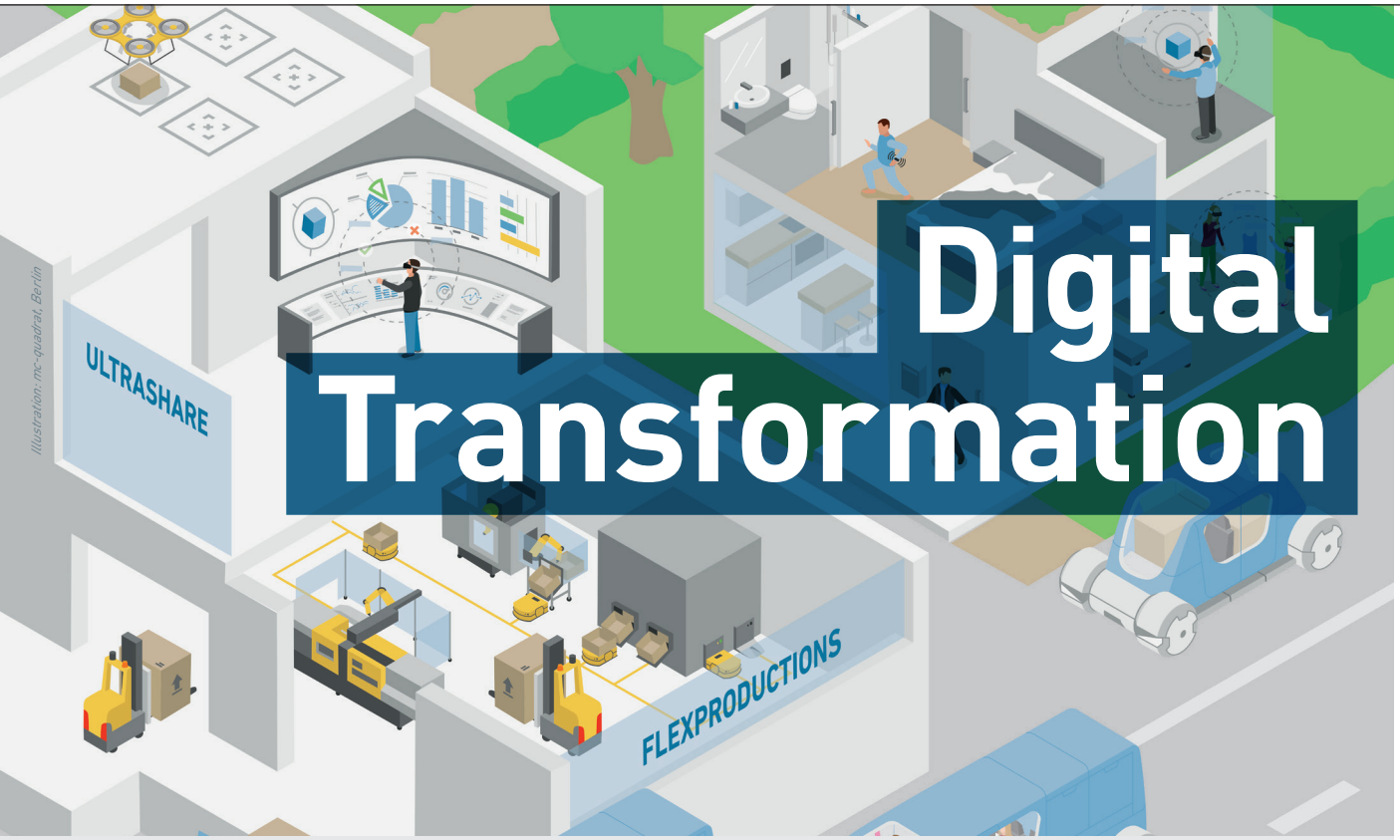
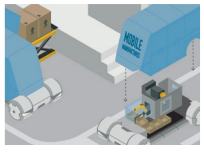
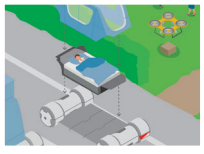


Digital Transformation

How information and communication technology is fundamentally changing incumbent industries

International comparison of the maturity level of the automotive industry, mechanical engineering and logistics industry





Final report of the joint project „IKT-Wandel“ funded by the German Federal Ministry for Economic Affairs and Energy

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aufgrund eines Beschlusses des Deutschen Bundestages

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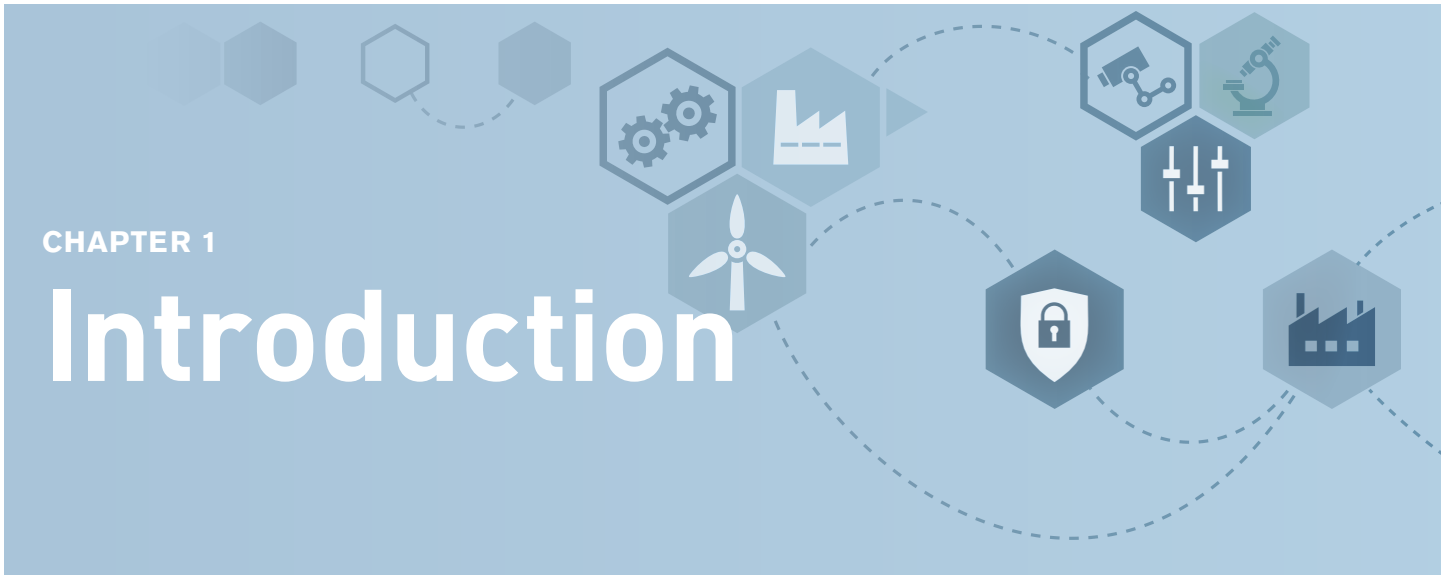


CHAPTER 1

Introduction

Information and Communication Technology (ICT) is becoming increasingly pervasive in our daily life and work. Sometimes it is unobtrusive, like the complex controller to improve energy efficiency in a washing machine or when an appointment is rescheduled via smartphone and automatically synchronized with our colleagues' calendars, sometimes more obvious, when we are unable to access a shared project folder in the cloud or our smart TV suddenly presents us with personalized recommendations for TV series.

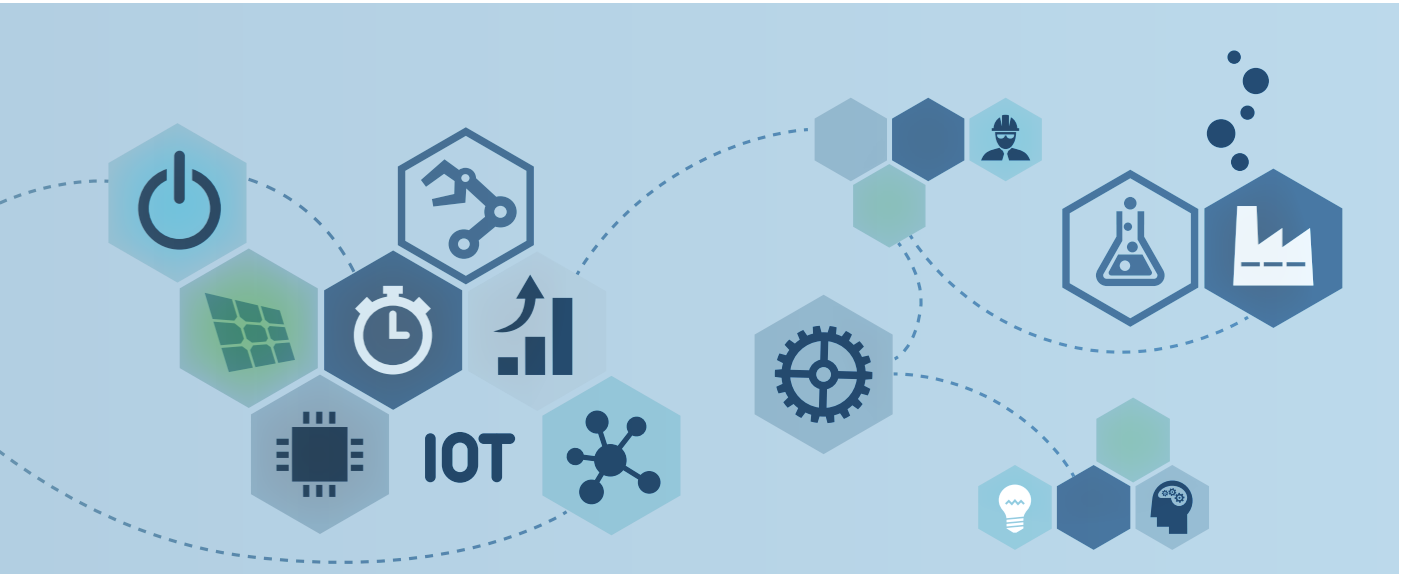
In the past, it seemed as if these changes mainly affect the consumer segment, because that was the segment in which companies like Google, Apple, Amazon, etc. predominantly operate. The transformation triggered by ICT in the business segment has been ongoing since the early 1950s, but was mainly sector-specific and as a result only a relatively small group of people were aware of it. Other segments are changing by stealth, with local retailers for instance being squeezed out by online marketplaces. Certainly, by the time Google announced in 2010 that it wanted to get involved in "driverless vehicles" it was clear that the boundaries between consumers and industrial customers were starting to blur.

Consumers associate all these changes essentially with the concept of the internet. The significance of the internet is now such that it has a massive influence on usage habits. Digitalization and the global networking of information and communication technologies have transformed the opportunities available to users and user behavior. On the one hand, user behavior is influenced by technological advances, on the other the direction of technological development is driven by user feedback, actions and needs. The change in media usage habits, in particular, is conducive to the convergence of different technologies, media and sectors. Increasingly, the public consumes content including radio, TV and print via online channels and mobile apps. The system boundaries that once existed between telecommunication, information technology, multimedia, entertainment and security services are disappearing and the result is convergence of the various markets.

The fact that there are virtually no barriers to the entry of new players into the marketplace is seen by many companies as a threat – it can however also be perceived as an opportunity, given that new interfaces and innovative offerings may emerge. The challenge for companies is to recognize the changes in usage habits and the new opportunities open to them for analysis, and to involve customers, for example, more closely in the value add process. [1]

We will now look in more detail at these changes and describe the motivation and aims associated with this project. We will also explain the structure of the present study, to make the individual topics easier to access.

1) Trends der digitalen Wirtschaft. Daten und Fakten aus der BVDW-Studiensammlung im Überblick, Bundesverband Digitale Wirtschaft (BVDW) e.V. 2012: http://bvdw.org/fileadmin/bvdw-shop/bvdw_studie_trends_der_digitalen_wirtschaft.pdf



1.1 Project aims and content

This project examines the effect disruptive potentials have on the penetration of ICT into established industry domains - specifically in the automotive, mechanical engineering and logistics sectors. Compared with the 2010 study ("Mehr Software (im) Wagen")[2] we have looked more closely at whether ICT merely enables change (i.e. acts as an "enabler") or if it is not in fact the key driver of change across the boundaries of traditional industry segments. In this context, important challenges for all relevant stakeholders seeking effective ways to secure Germany's competitiveness are identified and discussed. This relates to

- the automotive industry which is regarded as an important lead industry in Germany,
- traditional mechanical engineering as an important export industry, and
- logistics, which not only enables many processes in the above industries – for example Just-in-Time (JIT) and Just-in-Sequence (JIS) – but is facing major upheavals brought about by ICT.

A key objective of this study is to identify which core technologies and change processes industry must develop and address in detail, if these are to be available to the market in a timely manner. The authors of the study have also systematically processed and compared results from national and international interviews in the three lead domains. The strengths and weaknesses specifically of Germany as a business location are analyzed and recommended actions identified for policy makers, research and the industry sectors.

Digitalization produces a multiplicity of actors and this puts undue strain on the ability of the individual and groups to make decisions and manage complexity. The National IT Summit is the central platform for shaping digital transformation and as such typifies the challenge of complexity management in a multi-actor process.

Taking the IT Summit as an example, this study provides specific guidance on how platforms should be systematically created for successful collaboration between different actors from politics, the economy, science and society to meet future challenges. Existing systems and structures are also deliberately challenged, in order to describe disruptive changes.

The fact that this type of radical change also affects mechanical engineering and logistics, as well as the automotive sector, is underlined again by considering these sectors in parallel.

2) Mehr Software (im) Wagen: Informations- und Kommunikationstechnik (IKT) als Motor der Elektromobilität der Zukunft, 2010 study

1.2 | Project methodology and approach

To gain an insight into how digitalization is perceived in other parts of the world, interviews were conducted in Germany, the USA, China, Japan and Korea. These countries were chosen because the three sectors of interest, namely automotive, mechanical engineering and logistics are highly relevant to their national economies.

A total of 190 interviews were conducted. Of these, 110 were "decision-maker interviews" – as the name suggests, these were with individuals in senior management roles. The remaining 80 interviews were with experts from the various sectors. While some of these individuals also had management roles, the criterion for selecting them was their specialist expertise.

The aim of the interviews was to obtain qualitative statements and assessments of the mood in these industry sectors and countries and to identify early indicators.

Each expert interview was divided into three phases:

- General questions about assessment and impact of digitalization
- Status quo as regards maturity of the different aspects of digitalization
- Survey of the sector's strengths/weaknesses and opportunities/threats in terms of digitalization

The general questions were designed to capture the underlying mood and identify which factors (for example trends, technical developments) the interviewee felt were most relevant for the changes triggered by digitalization.

With the questions on maturity, the aim was – as alluded to briefly above – to provide a means of comparing the various sectors. The purpose of such a comparison is to establish whether, when it comes to digitalization, there are aspects where one sector can learn something from another. To achieve this aim despite the diverse nature of the sectors, we developed a special maturity model for the expert interviews. Using eight universal factors, this model examines the socio-economic aspects (business model, strategy, organization) as well as technical capabilities (data analysis, autonomous systems, digital engineering) and thus establishes the current digital maturity level for each sector.

The questions on strengths/weaknesses and opportunities/risks, at the end of each interview, served to concentrate and focus the various strands. All aspects of digitalization addressed in the course of the interview came together here and focused the interviewee on potential solution sets and recommended actions.

Irrespective of the particular phase of the interview, for each question the interviewee was asked to justify the answers given in each case. These justifications are crucially important for the qualitative evaluation of the interviews in chapters 4, 5 and 6.

Alongside the analysis of bodies on the politics/economy/science/society interface, a total of 110 semi-structured, confidential one-on-one interviews were conducted with decision-makers at the national and international level in the stated industry sectors.

In addition to technological and industry-specific aspects, the interviews also covered many cross-industry and societal topics. A key part of the interviews involved an examination of the politics/economy/science/society interface to support digital transformation from the perspective of the various actors. The study related mainly to the National IT Summit and other bodies in the field of digitalization. The questions focused on experiences with dialog platforms and bodies and what form an ideal interface would take.

More details on the interviews and the methodology used can be found in the annex.

1.3 Structure of the study

The next chapter, Chapter 2, defines the concepts relevant for the study and places them in context. The concept of disruption, in particular, is broadened and viewed in terms of digitalization. Next, the various forms of and main factors influencing ICT-induced transformation are described. The chapter ends with a future scenario that incorporates potential disruptive developments.

Chapter 3 deals explicitly with the automotive industry; we start by examining the current situation, looking in particular at software and architectures. Potential changes brought about by ICT-induced transformation are then highlighted, using electromobility as an example. In this context, as well as the scale of the transformation, consequences and opportunities are also highlighted.

Chapter 4 contains an overview of the industry sectors in question – automotive, mechanical engineering and logistics. Based on the interviews conducted worldwide, we give an insight into the perspective of the different companies and their understanding around digitalization. As well as contrasting the sectors in Germany, the different perceptions in the regions under consideration are also examined.

Next, in Chapter 5, we present the maturity model for assessing the socio-economic and technical trends. Based on the interviews conducted worldwide, the maturity level is classified in terms of the digital transformation of the sectors under consideration. Taking the assessments of the companies surveyed as the starting point, the chapter concludes with a critical discussion of desired future developments.

The findings obtained from the preceding two chapters are used in Chapter 6 to present the cross-sector trends that have been identified. These developments are directly related to the dimensions of the maturity model and appear to varying degrees in each of the sectors studied.

Many characteristics of these trends can be mapped with the aid of software platforms that exist increasingly often at the center of constantly growing ecosystems. Chapter 7 starts with an explanation of the economic relevance of these platform ecosystems, before going on to illustrate the underlying mechanisms and modes of operation by means of examples. Against this background, the authors conclude by outlining potential developments based on the example of the automotive industry.

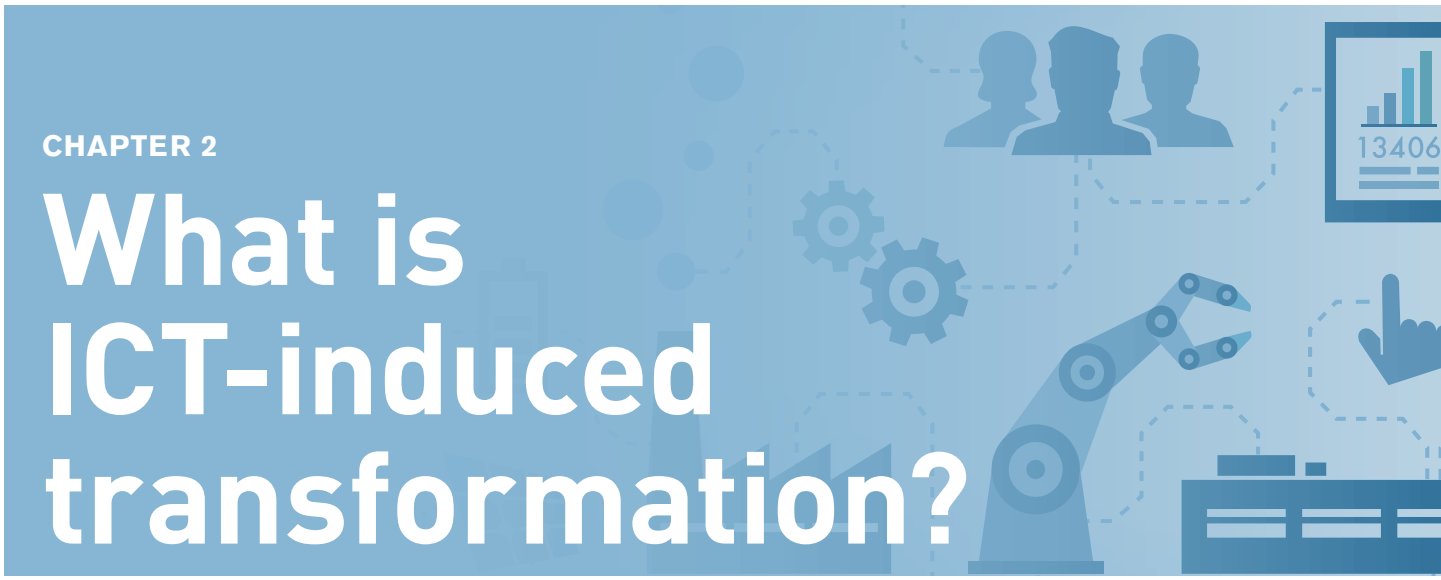
Chapter 8 deals with the interface between politics, the economy, science and society. Based on interviews with decision-makers, optimization potential is identified taking the National IT Summit as an example of a central platform for collaboration on shaping digital transformation. Finally, building on the analysis results, we present alternative methodologies for promoting collaboration between different actors and for creating a networked, effective and efficient interface.

In Chapter 9, the assessments obtained from studying the above sectors are presented as part of a SWOT analysis, with the aid of the interviews conducted. In addition to their evaluation of the individual sectors in Germany, the authors also conduct an international comparison. In evaluating the results, aspects considered include the interrelated social, economic and political factors.

Against this background and using the analyses of the interviews with experts and decision-makers, in Chapter 10 we identify recommendations for action in the fields of research, the economy and politics and discuss these in detail.

CHAPTER 2

What is ICT-induced transformation?



This chapter will start by placing the significance of ICT-induced transformation within the context of past theories (section 2.1). Underlying ICT-specific drivers that are related to disruptive changes are then summarized (section 2.2). These overarching aspects feature in all the domains examined and therefore form the basis for the following study. Next, a scenario is presented to help give the reader a real sense of the potential – and in some cases, radical – changes (section 2.3). The key question here is where and how these changes will make themselves felt for the consumer in a future shaped by ICT.

2.1 Thematic classification: creative destruction, disruptive innovation and ICT-induced transformation

Conceptually, the project is based on findings from scientific studies in the context of creative destruction described by Schumpeter and further discussion of Christensen's theory of disruptive innovation. Both authors made the observation, crucial to this project, that existing firms and markets are regularly and inevitably replaced by innovations and the opening up of new markets.

Following on from his early work "The Theory of Economic Development", published in 1912, Schumpeter summarized this trend for the first time in 1942 in "Capitalism, Socialism and Democracy": "The opening up of new markets, foreign or domestic, and the organizational development from the craft shop and factory to such concerns as U.S. Steel illustrate the same process of industrial mutation - if I may use that biological term - that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one." [3]

The process of creative destruction can be triggered by a variety of factors (for example, social, political or technical in nature). The focus of this study today is on ICT in particular as the technological trigger and key driver of change. The scale of the anticipated change is compared with earlier technological revolutions, including the steam engine and electricity (see *Table 1*).

The significance of ICT and previous technologies lies primarily in their cross-cutting nature – their wide and varied applicability in the economy and society – and their function as enabling technologies. [4] Thus, the invention of microprocessors in particular and the associated digitalization and transformation of atoms into bits constitute the basis of ICT and complementary developments (for instance memory and network technology) and of key follow-on innovations such as the internet and social media.

3) cf. Schumpeter (1942): Capitalism, Socialism and Democracy, New York (3rd ed., 1950), p. 83.
4) cf. Bresnahan/Trajtenberg (1995): General Purpose Technologies: "Engines of Growth"?, in: Journal of Econometrics 65, 1, p. 83–108.

The aim of this project is to examine the transformation unleashed by the application of ICT in German lead industries. Christensen's theory of **disruptive innovation**[5] provides a suitable definitional framework which identifies two fundamental types of technology-driven innovation:[6]

Sustaining innovation, that proceeds along a known path and enables performance improvement in established performance criteria.

Disruptive innovation, that disrupts a known path of performance improvement in established performance criteria and encompasses entirely new performance dimensions or redefines performance.

This project focuses in particular on ICT-based disruptive innovations that trigger fundamental changes in the economy. As well as identifying these disruptive elements of ICT, our main interest is in analyzing the **disruption process**. According to Christensen, established companies usually fail when they attempt to defend their market in the long term on the basis of evolutionary improvement of performance. In the process, they frequently overlook new market participants who offer superior basic functionality at lower prices,

Table 1: Six technological revolutions from 1770 to 2000 (based on Perez 2010, p. 190)[7]

Technological revolution	Popular name for the period	Big-bang initiating the revolution	Year	Core country or countries
First	The Industrial Revolution	Arkwright's mill opens in Cromfrod	1771	Britain
Second	Age of Steam and Railways	Test of the Rocket steam engine for the Liverpool–Manchester railway	1829	Britain (spreading to Europe and USA)
Third	Age of Steel, Electricity and Heavy Engineering	The Carnegie Bessemer steel plant opens in Pittsburgh, PA	1875	USA and Germany forging ahead and overtaking Britain
Fourth	Age of Oil, the Automobile and Mass Production	First Model-T comes out of the Ford plant in Detroit, MI	1908	USA (with Germany at first vying for world leadership), later spreading to Europe
Fifth	Age of Information and Telecommunication	The Intel microprocessor is announced in Santa Clara, CA	1971	USA (spreading to Europe and Asia)
Sixth	Age of Digitization	World Wide Web is invented by Tim Berners at CERN, Switzerland	1989	Europe (spreading worldwide)

5) cf. Christensen/ Bower (1996): Customer Power, Strategic Investment, and the Failure of Leading Firms, in: Strategic Management Journal 17, 3, p. 197–218.
6) For a summary, cf. http://www.innovationsmanagement.de/technologiemanagement/disruptivetechnology.html#tb947
7) Perez (2010): Technological Revolutions and Techno-Economic Paradigms, in: Cambridge Journal of Economics 34, 1, p. 185–202.

on the basis of new technologies. With the successive expansion of new market participants into the mass market, they become serious competitors for incumbent companies. At that point it is often too late for incumbent companies to react, because of significant path dependencies. The result is disruption and, not uncommonly, the replacement of one-time market leaders.

The examples used by Christensen to develop his theory come from a time when physical production (for example, steel production) and linear value add processes dominated.[8] That is why, in this project the reflections on **ICT-induced transformation** are informed by a broader understanding of the disruption process. Earlier findings are updated to include analysis of examples where ICT[9] is seen as having a disruptive effect (Apple, Uber and Amazon). Essentially two key features of the **ICT-induced disruption process** can be observed here:

- **Disruption is a process undergone by a product or service in a short period of time from the margins to the mainstream of the marketplace:** The new digital infrastructures (platforms, for example) and their end-user based ecosystems enable new business model based innovations to transfer rapidly from the margins to the mainstream. The potential for scaling and the ability to meet customer requirements quickly and cost-effectively mean that disruption ceases to be a process for outsiders. When, for example, Apple introduced the App Store, the company was able to rely on a server structure on which millions of music titles were already available. At the same time, in iTunes it had software that millions of users already had installed and this enabled much simpler, faster integration of the the App Store and the iPhone.

- **Disruptive firms design business models that differ fundamentally from those of incumbent established firms:** Disruptive firms often simply transfer business models from the internet-based world to real industry. The effect on incumbent industries, however, is as if entirely new business models were being applied to their industry. This is clear from the example of Uber. Uber fulfills the conventional value proposition of a taxi company, but expands this to include transparent pricing structures and pickup times. The customer is also able to rate the driver and can, for example, select a driver on the basis of past customer reviews. These are concepts that have become established practice on the internet and are familiar to the customer. Where the revenue model is concerned, both systems rely on commission on referred rides, with Uber using a digital platform for this (without human intervention), which is significantly more cost-effective to operate. Uber also uses a demand-based pricing model, i.e. at times of high demand journey prices are increased. This makes it more attractive for drivers who are registered, but currently idle, to offer their driving services at short notice.

In theory, all these services could also be offered by the local taxi companies. In practice, however, apart from having to develop new competencies, they would also have the problem that the costs of developing and operating the IT infrastructure could only be recouped through their regional customer base. As far as the value-adding architecture is concerned "a key difference between a full-time driver [...] and a casual part-time driver is that the latter does not use his vehicle exclusively for carrying passengers, it is primarily for private use or for other commercial purposes. Fixed costs are not therefore part of the equation, because the initial purchase and vehicle maintenance costs would be incurred in any event, regardless of work undertaken for uberPOP"[10].

Like significant basic innovations of the past (for example electricity and subsequent electrification), today's ICT-induced changes have both general and ICT-specific drivers. We will now outline key, generally-valid principles of ICT-induced transformation; these will be examined in depth in the subsequent survey and illustrated using actual examples.

8) cf, inter alia Wadhwa (2015): https://www.washingtonpost.com/news/innovations/wp/2015/11/23/what-the-legendary-clayton-christensen-gets-wrong-about-uber-tesla-and-disruptive-innovation/; Moazed/Johnson (2016): http://techcrunch.com/2016/02/27/why-clayton-christensen-is-wrong-about-uber-and-disruptive-innovation/; Leopore (2014): http://www.newyorker.com/magazine/2014/06/23/the-disruption-machine; Chase (2016): https://hbr.org/2016/01/we-need-to-expand-the-definition-of-disruptive-innovation; Economist (2015): http://www.economist.com/news/business/21679179-clay-christensen-should-not-be-given-last-word-disruptive-innovation-disrupting-mr

9) Broadly understood as an enabling technology and all complementary technical innovations based on it, including for example, the Internet of Things, big data, cloud computing, robotics, artificial intelligence – generally often also collectively referred to as "digitalization".

10) Haucap et al. (2015), p. 29: http://diw-econ.de/wp-content/uploads/2015/02/DIW_Econ_DICE_Gutachten_Uber_v6.01.pdf

2.2 | ICT-induced transformation

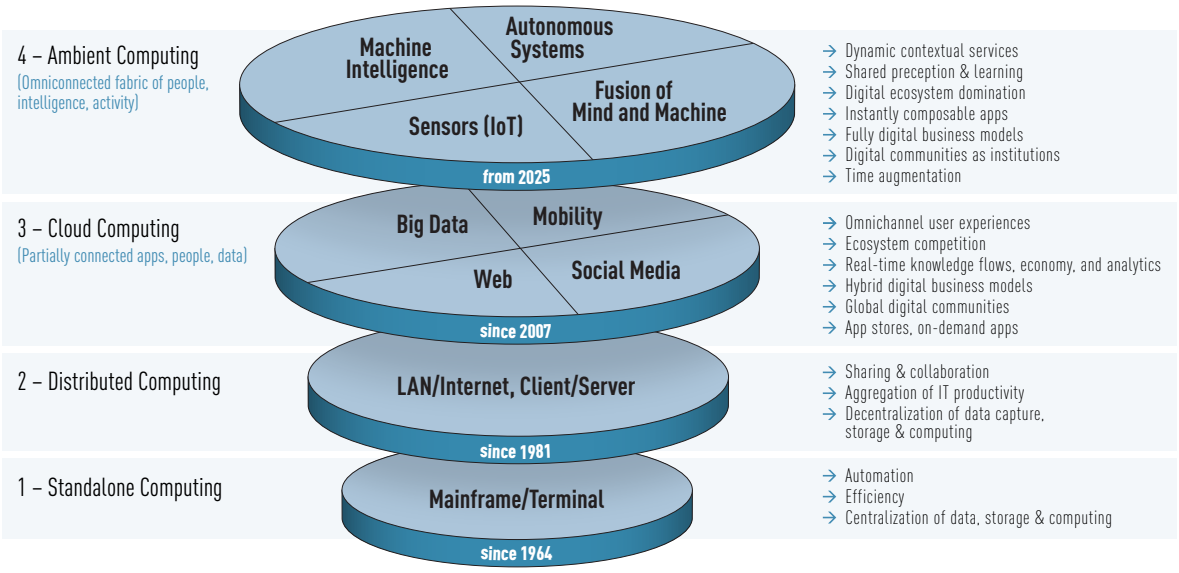
Information and communication technologies have become as important for society today as electricity and water supply. Life without them is now unthinkable. ICT is a key, cross-cutting technology: it helps businesses to cut costs, improve processes, become more innovative and improve value-add in a sustainable way. Information technology is used as the collective term for information and data processing and the hardware and software required for this. Communication technology refers to technically-assisted communication including mobile communication and telephony.

In recent decades, ICT has undergone a dramatic evolution. We are currently in the third phase (see *Figure 1*) in which digitalization is spreading to increasing numbers of markets. We are not just talking about digital media here (music, film, literature, etc.) but about processes and intelligence in all areas of the economy and society. Novel ecosystems are emerging in which digital infrastructures created by us are becoming hubs for digital data which can be accessed and evaluated via multiple devices.

According to market researchers at IDC the next step is "materialization"[11], i.e. physical products are no longer simply being digitized, instead the potential of digital technologies is increasingly changing the physical world too. This means that intelligent household appliances, self-driving automobiles and wearables will soon be an integral part of daily life. In the first three technology phases, it is predominantly the physical world that has been/is being digitized. In the fourth phase, the pendulum is swinging in the opposite direction. Digital information is being materialized in the real world. This phase covers technologies such as artificial intelligence (AI), cognitive systems, 3D printing and synthetic biology. Essentially, machines will create entirely new things from a digital design.[12]

The fourth phase is thus an opportunity to transform the material world in a sustainable way. In the assessment of Dion Hinchcliffe[13] and the IDC[14] the core technological drivers associated with this phase will not achieve significant market penetration and have a wide impact until around 2025. This means that cur-

Figure 1: ICT evolution as the driver of ICT-induced transformations[15]



11) Frank Gens, SVP & Chief Analyst, presentation at the IDC Directions Conference 2014: https://infocus.emc.com/ben_chused1/here-comes-the-4th-platform/
12) Goldberg (2015): The Internet of Everything Is Here: http://www.biznology.com/2015/01/internet-everything/
13) Based on Hinchcliffe (2015): The Rise of the 4th Platform: Pervasive Community, Data, Devices, and Intelligence: http://dionhinchcliffe.com/2015/05/04/the-rise-of-the-4th-platform-pervasive-community-data-devices-and-intelligence/
14) IDC (2014): http://www.idc.com.cn/uploadpic/1_Kitty_142020.pdf
15) Based on Hinchcliffe (2015): The Rise of the 4th Platform: Pervasive Community, Data, Devices, and Intelligence: http://dionhinchcliffe.com/2015/05/04/the-rise-of-the-4th-platform-pervasive-community-data-devices-and-intelligence/

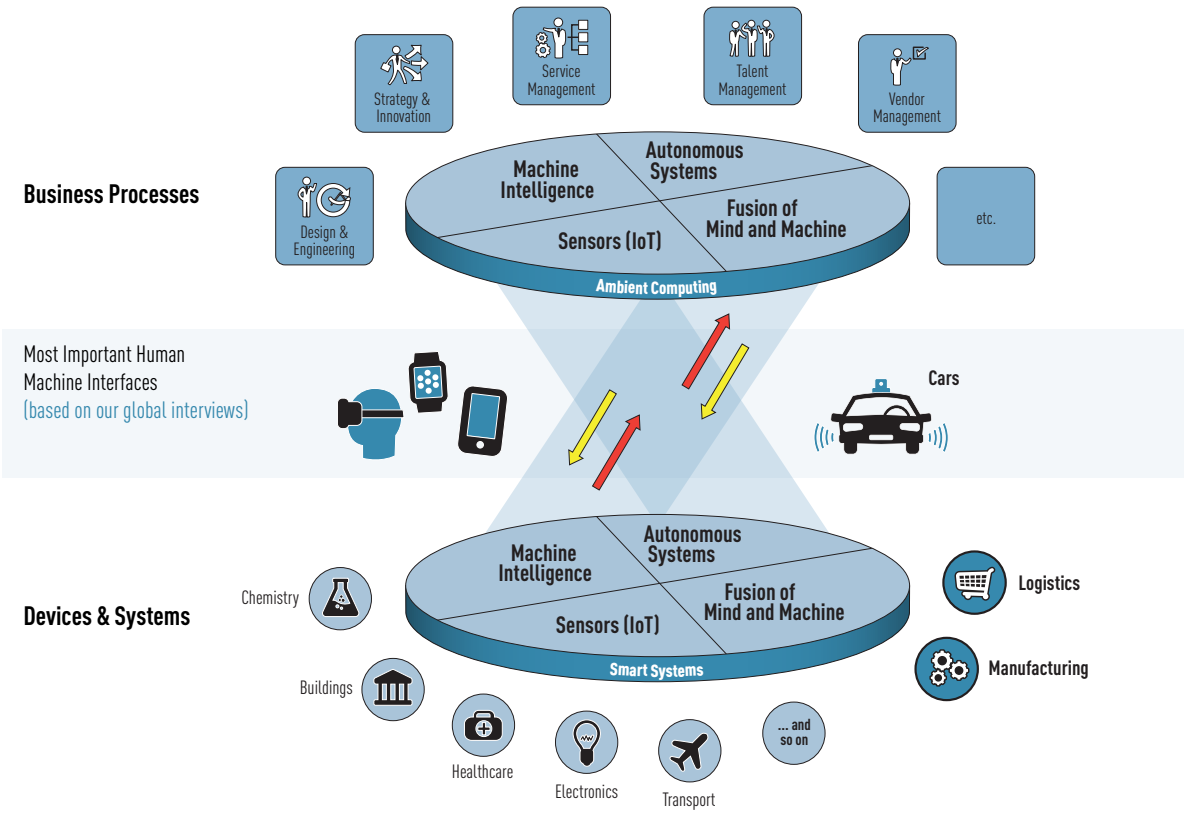
rent hot topics like the Internet of Things will not be used routinely or be an integral part of our lived world until then. The foundation for this – the digital infrastructures referred to above – is being laid now. Or to put it another way: Those who fail to invest in the basis today, will not be able to reap the benefits in 2025.

Digital products and services are solving increasingly complex problems in the real world. They are thus more and more becoming a universal tool, not tied to a specific purpose, with which we not only interact but increasingly also collaborate. AI-based systems like Fin [16] now offer personal assistant systems for instance, comparable with the once entirely human PA. The capacity of such systems to learn from interaction with humans will result in significant functional enhancements in the foreseeable future, and this in turn will mean ever more diverse areas of application. [17]

These increasingly universal tools present an opportunity for wider participation: people who once lacked the specialist knowledge to put their ideas into practice now have the tools to express their creativity. Physically highly integrated devices and systems will increasingly play a key role here. Smartphones are a typical example and represent a medium which we use to access digital products and services or which replicates the physical world.

These observations initially give the impression that this is happening predominantly in the consumer environment (B2C). It is evident, however, that the internet-centric IT world with its overarching systems, driven by shared ICT enabling technologies, is increasingly converging with the smart (physical) components of the industry domains (see *Figure 2*). Important systems that allow access to the digital element of both worlds include for example mobile devices, and in all probability driverless vehicles too in future. This emerging close link between the two worlds is producing a sustainable change/disruption in the industries affected.

Figure 2: The relationship of smart components to overarching systems [18]



16) https://www.fin.ventures/about
17) The limits to AI development can be seen in the fact that it first requires programming by a human whose commands are then executed by computers. This means that, initially, it relies on a human to define or understand the problem or task in its entirety in order to express it in the form of a program that can then be executed by the "machine"; cf. inter alia Franck (1991): Künstliche Intelligenz: Eine grundlagentheoretische Diskussion über Einsatzmöglichkeiten und -grenzen; Autor (2014): Polanyi's Paradox and the Shape of Employment Growth. NBER Working Paper Series. National Bureau of Economic Research.
18) Own illustration

The transformative nature of ICT-induced change lies in universal drivers that impact the economy and society equally. These drivers will now be discussed in more detail below.

Emergence of user-centric digital platforms

One of the fascinating phenomena in the emergence of user-centric platforms is the willingness of many users to generate their own content and share it with the world. In its simplest form, this is the Like button on Facebook, for example, or Amazon's product review feature. Even clearer examples can be seen, for instance, in Wikipedia, YouTube or Instructables. Here the platform operators generally only provide the technical framework, but no content at all. The more people there are who are willing to share their content on it, the more attractive the platform becomes.[19] In the case of the most successful providers, this creates a high barrier to market entry and can ultimately lead to a monopoly.

This fairly obvious principle can have far-reaching implications. Not only in terms of the concentration of capital in commercialization of users, for example in the form of customized advertising or commission on sales. Using appropriate data analysis, it is also possible to identify trends and preferences early and use these to develop new or improved products, for example. Also, listing products and services that do not in fact exist as such, in order to evaluate user acceptance in return for payment, might be an interesting new business model for platform operators which would strengthen their position of power. The principles and self-reinforcement effect are summarized in *Figure 3*.

Reduction of transaction costs and marginal costs

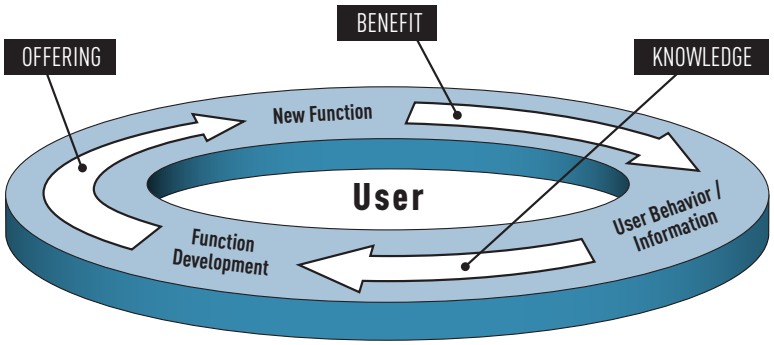
The economic viability of digital platforms and of the associated cycle shown below is based on the significantly reduced transaction costs thanks to ICT. A key driver for this is the increasingly global availability of the internet and internet-based services for standardized exchange of information and communication.

Another explanation for the proliferation of digital platforms can be found in Moore's Law which explains the availability of powerful computer technology at very low cost. The result is increasingly widespread dissemination of powerful ICT hardware in the economy and society. Which leads us to our third point: reduced transaction costs and widespread availability of ICT hardware provide the basis for a whole range of innovations. A host of operating systems, development tools, web servers, databases provided free of charge, together with instructions on how to interconnect the various components effectively – all this speeds the innovation process and also increasingly opens it up to individuals (the byword here is crowd-based innovation; cf. Picot/Hopf 2016)[20]. Given that a large part of ICT-based innovation is software-based, after the initial capital investment, variable costs for reproduction are virtually non-existent. Consequently, the marginal costs of integrating additional components or users are minimal.

Optimization through machine learning

The cycle shown in *Figure 3* is based primarily on the inherent ability of digital infrastructure to enable

Figure 3: Optimization through machine learning[21]



19) cf. concept of network effects, i.e. the value of the platform increases with the number of users.
20) Picot/Hopf (2016): Innovation mit Hilfe der Vielen – Crowdsourcing im Innovationsprozess, in: Rammert/Windeler/Knoblauch/Hutter (eds.): Innovationsgesellschaft heute, p. 193–218.
21) Own illustration

bi-directional communication. It also relies on the fact that many people are happy to share their knowledge with others. To fully exploit the potential here, processes first had to be developed to allow the ever growing volumes of data to be stored in a monetizable form. From the outset, the resulting data volumes were too large to be analyzed manually, so automatic processing was the next logical step. Machine learning, as demonstrated impressively by Alpha-Go [22] recently, is the logical development to enable even more precise information and forecasts to be generated from data.

Monetization using largely standardized revenue models

The aim of every digital offering is to exploit the above potential so as to be attractive to as many users as possible – all the more so, if it is pursuing commercial interests. This can be done using search engines (Google, Yahoo), free-to-play offerings, free distribution of video content, free shipping of books, etc. Only when sufficient reach has been achieved does the first wave of monetization kick in, and this is what we see everywhere today, for example:

- donation and foundation models (free encyclopedias, Open Source)
- advertising revenue (social media, search engines)
- referral commission (comparison websites, trading platforms)
- revenue for use of the platform (Messenger)
- revenue/subscriptions for media use (film, music, text)
- revenue for enhanced features (Freemium)
- revenue for virtual objects (model data)

There are two striking aspects to this list. First, there are revenue models from existing – non-ICT based – business models. The last item, virtual objects (for example, model data for 3D printing) is the only one that contains novel revenue sources. Second, user behavior and preferences can be captured, in particular using social media, search engines, comparison websites and trading platforms – and new complex information can in turn be acquired from such data (cf. Choi/Varian 2011) [23] (see *Figure 3*). Companies that do not learn from their users or do not have the database to do this often fail when it comes to continuing development of their service offerings and tend instead to comply with the traditional product lifecycle paradigm.

Expansion of platform-centric ecosystems

The second wave of monetization is now putting successful platform companies in particular, including social media providers (for example Facebook, Xing, LinkedIn), search engines (for example Google, Bing, Yahoo) and trading platforms (for example Amazon, Alibaba, eBay) in a position to expand into other ecosystems. They are able to do this, firstly, because they have extensively analyzed the different lived worlds of their users and are thus able to gear new offerings accordingly. Second, they are able to use the platforms they operate as a basis for making new products and services available to users quickly and cost effectively (cf. Amazon Web Services).

How well the new offering is received, what should be improved and which features still need to be added – all this can be established very quickly by these providers thanks to their broad database and advanced analysis capabilities. They can respond correspondingly quickly. At the same time, the financial risk is manageable – at least, where entirely virtual offerings are concerned as these are able to utilize largely existing resources. Thus, Amazon uses information about bestseller products to offer a comparable own brand product but at lower cost and possibly with shorter delivery times.

A powerful side effect is that this creates an additional pillar to support user loyalty. By this, we mean not only network effects and continuous improvement of existing offerings, but also an increasing diversity of offerings all accessed via the same account. Taking Amazon as an example, this means:

- access to millions of items
- Amazon Web Services
- music downloads and streaming
- video streaming
- borrowing and buying e-books
- own App Shop for Android

Increasingly this is bundled with Amazon's own hardware (Kindle, FireTV, Echo, etc.) and a subscription service (Amazon Prime) making it difficult to switch to rival products (lock-in effect). At the same time, Amazon is evolving into a brand that users trust. It has even reached a stage where other online shops are emerging that allow registration and payment to be handled via an Amazon account. From all of this, we can identify perhaps the greatest lever in the second wave of monetization: the ability to penetrate new domains in an extremely short space of time.

22) https://de.wikipedia.org/wiki/AlphaGo
23) Choi/Varian (2011): Predicting the Present with Google Trends: http://people.ischool.berkeley.edu/~hal/Papers/2011/ptp.pdf

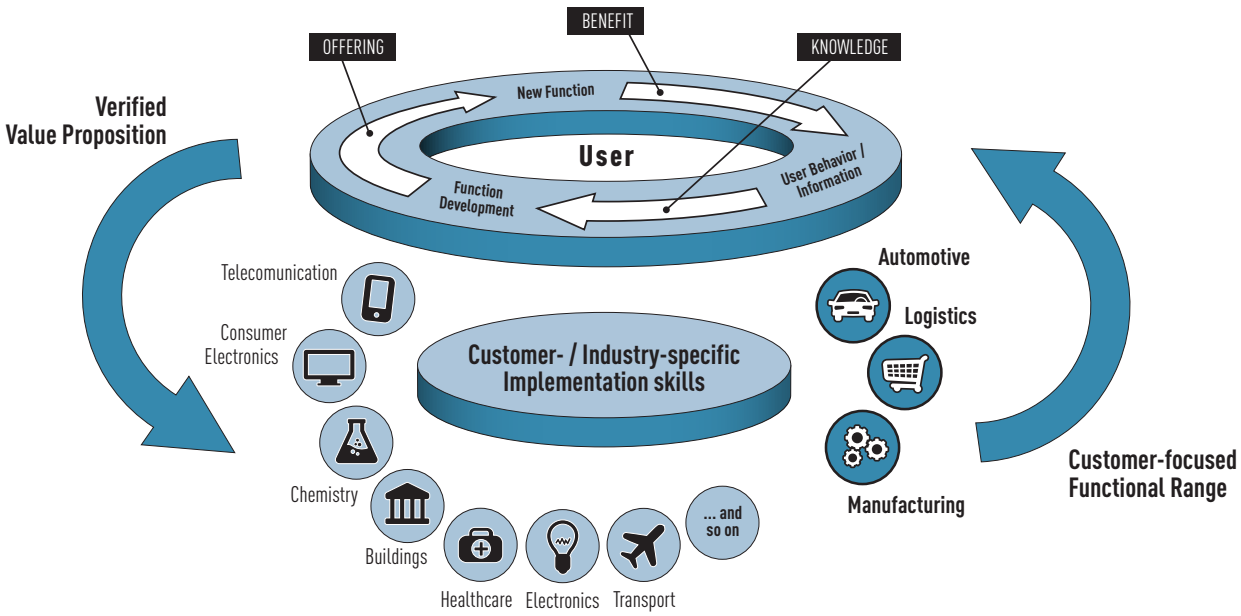
The last example shows that it is not a particularly big step for Amazon to go on to become a rival to PayPal. Similarly, one could well imagine that Facebook would be in a position to compete with Uber. Not to mention Alphabet (the parent company formed from Google) that is largely responsible for all the hype surrounding self-driving vehicles.

Even companies that in the past offered exclusively virtual services will attempt to use hardware products to strengthen user loyalty. Here, hardware is a means to an end: it is intended primarily to sell virtual offerings more effectively. This is why internet companies are not necessarily interested in earning money from hardware – it is often enough if the marginal costs are covered. At the same time, these companies will make sure that the hardware is as flexible as possible and that, for instance, functional upgrades are possible in the form of software updates (software-defined hardware), as is common practice with smartphones.

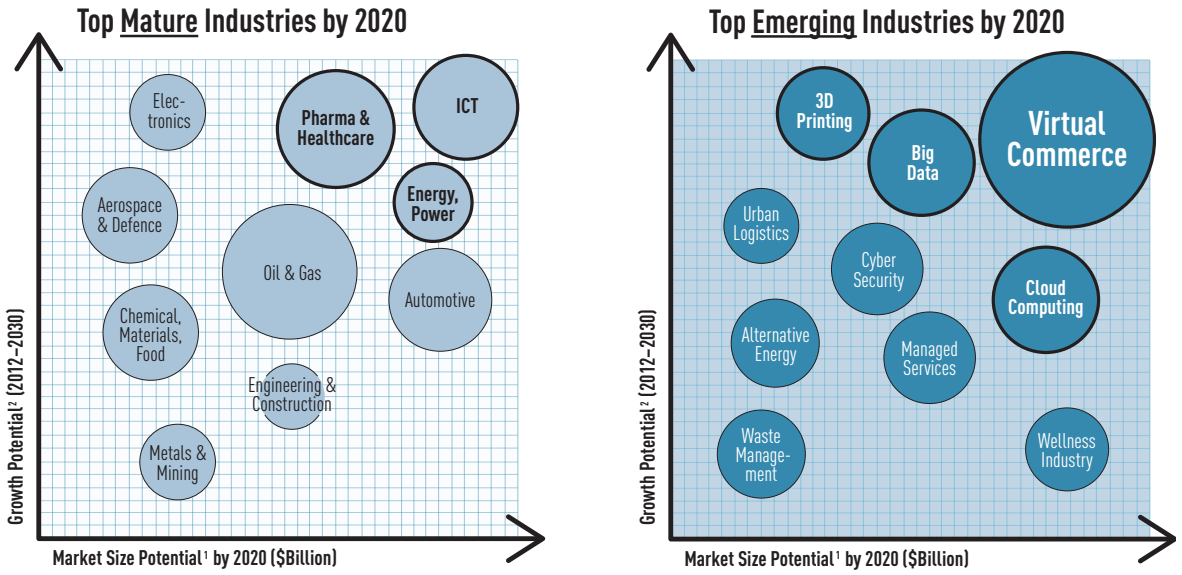
Fundamentally changed value add processes in industry

The examples and principles so far have been strongly influenced by Business-to-Consumer companies (B2C) but increasingly also apply for the Business-to-Business sector (B2B), which because of many factors [24] has not yet been affected to the same extent by ICT-induced transformation. *Figure 4* below shows the penetration of the changed business logic into established industries. First and foremost, it shows the cycle that the major platform providers establish around the user. Associated with this are fundamental changes to established value add processes. The domain-specific feed-outs indicate how users are turned into customers and how companies use the acquired knowledge to come up with perfectly tailored hardware products. From the point of view of the platform operators, the hardware producer who has the advantage is one who can meet requirements on demand and, if necessary, offer usage-based service models at an attractive price. Conversely, companies that previously relied exclusively on hardware developed and produced in-house will probably face significant competition if major platform operators that have assimilated ICT-based business logics and models expand into these domains. This may also bring significant shifts in established value add structures (for example value add of software increases) and roles (for example OEM becomes supplier).

Figure 4: Development of user-centric physical products [25]



24) These include, for instance, high specificity in plant engineering; requirement for high levels of reliability and security, generally high capital intensity; complex certification processes and comprehensive regulation; liability issues.
25) Own illustration



[1] Relative score assigned for potential annual turnover (revenue / shipment) of the industry in 2025
[2] Measured by qualitative factors that have the scope to create a boom in the industry such as new patents, innovation cycle and industry impact

Figure 5: Future significance of mature and new industries[26]

Increase in virtual products and services

A virtual or digital product[27] or service may be any element (or subfunction) that can be delivered electronically to the customer. Common examples of digital products and services include music and film downloads and apps. "Electronic transmission" describes the way in which the buyer accesses products and services. Unlike development of physical products where manufacturers have to choose between several product designs before market launch – often without consumer feedback – virtual products or virtual replicas of physical products allow cost-effective, parallel testing of different versions and customer requirements. Virtual prototypes evaluated over the web are thus a way of addressing the individual needs of potential customers more fully.

Systematic testing of product properties – physical properties too, in the case of material products – and features by the consumer, in the virtual space, is radically changing product development. In the process, development, marketing and sales are converging. This means that many product designs can be presented and evaluated in a virtual simulation (of an autonomous traffic intersection, for example), before then launching the best (material or virtual) product on the market.

Augmented Reality (AR) provides a novel medium for consuming virtual products and services. In future, AR could fundamentally change and extend business and mobility options, social interactions and experiences. In technical terms, AR is defined as a real-time augmented view of the environment through digital data such as text, sound, graphics, video and navigation systems that increases user interactivity with the local environment.

All that is needed for AR is a computer or a mobile phone screen with a camera or possibly, in future, a bionic lens (cf. Hoffmann 2015)[28]. Information that can be projected by AR includes reviews, user profiles, product information while shopping or even real estate information of properties in the surrounding area. This opens up entirely new ways of accessing customers and this in turn brings new opportunities for sales and marketing. Virtual Commerce – an umbrella term to describe trading in the digital world – represents the greatest market potential for established and

26) Bloomberg, Frost & Sullivan Analysis (2014): World's Top Global Mega Trends to 2025 and Implications to Business, Society and Cultures: http://www.investinbsr.com/ipaforum/wp-content/uploads/Iain-Jawad-IPA-Forum-2014-Presentation.pdf
27) Definition of "digital product" in: Sales and Use Tax Division Minnesota (2014): http://www.revenue.state.mn.us/businesses/sut/factsheets/FS177.pdf
28) Hoffmann (2015): http://iq.intel.de/bionic-lens-das-mogliche-ende-fur-brillen-und-kontaktlinsen/

emerging markets in the coming years according to Frost & Sullivan (cf. *Figure 5*).

Digital products and services will make up an increasing part of current and future markets. The lasting changes to the established media landscape illustrate how entire industries will be able to be virtualized as a result. The growth in these virtual or digital markets will accelerate further, to the extent that highly-integrated systems drive demand for software or content to provide enhanced functionality. An example of this is a new class of machines such as the 3D printer where all that is required, apart from highly functional materials, are CAD/CAM drawings and data. Other highly-integrated devices will follow. These new machines are characterized by the following features:

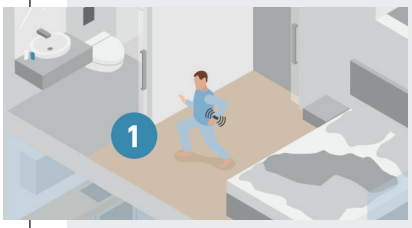
1. The number of production steps has been reduced to just two: virtual design/engineering and the integrated virtual sales/marketing/delivery process.
2. Real-time cycles that integrate customer requirements with design and engineering mean that ICT-based innovation cycles are much shorter.
3. The key value add no longer lies in the physical products but in the virtual product. As a result, market participants will offer physical products increasingly at or below cost price. At the same time, however, physical products must have the capacity to be relatively long-lived and service-free so that the virtual service business based on them is as hardware-independent as possible.

The ICT-induced transformation described in this section will become increasingly significant in all industries in Germany. The fundamental impact this will have in the long term is outlined below, using a scenario in which B2B and B2C have increasingly converged; the economic and technical changes from a corporate perspective are then examined.

2.3 | A glimpse into the future: an overarching scenario

Features of the wristband
- Multisensor: cardiovascular monitor, fitness tracker, calorie counter, etc.
- Infotainment: wake-up, reminder (calendar events), alarm, gesture control, social media
- Security: secure communication (health insurer, bank, calendar, etc.)

New services, for instance
- Dynamic health insurance tariffs
- Identification of emergency situations or preventive warnings for the user
- Social gaming and competitions



Features of the wearable jacket
- IoT jacket, communicates with weather services and calendar
- Learns wearer's habits and responds to weather and scheduled activities (as per calendar)

Multifunction vehicles:
- Flexible structure
- Variable interior for passengers and/or goods
- Extendable body (length, performance)
- Interchangeable chassis (passenger transportation, sleeping facilities, different versions for goods transportation and logistics, combined production and logistics)
- Different comfort levels available (at extra cost)
- Easy to clean, durable interior, low maintenance costs, high operating hours

The automobile as "mobile merchant"
- Goods and products (food, shopping, laundered shirts) are no longer delivered by parcel services as they once were, instead they are simply loaded into vehicles.
- Personalized infotainment content matched to travel habits (series, music, trailers, games according to travel time, schedule or preferences)

1 It is 6:30 in the morning. Carlos jumps out of bed. He should have been up half an hour ago but the material he was reading last night was so interesting that he stayed up late. That is why he simply did not notice the soft buzzing of his **sensor wristband**. He has only had this sensor wristband for six months; it was a gift from his health insurer as part of a heart health campaign.

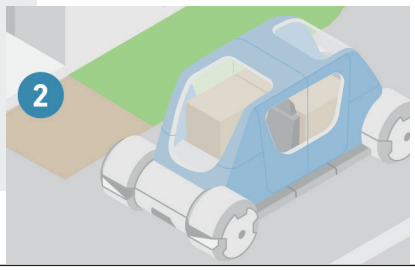
Fortunately his digital assistant did not sleep in. He was unable to wake Carlos, so he started to plan alternative mobility options. Today and for the rest of the week, the exception is in fact the rule: Carlos can't work from home, instead he has to visit one of his customers in person. Carlos will have to go without breakfast, but there is still time for a shower and to clean his teeth. He grabs his **jacket** in a subtle shade of green with flashing lights, and hurries downstairs. This type of jacket is the latest trend.

2 As Carlos steps out the front door, the vehicle ordered automatically by his assistant is just driving up. As it is approaching, Carlos sees that it is one of these new **multifunction vehicles**.

The introduction of a new platform for multifunction vehicles meant a radical change of business model for many manufacturers. Some automakers have specialized and now exclusively offer mobility services. They use their expertise to come up with the ideal design for the appropriate vehicle types and to decide which specification offers the best cost/benefit ratio. For vehicle production, they turn to the second large group of former integrated automakers. These have evolved into contract manufacturers whose core competence is the ability to produce virtually any batch size, locally, at the best price and within an extremely short timeframe. A few still develop individual vehicles for end customers, but these are in the luxury segment.

This change has a downside too, of course, as Carlos discovers when he gets into the vehicle. The cost of the trip is calculated not just according to distance covered, but is also based on the space he occupies during the journey, so two thirds of the interior of his vehicle is taken up with freight containers. On top of this, the booking was made at short notice and at peak time, so it is correspondingly expensive.

Fortunately, however, an additional **special order** has worked out. There, next to his seat, is a small box containing his breakfast: Coffee2Drive, a sandwich and half a grapefruit.



3 Many of Carlos' colleagues use this service on business trips to other cities. The fact that they no longer have to drive themselves means that more often now they return the same day. For some time now, sleeping modules have been offered for the


ULTRASHARE
FLEXPRODUCTIONS
MOBILE MANUFACTURES
3D PRINT SHOP
1
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Illustration: mc-quadrat, Berlin

App functions

- Diary with additional function
  - The brief entry "Barbecue, Borghese Park, from 7 pm" prompts the app to respond with "Good idea. Probability of rain is less than 10%" and it also takes account of the anticipated visitor density based on inquiries. The customer can then select a service package (based on price, availability, occasion).
- Carlos places his order:
  - Locally grown salad, fresh organic tomatoes and a source of vitamin A – but not carrots
  - Wine and peach flavor water for the children
  - Picnic blanket, silverware
  - Gas grill
  - Fresh sea bass, gutted and lightly seasoned
- Carlos chooses "mobile merchant" as the delivery option: passenger transportation including food transportation
  - Collection from home, all items ordered (apart from the fresh foodstuffs) will be in the trunk of the vehicle. The fresh foodstuffs will be delivered by drone to the GPS coordinates at 7.45 pm (the delivery time and place can be changed at any time, with 15 minutes' notice – the exact position is determined on approach).

The Ultrashare design platform

Selection of Ultrashare services:

- Design tools
- Proposals for suitable production partners
- Proposals for products (handles, cosmetic mirrors, seats)
- Contract management
- Processing of payment transactions

What Ultrashare offers its customers:

- Highest prediction quality in terms of product delivery date, price and quality

What Ultrashare offers its designers and production partners:

- New product trends (Ultrashare understands customer needs and the selected designs)
- Guidance on process design (processing of new materials, advice on missing design schemes)

modular vehicles and these cost significantly less than a hotel room. So it is becoming increasingly common for these to be booked just for vacation trips.

On the way to work, his wristband vibrates discreetly, reminding Carlos of another scheduled activity. The previous day, he and his wife had wondered if it would perhaps be nice to have a barbecue with the family in the Borghese Park the following evening. So he now opens the "Anytime Anywhere" **app**.

When this trend was in its early days, there were a few pioneers in this market segment – companies that prepared the fresh ingredients entirely by hand, made up packages and then distributed them by courier or by drone. The cost of ordering a customized picnic like this was correspondingly high. But the first low-cost providers soon appeared on the scene. They made use of the increasing availability of miniaturized, networked and in some cases autonomous systems to automate this service as fully as possible. A flexible system like this was able, for example, to wash, peel and chop all sorts of fruit and vegetables. Potatoes, carrots, asparagus or apples – it was all the same.

4 And power consumption is now so low that you see more and more mobile processing units that prepare dishes from fresh ingredients on the move, as they transport them to the customer. Once any technical, process-related problems had been solved, everything else was just a question of logistics. That is why, early on, the global logistics providers started working closely with the technology providers. In the end, the logistics companies bought up online trading platforms like Anytime Anywhere to safeguard their supply chain.

Carlos is also struck by other things that have changed radically in the last ten years. In the past, it was completely normal to drive to his workplace each day and to work there for a permanent employer. 5 For some years, however, Carlos has been part of the rapidly growing group of crowd workers who offer their specialist skills on online marketplaces.

6 Carlos has specialized in the design of new conversion parts for various mobility providers, with development and production being coordinated via the **Ultrashare design platform**. The design platform supports 3rd party development and crowd development for both the B2B and the B2C market.

Ultrashare has recently implemented virtualization of production resources across the board, based on decentralized production, in the form of "Production-as-a-Service" (PAAS).

7 Carlos does not work exclusively as a designer, though. He also works for **FlexProductions**, a company that specializes in conversion and spare parts. Carlos' creativity and experience are regularly in demand in cases where new materials or combinations of materials are being used for the first time. It is only from the direct interaction between design, material and processing machinery that Carlos discovers what adjustments need to be made to the machinery to enable customer requirements to be met.

Automation is now so advanced that the transfer of interim prod-

ucts from one machine to another has been optimized by autonomous intralogistics systems and production is entirely on-demand. Carlos is always aware of just how radical the change is when he observes his two daughters and their friends: ❽ they use consumer tools from Ultrashare to design their own technical devices and fashion accessories. ❹ Carlos' company frequently loses contracts to another production company called **MobileManufacturers**, which specializes in mobile processing and pre-production.

Carlos has now arrived at the large East Terminus on the outskirts of the city, where he catches the suburban train heading north east. Since the city authorities decided that each vehicle traveling in the city must make its movement data available to the city's data center, in anonymized form, realistic planning of **journey times** has once again been possible.

The system works so well that Carlos sold his private vehicle years ago. With virtually no public parking space available any more, it is even more expensive than living space. Added to which are the exorbitantly high toll charges for private transport.

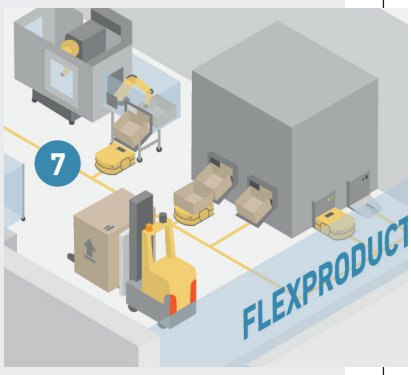
Carlos arrives home again on the dot of 6:30 pm. At 7 pm, he and his family get into the vehicle they have ordered, where chilled drinks are waiting for them. When they reach the pre-arranged meeting point, the other vehicle containing the prepared food and picnic utensils is already there.

❾ Together, they carry it all to the place they have reserved in the park. His wife had selected the location via live image transmission on their way to the park and had paid a small fee to the City Treasurer's Office to have it marked as "Reserved".

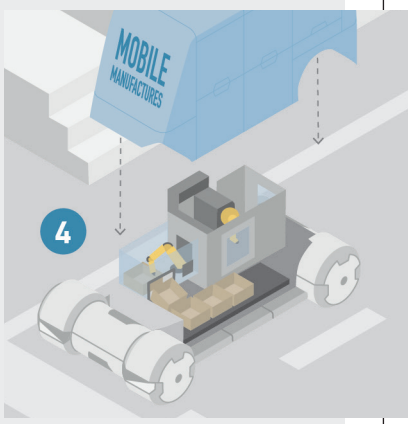
Once the family had made themselves comfortable, Carlos' wife Futura wanted the children to get some exercise before they ate. She had read about these new frisbees and decided on the spur of the moment to order some. ❿ Current stocks in the vicinity had sold out, so she ordered some to be produced by 3D printing in a print shop nearby. It may cost a bit more, but they will be ready in just 15 minutes. Because the weather is fine and to pass the time until the frisbees are ready, Carlos grabs the children and takes them on the short walk to the factory in the corner shop.

⓫ At the end of this pleasant evening, the family has to decide whether they will dispose of their trash themselves or whether they will pay a fee and have the City's cleaning robots do the job for them. Carlos and his wife think that a little more exercise will do their children good, so they decide to do their own trash removal on this occasion. When they finally get home, they are all so exhausted from the day's events that even the youngest collapses into bed without protest.

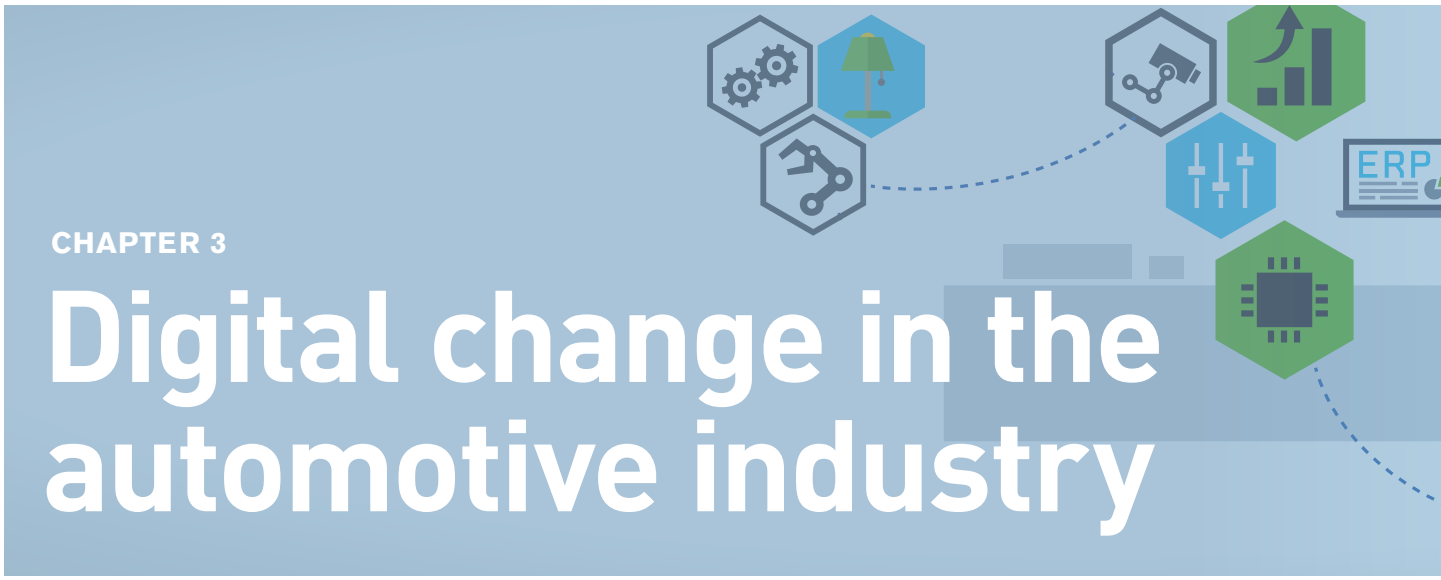
FlexProductions
- Owns autonomous manufacturing machines
- Specializes in the production of spare parts for mobility products
- Generates a production plan automatically from a design proposal
- Sub and final assembly of products
- Extremely flexible and optimum cost/benefit ratio



MobileManufacturers
- Production during delivery (linking of logistics and production)
- At present, however, only low-energy processes are viable (E-units with limited resources)



Mobility
- Commuter trains and metros run "on demand", there are no fixed departure times and no permanent bus stops either
- Train length, frequency and departure times are determined by demand
- Demand spikes and problems are identified in good time by linking different data sources and addressed using buses and robot taxis
- Routes and occupancy levels of individual vehicles are adapted to the traffic situation



CHAPTER 3

Digital change in the automotive industry

This chapter begins with a review of the current situation in automobile manufacturing. Particular attention is paid to technical software aspects and especially to architectures that the authors believe represent a significant foundation for future developments in automobile manufacturing.

3.1 Automobile manufacturing: the current situation

Compared to the extensive progress made at the functional level, the changes observed to date at the level of electrical/electronic (E/E) architecture are rather underwhelming. Manufacturers do not publish precise details of the advances adopted but although new approaches are being applied in a number of instances (Audi zFAS, BMW i, Tesla) and tested at relevant organizations, the predicted revolution has yet to materialize. Highly integrated systems are currently limited to just a few domains and their adoption cannot therefore be described as anything approaching a general trend. Even brands that are considered to be highly innovative and that actively leverage this reputation, such as BMW i and Tesla[29], are venturing nothing more in the field of E/E architecture than small-scale evolutions.

The consolidation and centralization trends identified in the 2010 study "Mehr Software (im) Wagen" are evident in some subdomains (see *Figure 6*). The study describes a complete centralization of architecture, but current developments point more to centralization at the level of intelligent driver assistance systems and autonomous functions. Interactions between these systems and functions are becoming increasingly important. Tesla's "Autopilot" feature is just such a centralized solution providing the ACC, lane departure warning system and blind spot monitor functions.[30] It does not, however, permit genuinely autonomous driving. The underlying layer of devices and control systems continues to be built on the established structures that have evolved over time.

The slow pace with which fundamental changes in architecture are being adopted can be attributed in part to the companies' established structures (Conway's Law) and the cost structures that permeate the OEM-component supplier relationship, which is still largely governed by the price per (hardware) unit (unit-based cost model).

29) http://electriccarsreport.com/2013/03/infographic-reveals-tesla-model-s-suppliers/
http://teslatap.com/undocumented/
http://www.dragtimes.com/blog/tesla-model-s-ethernet-network-explored-possible-jailbreak-in-the-future
http://www.teslamotorsclub.com/showthread.php/28185-Successful-connection-on-the-Model-S-internal-Ethernet-network
30) https://www.teslamotors.com/de_DE/blog/your-autopilot-has-arrived

3.1.1 Hardware architecture and integration

A number of manufacturers are currently working on the concept of the domain controller or domain controller architecture. A domain controller is a central control unit designed to take on the tasks of a multiplicity of devices within a specific vehicle domain. The most prominent example is the Audi zFAS.[31] The "central driver assistance control unit" brings preprocessing of vehicle environmental and telemetry data previously performed in a number of different controllers together in one place and provides a consistent environmental

Figure 6: Trend of actual and necessary complexity in E/E architecture[32]

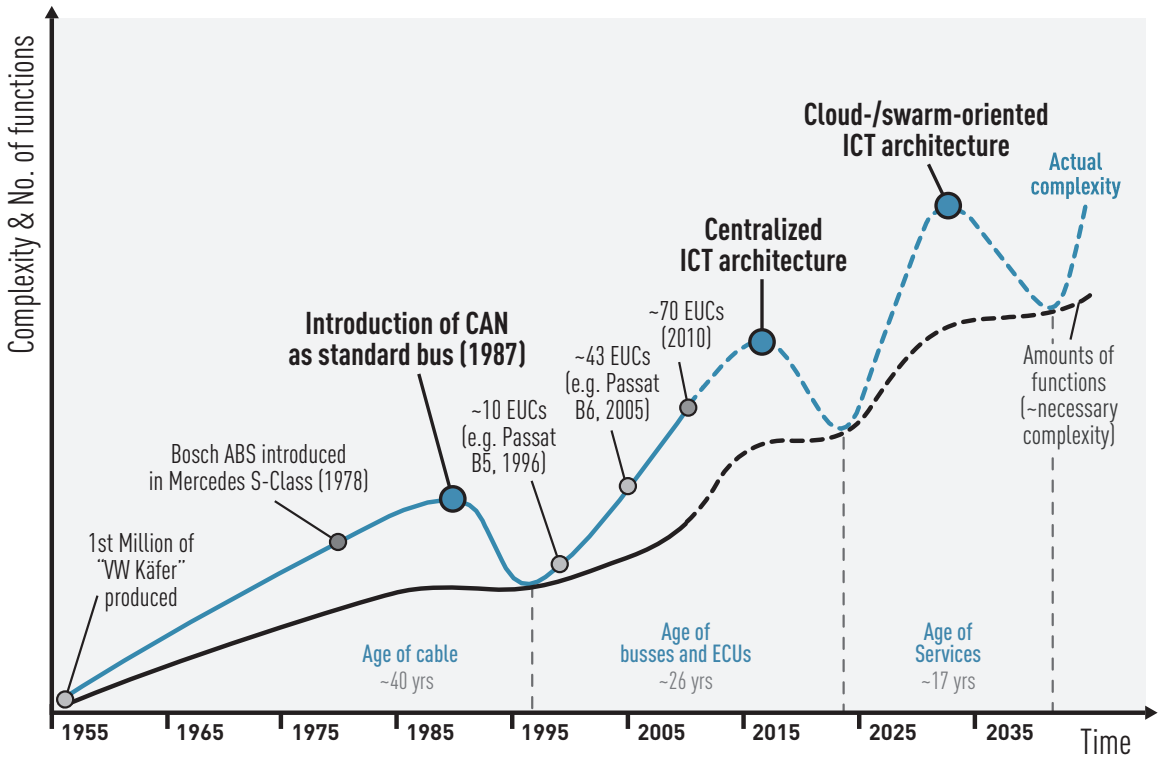


Illustration: © Mimi Potter - fotolia.de

31) http://www.audi.de/de/brand/de/vorsprung_durch_technik/content/2014/10/zentrales-fahrerassistenzsteuergeraet-zfas.html
32) Mehr Software (im) Wagen: Informations- und Kommunikationstechnik (IKT) als Motor der Elektromobilität der Zukunft, 2010 study, p. 48

model for all driver assistance functions. Centralizing data processing in this way removes the need in some instances to have multiple units of the same sensor type for different functions. The concept is restricted to individual domains at the moment, however, and the benefits have not yet begun to penetrate into other areas of the vehicle architecture.

Multicore applications too have now started to make inroads into automotive technology. Nvidia (the manufacturer of the zFAS CPU) in particular offers powerful multicore systems intended primarily for infotainment and HMI systems but also for more critical applications (like the zFAS).

The automotive industry is no closer to realizing the objective of homogenizing communication standards for the internal on-board network today than it was five years ago, although there have been promising trials with real-time Ethernet which is a fixture of car manufacturers' development plans for the next generation. Audi, for example, is using technology from TTTech to connect up the zFAS.[33] Otherwise, the industry continues to rely on a heterogeneous on-board network with CAN, LIN, Flexray, MOST and Ethernet (currently infotainment only). The use of Ethernet in addition to the systems already present only increases the level of heterogeneity.

An initial version of a standard for Car2x communication does now exist.[34] The new Mercedes E-Class (2016) marks the first time Daimler has explicitly marketed Car2x as a functionality forming part of the customer experience.[35] No standardized reliable, real-time capable protocol has been established with current technologies.

3.1.2 Architecture for software and middleware

While there are no obvious signs of disruptive changes having occurred in this area, manufacturers have come to appreciate the value of a highly developed runtime environment. Computer scientists and software developers are being appointed in increasing numbers and are also being joined by experts from the field of aviation brought in to give the automotive sector access to the principles and experience gained from the development of Integrated Modular Avionics (IMA).

Most controllers continue to use the established AUTOSAR and OSEK abstraction layers but the introduction of new hardware platforms and the domain controller concept is making the need for more advanced runtime environments ever more obvious.

The regulations pertaining to safety-critical functions, which are still regarded as highly complex as well as vital, mean that there is very little enthusiasm for plug-and-play at customer level other than in the infotainment area, in which the standardized interfaces provided by Android Auto and the proprietary Apple CarPlay have made it easy to integrate mobile devices and their functions into the vehicle architecture and control them using the operating options available in the vehicle concerned. Tesla has taken the first steps toward safety-critical functional enhancements with a software update applied after the vehicle has been sold that involves the installation of an autopilot function. Tesla does make it explicitly clear, however, that liability in the event of any incident lies with the driver.[36]

Configuring and protecting the functions and the middleware is a time-consuming manual task due to the lack of end-to-end specifications: requirements are specified differently – and often informally – in each sub-domain and much of the knowledge needed is held only by the implementing component suppliers. Creating a configuration at the level of a HiL (hardware in the loop) or SiL environment (software in the loop) would require a consistent model of the entire vehicle, but none exists. The task can therefore only be achieved by integrating all of the components (big bang integration) and gradually adapting them based on the developers' experience and best guesses. Ever more extensive integration of functions across domain boundaries is making this process ever more complicated.

A more detailed analysis of the forecasts from 2010 and the current situation is provided in the annex.

33) https://www.tttech.com/de/markets/automotive/projekte-referenzen/audi-zfas/
34) http://www.etsi.org/news-events/news/753-2014-02-joint-news-cen-and-etsi-deliver-first-set-of-standards-for-cooperative-intelligent-transport-systems-c-its
35) http://www.focus.de/auto/neuheiten/oberemittelklasse/neue-mercedes-e-klasse-2016-mit-sicherheit-gegen-audi-das-kann-die-naechste-e-klasse_id_4802609.html
36) http://www.spiegel.de/auto/aktuell/tesla-startet-autopilot-technik-per-software-update-in-den-usa-a-1057863.html

3.2 | ICT-driven change: electromobility

When the "Mehr Software (im) Wagen" study appeared in March 2010, electromobility was one of the hot topics of the moment. The study, while certainly noting the currency of the subject, found that the main reason for the anticipated rise to prevalence of this drive form lay elsewhere, with the authors actually basing their argument on the move to autonomy and the reduction in complexity required to achieve this. The central issue, in other words, was the question of which drive concept would integrate most effectively with a new software architecture to be developed in order to achieve better encapsulation of the system as a whole. This encapsulation was identified in the study as the critical step in achieving regulatory approval for autonomous driving.

The approach proposed was also intended to create the option of opening the vehicle up as a platform for external function developers (app developers) and thereby making it a part of a new, larger ecosystem. The electric drive, with its amenability to high-level integration – the capacity to address different functions readily via one software interface – is thus the logical choice.

One matter not considered in the 2010 study was the question of the future role of the vehicle itself. Is the vehicle to become a hardware platform (or another hardware platform) that – like the smartphone – is enabled by software to perform a variety of functions? This would make the (autonomous) transport of the vehicle occupants just one "app" among many in the same way as a smartphone is also still able to make telephone calls. Or is the vehicle essentially to become a part of a logistics ecosystem in which the variability of the interior and its autonomous capabilities play the decisive role? Or is the future perhaps to be a hybrid of the two? The following sections attempt to provide some initial tentative answers to these questions.

3.2.1 Changes in the vehicle ecosystem

An answer to the questions posed above was sought by investigating which companies already interact with a vehicle. The clear message from *Figure 7* is that the companies whose primary concern is vehicle development and manufacture are under pressure from an ever increasing number of companies with roots in completely different domains.

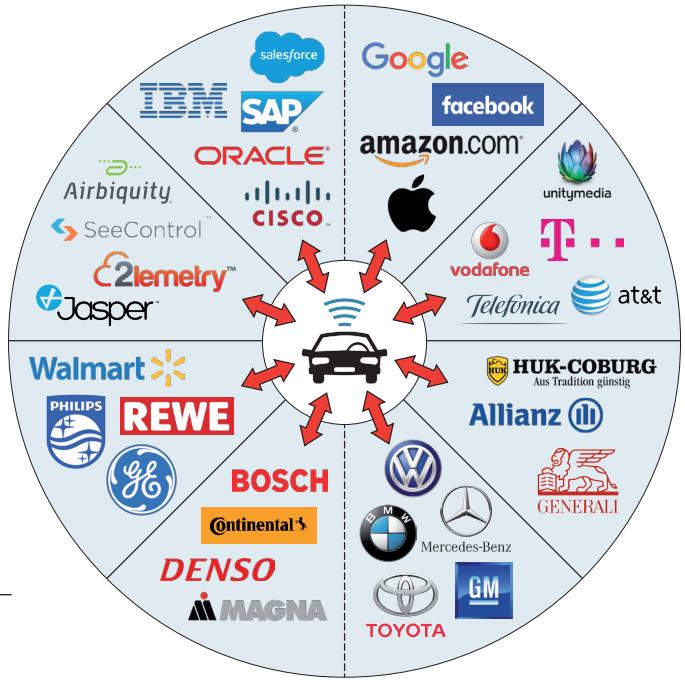


Figure 7: Connected car ecosystem[37]

37) Based on Desai (2015) referenced at the "Software Defined Car and Big Data for Automotive" event (http://www.meetup.com/ConnectedCarSF/events/223988011/)

The IT companies include a group that provide Internet of Things (IoT) including connection to the cloud and data analysis as a service, another that specializes in enterprise resource planning (ERP), databases and network components, a third comprising large companies that operate close to the end customer and primarily provide internet-based services such as social media, e-commerce, search engines, media content, smartphones, etc. and a final group contains the providers of mobile and fixed communication networks.

The composition of the different categories aside, the figure makes it abundantly clear that the automobile can no longer be regarded as an isolated entity. Assuming that each of the new companies moving into this area hopes its participation will yield a new source of income in the long term, a significant change in the distribution of value added appears inevitable. How the distribution will evolve in future and whether the automotive industry will be among the winners or the losers is still entirely uncertain.

The following two subsections consider how this shift in the value added distribution might be influenced by the changed role of the vehicle.

3.2.2 The vehicle as hardware platform

The interest that many internet platform operators have in developing the automobile in the direction of an autonomously-driven computer hardware platform can be explained in large part by their business model: like a shopping mall, they would like to see customers spend as much time as possible in their ecosystem and use their services to meet a diverse range of needs. Unlike a shopping mall, however, these companies record every action and evaluate it in order to provide an even more personalized user experience.

The average driver spends an hour a day in his/her vehicle according to current figures.[38] If the car could drive itself, this hour could be spent with the platform operators' propositions instead and of course the physical presence of the car offers a completely different set of content presentation possibilities to a smartphone or tablet. The quintessential mobility of the automobile too opens up new options for interaction with the physical world, from augmented reality as part of a sight-seeing tour, for example, to traveling restaurant following a short stop-off at a favorite food supplier.

Each of the examples listed offers additional potential sources of income for the internet companies, which explains why it is so important to them to occupy this customer interface as exclusively as possible. As various Android Car or Apple Car press releases that mention contractual negotiations with the automakers demonstrate, the battle for this interface is already under way.[39] Generally, however, the automakers are proving unwilling to allow full access to vehicle data in the belief that they too will be able to derive significant value from this data in the future.

The extent to which this closed door has encouraged companies like Apple and Google to launch their own vehicle projects and try to outflank, or at least apply pressure to, the established players is certainly a question worth pondering in this context. The fact remains, however, that the internet companies began some time ago to bring hardware to market in their own name in other areas.

Amazon, a representative of the digital platforms, has a wide range of such devices in its portfolio, including the Kindle, FireTV and the Echo,[40] and Facebook (Oculus Rift) and Microsoft (Xbox), for example, are following a similar strategy. One feature common to all of these propositions is that they are closely tied in to the virtual functions or products of the digital corporations in a way that enables them to control who is able to participate in their ecosystem. Ultimately the hardware serves merely as a bridgehead to the virtual world, with the effect that the more customers buy the hardware, the more transactions take place in the virtual world. It is not the hardware that earns the companies their money, but rather the sales that take place using the hardware.

The approach favored by the internet companies requires them to sell as many units of their hardware as quickly as possible. One obvious way to do this is to combine a low price with the strongest possible functionality and quality, a strategy they apply consistently across their current products, sometimes even offering the hardware for less than the cost of production.

This principle is hardly new, having been around at least since Rockefeller's Standard Oil company began

38) http://auto-presse.de/autonews.php?newsid=97075
39) http://www.cnet.de/88164352/ford-sync-3-mit-android-auto-und-apple-carplay-kommt-im-sommer-nach-europa/
40) http://www.netzpiloten.de/amazons-hardware-strategie-gib-ihnen-kindle-verkauf-ihnen-e-books/

selling oil lamps cheaply (or even giving them away) in order to concentrate on selling the oil needed to fuel them. The big difference is that the marginal costs for virtual goods are much lower than the marginal costs for oil-powered products and investment in hardware consequently pays for itself even faster. IT companies and many internet companies have now become such strong brands, moreover, that people will trust them to make a success even so far removed from their core field as making cars.

When platform operators look at the automobile, they see an attractive hardware platform through which to sell even more virtual products or services and can therefore be expected to keep on pushing the evolution of the automobile in this direction.

Success for the platform operators in this area is predicated on the car becoming autonomous (see Google Car). Platform operators also want to know as much as possible about the driver and the context in which the vehicle operates, as this is vital in order both to tailor offers perfectly to the customer and to derive new business models from the data. These companies need access to all relevant vehicle data, in other words. Finally, they also want the vehicle to be offered to the end customer at a low price so that this new platform quickly becomes as widespread as possible.

The potential impacts of this on the vehicle and the automotive industry are discussed in the final subsection. The following section looks at the factors that make the vehicle part of a logistics ecosystem.

3.2.3 The vehicle as part of a logistics ecosystem

The technology of autonomous driving and Car2x communication is a key factor to consider in the context of logistics systems too. The previous subsection considered the situation assuming that the vehicle was a personal possession of the user. The present subsection shifts the focus to carsharing. The wide range of possible driving factors behind carsharing have been pared down to just three examples that are particularly topical at the moment.

- **Use instead of ownership:** More and more people are looking to reduce their mobility costs by only paying for the time for which they are actually using the mobility platform.
- **Car-free cities:** Sanctions against private vehicles are increasing as residential, leisure and commercial space grows ever more crowded, especially in major cities.
- **Sustainable mobility:** Fewer vehicles means lower resource consumption, but with individual vehicles lasting longer and modular concepts ensuring the benefits of technical progress can still be enjoyed.

The profitability or otherwise of carsharing schemes for their operators is difficult to clarify. Where losses are acknowledged, this has generally been justified on the grounds of boosting brand recognition and customer loyalty in support of the core business. Operators also speak of the potential to use the data collected via the platform as a basis for effective new business models.

The possibility of state subsidies aside, the question thus arises of what other ways there might be to make the carsharing model financially attractive and what technologies this would involve.

- **Cross-financing with other services:** One example has already been mentioned in the context of the automobile manufacturers. Another involves the marketing of user data and environmental information or exploitation as an advertising platform.
- **Dynamic travel cost adaptation:** The higher the level of demand there is for the service, the higher the price for the space a user occupies in the vehicle. Users then have a choice of either paying more to travel or accepting additional passengers.
- **Maximum utilization of the asset:** As in freight transport and manufacturing, the asset should ideally be utilized 24 hours a day, seven days a week. Among the implications of this are that the interior should be as flexible as possible so that the vehicle can transport freight as well as people.

These possibilities can also be combined to good effect. Realizing most potential business models, however, requires extensive technical capabilities. Many of the aforementioned IT and internet companies are already bringing to the field the very expertise required.

Companies like Google, Facebook and LinkedIn are well-placed to cross-finance carsharing with other services, in particular advertising and user data market-

ing, thanks to their capable existing technical infrastructure, multi-channel access to end customers and highly developed analytical software. These strengths put them in a position to devise a closed user experience, for example in the form of a digital leisure time manager, and they are also able to use their existing digital assets to process the vehicle data.

The latter capability in particular gives them the potential to develop, at minimal additional cost, new data-based propositions that need not necessarily revolve around the vehicle. Google's Maps and Street View are good examples of this type of offer. Building on this idea, it is not difficult to imagine a Google carsharing fleet that uses every journey to bring its data fully up to date and utilize this information in multiple ways for marketing purposes.

The second model, "dynamic travel cost adaptation", is already used by Uber (for example with UberPOOL, which enables multiple users to share a vehicle).[41] Uber, moreover, appears convinced that its business model would thrive even better with autonomous vehicles, at least that would be one explanation for the remark by its CEO that if Tesla could produce 500,000 autonomous vehicles in 2020, he would want to buy all of them.[42]

Another possible explanation for this desire to acquire such a large number of autonomous vehicles might very well reside in concerns at Uber about the threat posed by potential competitors. No matter how smart Uber's algorithms are and how many users it has, it remains very easy to imagine Facebook, with its technical capabilities and huge user base, making serious inroads into this market with no real difficulty. The challenge for Facebook would probably be much tougher though if Uber were to be in control of its own fleet of autonomous vehicles. Uber has also made it clear that it wants to use its fleet to transport goods as well as people, which leads on to the third possibility for generating a profit through carsharing.[43]

This third possibility is of great interest to all companies with a business model based or dependent on logistics services. The potential of small autonomous mobility devices the size of a passenger car ranges from consumption-driven continuous supply to the retail sector to 24/7 home-delivery and pick-up. The advantage here rests with the companies that have the most thorough understanding of which consignments are available where at what time and to where and by when they need to be delivered.

The ability to wring precise conclusions about future demand from the data confers an even stronger advantage, allowing the time needed to respond to requirements to be reduced further. Companies like Amazon are especially well-placed in this respect, as their platform is used by suppliers and customers alike. Amazon thus not only has the ability to calculate the optimal vehicle assignment and route very quickly, but also, most significantly, knows what the packages contain.

This knowledge combined with the right analytical tools puts internet companies in a position to load into the vehicle for each route, on an individual basis, articles that have not yet even been ordered at the time. These companies will give preference in this to articles in relation to which customers are prepared to pay more for faster delivery. Other logistics service providers do not ordinarily have this knowledge, which gives internet companies like Amazon a competitive advantage in this respect.

The importance attached by Amazon to speed of delivery is evidenced by its current activities, from experiments with delivery by drone[44] to the development of its own fleet of vehicles[45]. Bearing these factors in mind it would be far from surprising to see such companies either collaborating closely with the operator of a carsharing fleet or acquiring a fleet of their own. In the latter case, transporting people would probably be the secondary source of income targeted to improve vehicle utilization.

It can be seen that there are various ways to develop carsharing into a successful business model and that transporting people for a fee is just one of several ways to finance the operation. All of the options discussed have one aspect in common, however, which is that data and its accurate interpretation play a central role. The success of this type of proposition has many benefits from the point of view of the internet companies: they learn even more about the user, gain an opportunity to offer the user other digital propositions and are able to implement their core business even more efficiently.

As already mentioned on multiple occasions, a carsharing vehicle is regarded in most cases as a machine that must at least pay for itself (acquisition and operating costs) over the course of its lifecycle. These eco-

41) https://www.uber.com/de/ride/uberpool/
42) http://www.greencarreports.com/news/1098997_uber-ceo-to-tesla-sell-me-half-a-million-autonomous-electric-cars-in-2020
43) http://www.welt.de/wirtschaft/article148014478/Uber-will-bald-auch-Essen-und-Pakete-fahren.html
44) http://www.handelsblatt.com/unternehmen/handel-konsumgueter/prime-air-mit-mini-drohnen-achtung-da-kommt-ein-amazon-paket-geflogen/9155732.html
45) http://www.spiegel.de/wirtschaft/unternehmen/amazon-eigener-lieferdienst-soll-dhl-ups-nicht-ersetzen-a-1074568.html

nomic considerations place quality factors such as reliability, longevity, ease of maintenance and low energy consumption center stage. Electric drive units have particular strengths in these areas, being not only virtually wear-free and, thanks to their modular design, very easy to maintain, but also sufficiently flexible in their construction to permit flat versions enabling a highly versatile vehicle interior space.

The extra freedom thus gained in design opens up entirely new vehicle concepts: with no hood, gearbox or exhaust system to be accommodated, designers are able to target an optimal ratio of usable space to footprint. While welcoming all of these advantages, platform operators will also want to see IT equipment that not only is as suitable as possible for future enhancements, but also provides transparent access to the available sensor data. Only with these additional prerequisites in place can these companies achieve the high level of flexibility they want for current and future business models.

The next section compares the two future roles identified for vehicles before going on to consider what the results of the comparison suggest for the future of electric vehicles and vehicle manufacturers.

3.2.4 How ICT is changing the role of the vehicle

All of the considerations addressed above presuppose vehicles that are able to travel autonomously – with no human intervention in the driving function – even in an urban environment. It is anticipated that vehicles with the requisite capabilities will become available at some point between 2020 and 2035. The first real indication that truly autonomous vehicles were a realistic prospect for the not too distant future came in 2010, when Google announced publicly that its vehicles had already traveled more than 100,000 kilometers autonomously. [46]

Google's interest in autonomous vehicles remains as strong as ever and if the rumors in the press are to be believed, it is now actively searching for a manufacturing partner. Apple too appears to have serious intentions in the area of vehicles [47] and Tesla is already selling cars and offering semi-autonomous functions as a software update. There are two factors common to all of these examples: all of the companies have their core business in the ICT sphere or, as in the case of Tesla, a very strong IT background and all of the vehicles have a fully electric drive system.

So which role will prevail, that of the traditional automakers or that of the internet companies? And who will gain most from the development?

It seems likely that the two roles will develop in parallel. One group of users will continue to maintain a vehicle of their own and be prepared to invest accordingly. The number of people using carsharing models will increase, especially in the cities, with carsharing becoming the dominant alternative in the long term. How the relationship between these two roles will develop cannot readily be foreseen, but the situation will probably end up resembling that in existing markets. Today's smartphone market, for example, shows an 80/20 percent split between Android (mass market) and iOS (premium), while in the automobile market the volume segment has an 88 percent share, the premium segment a 12 percent share.

Technological developments can be expected to benefit the digital platform providers most. One reason to suppose this is that the automotive industry and its means of production produce **one** product that addresses **one** specific need of its customers whereas the data-driven companies are able to use the same means of production to offer **multiple** products simultaneously to satisfy a **variety** of requirements. The automotive industry relies on the vehicle itself to earn its return, but the internet companies see the vehicle as just one more channel through which to support their core business without significantly increasing their costs. They do not necessarily need to make a return on the actual vehicle and could therefore make it available at a price equal to or even less than their marginal cost.

Their core competency of processing huge volumes of data to obtain forecasts of future trends and required functions gives the internet companies another advantage, as it enables them to adapt very quickly to new customer requirements and refresh their value proposition continuously. The automakers could not level the playing field in this respect without either building up/buying the requisite resources and expertise or engaging an external service provider.

46) http://www.nytimes.com/2010/10/10/science/10google.html?_r=0
47) http://www.spiegel.de/auto/aktuell/google-und-fiat-chrysler-produzieren-zusammen-selbstfahrende-autos-a-1090732.html

The case of mapping services provider Here provides an excellent example of how this might work in practice: the upfront cost of developing an equivalent service in-house would have been too high, so a group of automakers clubbed together to buy the company instead. Significantly, this particular example concerns "just" a mapping service. The purchase of Here was intended in part to help the companies involved close the gap on Google in the area of the high-precision maps required for autonomous driving.

The current Opel Astra model clearly demonstrates the great importance now attached by drivers – across all vehicle classes – to assistance functions realized using software.[48] Studies from Daimler and announcements from BMW go one step further to define the autonomous vehicle more as a well-appointed private cinema.[49]

The digital platform providers would view this development by the automakers as the creation of an interface with which to control access to the customer and their inevitable next step would be to buy content (movies, TV series, music, news, etc.) and sell it on via their platform to the occupants. The creation of a digital sales platform for software products (an app store) that can be operated from inside the vehicle would also be conceivable.

The critical question is, would customers who already pay for streaming offers from Netflix, Amazon Prime, Apple Music, etc. be prepared to enter into another contract with a car manufacturer, especially if they are used to having access to these services from any device?

There has to be some doubt as to whether the number of vehicles produced by each manufacturer every year would be adequate to attract a sufficiently large number of app developers to make the app store element work. Winning app developers away from the competing attractions of the enormous smartphone app market would not be easy: in the last quarter of 2015 alone more than 300 million Android devices and more than 70 million iOS devices were sold.[50] Total vehicle sales across all car manufacturers in 2015 amounted to around 72 million units.[51] Annual vehicle sales are growing at an average rate of four percent worldwide; the equivalent figure for smartphones is ten percent.

It could be argued, on the other hand, that there are already around one billion vehicles on the road around the world and that taken together these constitute an attractive target for software developers. Even if all of the automakers around the world could agree on a single common data interface to display and integrate apps, however, it would still take at least ten years for the new technology to reach all users. These numbers have to be viewed in the context of the estimated 2.56 billion smartphones that will be in use in 2018.[52]

The foregoing suggests individual automakers are unlikely to be able to establish a commercially successful proprietary app store, which leaves them with just two options: either they develop the apps themselves (possibly with the aid of component suppliers) or they allow in the Android or iOS platform.

The first scenario is potentially problematic on account of the fact that customers expect the function/app acquired to be their own property to take with them free of charge as and when they change vehicles, at least provided that they remain with the same brand. Accepting this model would ultimately require the automakers to wave goodbye to the "special editions" so cherished by German manufacturers in particular. The second scenario would unavoidably involve automakers having to concede a share of their value added to one of the major digital platform providers. Whether they would then still be able to provide the aforementioned content services independently of the platform used remains to be seen.

Digital companies have a number of inbuilt advantages that are putting the car manufacturers under pressure, not least the structure of the automobile market and the fact that electric drive systems are now sufficiently mature to replace the internal combustion engine. The key factor in favor of the digital companies, however, is that the basic mechanical knowledge required to build a car is universally available. The automotive industry, moreover, involves a highly differentiated supporting component supplier and engineering sector under considerable cost pressure which already accounts on average for over 70 percent of the added value in a vehicle, and contract manufacturers that already produce different vehicles in large numbers for familiar brands.

The increasing availability of high-quality electric drives paves the way to reduced vehicle complexity, lowering the barrier to entry for new providers. This development is putting the squeeze on established suppliers and creating very significant financial pressure, as they now have to remain competitive across three different drive concepts (IC, hybrid, full electric). The Tesla story shows how relatively simple it has

48) http://der-autotester.de/opel-astra-sponsored/
49) http://www.handelsblatt.com/unternehmen/industrie/100-jahre-bmw-ein-auto-mit-fischartiger-aussenhaut/13065188-2.html
50) http://www.pcworld.com/article/3035100/phones/android-leads-and-windows-phone-fades-in-gartners-smartphone-sales-report.html
51) http://www.gbm.scotiabank.com/English/bns_econ/bns_auto.pdf
52) http://www.emarketer.com/Article/2-Billion-Consumers-Worldwide-Smartphones-by-2016/1011694

become for a specialized new entrant to launch an electric vehicle successfully.

Another interesting example, this time from the logistics market, is that of StreetScooter[53], which has been able to develop a mass-produced electric vehicle successfully in just six years with a fraction of the budget of Tesla and was bought by DHL in December 2014. The most remarkable aspect of this second example is that a startup managed to beat every single one of the established manufacturers in the DHL bidding process.

Perhaps, however, it is not actually essential for each manufacturer to do everything for itself. The overcapacity in the global market and the resulting price competition could well persuade one automaker or another that making vehicles for Google, for example, is a good way forward.

The combined effect of all of these different factors in their favor is that the digital platform providers can afford to keep all of their options open when considering how to approach this market segment. If the automakers deny them access to the vehicle information they seek, they have plenty of scope to enter the market themselves both directly and indirectly. If, on the other hand, they are able to gain full access, they will effectively relegate the vehicle manufacturers to the status of mere hardware suppliers in the medium term, in the process almost certainly triggering even tougher price competition.

One collateral beneficiary of all of this could be the automobile component supplier industry, which has been accustomed to performing at a high level under enormous cost pressure since the 1980s but has accrued a vast wealth of in-house expertise at the same time. The component supplier industry, moreover, is much more highly consolidated than the automobile manufacturing sector and could thus provide an effective counterbalance to the monopoly structures of the digital platform providers.

53) http://www.streetscooter.eu/

CHAPTER 4

Current situation and trends in the principal domains

The march of digitalization is shaping our age. New information and communication technologies and changed customer expectations are revolutionizing markets and putting existing business models under pressure. The International Institute for Management Development (IMD) and Cisco predict in a study[54] that an average of four of the ten highest earning companies in each sector at the moment will have dropped out of the top ten by 2020 as a result of ICT-driven change.

This section begins by briefly summarizing the most influential factors in automobile manufacturing and describing certain fundamental changes in the domains of mechanical engineering and logistics. These initial considerations are followed by an analysis of the interviews conducted around the world to investigate the general state of understanding of ICT-driven change and, in particular, of digital disruption and of drivers and implications for the relevant sector.

4.1 Automobile manufacturing, mechanical engineering and logistics – an overview

4.1.1 Automobile manufacturing

This is a time of great upheaval in the automotive industry. New technologies such as the electrification of the power train, the automation of driving and vehicle integration are changing the face of the sector, with digitalization facilitating and promoting the exchange of information with the infrastructure in the direct environment of the vehicle and with other vehicles.

New players have established themselves in the market too, not least Tesla Motors, which has designed and successfully marketed vehicles with an all-electric power train in a very short space of time.[55] Other new competitors are preparing to bring largely automated or even autonomous vehicles to the market over the next few years, some in cooperation with established manufacturers (as in the case of the recent announcement from Google and Fiat-Chrysler). Although Google[56] and Apple are companies mentioned most often in this respect, other names including Faraday Cars[57], which is backed by Chinese investors, and European companies such as Next[58] are also breaking into the market. Also helping to shake up the mobility sector are other players pursuing new business models enabled by digitalization, for example Uber.

These newcomers to the market are putting pressure on the established automakers in part through their consistent promotion of the sharing and collective use of vehicles, which reduces primary demand (companies such as BMW and Daimler have already respond-

54) IMD/Cisco (2015): Digital Vortex. How Digital Disruption Is Redefining Industries: http://www.imd.org/uupload/IMD.WebSite/DBT/Digital_Vortex_06182015.pdf
55) http://www.manager-magazin.de/unternehmen/artikel/tesla-aktie-im-hoehenflug-60-prozent-kursplus-in-7-wochen-a-1085372.html
56) http://www.spiegel.de/auto/aktuell/google-und-fiat-chrysler-produzieren-zusammen-selbstfahrende-autos-a-1090732.html
57) http://www.faradayfuture.com
58) http://www.next-future-mobility.com

ed to this threat with carsharing initiatives of their own, including Drive and car2go), and in part through their widely publicized initiatives for electromobility (Tesla) and autonomous driving (Google), which have enabled them to stake out future markets at an early stage and claim ownership of these new forms of mobility in the customer's mind. The traditional manufacturers, in contrast, are still very closely associated with their competence in respect of traditional vehicles. Furthermore companies like Uber are pushing business models that have the potential to relegate automakers to nothing more than interchangeable contract manufacturers. Also counting strongly in these companies' favor is the fact that they are able to try out new technologies without historical baggage or fixed customer expectations in terms of quality and reliability. Some of the interviewees also stressed that the financial resources at the disposal of the newcomers, both those newly created and those crossing over from other sectors, would dwarf their own R&D budgets.

The technological innovations made possible by digitalization and the associated new business models and value creation networks thus represent a massive challenge for the established companies in Germany. Several interviewees from the automobile manufacturing industry believe these factors have the potential to produce disruptive change in the automotive industry sufficient to place in question the whole future of structures, technologies and business models that have been evolving for over a century.

It is clear from dozens of recent studies, press releases, keynote addresses and discussions at relevant trade fairs and conferences that many senior managers in the automobile manufacturing and component supplier industries are well aware of this threat. Daimler, for example, is investing in "startups and technology companies that offer mobility concepts other than traditional car sales" and aiming, not least through Moovel, to become the "Amazon of mobility".[59]

4.1.2 Mechanical engineering

Short product lifecycles, volatile markets and relatively small batch sizes are increasingly becoming the name of the game in industry automation and the associated mechanical engineering sector.[60] These trends have been particularly strongly in evidence at times of crisis such as the period from 2008 to 2010, during which existing production approaches did not cope at all well with the wildly fluctuating unit numbers requested. Requirements have changed as a result: machinery and plants are now expected to be significantly more flexible, production processes to offer a greater degree of autonomy and production to be horizontally and vertically integrated for better coordination of machines and better integration of machines into the overall system landscape. Putting these prerequisites in place makes it possible to change the products being manufactured quickly with the minimum amount of setup work. 3D printing, sensor and network technologies, artificial intelligence, sensors, autonomous robotics and, increasingly, drones and nanotechnology – to name but a few examples – have radically changed industrial manufacturing, making it both faster and more

59) Der Daimler-Chef duelliert sich mit dem Taxi-Schreck, in: Welt.de, March 30, 2016: http://www.welt.de/wirtschaft/webwelt/article153807044/Der-Daimler-Chef-duelliert-sich-mit-dem-Taxi-Schreck.html

60) These trends are increasingly being fueled in particular by demand from customers for custom solutions; (digital) technologies that significantly simplify individual configuration of products and processes (cf. Industry 4.0); bigger fluctuations in demand that can make the ability to cope efficiently with even the smallest production runs essential.

flexible. Some of these technologies and approaches have been known for 20 or 30 years, but have only recently been widely adopted as very powerful, highly miniaturized computing systems have become available and affordable.[61]

A number of elements and variants of the scenario outlined in Chapter 2 have already become reality. This scenario, referred to more generally in the manufacturing world as Industry 4.0, is concerned with the enhancement of production and value creation systems by linking the real and digital worlds using cyber-physical systems (CPS).[62] Industry 4.0 describes the vertical (within a company) and horizontal linking of these CPS for the efficient, locally organized and flexible manufacturing of products and the performance of services spanning both multiple corporate units and different companies along the value chain. The objective is to make it possible to manufacture small bespoke batch sizes with precision for the same cost as mass production.

The Internet of Things (IoT) is closely tied up with the Industry 4.0 concept and similarly creates a new set of possibilities for automation. Machine-to-machine (M2M) communication enables improved coordination and flexible sequential control of production processes and paves the way for automated monitoring of technical systems. Production data and diagnostic information can be provided directly to the management systems to help operators gain a better understanding of the production process, improve production process monitoring and analyze and, where applicable, directly control the use of technical products (maintenance, updates). Modular self-managing machines are increasingly coming to dominate the production landscape. Companies from other industries, including IBM, Intel and Cisco, have recently begun to move into the manufacturing sector, joining with telecommunication companies such as Deutsche Telekom, Huawei and Alcatel to create an M2M communication consortium with the intention of establishing new standards and specifications for M2M communication.[63] Other well-known companies have partnered with the Fraunhofer Society and the relevant German government ministries to launch the Industrial Data Space initiative, which aims to create a secure data space that will enable sovereign management of data assets for companies of all sizes from different sectors.[64]

The vastly increased level of communication between machines is expected to yield much-enhanced potential for self-optimization. Measured values are recorded wirelessly, for example, and forwarded to a cloud solution via the mobile network. The cloud solution provides a wide range of functions for analyzing, processing and comparing the data acquired. Such cloud solutions are available from companies including LineMetrics[65], for example. This approach increases the amount of software and the level of integration within and between machines dramatically.

Overall, the trend described is driving a change in mechanical engineering that companies will have to master in future simply in order to survive. Traditional mechanical engineering companies are transforming themselves into software houses with connected manufacturing. Just how profound the impact of a disruptive change can be is demonstrated by the still very current examples of the German textile industry and the printing machine manufacturing sector.

4.1.3 Logistics

Service providers are assigned to logistics types based on the company profile and range of services marketed (cf. *Figure 8*). Unlike fourth-party logistics providers (4PL) and application service providers (ASP), third-party logistics service providers (3PL) have their own facilities for transport, cargo handling and warehousing. 4PL providers do not have their own trucks, warehouses or cargo handling sites and instead just provide their expertise, for example in fleet management. Information and data intensity in the logistics value creation process generally increase from level 1 to level 4, whereas the asset and capital intensity of the respective business approach generally decrease. This means that ultimately, integrated data and information systems control the logistics processes and that logistics is essentially a data-driven business. It follows from this that ICT-linked change has a particularly big impact on logistics.

The boundaries between supply and value chains and between logistics and production are fluid already and becoming evermore so. The number of logistics ser-

61) According to a study by Nordhaus, the computing power available per working hour increased over the 20th century and up to 2005 by a factor of 10 to the 12th power, while costs for the provision of computing power fell at at least the same rate (p. 142, p. 157). Nordhaus (2007): Two Centuries of Productivity Growth in Computing, in: Journal of Economic History 67, 1, p. 128–159: http://www.econ.yale.edu/~nordhaus/homepage/nordhaus_computers_jeh_2007.pdf
62) http://www.plattform-i40.de/I40/Navigation/DE/Industrie40/WasIndustrie40/was-ist-industrie-40.html
63) http://www.onem2m.org/membership/current-members
64) cf. Fraunhofer (2016): Industrial Data Space: http://www.fraunhofer.de/de/forschung/fraunhofer-initiativen/industrial-data-space.html
65) https://www.linemetrics.com/de/

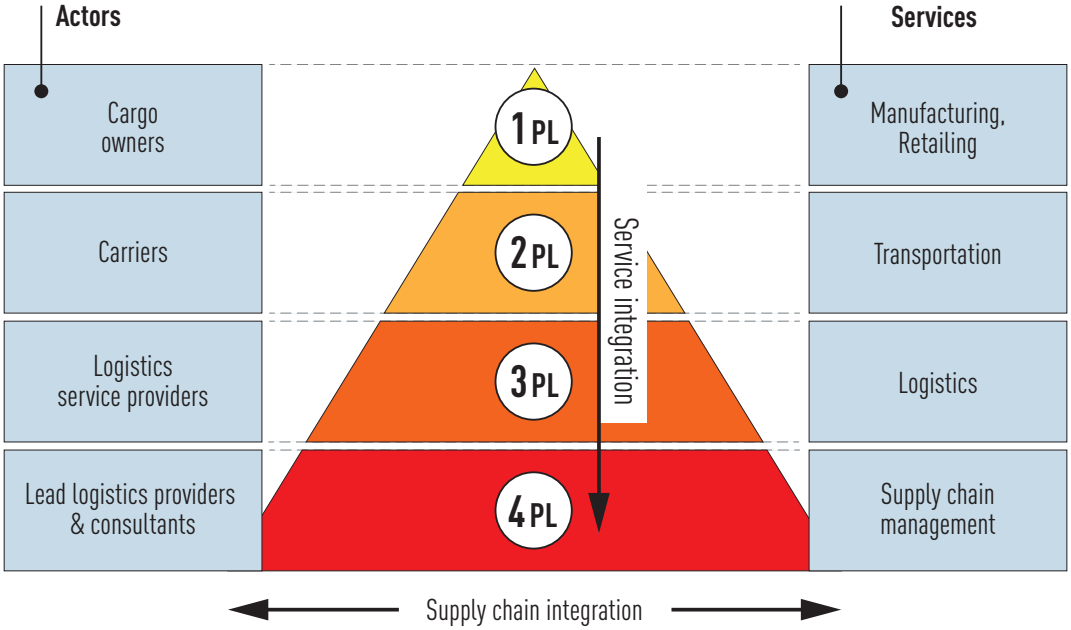


Figure 8: Structure of the logistics market [66]

vice providers taking on traditional manufacturing tasks is growing. Pre-assembly and final assembly are increasingly being taken on by companies that have previously only been responsible for transport and storage and the number of products and semi-finished products assembled or manufactured by logistics service providers is growing all the time [67].

The increase in online retail activity is further blurring the lines between retail and logistics. The product lifecycle is undergoing very pronounced change not just at the beginning, but also at the end: return and recycling initiatives, which make it possible to close material cycles and remove harmful substances safely, open up an increasingly attractive market for logistics service providers, especially with raw material and recycling costs rising.

Companies are also keen to enhance their transport efficiency, reduce their environmental impact and safeguard supplies. Logistics is first and foremost a matter of information logistics (just in time, just in sequence, optimization of fleets, routes, storage areas, etc.) and consequently has much to gain from the technical possibilities of ICT. Increasing levels of integration and digitalization in the transport sector, for example, make it possible to realize new approaches for solving the challenges of expanding transport flows. Such new approaches include not just the IoT and intelligent traffic management systems for road transport, but also intelligent autonomous means of transport, of which autonomous automobiles and drones [68] are emerging as the most interesting options.

There are strong indications that self-driving vehicles are being adopted much faster in intralogistics than in other industrial domains. [69] This can be explained in part by the limited regulations and low technical safety requirements pertaining to vehicles traveling in secure private zones. Unless hazardous materials are involved, moreover, liability concerns are much less of an issue when transporting goods than when transporting people. Intralogistics in warehouses and container terminals aside, analysts expect many more future applications along the overall value chain from field logistics to route planning (for example assisted conveyance using goods cars) to last mile delivery using autonomous shared vehicles or in the form of self-driving packstations or packages.

New companies have joined the global corporations and regional and local specialists of the logistics and package delivery markets in recent years. Most of them are "career changers" offering logistics services

66) Adurkar (2014): Study of Overall 3rd Party Logistics at Origin Logistics Pvt. Ltd.: http://de.slideshare.net/ajinkyaadurkar9/project-report-on-3rd-party-logistics
67) Prefabricated items such as rod and sheet.
68) D'Andrea (2014): Can Drones Deliver?, in: IEEE Transactions on Automation Science and Engineering 11, 3, p. 647f.: http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6827242
69) DHL Trend Research (2014): DHL Self Driving Vehicles in Logistics.

as a secondary business line and some are even crowdsourced.[70] The dynamic and flexible services offered by customer-to-customer delivery ventures (for example MyTaxi, mitpackgelegenheit.de) have managed to create a real alternative to traditional delivery business in the first and last mile.

These developments mean more competition for the traditional providers, but also give them the opportunity to capitalize on the capability and capacity of the new professional and non-professional service providers and outsource elements of their business cost-efficiently to the crowd.[71] Crowdsourcing has already generated a wealth of innovative solutions here just as in other sectors of industry (such as the share economy in the automotive industry). DHL's MyWays solution, for example, allows package recipients to have their delivery made at the time of their choice. It is based on a service provided by neighbors.

Another solution involving DHL and Audi that entered the testing phase in 2016 provides for the owners of the Audi pilot vehicles to allow DHL drivers temporary keyless access to the trunk. The service envisages the delivery operative opening the recipient's trunk at a specified point in time, placing the package inside, closing the trunk again and then continuing on to the next delivery.[72]

There is much speculation about 3D printing too. According to publicized scenarios, variable 3D printers could soon be available in every home, or at least as a service facility in every neighborhood, and will be able to print anything from food to children's toys to furniture and replacement parts. Such a scenario would transform the playing field for logistics, with a dramatic drop in finished product deliveries and a corresponding increase in deliveries of special materials. Automotive industry component suppliers and mechanical equipment manufacturers are already making more and more use of 3D printing in production, but the possibilities for 3D printing in the private home remain quite constrained due to the great technical complexity of the printing process. One problem is the wide range of different printing materials that have to be kept available for the many different fields of application. Budgets and the restricted space available are also still limiting the range of feasible applications in private households. If these scenarios do become a reality, however, the focus of logistics would shift very much to the transport and storage of printing materials – a change that would have enormous implications for the logistics sector's share of value added.

In the medium to long term, however, 3D printing technology has the potential to drive the transfer of production processes from the national and international space back to the regions and cities. Resource-efficient manufacturing close to the customer in the expanding major conurbations is becoming ever more important due to the problems associated with long transport routes and increasing traffic density. Logistics giant UPS wants to expand its existing business with external service providers and, in future, transform storage facilities at airports into mini-factories.[73] The idea behind this is to manufacture and deliver custom parts to order instead of maintaining giant halls full of parts ready for delivery as it does at the moment.

Similar expectations in respect of re-regionalization have been raised in connection with Industry 4.0. If it were possible to adapt production facilities to manufacture new products quickly and cost-effectively and at the same time flexibly automate relatively simple manual and cognitive production activities, it would no longer be necessary to finance the associated high fixed costs solely through the mass production of one product or to exploit low labor costs in distant locations.

70) DHL Trend Research (2014): Logistics Trend Radar.
71) DHL Trend Research (2014): Logistics Trend Radar.
72) http://www.dpdhl.com/de/presse/pressemitteilungen/2015/auto_wird_zur_mobilen_lieferadresse_fuer_pakete.html
73) D'Aveni (2015): The 3-D Printing Revolution, in: Harvard Business Review, May 2015, p. 40–48: https://hbr.org/2015/05/the-3-d-printing-revolution

4.2 Analysis of the survey of experts

The following sections introduce the interview questions and report on the answers given by the experts. The importance of ICT-induced change for each of the three sectors of interest (the automotive industry, mechanical engineering and logistics) is discussed with a specific focus on the significance of digital disruption for the companies concerned. The discussion looks in particular at the triggers and drivers and the question of which areas within the companies are most affected by the changes. Information from the interviews with decision makers is considered along with the statements from the expert interviews in some instances, although the decision maker interviews were conducted using a guided dialog rather than the structured questions. Further information about the regions investigated, the number of companies and experts and the procedure for implementation can be found in the annex.

Each section begins with a question and a chart showing the consolidated responses. The figure is divided vertically into three blocks. The upper block presents the statements from Germany, broken down by the industries surveyed (automobile manufacturing (A), mechanical engineering (M), logistics (L)). Then comes the block presenting the responses from the USA, then those from Asia. The Asia responses are shown separately for Japan, China and South Korea.

The numbers in the charts show which position was chosen for a response in each case within the possible responses defined. Only the top three responses occupying the first three places in the ranked list are shown. Results in the Germany row are shown separately for each of the three domains.

4.2.1 "What does the term 'digital disruption' mean to you?"

Question 1 about what digital disruption means to the interviewee (see *Figure 9*) serves as an introduction to the topic. The interviewee's responses provide a means of verifying whether their understanding of digital disruption matches that of the authors.

Automotive industry – the German perspective

The automotive industry predominantly associates digital disruption with a "transformation of business models/strategies". The main issue identified by the interviewees was the shift from selling a product to providing a mobility service. A subsidiary issue – but still very much a matter of concern – is the associated transformation of the product and service range and of the value creation networks. Long, hardware-driven innovation cycles are replaced by a need for fast responses to changed customer requirements:

> *"Upgrading software/virtual components of a service/product is much easier and takes less time than having to replace them physically."*

Other factors, such as a transformation of company organizational structure or of workflows/processes are not associated as strongly with digital disruption at the moment.

Automotive industry – regional comparison

The responses obtained from the US automotive industry companies interviewed suggest that digital disruption is understood in the USA to mean much the same as it is in Germany. The US respondents, however, identified a different driver in relation to the transformation of business models, with most US interviewees seeing the automakers functioning in future as suppliers to major digital platform providers such as Uber, Google and Amazon. This implies that the companies concerned do not expect the carsharing projects pursued by German manufacturers to prevail in the long term.

According to the interviewees, the Asian automotive companies, like their counterparts in Germany, understand digital disruption to mean a "transformation of business models/strategies" and "transformation of

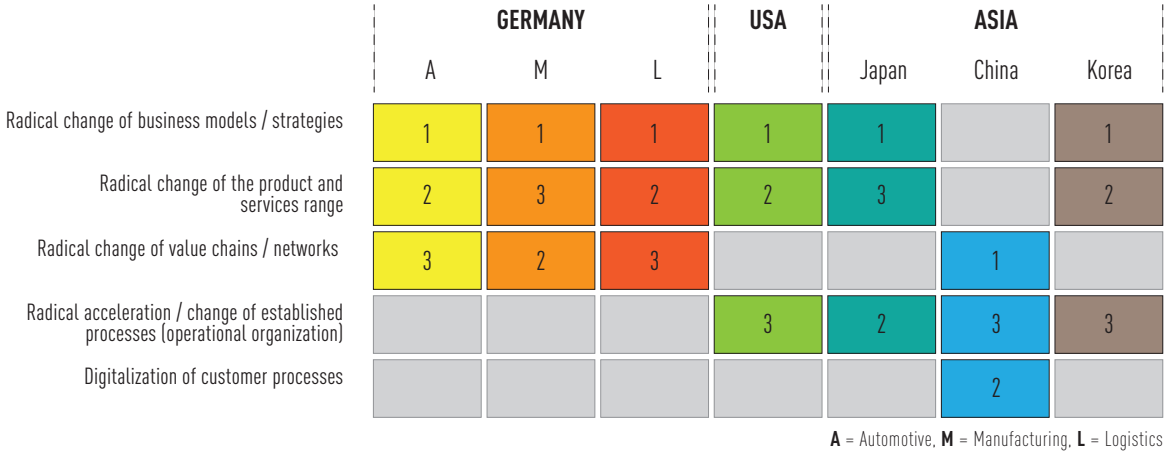


Figure 9: Analysis of the question: What does the term "digital disruption" mean to you?

the product/service range" except in China, where the transformation of value creation networks and the digitalization of customer processes are ascribed greater significance. A third factor identified as significant for all countries other than Germany is the radical acceleration/transformation of established processes and process organizations. The Asian and US companies specified the same reasons for selecting this factor: the ongoing proliferation of ICT in vehicles is also speeding up product cycles in software, among other areas, in the process making it necessary to deploy agile and parallel development methods, which is in turn driving the radical changes in the process organization.

Mechanical engineering – the German perspective

The mechanical engineering and industry automation sector also primarily associates digital disruption with the "transformation of business models/strategies". The transformation of value chains/value creation networks and the transformation of the product/service range are both associated with digital disruption by respondents due to the increasing penetration of software and increasing IoT connectivity within the domains. A change to existing processes follows in fourth position.

"Changes to existing processes include making them more flexible, for example so that it is possible to manufacture with a batch size of just one. An example of a product with a batch size of just one is Germany's mymuesli, which enables customers to specify the composition of their personal muesli blend."

Dr. Uwe Kubach, Vice President Internet of Things, SAP

It is clear from the interviews with decision makers that although companies recognize the potential inherent in the transformation or expansion of service ranges, realization is by no means complete.

"The ability to provide automated services confers a competitive advantage. We are too obsessed with engineering though, which is why so little has happened."

The statement about the potentially low barriers to market entry, which the authors considered to be highly relevant, did not appear in the top three and was not even universally accepted. Some interviewees do indeed think low barriers to market entry are relevant to their company, but others do not see this as a

problem because there is also a profitability barrier to be considered and this in their opinion is currently still sufficiently high.

Mechanical engineering – regional comparison

Changes in the business model and strategy lead the ranking of responses in both Germany and the USA. Changes to organizational structure follow in second position in Japan. Respondents explained that in their view, this was because Japan is very process-focused and has great confidence in its operational capability. It can be therefore be assumed that changes in strategy will lead directly to changes in organizational structure and processes.

Logistics – the German perspective

The main issues of concern for logistics in the context of digital disruption are a change in business models and the transformation of logistics functions, value chains and value creation networks. Business models are largely moving toward a focus on data and information as control variables in logistics. Hardware assets such as transport systems etc. are provided on a flexible basis by subcontractors. Examples of this model in action include Flixbus,[74] which relies on subcontractors to deliver the actual mobility service while focusing its own efforts on providing the software platform for billing, timetables, etc.

According to expert reports, 4PL logistics service providers are going to exploit the lever of ICT change consistently in order to keep on bringing forward new business process innovations. This approach in combination with their role as logistics integrators and their associated direct contact with customers opens up the possibility of completely new service propositions.

> *"Previously we did not have information transparency. Now we have complete information freedom and market transparency and the days of business as usual may well be at an end. Models are radical and replace established industries. Innovation was previously concentrated on products and services, but now we have innovation in business processes as well."*

According to the experts' statements, IT platforms are used here that will one day permit direct access to the 3PL subcontractors and effectively reduce the 3PL to mere performers in the logistics chain. This requires the establishment of end-to-end information chains, which is only possible with related industry-wide standards.

> *"Amazon is currently trying to optimize customer access, bringing the last mile of delivery into its own organization as a link in the value chain. It is driving inefficiency out of the market and at times investing in assets of its own in this area too."*

Amazon's aims in logistics include having direct access to customers and it is accordingly investing in its own vehicle fleet to establish an end-to-end information chain from order to customer (delivery and customer feedback).

Logistics – regional comparison

A change in business models is just one of the developments associated with digital disruption by respondents from the other regions, who also cite the radical speeding up/transformation of established processes (process organization), ubiquitous access to global resources (means of production, services) at low cost, lower barriers to market entry and the transformation of the product/service range. The assumption in those industries in which speed is an increasingly important factor is that production and logistics will move back closer to the end customer again.

> *"Postal logistics has already been digitalized (e-mail), logistics processes are increasingly being 'Uberized' and logistics as a whole is being 'Amazonized'. Marketplaces have the capacity to revolutionize logistics without owning assets."*

74) https://www.flixbus.de/

Interpretation of the responses

It can reasonably be concluded, in summary, that the principal development associated with digital disruption is the transformation of business models. This transformation of business models is attributable to internet platforms, which enable companies to develop and offer additional new services within a very short period of time. Uber is a commonly cited example. It relies on an internet-based mobility platform and, having already covered personal mobility solutions, is now moving into logistics solutions for goods. Uber introduced its UberRush delivery service on October 14, 2015 and has integrated it into the company's own network.[75]

"Entirely new business models are possible and they begin with a new strategy."

Internet-based business models are particularly exposed to rapid change and companies have to be capable of adapting accordingly.[76] Established German companies often lack the mentality necessary to think in terms of internet-based business models and make the most of the new possibilities. Also a factor in this connection is the comprehensive transformation process, which affects the value proposition – the principal performance-based differentiating factor(s) in the customer market – and the value creation architecture and revenue model. This has obviously been understood to entail changes in the product and service range and a transformation of value chains as well.

"The problem is that the entire company has to change the way it thinks."

The question then is whether these changes are tackled consistently. Speed and innovative strength are required in order not to fall behind at a time of business model transformation. The impression persists, however, that established German companies are hard put to deliver on these requirements. It appears that they are too rigidly focused on current market requirements, quality standards and established competitors and too firmly wedded to the need to "organize" any disruption process in detail.

"We are too fixated on plannable, highly optimized stable structures. We need to move out of the comfort zone of stable value chains into a world in which new collaborations and networks are created all the time."

The authors believe there also needs to be a transformation in understanding at management level and in organizational structure if companies are to be able to master today's ever shorter innovation cycles and adapt sufficiently quickly to changing market requirements.

"ICT has become the backbone of the organization. Only once the organization has understood and mastered these technologies can the associated benefits be exploited in all of the other areas of the company."

Answers to the question of which adaptations might be required for this were provided by a number of respondents using the R&D function as their example. The consensus view was that the organization ought to create (digital) structures that would enable it to interact with end customers and development partners continuously at every level. This subject is addressed in greater detail below in the context of question 4.

Background information about organization in South Korea

Korean company Hyundai has set up a separate company for electronics/ICT, demonstrating, as one of the decision makers observed, that companies in the country are well aware of the organizational aspects. Korea's major companies (Samsung, LG, Hyundai) maintain good conditions for systemic innovative strength on account of the sometimes extremely diverse nature of their business units and the intentionally high levels of staff rotation between departments, which are facilitated by their good organizational structure.

75) KEP: Von der Taxi-App zum Logistikdienstleister, in: Logistik-Heute.de, October 15, 2015: http://www.logistik-heute.de/Logistik-News-Logistik-Nachrichten/Markt-News/13716/Uber-koordiniert-in-den-USA-nun-auch-einen-Same-Day-Delivery-Service-KEP-Von
76) Xing half-year report 2015: https://corporate.xing.com/fileadmin/IR/XING_AG_Ergebnisse_HY1_2015.pdf

These organizational aspects were not mentioned among the first three possibilities by any of the German sectors of industry considered. The mechanical equipment manufacturers are the most likely to be aware of them. Interestingly companies in both Asia and the USA attach considerable importance to this factor, at least indirectly, emphasizing that processes (in the sense of the process organization) are going to see radical change.

The authors regard this discrepancy as an expression of the attitude, apparently still widespread in Germany, that the organization is merely the implementing mechanism for the gurus of top management. The idea that "structure follows strategy" proposed by Alfred Chandler in 1962[77] could be the model here, but perhaps the Ford (organizational) motto "culture eats strategy for breakfast" postulated in the Wall Street Journal in 2006[78] is a more important realization for the future. No matter how strong the strategy, if it runs counter to the corporate culture and the necessity of a change in strategy is not taken on board by the members of the organization, the organization will find a way to block developments.

The interviews with decision makers indicate with regard to dialog platforms that the existing communication structures between society, business and politics – and possibly even the very structures of such platforms – are being affected by digital disruption.

> *"A new structure is required in order to track and help shape the system change, but it must be consensus-oriented."*

> *"If SMEs were well-connected, a platform could help with the special challenges they face."*

> *"National [dialog] platforms are like using the rear-view mirror to predict what comes next."*

These statements indicate that decision makers regard dialog platforms as an aid in connection with digital change. It can be seen, however, that existing structures and interfaces for exchanges between players in the political, business, scientific and social spheres fall short of what is required, not least because they fail to include some important groups.

4.2.2 "What is the technological trigger of disruptive change in your sector?"

The second question (see *Figure 10*) concerned the technological triggers of disruptive change. A distinction can reasonably be drawn between technologies that the interviewees encounter every day, some of which have already contributed to disruption in other areas, and technologies that harbor corresponding potential for the sectors under consideration.

Automotive industry – the German perspective

The principal technical trigger of digital disruption is considered to be the high computing power now available on terminal devices (for example smartphones). Most of the interviewees explained this choice with reference to the way that the high volume of terminals sold (smartphones and tablets, for example) has dramatically driven down the cost of powerful components (displays, processors, sensors, etc.). This vast reduction in costs opens the door to making greater use of the components concerned in vehicles.

> *"Automated driving is only a possibility if the necessary computing power exists and can be provided affordably."*

Progress in human-machine interaction was considered primarily in the context of ensuring drivers are not overloaded by the increasing number of functions. Most of the interviewees viewed new key industrial technologies (such as 3D printing, electromobility and smart sensors) as a way to shorten experimental cycles with prototypes in pursuit of a faster response to customer requirements. Global integration and the access thus provided to data from different sources and levels are also regarded as technological triggers, but of lesser importance than the three triggers already dis-

77) Chandler (1962): Strategy and Structure: Chapters in the History of the American Industrial Enterprise, Cambridge, MA.
78) http://www.wsj.com/articles/SB113797951796853248

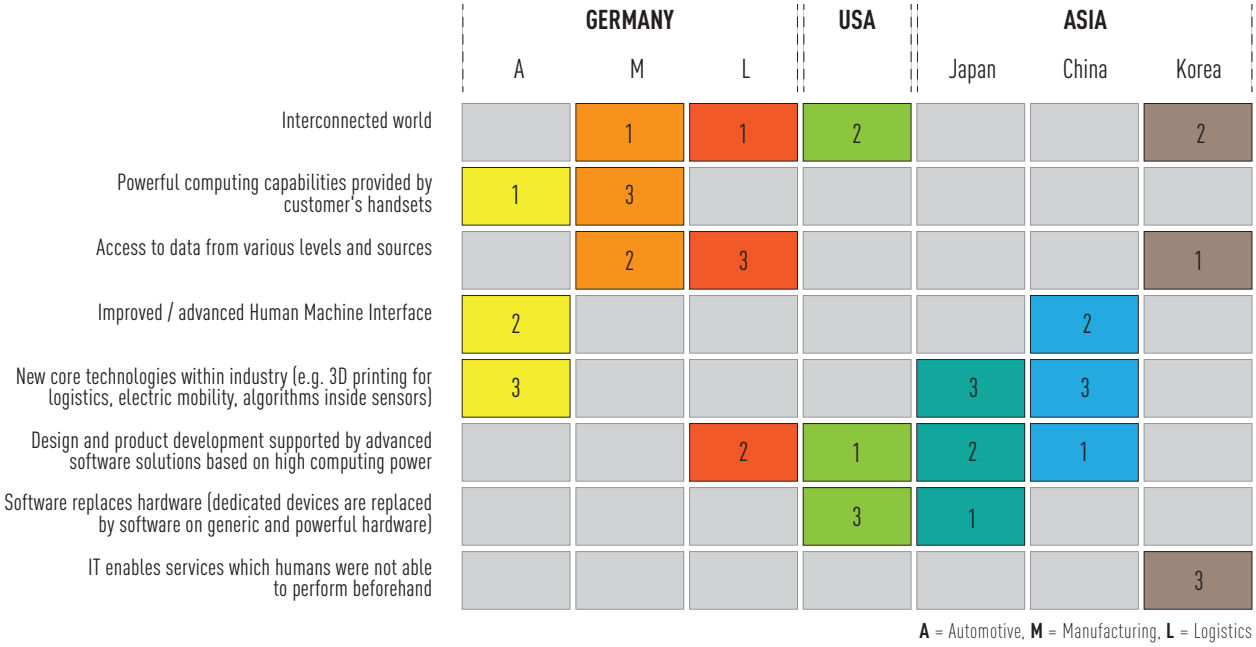


Figure 10: Analysis of the question: What is the technological trigger of disruptive change in your sector?

cussed. There were, however, several alternative opinions that ranked global integration and the concomitant rapid spread of knowledge and value creation systems as key causal factors.

Automotive industry – regional comparison

The support for design and product development provided by advanced software solutions is regarded as the main technical trigger in the USA and Asia, with respondents emphasizing the ability to detect errors in the virtual space and validate the software in particular. This contrasts with the view from Germany. New technologies are recognized everywhere as another technical trigger.

It is interesting in this connection that the experts in the USA cited algorithms and machine learning as examples, whereas in Asia the high performance of hardware tended to be the dominant factor. Finally, respondents from both Asia and the USA mentioned how functions are increasingly being provided by software rather than hardware. Responses from the USA stressed the ability to enhance functionality and correct errors easily, quickly and inexpensively, whereas the experts in Asia, especially Japan, were concerned not so much with the benefits as with the potential threat inherent in the technology. The interviewees suggest that Japan does not have the required software capabilities in sufficient measure. This is seen as a threat.

"Information/data are the key, access to information is everything! The nature of the product is changing from being physically-based to information-based."

"This is very dramatic for Japan, since they are not good/well established in software. It is a huge challenge for Japan (...) to become a software company. They are used to make things."

Mechanical engineering – the German perspective

The technical triggers for digital disruption in mechanical engineering apparently differ from those in the automotive industry, with most respondents singling out global integration as the main factor. Global integration in this context includes the ability to access different data from different sources and levels.

"Digital disruption in industry automation is associated with the introduction of IoT in the automation domains such that sensors are able to communicate. It changes the business not just in that it opens up the possibility of intelligent products [products of the mechanical equipment manufacturer or plant operator], but also in that it allows them to be linked together and enables information to be shared with other related systems (for example PLM, ERP)."

Jeffrey Penkowski and Perry Yang, Schneider Electric US

Several experts envisage a "data market" for production and machine data. The high computing power available in mobile devices is also cited as a driver of change, as it provides a variety of possibilities for accessing data, processing information and visualizing relationships. This, in turn, facilitates better maintenance of production facilities and optimization of production processes. A few experts do warn though that this trigger relies on the assumption that it is possible to obtain useful information easily and directly from a huge quantity of data, something for which there are so far very few precedents or success stories.

The drivers mentioned by the experts essentially represent the foundations of Industry 4.0. The interviews with decision makers make it clear in relation to this topic that the migration of existing production facilities to the 4.0 paradigm involves complexity of an unprecedented magnitude, especially for SMEs, and requires new skills not previously to be found within the types of organization concerned.

"Industry 4.0. has yet to arrive for many SMEs. Guidance, support and dialog are needed if these challenges are to be met successfully."

Mechanical engineering – regional comparison

The interview results did not place integration within the top three in Japan, where "software that can take the place of hardware" and "design and product development supported by advanced software solutions and high computing power" were viewed as the key triggers. The experts believe replacing hardware with software opens up very significant potential cost savings. Regarding the use of advanced software solutions to support design and product development, the respondents asserted that it can often be difficult for humans to maintain a complete overview of the workflows and relationships within the factory hall. New simulation methods and software solutions based on them make it possible to infer complex processes and relationships.

Design and product development aided by advanced software solutions occupies the top position in the USA, with global integration coming next and "software takes the place of hardware" also a prominent matter of concern in third position. Although this issue was not listed among the top three in Germany, it was certainly mentioned by a number of experts.

"One example we can imagine under 'software takes the place of hardware' is the virtualization of legacy systems. Legacy systems can be executed on virtual hardware platforms in modern computers, which allows maintenance costs to be massively reduced. This makes it possible to continue support for old control software that cannot be run on new control systems without the need for a new implementation."

Dr. Roland Weiss and Dr. Heiko Koziolek, ABB Research Germany

Logistics – the German perspective

"Global integration" is identified as the main technical trigger for digital disruption in the logistics sphere just

as in mechanical engineering. Also of importance for ICT-based change in logistics are the design of logistics chains and development of logistics services aided by advanced software solutions and high computing power plus the ability to "access different data from different sources and levels".

> *"An end-to-end information chain presupposes the integration of business administration data and technical data. Local elements, such as objects/packages, etc. also have to be integrated. Local integration thus also enables data management and sovereignty."*

According to the experts, innovative software and high computing power are the aspects that will contribute the most to progress in logistics. Cloud computing and the Internet of Things are key factors here. One important prerequisite in this connection is that the different data available on fragmented web-based marketplaces must be rendered usable. Making these marketplaces easy for end customers to use would confer a crucial competitive advantage.

> *"The drivers in logistics are companies with a completely different scale of market capitalization (Amazon, Uber). Using web-based marketplaces makes it possible to scale up propositions rapidly. This is simply not possible in Germany because nobody is making corresponding levels of capital available. The driver is not really the technical solution itself. Technically the more interesting area in future is likely to be semantic intelligence."*

The interviews reveal that core competencies such as transport and warehousing are very much under attack and that Uber models for logistics are generally feasible. Logistics companies thus have to turn themselves into solution providers or face seeing their share of value added dwindle. Logistics companies need to attract customers to their own platforms. The effect on the market of 3D printing will be significant within ten years. Airbus, DHL and others are currently having difficulty finding certified service providers for 3D printing and it remains unclear who bears the warranty risk for products created with a 3D printer.

Logistics – regional comparison

The technical triggers for digital disruption in logistics were identified as "global integration", "access to data from different sources and levels", "improved/advanced human machine interfaces" and "new core technologies" in logistics. The technical possibilities for simplification and the use of autonomous transport systems dominated the discussions.

Interpretation of the responses

Respondents in Germany tend to link the technological drivers with digital infrastructure and the associated possibilities for combining the original core business with new business models and developing corresponding products, services and business strategies. The automotive industry in particular is noticeably concerned about the perceived threat stemming from the increased capacity for innovation accompanying the digital change.

It was hardly surprising that the response most cited in the automotive industry was "high computing power available on terminal devices (for example smartphones)", but the authors were surprised to discover that, confounding their initial assumption, the respondents were not concerned about powerful terminals eliminating expensive extras such as navigation/entertainment functions. In actual fact the responses from the automotive industry indicated that it welcomed the increase in computing power available on terminal devices, for example because the scale effects of smartphones are also making the hardware needed for their current and future driver assistance systems more affordable. This is an understandable and logical piece of reasoning for an industry known to be very much preoccupied with the bill of material (BOM). The authors remain of the opinion, however, that there are still too many people in the automotive industry who have yet to grasp the fact that value propositions and the architecture of value creation are now determined by integration, open interfaces, proprietary apps and updatability rather than by the BOM (all factors that smartphones and tablets have rendered self-evident for end users).

Responses from the USA and, in some instances, Asia as well indicate that unlike their counterparts in Germany, companies in these regions consider the driving force to be not the infrastructure itself but rather the innovations and technologies based on it. Examples

include design and product development, which are aided by advanced software solutions, and the replacement of dedicated devices with software running on powerful generic hardware that has been designed to accommodate future functional enhancements of the software. In the fast-moving world of IT, these are critical factors representing a potential competitive advantage. The focus of innovation in these regions thus now appears to have shifted away from hardware in favor of software functionalities, a trend it is much more difficult to detect in Germany. It is also interesting to note that access to data from different sources is considered to be relevant only by the mechanical equipment manufacturers and logistics companies.

Corresponding analyses and pooled information resources can point to new services and products or options for the continuous improvement of existing products. This appears not to play a role in the domains considered in either the USA or large parts of Asia. One exception in this context is South Korea, which, one decision maker asserted, finds the change of mentality from selling products to selling services much less of a leap. It is difficult to settle on any definitive interpretation, however, as interviewees in the USA, for example, often viewed the response "global integration" as essentially synonymous with "access to data from different sources".

"Data could potentially become a sort of new currency. But who is entitled to access what data and when? Access has to be handled prudently, as this is precisely the type of data that opens the door to new services and business models."

"A physical infrastructure is too limiting. Virtual mechanisms should also be employed. With no barriers for relevant companies – distributed, virtual, digital."

"Far too much happens just by e-mail."

The decision makers shared the following observations regarding their experiences of cooperation in the area of technical innovations in committees comprising different representatives from business, politics, science and civil society:

These statements suggest the interfaces are still too "analog" in their methods. It emerged from the interviews with decision makers that powerful software capable of supporting effective cooperation and integrating a large number of players is not used.

4.2.3 "What is the societal trigger of disruptive change in your sector?"

The internet and the transformational power of digitalization in the context of business, society and politics are matters of widespread concern in the current environment. It is important the industrial structures that have evolved over time are brought into the digital age. How can a fundamental shift be completed with existing customers, management and employees? Social factors in particular must be considered here if the process is to be successful. Question 3 (see *Figure 11*) is intended to sound out which societal drivers the interviewees believe have the greatest influence on disruptive change in their sector.

Automotive industry – the German perspective

The principal societal triggers of disruptive change according to respondents from the automotive industry are the "strong affinity for IT in everyday use" and the "high penetration of IT" in society. The information

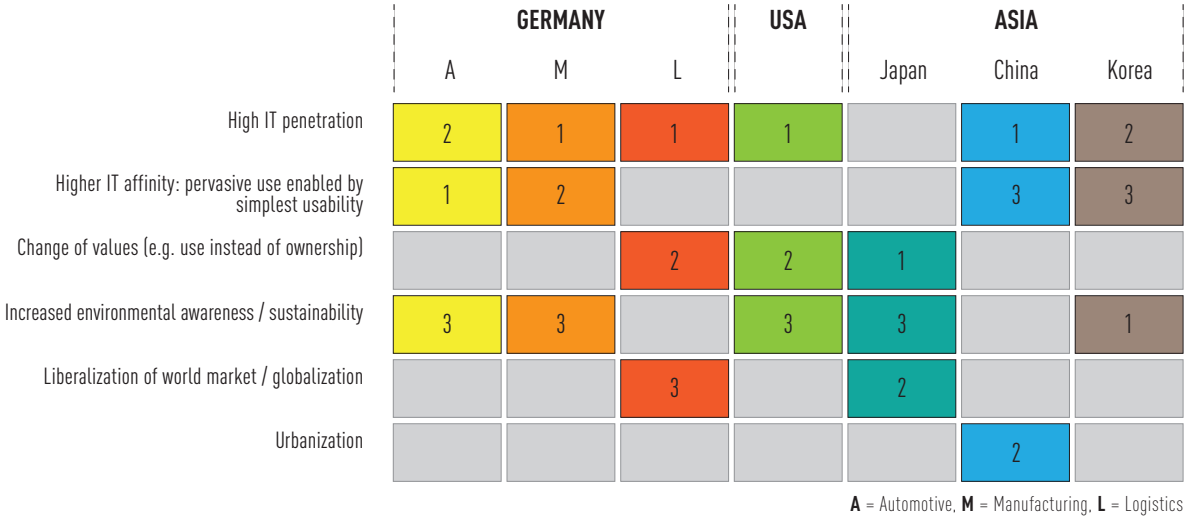


Figure 11: What is the societal trigger of disruptive change in your sector?

provided by most respondents points to the conclusion that their customers expect the possibilities they have become used to from digital platforms and their private IT use, be it ease of operation, customization, individual enhancements or automatic updates, also to be available in other areas of their life.

> *"Users are used to it from their private use and have rather high expectations. They vote with their feet and if the OEM is unable to deliver, they take their business elsewhere."*

or

> *"In our company, for example, we use Salesforce, so the updates turn up automatically without anyone having to worry about it. Trends from B2C are crossing over to B2B."*

A few interviewees go even further, speculating that new products and services will increasingly be invented by consumers (which will make them "prosumers"). Examples might include personal apps for data analysis, software interfaces for integrating wearables and the connection of VR headsets. One American hobby developer has already demonstrated what this could mean in practice: he uses Siri voice commands to park and retrieve his Tesla.[79]

> *"Significant changes are coming from the end customer."*

Another trigger mentioned was "increased environmental awareness", with respondents mentioning aspects such as the pursuit of energy neutral production facilities and the re-use or recycling of used parts (batteries, etc.). The fate of used parts in particular ties in with the end of the product lifecycle (as discussed above), which can be viewed as an opportunity for the logistics sector.

Automotive industry – regional comparison

Respondents for the USA also identified the "high penetration of IT" in society and "changing values" as societal triggers, with "use instead of ownership" the main example cited in relation to the latter aspect. "Urbanization" and low incomes were specified as the main factors behind this trend. These triggers were actually also mentioned in Germany in a few instances, but were very much in the background. The view from Asia in respect of societal causal factors coincides more with that of the US companies than of the German. "Use instead of ownership" (an example of "changing values")

79) http://www.golem.de/news/elektroauto-siri-kann-tesla-model-s-ueber-homekit-ausparken-1605-120792.html

was identified as the primary societal trigger in Asia too and the reasons given matched those for the USA. The other societal triggers mentioned – the high penetration of IT and increased environmental awareness – reflected a similar view to that of the German companies in the automotive sector.

Mechanical engineering – the German perspective

The societal triggers for disruptive change reported by respondents for the mechanical engineering sector reflect the very same concerns as the automotive industry: "high penetration of IT" and "affinity for IT as a result of everyday use". The respondents identify the main effect of IT penetration as being its ready availability in machinery and its ability to provide digital services. Ease of operation is also regarded as being very important. The experts surveyed take the view, for example, that it will be unacceptable for new generations to configure machines or systems without portable devices.

There is no consensus among the experts in respect of the third factor as to whether "demographic change" in the area of experienced white-collar staff, "increased environmental awareness" or "changing values" in favor of "use instead of ownership" plays the greater role. Responses from other interviewees signaled a general view that big companies are likely to have already made plans to deal with demographic change and that this factor is consequently no longer a potential trigger of disruptive change for them.

Mechanical engineering – regional comparison

Not all of the regions share the German belief that "IT penetration" is a key societal factor for digital disruption, with "increased environmental awareness" and "liberalization of the global market" seen as more important elsewhere. Japanese experts stated that market liberalization is bringing the effects of regulatory measures such as taxes to the fore on the basis that taxes provide a benefit only for products produced locally.

"Changing values" are regarded as the most important societal factor for digital disruption in Japan. The observations made in connection with changing values included the familiar "use instead of ownership" and similar. Interestingly mention was also made of the trailblazing role of companies such as Apple and Tesla, with the experts referring not only to their importance for stakeholders, but also to the value that these companies offer for their customers and employees.

Logistics – the German perspective

IT penetration, changing values and the liberalization of global trade were identified as the principal societal triggers for disruptive change in logistics.

> *"Social change is driven by the younger generation, which has completely different expectations for IT/digitalization."*

Some experts were explicit in their conviction that demographic change is going to change society.

> *"It is quite possible then that youth as a driver of change will end up having little or no effect, which would result in us here in Germany taking a different approach to dealing with the radical changes associated with technology. A conservative mentality could prevail, leading to a correspondingly low appetite for risk."*

Logistics – regional comparison

The discussions conducted around the world on the subject of logistics consistently pointed to increased environmental awareness and sustainability as key issues. Changing values were the most prominent factor in the USA, while demographic change led the way for Asia. There was great uncertainty as to future growth and employment in the regions.

Interpretation of the responses

There is a high level of agreement worldwide on the question of the societal trigger of disruption. Everyday hands-on familiarity with IT, the high level of IT penetration and increased environmental awareness are the major drivers around the world. Most of those surveyed use the same IT/digital platforms in both private and professional life (for example Google/Maps/Gmail, Android/iOS, Office 360, Xing/LinkedIn, WhatsApp, Amazon, Farnell). One result of this is that the same expectations in terms of ease of operation, customization, individual enhancements and automatic updates extend to all areas of life. Another crucial factor is the way

that values have changed to favor "use instead of ownership". This is the cornerstone of the sharing economy idea, which first emerged in the USA in the mid-1990s and is driven predominantly by big American companies like eBay and Uber.[80] A disproportionately large number of German consumers under the age of 30 support the concept, but consumers over the age of 40 are less enthusiastic, in some cases quite markedly so.[81] This societal driver accordingly harbors very substantial potential for the future in Germany.

Almost two thirds of Germans believe that protecting the environment and combating climate change are fundamental prerequisites for the successful mastery of future challenges such as globalization.[82] This attitude was also identified as an important societal driver in the present survey.

According to the interviews with decision makers, everyday IT use and the utilization of digital platforms are also going to have an impact on people's political life and on how they involve themselves in shaping the state. The "analog" interfaces still present need increasingly to be digitalized in the interests of constructive collaboration through dialog platforms. "It wasn't just for credibility reasons that the German National IT Summit needed to set a good example and go digital", remarked one of the decision makers interviewed.

4.2.4 "Which areas of your company are most deeply affected by digital disruption?"

The first three questions were discussed from the macro-perspective of digitalization (technical drivers and societal drivers). Question 4 (see *Figure 12*) shifts the focus to the individual company in order first of all to identify those areas of their organization in which companies need to make the most far-reaching changes. Which current company processes are still appropriate, which are affected and to what extent are current organizations optimally configured?

Automotive industry – the German perspective

Research and development (R&D) and strategy were identified as the main corporate functions to be affected by digital disruption in the automotive sector. The R&D function is growing ever more dynamic. Expert reports assert that innovation in the automotive sector over the last 30 years has almost invariably been an evolutionary process. The past five years, however, have brought a period of radical change.

> *"We have spent most of the last 30 years working on essentially the same issues. Today though everything has changed: the research and development function has been transformed over the last five years based on digitalization and increased computing power."*

The people surveyed addressed two different aspects of these changes in their responses. The first aspect involves the change in technical subject matter, which now principally revolves around IoT, autonomy, integration and secure software updates "over the air".

> *"Automobiles have been running internal combustion engines for 100 years (only consumption, weight and maintenance intervals have changed). Today topics like autonomy, robotics, system modeling/engineering, IoT and integrating IoT for production (Industry 4.0, in other words) are the priority."*

The second aspect, clearly alluded to in the above quotation, relates chiefly to changes in organizations and ever shorter innovation cycles. Issues of concern in this connection include, by way of example, how data from vehicles can be translated into useful information sufficiently quickly and how this information can then be used to mount a dynamic response to customer wishes.

The R&D organization needs to be able to acquire external expertise and integrate it into its own workflows much more quickly too, otherwise it will find itself unable to keep pace with changes in the market in future.

80) Schor (2014): Debating the Sharing Economy: http://www.tellus.org/pub/Schor_Debating_the_Sharing_Economy.pdf
81) TNS Emnid (2015): Sharing Economy. Die Sicht der Verbraucherinnen und Verbraucher in Deutschland: https://www.tns-emnid.com/studien/pdf/sharing_economy-umfrage-bericht-emnid-2015-06-29.pdf
82) German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (2015): Umweltbewusstsein in Deutschland 2014. Ergebnisse einer repräsentativen Bevölkerungsumfrage: https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/umweltbewusstsein_in_deutschland_2014.pdf

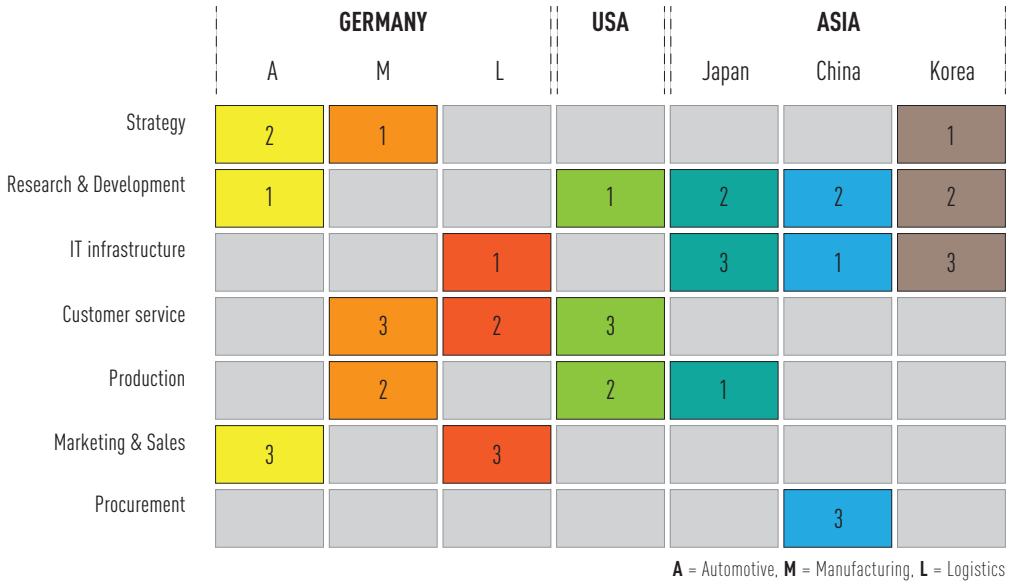


Figure 12: Which areas of your company are most deeply affected by digital disruption?

"R&D needs to draw in far more data and information and there is much more data coming back from customers, which helps with product improvement. Suddenly I can see how people actually use their vehicle. I can make the development process faster and more dynamic. And it is also possible to pay more attention to customer wishes."

"Innovation labs are a good thing, but often they fail to work because they have been created out of the company of which they are part. There is a need for external experts who bring new knowledge into the company. Companies need to look beyond their own four walls and bring in external expertise and work together with small, young companies."

The interviewees were quite clear in their conviction that new business areas need to be developed and that new strategic approaches, especially with regard to digitalization, need to be devised to this end. Among the points made in this context was that strategy must be more closely aligned with technical developments. Another of the interviewees shared the following summary on this subject:

"Talk of change and disruption must be reflected somehow in strategy. At the moment people know that things cannot continue as they are, but they do not really know how things are going to continue in the future."

The third area mentioned by respondents as being significantly affected by digitalization, although not to the same extent as R&D and strategy, is sales and marketing. The future challenges outlined for this function are broadly the same as those facing R&D: using digitalization to increase proximity to the customer and trying to achieve much closer interaction. Key words such as "crowdsourcing" and "app store marketing" cropped up repeatedly in responses. There were also a few calls to allow more trial and error by developing vehicles together with the customer and refining the results by means of updates.

Automotive industry – regional comparison

R&D, production and strategy were identified as the corporate functions most affected in the USA. The interviews indicate that in Germany, the effect on production is considered to be minimal. The observations in relation to R&D largely coincide with those from Germany, although mention was made of the shortage of data analytics and software development specialists. This was attributed to the presence in the USA of companies like Apple, Google and Facebook, whose attractions the automakers in Detroit are rather hard pushed to match. The observations concerning strategy are also similar to those from Germany.

The responses from the USA were somewhat more general and focused essentially on pillorying silo thinking. The experts spoke out for an integrated view encompassing the entire ecosystem. The impact of digitalization on production was associated first and foremost with Industry 4.0 and the Industrial Internet Consortium, although one interviewee went so far as to predict that autonomous carsharing fleets would lead to a collapse in production figures and thus also to a reduction in vehicle sales.

The R&D departments were named among the affected corporate areas in Asia too and the changes reported by the interviewees in this sphere were a very close match with those mentioned for Germany and the USA. Like their counterparts in the USA but in contrast to their counterparts in Germany, the respondents for Asia also included production as one of the most affected areas, their reasoning following much the same lines as that for the USA.

Industry 4.0 is regarded as essential in order to be able to respond faster to customer wishes. Another difference between Asia and Germany with regard to the corporate functions affected is that in Asia, it is primarily company IT infrastructures that are considered to be particularly deeply affected. This reflects an understanding of IT infrastructure that includes skills in fields such as cloud computing and data analytics, which skills are required but not yet in place. This aspect was felt to be very much of secondary importance in Germany and the USA.

Mechanical engineering – the German perspective

The interview results for this domain reveal, rather surprisingly, that the area most affected by digital disruption is strategy, with production and customer service rounding out the top three. Research and development ranks fourth, marketing fifth. Many of those surveyed are of the view that in the age of the Internet of Things, it is necessary to consider not just hardware products, but also the (software) services that are associated with the products.

Making the change and implementing a digital strategy, however difficult it seems, still appears to be a feasible prospect. The respondents asserted that the examples of IBM (a hardware company that became a software service company), GE (software as core competency) or Microsoft (cloud business, although that was not originally part of the strategy) demonstrated clearly enough that such a change is possible.

Finally, some of the experts believe that changes in sales can generally only be realized if customers are helped to understand the advantages of digitalization.

Mechanical engineering – regional comparison

R&D was identified in the other regions as one of the areas most deeply affected. There were differing views as to the nature of the changes in this segment: some of the experts surveyed stated that R&D follows the requirements of sales, although R&D is actually able to decide for itself what to research or how to solve a problem, while other experts believe that strategy and R&D are tightly interlinked and that R&D must follow a long-term strategy. In fact, however, nobody knows what such a planned long-term development should look like.

Logistics – the German perspective

The discussions held indicate that digital disruption impacts most heavily in the logistics sphere on strate-

gy, research and development, and marketing and sales. According to the experts, the core aim is for upstream and downstream value creation steps to be permanently integrated so that customer requirements can be satisfied more quickly.

This integration requires the existence of corresponding standards. The experts emphasize the great significance of IT security. How can security against potential attacks from all over the world be guaranteed for customers? All logistics service providers are consequently trying to force customers to use their APIs.

Logistics – regional comparison

The international expert interviews single out IT departments as the area most affected by digital disruption in logistics. Strategy, customer service and marketing and sales were also frequently mentioned in the discussions.

Interpretation of the responses

The importance attaching to a company's strategic orientation was universally recognized as a key challenge. The interviewees acknowledge that the requirements for strategies have changed. The time frame within which effective decisions have to be made has shrunk dramatically and ever shorter innovation cycles only amplify this effect. This means that long-term thinking is becoming more and more important: making the right decisions entails properly understanding the wider context within which short-term changes occur.

> *"The consequences of poor decisions have become much more grave and strategy determination is now subject to far more requirements."*

German companies are endeavoring to open up their systems for digital solutions, but this potentially leaves them vulnerable to the threat of internet companies staking out a role as intermediaries between customers and German manufacturers. Companies could be recklessly giving away their future business, in other words. One scenario arising out of the interviews sees automobiles becoming platforms for digital products, shopping and advertising. The automotive industry is generally preoccupied with autonomous vehicles and new power train concepts, however, leaving the door open for others to gain control of future vehicle-as-platform business. The German mechanical engineering sector appears to have a better grasp of this threat and regards customer service – and hence proximity to the customer – as an important corporate function in the context of digitalization.

> *„Permanent integration will make it possible to predict what customers are going to want. Customer wishes will be met applying different payment models for different customers and this will include models suited to the less affluent layers of society."*

> *"Customers expect to be more closely involved – as co-creators, prosumers for a batch size of one."*

Discussions with experts also revealed that German companies often prefer incremental innovations focused on their original core business, as continuous improvements are easier to plan, cost and realize. When it comes to pushing through issues with the potential to set off disruptive changes for their core business, they often assess the risk to be too great. The innovations that endanger the existing business model often originate from outside, in many cases from companies having little familiarity with the sector. What these outsiders have in their favor, however, is the ability to identify solutions and spot inefficiencies that the incumbents cannot (or do not wish to) see. This mindset, which makes it difficult to come up with strategic solutions, seems likely to remain a feature of strategy departments at German companies for a long time yet.

It was generally acknowledged in respect of R&D that digitalization leads to a change in development cycles. The experts see more software in products, a corresponding increase in scalability and adaptability, a greater degree of customization and a move toward thinking in terms of modules and platforms. Modes of thinking are still very much rooted in the physical world though.

"Today everything to do with development revolves around the physical. In the future the approach will be all-encompassing (everything integrated) across solutions, etc."

The importance of marketing and sales and the provision of data from these corporate functions for R&D in particular were recognized as being very valuable for the digital transformation. Changes to production as a consequence of digitalization are highlighted in Germany only by the mechanical equipment manufacturers. Despite the fact that its importance actually spans just about all sectors, the statements made in the interviews suggest that Industry 4.0 plays only a secondary role for production in the automotive industry.

4.2.5 "Who drives disruptive change?"

It is useful to ascertain the commercial and institutional drivers identified by the experts in the various companies as well as the changes occurring or anticipated within these companies. Question 5 (see *Figure 13*) provides a way to determine whether innovative ideas are developed within or outside of a sector and whether the corresponding momentum stems from young or established companies.

Automotive industry – the German perspective

The list of companies constituting a driving factor for the German automakers and automotive component suppliers in the context of digitalization is dominated by companies, both established and new, from outside the sector. Typical examples are Apple, Google, Uber and Amazon.

"The nature of change in the sector would be more evolutionary and not so radical without the threat posed by data-led companies. The presence of Google creates an increased sense of urgency!"

New companies within the sector, principally Tesla, were named as the third most significant driving force. The established automakers and automotive component suppliers do not regard themselves and their traditional competitors as drivers of disruptive change. They certainly see the new competitors from other domains that are becoming increasingly active in the automotive sector as drivers of disruptive change though, primarily due to the integration of digital services into traditional products (for example the integration of smartphones and the associated services and apps into the automobile) but also as a result of new direct competitors that operate at a more fundamental and intensive level with procedures, technologies and principles from the IT world.

Automotive industry – regional comparison

It is notable that in the USA, research institutions are viewed as drivers of disruptive change in the same way as new companies from within or outside the sector.

"Like MIT who pushes out hundreds of startups. "

Respondents explained the strong position of the research institutions in the USA with reference to the virtual absence in the country of established SMEs/SMEs that operate internationally. The universities fill this vacuum and promote spinoffs. They often retain a commercial interest in the patents and/or new companies created out of their research, meaning that as well as functioning as incubators they are also increasingly acquiring at least some of the characteristics of traditional corporations. Research institutions and the technologies and methods they develop are not perceived as drivers in Germany.

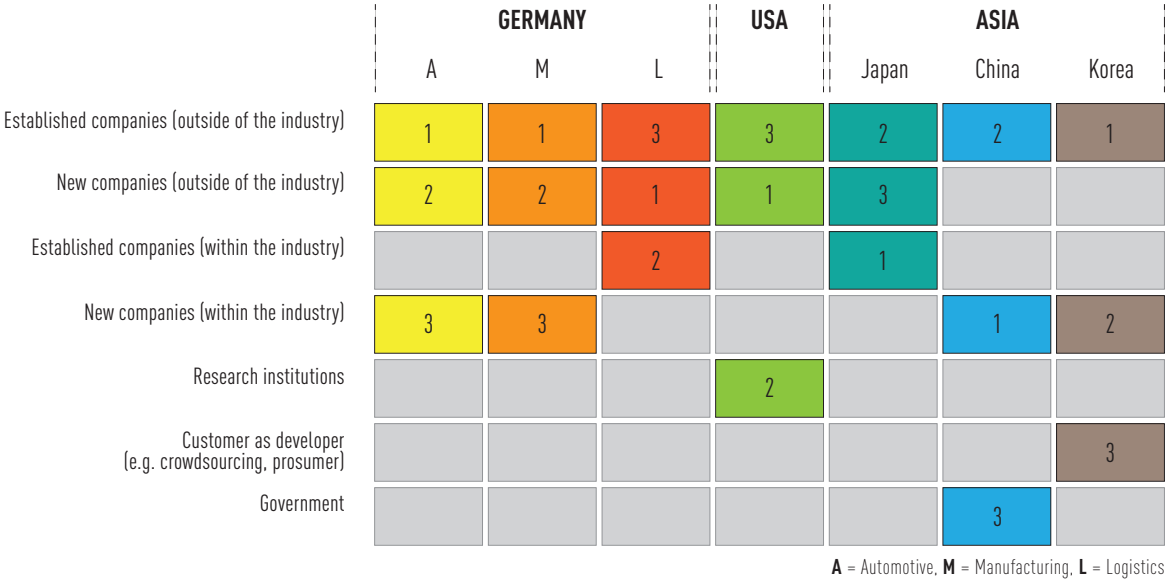


Figure 13: Who drives disruptive change?

The primary drivers identified in Asia are established companies within the sector. This was explained as follows: each sector essentially has one company that is regarded as the leading light (Toyota in the case of the automotive industry) and social conventions dictate that no company, whether from within or outside the sector, challenges this leading position, so it is only when this special company adopts a new course that the others will follow and the sector as a whole undergoes change. The situation is quite different in Germany and the USA.

New companies from within and outside the sector were in fact identified as drivers even in Asia, presumably because companies like Apple or Google, for example, are regarded as direct drivers by the leading companies even if they only affect the subordinate companies indirectly. Respondents for Asia, like their counterparts in Germany but in contrast to those in the USA, did not consider research institutions to be drivers.

Mechanical engineering – the German perspective

The expert responses from the mechanical engineering and industry automation sector differ from those from the automotive domain in that established, as well as new, companies from within and outside the domain are regarded as drivers of disruption. Established companies from outside the domain have only a slight advantage in terms of leading the way in innovation.

Several experts believe that IT companies, which usually only serve end customers through standardized solutions, could struggle to break into this market due to its B2B nature in this area and the high physical specificity of development. The respondents do all agree that new companies are capable of generating innovative solutions, but these new companies are not yet considered to constitute a threat. Large companies in particular can make up ground quickly by means of acquisitions. One example mentioned was Siemens, which is moving toward an incubator role for small companies.

Interestingly the list of established companies mentioned from outside the domain is not, as might have been expected, limited solely to IT companies. Some of the experts think that major automotive companies, for example, will be the ones setting out the course for the mechanical equipment manufacturers or component suppliers in the automation pyramid to follow and that this will ultimately lead to disruptive change.

Mechanical engineering – regional comparison

The other regions regard the impact of established companies from outside the industry domain in much the same way as Germany. The interviewees are of the opinion that it is necessary to integrate companies from outside the sector, principally from the IT industry, in order to create additional value. Only the respondents from the USA took a different view, identifying new companies from outside the sector and research institutions as the main drivers.

Experts from China also take the role of government into consideration in this context. Government regulations can have a big impact on business, for example in connection with initiatives concerning robotics or the Internet of Things.

Decision makers in Korea assert that customers are the driving force. Customers want flexibility and short time-to-market cycles and manufacturers/production line operators have to bring themselves into line. A government loathe to let any opportunity go to waste also counts as an important driver of digitalization in Korea.

Logistics – the German perspective

Established companies from outside the sector, established companies from within the sector and new companies from outside the domain are all identified as drivers of disruption in logistics. There is a risk that with margins under such intense pressure (in the two to three percent range), it will be risk capital – which lies largely in the hands of investors with an IT background – that drives change. The big change to come, according to the expert interviews, is that 3PL logistics providers will lose their central position to 4PL providers. Major players like Amazon have money, volume and influence in abundance and could have a very disruptive effect on the logistics sector.

> *"New companies from within and outside the sector are very actively driving change in logistics. The customer is also a strong, if unknowing, driver. New companies are well on track with IT and have no historical baggage to preserve. They don't have to worry about undermining any established technologies."*

Solutions are introduced in passenger logistics first and then extended to goods logistics. The platform operators are held to possess the greatest potential.

> *"Progressive players utilize completely new solutions, offer parts as available without having them in stock. They just obtain them when they need them."*

This trend is also confirmed by the SME decision makers.

Logistics – regional comparison

The unanimous verdict of the international interviews was that disruptive change in logistics will be driven by new and established companies from outside the sector.

Interpretation of the responses

The majority of the German companies are of the view that change is being driven by companies from outside the sector. New companies within the sector are important in mechanical engineering and the automotive industry whereas in logistics, a significant role is played by established companies within the sector. Companies driving change from outside the sector and new companies within the sector are usually companies that are no more than 20 years old. These companies have young employees who are IT-savvy and highly motivated.

Society as a whole, on the other hand, is aging and this could affect the impact of youth as a driving force. This would result in Germany taking a different approach to dealing with the radical changes associated with technology.

> *"There are barriers for a 'community' (OEMs see to this) that make it difficult (for example in the form of a verification of suitability for use) to bring an autonomous vehicle to market."*

The interviewees see a conservative mentality at work with a correspondingly low appetite for risk. This would explain why it is only in logistics that established companies play a role. Most of the companies breaking into the market from outside have a mastery of current ICT and have nothing they need to pre-

serve. They can progress without worrying about undermining any established technologies.

> *"It is possible to overdo the focus on hardware with IT. Just let it be built wherever. IT is particularly useful for customer service, for marketing and sales and for procurement and this can be copied across different sectors, which makes it possible for the new providers constantly to be moving into new markets."*

The customer, as a possible driver of or contributor to value creation, is not generally regarded as a direct driver. The end customer is, however, understood in logistics to be a very strong indirect driver.

In Asia it is principally the big established companies within the sector that are seen as drivers, something the interviewees explain as an artifact of social conventions. Innovations in the region do not come from SMEs. Decision makers emphasized the importance of startups in Korea, reporting that they play the role of incubators and are absorbed by one of the major companies if successful.

It is notable that overall, the experts attach very little importance to politics or government as drivers of disruptive change. This contrasts sharply with the decision makers from German companies in particular, who consider national industrial policy to be a critical factor in setting the tone and consequently also believe that the political sphere has a responsibility to create the necessary conditions for participation.

> *"Politics should create a framework and mechanisms for integration. It is important to reach new and innovative players rather than always relying on the usual suspects that are always involved."*

> *"One company on its own cannot dictate the course of change because the change concerned is a systemic phenomenon. It needs an orchestrator."*

> *"Providing a vision for the future is the job of politics."*

These statements leave no doubt as to the desire in Germany for frameworks created by the political sphere to guide and manage digital change. The decision makers observed that transparency and participation regarding the establishment of ground rules and roadmaps were considerably stronger at EU level than at the German national level.

> *"The EU is further advanced than Berlin: drafts of new directives and roadmaps are made public, consultations are open to everyone and input is welcomed."*

One aspect of the structural shortcomings highlighted by the SMEs in particular was the limited scope for contributions and integration at their level owing to the fact that with the existing dialog platforms, it is "well organized interests" and established companies that call the tune and not SMEs and startups. References to "an unholy alliance of single-issue interest groups" and "a hotbed of subsidy specialists" tend to support this claim.

Building on this chapter, which has examined what different players understand by the terms ICT-induced change and, in particular, disruptive change and their triggers in different sectors, the next chapter looks at how prepared the selected sectors currently are in terms of significant socioeconomic and technical factors.

CHAPTER 5

Estimates and forecasts for the key sectors

This chapter begins with a presentation of the maturity model developed and used in this study. It forms the basis for comparison of the companies surveyed from the different sectors in the regions under investigation. The maturity values relate to socio-economic and technical developments, which were also addressed during the interviews, and they can be used for multi-dimensional classification. After the maturity model, we present the results of the analysis and the expected future development. Finally, we discuss the industry-wide trends that can be discerned from the interviewees' replies and from forecasts.

5.1 The maturity model: the basis for socio-economic and technical analyses

The maturity model allows the companies surveyed from the automotive, logistics and mechanical engineering sectors to be evaluated in terms of their capacity to take advantage of the digital transformation. The aim ultimately is to identify potential opportunities and to make recommendations for specific industrial policy actions. [83]

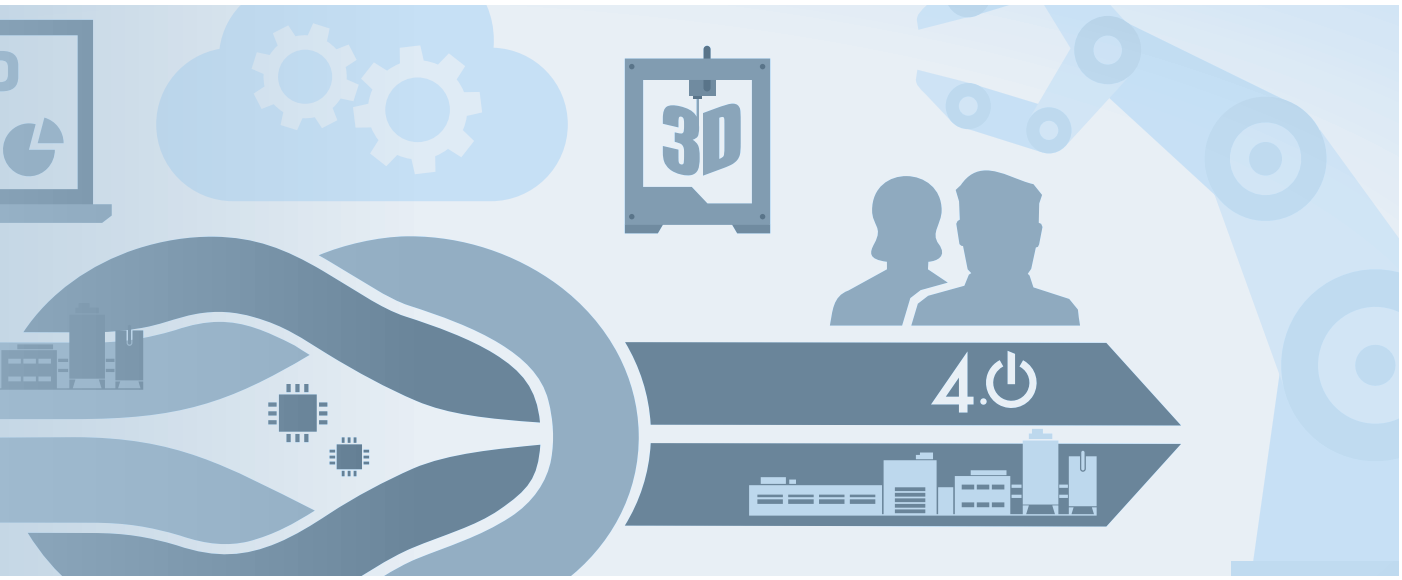
Conceptually, the maturity model developed here is based on Venkatraman's "Five Levels of IT-Enabled Business Transformation" shown in *Figure 14*. Depending on the influence of IT on business transformation, the model differentiates between evolutionary levels, which are characterized by minimal IT-driven changes to organizational/business processes (levels 1 and 2), and revolutionary levels (level 3 and above) involving fundamental change. [84]

The localized exploitation level describes the implementation of isolated system in general terms, for example the introduction of a merchandise information system in the company. This implies the use of standard applications causing minimal, if any, changes to the business process.

At the internal integration level, an attempt is made to make systematic use of the potential of IT throughout the business process. Integration here relates to the technical interconnectivity of different systems using a common IT platform, but also to business process interdependence – in other words the mutual dependency of organizational roles and responsibilities across multiple specific functional units (for example merchandise information systems).

Whereas the two first levels are classed as evolutionary because they only entail relatively minor changes to the business process, the third level – business process redesign – is the first of the three revolutionary levels. At this

83) Annex XX contains a detailed description of the aims, concept and content of the maturity model.
84) Venkatraman (1994): IT-Enabled Business Transformation: From Automation to Business Scope Redefinition, in: Sloan Management Review 35, 2, p. 73–87.



level, core processes of the company are fundamentally redesigned on the basis of the internal integration of ICT systems, in order to take advantage of the potential benefits made possible by ICT (for example agility, efficiency). Here, IT is an enabler for the further development of the organizational capabilities of the company.

These three levels treat the IT induced business transformation primarily in the context of an isolated company (internal point of view). Despite many different interactions with external actors such as suppliers or customers, the company boundaries are considered to be fixed and the distribution of business activities across the various actors remains unchanged.

In contrast, the business network redesign level assumes that the effective deployment of IT capabilities will result in a reconfiguration of the interaction with and be-

Figure 14: Digital organizational transformation

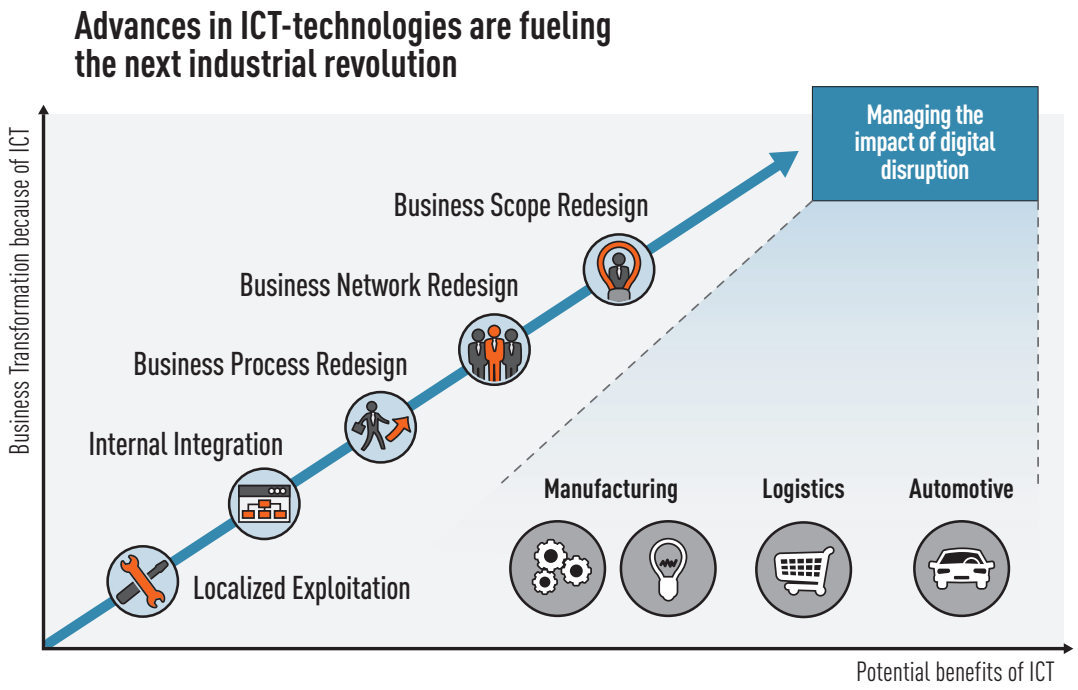


Illustration: © Mimi Potter - fotolia.de

tween multiple business partners. For example, the deployed technologies have functions that are necessary in order to obtain information or to train the actors, and also to coordinate and control the extended network, as with co-design/engineering or PLM for example.

At the fifth level – business scope redesign – the deployed ICT causes a change to the business scope and fundamentally alters the business relationships in the extended business network. As such, a redefinition of the business scope is needed – internally: what do we do inside the company?; externally: what can be achieved with the specific partnerships and relevant agreements? – and this is enabled or made easier by IT functionality (for example "servitization" using a platform, blockchain for contract content).

Our maturity model concept is based on these levels, converting them into socio-economic and technical characteristics. For example, the interviewees from the automotive, logistics, mechanical engineering and plant engineering sectors were asked to assess the maturity of their business model according to various dimensions representing ICT-induced change in central aspects:

The socio-economic area covers the dimensions of business model, strategy and organization, and Stähler further subdivides the business model into fundamental components: value proposition, value architecture and revenue model.[85] From a technical point of view, the maturity is considered according to the dimensions of data analysis, autonomous systems and digital engineering, which in the opinion of the authors could be regarded as overarching topics in ICT-induced change.

For each of these dimensions, the interviewees could select one of five predefined maturity levels and thereby indicate the current situation in that particular area. They were then asked to assess when the next maturity level is expected to be reached.

5.2 Business models in change – progress in socio-economic transformation

The significant responses from interviewees in the automotive, logistics and mechanical engineering sectors regarding the maturity of their business models are summarized below. They are differentiated according to the three dimensions above: value proposition, value architecture and revenue model. There follows a discussion of the central responses regarding the maturity of the corporate strategy and the corporate organization. This descriptive summary illustrates the maturity assessment of German companies in the sectors studied, based on the answers that were given most frequently. There is also an international comparison if the data obtained from the interviews permits this.

5.2.1 Explanation of characteristics

Specific dimensions were defined in order to establish the influence of digitalization in the socio-economic context, and consequently to determine a maturity level for the companies in the study. They are explained briefly in this section:

- **Business model – value proposition: What value does an activity create?**
  The value proposition describes the value created for the customer by an actual product or service.

- **Business model – value architecture: How is an activity created?**
  The value architecture describes the steps in (internal and external) value creation, and the various economic agents with their roles in the process.

85) Stähler (2002): Geschäftsmodelle in der digitalen Ökonomie. Merkmale, Strategien und Auswirkungen, 2nd ed., Lohmar/Cologne, p. 41ff.

- **Business model – revenue model: How are revenues generated?**
  The revenue model describes how and from what sources the company generates revenues. [86]

- **Strategy: What are the corporate goals and how will they be achieved?**
  The strategy defines the planned actions of a company aimed at achieving defined long-term corporate goals. [87]

- **Organization: What is the organizational structure of a company?**
  The organizational structure describes the totality of organizational rules of a company and forms the general framework in which permanent tasks are apportioned. [88]

Regarding maturity[89] in the context of ICT-induced change, the possible answers for the value proposition ranged from "no change with rudimentary addition of digital functionality" to an "ICT-based fundamental reorientation of products and services". In the automotive industry, a car manual provided as a PDF document could be one example of an addition. A fundamental reorientation, on the other hand, might involve the vehicle manufacturer becoming a platform orchestrator, in which the customer just enters a time and destination to receive a mobility solution tailored from various transport options and customer preferences.

The change to the value architecture and the revenue model resulting from the digital transformation was represented using a similar scheme, graded from a low change potential initially to a fundamental reorientation. The latter is characterized by a fundamentally changed internal and external value architecture or by a reoriented revenue model with high differentiation potential based on direct or indirect revenue components and real-time adjustments.

In the dimension of strategy, digital change in the lowest maturity is not (yet) covered by the corporate strategy and as such it is not taken into account in the individual functional areas. In the highest maturity, however, this dimension is a key component of strategic planning, and operationalization has already taken place in all functional areas in the company.

In the dimension of organization at the lowest maturity level, it is assumed that the organizational structure has centralized decision making authority, that there are independently operating functional silos, and that the general capacity to adapt to changes is low. In contrast, ICT-induced change at the highest level shatters organization-specific rigidity, distributes the decision making authority and allows cross-functional teams to work together in an agile way.

The following sections present the maturity of the sectors initially for the socio-economic dimensions. The individual dimensions are logically related to each other but unlike the maturity levels, they should not be seen as based on each other.

5.2.2 Evaluation of current maturity: value proposition

5.2.2.1 Automotive

The majority of interviewees in the automotive sector agreed that their value proposition has changed at least minimally due to ICT-induced change (level 2), or that the change, in the opinion of the experts, clears the way for partially integrated digital functions (level 3). Only one interviewee thought there was no tendency yet toward change in the value proposition (level 1). Most interviewees thought differently, for example stating that even now, the vehicles they produce already have the technical capability to send error codes to service centers automatically or, in the higher maturity level, to support interaction with the immediate surroundings. Examples include finding parking spaces nearby or automatically optimizing routes according to the driver's individual preferences.

According to one interviewee, the digitalization process meant that even now, what was on offer to the customer was not primarily a physical vehicle, but mobility as a service. For him, this involves the additional offer of services based on a real time data analysis, the integration of heterogeneous data sources, and suggestions regarding alternative travel options and means of transport (level 4). However, no one said they were in a position as yet to operate a completely new value proposition and to offer the customer seam-

86) cf. Hass (2002): Geschäftsmodelle von Medienunternehmen. Ökonomische Grundlagen und Veränderungen durch neue Informations- und Kommunikationstechnik, Wiesbaden, p. 89ff.; Stähler (2002): Geschäftsmodelle in der digitalen Ökonomie. Merkmale, Strategien und Auswirkungen, 2nd ed., Lohmar/Cologne, p. 31ff.
87) cf. Müller-Stewens (2016): Strategy: http://wirtschaftslexikon.gabler.de/Definition/strategie.html
88) cf. Picot/Dietl/Franck (2008): Organisation: Eine ökonomische Perspektive, 5th ed., Stuttgart, p. 27]; Schewe (2016): Organizational structure: http://wirtschaftslexikon.gabler.de/Definition/organisationsstruktur.html
89) Annex XX contains a detailed description of these attributes.

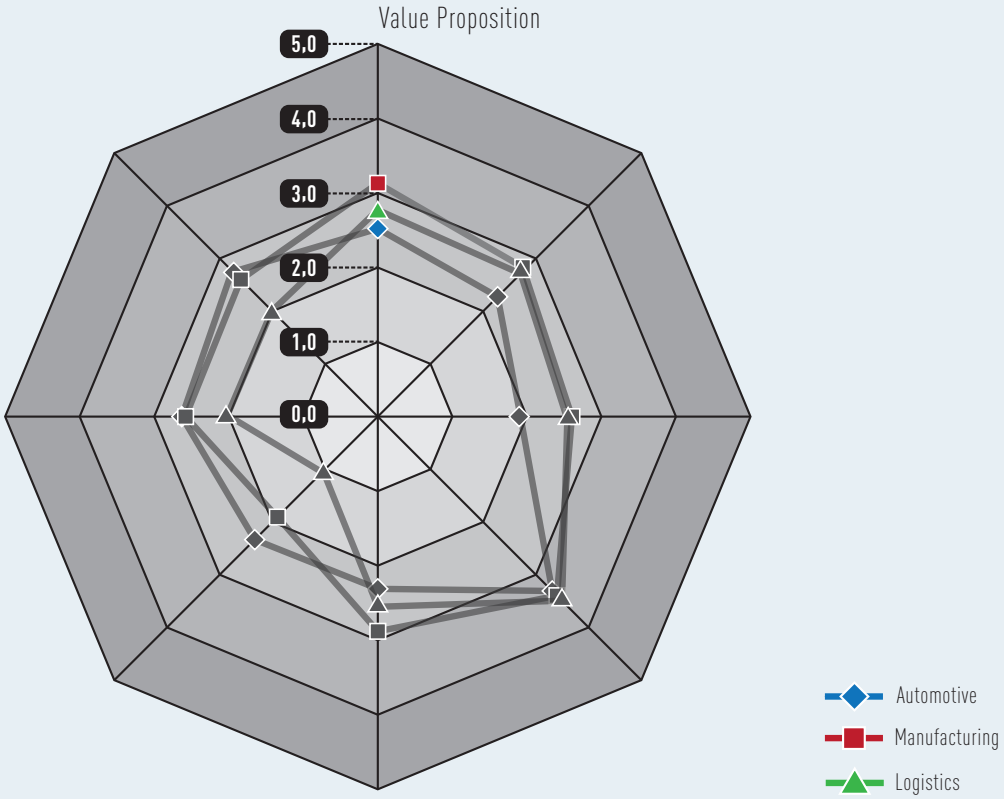


Figure 15: Assessment of the sectors regarding the maturity of the value proposition

less intermodal travel planning, execution and billing as an orchestrator of multiple modes (level 5).

Automotive OEMs in the USA and Asia see things in more or less the same way as in Germany. Nevertheless, in the US conurbations (especially San Francisco Bay Area or Austin), there is a distinct trend toward differentiation of the value proposition in the area of mobility. This development tends to be driven by relative newcomers (such as Uber, Getaround, Metromile, Turo, ZIRX) as opposed to established companies.

The surveyed automotive firms in the USA are aware of the development and understand the need to move their original value proposition forward. For example General Motors (GM) spent 500 million US dollars to buy into Lyft, a competitor of Uber [90], before announcing just four months later that it planned to start testing self-driving taxis based on the Chevrolet Bolt in conjunction with Lyft. [91] GM also acquired a startup specializing in self-driving vehicles for a billion US dollars, indicating a desire to proceed independently of third parties where possible. [92] The current self-driving car partnership between Fiat Chrysler and Google is an exception. The approach of the American automotive companies appears to accord with that of German and Asian companies, in particular the Japanese.

5.2.2.2 Mechanical engineering

The interviewees in mechanical engineering indicated a changed value proposition with partially integrated digital functions (level 3) in the maturity model. This translated into the highest average value of the three sectors under consideration. There was a considerable spread of replies from levels 2 to 5, but most of them were at levels 2 and 3, and just one interviewee indicated level 5.

90) http://www.heise.de/newsticker/meldung/Autonome-Taxis-General-Motors-investiert-500-Millionen-Dollar-in-Lyft-3059405.html
91) http://www.heise.de/newsticker/meldung/General-Motors-und-Lyft-wollen-autonome-Taxis-testen-3197659.html
92) http://www.heise.de/newsticker/meldung/Opel-Mutterkonzern- kauft-Startup-fuer-autonomes-Fahren-3133422.html

According to some interviewees, digitalization implies a redesigned value proposition. Although certain experts argue that digitalization started quite some time ago, new customer-focused technologies and processes are now coming into play, such as IoT-based, collaborative business processes. In mechanical engineering in particular, the value proposition is changing from simply selling and maintaining hardware to complementary, data-driven services that enhance the unique selling propositions of the products, such as predictive maintenance.

Some interviewees think the sale of hardware functionality has a much brighter future than hardware sales alone. This results in concepts like "use instead of ownership" or "production as a service". One frequently quoted example comes from Rolls-Royce in avionics. The manufacturer sells hours of flight time for its turbines instead of the engines themselves. Many of the interviewees also stated that this kind of model (use instead of ownership) was difficult to implement because the industrial sectors have very specific requirements.

5.2.2.3 Logistics

The logistics sector is placed between two levels – a substantially unchanged value proposition with minimally integrated digital functions (level 2) and a changed value proposition with partially integrated digital functions (level 3). Most of the companies surveyed are in a position to enable an on-demand adjustment of delivery options though additional digital offerings. Others are not there yet, although they do try to inform the customer of unexpected events by e-mail or SMS, for example. Overall, the transport segment will develop more quickly than other logistics segments. Statements such as those below were also made in an international context:

„4PL vendors will increasingly coordinate the logistics chains. Two speeds are relevant in this context:
1.) Speed of delivery
2.) Speed of development as a company"

5.2.3 Evaluation of current maturity: value architecture

5.2.3.1 Automotive

Most participants in the survey stated that as a result of ICT-induced change, their company has undergone at least a minimal change to its internal value architecture with increasing integration of value creation activities (level 2). One example is the use of purchase and sale data, which in turn enables just-in-time warehouse management.

Some representatives of the companies surveyed went a step further, stating that changed business processes are already causing a transformation of the value architecture. This means for example that internal processes can be coordinated across the different functional areas and designed to be flexible and efficient on the basis of digital capabilities (level 3).

Interviewees in the USA and Asia view the changes to the internal and external value architecture similarly to the Germans. According to the responses, ICT has allowed internal processes to be substantially integrated, primarily using classic ERP and CRM systems. The automotive sector is characterized by its large number of supplier relationships, meaning that the integration of intercompany (external) business processes is growing in importance.

Bearing in mind the bigger role played by software and data in the value creation process, the Japanese interviewees in particular identify a significant deficit in both respects. These new areas of value creation tend not to be regarded as a risk to the existing internal value creation structures (in the sense of "software replaces hardware"), but as additional growth areas.

Respondents in the USA, on the other hand, do regard the growing importance of software and the resulting data economy as a threat to their own hardware-heavy value creation in the automotive industry. The risk is felt to consist primarily in the degradation to a mere supplier of hardware to be used as a basis for third-party software solutions and platforms (cf. self-driving cars in the cooperation between Fiat Chrysler and

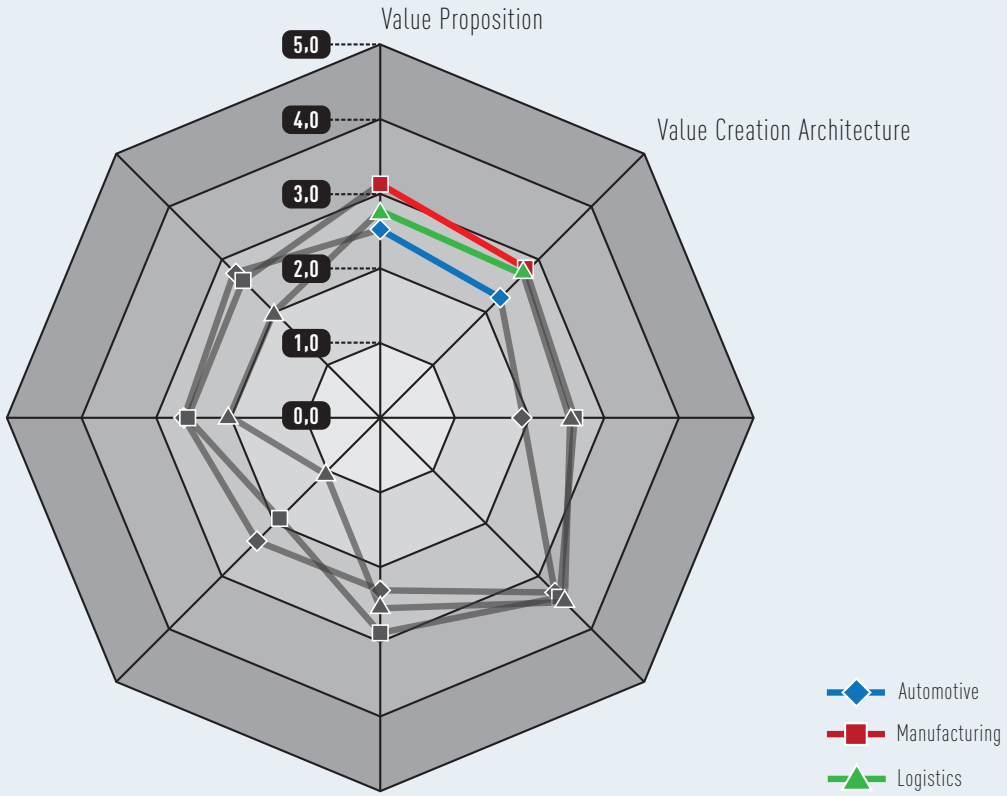


Figure 16: Assessment of the sectors regarding the maturity of the value creation architecture

Google and unresolved issues around data sovereignty and source code [93]). The automotive sector is trying to build up expertise by appointing specialists, but is facing stiff recruitment competition from attractive ICT companies and startups in the USA.

5.2.3.2 Mechanical engineering

Averaging out the observations of the companies surveyed produces a changed value architecture based on changed internal business processes due to digitalization (level 3). For example, third-party partners like data providers are now included in the value creation process with the customer – something that did not happen previously. Within the responses, however, the distribution is interesting. There is one grouping at the lower end of the scale and another at level 4. This is a reflection of the heterogeneity of the sector. Even so, many of the experts have recognized the wish and the need to catch up.

Some respondents from the sector also felt that certain competencies should be outsourced in order to remain flexible. This is confirmed by various experts:

> *„In the era of Industry 4.0, each company must go all-out to find its role in the market. There will be a separation of value creation, for example at present the market is viewed as a whole, whereas in future it will be divided into different layers. Companies will have to prepare themselves for this."*
>
> *Prof. Dr. Orestis Terzidis, head of the Institute for Entrepreneurship, Technology Management and Innovation (EnTechnon) at KIT*

93) http://de.engadget.com/2016/05/09/google-und-fiat-chrysler-noch-uneinig/

Many experts agree that 3D printing technologies will drastically change the production process by making it much more flexible. For an established company in the B2B world, there is no rush, according to some experts, to move to the next level because the product lifecycles are usually very long. It is much more important to get things right.

Many companies recognize the potential of digitalization, with the opportunities it brings for new products and services. However, most people tend to have quite a narrow focus on their own company/their own products. They are unaware that a wider focus has disruption potential. Digitalization opens up new ways to cooperate, with improved market opportunities. But there are also risks if digitalization is turned against the company itself. Established companies are often taken by surprise by newcomers to the market because they are usually distracted by poor customer access or a lack of experience in the relevant field. The search for new business models though, especially new approaches to customer retention, is a real concern for many companies. They fear that higher prices are sustained by a deliberate lack of transparency in the cost structures, or that new customers are bound into a very strong dependency relationship that could then be exploited.

According to the interviewees, tie-ups with companies outside the sector mean that expertise can be built up more quickly, with significant competitive advantages. This throws up some questions around the extent to which a competitive approach hinders innovation and whether greater partnership and working for the common good results in faster and better progress for everyone.

5.2.3.3 Logistics

The integration of sales and procurement data and end-to-end inventory management for just-in-time deliveries are now standard in the logistics sector (level 2). That means that all logistics companies have achieved integration of internal value creation activities through digitalization – even if they only have a substantially unchanged value architecture.

In most of the logistics companies, digitalization has also resulted in a changed value architecture through changed internal business processes (level 3). On the basis of digital capabilities, most companies have achieved a general process optimization across multiple operating departments aimed at greater efficiency and flexibility.

Internationally, experts rate the progress of logistics in digital transformation higher than this. There is already a substantially changed value architecture based on changed external value creation networks.

„Logistics used to mean a combination of physical flow and warehousing. From this perspective, logistics has undergone dramatic change."

„Most logistics companies still have people to do the picking. But there are digital systems telling the people what to do."

The logistics market has highly innovative participants with Uber and Amazon. Both companies rely heavily on digital platforms and have mostly changed value architectures. German logistics providers will find it difficult to keep pace as they cling to established value architectures.

5.2.4 Evaluation of current maturity: revenue model

5.2.4.1 Automotive

Whereas just two of the experts surveyed felt there was no change in their revenue model (level 1), most interviewees from the automotive sector stated that their revenue model had changed at least minimally as a result of digitalization (level 2). As such, there are already a small number of opportunities to combine/differentiate between direct revenue sources (such as monetary payment) and indirect revenue sources (such as advertising or data sharing). At this maturity level, it is assumed that an OEM is in a position to vary the sales price instead of simply offering products and services at a rigid fixed price. For example this could depend on what usage data generated by the driver or the vehicle can be obtained and analyzed.

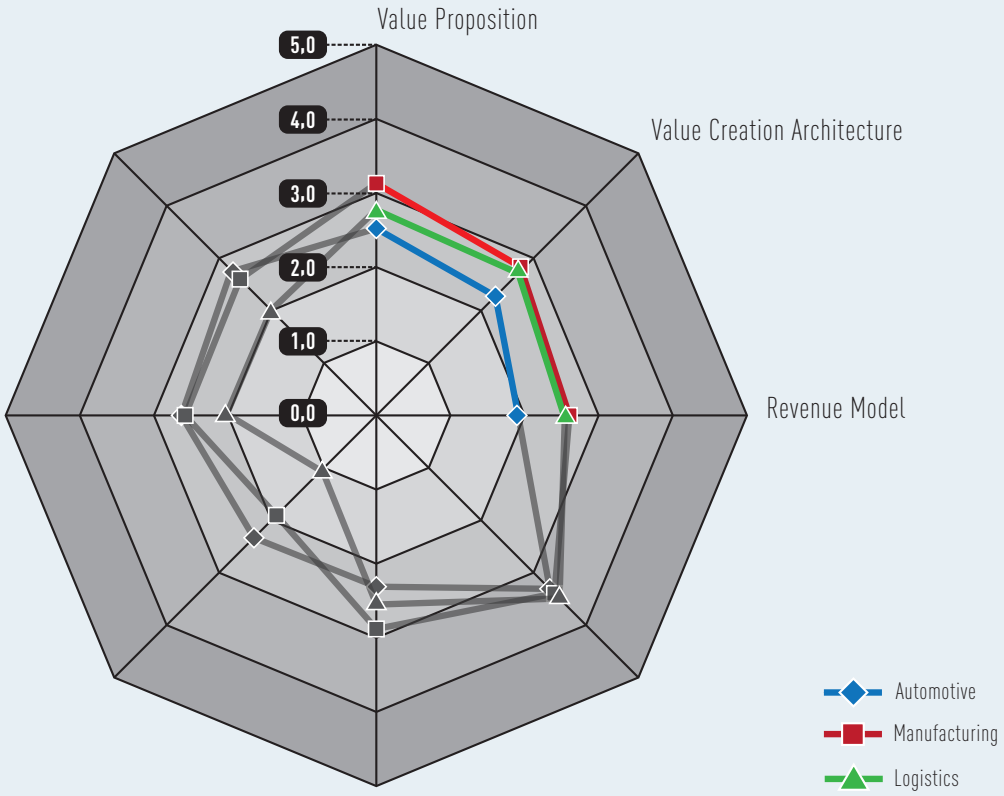


Figure 17: Assessment of the sectors regarding the maturity of the revenue model

One of the participants says he is ready now to add more forms of price differentiation to his revenue model – similar to Uber's surge pricing model, which takes account of real-time supply and demand (level 3). Other possible combinations of fixed prices and usage-based pricing – for example based on the individual mobility preferences of the customers and their specific patterns of behavior – and other direct and indirect revenue sources are not identified at present (level 4).

The German perspective is largely in line with the Asian findings. There, traditional revenue models and sources continue to dominate. In the USA, on the other hand, the importance of greater flexibility in revenue models has largely been recognized and to some extent put into practice, especially among newcomers to the market. For example, Metromile's "Pay-per-mile insurance" is a highly individual insurance product that depends on the actual mileage.[94] Turo is in a position to make automatic price adjustments for customers wanting to rent a car, according to defined criteria like the weather, day of the week, supply and demand. This improves the utilization of the vehicles on offer.[95] Uber, in turn, combines revenue sources from passenger transportation with logistics services.[96]

5.2.4.2 Mechanical engineering

Many of the interviewees indicated that they followed a minimally changed revenue model with few opportunities to combine direct and indirect revenues (level 2). A small number of the companies surveyed are already using a changed revenue model with some (level 3) or many (level 4) opportunities to combine products and services as direct revenues or even indirect revenues in the form of usage data.

94) https://www.metromile.com/about-us/
95) https://support.turo.com/hc/en-us/articles/207337887-What-is-Dynamic-Pricing
96) http://digiday.com/brands/uber-combine-ride-sharing-delivery-services/

Software as a service, machine as a service and rental models in production are widely expected for the future. However, it is assumed that the pay-per-use concept will only succeed where it represents a genuine improvement. The reasoning is that the pay-per-use model does not allow for effective cost planning, even if it is more scalable The assumption therefore is that concepts such as this tend to be used by startups as a way of keeping down investment costs.

Note, too, that flat-rate pricing has prevailed among consumers as opposed to pay-per-use. However, customers have already started looking for new service models, and maintenance concepts at flat-rate prices could take the place of spare part purchases. This would also be in line with growing environmental awareness among the population, as the products would be developed for the longest possible service life.

5.2.4.3 Logistics

Most logistics companies have at least a minimally changed revenue model, even though it is not significantly differentiated. At present, much use is made of flexible prices for logistics services combined with central, highly-automated logistics warehouses. Some companies have a changed revenue model including a partially differentiated logistics offering. This revenue model is already prevalent in the international companies surveyed.

„The value chains are changing, and this is causing the revenue models to change too.“

According to the expert interviews the change in the revenue model is closely related to the change in the value creation structure. A changed revenue model appears to be heavily dependent on the change in the value architecture, say the experts, and follows along behind.

5.2.5 Evaluation of current maturity: strategy

5.2.5.1 Automotive

The ICT-induced change in the corporate strategy is at least considered as a factor by all the surveyed representatives from the automotive sector. As such, there was no level 1 assessment, which assumes that the digital transformation is not addressed in the corporate strategy. There is a range of opinions as to the importance placed on change in the strategic orientation and whether and how much of the strategy has been implemented in the functional areas of the company.

There is, however, a discernible trend indicating that digital transformation is merely a minimal phenomenon in the corporate strategy in most companies, hardly even meriting consideration in the functional areas (level 2). It is noteworthy that the highest maturity (level 5) was quoted as frequently as the lower levels 3 and 4. In level 5, digital change is the core element of the corporate strategy and operationalization has already taken place in an integrated roadmap. The strategic approach has also been implemented in all functional units. At levels 3 and 4, there is a gradual increase in the importance of digital change for the corporate strategy and the degree of implementation in the functional areas.

Overall, in relation to the other questions about maturity in the socio-economic context – in other words with regard to business model, strategy and organization – the highest level of maturity among the interviewed companies is found in the area of strategy.

The strategic relevance of ICT-induced change for the automotive sector is recognized equally by respondents in Asia and the USA. However, they do not give the associated changes the same degree of urgency. In Asia, and especially in Japan, ICT-induced change is associated with successive and not particularly disruptive changes. The main impetus is expected to come from established automotive companies (primarily Toyota), which respond late to changes of this kind, and even then, only incrementally. In the USA, on the other hand, ICT-induced change is perceived as a serious and urgent threat to the core business, particularly the disruptive changes brought about by the nation-wide competition with new OEMs (such as Tesla or Local Motors) and the mobility ecosystems that have been introduced with such success

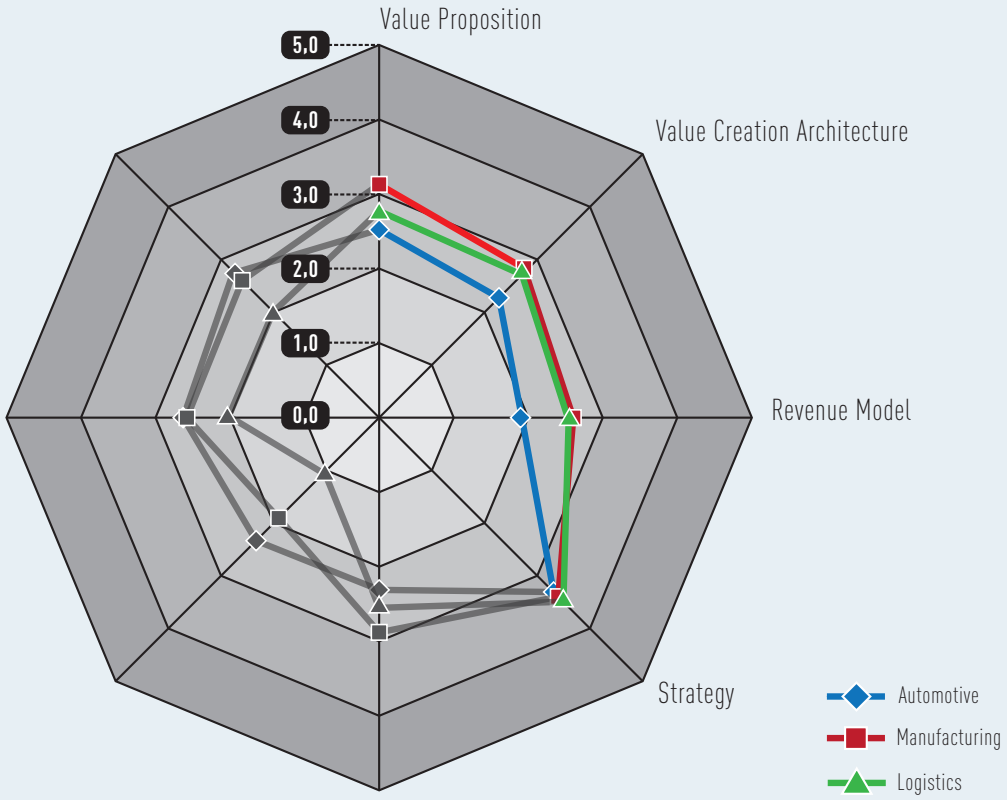


Figure 18: Assessment of the sectors regarding the maturity of the corporate strategy

(e.g. Uber, Getaround, ZIRX). There is a corresponding willingness to undergo strategic reorientation and general change, as demonstrated by the partnerships now being forged (for example GM and Lyft [97] or Fiat Chrysler and Google [98]).

5.2.5.2 Mechanical engineering

The surveyed company representatives in mechanical engineering paint a similar picture to the automotive sector when assessing the strategic relevance of digital change in their own companies. ICT change is predominantly an element of the corporate strategy and has been put into action across multiple functions (level 3). Nevertheless, consulting experts indicated that machinery manufacturers do not generally have well-developed expertise in the field of software. That said, awareness of the growing strategic importance of software is growing in this sector.

„Our most expensive research and development project was a software project."

A digital strategy must be implemented with appropriate project management (such as Agile, Lean), involving further changes to the corresponding R&D activities. There is some skepticism about whether established mechanical engineering companies can fully transform themselves into digital, software-based companies. Respondents from large companies also thought that level 5 of the maturity model (ICT change as an element of strategy in all functional areas) would be undesirable as it would neglect certain special features and priorities of the business units.

5.2.5.3 Logistics

In logistics, there is at present no agreement as to how ICT-induced change is understood in the context of

97) http://www.manager-magazin.de/unternehmen/autoindustrie/zukunftsmobilitaet-gm-steigt-bei-uber-konkurrent-lyft-ein-a-1070431.html
98) http://www.spiegel.de/auto/aktuell/google-und-fiat-chrysler-produzieren-zusammen-selbstfahrende-autos-a-1090732.html

strategy. Major companies with their own strategy departments come up with many conceptual ideas. They know that companies will have to become solution providers in future:

„You can't earn money with unintelligent services. Logistics companies must produce software themselves. This is a primary business, and these products must not come from outside. Amazon writes all its software itself, yet still sees itself as a logistics service provider."

However, this insight and the corresponding conceptual ideas are not necessarily applicable to all of the companies surveyed.

„All the ingredients are in place for a digital transformation strategy for the company, covering most of the functional areas. The company follows the management's guidelines to the letter. Only the mindset needs to change. People prefer to buy a new hall rather than a new IT company because a hall is much more tangible in terms of the business."

A lack of sustainable, realistic strategies around digital transformation in logistics is also seen internationally.

„The company's senior managers pay lip service to digital transformation but don't really have any idea of what needs to be changed."

Generally speaking, logistics companies are very conservative. The response to completely different business models and changed core competences in commercial and technical areas appears to be to cling onto established value chains and revenue models in an effort to minimize risk.

5.2.6 Evaluation of current maturity: Organization

5.2.6.1 Automotive

Many of the surveyed representatives of the automotive sector reported that some loosening of the organizational structure has already taken place as a result of ICT-induced change. There are also discernible trends toward shared decision making, cross-functional teams and greater adaptability in the company (level 3). This means that digital capabilities are increasingly being used to decentralize the decision making process in the company and to foster cooperation across individual functional areas. However, the necessary change processes are sometimes slowed by structures that have grown up over time and the prevailing corporate culture.

Some interviewees rate their companies one level higher, reporting a high level of dynamism in the organization, a real eagerness to learn and an ability to adapt flexibly according to the particular problems and tasks (level 4). A similar number of companies were found to have a rigid organizational structure with centralized decision making and independently operating functional silos with little adaptability (level 1), or an organizational structure with minimally shared decision making and substantially independently operating functional silos with slow adaptability (level 2). Most respondents indicated that theirs was a rigid organizational structure with centralized decision making and substantially independently operating functional silos with slow adaptability (levels 1 and 2).

The organizational structures of the international automotive companies in the survey are also largely focused on the needs of industry-specific research, development, production and other processes. That means they are characterized primarily by the strin-

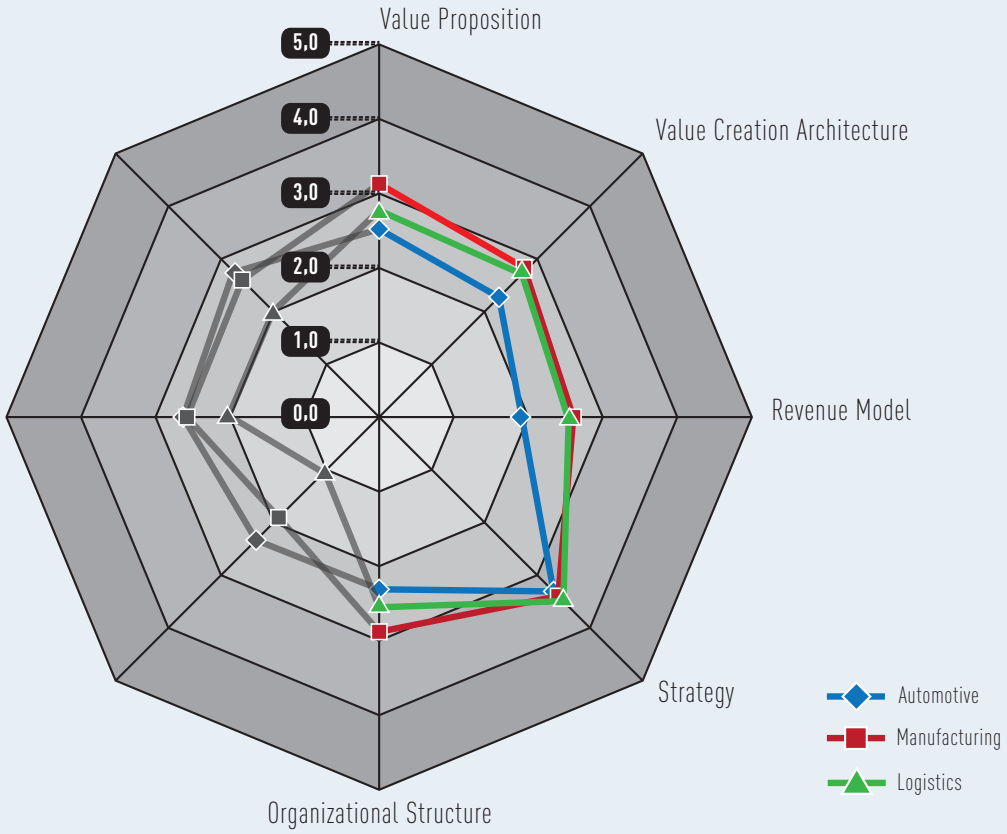


Figure 19: Assessment of the sectors regarding the maturity of the organization

gent safety requirements imposed upon certain functions, and multi-layered supplier relationships. The national culture has a fundamental influence too, in particular the prevailing context of social relationships. For example, organizational structures in the surveyed companies in Asia appear to be more influenced by hierarchies and seniority than in the USA.

Furthermore, decision making in Asia is predominantly consensus-based, involving all employees if possible – in the USA, the decision making process is often competence-based and does not ultimately require majority support. ICT-induced changes to the organizational structure are found mainly in the USA, where a greater emphasis on software in development results in significant organizational changes (for example team formation based on competence alone) and software-based collaboration (for example the Slack team communication app).

5.2.6.2 Mechanical engineering

In mechanical engineering a relatively high maturity level was found regarding the influence of ICT change on the organization. Within the responses, however, there is a wide variation. Representatives of SMEs and family firms with a rigid organizational structure and a shallow hierarchy place themselves in level 2. In large companies, the decision makers are already divided between multiple business areas, making it easier to achieve a higher level in the maturity model.

A clear majority of companies reported having decentralized decision making structures in which some teams perform cross-functional tasks (level 3), improving the way the company adapts to changes resulting from digitalization. A certain degree of agility is also advisable when it comes to integrating acquired companies. Some interviewees still think that a central

unit is necessary in order to establish and implement a digital strategy in the company. After all, large companies always have synergies that should be taken into account.

The search for qualified and committed staff is widely seen as problematic. Many respondents stated that this was not due to a shortage of skilled staff. Much more intensive integration is needed in personnel management in order to find the right people and provide the right training and qualifications for existing employees. ICT could help here to fill the gap in terms of integration. There is also a desire to retain older and usually highly experienced staff for as long as possible while also bringing in young staff with new ideas and new ways of working with today's technologies.

5.2.6.3 Logistics

Organizational structures in logistics are mainly based on partially decentralized decision making, with a small number of cross-functional teams and moderate adaptability within the organization. Some companies are only just beginning to develop digital capabilities for reorganization, with early signs of cross-functional collaboration and optimized change management practices. Most logistics companies in Germany try to use digital functions to decentralize decision making and to simplify cross-functional collaboration. Organizational change processes are institutionalized and progress is slow because of the prevailing corporate culture.

> *„The manager thinks everything has to change. Except himself, of course, so that he can manage the process."*

Old management-based hierarchies are the problem – they want to direct the change process but do not see themselves as part of the change. This is also the reason why a large number of companies fail to achieve the transition to fully digital processes with a high degree of organizational dynamism, and a willingness to learn and adapt.

At the international level, logistics companies are only just beginning to make use of digital capabilities as a way of forcing organizational change. Large, established logistics companies lack the leadership needed to implant digital change in the company. They would rather leave new organizations to develop outside the company in the hope that they can be used as blueprints for change.

5.3 Technology in change – progress in technological transformation

This section starts by describing the topics with relevance to our analysis, before going on to discuss the results of the survey. Using these topics as a starting point, the automotive, mechanical engineering and logistics sectors are classified and compared in terms of their technical maturity on the basis of the maturity model described above. In the previous chapter, the experts were asked about the technical drivers in general terms. In contrast to these specific technologies, the focus now is on expertise in various software-related areas which in the opinion of the authors must be mastered in the context of ICT-induced change. After the assessment of the experts for each sector, we present general trends and development aspirations.

5.3.1 Explanation of characteristics

To enable the sectors to be classified according to maturity, different competencies were identified and the individual development steps of the dimensions were compiled. The generic aspects represent general overviews, which are composed of a number of necessary sub-competencies:

1. **Data analysis:** This includes competencies in the fields of data acquisition, storage and processing and the extraction of knowledge from unstructured data. Competency of this kind forms the necessary foundation upon which self-organization and autonomy can be established.

2. **Autonomous systems:** When fully rolled out, the autonomous systems are able to recognize complex relationships in their environment and to develop solution strategies. In the lower levels, the use of automation technology to create (complex) control systems is covered. In the context of autonomous systems, technologies such as networking, integration, decentralization and service orientation are relevant.

3. **Digital engineering:** This sub-competence describes a concept for the overarching integration of development tools and data. In this study we couple virtualization[99] with the automated interaction between product design and production systems. Digitalization is a prerequisite of virtualization because the necessary models and data must be available in machine-readable form.

5.3.2 Evaluation of current maturity: Data analysis

5.3.2.1 Automotive

In the field of data analysis, most of the German automotive industry is at a lower level. Although data is evaluated, there is still no available usage or crash history. In terms of the technology and the infrastructure, the conditions for acquiring and analyzing vehicle user data could be in place within the next two years. One major challenge is to combine the various information from different domains (vehicle, environment, subdomains within the vehicle such as the drive train or the multimedia system) and turn it into a value add.

It should be noted that the factors standing in the way of achieving higher levels are felt to be less technical than organizational. Whereas dynamic models (level 3) are already in use on the product side, it appears that large sections of the existing organizations are not yet ready to engage with data-driven applications (level 1). The organizations must first learn to appreciate the value contained in the usage data before the right environment can be established to exploit it. The evaluation of vehicle data by advanced, intelligent analytical systems is considered to be a base technology for the development of (fully) autonomous driving functions.

At the global level, the established car manufacturers and suppliers report a very similar situation. The integration of data analysis technologies in operations and development is rated as highly promising. The first steps toward achieving higher development levels than level 3, which covers dynamic models, have already been taken.

Among the factors affecting the organization and infrastructure, data protection is given considerable prominence in Europe whereas a more liberal approach is taken elsewhere in the world. Newcomers to the market already have the infrastructure to receive all telemetry data from their fleet of vehicles and to analyze it centrally. For example, Tesla or BMW include the capture and use of this information in their data protection arrangements or their general terms and conditions. [100, 101] This information is already being used in the continuous improvement of products.

5.3.2.2 Mechanical engineering

In mechanical engineering, only a small number of companies reported the use of dynamic models for data analysis across the company (level 3) – the sector is at present in the preliminary stage. About half of the inter-

99) Here, virtualization means the transfer of physical and logical reality into the computer. The term „digital twins" is also in widespread use.
100) https://www.teslamotors.com/about/legal
101) http://www.bmw.de/de/topics/service-zubehoer/bmw-service/teleservices/agb.html

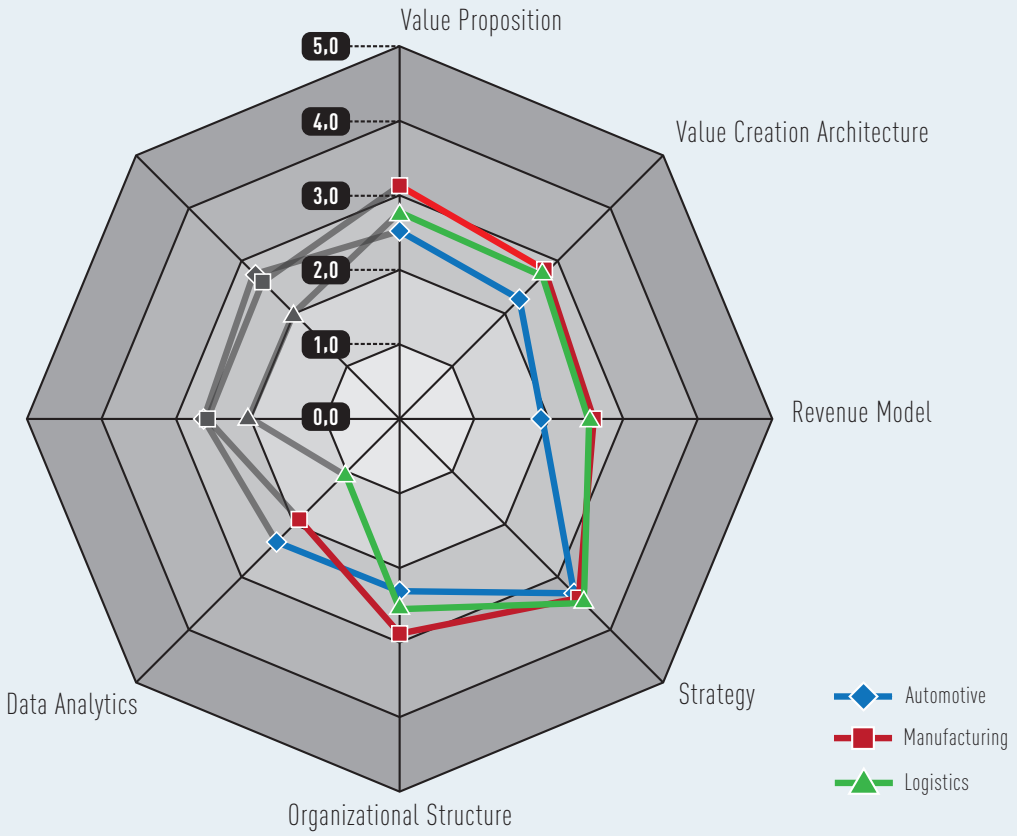


Figure 20: Assessment of the sectors regarding the maturity of data analytics

viewees said that they use predominantly static and statistical data models, often based on ex-post data, in other words data that is processed after it is collected (level 1). This means that outages cannot really be predicted, simply analyzed after the event. Production process are optimized little by little, and not "online".

This result suggests that data analysis and possible applications are still in the design and evaluation phase. Some experts state that continuous data would need to be made available by remote services. In the opinion of the interviewed experts, the shortage of specialists in the field of data analysis is impeding the application of continuous data to dynamically adaptable models. In addition, some interviewees referred to the necessary process knowledge of specialists in the field of data analysis.

The majority of interviewees felt that data analysis in mechanical engineering is growing in importance as a result of digitalization. According to one respondent, "the average mechanical engineering firm already stores vast amounts of data, but doesn't use it yet". The data for analysis seems to be more prevalent for the machinery used within the company. The data produced within the company is usually very sensitive data that the company is often reluctant to release for analysis by external companies. It does not seem to be possible to separate the data into sensitive and non-sensitive data as there is always a fear that the data could give away information about the systems or production methods, potentially jeopardizing the company's competitive advantage.

A comparison of the regions does not add any more insight than the interviews conducted in Germany. Just one interviewee reported that AI is already being used to generate new models from raw data, although it should be noted that this system is still at

the prototype stage and is not implemented across the company.

The experts from Asia agreed with their German counterparts when they stated that the "average mechanical engineering company usually only stores data and doesn't use it". Some Asian respondents admitted that their country is always lagging behind the market and that most companies only respond if a fault occurs.

Interestingly, some interviewees think that systems that are capable of deciding for themselves which input to use for the model, for example in the context of machine learning, are not desirable at all.

5.3.2.3 Logistics

In logistics, statistical models based on ex-post data are used (level 1). There are causal models and forecasts relating to a few logistics functions, but they do not cover the company as a whole. Most logistics companies can record a delivery delay and take the necessary steps (ex-post processing), and the utilization of warehouse and transport capacity is also recorded. At present, logistics companies are divided into divisions with one corporate center.

„New organizations are required which allow the leap to be made to digital (static) models of logistics chains in order to optimize delivery times and warehouse/ transport capacity."

Established logistics companies will not revolutionize the market technologically by themselves – the major digital players like Amazon are being left to shape the market.

„We won't revolutionize the market ourselves. When someone else does it, we will follow."

5.3.3 Evaluation of current maturity: autonomous systems

5.3.3.1 Automotive

The results of the expert interviews are largely in line with previous studies. The interviews in the automotive sector in Germany were strikingly similar with regard to the assessment of maturity of autonomous driving. The surveyed German suppliers, engineering service providers and vehicle manufacturers predominantly rated their current maturity as providing "partially autonomous capabilities including object recognition and planning of complex actions with driver interaction in defined but dynamic environments" (level 3).

The outstanding legal issues were cited as an obstacle to the introduction of autonomous driving. The car manufacturers also mentioned the pricing of the self-driving vehicles, which is yet to be determined.

In the technical area, the suppliers said there are unanswered questions about the theoretical basis for machine learning, which is necessary for certain aspects of autonomous driving. According to experts, there is as yet no adequate theory able to model and guarantee the integrity of the results of machine learning decisions. Machine learning systems are still unable to provide sufficient certainty about their own integrity. There is a need for action in the context at the theoretical, academic level.

The maturity level of autonomous driving is similar in the USA and in Germany. In Asia, however, the current maturity level was still described as the control of vehicle functions with "predefined reactive behavior including the capacity to sense the environment and perform coordinated movements" (level 2). This is a lower maturity level than the level reported by the German and US companies.

5.3.3.2 Mechanical engineering

The interviews conducted in Germany showed that the mechanical engineering companies base their own production on traditional actuator, sensor and control technologies and deploy a substantially reactive behavior in their automation systems (level 2). For example, the automation systems sense the environment and control actuators on the basis of simple adaptive AI algorithms and defined rules. This places the com-

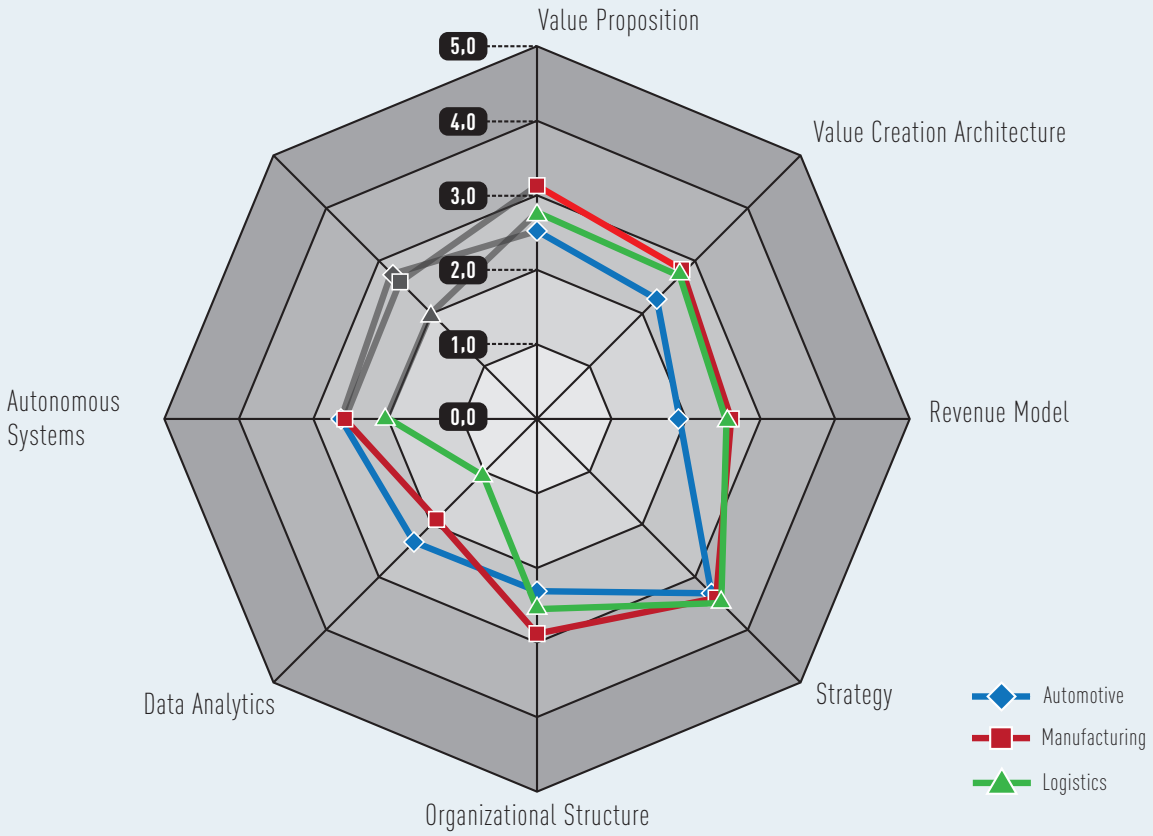


Figure 21: Assessment of the sectors regarding the maturity of autonomous systems

panies on the level below partially autonomous functions (level 3), which appears to have been achieved to a minimal extent.

Mechanical engineering companies are currently gearing up for semi-autonomous systems. They are investing more in intelligent products such as collaborative robots (such as YUMI from ABB, IRC3 from Universal Robots). Some companies that report having partially autonomous functions like object recognition and planning of complex actions are already using them for self-optimizing workflows in machines. Certain experts regard the implementation of autonomous functions for a company (level 4) as technically unproblematic, but feel that this should be driven by a corresponding need.

„To reach level 4 we first need to find an application in industrial automation that benefits from fully autonomous functions. For example there was an internal project about autonomous mining robots."

Dr. Roland Weiss and Dr. Heiko Koziolek, ABB Research Germany

In contrast to the interviews conducted in Germany, experts in the other regions think that their company uses simple control strategies (as opposed to partially autonomous functions to a minimal extent) to perform predefined actions or coordinated movement sequences on the basis of sensor signals (level 2). Only two experts reported any use of partially autonomous functions. One was in shipbuilding and the other was a manufacturer of rescue robots for dangerous incidents like nuclear disasters.

According to the interviewees, the 2020 Olympic Games in Tokyo are a major driver for autonomous systems in the Asian region, as a way of projecting a forward-looking image on the world stage. The respondents were skeptical, however, about whether increased autonomy is a benefit for mankind. Japanese experts also warn about the growing competition in the field of autonomous systems, which in their opinion can only have one winner – in effect creating a monopoly.

5.3.3.3 Logistics

According to the interviewees, most logistics companies are only able to deal reactively with disruptions in the logistics process. That is why the logistics sector was predominantly rated at level 2 of the maturity model. Even today, logistics is principally a manual affair – after all, logistics is much more complex than intralogistics. Express logistics and intralogistics appear to achieve the highest degree of automation in the logistics sector. According to some respondents, the use of autonomous systems was abandoned in the past because they were too inflexible. Robotics technology still does not offer the multicustomer/multipurpose flexibility that would be necessary in logistics. This means there are currently opportunities to be had in robotics technologies.

„We have the opportunity to revitalize robotics technologies."

In 2012, Amazon acquired Kiva Systems and renamed it Amazon Robotics. This was part of Amazon's attempts to react more quickly to changed customer preferences without increasing personnel costs.

Logistics is the sector with, on average, the lowest maturity level in the category of autonomous systems in our model. It is true that developments like autonomous intralogistics and company acquisitions (for example Amazon and Kiva) make the headlines, but on average only ten percent of warehouses are currently automated.

„Autonomy does not represent disruption for logistics."

5.3.4 Evaluation of current maturity: digital engineering

5.3.4.1 Automotive

German automakers are unique in offering such a high degree of individualization in the cars they sell. In addition to colors and finishes the customer can choose from a wide range of options, even in small cars. These include different engines and gearboxes and various assistance and infotainment systems.

They managed to do this thanks to a highly optimized process chain in which the suppliers and the integrator work closely together. This relationship between design and production means that the German manufacturers already consider themselves able to adapt the production process dynamically in response to changes in the design (level 3). The next stages of development will be supported by the use of software to define product features. Standardization, too, brings greater flexibility when selecting development and production partners, and this should further simplify and speed up on-demand production.

5.3.4.2 Mechanical engineering

All the mechanical engineering and automation companies are using data-driven simulatable models, at least to a minimal extent (level 2). The experts state that the intention of Industry 4.0 is to combine the design and production process with partially dynamic adaptation of production, representing the next level in the maturity model. Some aspects of these technologies have already been demonstrated in projects. However, they have not been rolled out across the company so a higher level is not justified. For the mechanical engineering companies, the benefits of this step do not appear to be sufficient yet, especially as the number of units sold is much smaller than in the automotive industry.

Our international interviews reflect the views of the German experts. Some of the respondents think that simulations are predominantly data-driven at present – without integration of a physics simulation – so they see further potential in that area. Interestingly, experts

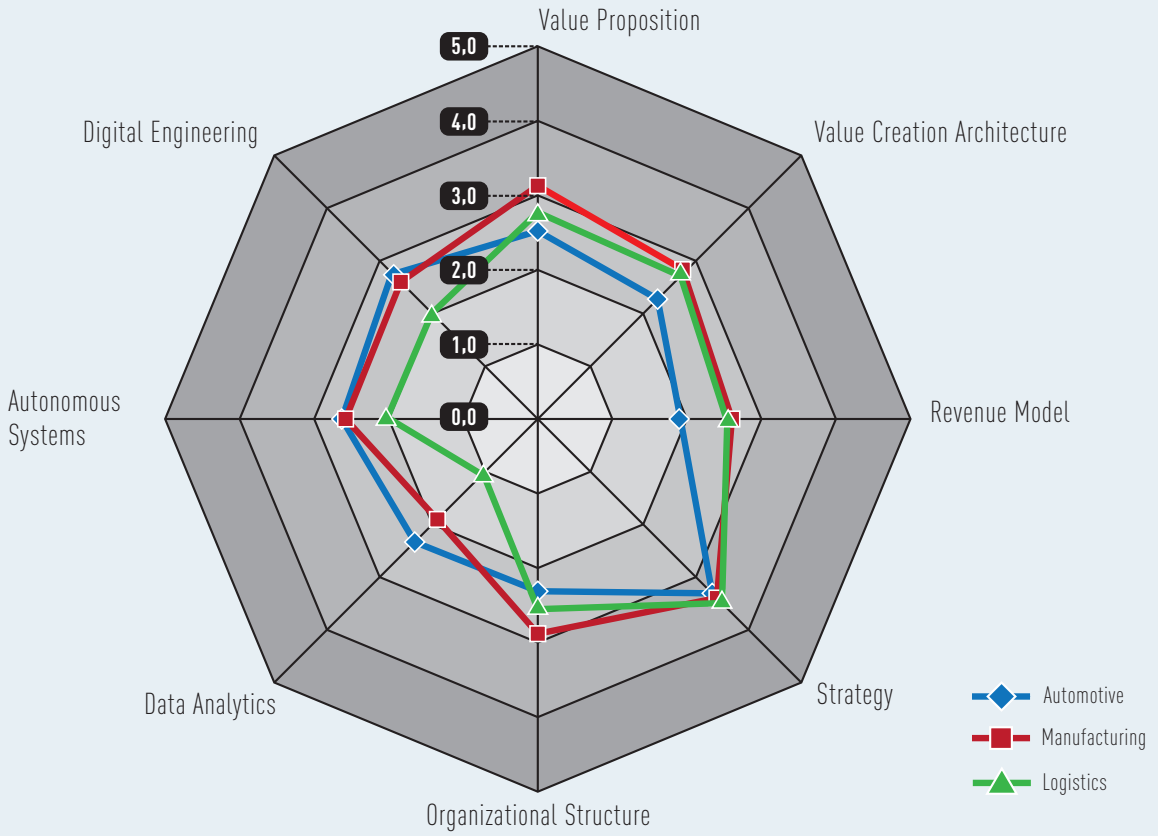


Figure 22: Assessment of the sectors regarding the maturity of digital engineering

in Japan said the following regarding the implementation of digital engineering technologies: "Advances only take place when one company starts implementation. All the other companies then follow."

5.3.4.3 Logistics

Data-driven design support and simulation of logistics processes appears to be widespread in the logistics industry, which is why the experts surveyed rated their own companies at level 2. As things stand, the bulk of the logistics market still consists of B2B business as opposed to end customer/last mile delivery.

„B2B logistics customers usually want to keep control of the supply chain."

That means dynamic adaptation of the logistics process – the next level in the maturity model – is not always possible because customers, and especially B2B customers, will not readily accept it. As a result, the logistics chain still contains manual steps that mitigate against combining the logistics design and the logistics process.

„The next level involves combining the elements, and this can only be done by an actor that is not scared of investing and running the necessary risk."

As such, the reticence of the logistics companies constitutes a hazard: Companies such as Amazon, which have already mastered digital engineering and currently provide it for logistics chains in the B2C segment, can expand it to the overall logistics market, taking considerable market share from traditional providers.

5.4 Assessment of desired future developments in the sectors

The previous section discussed the current situation, and we now turn our attention to a critical discussion of predicted developments. The analysis will focus on the way the various factors relate to each other and the reported time frames. In the previous section, we took a purely descriptive approach, whereas here, we will interpret the results on the basis of interview responses and research.

5.4.1 Automotive

With regard to the situation in the German automotive industry at the end of 2015, there are no factors apart from strategy in which it can be said to be acting in a revolutionary way. [102] According to its own assessment, however, it is firmly resolved to fundamentally reinvent itself over the next three to six years.

Remember that one of the most well-known public drivers of change happened back in October 2010 when Google published the results of its fleet of self-driving vehicles. [103] The authors estimate that Google is currently significantly higher than level 4 in the dimensions of data analysis and autonomization. To put it bluntly, even in the next three to six years, the automotive industry will not manage to get to where Google is today. Against this background, Fiat's move to tie up with Google makes a lot of strategic sense. After all, it potentially allows Fiat to overtake other manufacturers in these two technical factors. The Italians are perhaps also hoping to learn from the example of Samsung, which became the world's largest smartphone manufacturer with the help of Android. [104]

The very low value for data analysis in the German automotive industry is particularly eye-catching. In the opinion of the authors, mastery of these technologies is one of the central pillars of machine learning – in other words it is not just a matter of identifying objects on the road in time, but also of predicting what they might do in order to develop an optimum reaction strategy. All in all, these technologies are essential in order to realize self-driving vehicles. The rapid development and review of alternative strategies, in particular, has been impressively demonstrated by Google in the AlphaGo system described above (see section 2.2). The relevant academic paper in "Nature" [105] shows how important it was to analyze and learn from human Go matches. Google is clearly in a very good starting position in order to take technical control of the field of autonomous driving. Especially as the company appears to be the only one currently able to combine this expertise with the detailed maps from Streetview/Google Maps.

In the similar initiative by Tesla, too, the ability to analyze large amounts of data is vitally important in the development of self-driving vehicles. Tesla cars record the data of the integrated environmental sensors and the driver's reactions in parallel, and upload them to the analysis cluster every day. In simplified terms, two things happen in this offline process. First, Tesla continuously adds new environmental details like exits or road signs to the map data. Second, Tesla cars analyze how drivers react to known or new situations, and use this to optimize the driving functions. The distilled practical knowledge is made available to all Tesla drivers in an over-the-air update (OTA) a few days later. [106] At present, Tesla can access a million kilometers of driving data every ten hours – this is the distance covered by 70,000 drivers within this time – continuously optimizing the driving functions on that basis. [107]

Google's self-driving cars may only cover slightly over 1,000 kilometers per day on US roads, but Google's data centers do something much more: every day, they simulate up to three million kilometers of driving data. That means they can try out new functions and software versions virtually at first, introducing them to real-world roads in the vehicles later on. The results of all real-world journeys are also fed back into the system. [108]

For comparison, the old rule of thumb in the automotive industry was that a new car should have covered around a million test kilometers in real-world condi-

102) See the description of the maturity model in section 5.1
103) https://googleblog.blogspot.de/2010/10/what-were-driving-at.html
104) http://www.idc.com/prodserv/smartphone-market-share.jsp
105) http://www.nature.com/nature/journal/v529/n7587/full/nature16961.html
106) http://cleantechnica.com/2015/11/05/tesla-right-approach-self-driving-cars/
107) https://www.technologyreview.com/s/601567/tesla-tests-self-driving-functions-with-secret-updates-to-its-customers-cars/
108) https://static.googleusercontent.com/media/www.google.com/en//selfdrivingcar/files/reports/report-0116.pdf

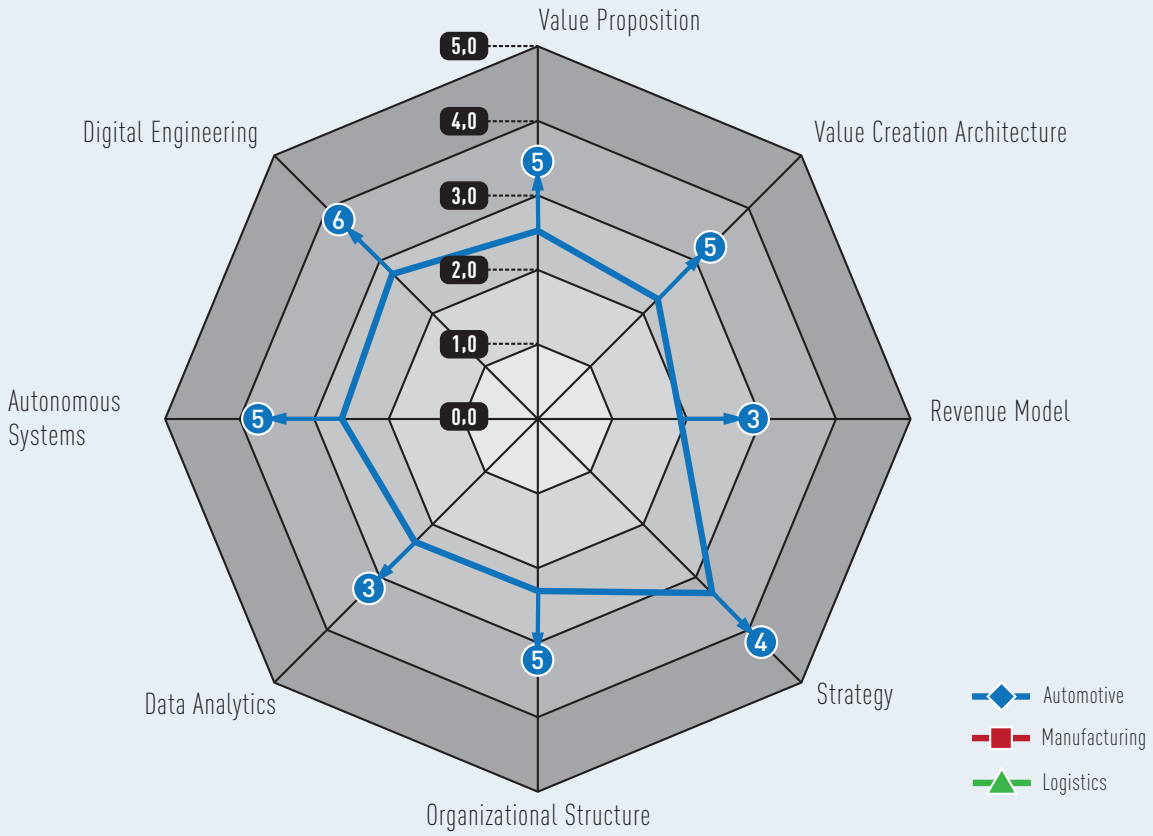


Figure 23: Assessments of the automotive industry on how the maturity dimensions will develop [109]

The line shows the current status and the number indicates the years until the next level is reached.

tions before it is released on the market. [110], [111] Experts assume that 240 to 500 million test kilometers are necessary before an autonomous vehicle will be approved. [112], [113] In practice, Tesla currently achieves this kind of result after about 2,400 hours or 100 days.

In addition to vehicle autonomization, the interviewees also felt that data analysis had an important bearing on new revenue models and value architectures. For example, they emphasized the inherent risk that automakers will be degraded to mere hardware suppliers of vehicles to software companies. Especially if the classic manufacturers do not in future manage to establish a high level of competency in data collection, storage, processing and analysis and use it to develop new services. One example given was the use of machine learning in order to individualize mobility offerings.

Overall, the business model cluster (value proposition, value architecture, revenue model) in the automotive sector leaves a very mixed impression. One reason is that although new revenue models are likely to make a substantial contribution in three years – the most common example given was car sharing – it will take an expected five years for new value propositions and value architectures to emerge. For a successful business model, however, all three components should be developed alongside each other, if possible at the same pace.

It is also striking that there is expected to be a substantial difference between the value proposition and the revenue model, even into the future. Here, the authors are left with the impression that although the interviewees place a high value on the new offerings described above, they are highly uncertain about whether

109) The levels are midpoints of the relevant dimensions, so the position of the point also represents the midpoint of the next level up in this sector. The same applies to the next two figures.
110) http://www.spiegel.de/spiegel/print/d-90750488.html
111) http://blog.mercedes-benz-passion.com/2009/08/fur-hochste-anspruche-%E2%80%93-zeitraffer-der-extreme-entwicklung-des-e-63-amg/
112) http://www.heise.de/tr/blog/artikel/Driften-fuer-Dumme-2054962.html
113) http://www.faz.net/aktuell/wirtschaft/unternehmen/langer-atem-in-der-forschung-240-millionen-kilometer-mit-dem-roboterauto-12646674.html

they will develop into a major source of revenue. This impression is reinforced by the fact that the respondents do not expect any fundamental changes in the next ten years at least, for example the emergence of car manufacturers as orchestrators of seamless, intermodal travel planning, execution and billing as opposed to the current self-conception as producers of physical vehicles. Another example would be advertising to finance vehicle use instead of direct payment.

The lack of uniformity identified above is further confirmed by the high value given to the dimension of strategy. From a company's point of view it is in many ways right that the organization's strategy moves forward more quickly to become the initial impetus for new business models. In the authors' opinion, however, this should be seen as a clear warning sign that the already wide gulf between the business model dimensions (apart from the revenue model) and the maturity of the organization is set to widen even more over the next five years. In tangible terms, there is a risk that strategically motivated initiatives will increasingly fail due to the inability of the organization to implement them. In extreme cases, this disconnect might mean that although relevant and necessary strategic decisions are taken, the established organization no longer understands how they were arrived at and is therefore unable to implement them. In the worst case, this could mean losing touch with reality or a blindness to relevant innovative developments, resulting in incorrect strategic decisions that can only end badly.

The following example, discussing how products should be developed in future, backs up the earlier assumption about the impact of the gulf between strategy and organization. The interviewees all agreed that a classic, sequential process based on the logic of a waterfall model no longer seems to be adequate – instead, greater agility is called for (see the "Scrum" model). What they are saying is that the automotive industry should follow the lead of software companies, in terms of the organization too, so they can work in a flexible and problem-oriented way with dynamic, collaborative teams. This is wishful thinking, bearing in mind the sharply contrasting finding, documented in a previous section (5.2.6), that most interviewees regard their organizational structure as centralized, rigid and silo-oriented.

Background

Established OEMs and IT giants are not the only players working on developing autonomous driving. Startups too have identified the potential of data analysis, feeding customers' driving data into continuous improvement of their solutions, for example Comma.ai, which works in artificial intelligence. Company founder George Hotz, who incidentally performed the first iPhone jailbreak, claims to be able to retrofit any car with autonomous driving functions for just USD 1,000, using electric servo steering and ESP. The hardware is driver-installed – anyone who can assemble IKEA furniture should be able to manage the installation[114] – and the system also learns continuously.

However, the "learning" cannot start until the hardware is available. The Chffr app is already available for anyone to download, and is actively helping to improve the system's driving functions. The smartphone is attached to the windscreen and the app uses the smartphone camera to record everything that happens on the road in front of the vehicle. The collected data is then anonymously uploaded to the cloud via wifi and used to "train" the underlying algorithm. As an incentive for drivers to provide their data, they are given Comma Points, a kind of virtual currency whose actual benefits are as yet unknown. Comma.ai wants to start supplying the hardware in 2016 – for less than the price of adaptive cruise control in the options lists of the OEMs.[115, 116]

114) http://money.cnn.com/2016/04/04/technology/george-hotz-comma-ai-andreessen-horowitz/
115) http://www.cnet.com/roadshow/news/comma-ai-george-hotz-autonomous-car-first-test/
116) http://www.audi.de/etc/medialib/ngw/product/pdf/price_lists.Par.0003.File.pdf/2009-02-05-preisliste-a4-s4-allroad-final-online.pdf

5.4.2 Mechanical engineering

German mechanical engineering consistently rates itself at a higher maturity level than the automotive industry. Note, however, that there is a very wide spread of results in this sector. The external impetus generated by Industry 4.0, in particular, was a wake-up call for many mechanical engineering companies, making it clear how much work some of them had to do to catch up. Accordingly, all dimensions in our maturity model are expected to reach the next level in the short to medium term, and the strategies of the mechanical engineering companies are either already oriented to digitalization or the process is underway.

The only cloud on the horizon is the dimension of data analysis, and these competencies in particular are becoming increasingly important in mechanical engineering because they form the basis of problem-free operation and greater efficiency in maintenance and service. In mechanical engineering, data analysis tends to be classed as a downstream process because without a flexible control architecture, it is difficult to implement autonomous concepts or apply the results of a data analysis to existing production systems. Whether the results of a data analysis can actually be applied depends on the capacity for simulation and virtual commissioning. Manufacturing companies are generally reluctant to intervene while a system is running because any change can entail expensive down time.

In particular, the use of big data also throws up questions around ownership of the data and the resulting technical and commercial potential. Industrial robots were cited as an example – in ideal situations they send operational data to the robot manufacturer in order to improve the robots as well as the process. Although robot manufacturers would like to offer robots with improved performance, they would rather not reveal how their robots work internally. Conversely, users do not want to give the robot manufacturers details of their production through the operational data. The same issues arise with production machinery, but more forcefully. That is why some experts referred to technologies such as (partially) homomorphic encryption as possible solutions that should be attentively monitored. Homomorphic encryption allows computations to be carried out on ciphertext, generating an encrypted result which, when decrypted, matches the result of operations performed on the plaintext.

Note that it is not sufficient simply to have access to large quantities of operational data from machines and robots. In the past, the quality of the data obtained was more important than the quantity, especially in mechanical engineering. In particular, the selection of measuring principles and the measuring point used to be crucial in determining the impact of data analysis. These points must be taken into account when data analytics competencies are developed.

According to the information provided by the surveyed representatives of companies in the mechanical engineering sector, a period of around five years is necessary in order to alter the value proposition so that integration beyond the narrowly defined value chain becomes possible. There will be greater integration of suppliers and consumers in the production process as a result, but end customers too will be more closely involved in the development and manufacture of the product. Some mechanical engineering companies think that software and services will be the main drivers of change to their value proposition. Companies aiming to work their way up to maturity level 5 in this segment regard a period of ten years as substantial for this change.

Many interviewees stressed that they are accustomed to building machinery that is able to react flexibly to changes in the products they produce. That means it is not enough simply to equip the existing machinery with digital functions. It seems to them to be much more important to manufacture highly individualized products (lot size 1) and to provide flexibly reconfigurable machinery or production lines and new digital services with which to do so. It is more important than ever to take account of the fact that when machines are commissioned, the product mix they will be expected to handle is not fully known. The best approach is end-to-end digitalization and integration of the machines with each other, alongside virtual mapping of the status and the capabilities of these clusters in higher-level systems.

In addition, "manufacturing/production as a service" offerings and similar international trends have recently grown in importance. For example the EU ManuCloud project[117] used a service-oriented IT environment to test the concept of production as a service, as a basis for the next level of manufacturing networks.

117) http://www.manucloud-project.eu/index.php?id=233

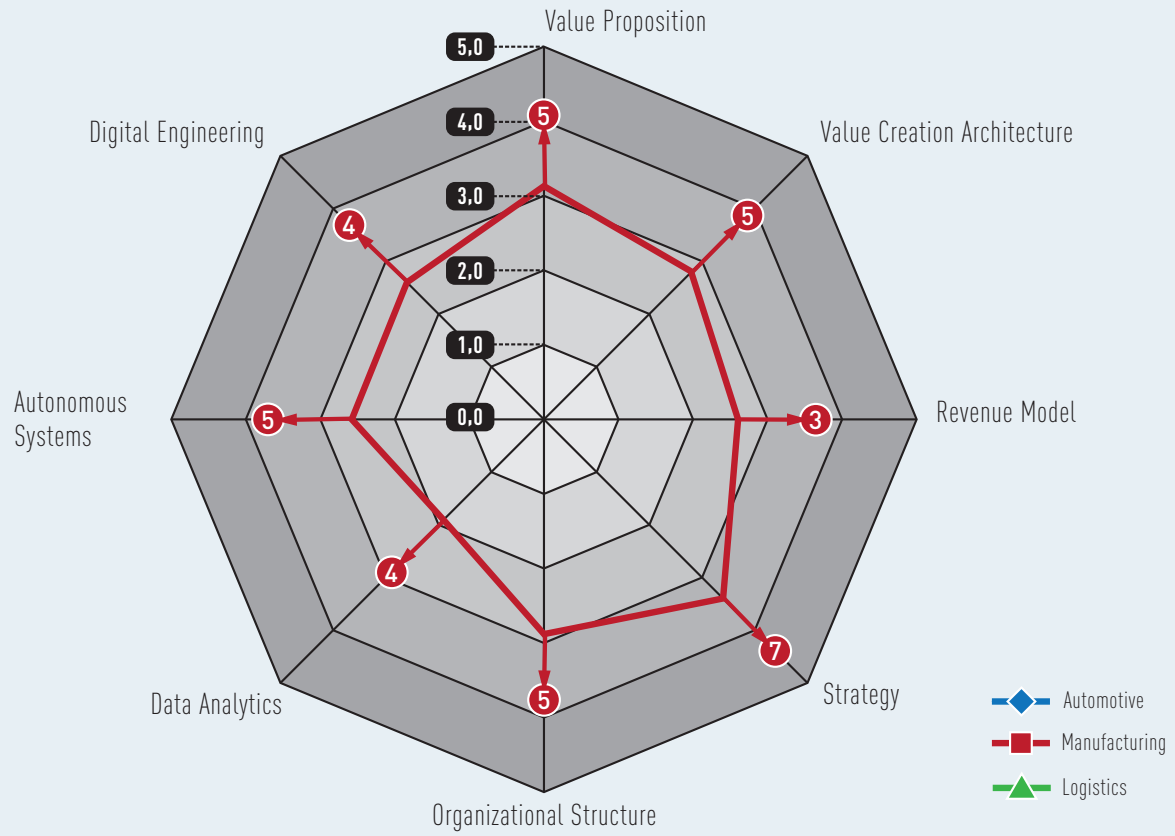


Figure 24: Assessments of mechanical engineering on how the maturity dimensions will develop

The line shows the current status and the number indicates the years until the next level is reached.

ManuCloud is run by a consortium of European companies, universities and industrial organizations, and attempts to implement the vision of a cloud-like architecture concept.

It consists of two levels. The first level is based on the capabilities of machines within a production site, using features like OPC-UA (Open Platform Communications Unified Architecture) to publicize their services, which can be made available to the manufacturing group (intra-factory environment). The idea is to quickly adapt local manufacturing to new products. If a number of production sites are equipped with this technology, it moves to the second level. The second level accesses all the services offered by all production sites, combining them to form a large virtual factory (inter-factory environment). Product developers can then use just one interface to select the processing and manufacturing steps they need to create a product. The system decides automatically how the elements are allocated to the various sites.

Another example of production as a service is the automated production solution from KUKA Systems in Toledo, which is based on IoT technologies and which allows many different car bodies to be made on the same production line.[118, 119] The contract manufacturing concept is nothing new in some industries. For example Magna Steyr[120] based in Graz (Austria) has been active in the automotive sector since 2001. One of the best-known contract manufacturers in electronic products is Foxconn Technology Group (Hon Hai Precision Industry Co., Ltd.). Foxconn has been working on behalf of Apple (iPhone), Samsung,

118) https://customers.microsoft.com/Pages/CustomerStory.aspx?recid=17254
119) https://www.microsoft.com/en/server-cloud/customer-stories/kuka-robotics.aspx
120) http://www.magna.com/

Microsoft, Cisco, Nintendo and other major customers for many years.

There are usually two reasons explaining any reluctance on the part of the ordering party to outsource production: the contract manufacturer may also be working for the competition, giving it access to a concentration of production data and production know-how. However, digitalization will consolidate the trend toward the contract manufacturing business model because it reduces the ordering party's investment risk. If processes like the ones studied in ManuCloud, for example, make more headway, the ordering party will also be able to cut its planning, commissioning and processing costs. In addition, technologies like additive manufacturing combined with a cloud connection are destined to allow different products to be manufactured for different ordering parties with short lead times. However, if 3D printers develop as fast as laser printers in terms of technology and price, it could become harder for many contract manufacturers to make money in the long term.

For autonomous systems, the transition to level 4, in which fully autonomous functions predominate, will take less than five years. Experts agree that the underlying technologies are already very highly developed in the field of robotics, in particular turning collision-free robots into collaborative robots. Some experts also claim that a number of self-optimizing machines could already be on the market in the next five years. These claims sound plausible, bearing in mind that they are based on more than 20 years of research. Some of the results of this research are very striking, demonstrating how self-organization (e.g. Holonik Manufacturing Systems) can improve the way production facilities operate. The main drawback of these approaches has so far been that the autonomous decisions of the machines are often difficult for humans to understand or follow. Before these technologies can be implemented successfully, it will be particularly important to iron out these issues.

Compared to the automobile sector, mechanical engineering companies paint a less conservative picture of the revenue model. It is true that companies in this sector make money predominantly by selling hardware. However, a number of mechanical engineering subsectors are switching to service models, increasingly generating revenues from maintenance and additional services. So it is no surprise that the experts think it will take less than three years to construct a differentiated revenue model. However, there is some pessimism about achieving the next level after that. For example, companies at level 4 indicated no ambition to go higher because for them, the sale of machines is indispensable as a basis for their business and business model. A small number of experts rating themselves at level 2 and wishing to climb to level 3 betrayed a lack of confidence with statements like "there will only be minimal changes in Germany in the next five years" and "no one knows much about monetizing data, etc.".

Silos remain a characteristic feature of the organizational structure in most mechanical engineering companies in Germany. As the machines are increasingly digitalized it is becoming more important to break up these silos and replace them with agile interdisciplinary teams that develop and own system solutions ("systems engineering"), as in mechatronic production systems. In this connection, some respondents said that they will need system experts to handle aspects of the system, as well as IT experts to provide autonomy and data analysis capabilities. The problem is that there are very few trained system experts around. Similarly, a number of interviewees identified the issue that as mechanical engineering companies they have no profile as employers of IT experts, and so find it difficult to recruit the right people.

The mechanical engineering companies stated that the next step – greater integration of design/engineering and the production process – could be achieved by applying standards. For example, the design phase could be supported by partially automated functions. For manufacturing/production as a service, in particular, this capability will be crucial for commercial success. The experts are still uncertain, however, about how such standardization can be achieved. The classic standardization methods are thought by them to be too sluggish to keep up with the fast pace of digitalization. They are also not convinced about marketing-driven approaches such as the Industrial Internet Consortium (IIC), as they lack sufficient detail about them.

Some experts think that implementation would take at least ten years. A number of companies consider the fully automatic design of a product or an entire series of products as a completely Utopian scenario, although at least one respondent indicated that this level would be achievable within the next ten years.

5.4.3 Logistics

As things stand in the German logistics industry at the end of 2015, the main weak points are digital revenue models and the technology needed for data analysis. In the opinion of the respondents, the companies have set themselves the target of achieving fundamental change in the next three to five years. Another feature of this sector is the progress made on the three technical dimensions in the survey, which is generally rated as being slower than the automotive industry and mechanical engineering.

Substantial progress toward completely transparent logistics processes – offering predictive information and supporting on-demand real-time integration and process changes from different parties in the logistics chain (level 4) – will be extremely difficult to achieve because the information chains are not yet complete. This makes it impossible to make consistent use of the opportunity presented by data analysis.

This not the case with Amazon, for example, where customers are in constant touch with the logistics service provider via the free Prime Now app for Android and iOS on their smartphone or tablet. This offering stands out because the primary search criterion is the time needed to deliver the product to the customer's address. That means the customer can display the products that can be delivered in an hour, or search for a particular product and, if it is in the Prime range, select a delivery time. If the customer still cannot be at home at the time of delivery, an alternative delivery address can be selected in the Prime Now app, and the logistics chain adjusts accordingly. [121]

Applications of this kind used by customers act like sensors continuously collecting data, so they can help with the continuous improvement of the logistics service and other functions. That enables Amazon to establish a closed information chain to the customer and to the item. This advantage will equip Amazon to grow into other logistics segments.

The central driver is the effort to deliver products more quickly for customers. For example, Amazon has entered into partnerships with Air Transport Services Group (ATSG) to lease around 20 Boeing 767 aircraft. [122] Amazon is also working with air freight provider Atlas Air Worldwide Holding, [123] to extend its reach to air freight logistics. Aiming to build a global logistics network, Amazon has also acquired a sea cargo license [124] and is experimenting with other modes such as taxis, bicycles and drones. The company is becoming increasingly involved in the delivery business.

The above examples clearly show that this company will leave no stone unturned in its efforts to meet the growing challenges in the logistics business. Amazon has an increasing presence in more and more parts of the logistics market, and it will ultimately be in a position to integrate all elements of the delivery chain. Only logistics providers with this kind of close digital relationship with the orderer will in future be able to offer a substantially changed value proposition. This does not automatically mean that a logistics service provider can only be successful if it has its own shop. But in order to offer an enhanced value proposition, the online shops must be able and willing to supply the logistics company with real-time data about the precise content of the parcels. In return, the logistics service provider could offer Amazon-like services and data analytics, even to small vendors.

Things look different in the transport segment, where major companies like DB Schenker are breaking fresh ground and others are looking to collaborate on digital platforms. For example logistics service provider Nellen & Quack – The Green Line, SLK-Kock and Euregio Cargo-Hub have joined forces to introduce the alH.4 transportation management system from active logistics. About 80 employees of the three companies have been using the software since the start of the year to control their consolidated general cargo traffic. The collaboration is based on a shared platform that allows them to provide their customers with real-time status information 24 hours a day. The software supports all aspects of general cargo handling, from quotation, order entry, transport organization and planning of national and international general cargo shipments, all the way to billing. [125]

Surveyed logistics experts outside Germany assume that a mostly changed value proposition in logistics with substantially integrated digital functions will not be achievable across the board until 2025 at the earliest. This makes it unlikely that a substantially changed value architecture based on changed external value creation networks (level 4) is achievable in Germany by 2020.

121) Reichel (2016): Amazon Prime: Lieferung per Lastenrad in einer Stunde, in: Logistra: http://www.logistra.de/news-nachrichten/nfz-fuhrpark-lagerlogistik-intralogistik/7483/maerkte-amp-trends/amazon-prime-lieferung-lastenrad-einer-stunde
122) Press release from Air Transport Service Group 2016: http://www.atsginc.com/Press-Releases/2016/pr2016-05-10.pdf
123) Press release from Atlas Air Worldwide 2016: http://www.atlasair.com/holdings/news-events.asp?Pressid=21057
124) https://www.flexport.com/blog/amazon-ocean-freight-forwarder/
125) Company declarations: http://www.active-logistics.com/storage-folder/newsletter/active-logistics-newsletter-ausgabe-2-2015.html; http://www.slk-logistik.de/pressestimmen/

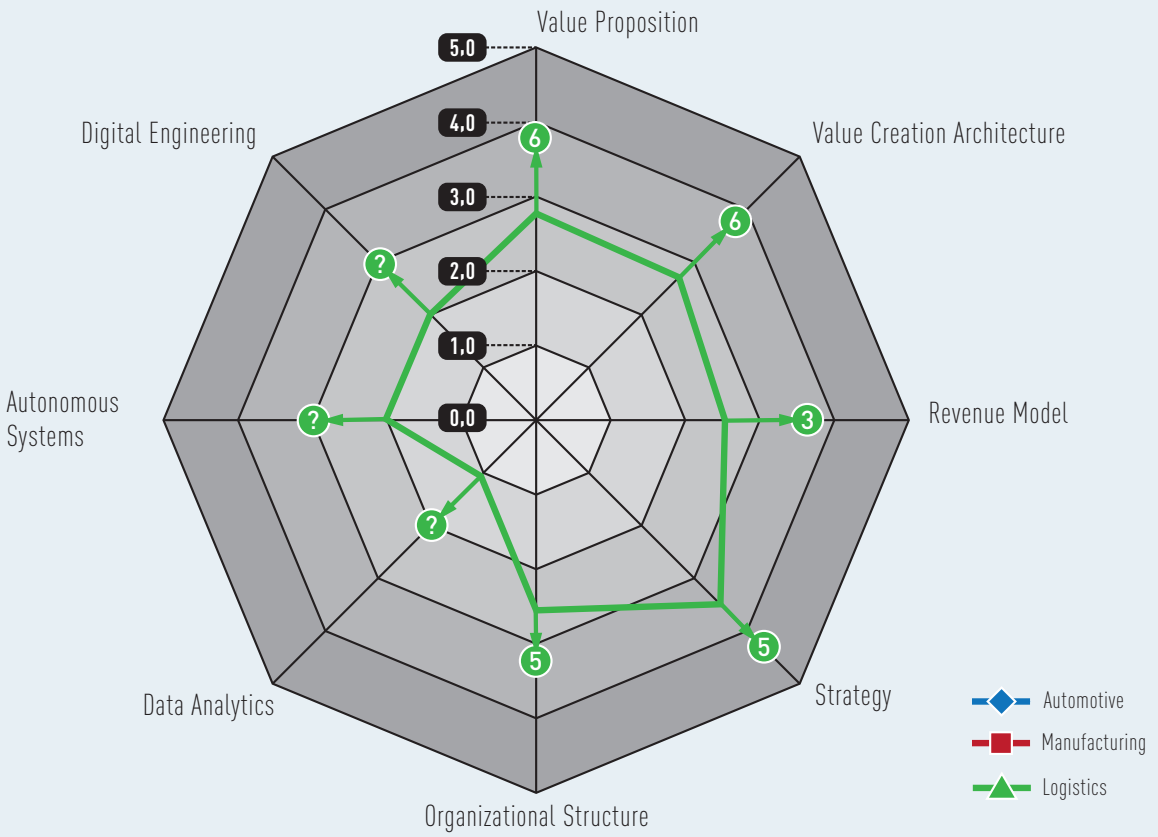


Figure 25: Assessments of the logistics industry on how the maturity dimensions will develop

The line shows the current status and the number indicates the years until the next level is reached. The underlying data for the technical questions mean that some time information is missing.

The surveyed logistics experts are fully aware of the urgent need to take the action addressed above. Yet they are not really sure that this awareness is genuinely widespread across the sector as a whole. The comments of some of the experts interviewed may indicate whether this assumption is right or not. They expect that it will be possible to follow the lead of an industry pioneer when the time comes.

"The revenue model will change to a digital, content-based service. In five years, some companies will also tap into indirect sources of revenue based on digital services (such as advertising, individual usage data, location data)."

This interviewee's comment shows that the industry is absolutely aware of the need to regroup. To make this happen, the technical capabilities around data analysis and digital engineering will need a major boost. According to the interviewees, the shortage of IT experts will hamper development in the logistics industry in the next three to five years.

The situation is compounded by the highly fragmented nature of the logistics sector, which, apart from a few exceptions, is characterized by small and micro-enterprises. About 50 percent of enterprises have a workforce of 50 or less, and only 14 percent have more than 200 employees.[126] This, along with tough price competition, makes it doubtful that the majority of providers will manage to establish any IT expertise at

126) http://www.dslv.org/dslv/web.nsf/gfx/6CFE028FC9D5A06BC1257E5B003C8189/$file/DSLV_Zahlen-Daten-Fakten_2015-Downloadversion.pdf, S. 22

all. The low values for data analysis and digital engineering could be interpreted as reinforcing this view. Against this background, it is questionable whether a substantially changed revenue model can be achieved within the next three years.

According to the logistics experts, the digital transformation will be a permanent element of corporate strategy for all companies in the logistics sector in five years, taking the form of operational initiatives covering multiple logistics functions. Until this happens, the authors consider it unlikely that the organizational structures will change significantly. it is likely to take longer than the predicted five years for the organization to settle in its new form and achieve full strength (cf. the similar comments concerning the automotive industry).

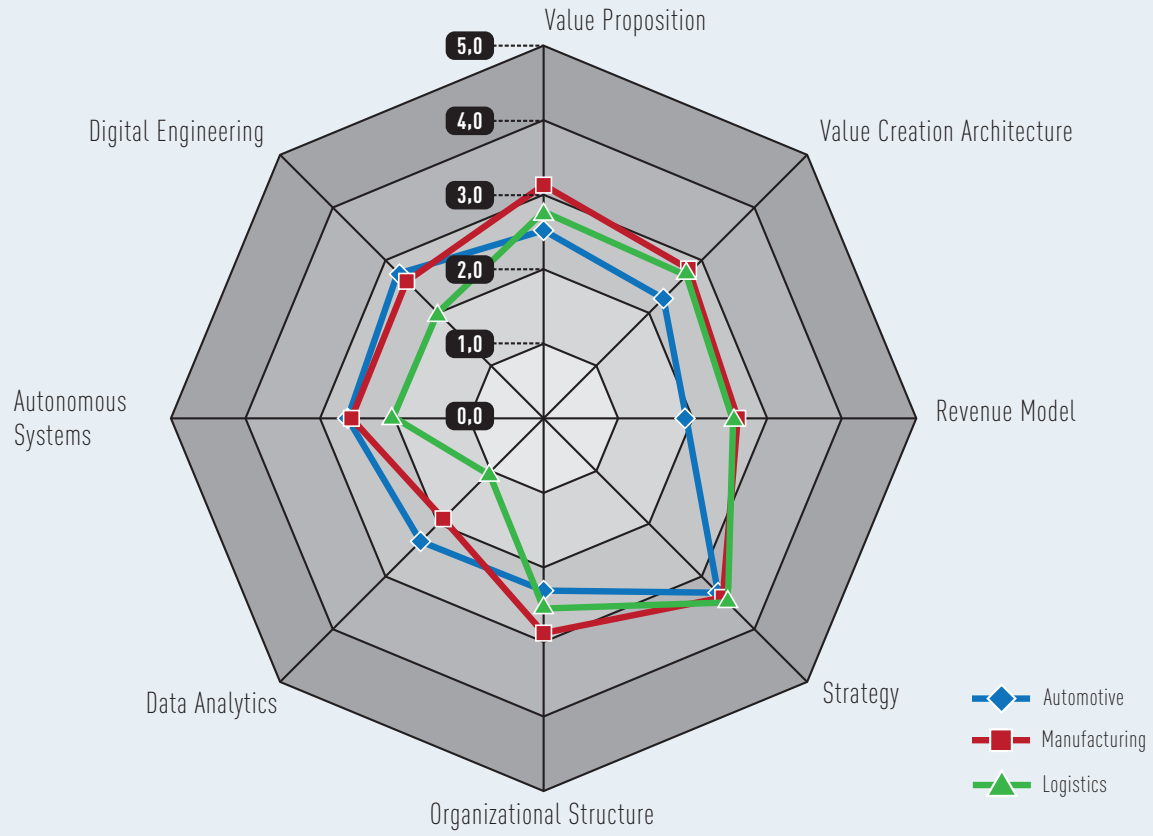
Unlike larger companies, small companies may be assumed to find it easier to harmonize strategy and organization because decision-making paths are generally shorter and there are not so many employees who need to be won over. Autonomization has the potential to displace many jobs, although this depends on how flexibly robots will be deployed in logistics. The technological changes from the automotive sector in particular will take root in logistics (for example autonomous car-sharing vehicles for cargo transport or autonomous truck fleets).

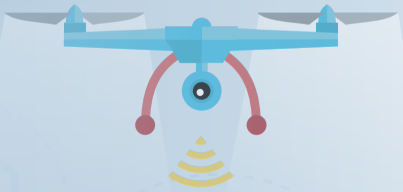
5.4.4 Summary

To secure their position in the market long-term, companies must ask themselves how they can change and enhance their existing range of services using digital platforms and technologies, thereby offering their customers a more attractive value proposition. Digital offerings also present an opportunity to develop new revenue models and to expand into completely new markets. The development of digital technologies is a continuous process and will act as a steady driver of dynamic change. In the newly created markets, the revenue model, data analysis and a changed value proposition are essential success factors.

It can be stated in summary that in established business models, adherence to inherited value propositions and to existing revenue models represents a serious weakness in all the sectors in the study. In terms of the technology, modern data analysis methods, in particular, mean that large amounts of market and customer data can be analyzed more and more quickly and intelligently. This forms the basis for innovative products and services which enhance the value proposition. There are particular weaknesses in the automotive and logistics sectors. All the sectors investigated had deficits in the technological dimension of data analysis.

Figure 26: Current maturity in the sectors studied





CHAPTER 6

General trends and findings

This chapter presents a summary of the principal findings of the interviews analyzed in the preceding two chapters. Analysis has resulted in the identification of a number of general trends with regard to ICT-driven change that are directly associated with the dimensions of the maturity model. These trends are in evidence at varying levels of intensity in each of the sectors considered and are also becoming apparent in other sectors.

6.1 Productization and servitization

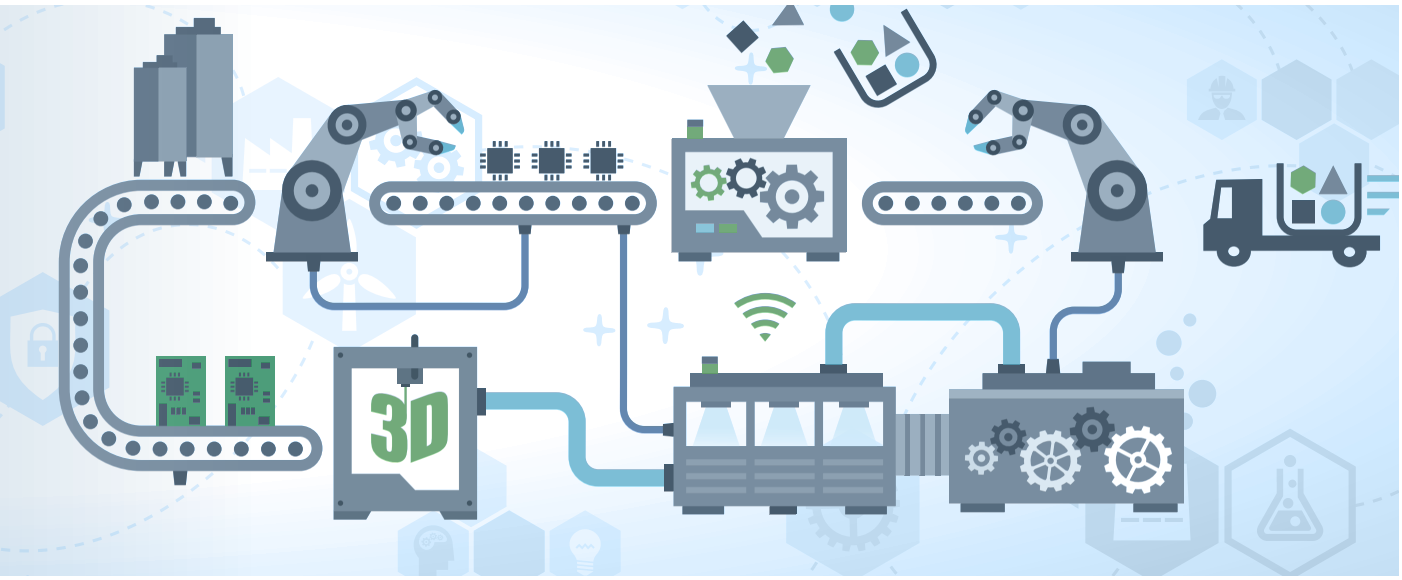
Two trends particularly closely associated with the comprehensive satisfaction of customer needs in the area of platform-centered ecosystems are „use instead of ownership“ [127] and „self service“ [128]. The advancing integration of different component activities (product creation, operation and maintenance, for example), which is becoming more attractive financially as a result, in part, of the use of ICT, is increasingly enabling what were previously just product providers to become providers of usage-oriented customizable services as well. This shift entails a generally to be expected redistribution of sales revenue from traditional product sales business to service/self-service business.

This trend is leading in the mechanical engineering sector to what is known as servitization, [129] with companies increasingly taking advantage of their new ability to acquire and analyze large volumes of machine and usage data to combine supplementary services with their product offering. Rather than just selling technical products as they have done in the past, they are now marketing customer-specific services, where appropriate, as part of novel business models. Companies moving down this road have to ensure their products meet the concomitant more demanding interoperability requirements as well as building up their own service provision capabilities.

Equally, the service sector itself also harbors very substantial potential for innovation under the influence of digitalization. Service activities are increasingly being marketed in the same manner as physical products. Services such as a consultation are inherently intangible, however, so must first be incorporated into a tangible wrapper. This process, sometimes referred to as productization, involves steps such as automating a service in the form of a software application, for example. Jaakkola et al. [130] define productization as, „One possible tool to systematize both the development and the production of services so that continuous innovation, cost efficiency and customer orientation become a part of everyday life.“

There is in fact no generally accepted definition for the productization of services, but the term is usually used to denote the production of a service that is rendered tangible in more or less the same way as a product

127) German Federal Environment Agency (2015): Nutzen statt Besitzen: Neue Ansätze für eine Collaborative Economy: http://www.rohkraft.net/wp-content/uploads/2015/10/2015.10.28_uib_03_2015_nutzen_statt_besitzen_0.pdf
128) Schieber (2014): Self Service Trends & Innovations, Carmelon Digital Marketing: http://de.slideshare.net/YairCarmel1/self-services-trends. Self-service is „A phrase that describes methods and processes a business uses to allow its customers to complete most steps in purchasing products or services on their own – such as shopping in a retail store... Self-service also extends to Web-based transactions and CRM (customer relationship management) whereby customers manage account information primarily on their own.“ (Source: http://www.webopedia.com/TERM/S/self_service.html).
129) Forschungskuratorium Textil (2015): Textilforschung 2014. Report 61, p. 104: http://www.textilforschung.de/uploads/Forschungsbericht-2014.pdf
130) Jaakkola/Orava/Varjonen (2007): Competitiveness through Productisation. Guide to the Companies, Helsinki (in Finnish): https://thesai.org/Downloads/Volume3No12/Paper_32-Productisation_of_Service_A_Case_Study.pdf



proposition. This necessarily involves defining stable core processes and clear results that the customer can easily appreciate and understand. Specific customer needs can be factored in by allowing minor changes to the core service or going down the modular route. In practice services are usually adapted to need by configuring different combinations of modules. Successful productization of services protects revenue and margins. The mechanisms to be observed here are similar to those at work in connection with the servitization of products. The result of the productization of a service might, by way of example, be a software application that can be scaled as required and offered to a larger group of users at a correspondingly lower price. This, in turn, further increases the potential user group to boost both revenue and margins.

Figure 27: Function-oriented business models lead to the servitization of products and the productization of services [131,132]

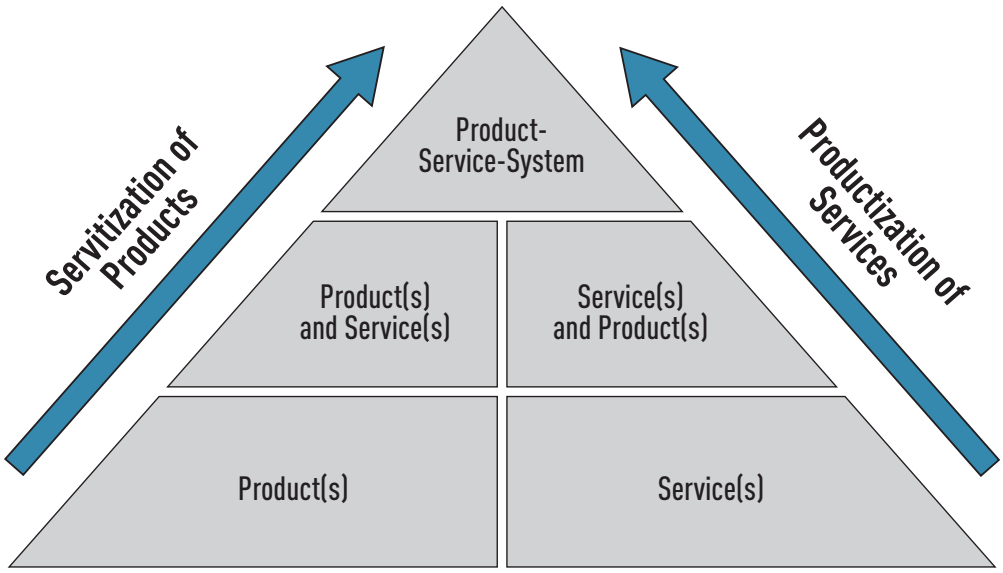


Illustration: © Mimi Potter – fotolia.de

131) Britchfield (2007): State of the Art in Product Service Systems. T.S. Baines et al.: https://et4407.files.wordpress.com/2014/10/pssreport11128887.pdf
132) Figure based on: https://www.quora.com/What-are-the-best-examples-of-Product-service-systems-function-oriented-business-model-in-terms-of-improved-sustainability

The servitization of products and productization of services has prompted the emergence of a new field of research into what are referred to as product service systems or PSS (see *Figure 27*). PSS research suggests co-design methods that consider the value of the product and the services associated with it as a whole rather than separately. Specific optimization studies are still very limited.[133] The PSS concept encourages a shift of focus away from the straightforward sale of products and onto the sale of a benefit realized through a combination of products and services, with customer requirements being met while simultaneously reducing environmental impact.[134] The concept is intended to achieve two key objectives of the modern age by delivering economic advantages while reducing resource consumption and environmental impact.

Confidence in the new model (selling services instead of products) is boosted within companies by the scope the model brings to increase substantially the potential applications of their products. IoT and system monitoring supported by analytical algorithms can help in this connection.

It is reported that the platform concept can be used in this context to implement certain aspects of PSS, such as co-design. Customers could be involved in enhancements to hardware and software, for example, or associated partners could be given a protected space in which to coordinate activities or exchange ideas. The aim of involving customers and partners in this way is to build loyalty to the company. One service offered through the platform might be a free product update as a reward for good suggestions for improvements. The subject of platforms is considered in detail in *Chapter 7* in the context of ecosystems.

Customer proximity and data-driven differentiation of the value proposition

ICT has now penetrated products (and the world in general) to such an extent that the presence of an ever-expanding software component is commonplace and basic connectivity, as with the Internet of Things, is frequently provided. The associated virtualization of particular functions and the ability to analyze data relating specifically to use – in the main using machine learning algorithms – pave the way to a thorough understanding of customer behavior and patterns of use and of the status of the technical systems, knowledge that can be used to deliver continuous refinements and/or differentiate the value proposition further as a function of customer behavior.

Unlike purely physical, mechanically controlled objects, objects with a material software component offer the potential to change specific functions of products and things (often after they have already come to market) retrospectively and adapt them in line with how the customer actually uses them in practice, for example with over-the-air updates. These adjustments are by no means limited to the value proposition and can also touch on aspects such as value creation architecture and revenue models. It is thus possible, with a virtual abstraction of real-world processes, to reconfigure and differentiate entire business models dynamically based on data gathered in the wild – and potentially to do so almost in real time. This approach is facilitated by largely autonomous systems that adapt individual parameters of a business model (price, for example) in accordance with a codified business logic.

This differentiation and the iterative procedure described can even be used to test value propositions that have yet to be realized in the marketplace before the major investment needed to make them a reality is committed. This involves investigating the attractiveness of different variants of a value proposition in the market and the market response generated by advertising the envisaged proposition in appropriate settings (for example using social media or other media relevant to the target group). Such methods also yield information about the target groups interested – who clicks on the advertisements for example – that can be used to refine the proposition. A/B testing is one of the options available for this purpose. The knowledge thus gained makes it possible to base the development of a value proposition directly on customer needs right from the very outset.

Comprehensive satisfaction of a customer need

Another significant trend across sectors is the increasing expectation that the customer needs to be satisfied in their entirety in one shot. Many of today's dominant value propositions cover only certain aspects of a significantly greater need. Many customers purchasing an automobile, for example, are motivated principally by a need for mobility, but achieving mobility requires not just access to a vehicle, but also a great many other elements directly associated with the vehicle (such as parking, fueling and navigation) plus other activities

133) Vasantha/Roy/Lelah/Brissaud (2012): A Review of Product-Service Systems Design Methodologies, in: Journal of Engineering Design 23, 9, p. 635–659: http://ode.engin.umich.edu/publications/PapalambrosPapers/2013/318.pdf
134) United Nations Environment Programme (UNEP): Product-Service Systems and Sustainability: http://www.unep.org/resourceefficiency/Portals/24147/scp/design/pdf/pss-imp-7.pdf

such as intermodal transfers for long-distance travel. Putting these additional elements in place to satisfy the need in its entirety involves significant search costs (to identify relevant elements), integration costs (to integrate compatible elements, for example) and administrative costs (settlement with different providers, for example) for the customer.

A few companies recognize this problem and are changing the range of services offered accordingly. Originally the various elements were available only in isolation, often as individual hardware products, but now they can be smoothly combined and orchestrated using high level technical integration and autonomous systems. The introduction of additional services replaced the original, fragmented approach with propositions encompassing complete platforms intended to satisfy a need in its entirety. One notable example is the transformation of automakers into platform-based mobility service providers and/or integrators of different elements of the mobility service. This approach has the potential to result in the creation of platform-centered ecosystems (see *Chapter 7*). Proper monitoring of the progress of this process is of critical importance strategically because it could potentially spawn new, asymmetric growth opportunities extending beyond the traditional product portfolio and across industries.

6.2 Customer interface – a key strategic and economic position

> *„Companies that know how to make good equipment or good cars but do not have sufficiently good access to the customer stand to lose their status as producers and their role as the principal link in the value chain"*
>
> *Angela Merkel* [135]

The customer interface is the absolute key position both economically and strategically in the emerging value creation networks. This is essentially because the connectivity now available through ICT, especially the internet, makes it possible to target people all over the world and because it is the interface role that brings together the output of a value creation network (in which most of the costs arise) with the end customer (who picks up the bill).

Traditionally, manufacturing companies have either occupied this interface themselves or arranged for it to be covered by third parties (commercial agents and dealers). The advent of digitalization has increasingly brought software-based intermediaries (go-betweens linking the value creation network with the end customer, such as Uber) or aggregators (integrators that bring different services together based on a platform or a consumer-friendly user interface, such as Moovel) to the fore. Typically the customer pays the intermediary or aggregator for the whole service. The operator behind this intermediary or aggregator role, which is clearly vital for the entire transaction, receives compensatory payments for its contribution from the rest of the value creation network – payments that grow in step with the number of users and hence the negotiating power of the operator.

The fact that the intermediary or aggregation service often involves only a small – in relation to the size of the total value creation process – commitment of resources makes no difference: what counts is the quality and ease of use of the intermediary or aggregation service from the customer perspective and its scalability. The service is usually provided with relatively inexpensive software, meaning that control over the customer interface confers access to a disproportionately large share of the value created. Players in the value chain that are remote from the customer, especially those that provide capital intensive infrastructure-related services, consequently often find their role degraded to that of technical service provision, a function which, once "commoditized", harbors little commercial appeal despite still being essential. The DSL network operators serve as an example of how this process can unfold.

This situation favors two different value creation models: companies that are fully vertically integrated from research and development to sales/the end customer

135) http://www.bundeskanzlerin.de/Webs/BKin/DE/Mediathek/Einstieg/mediathek_einstieg_podcasts_node.html?id=1923720&cat=podcasts

interface (for example Tesla or Nest) and companies that focus exclusively on the customer interface and potential intermediary or aggregation services (for example Uber, WhatsApp or Google).

It should be noted that the same development positions the customer as the chief driver of ICT-induced change. Customer preferences and usage behavior are analyzed in support of refinements to the service range, customer service and business models in general, but this attention to the customer's operations and needs also – and more importantly in the present context – paves the way for the customer to assume an increasingly proactive role in the value creation process. The customer becomes an integral player and value driver, especially with regard to platforms and the associated network effects. Microsoft's acquisition of LinkedIn for 25.4 billion US dollars, which effectively values each user at 60 US dollars, [136] provides an excellent example.

The consumer is increasingly assuming an active role in value creation processes

Historically the value creation process was a linear exercise in which customers became involved only sporadically. Many of the functions indicated in *Figure 28*, moreover, were performed, or at least strictly controlled, by the company responsible.

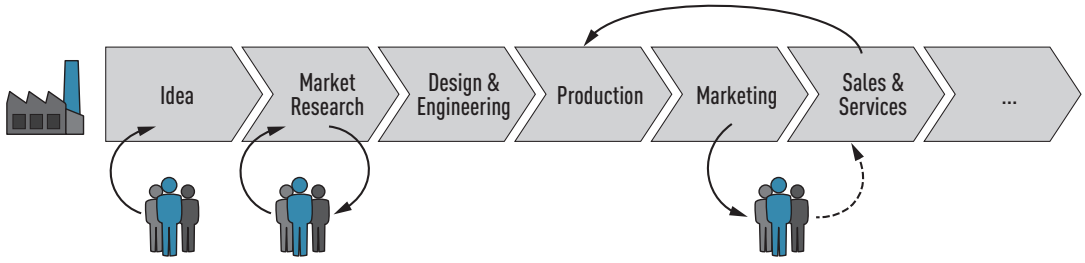
The increasing presence of software in products and services is changing the value creation process fundamentally. Software can be developed and tested with much greater agility and with completely new methods. Development & Operations (Dev-Ops), [137] which is all about distributing software developed using agile methods to customer devices at short intervals, is the most recent broad manifestation of this trend. One of the aims of this approach, which is also sometimes referred to as continuous delivery, [138] is to ascertain very quickly which new functions are well received by the customer and how the customer uses the functions. Ideally there emerges an enormous test community that (in)voluntarily helps to improve products (for example in the case of Tesla) or prevent expensive mistakes.

Software, in the form of ICT-based tools, also opens up new ways for companies to organize the various in-house and external value creation steps. ICT tools based on the open innovation paradigm (such as crowdsourcing platforms [139]), for example, can be used to open up the value creation process in the idea phase so that specific customer wishes and suggestions can be integrated. Market research can likewise be carried out recursively by involving potential customers, for example using the A/B testing method already mentioned.

The next step, turning the idea into a physical product, has also been supported by software tools like Autocad (Autodesk), Catia (Dassault) and NX (Siemens) for more than 20 years. The latter two tools in particular are regarded as extremely powerful, highly integrated resources. Not only are they capable of visualizing complex products (computer-aided design or CAD), but they can also factor in material properties to simulate the durability of the product (computer-aided engineering or CAE). They can even generate a machine-readable code for suitable machine tools (computer-aided manufacturing or CAM). They are highly complex themselves too, however, and very expensive to buy and maintain, making their primary focus professional users.

The path Autodesk has chosen to follow in recent years is all the more interesting for its distinctiveness. Typical of its approach are its purchase of software compa-

Figure 28: Linear value chain



136) http://www.theregister.co.uk/2016/06/13/microsoft_pays_60_per_linkedin_user/
137) https://de.wikipedia.org/wiki/DevOps
138) https://de.wikipedia.org/wiki/Continuous_Delivery
139) Picot/Hopf (2016): Innovation mit Hilfe der Vielen – Crowdsourcing im Innovationsprozess, in: Rammert/Windeler/Knoblauch/Hutter (editors): Innovationsgesellschaft heute: Perspektiven, Felder und Fälle. Wiesbaden, p. 193–218.

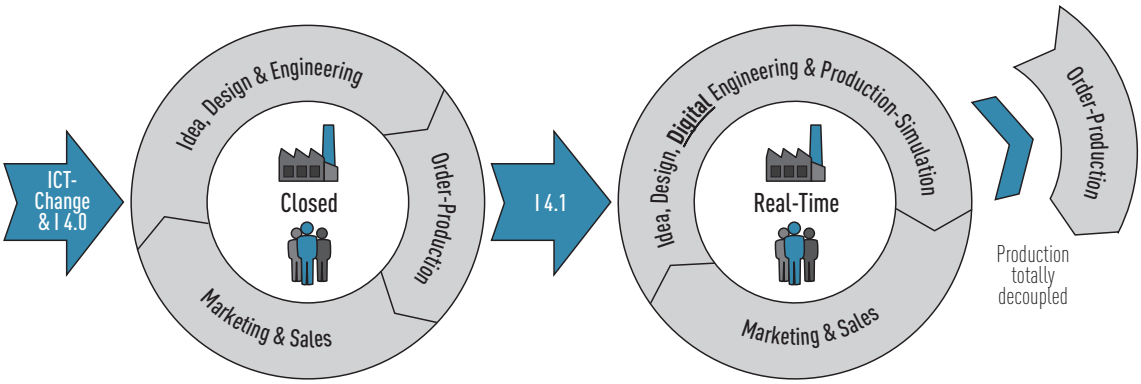


Figure 29: From consumer to prosumer

ny Tinkercad [140] and the launch of 123D Design [141], both of which provide very straightforward and intuitively designed user interfaces targeted mainly at non-professionals, to whom they are made available free of charge. The company's acquisition of the internationally known Instructables DIY platform [142] is another signal of its drive to expand its customer group. Autodesk CEO Carl Bass described this shift in favor of end users in a 2014 interview with German business magazine „brand eins": „We noticed that there were more and more people using creative tools and decided to conduct an experiment." [143] The experiment in question was the Sketchbook app, a drawing program for smartphones and tablets. „Many of us, myself included, thought it was a crazy idea," he continued, „but it turned out that 25 million people disagreed." Other companies have taken similar steps. Siemens, for example, another that previously concentrated mainly on business customers, now offers an end-user-oriented 2D drawing app for smartphones and tablets called Catchbook. [144]

Autodesk has backed up its acquisitions in this area by becoming actively involved in the steadily expanding maker movement, for example by sponsoring the UnternehmerTUM MakerSpace GmbH high-tech open workshop in Garching near Munich, Germany. The opportunities proffered by the MakerSpace are used by students and advanced-level individual developers for their own projects and also by startups and industry for rapid prototyping. Its involvement enables Autodesk to reach new target groups that then make use of the products in subsequent projects or in their companies. Similar strategic considerations inspired the company's 2014 acquisition of Circuits.io, [145] whose 123D Circuits product it hoped would help to strengthen its relationship with the maker scene.

One consequence of the developments described is that end users are increasingly able to assume a more active role in value creation and are in fact becoming an integral part of the process: business owner and consumer in effect merge into one and the same entity, the prosumer (a neologism from „producer" and „consumer"). The initial product idea, the design and the development process all originate with the prosumer. The prosumer controls sales via Amazon, for example, and marketing via YouTube, Facebook or LinkedIn. The resulting system yields „rolling" value creation chains that repeat, wave after wave and ever faster, such that products are constantly being refined and enhanced. The first port of call for the time being when prototypes need to be developed and tested are contract manufacturers, „FabLabs" (fabrication laboratories) or similar facilities. Prototyping is currently also required in order, for example, to establish whether a product can actually be manufactured as planned and whether it has the desired quality properties (*Figure 29*, left).

Physical production, however, is starting to become a limiting factor as the pace of development continues to accelerate. The increasing digitalization of the production process and the availability of enhanced digital development and simulation methods are making it possible to virtualize more and more of the preliminary stages of physical production. Once a certain point is reached (referred to symbolically as „Industry

140) https://blog.tinkercad.com/2013/05/18/autodesk_tinkercad/
141) http://www.autodesk.de/adsk/servlet/item?siteID=403786&id=20898787&linkID=411015
142) http://www.instructables.com/community/Instructables-Joins-Autodesk/
143) http://www.brandeins.de/archiv/2014/geld/autodesks-2d-3d-software-phase-drei/
144) https://www.plm.automation.siemens.com/de_de/products/catchbook/
145) http://www.heise.de/make/meldung/Autodesk-uebernimmt-Circuits-io-2080494.html

4.1“ in *Figure 29*), there will be contract manufacturers for which the distinction between prototype manufacture and series production will effectively disappear in terms of time and costs (*Figure 29*, right).

Developments in the area of additive manufacturing and the Franka cloud-dwelling robot arm,[146] for example, point to another nascent trend whose potential impact invites comparison with Apple‘s 1985 introduction of the first consumer laser printer,[147] which turned the whole printing industry upside down: the standardization of the interface between the virtual and physical worlds makes it possible for an expensive specialist machine designed for use in mass production and manufactured in small unit numbers to evolve into an affordable multifunctional machine manufactured in large unit numbers for use in the production of small batch sizes. This possibility is also discussed in an April 2016 article published on TechCrunch,[148] in which the author mentions two other trends as well as the laser printer effect mentioned:

- Professional trading platforms like Digikey now not only supply quantities all the way down to one, but also make these small quantities available in a form that enables them to be processed automatically in production machinery (for example in reels for SMT machines).

- The often expressed desire to see manufacturing companies return to/begin manufacturing goods in their home country combined with calls for increased purchasing of locally-sourced products – referred to in this article as „reshoring“ to emphasize the connection with the offshoring movement observed since the 1980s.

The anticipated outcome of this trend is summarized under the term „micromanufacturing“. Platform-based and ICT-based products and services have potential to tap into generally novel revenue opportunities in addition to the traditional and widely known revenue models of the internet economy.[149]

6.3 | Monetizing products and services

Two of the key aspects of the penetration of ICT into products and services are the aforementioned virtualization of functions with software and ICT-based connectivity. These developments have helped usher in two significant changes with regard to monetization: firstly the initial functions of products and services can be improved and enhanced retrospectively and secondly these improvements and enhancements can increasingly be provided „over the air“. The expanded scope of functions, in other words, can now be made available and maintained easily and relatively inexpensively by the provider and accessed extremely conveniently by end users.

These retrospective function enhancements not only change the lifecycle of products and services, but also offer significant potential for monetization even after their initial sale. Tesla users, for instance, are able to purchase retrospectively various functions that extend the basic functionality of the product. The autopilot function, which costs 2500 US dollars, is made available to paying users as an uncomplicated over-the-air update and improved continuously.[150] Monetization opportunities of this type can essentially be broken down into basic services, connectivity services and higher order function enhancements (see *Figure 30*).

Retrospective function enhancements thus not only afford providers an additional potential source of revenue, but also enable them to offer products and services below cost or at cost to begin with, which enables them to make substantial inroads into the market quickly at first and only then to start monetizing the product or service fully. These novel possibilities for monetization also extend to integrating into the hardware in-house additional functions that can only be activated later with corresponding software. Activation might, by way of example, be enabled only once functional performance has been optimized as required through shadow operation during initial use (an approach similar to that taken with Tesla‘s autopilot function).

Dynamic pricing as a function of proposition and demand

The idea of changing price as a function of proposition and demand has been around forever: when a particu-

146) https://www.franka.de/
147) https://de.wikipedia.org/wiki/LaserWriter
148) https://techcrunch.com/2016/04/03/micromanufacturing-the-future/
149) Established categories include: free (revenue generated by complementary services), free (freemium; revenue generated by paid provision of more powerful versions), transaction-based, advertising-based, usage-based and license-based revenue models. – cf., for example, Zerdick/Picot et al. (1999): Die Internet-Ökonomie. Strategien für die digitale Wirtschaft, Heidelberg; Cusumano (2008): The Changing Software Business: Moving from Products to Services, in: IEEE Computer 41, 1, p. 78–85.
150) http://www.heise.de/newsticker/meldung/Tesla-bringt-Autopilot-Funktion-per-Software-Update-2848008.html

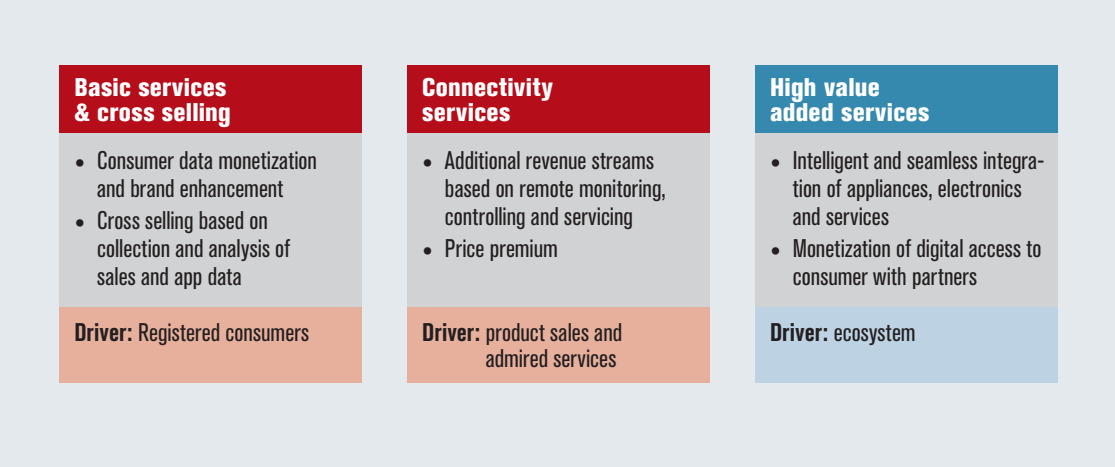


Figure 30: Additional monetization opportunities for ICT-based products and services [151]

lar product or service has proved less popular, its price has been reduced and vice versa. This is the mode of thinking that led the taxi business, for example, to adopt price models built around different (regulated) fares for different times of day. Such price models have been largely static phenomena in the past, however, distinguishing only between different times of day or between working days and the weekend. Now though many products and services are requested, offered and reserved in real time using the internet. This immediacy in conjunction with the accessibility of relevant environmental data (concerning weather, events, traffic density, changing consumer preferences, etc.) has created unprecedented transparency with regard to proposition and demand that can be used by providers for dynamic price adjustment in almost real time. Such dynamic adjustments are of particular interest in the context of platform-centered business models, as these offer the option to adapt the proposition dynamically as well as adjusting pricing as a function of demand.

Periods of higher demand for Uber, for example, initially trigger higher prices per journey (see Uber surge pricing). This higher price makes the proposition more attractive for other Uber drivers, who then add their own services to the offer (for example at times of peak demand). This additional availability can in turn lead to prices coming back down again. The overall effect of these dynamic price adjustments is that more journeys can be provided, which means more customers served and more revenue for drivers and generally benefits all sides. [152]

Dynamic pricing could be implemented for many ICT-based products and services using pricing algorithms and to a great extent optimized automatically. The Getaround P2P carsharing portal, for instance, already offers automobile providers dynamic price suggestions to help them optimize their vehicle utilization. Similar models, albeit most of them static, already exist in the tourism sector, in air transport and in the commodity trade. Dynamic price models have the potential overall to deliver meaningful economic added value.

151) Schömann (2015): Veränderung von Geschäftsmodellen durch Digitalisierung am Beispiel vernetzter Produkte. Conference presentation, „Bridging the Gap X: Grenzenlose Digitalisierung – Eine Reise mit Chancen und Herausforderungen", Munich, November 13, 2015.
152) cf. Haucap et al. (2015), p. 49 et seq.

6.4 | Rethinking strategy and organization

Strategy

Strategy is understood in the corporate context to mean the medium-term and long-term plan for how to achieve the corporate objectives. It is accordingly incumbent on management to devise at regular intervals a strategy compatible with the mission and objectives of the company that can then be translated, in a subsequent step, into specific measures (including a business model and business processes). Digitalization is regarded in this context as a core long-term challenge requiring a transformation of the organization and its capabilities and processes (internal perspective) and of the range of products and services offered (external perspective). [153] This challenge, also referred to as „digital transformation", is recognized in much the same way by all the companies surveyed across the various sectors and factored into strategy development accordingly. The survey does, however, reveal significant differences in how companies of different sizes approach the issues, in the need for change and in how corporate strategy is translated into specific operational measures. These differences are summarized in the following.

Recognizing the strategic relevance of ICT-induced change as a function of company size and distress-driven appetite for change

The respondents were unanimous in identifying companies from outside the sector, most of them relatively young, as the drivers of ICT-induced change. These newcomer companies are increasingly undermining established value creation structures by devising innovative business models and assuming new value creation roles – usually without the influence of path dependency (see the following section on organization).

Company management generally appreciates the strategic relevance of this change, but there is often a significant difference between SMEs and their larger counterparts: while many of the large companies surveyed have set up a dedicated department for digital transformation or assigned responsibility for the subject to defined individuals in their technical departments, the SMEs have frequently yet to do either. Unlike in the case of the major companies or corporate groups with their often complex and highly political management and leadership structures, however, there is always the possibility with the SMEs of the proprietor or managing director being able to initiate, facilitate and implement a strategic realignment directly. This assumes, of course, that the strategic relevance of ICT-induced change is recognized at management level.

The willingness to embrace change (in the sense of a strategic realignment) depends to a significant extent on the level of distress associated with not changing. This relationship is explained in the field of psychology as follows: „People are often only willing to change their behavior if the negative consequences of this behavior become too great." [154] The concept of distress in the business world in this context thus relates to the fact that the need for change, which is usually widely recognized, is only converted into action and a genuine effort to bring about the necessary change once the negative consequences become too serious, for example in the form of a collapse in revenue in what was previously a core business area. That a reactive change of this nature may well come quite late on and prove less effective than a proactive, forward-looking change is self-evident, but it is usually better for established companies to flow with these forces of change rather than trying to ignore the need for change.

This realization is apparent in the context of the present study and the aggregated results in the form of the comparatively high strategic relevance of ICT-induced change in the automotive industry (see figure in section 5.2.5), which is probably the area with the highest distress levels at the moment. The associated insight and the slowly crystallizing willingness to change have taken their time to arrive: Tesla, for example, has been up and running since 2003 and yet it is only now – with its sales growing at a rate difficult to ignore – that its presence has precipitated a rethink within management ranks at the hitherto IC-focused established OEMs.

Rising distress levels can be detected among established companies in the logistics and mechanical engineering sectors too. The expansion of what were originally just trading companies (such as Amazon) [155] or personal transport companies (such as Uber) [156] is driving up competition in the logistics sphere. The

153) cf. e.g. Kranz/Picot: Internet Business Strategies in: Bauer, J. M.; Latzer, M. (Eds.): Handbook on the Economics of the Internet, Cheltenham, UK (Edward Elgar Publishing), pp. 365-384.
154) http://www.spektrum.de/lexikon/psychologie/leidensdruck/8692; cf. also Picot et al. 2015 (Organisation..., chapter 8)
155) http://www.faz.net/aktuell/wirtschaft/unternehmen/globaler-paketversand-amazon-legt-sich-eine-eigene-flugzeugflotte-zu-14115983.html
156) http://www.theverge.com/2015/10/14/9529765/uberrush-officially-launches-in-three-cities und https://techcrunch.com/2015/12/16/the-delivery-backend/

high level of specificity in development and manufacturing in the mechanical engineering sector suggests at first glance that ICT-induced change might be expected to progress less rapidly in this area. Cyber-physical systems, the Internet of Things and, in particular, the applications discussed in the context of Industry 4.0, however, point to significant changes that do indeed demand a strategic realignment. The most striking examples of this are business models in the energy, drives and plant sphere that are based on big data analyses (for example „power by the hour" and fleet management) and concerns that platform-based and data-based providers could insert themselves between industrial producers and customers to take control of the customer interface.

Discrepancy between understanding ICT-induced change in general and interpreting it and translating it into operational measures within a company

The fact that a general understanding of the principles of how ICT-induced change works (including the process of dematerialization, integration, informatization, autonomy) appears to be almost universally present should not be taken to imply that companies necessarily also know how to apply these principles to their own area of interest. Such a move from the general to the particular requires a context-specific interpretation and assessment of the fundamental operating principles of ICT-induced change in conjunction with domain-specific business models. This leads ultimately to domain-specific visions such as Industry 4.0 and connected car and to cross-domain visions like smart city and autonomous world.

Although these visions provide valuable guiding principles, they still leave individual companies with much work to do to turn them into operational measures. Responses from most of the interviewees confirm that while the guiding principles associated with ICT-induced change are thoroughly familiar in their sector, there has so far been a significant lack of action to apply them to the company's own context. Industry 4.0, for example, not only promises considerable efficiency gains, but also opens up new opportunities for growth founded on innovative business models – opportunities that in Germany at least have yet to be fully grasped. [157]

Finally, operational implementation requires a thorough analysis of a wide range of issues that few of those surveyed have yet tackled in anything approaching the necessary level of detail. Such issues include: „What are the specific implications of Industry 4.0 for my business model?", „What new value creation opportunities are going to emerge?" and „Will there be new possibilities for interaction and new customer interfaces?" Forging closer ties between different departments (between strategy, R&D and sales, for example) will be crucial in this process. The HR function too needs to lend its support by recruiting new staff with appropriate expertise and helping existing employees to acquire the skills necessary in respect of digitalization.

This problem is all the more pressing for the SMEs. According to the decision makers, SMEs are still far from comfortable with Industry 4.0: „Migrating existing production systems to the 4.0 paradigm brings with it unprecedented complexity (decentralization, integration, the volume of data and so on) and requires new skills not previously held within the business. Implementation is complicated. Advice, expertise, cultural bridges – all these things are essential."

Organization

Organizational structures tend strongly to reflect the organizational requirements of the sector and cultural factors [158] in the countries concerned. Various aspects associated with ICT-induced change, including new business areas, increased competition and the more active collaboration between companies made possible by software-based collaboration tools, make it inconceivable to retain existing organizational structures as they are. [159] The results of the survey conducted for this project, however, show only very limited ICT-driven changes to organizational structures. Efforts to implement fundamental change frequently go awry for two reasons: the difficulty of overcoming rigid path dependence and the need for ambidextrous organizational structures (see next section).

Overcoming path dependence

The concept of path dependence offers an answer to the question of why companies so often appear to be bound in structural terms to continuing more or less as they have always done. Current decisions and structures are heavily influenced by external environmental factors including capital expenditure already committed, skills, corporate culture, social setting, routines and informal rules. Traditional OEMs in the automo-

157) https://netzoekonom.de/2016/03/09/industrie-4-0/
158) Hofstede (2001): Culture's Consequences – Comparing Values, Behaviors, Institutions and Organizations Across Nations. 2nd edition, Thousand Oaks, CA.
159) Picot/Reichwald/Wigand (2003): Die grenzenlose Unternehmung – Information, Organisation und Management: Lehrbuch zur Unternehmensführung im Informationszeitalter. 5th updated edition, Wiesbaden, and/or English edition 2008 Springer (IOM)

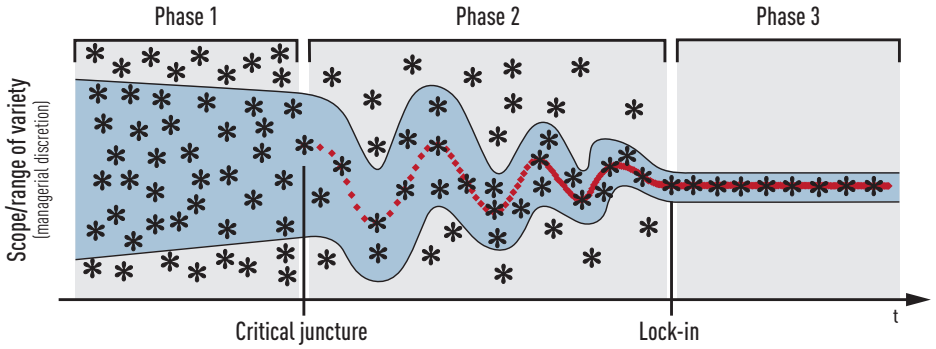


Figure 31: Path dependence – how a company's available scope for action is determined (cf.. Sydow et al.)[160]

tive sector, for example, have been concentrating for decades on optimizing internal combustion engines and are consequently finding the move to electromobility and the associated development of new core competencies rather a wrench. This can also be attributed in part to the fact that „It is difficult to row back on investment decisions already made because of the unacceptably high costs this would involve. This is sometimes referred to as the lock-in effect: the managers involved are trapped in the grasp of implicit rules and routines and constrained by the sums already invested in the company's traditional business areas. These forces acting to perpetuate the status quo can become a significant problem because of the self-reinforcing mechanisms – positive feedback loops – that operate between employees, management, structures and markets. These mechanisms are difficult for the individuals involved to perceive and a paradoxical situation thus arises in which managers are actually a part of the system they are supposed to be managing.“ [161] The initially unrestricted scope to act is thus significantly restricted by „critical junctures“ in the decision-making process and then further constrained by positive feedback effects. This eventually leads to a lock-in situation, with scope for action severely limited and the remaining options often far from efficient in strategic terms (see *Figure 31*).

Companies have to depart from their previous path in order to achieve fundamental change. One method of doing just this that has been observed in practice involves ambidextrous organizational structures, which are described in the following.

Requirement for ambidextrous organizational structures

A radical change in service range often demands equally radical changes in organizational structure in order to enable a break from established path dependence effects. Companies consequently often set up a dedicated corporate unit (such as the BMWi unit established to develop electric automobiles) to develop a completely new product and service range and create the organizational structures necessary for the purpose. The new corporate unit generally cannot generate any significant revenue in the initial development phase and must therefore often be cross-subsidized by the established core business. Daimler boss Dieter Zetsche made this very point in relation to electromobility at the Beijing motor show: „We are going to have to rely on internal combustion engines for our income for some time yet.“ [162]

The old core business is thus continued and further optimized for a certain period (exploitation), with new business areas having to be developed simultaneously (exploration). The challenge, especially for established companies, is to achieve both in a balanced and strategically effective manner, that is to say to be properly ambidextrous in the development of mentality, culture, structure and human resources.

The disruptive character of ICT-induced change necessitates the development of ambidextrous organizational structures. The new units (whether self-created or acquired) can be developed in parallel with the core

160) Sydow/Schreyögg/Koch (2009): Organizational Path Dependence: Opening the Black Box, in: Academy of Management Review 34, 4, p. 689–709.
161) http://www.harvardbusinessmanager.de/heft/artikel/a-622046.html
162) http://www.manager-magazin.de/unternehmen/autoindustrie/daimler-dieter-zetsche-haelt-am-diesel-fest-a-1089052.html

Alignment of	Exploitative (old) business	Exploratory (new) business
Strategic intent	cost, profit	innovation, growth
Critical tasks	operations, efficiency, incremental innovation	adaptability, new products, breakthrough innovation
Competencies	operational	entrepreneurial
Structure	formal, mechanistic	adaptable, loose
Controls	margins, productivity	milestones, growth
Culture	efficiency, low risk, quality	risk taking, speed, flexibility, experimentation
Leadership	authoritative, top down	visionary, involved

Table 2: Ambidextrous organizational structures (based on O'Reilly/Tushman) [163]

business according to a „spin-along" approach [164] and then integrated into the parent company in whole or in part temporarily or at a suitable point in time. The successful development of a new organizational unit hinges on the largely unconditional support of the management board of the parent company, without which the (often associated) cannibalization and cultural realignment of the existing core business cannot be completed.

One decision maker made the following observations on the matter: „It's time to get used to the fast lane. There will be winners and losers. Some once successful companies will be numbered among the losers, but which they will be it is too early to say. Sometimes it can be helpful to look back into history. The iPhone came to market less than ten years ago, at a time when Nokia had already sold ten million telephones. Since then Nokia has been taken over by Microsoft." And: „The Americans have realized that innovations happen outside their home sector and they are consequently prepared to buy and sell young startups and companies from other sectors. This does not happen in Germany. Cisco does not conduct its own research any more; instead it buys startups, in the process acquiring the people it needs as well."

6.5 Understanding of technology as the cornerstone of the transformation

6.5.1 High-level integration

One key technical finding from the two preceding chapters confirms Marc Andreessen's assertion in the Wall Street Journal [165] in 2011 that „Software is eating the world." This development is also often succinctly summarized in the phrase „software-defined everything". [166]

Bringing the mechanics, electronics and information technology technical fields together in the context of high-level integration makes it possible to create components that can to a large extent be programmed exactly as required. Integration of this type opens the door to systems that would simply be impossible to realize within the bounds of any one technical field. These highly integrated systems make it easier to enhance and modify functions using software alone, meaning that systems become scalable and that sometimes customer wishes can be implemented much more quickly with no changes to hardware.

163) O'Reilly III/Tushman (2004): The Ambidextrous Organization, in: Harvard Business Review 4, 82, p. 74–81.
164) Michl/Gold/Picot (2012): The spin-along approach: ambidextrous corporate venturing management, in: International Journal of Entrepreneurship and Small Business 15, 1, p. 39–56. Michl/Gold/Picot (2013): Managing strategic ambidexterity: the spin-along approach, in: International Journal of Technology Management 61, 1, p. 47–63. Klarner/Treffers/Picot (2013): How companies motivate entrepreneurial employees: the case of organizational spin-alongs, in: Journal of Business Economics 83, 4, p. 319–355.
165) http://www.wsj.com/articles/SB10001424053111903480904576512250915629460
166) Marv Langston, Keynote, Americas Conference on Information Systems (AMCIS) of the Association for Information Systems (AIS), San Diego, Ca., August 12, 2016.

The approach makes technology so adaptable that it can even be used to realize new business models with no need to replace the entire installed base. It would thus be able to satisfy the requirements defined for it in the socioeconomic section of this chapter. The steps most commonly cited by the interviewees as helping to ensure that this is so can be summarized as follows:

- Install more powerful hardware than is initially needed for the intended use. This does not just mean more computing power or memory, but also, where appropriate, more sensor systems or communications interfaces (overprovisioning).
- Where feasible and expedient, use non-specialist hardware for which support is widely available in the community and that is encapsulated with a flexible and well-documented API.
- Provide mechanisms with which the software can be updated easily and securely (the APIs and communications interfaces mentioned above can be most useful here too).

The extension of agile software development in the direction of DevOps currently under discussion in the German automotive industry cannot be realized without the aforementioned structures and mechanisms. [167]

6.5.2 Data acquisition and analysis

Access to data from a wide range of sources and its prompt, targeted analysis are regarded as another core issue in the technical area.

A distinction can drawn between system-wide data acquisition and comprehensive data acquisition. System-wide data acquisition is in principle an activity from quality management. The term denotes all of the organizational measures that improve process quality and system-wide data acquisition is one of the main tasks of management. An intelligent complete concept that links production-related, logistical and business administration processes and systems with goods and traffic flows provides management with an insight into the necessary data.

This makes the workflows of the value chain more efficient and transparent from a quality management perspective, facilitating efforts to simplify complex workflows in the company and monitor effectively all operations in the working process. Automation in this context enables the company to optimize work steps for cost-efficiency as well as minimizing sources of error. [168] „Comprehensive“ data acquisition, in contrast, provides a supply of reliable, meaningful information, which is a prerequisite for accurate decision making and enables a systematic learning process.

It also became apparent in the interviews conducted, however, that some of the experts are not at all confident the data collected is sufficiently comprehensive to form a reliable basis for deriving sound information. There was much discussion in this connection of the relevance of the context in which the data was acquired. Respondents wondered, by way of example, about the extent to which the result (from a sensor, for instance) depends on environmental factors that act only indirectly and may not have been measured separately.

This problem can be solved at the moment insofar as the question to be answered can be described precisely and the necessary dependencies and input factors can be derived on this basis. This is usually done today by having senior specialists investigate a precisely described and delimited problem domain (experimentally and/or using simulations) and develop a model on this basis that determines the correct response for the most significant events – sometimes even all events – that occur. The nature and scope of the data needed for this model can then be ascertained exactly. This means that it is also perfectly possible to work out definitively which sensors are required, how the data volume will develop and in what structure the data should be stored.

Everything changes, however, if the question cannot be formulated precisely; indeed in extreme cases the question may simply not exist or the problem domain may be highly dynamic because the set of combinations of possible events approaches infinity. The latter issue was addressed several times in the preceding chapters with reference to the example of autonomous driving. The same applies for certain instances of Industry 4.0 too, however, such as situations in which there is a need for dynamic collaboration between robots and people or robots and machines.

167) http://www.automobil-industrie.vogel.de/devops-updates-fuer-die-automobilindustrie-a-538642/
168) http://www.globos.de/ratgeber/industrielle-komplexitaet.html

Some aspects of these matters actually still require considerable research,[169] not least in respect of verifying that the model does in fact cover all relevant scenarios. It is also necessary as a matter of priority to clarify how the degree of relevance of a scenario can be verified (for example using a suitable measure). It should be noted that this discussion about formal assurance in respect of autonomous systems (safety verification) appears to be of interest primarily within Germany. As described in section 5.2, American companies – especially in the mobility field – are following a more pragmatic approach here or using their expertise in data analysis. This can be judged in different ways.

Inherent in this form of pragmatism, however, is a need to master specific technologies that currently lie outside the core competency of the three sectors surveyed. Responses received in the present study suggest a tendency to underestimate these technologies in some quarters.

A modern automobile generates around one gigabyte of data every minute assuming that all sensor data is recorded.[170] A volume of up to five petabytes (5,000,000 gigabytes) is required to verify reliably the safe operation of a driver assistance function.[171] The many questions to be tackled in working out how to handle this quantity of data include:

- Is there any data that can be dispensed with in every scenario?
- What data can be preprocessed in situ (sensor fusion, object lists, edge detection, etc.) without important (contextual) information being lost? And what data really should be stored in the raw state?
- What data is transmitted directly (over the air) and what data is stored locally ready to be sent to the server later, for example via the home WLAN?
- In what format is the data stored centrally to ensure optimal processing speed and structural flexibility? Note that the aggregate quantity of data from x vehicles per day will on average already amount to y GB/TB.
- What form might an API take to allow third parties to access the data as well where applicable?

There are other far more mundane questions to be addressed in this connection too, such as the availability of data analysts, the size and scalability of the data center and the matter of how and when the results are transmitted back to the vehicle.

Other approaches can also be considered, for example how each vehicle is identified as a node in a virtual computer cluster and how analysis is shared between this cluster and the data center. Certain aspects of this issue are also being discussed at the moment in the context of IoT under the banner of edge computing. The edge computing approach aims to reduce the volume of communication between local nodes and the backbone by providing additional computing power at the extremities of the network so that specific tasks can be completed before data is transmitted. This approach effectively embodies the overprovisioning idea described in the preceding section.

For all that there may be differences in the detail (IoT is identified explicitly as a trigger of the change, for example), the issues for the automotive industry can certainly be carried over to the mechanical engineering sector as well. The only major difference is that the question of where to store and process what data takes on a rather different complexion in the mechanical engineering setting due to the priority attached to protecting trade secrets. Interestingly, potential solutions that factor in this problem could also be of relevance for the automotive industry should it decide to conduct joint data collection and analysis.

The logistics industry appears to be at a different stage entirely. It already possess a huge amount of data, for example to permit the location of consignments to be determined almost in real time, and the quality of its predictions as to when a particular consignment will be delivered where is improving continuously. The autonomous delivery of freight and packages, however, involves a new set of requirements as to the nature and scope of data. The recording and management of the precise local conditions (width of street, form, height and size of the delivery zone, size of the mailbox, etc.) are of the utmost importance in this case, which suggests, in the view of the authors, that in the medium term the logistics sector is going to have to find answers to the same questions as the automotive and mechanical engineering industries.

169) Attention is drawn in this connection to BMWi's SADA research project, which addresses some facets of the problems described (http://projekt-sada.de/).
170) http://www.zeit.de/mobilitaet/2015-08/autonomes-fahren-sensoren-datenmenge/seite-2;
http://www.continental-corporation.com/www/presseportal_com_de/themen/pressemitteilungen/1_topics/messen_veranstaltungen/pr_2016_03_31_bausteine_automatisiertes_fahren_de.html
171) http://www.bertrandt.com/fileadmin/data/downloads/02_Presse/04_Bertrandtmagazin/BM_15_BigData.pdf

6.5.3 Machine learning and autonomy

Machine learning makes it possible to use autonomous systems in an under-determined environment by identifying and classifying patterns in large datasets. Scenarios such as traffic situations, management interventions and sequenced actions can be derived on this basis along with decisions for behavior.

The mechanical engineering and automotive industries in Germany consider themselves to be well prepared with regard to the future development and mastery of autonomous systems, a confidence they base on their current capabilities in the area of semi-autonomous systems. The two sectors agree, moreover, that there are no significant technical obstructions to implementation and that they are held back merely by legal concerns (the automotive industry) or a lack of customer demand for such systems (mechanical engineering). It is difficult to know in this connection how seriously to take a remark from the logistics sector to the effect that the very limited use of autonomous systems in its operations stems from the fact that the mechanical equipment manufacturers are not offering anything in the way of universal, readily-adaptable autonomous systems.

There must though be at least an element of doubt from an engineering angle as to whether a mastery of partial autonomy necessarily implies the ability to develop fully autonomous systems as well. Gaining formal approval for a single vehicle could involve a requirement for up to five billion kilometers of test driving according to one interpretation of the specifications defined in the ISO 26262 standard, for example.[172] Another objection (of German origin) points out – correctly – that no theory yet exists for modeling and assuring the integrity of the outcomes of machine learning decisions.

These concerns contrast with the approach of Tesla and Google mentioned by way of example in subsection 5.2. Both of these companies are taking the statistically supported verification path and have for many years been sending vehicles out into the field to rack up the test kilometers and collect iterative data. Google is currently recording approximately 1.1 billion virtual test kilometers every year, Tesla approximately 880 million real test kilometers. Both apply machine learning algorithms to the data acquired to enable the vehicles to travel (semi-)autonomously. This policy clearly ignores the formal interpretation of ISO 26262 followed in many working groups.

Statistics for 2014 show that there were around 6.1 million accidents on American highways that year, with on average one death and 77 instances of personal injury per 100 million vehicle kilometers.[173] These figures could be taken to suggest that the scale of the aforementioned testing conducted by Tesla and Google is indeed sufficient to demonstrate, over time, that their systems result in fewer accidents than human-piloted vehicles. This, in turn, would represent a good starting point from which to absolve them of allegations (allegations that could potentially involve suggestions of criminal behavior) of intent or gross negligence. Cynical as it might sound, an accident at this point would be purely a matter of determining liability: the damage done could almost certainly be insured.[174]

Reference is repeatedly made in the context of the large number of test kilometers required to the fact that each separate vehicle type needs to have completed this distance in order to receive a type approval. This must be an accurate assessment provided that there is no suitable decomposition of the overall vehicle system – and no such decomposition exists at the moment (see section 6.5.1 High-level integration). Should it prove possible to link the individual algorithms, for example for environment recognition or decision making, with the physical world using middleware[175] (hardware and software), this would represent one possible route for the independent development of subcomponents and for integration, verification and assessment.

Such a decomposition and standardization would also make it much easier to close the gap between simulation and reality. This ties in with the aforementioned subsections 6.5.1 (High-level integration) and 6.5.2 (Data acquisition and analysis) in a scenario in which the findings discussed there could also be used to facilitate the virtual type approval. This being the case, it would appear the discussion about test kilometers – insofar as it retains any relevance at all – is more likely to be conducted in the virtual world. Google is active in all three areas (apart from the physical world aspect) and is also actively involved in simulation, suggesting that it may well be following this very path.

172) Prof. Lienkamp at the first e-Monday convention „Mobilität 4.0: Elektrisch, vernetzt und autonom" on June 7, 2016: http://www.e-monday.com/wp-content/uploads/2016/06/Markus-Lienkamp.pdf, p. 21.
173) http://www-nrd.nhtsa.dot.gov/Pubs/812263.pdf
174) https://www.theguardian.com/business/2016/jun/07/uk-driverless-car-insurance-policy-adrian-flux
175) The BMWi-backed RACE project (http://www.projekt-race.de/) has developed a prototype of such an architecture.

While it is true that the problem described relates to the automotive industry, it is by no means unlikely that both mechanical engineering and logistics will have similar questions to tackle in the medium term. Ultimately, all systems that have close autonomous interactions with people in fluid situations not planned in advance will be affected.

6.5.4 Summary and review of international implications

The trends highlighted point to the conclusion that ICT-induced change will shake up operations across sectors, most notably through the productization of services and servitization of products. Keeping pace with the international competition against this background will require not just software expertise, but also a thorough understanding of the possibilities and mechanisms of digitalization. The German mechanical engineering industry has in the main already recognized that it is going to have to change its proposition, a realization neatly summed up in the following quote: „If today is about manufacturing products, tomorrow will be about providing a service to support an ecosystem."

In Japan, in contrast, information technology is hardly used at all in this particular sector because of a tendency to focus on other areas and a lack of familiarity and of the necessary expertise. The interviews conducted in Japan show that the shortage of software expertise in industry is recognized as a matter of great concern in the country and this may well explain Japan's efforts to introduce software development as a core subject in primary-level schools from 2020.[176] The Japanese economy is also aligning itself closely with German initiatives relating to Industry 4.0, pushing through the associated transformation primarily in the Industrial Value Chain Initiative (IVI).[177] Companies from the mechanical engineering sector in the USA have organized themselves along similar lines with the Industrial Internet Consortium and are considered to be only slightly behind Germany (and well ahead of Japan) in terms of implementation.[178]

ICT expertise is also a key factor in the ability to create highly integrated systems, which in turn is a prerequisite for – or at least simplifies – productization. The provision of functionality and differentiation are accomplished here with software rather than with hardware, which makes it relatively simple to accommodate enhanced functionalities. A typical example of this is the smartphone, which brings together numerous functionalities including camera, navigation system and scheduler. Propositions of this nature also harbor potential for monetization extending beyond the initial sale.

Another development in evidence is that even providers that have hitherto focused exclusively on the business customer interface are increasingly seeking contact with end users and adapting their propositions ever more rapidly to the latter's requirements. In South Korea this trend is particularly apparent in the logistics sector, with the customer interface and the analysis and forecasting of end user requirements much more important than in the B2B setting. US company Amazon is already in a position to put this information to full use in the logistics sector having put in place all of the necessary conditions. As already observed by the German Chancellor, among others, the interface to the customer is critical.[179]

It is in the USA that this realization is being converted into action most consistently. No less than Uber and Apple – in cooperation with Didi Chuxing – are competing over the intermediary role for driving services in China with investments running into the billions.[180] Another prominent example is Microsoft's takeover of LinkedIn,[181] which can be interpreted as an attempt to gain a more direct connection to the needs of several hundred million customers. The LinkedIn example in particular highlights how the lines between business customers and end users are becoming blurred. The Japanese view of digitalization, in contrast, treats it principally as another opportunity to boost efficiency with regard to existing products and production. Japanese companies do not see digitalization as a way to involve the end user; in fact they tend to view such end user involvement as a potential threat to the reputation for high quality enjoyed by Japanese products.

Involving users – including in the form of prosumers – can nevertheless be seen to be a strategically important

176) http://the-japan-news.com/news/article/0002951918
177) http://www.vdi-nachrichten.com/Technik-Wirtschaft/Japan-entdeckt-Industrie-40-fuer
178) cf. inter alia https://www.mckinsey.de/files/mckinsey_industry_40_2016.pdf and https://www.bcgperspectives.com/content/articles/lean-manufacturing-operations-time-accelerate-race-toward-industry-4/?chapter=2#chapter2
179) Handelsblatt, March 14, 2016, p. 14
180) http://www.reuters.com/article/us-apple-china-idUSKCN0Y404W
181) https://www.tagesschau.de/wirtschaft/microsoft-linkedin-101.html

factor in the age of digitalization. Active or passive, the customer is a supplier of data. Combined with the right expertise, this data can be converted into a valuable resource and then, thanks to informatization, be analyzed to yield intelligence about trends, needs and even improvements to products, propositions or processes. The significance of data analysis and the potential it appears to offer are recognized in China, but the costs involved in obtaining the associated specialists are still stifling enthusiasm. The Chinese companies surveyed are not yet willing to take the risk of making the investment required on account of the fact that it is not possible to estimate the ensuing economic benefits with any precision.

The technical possibilities that make it possible to recognize promptly what are at times very rapid changes in customer requirements cannot be exploited properly unless the corporate strategy and, in particular, the organizational structure are able to understand the short innovation cycles involved and put them into practice. Methods such as scrum or agile software development are regarded in the USA as suitable or amenable to adaptation for the automakers, for example. The anticipated effect does, however, depend very much on a company's organizational structure and the possibilities that emerge from it. The German mechanical engineering sector is of particular interest in this connection: German mechanical equipment manufacturers tend to be small and midsize companies with flat structures in which the decision makers are often also responsible for strategy and the corporate pathways and processes are correspondingly lean and efficient.

The developments described are most commonly found in combination in software platforms, which are increasingly developing into complex platform ecosystems with many millions of users. These platforms offer not just mechanisms for customer retention, but also numerous opportunities for actively involving users and/or monetizing their data by other means. The expansion of such platforms – for example to include tools for digital engineering, simulation and other software-based functionalities – is further accelerating the development of (digital) products and services. Formerly independent value creation activities are being transformed into emerging digital ecosystems on the basis of these platforms, which is in turn fundamentally altering relationships between the economic actors involved. Related companies, especially those behind the newer, very successful platforms, are also attempting to transfer methods and processes from IT to the organization itself. Amazon CEO Jeff Bezos, for example, instructed his company to ensure that all teams publish their data and that all data sharing between departments uses standardized service interfaces based on web technology. This has opened up entirely new options for strategy, such as the introduction of the world's most successful cloud platform, Amazon Web Services (AWS). [182]

182) http://jesusgilhernandez.com/2012/10/18/jeff-bezos-mandate-amazon-and-web-services/

CHAPTER 7

ICT-driven platform ecosystems

Platforms are now at the heart of the most successful companies in the world. Fundamentally, platforms consist of a market maker or intermediary that brings together different customer groups. For example, Facebook links members of its social network to each other and to advertisers. The result is a two-sided or multi-sided market in a network of reciprocal transactions.

The attractiveness of platforms depends on network effects – in other words, with each new user, a platform becomes more attractive for other participants. This can produce a virtuous circle, triggering rapid growth and sometimes also creating significant market concentration. Open platforms also allow third parties to enhance and add new products and services to complement the existing functions.

Facebook, for example, has opened up programming interfaces (APIs), meaning that external software developers can transform the functionality of the Facebook platform by providing apps. A prospering ecosystem can be developed on this basis, characterized by many different interactions and actors and extending far beyond the original platform in terms of the range of functions and its economic influence.[183] A social media ecosystem has grown up around – and in part because of – Facebook, containing various different and sometimes competing platform providers (like Instagram, YouTube, Twitter, Flickr, blogs) all interfacing with each other. About a third of the global population is now active in this ecosystem[184], which accounts for advertising spending and revenues of more than 20 billion US dollars.[185]

Platforms and the ecosystems they support are not exactly a new phenomenon. Fishman and Sullivan[186] cite the Champagne fairs in 12th century France as an early example of platforms. The Count of Champagne established these fairs as a multi-side marketplace for traders and customers, with strict eligibility requirement and rules. The Count grew very rich from his small cut in each transaction, and the marketplace became pivotal in European trade.

Although platforms and their ecosystems[187] still operate along the same lines as they ever did, the pace of change is much faster thanks to the global integration and dematerialization brought about by digitalization. Compared to physical platform ecosystems, it is often easier, cheaper and more flexible to participate in digital platform ecosystems because involvement is usually only virtual and therefore independent of time and place. In addition to lower barriers to participation, purely digital services can now be provided at extremely low cost in near real time throughout the world using digital data transmission, for example via the internet (see also *Chapter 2*). Overall, these and other attributes of digital platform ecosystems mean that they spread further and more quickly than traditional platform concepts, which are usually based on physical interactions and transactions.

Creating and controlling digital platform ecosystems – or at least participating in them – is at once an opportunity and a challenge for many companies these days, and there are many issues that need to be resolved concerning the business model, the wider industry and specific customer problems. The literature draws a distinction between two roles. There are shapers, which provide and control the platform and steer the platform architecture and future development by defining standards and interfaces. And there are

183) cf. for example The Economics of Platforms: Is That a Market in Your Pocket or Are You Just Happy to See Me?, in: Fishman/Sullivan (2016): The Inner Lives of Markets: How People Shape Them – and They Shape Us, Philadelphia, PA, p. 105–130; Picot/Kranz (2016): Internet Business Strategies, in: Bauer/Latzer (Eds.): Handbook on the Economics of the Internet, Cheltenham, p. 365–384.
184) cf. http://www.statista.com/topics/1164/social-networks/
185) cf. http://www.emarketer.com/Article/Social-Network-Ad-Spending-Hit-2368-Billion-Worldwide-2015/1012357
186) cf. https://hbr.org/2016/03/everything-we-know-about-platforms-we-learned-from-medieval-france
187) These are also referred to below as platform ecosystems.

adapters, which offer complementary services to create platform ecosystems together with the shapers.[188]

This chapter describes central characteristics and classifications of digital platform ecosystems using illustrative examples, and discusses the significance for German industry. Taking the insights and general trends described above as our starting point, we examine the economic importance of digital platform ecosystems before moving on to the associated business models and the formation of value networks. After categorizing ICT-driven platform ecosystems, we use examples to illustrate the mechanisms and operation of digital platform ecosystems. We then look ahead at the opportunities and risks associated with this development for the German economy, with its characteristic predominance of medium-sized firms. We conclude with the example of the HERE platform to illustrate the vision of a platform-centered ecosystem in the automotive industry – showing the principle of implanting platforms in established B2B industries.

7.1 Economic relevance of platform ecosystems

Platform ecosystems represent a major expansion of the simple product business, in which unrelated, independent products or services are offered.[189] For example in the last 15 years an extremely complex multi-sided market has grown up around the mobile telephone – in essence quite a rigidly standardized and interchangeable product. The market is dominated by two large ecosystems based on their corresponding platforms[190]: The platforms for Apple and Android-based systems have pushed all other market players into the margins.

The rapidly increasing economic importance of such platforms is demonstrated clearly by the change in the ten most valuable companies in the world between 1995 and 2015. In 1995, the list was still dominated exclusively by classic industrial companies working in the product business. In 2005 Microsoft became the first ICT-platform company to enter the list, in fourth position (based inter alia on Microsoft Windows as the dominant operating system for PCs). Ten years on, five platform companies account for 58 percent of market capitalization of the ten most valuable companies in the world (see also *Figure 32)*.

The market capitalization of the 15 largest platform companies in the world[191] is estimated at 2.6 trillion US dollars in 2015.[192] The market value of all 176 iden-

188) cf. Franz (2003): Management von Business Webs: Das Beispiel von Technologieplattformen für mobile Dienste, Wiesbaden, p. 55ff.; Picot/Schmid (2006): Wettbewerbsstrategien von Internet-TV-Plattformen und Business Webs, in: Information Management & Consulting 21, 3, p. 30–40.
189) Defined as „a network of interconnected organizations that are linked to or operate around a focal firm or platform", p. 205, cf. Autio/Thomas (2014): Innovation Ecosystems: Implications for Innovation Management, in: Dodgson/Gann/Phillips (Eds.): Oxford Handbook of Innovation Management, Oxford, p. 204–228.
190) Defined as „foundation technology or service that is essential for a broader, interdependent ecosystem of businesses", in: Gawer/Cusumano (2008), p. 28.
191) In alphabetical order: Alibaba, Alphabet, Amazon, Apple, Baidu, eBay, Facebook, JD, LinkedIn, Netflix, Priceline, Salesforce, Tencent, Twitter and Yahoo.
192) Accenture Technology Vision 2016, p. 38: https://www.accenture.com/t20160202T102002__w__/us-en/_acnmedia/Accenture/Omobono/TechnologyVision/pdf/Technology-Trends-Technology-Vision-2016.pdf

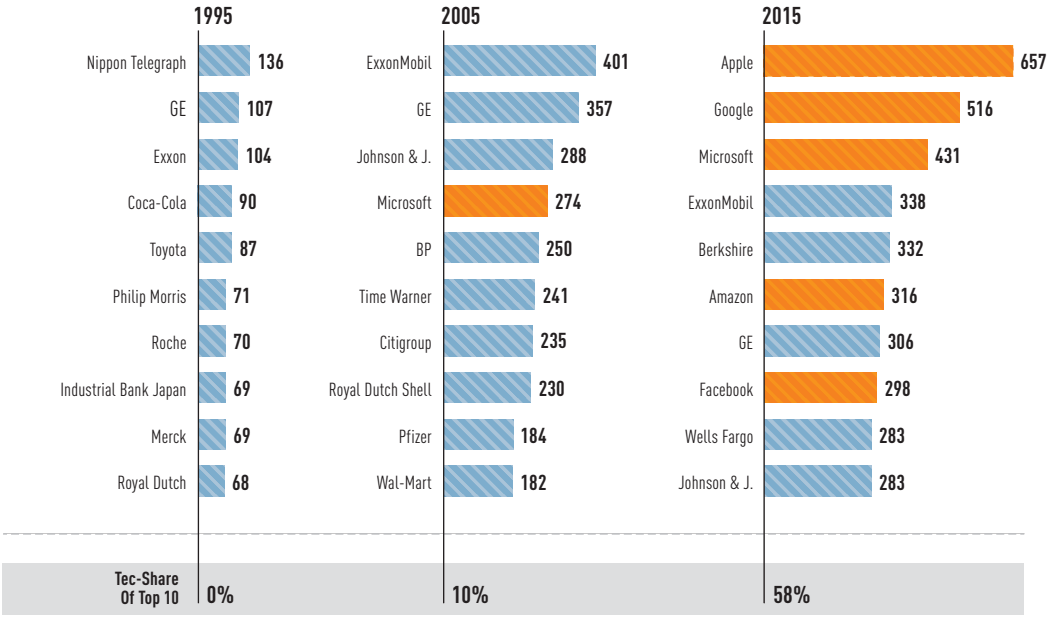


Figure 32: The ten most valuable companies in the world between 1995 and 2015 in billions of US dollars [193]

tified platform companies worldwide is reported as 4.3 trillion US dollars.[194] An analysis of the global distribution of platform companies reveals a strong concentration in North America and Asia – with most platforms in Asia and the largest combined market capitalization in North America. Europe is further down the list in terms of the number of platforms as well as market capitalization, ahead of Africa and Latin America (see *Figure 33*).

The figures show that compared to the major US platform companies, German companies have a lot of ground to make up. This is illustrated by the following comment:

„Whereas Germany continues to build seaports and is banking on larger and larger container ships, GAFA [Google, Apple, Facebook, Amazon], Microsoft and other US companies in the digitalization economy are securing the mining rights of the future. As we speak they are setting the technical standards, learning the difficult lessons, making the advances and establishing the global networks that will make them unassailable by competing imitators and by the European regulatory authorities in their futile attempts to tackle the normative power of the internet giants" [195]

193) Yahoo Finance; based on Schmidt (2016): https://netzoekonom.de/2016/01/19/keine-industrie-ist-vor-digitaler-disruption-gefeit/
194) Evans/Gawer (2016), p. 10: http://thecge.net/wp-content/uploads/2016/01/PDF-WEB-Platform-Survey_01_12.pdf
195) Straubhaar (2016): GAFA – Vier Buchstaben lassen die USA wiedererstarken, in: Welt.de, February 8, 2016: http://www.welt.de/print/die_welt/wirtschaft/article151953032/GAFA-Vier-Buchstaben-lassen-die-USA-wiedererstarken.html

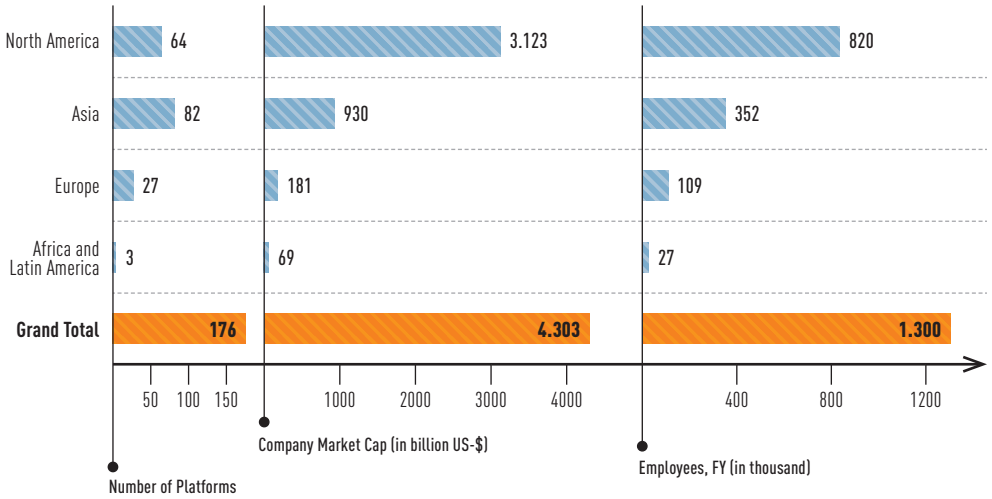


Figure 33: Global distribution of platform companies by number, market capitalization and number of employees [196]

7.2 | Classification of platform ecosystems

In principle, platforms can arise in any industry and with varying capital intensity and asset intensity. For example, many platform providers in the business-to-consumer market have no platform-related assets at all, acting purely as intermediary:

> *„Uber, the world's largest taxi company, owns no vehicles. [...] Alibaba, the most valuable retailer, has no inventory. And Airbnb, the world's largest accommodation provider, owns no real estate."* [197]

There are also platforms, on the other hand, that are based largely on physical assets, which are sold to users either by the platform provider or other market players, or offered by the platform provider on a usage basis as part of a service (see *Figure 34*).

In the capital/asset intensive business-to-business market, the formation of platforms is still at an early stage. Unlike platforms based on everyday objects or goods, things like production facilities, for example, require highly specific development processes which to a considerable extent must be physically adapted to meet individual customer requirements. Established major industrial companies could play their trump card here, using their existing industrial and production expertise to meet customer wishes in a completely new way, by combining physical goods with software and platforms. For many established ICT platform providers, the development and production of a physical good remains a significant barrier to market entry (take Apple's attempts to build its own car). Conversely, traditional industrial companies have their own formidable barrier to market entry – designing, developing and operating platforms with suitable software and standards in a way which is compatible with their business model.

Another example is the GSM cellular standard based on terminals and SIM cards, introduced over 20 years ago. This one standard paved the way for a vast array of devices, providers and services. In this case, an ecosystem has been created on the basis of the platform and its standards, with an attractive service offering for users

196) Evans/Gawer (2016), p. 10: http://thecge.net/wp-content/uploads/2016/01/PDF-WEB-Platform-Survey_01_12.pdf
197) Goodwin (2015): The Battle Is for the Customer Interface, in: Techcrunch.com, March 3, 2015: http://techcrunch.com/2015/03/03/in-the-age-of-disintermediation-the-battle-is-all-for-the-customer-interface/

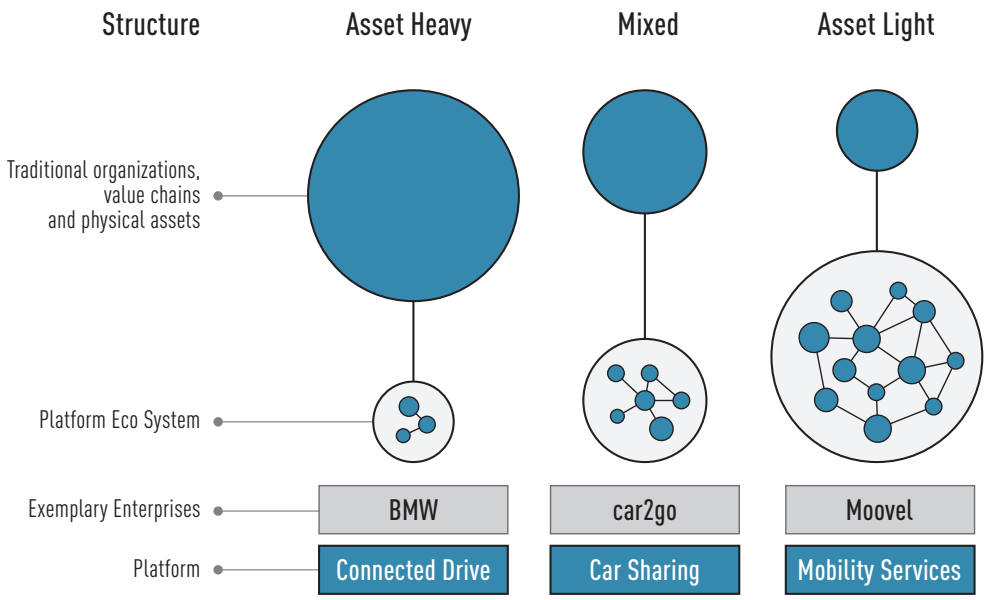


Figure 34: Platform types in combination with physical assets, using the example of mobility [198]

and a secure investment opportunity for providers. This ecosystem is regulated with mobile licenses and standards and requires massive infrastructure development by the network providers. This infrastructure has in turn formed the basis for the familiar operating-system-based Android and Apple platform ecosystems which have grown up in the last ten years.

The strategic importance of platform companies (as "shaper" of a platform) is down to their control of the platform (for example controlling the technology used, defining and establishing standards and processes) as well as the interface with users and providers and with complementary products and services – all essential ingredients of the resulting ecosystem.

7.2.1 Software-based platform ecosystems

In the field of ICT, different characteristics can be identified for software ecosystems, and we assign various classes below using the main features. It is difficult to establish clear dividing lines because ecosystems are usually distinguished by multiple characteristics, although they may be weighted differently.

A classic (open) software platform is built on software for which a wide range of applications and services is available. These ecosystems are often engendered by standards or de-facto standards like operating systems, sometimes open but also proprietary. Windows and iOS are examples of early software platforms. In this context, platforms differ in terms of the available products or services, which either cover a wide range of functions within the platform ecosystem or are focused on the user in a highly target-oriented or problem-oriented way. For this kind of ecosystem, however, success does not necessarily hinge on a large number or a wide variety of offerings. Instead, the crucial element is the interplay between variety, relevance and quality. That means that platform operators with a very narrow but targeted offering, for example Uber, can be successful.

Another class of platform allows the exchange of goods, services or content. Success is determined by the offerings and the content, which in this case means

198) Own illustration based on Accenture Technology Vision 2016, p. 44: https://www.accenture.com/t20160202T102002__w__/us-en/_acnmedia/Accenture/Omobono/TechnologyVision/pdf/Technology-Trends-Technology-Vision-2016.pdf

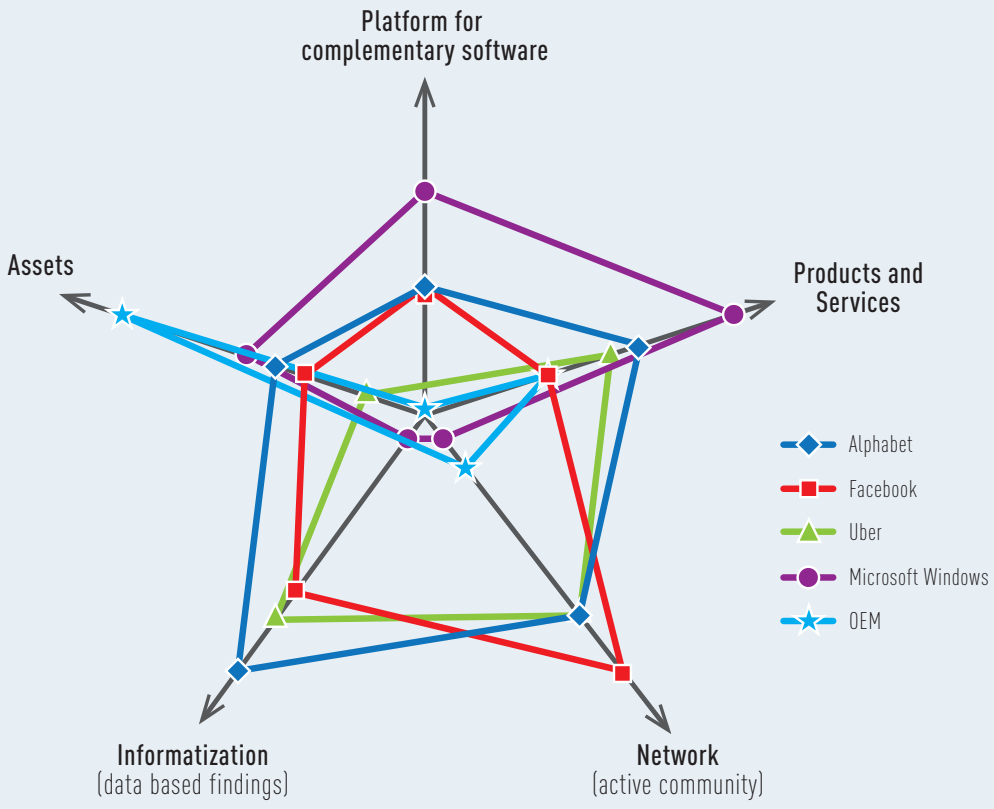
a network of active users engaging either with the platform directly or with each other via the platform. The decisive factor is thus not the absolute penetration rate of a platform, but the number of participating users actively exchanging information. For example Microsoft operating systems are prevalent but users hardly ever exchange information with each other or with the manufacturer. In terms of content, Instagram and Wikipedia benefit from user content or contributions, whereas other platforms such as Facebook or eBay have a strong network, which often offers important advantages for users. In eBay, for example, there are very large numbers of potential buyers and sellers, likely boosting sales revenues.

In platforms like Alphabet or Google, the value of a platform is increasingly determined by the analysis of the data in the ecosystem and the resulting quality of information. Especially in this example, the data from different platforms of an ecosystem (Search, Android, Maps, etc.) could be combined and knowledge extracted from it. This informatization is thought to have great potential to open up new business models, because trends and forecasts can be gleaned from the actions of platform users in real time. The knowledge obtained can then be used to improve, expand or generate new offerings on an ongoing basis.

Compared to software-based companies and their platforms, companies in the sectors studied (automotive, logistics and mechanical engineering) are (still) predominantly in the hardware business, which is characterized by physical assets and/or products. Examples include vehicles, but also production facilities, machines, warehouses, sorting and loading stations, etc. In the context of software, too, fixed assets can be tied up by intangible assets. In any case, the companies surveyed intend to develop new business models

Figure 35: Factors in the classification of platform ecosystems [199]

The various features of selected ecosystems are shown here schematically with the associated platform.



199) Own illustration

based on digital ecosystems, thereby opening up new markets.

The factors for classifying platform ecosystems are not disjoint – instead, many platform ecosystems are based on one or more of these elements. *Figure 35* illustrates the features of known platform ecosystems with the various attributes. It shows the use and the importance of software platforms in ecosystems like Windows. But it also represents products and services in terms of the interplay of variety, relevance and quality. The network of active users, which can include customers and sellers or even potential competitors, is another crucial feature. For the most part, it is important that users are not anonymous customers for the individual companies in an ecosystem. Instead, it must be possible to use their habits and preferences to optimize the services provided in an ecosystem.

In particular, informatization will become increasingly important for platform ecosystems as a way of discerning trends, making predictions, analyzing habits and understanding users. In the opinion of the authors, data in platform ecosystems will therefore play a special role in future. This will be examined in more detail in the next section. We then go on to illustrate examples of platform ecosystems in the context of smartphones and industrial automation. Finally, we discuss the importance of platform ecosystems to the sectors under consideration in this study, in particular to the automotive industry.

7.2.2 Importance of data and operation of platform ecosystems

It is important to understand exactly what data is generated in platform ecosystems. We will show how this data can be exploited by the owner or operator of a platform. Data, and the information gleaned from data, can be used both to add value and to exercise control over a platform ecosystem.

The example of online music or literature providers clearly demonstrates this. Such platforms are targeted ecosystems with explicit reviews of books or music titles, as well as accessible usage data for platform operators and other parties where applicable. In conventional media, only the sales figures were known, but with digital platforms it is now possible to record which titles, pages or tracks are consumed when, how often and by whom. This requires control to be exercised over the applications used to read or listen to the content. This data allows service providers to manage and optimize supply and demand much more accurately. For example, payment for music can be based on actual usage (e.g. number of minutes of listening). However, this is only possible if the interfaces to the actors within the platform ecosystem are tightly controlled.

Figure 36 shows a universal structure of a data-driven platform ecosystem with general roles and possible data, payment and product/service flows. It is not necessary for all roles to be occupied and all flows to be used in every implementation of a platform of this kind. A digital marketplace, for example, puts customers wishing to purchase products in touch with providers selling them. This can place the marketplace operator in both roles (e.g. Amazon as platform operator and service provider at the same time). The operator can demand payment for brokering a transaction. If the transaction is conducted via the platform, the operator also has the opportunity to use the resulting data about purchasing habits, the success of the products and the transaction itself in order to improve its own offering, or to generate marketable products from the data, such as data services (determining sales trends, for example).

Customers of such data services could be traders wishing to improve their own offering. According to the trends described in the previous chapter, a suitable platform could be expanded and also used in some instances to handle products that are offered as a service, for example by online music providers, as well as services in the conventional sense (such as car servicing) via a service app, in other words via a software product.

In many new digital platform ecosystems, the platform shaper or the standards they define are no longer the only deciding factors - it is the history of the data exchanged and generated during use, and the profile of the users. Examples include:

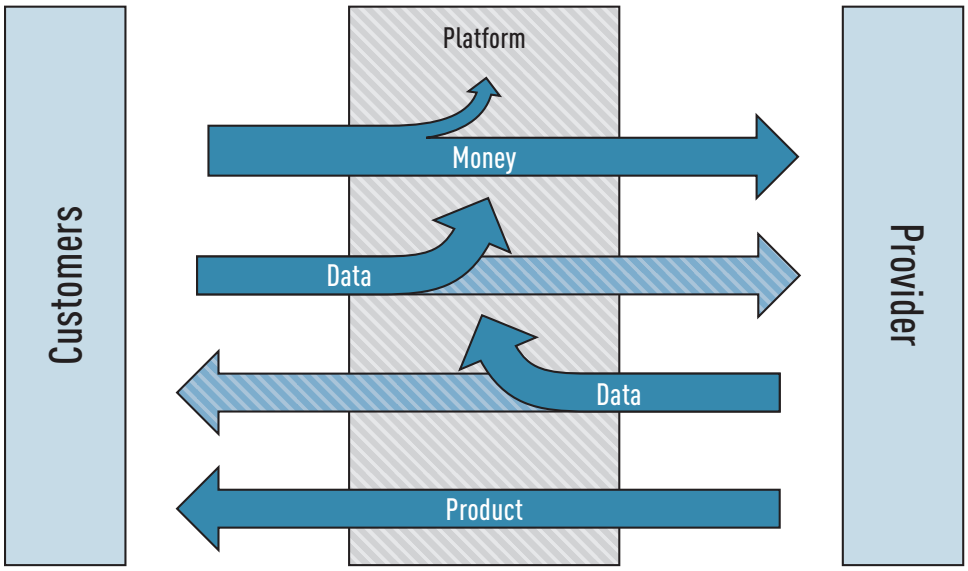


Figure 36: Flows of services, payment and data in data-driven platform ecosystems [200]

- Ratings and reviews of products by users
- Content added by users, for example on YouTube or Facebook
- Usage data for a service – what products are viewed and what products are purchased
- Data generated automatically by machines or products themselves - for example data on usage or capacity
- Customer relationships – who purchased what from whom, who contacted whom, etc.
- Customer data, e.g. contact data

For many internet services, the above data presents new opportunities to add value and forms the basis for long-term user retention. Ratings deliver obvious benefits, allowing tailored offerings to be created from usage data. Combining the defined data points, too, makes it easier to spot fraud or misconduct.

As the penetration and use of internet services pick up pace, data can be captured quickly to generate a solid foundation of data. If the offering is attractive enough, there is a self-reinforcing effect – once a critical mass of users is reached, the numbers grow exponentially. On the flip side, this presents considerable barriers to entry for new platform operators.

The algorithms and computing capacity needed to analyze the data are now ubiquitous. However only those with access to the data and the relevant expertise in data analysis are able to evaluate the data and use it to continuously improve the customer experience. Generally speaking it is difficult for (potential) competitors to emulate this advantage, especially without the data. Without continuous capture, processing and analysis of the transactions – in other words without the relevant data – it is impossible to respond to sudden changes in user habits.

The examples given above are based on applications for end users, but the underlying principle can also be generally applied to the sectors investigated in this study and to the B2B market. Take, for example, the measurement data from industrial production, generated when materials are processed. The data can reveal information about the quality of the materials and can be used for product maintenance. This data can in turn form the basis of a separate business model. Nevertheless, B2B platform markets establish and consolidate themselves in a much more nuanced way and more slowly than B2C because inter-industrial business relationships are generally more specific. Where inputs (materials, equipment, services) are standardized, B2B platform markets are indeed emerging (for example simpel system [201], Amazon Business [202], JumpStartFund as the crowdsourcing platform for the Hyperloop project [203]), and this development is expected to continue.

200) Own illustration
201) http://www.simplesystem.de/
202) https://www.amazon.com/b2b/info/amazon-business?layout=landing
203) https://digit.hbs.org/submission/crowdstorming-the-hyperloop-jumpstartfund-htt-and-spacex/

Platform ecosystems have the potential to make the relationship with users closer and longer lasting. However, the barriers to entry for potential new platform providers are high because an attractive platform requires a critical mass of users and consequently data, generated from a large number of activities in the platform. That is why (successful) platforms frequently experience difficulties when first starting up. It is common for the competitive environment to be dominated by a small number of platforms or even just one. [204]

A successful ecosystem cannot emerge until a platform has built up enough users, providers and content. The platform should therefore be created with the close involvement of customers, based on customer feedback and customer data. There is often stiff competition in a very early phase, during which a number of market players attempt to established their own platform and to occupy the strategically important position – particularly the role of shaper, which determines standards and guidelines, for example. [205]

The offering of mobility services is one example of the fight for supremacy in data-driven platform ecosystems. More and more mapping applications and web portals like Google Maps and Here.com have emerged in recent years, offering intermodal connections by car, rail and other providers (taxi, car sharing) based on clever data aggregation. The result is an attractive offering for the customer, with the possible routes shown on a map where they can be compared easily, even including up-to-date congestion and price information.

With increasing acceptance of these offerings, some mobility providers such as Deutsche Bahn feared a growing dependence on these platforms and started limiting the options for mobility service providers of this kind. Deutsche Bahn tickets can therefore only be purchased directly from Deutsche Bahn. This guarantees that the company retains contact with the customer and reduces its dependency on the platform-based mobility aggregators.

As discussed in *chapter 6*, companies with access to the customer interface occupy a key position, especially in platform-based ecosystems. For example, mobility portals can redirect users to other attractive offerings without having any contact with the actual providers. A mobility data platform of this kind is also able to collect extensive customer data. If the provider has a critical mass of customers and therefore also data, it can start doing things like extracting information about mobility inquiries either in aggregated form or individually. This can be used to create additional offerings, for example running extra long-distance buses on busy routes at selected times. Add-on services can also be offered, such as tailored insurance.

If more than one ecosystem is established, there are questions around whether and how competition takes place between the ecosystems. [206] To exist in the market it is not usually enough for a market player to improve just its own offering. Instead, the ecosystem as a whole must be strengthened as well as the position within the ecosystem. This creates a potential conflict of interests – a provider's own position is often strengthened at the expense of other providers. There is an impact on the general attractiveness of the ecosystem, keeping potential new providers away.

It is very clear that the transition from a product or service business to platform-based ecosystems can significantly alter the market situation because the competition with and between ecosystems is usually subject to completely different criteria – including network effects, critical mass, lock-in situations, technological standards – than in the product business.

204) cf. Schmid (2010): Der Wettbewerb zwischen Business Webs: Strategien konkurrierender Unternehmensnetzwerke im IPTV-Markt, Wiesbaden, and Franz (2003): Management von Business Webs: Das Beispiel von Technologieplattformen für mobile Dienste, Wiesbaden.
205) Defined in: Zerdick/Picot et al. (2001): Die Internet-Ökonomie, and Franz (2003): Management von Business Webs.
206) Bosch-Sijtsema/Bosch (2015): Plays Nice with Others? Multiple Ecosystems, Various Roles and Divergent Engagement Models, in: Technology Analysis & Strategic Management 27, 8, p. 960–974.

7.3 Examples of current platform ecosystems

In the following section we present established platform ecosystems. Because platform-based ecosystems are primarily a feature of the consumer space, we illustrate the mechanisms and relationships between the parties involved using Google's ecosystem built around the Android operating system as the central platform. We discuss the various roles of the players involved and also the importance of data in the Android ecosystem. We use General Electric's (GE) Predix platform, which provides big data analytics services for interlinked machines, to show that platform ecosystems are becoming relevant beyond the consumer space even now.

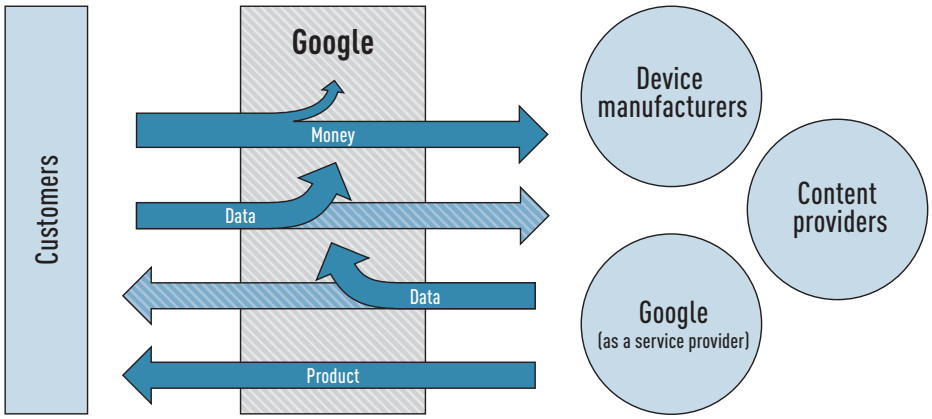
7.3.1 Google Android

Using Android as a platform, Google has created an ecosystem of hardware and software providers and consumers – i.e. a multi-sided market. This system now dominates the market – in 2015 there were 1.66 billion devices (source: Statista) and 24,000 different models (source: Opensignal) – and all the rules of participation are set by Google alone. The ecosystem is defined only to a small degree by the operating system itself (Android). The Open Handset Alliance, which is responsible for the further development of Android, is more of an industrial consortium working for open standards and operating systems. Access to the Play Store, a proprietary marketplace, and the Google Account required for access form the core of the Google ecosystem.

The basic functions of an Android smartphone – internet access and telephony – will work without a user account. However, every end user must have an individual account with Google in order to access integrated Google services and to download apps. This opens the door to popular and convenient services like Gmail, Google Calendar and the Play Store, through which users can add extra functions (apps) to their smartphone. It also means the customer is always uniquely identifiable even across multiple devices, allowing Google to create a detailed digital and real-life behavioral profile (searches and locations).

The real heart of the Android ecosystem is the feature called the Play Store. With the Play Store, users can purchase applications and media and providers can offer their programs and add-ons for download or sale. To access the Play Store, the actors involved in this ecosystem must enter into agreements with Google that differ depending on their roles.

Figure 37: Stakeholders and roles of Google's platform ecosystem



Technical features of the Android/Google ecosystem

The technical platform of the ecosystem sits on top of the existing Google infrastructure. Apps are developed for this platform using a framework in the popular Java programming language, whose runtime environment Dalvic has been optimized to make efficient use of the limited resources of mobile devices. Google is one of the few companies worldwide that is capable of processing the vast quantities of data generated during use, and offering all services with maximum availability. Android was Google's answer to the Apple/iPhone ecosystem. Google's plan was to differentiate itself by lower barriers to entry for application developers and greater availability with a wide variety of compatible devices.

The Android/Google ecosystem in figures:

- 1.66 billion devices
- 24,000 different models
- 1.6 million apps in the Play Store
- 900 million active Gmail/Google user accounts

7.3.1.1 Examples of current platform ecosystems

- **Google** provides the infrastructure of the ecosystem and defines the terms on which the various actors can participate. The infrastructure includes the marketplace and the corresponding identity management, but also the Android operating system, which is made available free of charge. There is also the technical documentation and the tools to develop Android-compatible programs (apps) as part of a software development kit (SDK). That means there are no direct financial obstacles such as license payments or participation fees.

- **Hardware providers** must meet criteria defined by Google to ensure their products are compatible with the Android ecosystem and to obtain access to the Play Store. The criteria are contained in the Mobile Application Distribution Agreement (MADA) and include the sensor technology that must be installed in the device, and the mandatory inclusion of certain Google applications.

- **Content providers** can use the Play Store infrastructure free of charge, although Google is entitled to a percentage of revenue from paid-for programs and content. Google reserves the right to remove „undesirable" applications from the marketplace. This mainly happens to applications which negatively affect the original Google business model – in other words the sale of advertising. Ad blockers are regularly removed from the Play Store or not allowed in the first place.

- **End customers** must have a valid personal user ID in order to participate in the ecosystem. This means they are uniquely identifiable across all the devices they use to log onto their account. Users can attach payment information to the user account so they can purchase content such as media or apps.

7.3.1.2 The role of data in the Android ecosystem

End customers can use most Google services free of charge. They "pay" indirectly through the data trails they leave behind. Apart from around 1.2 trillion searches (as at 2015), Google can also analyze location histories, images and other activities of its users, and generate information from them. The knowledge gained can do much more than simply enrich user profiles:

- Congestion information is generated from location histories.
- Images are used to train powerful face and object recognition algorithms.
- Searches say something about the user's current interests or trends in entire regions.

The underlying algorithms are not the main competition factors. Much more important are the size, scalability and access to user feedback:

- Large amounts of training data
- Availability of infrastructure to analyze the training data
- Feedback from users to check the algorithm is working properly

User feedback is either requested directly (for example "Suggest an edit" in Google Maps) or is deduced from indirect user actions (the returned route is altered manually). This feedback can only be reliably processed automatically if the amount of data reaches the level required to use statistical methods. As such, competitors without access to such large amounts of data are unable offer their own services to the same quality or develop them at the same pace.

7.3.2 GE Predix

General Electrics (GE) Predix is an example of a platform-centered ecosystem in the B2B environment. In 2012, GE formulated a vision of the "Industrial Internet". The business unit GE digital was established in 2015 to handle all related business activities. Hundreds of millions of US dollars were invested in Pivotal Software (a spin-out of VMware/EMC) in order to integrate the analysis and development functions of GE Predix Cloud in Cloud Foundry, Pivotal's platform-as-a-service software. The purpose of Predix Cloud was to create a computer platform for developers of web-based industry apps. The idea was to avoid the complexity that normally surrounds the development and introduction of an industry app.

A platform strategy for B2B differs from a B2C platform strategy. A B2C platform (for example Apple App Store or Google Play) is largely used as a marketplace where apps or digital content (for example music) are downloaded. The platform itself is more of a hub than a medium for knowledge reproduction or the extraction of information from data.

For B2B activities in many industrial sectors, a platform is understood as a medium for creating services that are based on data and that otherwise add value, but without incurring the associated risks. From the technical point of view, there are many stable open source solutions in the big data technology stack (for example NoSQL, PaaS, in-memory database, Hadoop) which can be used to create ICT-based and data-centered platforms. Companies can do things like create their own (private) clouds by purchasing the right hardware or renting virtual machines like Amazon AWS or Microsoft Azure, and putting together a suitable set of software components. Nevertheless, the cost of maintaining software updates, managing users, employing qualified staff and guaranteeing security is so high that many companies, especially small data analysis companies or traditional companies from sectors like oil and gas, are forced to outsource these cloud-related functions anyway.

7.3.2.1 Risk mitigation for SMEs and companies without cloud expertise

The value add of GE Predix or any other platform-based system lies in the accessibility for small and medium-sized companies with no in-house cloud expertise. All administrative functions (for example infrastructure-as-a-service, IaaS) are handled by Predix, meaning that security, data protection and performance are all guaranteed or that responsibility is assumed by experienced companies.

7.3.2.2 Industrial hardening

Another aspect to consider is known as industrial hardening for basic PaaS systems (platform-as-a-service), in which user friendliness and security features are made available at application level in addition to the platform itself. For example, GE has developed security functions built around Cloud Foundry's user account management and authentication services (User Account and Authentication, UAA). In industrial automation, such mechanisms are common, whereas they are seldom used in B2C markets. Another example is the integration of multiple microservices. The Analytics Catalog Service offers a list of basic algorithms for analysis, and individual algorithms can be combined to form aggregated services.

7.3.2.3 Openness as a technology driver

Cloud Foundry's openness (Apache 2.0 license) makes it one of the most popular PaaS tools. There is a large community of users with extensive online documenta-

tion and many discussion forums to aid the development of industrial applications. Closed systems, in contrast, usually only provide a small amount of documentation. The option of switching from the proprietary version GE Predix to the open-source Cloud Foundry is a special incentive for small companies without cloud experience to start with versions like GE Predix and then switch to the open-source version as they develop their skills. In closed systems, this kind of independent flexibility does not normally exist.

In summary, it takes a considerable amount of expertise and, depending on the platform capabilities, a significant outlay to create ICT-based platforms. So small and medium-sized companies find it harder than large companies to set up and entrench platforms. They are forced to either join consortia or other organized communities of interest and participate in platform development that way, or provide specialist microservices or other services as providers on the platforms. However, if companies are just providers, they are often highly dependent on the owner/shaper of a platform – a power imbalance that rarely favors the provider (eBay can easily increase commissions, for example, or Apple can change the price structures for music).

7.4 German business underestimates the potential of platform ecosystems

The interviews carried out allow us to draw the following conclusion in the context of platform ecosystems: The interviewees, especially in Germany, underestimate the future relevance of platforms and overestimate their ability to shape the rules in future platform ecosystems.

The companies surveyed are familiar with the concept of the ecosystem/platform ecosystem but they do not always consider it to be relevant to their own sector. Most companies planning to be involved in platform ecosystems regard themselves as shapers, establishing the platform and defining and implementing the rules. None of the respondents talked about simple participation in platforms and corresponding strategies for the successful use of a platform as a secondary partner. Considering that German industry is dominated by medium-sized firms, these findings are critical. If companies focus on their own leadership role in platform-centered ecosystems, it becomes harder to realize the synergies and collaborations made possible through interaction as equal partners in ecosystems where complementary products and services are offered.

The following principles determining the success and durability of a platform ecosystem can be distilled from the development of various platforms in recent years:

- You will not survive as a shaper of the platform ecosystem unless you can decide the rules governing access to the platform. Access can be controlled either by customer lock-in (Apple's App Store) or by standardization (Android). In both cases, the platforms are tightly bound to a base product – software (Android) or a hardware/software combination as with Apple iOS and the iPhone. Intel's AppUp! store was an attempt to offer applications for the Windows platform without controlling access to the platform. After four years (2010 to 2014) Intel closed the store down because there was no incentive for providers and customers to use this particular channel to sell or buy applications.

Figure 38: Typical steps in a purchasing process

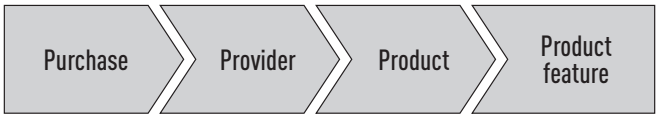


Figure 39: Reorganization of the purchasing process

- Whenever possible, providers and customers are automatically drawn to the platform with the widest reach. Small or incompatible platforms are highly unlikely to last unless they have a significant unique selling proposition that cannot be copied, for example by concentrating on isolated, highly specialized topics. It is also virtually impossible for new providers to catch up with an established platform if the offering is more or less the same. This can be seen very clearly in used car or real estate platforms.

Platform ecosystems mean that products and services are offered in a standardized way so they can be compared across the world. The first providers of data platforms are already leaving the consumer segment to offer products for industry – for example industrial data analysis as described above for Predix. This trend is expected to intensify, with companies using platforms to offer physical products/goods alongside the corresponding purely software-based products (services, apps). It is important to ensure that it is not the manufacturers but the products (or more accurately product functions) which are made directly comparable to one another. This directly affects the relationship with customers who are looking for particular product features to solve their problem. Unlike the classic purchasing process in business, with its typical steps (see *Figure 37*), platforms allow product characteristics to be compared and purchased, removing the need to buy large, complex products from which only a small number of functions are needed.

The platform is able to create solutions from individual modules. Compatible interfaces and offerings with a modular structure are an inevitable consequence as well as a necessary prerequisite. This transparency requires providers to restructure and unbundle their products for these platforms if they are to remain competitive. As a result, the old process chain shown in *Figure 38* has to be reorganized.

The platform is now a middleman or intermediary in the relationship between provider and customer. Clearly, the product itself and especially the provider are becoming less and less prominent as the architecture of the platforms makes it much easier to compare product characteristics in a standardized way. Solutions are not necessarily offered by specialist providers on a sector-specific basis any more, but on a problem-specific and application-independent basis as individual functions. Providers which used to be considered unassailable in their specific sector/niche are suddenly under pressure.

In our view, this makes it essential for German industry to develop an awareness of the mechanisms at work in platform ecosystems and to use what capability it has to establish platforms as a starting point for digital ecosystems. Alternatively, suitable strategies should be developed around participation in these platform-based ecosystems. The interviews lead the authors to conclude that at present, the impact of the change on the companies is underestimated, whereas the companies‘ ability to shape the change is massively overestimated.

7.5 The vision of a platform-centered ecosystem for the automotive industry

In this section we describe a possible future scenario for the automotive industry as a way of illustrating the opportunities presented by digital data-driven platform ecosystems for key established German sectors.

The sector makes an enormous contribution to the German economy, and automakers have been trying in recent years to place their own product – cars – at the heart of an extended mobility ecosystem with additional offerings from third parties. The online back ends of the infotainment solutions are currently implementing the platform on which the Connected offerings of BMW, Audi and Daimler will be made available.

What initiatives like this have in common is that they are a loose, functional and superficial integration of independent external providers. These providers are not dependent on a particular platform, and the reach is correspondingly narrow. The offerings are proprietary, limiting the number of potential customers. Consequently there are limited scaling opportunities for a platform of this kind and the ecosystems using it.

The following scenario is intended to illustrate the mechanisms that make platform-centered ecosystems so successful in the digital world, and to warn of the potential hazards if too much power is concentrated in the hands of the shapers of these platforms.

In December 2015, the FTC in the US and the EU Commission followed the German Federal Cartel Office[207] in approving the acquisition of map maker HERE by a consortium of BMW, Daimler and Audi. This means the automakers now own highly accurate mapping data, which is essential for navigation functions and, in the longer term, autonomous driving. HERE is also developing a platform that integrates mapping data, real-time traffic data and telemetry from all connected vehicles, plus additional information.[208] A platform like this is needed to collect and analyze large amounts of data, and to achieve a critical mass of up-to-date data for self-driving vehicles.

HERE currently supplies most vehicle manufacturers with mapping data for their integrated navigation systems (see *Figure 39*). Apart from HERE, only Google is currently large enough to provide the information necessary for autonomous driving. The other providers are not thought to be capable of supplying up-to-date mapping information of sufficient quality.

The HERE platform can be used to establish a platform-centered ecosystem based on near-real-time mapping data, and the use of trip data and other vehicle data. The participants and their roles in a data-driven platform ecosystem are as follows:

Shaper: HERE's consortium of operators

Most navigation systems installed in vehicles are already based on mapping data from HERE. HERE's dominance means that the consortium of operators can create an ecosystem where it is in charge of defining the barriers to entry and the rules of interaction in order to increase the reach of the platform.

Secondary commercial or public participants

- **Other vehicle manufacturers**
  Other vehicle manufacturers outside the consortium of owners have no choice but to use what data is available if they want to develop autonomous driving. They are therefore compelled to join one of the existing ecosystems, although there is only room for a very small number of competing platforms. And as more OEMs join, the number of vehicles connected to the platforms increases further. This in turn improves the quality of data for all participants, making the platform even more attractive.

- **Data producers**
  The most important factor determining the attractiveness and therefore the penetration of the platform is the quality of the mapping data on offer and how up to date it is. The number of potential users is very large, so it is attractive for providers of location-based data (congestion information or traffic light timing information) to make their data available free of charge or for a usage fee.

- **Data consumers**
  The platform provides up-to-date location-based traffic information of a quality never seen before. The

207) Press release from the Federal Cartel Office dated October 6, 2015: http://www.bundeskartellamt.de/SharedDocs/Meldung/DE/Pressemitteilungen/2015/06_10_2015_HERE.html
208) http://360.here.com/2016/02/15/we-must-pool-car-sensor-data-to-solve-problems-on-road/

Figure 40: Manufacturers of navigation solutions based on HERE [209]

data is extremely useful not just for mobility services but for other sectors as well. For example, reliable information about traffic levels on particular routes allows for much greater precision in everything from advertising billboards to road planning.

- **Providers of other services**
  Providers of location-based services like car parks can also offer their products or services in this ecosystem. All connected vehicles can access these services directly via the HERE platform. Here, too, what makes the platform so attractive is its penetration, allowing large numbers of potential customers to be reached with little (development) outlay.

End customers

The end customer benefits from highly accurate and up-to-date data and an enhanced service offering thanks to the attractiveness of the platform. Because the data is used in various ways by different participants, the navigation service can be offered seemingly free of charge, with monetization based on other secondary participants. Data protection agreements are in place to ensure that although the customers "pay with their data", the right to privacy is protected. The HERE platform is subject to European data protection law, giving it the edge in terms of consumer trust.

Operator-OEMs

The operator-OEMs with their vehicles have a dual role as operators and participants, putting them in the enviable position of being able to adjust and expand platform functionality to meet their own needs. In addition, they benefit from the traffic data submitted by third-party providers and other OEMs. Even so, they should not ignore the potential to extend their reach to other sectors.

Alongside the original purpose of supplying vehicles with accurate real-time mapping data, the platform can use the same infrastructure to give manufacturers secure access to the internal data of their vehicles as an additional service. This trove of data can be used in the continuous improvement process and to adapt prod-

209) HERE, navigation.com

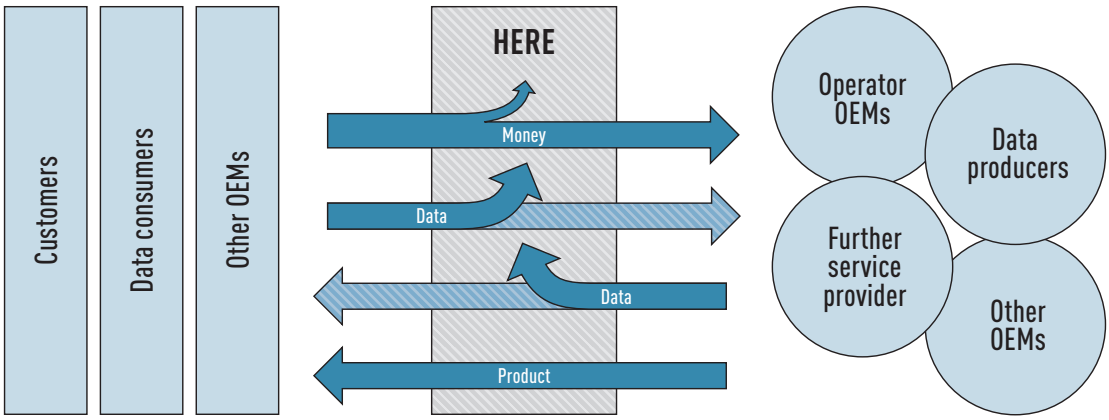


Figure 41: Participants and roles of HERE's platform ecosystem

ucts to ever-changing customer requirements (see sections 5.2 and 6). Applying this principle, Google and Tesla are already going all out to develop vehicles and, especially, their driving functions.

Compared to the existing Connected offerings, the striking feature of the HERE platform is the market power. OEMs are entirely dependent on this data, which can only be supplied by a very small number of providers. Network effects quickly make one platform much more attractive than others, squeezing out most, if not all, other platform providers. This produces market structures that are similar to the Android ecosystem. Unlike Apple or Google, which only use their platforms to serve their own interests, it remains a major challenge for the consortium to align the individual interests of the consortium members with the wider interests of the consortium.

This vision is mainly focused on the potential platform ecosystems in the automotive industry, but digitalization increasingly requires sights to be raised. After all, value networks increasingly cover multiple sectors, as shown by the platform ecosystems outlined here. And customers are increasingly thinking in terms of solutions to problems. With regard to mobility, this means that customers want to get from A to B and to use additional services as they go. It is easy to imagine a multi-sector platform emerging which takes a problem-oriented approach to the configuration of suitable and different means of transport and services. In principle, the platform could be set up and controlled by different players: traditional mobility players like Deutsche Bahn or existing OEMs; traditional platform providers like Apple or Google; or completely new platform providers as yet unknown. Whoever the platform provider is, the platform holds the strategic interface to the customer.

In general, it is clear that the software element will become increasingly important in platform ecosystems, too. The power and influence of platform companies have grown exponentially in recent years along with their economic relevance. The software normally deployed is used to optimize the interactions and transactions between providers, customers and prosumers. From the operator's perspective, additional information – for example based on behavior, participation and direct feedback (in real time) – can be extracted and used in the continuous improvement of the system as a whole.

From a political perspective, the exchange of information between actors, businesses, science and society is just as essential as the commercially important links between providers, customers or prosumers. In the context of digitalization, and bearing in mind the potential impact on these groups of actors, the various representatives must be given the opportunity to inform themselves and exchange ideas. It is particularly important to discuss strategies and consequences, to set the framework of options available and to develop constructive solutions that make the best use of the potential offered by digitalization. That is why the next chapter discusses the various ways in which these different actors can connect and cooperate.

CHAPTER 8

Digital transformation as a collaborative task

In this chapter, we will start by outlining the development of the interface between politics, the economy, science and society through to the National IT Summit. This body which has been described as the „central platform for shaping digital transformation“ [210] will also be considered in terms of its composition and the work it undertakes. This will then be followed by an insight into social and technical methods for more efficient, more effective management of the complexity arising from the large number of actors involved. The primary objective is to build a creative ecosystem for effective problem solving. The aim is to systematically optimize the networking and collaboration of the different actors from politics, the economy, science and society in the shaping of digital transformation.

8.1 Progressive involvement of actors in policy making

The process of digitalization creates new action spaces and this enables an ever-growing number of actors to interact. The complexity arising from the increasing numbers of actors involved and their heterogeneous nature, the greater dynamism and the phenomenon of information overload can very rapidly outstrip the ability of individuals and groups of actors to collaborate and make decisions. Stakeholders - both those relevant and less relevant to decision making, as well as those affected by the decisions, all want to be involved in decision processes. Also, the viral spread of information and emotion means that any actual or perceived lack of transparency is met with a loss of legitimacy and acceptance problems. The National IT Summit illustrates the challenge of complexity management in a multi-actor process. Here, unlike in preceding chapters, the term „platform“ is used to describe a body that supports policy. [211]

The ability to exert influence on the development of economic or industrial policy in Germany lies in very many hands. All German governments since Adenauer have tried to act in concert with power groups in society. Over time, this has meant that the number of advisory and coordination bodies [212] has steadily increased. Despite all the criticism leveled at these bodies [213] this form of policy making has major advantages:

- **in terms of content** – by improved and more systematic alignment of policy to the needs of stakeholders
- **in terms of procedure** – by involving stakeholders in the political process. [214]

210) http://www.bmwi.de/DE/Themen/Digitale-Welt/nationaler-it-gipfel.html
211) The Duden dictionary gives the following meanings in this context: 3. a) Basis, stance assumed in the context of reflections, intentions, actions, political objectives, etc.; 3. b) Place or group of persons that serves to exchange and disseminate ideas, views or products“, cf. http://www.duden.de/rechtschreibung/Plattform
212) In this work the term „body“ is understood to mean any association of different actors - including platforms, forums, consortiums, working groups, round tables, etc. - that supports policy making (definition based on Eva Krick, 2013).
213) In the first legislative period of the coalition government of the SPD and Alliance 90/The Greens, the seeking of consensus outside of formal bodies increasingly became a central element of politics and the focus of public criticism. Cf. Peter Ramsauer: Wider die Kommissionitis, in: Die Welt, July 4, 2000, p. 7; Heribert Prantl: Schröders Räterepublik, in: SZ, May 19, 2001, p. 4. Another criticism is the fear that these forms of decision-making risk the informalization of politics in the substructures of negotiation rounds and networks, in other words the closing or privatization of political decision spaces. Cf. Birgit Sauer: Die Allgegenwart der Andokratie, in: Politik und Zeitgeschichte, January 3, 2011, p. 34.
214) Kotzian/Quittkat (2014): Konsultationsprozess der Kommission: Steuerung von EU-Lobbying?, in: Dialer/Richter (Eds., 2014): Lobbying in der Europäischen Union: Zwischen Professionalisierung und Regulierung, Wiesbaden, p. 73.

The decision-maker interviews revealed that wrong decisions, particularly those involving the dimensions strategy and long-term planning, have more dramatic effects. The involvement of bodies has the effect of making political decisions more broadly based and as a result significantly adds value in terms of the quality of and acceptance of such decisions. Particularly in thematic areas that are deeply relevant for society as a whole, interest groups (lobbies) from very diverse backgrounds are nowadays involved in the political decision-making process.

Digital transformation means a fundamental change in society. This can only be successfully managed by involving the various actors affected. Thus, the Digital Strategy 2025 reminds us that the era of isolated solutions must come to an end. Only by working across institutions, in a network and in a concerted effort will we be able to find and implement answers to questions about our future. [215]

Bodies in the thematic area of digitalization

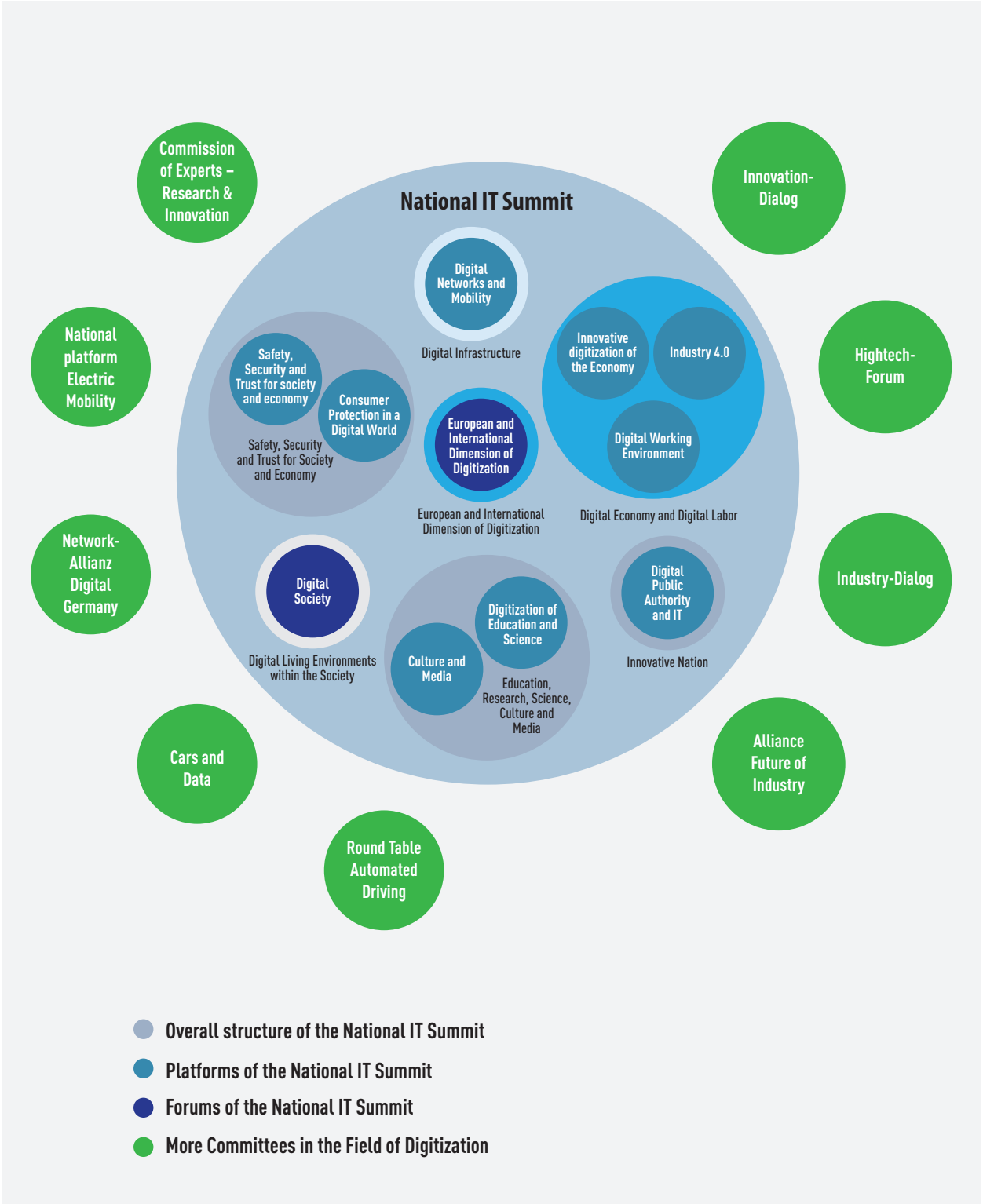
The continuing development of the politics/economy/science/society interface and the progressive and coordinating involvement of relevant actors is evident for example in the German government's High-Tech Strategy adopted in 2006. In this, the research and innovation policy is aligned with the major global challenges in society, one of which is digitalization. The **High-Tech Strategy** has evolved into an innovation strategy that encompasses virtually every Federal Government department and includes all aspects and actors involved in the innovation process. It defines six priority future tasks, one of which is „Digital Economy and Society" with action fields including Industry 4.0, smart services, smart data, cloud computing, digital networking, science, education and life environments.

The **High-Tech Strategy** is supported by the **High-Tech Forum** with the formulation of research tasks and future scenarios, ideas and recommended actions for innovation policy – three of its eight Expert Forums are devoted explicitly to aspects of digital transformation. The **National IT Summit** on the other hand, has evolved into the central platform for collaboration between politics, the economy, science and society in shaping digital transformation. The IT Summit is thus the central tool for implementing the **Digital Agenda**.

Digital transformation is also facilitated and supported by other bodies devoted to specific topics. *Figure 42* on the next page gives an overview of important bodies that are concerned with digitalization. At the center is the National IT Summit with nine platforms and two forums that focus on the seven action areas identified in the Digital Agenda.

215) Digitale Strategie 2025 (2012), p. 7: https://www.bmwi.de/BMWi/Redaktion/PDF/Publikationen/digitale-strategie-2025,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf

Figure 42: Bodies in the thematic area of digitalization [216]



216) Own illustration

8.2 National IT Summit as central dialog platform

The annual IT Summit and its in-year process are the central platform for collaboration between politics, the economy, science and society in the shaping of digital transformation.[217] The increasing pace and breadth of advances in digitalization since the first IT Summit in 2006, the emergence of new opportunities and issues together with public criticism of certain aspects have all meant that the summit process has needed to be changed over the course of its history.

While it was announced at the 2006 IT Summit that it „sent a joint political and economic signal"[218], in 2014 the Federal Government decided on a change of course in response to a proposal from the three Ministries with responsibility for the Digital Agenda (Ministry for Economic Affairs and Energy, Ministry of the Interior, Ministry of Transport and Digital Infrastructure): Going forward, the IT Summit would be developed, strengthened and opened up as a platform for collaboration between politics, the economy, science and society to enable a broad process of social and economic dialog.

Efforts are also being made to focus the IT Summit with a few platforms and forums on the key policy action areas in the Digital Agenda while at the same time expanding it to all relevant stakeholders. The idea is to make it a place where IT providers and IT users from traditional industries and the online community of individuals can meet as equals. The in-year working structure was also streamlined. Regular meetings of the chairs of the Summit bodies with the Government Steering Committee for the Digital Agenda are designed to ensure consistency of work and an effective focus on the Digital Agenda.

The structural principles for realignment of the IT Summit in terms of the seven action areas of the Digital Agenda[219] were announced at the 2014 summit:

- Digital infrastructures
- Digital economy and the digital workplace
- Innovative public administration
- Digital environments in society
- Education, research, science, culture and media
- Security, protection and trust within society and the economy
- European and international dimensions of the Digital Agenda

Within these seven action areas, three key goals of the Digital Agenda are to be achieved:[220]

1. **Better exploitation of the innovative potential of Germany** for digital value creation and digital networking, specifically in medium-size enterprises in the traditionally strong fields of industrial technology and production engineering in order to secure growth and employment.
2. **Development of ubiquitous, powerful high-speed networks** in all regions and strengthening of digital media skills for all generations in order to improve access to and participation in digital technologies.
3. **Strengthening IT security and protection of IT systems and services,** in order to maintain trust and ensure that Germany remains one of the most secure digital locations in the world.

The IT Summit process is thus the central tool for implementing the Digital Agenda. Nine platforms and two forums deal with the central issues in the particular action area from the Digital Agenda and develop specific projects which are then presented at the next summit.

The platforms with 33 focus groups/working groups[221] address the key policy questions in the particular action area and develop[222] strategies to drive implementation[223] with the help of a large number of project groups[224]. The forums, for their part, create space for political discussion of fundamental and cross-cutting issues raised in the Digital Agenda from a socio-political and European/international perspective.

The IT Summit's platforms were established in early 2015. Each is headed by co-chairs, consisting of a representative from a Federal German Ministry and - de-

217) http://www.bmwi.de/DE/Themen/Digitale-Welt/nationaler-it-gipfel.html
218) http://www.bmwi.de/BMWi/Redaktion/PDF/IT-Gipfel/ag-it-gipfel-1,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf
219) http://www.bmwi.de/DE/Themen/Digitale-Welt/digitale-agenda.html
220) Digitale Agenda (2014), p. 2f.: http://www.bmwi.de/DE/Themen/Digitale-Welt/digitale-agenda.html
221) As at April 2016.
222) Examples include the position or outcome documents with challenges and recommended actions produced by the project groups belonging to the „Digital Networks and Mobility" platform. http://www.bmvi.de/DE/DigitalesUndRaumentwicklung/DigitaleAgenda/NationalerITGipfel/FokusgruppeKonvergenzDerNetze/fokusgruppe-konvergenz-der-netze_node.html
223) http://www.bmwi.de/BMWi/Redaktion/PDF/M-O/nationaler-it-gipfel-2015,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf; additionally for the „Digital Administration and Public IT" platform: https://www.bmi.bund.de/SharedDocs/Downloads/DE/Broschueren/2015/it-gipfel-positionspapier-staat-4.0-digital-souveraen-innovativ.pdf?__blob=publicationFile
224) The three focus groups of the „Digital Networks and Mobility" platform, for example, include a total of nine different project groups; cf. Nationaler IT-Gipfel (2012), p. 30: http://www.bmwi.de/BMWi/Redaktion/PDF/M-O/nationaler-it-gipfel-2015,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf

	Platforms/forums	Area of action	Working groups (WG) Focus groups (FG)	Presiding Federal Ministry	Politics	Large enterprises	SMEs (excluding startups)	Startups	Business associations & interest groups	Trade unions	Research and academia	Society	Total
Platforms	Digital networks and mobility	Digital infrastructures	3 FG	BMVI	10	33	9	2	14	–	9	–	77
	Innovative digitalization of the economy	Digital economy and the digital workplace	4 FG	BMWi	12	43	18	8	16	2	33	5	137
	Industry 4.0		5 FG	BMWi / BMBF	11	51	12	–	9	1	22	–	106
	Digital work environment		3 FG	BMAS	5	12	–	–	6	4	7	–	34
	Digital administration and public IT	Innovative public	7 FG	BMI	17	10	1	–	–	–	4	1	33
	Digitalization in education and science	Education, research, science, culture and media	5 WG	BMBF	2	6	1	–	5	1	7	2	24
	Culture and media		–	BR	1	2	–	–	10	–	–	3	16
	Security, protection and trust within society and the economy	Security, protection and trust, society and the economy	4 FG	BMI	4	12	3	–	7	–	2	1	29
	Consumer policy in the digital world		2 FG	BMJV	2	6	1	–	7	–	5	2	23
Forums	Digital society	Digital environments in society		BMWi / BMI / BMVI	5	11	2	1	3	1	4	5	32
	European and international dimensions of digitalization	European and international dimensions of the Digital Agenda		BMWi	3	4	–	1	2	–	–	–	10
	Total		33		72	190	47	12	79	9	93	19	521
	Total (excluding double counting)		33		46	122	43	12	54	4	72	19	372

Table 3: Bodies within the National IT Summit [225]

pending on the platform's particular focus - a representative from business, science or society. The discussion events held as part of the two forums are arranged by the Ministries with functional responsibility. The participants vary depending on the particular area of focus.

The platform chairs meet twice a year - at the IT Summit and at CeBIT - to discuss topics of public relevance. Results of the IT Summit are presented at the Hanover Trade Fair and other major events. The German federal state which hosts the IT Summit can develop projects for one of the action areas, as before, and present these at the Summit. Progress on implementation of the Digital Agenda and the contribution made by the IT Summit are subject to annual review at the IT Summit. [226]

Figure xx provides an overview of stakeholder involvement in the IT Summit.

As *Table 3* shows, SMEs and startups are relatively poorly represented. Of the 372 actors in the nine platforms (excluding double counting resulting from multiple representation), startups with a total of twelve firms are represented in only three of the platforms. It is a similar picture for SMEs - again these are concentrated on three platforms. Some large enterprises are able to afford multiple representation in different platforms and working/focus groups. This can be in the form of direct representation – as can be seen from the difference between the total for large enterprises (190) and the same total with double counting stripped out (122) – or indirect representation via an association.

225) Own illustration
226) http://www.bmwi.de/BMWi/Redaktion/PDF/I/it-gipfel-2014-neuausrichtung,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf

8.3 Work of the bodies and the IT Summit from the actors' point of view

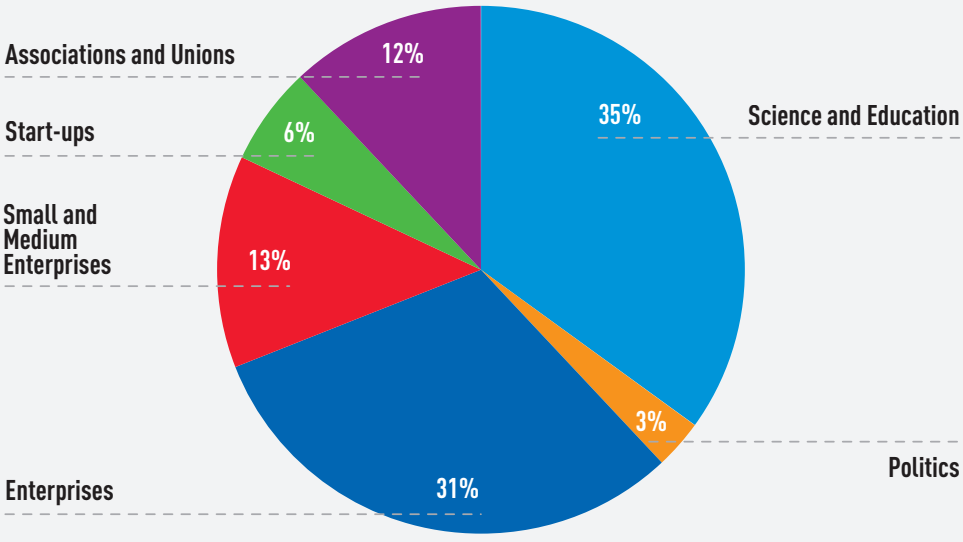
The methodology used in this present study acknowledges that addressing digitalization and, ultimately, the future of Germany as a business location depends crucially on the beliefs, views and needs of the actors involved. For this reason, a key part of the project consists of semi-structured, confidential one-on-one interviews with decision makers in business and science. Specifically, this enables solution spaces for sensitive issues to be mapped out that are not accessible to traditional survey and study formats.

For analysis of Germany's strengths, weaknesses, opportunities and risks in the field of digitalization and in order to identify potential options for action, this methodology extends and updates existing action-relevant knowledge for policy making and specifically for the BMWi (Federal Ministry for Economic Affairs and Energy). At the same time, it provides impetus for the actors involved in business and science.

In around 110 interviews and meetings, experts and decision-makers provided information on how they view the interface between politics, the economy, science and society for supporting digital transformation. The interviews were conducted preferably with representatives from business (specifically large enterprises, SMEs and startups), associations and also from research and academia (*see Figure 43*).

In addition to industry-specific aspects - the role of logistics, for example, the upheaval in the automotive and mechanical engineering sector or the importance of ICT - cross-industry topics were also discussed. These include specific challenges for SMEs as well as issues and problems at the interfaces between large enterprises, SMEs, science and politics. Interviewees were also asked about their experiences with existing platforms and suggestions were sought on how to improve these.

Figure 43: Interviews - breakdown by stakeholder



8.3.1 Key cross-body messages from the interviews

Virtually all respondents were agreed that the initiative to establish platforms in order to obtain **input** for policy is fundamentally the right thing to do. The interviewees stated that **agenda setting** by the platforms often provides good justification for engaging with a particular issue within an organization. **Networking opportunities** within the individual bodies were cited as a positive aspect.

The **lack of transparency around exploitation of the results**[227] of the work done by bodies was criticized on two counts. The stakeholders interviewed expressed the criticism that the **lack of transparency around exploitation of results** can mean that decisions increasingly circumvent legitimacy. Decisions that are important for society are discussed here in the pre-parliamentary or non-parliamentary space. The extent to which proposals from the bodies feed into political decision-making is not obvious to the public. This also has an impact on the motivation of the members of the bodies. Some of the respondents noted that **uncertainty about the exploitation of results** causes frustration for members – leading ultimately to them standing down, as they are unhappy working „in a vacuum".

Some interviewees cited lack of transparency around the evaluation of results as a reason for a **lack of focus on results** in the work of the bodies. They noted that the discussion rounds are not sufficiently performance-oriented and contributions are not sought from the participants. In terms of content, there is a lack of collaboration within specific projects, and this has a negative impact on motivation. These rarely result in action plans for the companies. The outcome documents produced by most bodies often simply reflect a **minimum consensus** and seldom convey the actual state of discussion.

Most interviewees expressed the view that the **quality of collaboration** is very much dependent on the individual chairing the body. Also, a majority of respondents criticized the **composition of the bodies** - they stated that the „sherpa system" did not work that well and what was lacking was a „forum of doers" with accountability. Representatives of associations and lobbyists without decision-making competence are not enough to move issues forward. The **lack of representation of SMEs** was mentioned in almost every interview.

Many failings could have to do with a **lack of clarity in the allocation of roles** between Federal Government and participants, a criticism expressed by the interviewees. The Federal Government often sees its role as merely that of observer rather than a partner within the bodies, which is what many participants would in fact like to see. **Openness and participation** are very good ideas in principle, but the Government is not always credited with a genuine willingness to embrace these. According to the respondents, Brussels is a step ahead in this respect. Drafts of new Directives, as well as roadmaps, are published and anyone can take part in consultations, provide technical input and impetus.

8.3.2 Key messages from interviews on the IT Summit

In the interviews on the IT Summit, virtually everyone involved commented that **SMEs and startups** are **highly under-represented in all platforms**, even though participation of medium-size and young, innovative companies is precisely what is needed if the challenges of digitalization in the economy are to be successfully overcome. Failure to involve startups means that disruptive change tends to be underestimated, as generally only incumbent actors are represented, not the disruptors. The interviewees also commented on the lack of transparency around **the selection of participants**.

As for the results coming out of the IT Summit, the interviewees noted the lack of **specific recommendations for action**. They were skeptical about the extent to which the considerable time invested in these bodies by often high-ranking participants actually pays dividends and leads to optimum strategic action both in the economy and in politics. In their view, the IT

227) It is true that results are taken up by the „Future of Industry" Alliance (http://www.bmwi.de/DE/Themen/Industrie/buendnis-zukunft-der-industrie.html), but it is not immediately obvious here either which results are taken forward and with what priority.

Summit is primarily a vehicle for political communication and image projection. Its outcomes, studies and reports are somewhat secondary. In several instances, respondents stated that the only reason they were involved was to avoid being accused of having missed something or refusing to take part.

All the actors surveyed agreed that more **online tools** needed to be deployed to support collaboration. This was justified, firstly, on grounds of credibility, in that anyone engaging with digitalization should themselves also use digital tools. The respondents also argued that digital tools save on lengthy travel times, allow shared access to working documents, facilitate the involvement of SMEs and startups, help combat the culture of „sending someone else", enable collaboration between decision-makers and ensure that work is documented. At present, the use of digital tools is only sporadic and is very much driven by the individual - which means that it varies greatly from group to group. Communication is mostly by e-mail.

Another aspect addressed in the interviews was the **complex structure** of the IT Summit. The interviewees said that its organization into platforms, focus groups and working groups with their respective project groups and expert groups was excessively complex and this complexity had ceased to be manageable. Even after restructuring of the IT Summit, most members felt there was no **obvious improvement in collaboration or integrated working** by the various platforms. There was no evidence even of interaction between focus groups within the same platform. This is needed, however, if synergy effects are to be leveraged and redundancies avoided.

8.4 Optimization potential for the IT Summit

The interviews conducted, documents examined and discussions with members from other bodies were evaluated with regard to the risks inherent in how interfaces work. This identified the following optimization potential for the National IT Summit:

- In order to achieve the first of the three key goals of Agenda 2015, i.e. „better exploitation of the innovative potential of Germany for digital value creation and digital networking, specifically in medium-size enterprises", the **involvement of SMEs and startups is imperative**.
- If the National IT Summit and its in-year process is not to suffer in terms of legitimacy, it is important to guarantee maximum **transparency**. This relates to the **selection of participants** in the various platforms, working groups, focus groups and project groups, the **decision-making processes and results** as well as **documentation**.
- There is scope for improvement in **collaboration** both within and between the bodies. The **composition of the groups**, the **specific projects, confidence around exploitation of results,** a **clear allocation of roles, professional moderation,** the use of **digital tools** and last but not least **networking** of the actors and also of the different groups - all these are vital for effective and efficient collaboration.

The key takeaway here is that, in the view of the authors, SMEs and startups must play their part in significantly higher numbers and in each of the nine platforms. This would help counter the dominance of a few actors – including those involved through associations – and the related problem of preserving the status quo, which is characterized by risk aversion. First, as we saw above, these companies are precisely the ones that drive innovation. In many cases, they also include the disruptors. Second, SMEs and startups are the very companies that can benefit from digital value creation and networking. [228]

In the next sections we will show which methods and tools can be used to realize this optimization potential.

228) https://www.kmu.admin.ch/kmu/de/home/praktisches-wissen/kmu-betreiben/innovation/grundlagen/vor-und-nachteile.html

8.5 Promotion of collaboration in complex environments

The National IT Summit, with all its associated and affiliated bodies, platforms, working groups, focus groups, project groups and forums, is a unique mosaic for bringing together the diverse forces in politics, the economy, science and society with the aim of collectively shaping digital transformation. Opening up this platform for a broad social and economic dialog process is an attempt to involve all relevant actors.

This is an extremely ambitious undertaking and the resulting complexity is huge. The spaces in which very heterogeneous actors with differing interests engage with different topics and key policy questions require proven methodological support to enable collaborative solution finding. This in turn enables the creation of an effective, efficient collaborative workspace.

For centuries, the ability to reproduce a message was seen as the fundamental problem in communication. Now, and not just in bodies that deal with digitalization, the „fundamental problem of communication" is no longer „that of reproducing a message" as Claude E. Shannon, the founder of information theory, wrote.[229] This is because the „engineering problem" has been virtually solved by the advances in digitalization and the networking this enables. However, this networking creates new action spaces in which increasing numbers of ever more diverse actors meet and this in turn increases the existing potential for conflict. Science has long recognized that inherent potential for conflict is an inevitable feature of group interaction.[230]

On the one hand, there is a risk that some actors will resort to the DAD approach (Decide-Announce-Defend[231]) and as a result accept negative consequences including an escalation of conflict, exploding costs, delays, reputational damage and poor relationships. On the other hand, straight majority decisions are not ideal as they ignore minorities.[232] Both run counter to the intention of cooperation.

8.6 Mutual Gains Approach (MGA) or Consensus Building Approach (CBA)

The Mutual Gains Approach (MGA) or Consensus Building Approach (CBA) developed in the USA as a model that is particularly suited to promoting collaboration in highly-complex environments.[233] This is a process model that evolved from extensive experience of real-world negotiation over many years,[234] provides appropriate support for collaborative[235] solution-finding in groups and can also be used for conflict avoidance and conflict resolution. The model enables better outcomes to be negotiated while building good relationships and protecting reputation. A central tenet of the model and of the theory that underlies it is that most negotiations involve parties who have more than one goal or concern in mind.

These can be aired during negotiations, placed on the table and included in the agreement negotiated. The MGA approach thus opens up more options for the parties round the negotiating table and increases their chances of reaching better agreements.

229) Shannon (1948): A Mathematical Theory of Communication, in: The Bell System Technical Journal 27, 3, p. 379–423.
230) Deutsch (1973): The Resolution of Conflict, New Haven, CT; Robbins (1974): Managing Organizational Conflict: A Non-traditional Approach, Prentice Hall, NJ; Strauss (1978): Negotiations: Varieties, Contexts, Processes and Social Order, San Francisco, CA.
231) Term used in the USA to describe an approach where you first decide without considering stakeholders and those affected by the decision, then announce the decision and later defend it against objections and resistance.
232) Susskind/Cruikshank (2006): Breaking Robert's Rules: The New Way to Run Your Meeting, Build Consensus and Get Results, New York, NY.
233) Susskind/McKearnen/Thomas-Lamar (1999): The Consensus Building Handbook: A Comprehensive Guide to Reaching Agreement, Thousand Oaks, CA; Gray (1989): Collaborating: Finding Common Ground for Multiparty Problems, San Francisco, CA; Strauss (2002): How to Make Collaboration Work: Powerful Ways to Build Consensus, Solve Problems, and Make Decisions, San Francisco, CA; Susskind/Field (1996): Dealing with an Angry Public: The Mutual Gains Approach to Resolving Public Disputes, San Francisco, CA.
234) Susskind/Cruikshank (1987): Breaking the Impasse: Consensual Approaches to Resolve Public Disputes, New York, NY; Susskind/Amundsen/Matsuura/Kaplan/Lampe (1999): Using Assisted Negotiation to Settle Land Use Disputes: A Guidebook for Public Officials, Consensus Building Institute and Lincoln Institute of Land Policy; Kirk/Orr/Keyes (2008): Environmental Conflict Resolution Practice and Performance: An Evaluation Framework, in: Conflict Resolution Quarterly 25, 3, p. 283–301; Bingham, (1986): Resolving Environmental Disputes: A Decade of Experience, Washington, DC; Lewicki/Gray/Elliott (Eds., 2002): Making Sense of Intractable Environmental Conflicts: Concepts and Cases, 1st Edition, Washington, DC; Anderson/Yaffee (1998): Balancing Public Trust and Private Interest: Public Participation in Habitat Conservation Planning, A Summary Report. A research report commissioned by the National Wildlife Federation, Ann Arbor, MI.
235) „Cooperation is used to describe tasks where all contributors perform the same role, as in rowing a boat, in contrast to collaboration, where, although multiple contributors may perform the same role, some contributors, or groups of contributors, perform different roles", cf. http://www.collaborative-intelligence.org/definitions.html

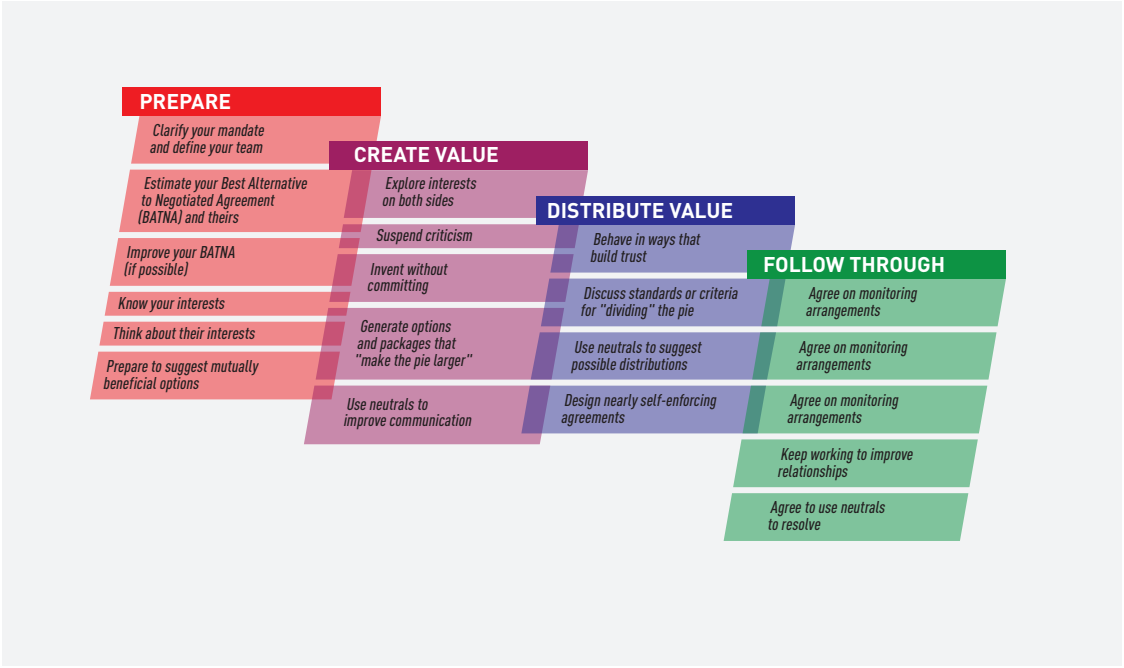


Figure 44: The four phases of the Mutual Gains Approach

(© 2003 Consensus Building Institute, www.cbuilding.org)

This approach is already used in the USA, in implementation of the Sustainable Groundwater Management Act in California, for instance. [236] Successful introduction of a legal framework for sustainable groundwater management required constructive collaboration between representatives from politics, science, business and society. The CBA or MGA methodology proved to be a suitable tool. All relevant stakeholders were involved, from individuals all the way up to large enterprises. In a cross-sector process, their submissions on the draft act were considered and reviewed. As a result, a Sustainable Groundwater Management Act was passed that had the support of all stakeholders.

The Mutual Gains Approach was developed by researchers and practitioners at the Consensus Building Institute [237] which was founded in 1993 in Cambridge in the USA by Professor Lawrence Susskind from the Massachusetts Institute of Technology (MIT). The MGA approach is part of the „Program on Negotiation" [238], a program set up in 1983 with consortium partners Harvard University, MIT and the Fletcher School of Diplomacy at Tufts University.

Characteristic features of the MGA/CBA approach:

- **It is ad hoc** – the stakeholders decide on the preferred process depending on the particular problem.
- **It is informal** – the parties interact in an non-bureaucratic way, not via attorneys.
- **It is consensual** – the approach focuses on finding solutions.
- **It is face-to-face** – representatives of all relevant stakeholders are involved and interact directly with one another

The Mutual Gains Approach involves the following four steps (*see Figure 44*):

Preparation

The focus here is on understanding interests and alternatives. This means working to understand the interests hidden behind people's positions. BATNA assessments (BATNA: „Best Alternative to a Negotiated Agreement" [239]) play an important role as these are the basis for the relative negotiating strengths. [240]

236) Implementation of California's Sustainable Groundwater Management Act: http://www.cbuilding.org/publication/case/implementation-californias-sustainable-groundwater-management-act
237) http://www.cbuilding.org/about/mission
238) http://www.pon.harvard.edu/
239) Fisher/Ury/Patton (2011): Getting to Yes: Negotiating Agreement Without Giving In, 3rd revised edition, New York, NY, p. 1-170.
240) Raiffa (1982): Analytical Models and Empirical Results, in: The Art and Science of Negotiation, Cambridge, MA, p. 44–65; Fisher/Ury/Patton (1991): What If They Are More Powerful?, in: Fisher/Ury/Patton (1991): Getting to Yes: Negotiating Agreement Without Giving In, 2nd Edition, New York, NY, p. 97–107; Zartman/Rubin (2000): Symmetry and Asymmetry in Negotiation, in: Zartman/Rubin (Eds., 2000): Power and Negotiation, Ann Arbor, MI, p. 271–294.

Value Creation

Without committing to anything, stakeholders start by exploring options and asking „What if ...“ questions. This means that in the discussions they run through different alternatives and „packages“ and in so doing test bundles of options across multiple aspects. [241] As a result, the parties discover additional interests or find new options they had not previously imagined. By negotiating aspects they value differently,[242] they generate opportunities for joint gain. The informal learning process of „joint fact-finding“ creates a shared understanding of the challenges and alternatives and this, in turn, increases the chance of finding new and better solutions. Such joint action - including communication, joint fact-finding and generation of alternatives - ultimately builds trust between the parties.

Value Distribution

At some point in a negotiation, the parties have to decide on a final agreement. The more value they have created, the easier this will be. [243] Nevertheless, experience shows that parties can default very quickly into positional bargaining when they try to tie down details of an agreement. [244] To prevent this, parties should find objective criteria for the division of value that each party can use to justify to itself and its stakeholders that it has received its „fair share“. [245] These criteria also help the parties at the negotiating table to persuade their own organizations of the fairness of the agreement reached. [246] This ensures the stability of the agreement and its implementation. [247]

Follow through

To facilitate implementation of the agreement,[248] it is sensible to make provision for contingencies and include specific clauses in the final agreement. These provisions cover, for example, regular communication, the procedure for resolving conflicts that arise or the necessary alignment of resources to meet commitments made. [249]

To sum up, the characteristic features of the Mutual Gains Approach are that the parties involved take the initiative, seek an informed consensus [250] in a participatory and transparent process, put the emphasis on outcomes, maintain credibility and increase legitimacy. The aim is to achieve agreements that

1. satisfy the various parties,
2. are reached efficiently and
3. enable long-term good relationships to be built.

The MGA/CBA approach focuses the negotiating parties on shared solution-finding by giving equal status to each other‘s views and experiences and by initiating joint fact-finding. Seen in these terms, it enables a learning process which creates value, achieves sustainable results and builds better long-term relationships. Extreme credibility is the great success factor of the MGA/CBA approach. The process opens communication channels, prevents polarization and mutual discrediting, builds trust through joint action and joint activities, achieves better solutions and by actively involving actors it ensures better implementation of the agreements reached.

At this point, it is important to stress that the legitimacy of the process depends on its transparency - specifically on the perception of those who are likely to be most affected by the outcomes.

241) „3.4 Seek to maximize joint gains through the brainstorming of packages“, in: Susskind/Cruikshank (2006): Breaking Robert's Rules: The New Way to Run Meetings, Build Consensus, and Get Results, New York, NY, p. 178.
242) Bazerman/Neal (1992): The Mythical Fixed-Pie, in: Bazerman/Neale (1992): Negotiating Rationally, New York, NY, p. 16–22; Susskind/Cruikshank (1987): From Win Lose to All-Gain Solutions, in: Susskind/Cruikshank (1987): Breaking the Impasse: Consensual Approaches to Resolve Public Disputes, New York, NY, p. 33–34; Fisher/Ury/Patton (1991): Invent Options for Mutual Gain, in: Fisher/Ury/Patton (1991): Getting to Yes: Negotiating Agreement Without Giving In, 2nd Edition, New York, NY, p. 56–80; Lewicki/Litterer (1985): Strategies of Integrative Bargaining, in: Lewicki/Litterer (1985): Negotiation, Homewood, IL, p. 114–123.
243) Fisher/Ury/Patton (1991): Separate Inventing from Deciding, in: Fisher/Ury/Patton (1991): Getting to Yes: Negotiating Agreement Without Giving In, 2nd Edition, New York, NY, p. 60.
244) Mnookin/Pepper/Tulumello (2000): The Tension Between Creating and Distributing Value, in: Mnookin/Pepper/Tulumello (2000): Beyond Winning: Negotiating to Create Value in Deals and Disputes, Cambridge, MA, p. 11–43.
245) Fisher/Ury/Patton (1991): Insist on Using Objective Criteria, in: Fisher/Ury/Patton (1991): Getting to Yes: Negotiating Agreement Without Giving In, 2nd Edition, New York, NY, p. 81-94; Lewicki/Litterer (1985): Generating Viable Solutions: Moving from Positions to Needs, in: Lewicki/Litterer (1985): Negotiation, Homewood, IL, p. 123-125.
246) Mnookin/Pepper/Tulumello (2000): The Tension Between Empathy and Assertiveness, in: Mnookin/Pepper/Tulumello (2000): Beyond Winning: Negotiating to Create Value in Deals and Disputes, Cambridge, MA, p. 44-68.
247) Susskind/Cruikshank (1987): Fairness, in: Susskind/Cruikshank (1987): Breaking the Impasse: Consensual Approaches to Resolve Public Disputes, New York, NY, p. 21–25; Caldini (2001): Commitment and Consistency: Hobgoblins of the Mind, in: Caldini (2001): Influence: Science and Practice, 4th Edition, Needham Heights, MA, p. 52–97.
248) Susskind/Cruikshank (1987): Stability, in: Susskind/Cruikshank (1987): Breaking the Impasse: Consensual Approaches to Resolve Public Disputes, New York, NY, p. 31–33; Susskind/Cruikshank (2006): Crafting „Nearly Self-enforcing“ Agreements, in: Susskind/Cruikshank (2006): Breaking Robert's Rules: The New Way to Run Meetings, Build Consensus, and Get Results, New York, NY, p. 133-153.
249) Lax/Sebenius (2006): Making Lasting Deals, in: Lax/Sebenius (2006): 3D Negotiation: Powerful Tools to Change the Game in Your Most Important Deals, Boston, MA, p. 149–161; Susskind/Cruikshank (1987): Creating a Context for Renegotiation, in: Susskind/Cruikshank (1987): Breaking the Impasse: Consensual Approaches to Resolve Public Disputes, New York, NY, p. 132-133.
250) Not unanimity, but overwhelming agreement that takes account of most interests and with which all stakeholders can live.

8.7 The importance of neutral process facilitators

Successful negotiations are not easy to manage. The task is all the more difficult if more than two parties are involved. For this reason it is important to have the impartial support of professional process facilitators in the core phases of the MGA/CBA process. In their book „Breaking Robert's Rules", Susskind and Cruikshank described this process in detail (see Appendix „The MGA/CBA process in detail"). [251]

Neutral process facilitators are particularly important as their involvement can complement stakeholder participation, improve communication, suggest potential value distribution and resolve differences of opinion. To prepare for the process, they carry out thorough stakeholder mapping, identify key stakeholders, design and manage the process and then guide the participants through it. They also set the agenda, discover the interests of the participants and establish the current information status. In addition, they clarify complex situations, stimulate discussion, promote communication and collaboration/coordination of subgroups, support development of preliminary solutions and finally, document the results. [252]

8.8 Collaboration software to support teamworking in larger groups

As tasks become increasingly complex, they can no longer be handled by individuals alone. Instead, they require collaboration by groups of people. This explains the growing importance of teams. The move to team-based organizational forms and the associated need for communication and coordination means that more and more people need to organize their work in meetings and discussions. [253]

The result has been a veritable explosion of meetings. At the same time, these are generally felt - and not just by managers – to be inefficient and ineffective. This negative assessment and frustration is widespread, as was expressed in the interviews with decision makers. The growing need for communication and coordination in project-based collaboration cannot be met by the proliferation of conventional „analog" meetings and discussions. Unproductive meetings cause significant economic harm if we count HR costs, travel costs, not to mention opportunity costs. [254]

Involving SMEs and startups via the usual participation formats (meetings in fixed locations) is also extremely problematic as it entails high cost. In order to ensure the legitimacy of the National IT Summit and its in-year process in the various platforms and working groups, total transparency of collaboration in the bodies must be ensured, however, and all relevant actors must actually be involved. This also includes SMEs and startups as being particularly innovative actors.

Digital tools can enable the involvement of all stakeholders irrespective of location, support collaboration within and between groups, build networks of participants and groups and increase transparency. Comments made in the interviews also indicated the need for a software-assisted process to support their successful involvement. Given that the efficiency of traditional meetings drops off rapidly once the number of participants exceeds six or so,[255] a software-assisted meeting is the only way of delivering productive collaboration in larger groups.

Web conferences, webinars and webcasts have become mainstream digital tools for supporting group processes. Electronic Meeting Systems (EMS) [256] – a form of **collaboration software** for groups – go far beyond these formats by offering special features for creative problem-solving and decision-making. EMS systems have been described as „a combination of several tools

251) Susskind/Cruikshank (2006): Breaking Robert's Rules: The New Way to Run Your Meeting, Build Consensus, and Get Results, New York, NY, p. 169–215; see also Appendix „The MGA/CBA process in detail".
252) Susskind/Cruikshank (1987): Breaking the Impasse: Consensual Approaches to Resolve Public Disputes, New York, NY, p. 140-150.
253) See Schäfer (1997): EMS – Electronic Meeting System. Computerunterstützung für das Meeting Management im Architekturbereich, Hanover 1997, page 1.
254) Kaiser (1997): Vergleich von Electronic Meeting Support Software, Institut für Wirtschaftsinformatik, Universität St. Gallen 1997, p. 1.
255) Nunamaker/Briggs/Mittleman (1997): Electronic Meeting Systems: Ten Years of Lessons Learned, Center for Management of Information, University of Arizona, Tucson, AZ, p. 9.
256) Dennis/George/Jessup/Nunamaker/Vogel (1988): Information Technology to Support Electronic Meetings, in: Management Information Systems Quarterly 12, 4, p. 591–619.

allowing users to communicate, deliberate and manage information in a concerted effort“ [257]. Special tools support meeting activities including the collection of information, the generation, organization, evaluation, exploration and presentation of ideas. [258]

EMS systems represent „many-to-many“ solutions that promote intense interaction between users. Involvement of very high numbers of participants is technically feasible. Advanced software solutions and high computing power are the technological triggers for disruptive change in value chains (see Chapter 4) – and will be in collaboration too.

The high penetration of IT (see Chapter 4) and the widespread use of smartphones and tablets mean that users have already developed a strong affinity with IT. This is why they want IT solutions to be applied in their professional life too. When we consider how much of our working life is spent in meetings and how unproductive this time is generally felt to be, we have some indication of the need for effective meetings. Experience shows that dramatic reductions in work costs (between 50 and 70 percent) and project duration (as much as 90 percent) can be achieved by using EMS systems. [259]

With EMS, exchanges between participants can be synchronous or asynchronous, contributions can be anonymous or not, interaction verbal or written. Giving participants the option of making anonymous parallel contributions is a way of overcoming typical barriers to group working. The ability to maintain anonymity means that feeling compelled to project an image, group pressure and similar conflict factors become less of an issue. [260] As a result, interactivity and participation are increased.

The option of asynchronous subtasks and meetings increases the availability of participants. The ability to attend meetings irrespective of location means that opportunity costs are dramatically reduced, as are travel costs and time spent traveling. Lowering barriers to attendance increases participation. In this respect, EMS acts as an „enabling technology“ as it enables meetings with participants that would not otherwise have taken place. [261]

Standard functions of EMS: [262]

- **Brainstorming:** Anonymization and parallelization means that more ideas are generated in a shorter space of time than with typical brainstorming and are available to all participants in real time. The larger the group, the more beneficial is the use of electronic brainstorming. [263]
- **Discussion:** As is the case with structured chats, multiple topics can be discussed simultaneously, anonymously, semi-anonymously or under the participant‘s own name. Anonymization and parallelization is a way of overcoming barriers, such as pressure to conform from superiors or groups[264]. The result is that more ideas are exchanged than in a verbal discussion.
- **Voting:** Different forms of voting can be used, with scales, multiple choice, preferences, rank order, etc. and based on different criteria too. Participants cast their vote anonymously or semi-anonymously based on group membership. The results of the vote are available in real time and allow fast and improved analyses and evaluations.
- **Agenda:** This allows activities to be organized chronologically and by topic. Agenda templates reduce time spent on preparation and encourage repeatable meeting processes.
- **Minutes:** Contents of meetings are recorded in a database. Documentation is produced automatically and impartially.

In addition, many other functionalities are offered. Some software even allows mind maps to be created and shared by the group. [265]

257) Nunamaker/Briggs/Mittleman/Vogel/Balthazard (1997): Lessons from a Dozen Years of Group Support Systems Research: A Discussion of Lab and Field Findings, in: Journal of Management Information Systems, 13, 3, p. 163–207.
258) Nunamaker/Briggs/Mittleman (1997): Electronic Meeting Systems: Ten Years of Lessons Learned, Center for Management of Information, University of Arizona, Tucson, AZ, p. 10.
259) Nunamaker/Briggs/Mittleman (1997): Electronic Meeting Systems: Ten Years of Lessons Learned, Center for Management of Information, University of Arizona, Tucson, AZ; p. 12f. Petrovic (1993): Workgroup Computing – Computergestützte Teamarbeit: Informationstechnologische Unterstützung für teambasierte Organisationsformen, Heidelberg, p. 199 and p. 244.
260) Peterhans (1996): Informationsmanagement: theoretische Grundlagen und Führungskonzept, vdf Hochschulverlag AG der ETH Zürich, p. 148.
261) Schäfer (1997): EMS – Electronic Meeting System. Computerunterstützung für das Meeting Management im Architekturbereich, Hanover, p. 11.
262) https://de.wikipedia.org/wiki/Elektronisches_Meetingsystem
263) Dennis/Valacich (1993): Computer Brainstorms: More Heads Are Better than One, in: Journal of Applied Psychology 78, 4, p. 531–537.
264) Schäfer (1997): EMS – Electronic Meeting System. Computerunterstützung für das Meeting Management im Architekturbereich, Hanover, p. 6.
265) http://www.spreed.com

8.8.1 EMS and the Mutual Gains Approach/ Consensus Building Approach

EMS systems reinforce the principles of the MGA/ CBA approach: focusing on problems not personalities, on interests rather than positions, generating options for mutual benefit and applying objective criteria.[266] EMS systems contain all the tools needed to support the MGA/CBA process (brainstorming, idea organizer; voting; comments feature; stakeholder identification, analyses matrix).[267]

EMS technology provides an excellent forum for building trust by enabling complete collaboration in the generation, organization and prioritization of ideas and in the development of an action plan. EMS facilitates the MGA/CBA approach for the parties involved by minimizing the factors that inhibit interest-based behavior in group dynamics. At the same time, factors that typically promote collaborative behavior are maximized.[268] EMS systems promote creativity as everyone involved generates ideas at the same time, enabling them to build on the ideas of others. EMS systems improve participation, lead to faster decisions and increased satisfaction. Groups that use EMS find many more potential solutions to a problem and feel that their involvement in the decision process is both active and fair.

With EMS systems too, however, neutral process facilitators are essential[269] – especially where larger groups are concerned. This is because certain aspects of how groups work that are critical to success - preparation for a meeting, for instance, or additional verbal communication to avoid dysfunctional conflicts - cannot be addressed by digital technology in itself.

Impressive advances in software have really pushed the boundaries of interactive collaboration. Supporting groups of 12 to 15 participants was the norm just a few years ago, while now several thousand actors can be involved interactively, as demonstrated by nextmoderator[270]. According to the developers of the nextmoderator tool, there are no technical limits to group size.

8.8.2 Web 2.0 is changing how people behave

When considering collaboration within and between bodies, the many possibilities of Web 2.0 and their importance for very wide involvement of actors and stakeholders should not be overlooked. These include the generation of ideas, communication with the public and opinion-forming processes. Unlike **Web 1.0**, where a few sources generate content for the web or provide information and large numbers of consumers passively use the provided content, **Web 2.0** will be defined by interactive modes of internet use.

„As well as describing specific technologies or innovations like cloud computing, the term **Web 2.0** refers primarily to a change in the way the internet is used and perceived. It is users themselves - supported by interactive applications – who create, edit and distribute content to a critical extent, in terms both of quantity and quality. The term **prosumer** has now entered the language to describe the new role of the user. Content is no longer created exclusively and centrally by large media organizations and distributed over the internet, instead it is also created by large numbers of users who additionally form networks using social media software.“[271]

The technical ability to network and communicate with anyone and everyone at all times has a sustained impact on the behavior of very large numbers of people worldwide. Wirtz et al. summarize the results of this changed behavior[272] in the following four points:

- **Social Networking:** A growing number of people who communicate over an internet-based platform on a very wide range of subjects, connect with friends of friends or provide access to information. The result is the viral spread of information.
- **Interaction oriented:** The social networking platforms themselves, discussion forums, e-mail, YouTube and specialist platforms enable fast, easy exchange of information.
- **User added value:** Users themselves assume an active role and use the technology to generate their own content and, with minimal effort, can potentially reach anyone connected to the internet.

266) Fisher/Ury/Patton (1991): Getting to Yes: Negotiating Agreement Without Giving In, 2. Aufl., New York, NY.
267) Leventhal (1995): Using Groupware to Enhance Team Decision Making, in: Information Strategy 12, p. 6–13.
268) Galaczy (1999): Electronic Meeting Systems: Win-Win Group Decision Making?, Industrial Relations Centre, Queen's University, Kingston, ON, p. 7–11.
269) Anson/Bostrom/Wynne (1995): An Experiment Assessing Group Support System and Facilitator Effects on Meeting Outcomes, in: Management Science 41, 2, p. 189–209; Niederman/Beise/Beranek (1996): Issues and Concerns about Computer-Supported Meetings: The Facilitator's Perspective, in: MIS Quarterly 20, 1, p. 1–22.
270) http://www.nextpractice.de/nextmoderator.html
271) https://de.wikipedia.org/wiki/Web_2.0
272) Wirtz/Schilke/Ullrich (2010): Strategic Development of Business Models, in Long Range Planning 43, 2–3, p. 272–290. DOI 10.1016/j.lrp.2010.01.005.

- **Customization and personalization:** Users are able to improve web sites, services and products, adapting them to meet their own needs.

We have known for years how important it is for companies that stakeholders other than their own employees are involved in innovation processes.[273] Chesbrough[274] took up and expanded this idea which he termed **Open Innovation**. He takes the view that the internet has simplified the global flow of information to the extent that the best/most appropriate experts could collaborate easily at any time to develop new solutions - irrespective of where they are employed or which organization they work for. No one organization alone can replicate this diversity.

Co-Ideation is one of the possible forms of implementation that are based on the open innovation principle. The focus is on the collective development of ideas, where „collective" in this case refers not only to collaboration with the direct stakeholders, but more particularly to the **conscious involvement of the outside world**. This outside world can encompass all actors directly or indirectly related to the body. To establish contact with these stakeholders, the body uses a web platform that can be accessed via the internet. This platform enables ideas to be submitted, discussed and voted on.[275]

Collaborative Intelligence describes the next generation of social networks which are evolving into problem solving systems. Diverse, generally non-anonymous input is entered into an interactive system and tagged. Similarly, the knowledge, expertise and priorities of participants are preserved in a database and diverse methods of clustering, searching and accessing their input are offered.[276]

To sum up, we can say that open innovation and co-ideation provide a massive boost especially in the creative phase of the MGA/CBA approach thanks to **limitless generation of ideas**. Collaborative intelligence is supported by very powerful collaboration software that is capable of involving virtually **unlimited numbers of actors** in interactive collaboration. The changed behavior of prosumers, particularly in terms of opinion forming processes via social networking, needs to be taken on board by all actors and bodies.

Summary

In the preceding sections we demonstrated that it is possible to realize all the potential identified for optimizing the way the National IT Summit operates.

- **Involvement of SMEs and startups**
  The thorough stakeholder mapping in the MGA/CBA approach ensures that relevant stakeholders are included in every working group, focus group and project group. Effective use of collaboration software enables large numbers of SMEs and startups to be involved (and they are the drivers of digital transformation) and allows all stakeholders to collaborate either synchronously or asynchronously and independent of location.

- **Legitimacy through transparency**
  The use of professional process facilitators, collaboration software and social networks ensures maximum transparency around selection of participants, decision-making processes, results and documentation of these in the various platforms, working groups, focus groups and project groups.

- **Effectiveness and efficiency of collaboration within and between bodies**
  Optimum composition of the various groups, clear allocation of roles, precisely-defined problems and tangible results can be achieved by adopting the MGA/CBA approach supported by professional process facilitators and collaboration software.

The National IT Summit can set an example as a driver of digitalization and use collaboration software to drive forward **digital networking** of members of the following groups:

- between the members of each group (project/focus/working group, platform, forum, relevant departments in Ministries),
- between project group leaders of a focus/working group,
- between focus/working group leaders in a platform,
- between platform and forum leaders,
- between the various Ministry departments involved,
- between the IT Summits and other bodies concerned with digitalization.

This would achieve the mutation from an analog to a digital interface. In terms both of methodology (MGA/CBA) and technology (collaboration software, Web 2.0), the conditions are right for taking a quantum leap forward in collaboration within bodies and between bodies. The National IT Summit thus has the opportunity to transform itself from a „mosaic" into a dynamic, learning nexus or creative ecosystem – in other words, into a networked, effective, efficient interface between politics, the economy, science and society with a focus on shaping digital transformation.

273) Hippel (2005): Democratizing Innovation, Cambridge, MA, S. 22: http://books.google.de/books?id=BvCvxqxYAuAC
274) Chesbrough (2003): A Better Way to Innovate, in: Harvard Business Review 7, p. 12–14.
275) Russo-Spena/Mele (2012): „Five Co-s" in Innovating: A Practice-based View, in: Journal of Service Management 23, 4, p. 527–553. DOI: 10.1108/09564231211260404.p. 535 ff.
276) http://collaborative-intelligence.org/definitions.html

8.9 | ICT-induced transformation in politics

Taking the IT Summit as an example, we have demonstrated the opportunity that exists for it to transform itself from a „mosaic" into a dynamic, learning nexus or creative ecosystem and thus achieve the transition to a networked, effective, efficient interface between politics, the economy, science and society with a focus on shaping digital transformation.

In terms both of methodology (MGA/CBA) and technology (collaboration software, Web 2.0) – given its complexity and high affinity for digitalization – the conditions are right for a **fundamental change in collaboration** within and between the bodies that make up the IT Summit. The potential identified from the example of the IT Summit can essentially be read across to all organizations and bodies, including those of the state.

Digitalization is a disruptive force that also manifests itself in corporate structures in the form of flatter hierarchies with cross-function and cross-regional teams. Silos and the silo mentality are disappearing, leadership is taking on a new dimension with the end of the information monopoly that once justified and legitimized the claim to leadership. The technical features of Web 2.0 – a blurring of boundaries, speed and interactivity [277] – have an impact on political life. New forms of citizen participation are emerging, including forums and consensus conferences, there are new opportunities for people to become informed, to get involved and contribute to political debate and decision-making.

Web 2.0 has the potential to „produce a fully informed, networked public, with individuals engaged in discourse with one another", to enable „participation of citizens not only in the consensus-building process but also in the political decision-making process" and to increase the „responsiveness of politicians", in other words their willingness to address the needs of citizens. The „arsenal of democratic participation and legitimization"[278] is already established and will continue to develop. Web 2.0 appears „to constitute a reorganization of social relationships and political consensus-building that goes beyond media and instrumental functions and redefines the meaning of autonomy and association as well as the relationship between deliberation and decision, between social discourse and political consensus-building" [279]. „Politics is breaking open and erupting beyond formal responsibilities". [280]

While this is happening, the crisis in Western democracy threatens to intensify. „The symptoms of the fatigue affecting representative democracy are unmistakable: declining voter turnout, falling membership, the alarming loss of public trust in government, parliament and politics" [281]. These could call into question the legitimacy of the political system. The public is showing a growing sensitivity to legitimacy issues [282], caused by the lack of transparency of political decisions and poor accountability. The result is depoliticization and disillusionment with politics.

The political scientist Colin Crouch coined the term „post-democracy" to popularize the idea of the crisis of Western democracy. He describes how political actors and institutions are increasingly under the influence of vested interests from business, associations and privileged elites and act in their interests rather than for the common good. While citizens have lapsed into a silent, apathetic, passive state, the real politics happen behind closed doors. Citizens are „downgraded to mere consumers of an offer that is politically virtually indistinguishable" [283]. The community becomes hostage to the interests of business associations, corporations and privileged elites. [284]

277) Kneuer (2013): Zur Sache – Mehr Partizipation durch das Internet?, Landeszentrale für politische Bildung Rheinland-Pfalz, Mainz, p. 10.
278) Nolte (2011): Von der repräsentativen zur multiplen Demokratie, in: APuZ 1–2/2011, Bundeszentrale für politische Bildung, Bonn, p. 7.
279) Nolte (2011): Von der repräsentativen zur multiplen Demokratie, in: APuZ 1–2/2011, Bundeszentrale für politische Bildung, Bonn, p. 10.
280) Beck (1993): Die Erfindung des Politischen, Frankfurt am Main, p. 156.
281) Kneuer (2013): Zur Sache – Mehr Partizipation durch das Internet?, Landeszentrale für politische Bildung Rheinland-Pfalz, Mainz, p. 6.
282) Sarcinelli (2012): Auf dem Weg zu einer Kommunikationskultur? Alte und neue Formen und Verfahren der Bürgerbeteiligung im Kontext politischer und staatlicher Willensbildung, Mainz, unpublished manuscript, p. 5.
283) Sauer (2011): Die Allgegenwart der „Androkratie": feministische Anmerkungen zur „Postdemokratie", in: APuZ 1–2/2011, Bundeszentrale für politische Bildung, Bonn, p. 32.
284) Crouch (2004): Post-Democracy, Cambridge; Crouch (2011): The Strange Non-death of Neo-liberalism, Hoboken, NJ, published in German as: Das befremdliche Überleben des Neoliberalismus. Postdemokratie II, Berlin; Crouch (2015): Die bezifferte Welt: Wie die Logik der Finanzmärkte das Wissen bedroht. Postdemokratie III, Berlin.

8.9.1 Mutation will extend to political systems too

According to Shoshana Zuboff we are in a phase of capitalism in which a **mutation** is becoming apparent. This is much more than an innovation or an industrial shift. Mutations create new frameworks – they are not simply new technologies, rather new technologies are used to create something quite new. This happens when fundamental changes in human needs call for new approaches – new objectives (new meaning, new meaningfulness), new methods, new results.[285] Mutations do not arise within industries; they arise as reconfigurations of assets defined by the unmet needs of individual end users. Mutations take root in individual space („I-space") and they quickly blur the boundaries between industries, sectors, and enterprises as well as between producers and consumers.

According to Schumpeter, capitalism must be understood as an evolutionary process.[286] Capitalism is not always the same thing. Only certain changes are of evolutionary significance. These rare events are what he calls „mutations". They are not random, temporary or mere reactions; they are enduring, sustainable, qualitative shifts in the practice of the capitalist enterprise. Mutations include new ways of institutionalizing social relationships as they align with new customer needs.[287] Social inventiveness and institutionalization are critical.

The era of mass consumption is coming to an end and is being replaced by a new era where the focus is on the individual. Better education, higher living standards, greater social complexity and longer life expectancy have all fueled the desire for personal self determination over the past century. Individuals want to have control over the things that matter to them. To have their voice heard, for instance. Or to be able to organize their social relationships as they wish.

Enterprises that leverage technology and real world social connections so that they can offer new individualized products and services at radically reduced cost will prosper. They will discover new sources of value that remain hidden to companies that cling to conventional business models.

Successful mutations – those that create value by offering individualized products at a radically reduced cost – are an expression of the **convergence of technological capabilities and values associated with self determination**.

The „new genetic code" encompasses five key functions:[288]

- **„Inversion":** The new logic starts with the user, not with existing organizations. This inverted thinking makes it possible to identify new assets that represent real value for the individual user. (In the case of the citizen: knowledge, analyses, diagnoses, plans, budgets, costs, output, priorities, participation in decisions, follow-up, monitoring, etc.)

- **„Rescue":** Rescuing assets means digitizing them – whenever possible – for easy, affordable distribution to users in I-space.

- **„Bypass":** By leveraging digital technologies and new social arrangements, mutations bypass existing structures. They connect individual users directly with the goods they seek. Mutations thus bypass unnecessary costs, outdated assumptions and value-destroying practices of legacy systems.

- **„Reconfiguration":** Once users have the goods they want, they must be able to reconfigure these according to their own values, interests and preferences.

- **„Support":** Successful mutations offer users the digital tools, platforms, and social relationships that support them in living their lives as they choose. New sources of value can be discovered and realized in I-space if the experience strengthens the sense of personal control, delivers opportunities for voicing ideas, and enables freely chosen social connections.

It can be assumed that these mutations will not be restricted solely to the economic dimension: they will also affect the political dimension.

The desire for self-determination is deeply felt and widely held by all - not just as consumers, but as citizens too. Digitalization changes the expectations not only of customers, as we saw in Chapter 4, but of citizens too. The quote from that chapter „Now we have complete information freedom and market transparency and the days of business as usual may well be at an end" refers to business life. But it also applies to political life. „The transparency enabled by the internet also means that citizens have higher expectations when it comes to provision of information and participation in decision-making."[289] Everyday use and high penetration of IT are transforming political life too (cf. section 4.2.3.). Furthermore, current conditions mean that mutation of

285) Zuboff (2010): Creating Value in the Age of Distributed Capitalism, in: McKinsey Quarterly, September 2010. Distributed capitalism - and the end of business models based on economies of scale, asset intensification, concentration and central control - was described for the first time in Zuboff/Maxmin (2002): The Support Economy: Why Corporations Are Failing Individuals and the Next Episode of Capitalism, New York, NY.
286) Schumpeter (1947): The Creative Response in Economic History, in: The Journal of Economic History 7, 2, p. 149-159.
287) Zuboff (2015): Die Vorteile der Nachzügler. Sharing Economy und Europa, in: FAZ, March 23, 2015.
288) Zuboff (2010): Creating Value in the Age of Distributed Capitalism, in: McKinsey Quarterly, September 2010, p. 5–6.
289) acatech/Münchner Kreis (Eds., 2015): acatech Begleitprozess zur Strategie Bayern Digital. Ergebnispapier mit Handlungsempfehlungen, Munich, p. 43.

the political system – similar to the mutation taking place at corporate level[290] – is very likely:

1. The „products and services" of today's political system benefit the few - namely, the political class. Citizens would like to participate in political life and be involved in decisions. They are not content simply to vote in elections once every few years.
2. Trust between the political class and citizens will continue to be eroded.
3. The „business model" of politics is concentrated and burdened by high fixed costs.
4. Existing organizational structures, systems and activities can be replaced by networks that are flexible, receptive and cost-effective.
5. Beyond institutional boundaries there are hidden, unused resources that could replace fixed costs and, specifically, could add new capabilities.
6. There is a lack of tangible and intangible resources to meet the needs and aspirations of citizens.
7. Citizens have needs and aspirations that the political class is unaware of and cannot envisage. Unless the political class were to make a strategic commitment to explore the I-space.

The modern state which emerged after the American and French revolutions at the end of the 18th century is showing real signs of fatigue. Most states are deemed to be „failed states". The common good - the real purpose of the state - is very seldom realized. Digitalization presents the organized majorities with the opportunity to disempower the organized minorities. As a result, the whole question of political power will be reframed. Since the stone age, power has relied on a minority organizing itself and demanding the allegiance of unorganized majorities.

The vacuum created by frustration with the current political system is motivating citizens to take the initiative themselves. New platforms are emerging whose aim is to collect, interpret and distribute information - a role previously the preserve of the political class and one controlled by it. Citizen networks are emerging. Citizens want to and will play their part in actively shaping the common good.

But, what if these new platforms fall into the hands of private enterprise and associations? What if they assume ultimate authority for interpretation and indulge in subtle manipulation? This would intensify the „post-democracy" crisis – entrenching the hostage-taking of the community by business associations – rob politics of its raison d'être and increase the frustration felt by the population. With untold consequences.

Clinging too tightly to the old structures of representative democracy and continuing with „business as usual" will increase dissatisfaction with the present political system. Mistrust will spread, the divide between the „ruling class" and society as a whole will widen. The political class with its overstretched, expensive apparatus and its presumption that it alone can correctly divine the deep will of the sovereign, will become increasingly discredited. Digitalization and the political needs of the citizens will illuminate more and more dark corners of the present system and bring to light well-organized lobby interests and primitive power games. More and more „crowd citizens" will emerge and become organized. Activists, „crowd demagogues" and „crowd populists" will probably also use the net as a hunting ground.

Digitalization will increase transparency but subtle manipulation by well-organized vested interests and a threat to the fundamental rights enshrined in the constitution cannot be ruled out. Another possibility is that the internet will reinforce certain usage profiles and a superior political information elite will emerge.[291] This would result in a very small minority taking decisions for correspondingly large majorities.[292] „More intensive participation of the well-educated middle classes while at the same time those who have lost out in the modernization process are retreating from the channels of political consensus-building threatens to accelerate processes of social division".[293]

How is politics dealing with the disruptive impact of digitalization, with the emerging mutation?

It can try to help shape this mutation. Or it will find itself shaped by it. Rigid adherence to political ideas, institutions and procedures rooted in the 19th century will continue to weaken the acceptance and legitimacy of politics and its representatives in the eyes of the people. Politics would continue to focus on its own power political needs and power political timeframe. It would not however be in a position to pursue architectonic policy which requires longer implementation times and an executive that is not split into silos by party political tactics and weakened by vested interests. If politics loses its architectonic dimension, however, it loses its very core. It then becomes purely tactical and is driven solely by what is expedient for retaining power from one election to the other. Instead of serving the common good, politics is self serving. And citizens are reduced to a malleable mass of voters.

290) Zuboff (2010): Creating Value in the Age of Distributed Capitalism, in: McKinsey Quarterly, September 2010, p. 11-12.
291) Schenk/ Wolf (2006): Die digitale Spaltung der Gesellschaft: Zur politikorientierten Nutzung des Internets und der traditionellen Medien in den sozialen Milieus, in: Imhof/ Blum/Bonfadelli/ Jarren (Eds.): Demokratie in der Mediengesellschaft, Wiesbaden, p. 258.
292) Fuchs (2004): Modelle der Demokratie: Partizipatorische, Liberale und Elektronische Demokratie, in: Kaiser (Ed.): Demokratietheorie und Demokratieentwicklung. Festschrift für Peter Graf Kielmansegg, Wiesbaden, p. 42.
293) Jörke (2011): Bürgerbeteiligung in der Postdemokratie, in: APuZ 1–2/2011, Bundeszentrale für politische Bildung, Bonn, p. 17.

8.9.2 Politics for the digital age – „Politics 2.0“

The scenario described need not and must not be inevitable. The major global and national challenges call for answers and actions that have to be developed through intense interaction and collaboration between extremely diverse actors. The analog-driven distinction between „relevant“ and „less relevant“ stakeholders will cease to exist. At the same time, the representation question will be asked again - why should the responsible, well-informed citizen still need representatives maintained by his taxes and still finance the very expensive apparatus? If man is by nature a political animal („zoon politikon“), then everyone will want to participate in shaping the „res publica“ and to be involved in consensus-building and decision-making processes.

Digitalization gives us all the opportunity to meet, debate and take decisions online, just as the ancient Greeks did centuries ago in the Agora in Athens. Citizens can be involved in consensus-building and decision-making processes through e-consultation and e-participation. Collaboration software and Web 2.0 enable and also require a corresponding „Politics 2.0“ fit for the digital age. Powerful tools such as „LiquidFeedback“ [294] already exist and enable a fluid transition between representative and direct democracy and provide politics with sustainable tools for building the modern state.

What key features ought politics to have in the 21st century? The creation of new social and political frameworks that operate in the interests of the individual citizen and that empower citizens, through tools, platforms and relationships, to live their political life as they wish, as active members of the political community. This is a time rich in opportunities for societies to decode the emerging patterns of mutation and to transform these insights into new political models. In this way, the complex needs and aspirations of the „zoon politikon“ of the 21st century will be able to be satisfied.

294) http://www.liquidfeedback.org/; http://www.interaktive-demokratie.org/news/2015/20151214-LiquidFeedback-3_1-for-democratic-software-and-product-development.de.html; Behrens/Kistner/Nitsche/Swierczek (2014): The Principles of LiquidFeedback, Interaktive Demokratie e. V., Berlin; http://www.liquid-democracy-journal.org/issue/4/The_Liquid_Democracy_Journal-Issue004-02-A_Finite_Discourse_Space_for_an_Infinite_Number_of_Participants.html; http://www.interaktive-demokratie.org/

CHAPTER 9

International comparison of the risks and potential associated with digitalization

This chapter looks at the threats, weaknesses and opportunities associated with digitalization and ICT-induced change across the various sectors as reported by the experts surveyed. Unlike a traditional SWOT analysis, however, strengths are considered on the basis not of the position at the moment, but rather of the strengths those surveyed believe their organization needs to acquire. The study is thus concerned primarily with the priorities adopted by the companies in order to prepare for the global advance of digitalization. The statements received from the German companies across the four SWOT elements are addressed separately for each of the three sectors (automotive industry, mechanical engineering and logistics). Non-sector-specific statements [295] from the other countries included in the survey (China, Japan, South Korea and the USA) are also presented.

The primary aim of the questions to the interviewees and the subsequent analysis was to ascertain the extent of congruence with the prior statements and analyses. The statements are therefore simply described below with no attempt at detailed interpretation in order to avoid redundancy in the conclusions.

The figures presented serve to visualize the key themes in respect of the SWOT dimensions from the point of view of the experts. The size of the circle corresponds to the frequency of the response, with the most common responses, which are also explained in the text, being highlighted in color. Circle size has been normalized based on the complete set of interview responses. This makes it easier to perform meaningful comparisons across sectors and regions. The responses received from interviewees in the sectors considered in Germany are also sorted (in descending order) by frequency. Finally, the most important statements are summarized once more and the connections between the SWOT elements are discussed.

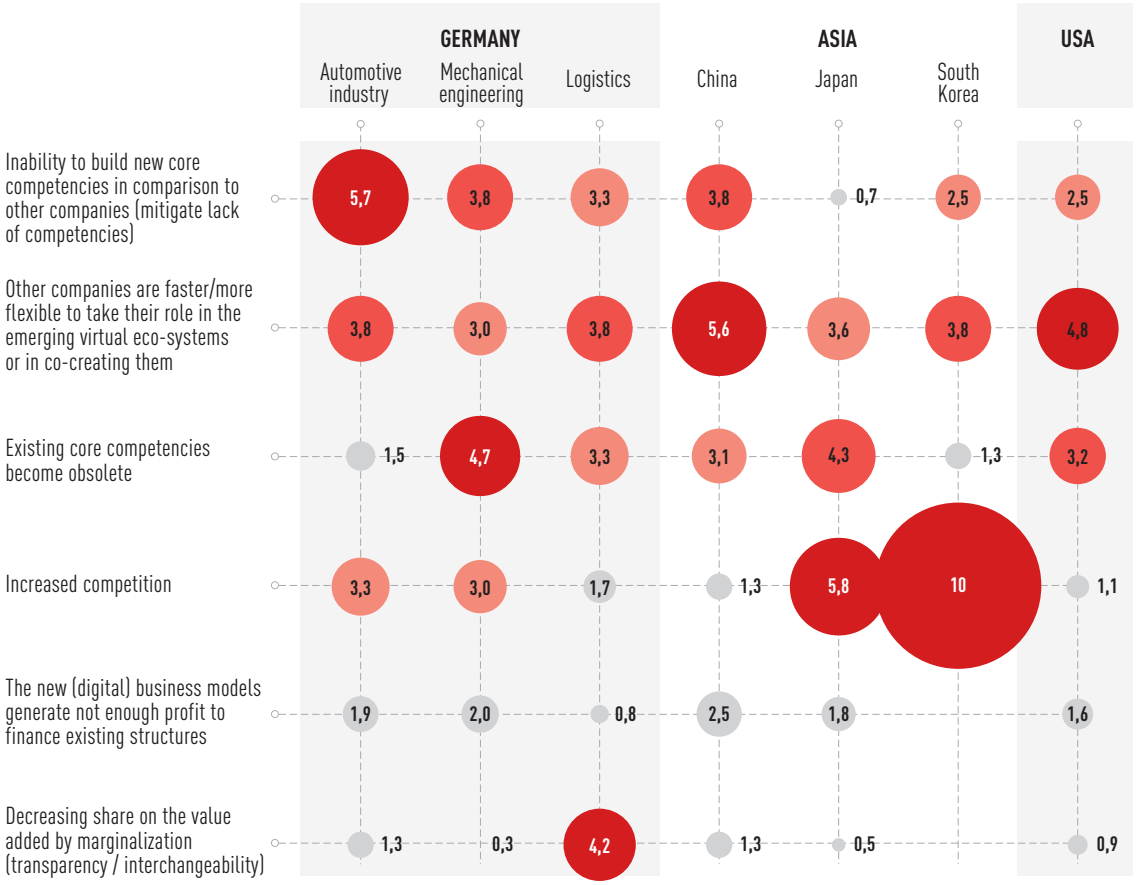
9.1 Threats

All respondents in all of the countries surveyed stated that one of the main threats was the possibility that other companies (from outside the sector) would be able to move faster in occupying/shaping their role in the virtual (platform) ecosystems emerging as part of digital transformation. The companies surveyed are actually also currently attempting to develop and establish their own self-contained ecosystems, which, in the view of the authors, suggests that the mechanisms of digital ecosystems and how they work have yet to be fully understood.

295) The data obtained did not support a breakdown by sector at the international level.

Figure 45: Overview of the threats identified by the interviewees

The commonest responses are highlighted in color.



All of the interviewees apart from those representing Japan and the German logistics companies also identified the possibility of other players in the market being able to build up new core competencies faster than them as a threat. This is a sign of rising pressure of competition overall. Neither the German automotive industry nor the South Korean companies surveyed viewed the erosion of their own core competencies as a threat even though new companies are already gaining a foothold in the automotive sector using different technologies and competencies. Increased competition as a consequence of digitalization was nevertheless identified as a threat in the Asian region – principally in South Korea and Japan – and, somewhat less frequently, by the German automotive and mechanical engineering industries. The German logistics sector differed from the other sectors and countries in the seriousness of its concern about the threat posed by the declining share of value added due to marginalization as a result of the transparency and interchangeability that come with digitalization.

9.1.1 Automotive industry – the German perspective

According to those surveyed, the greatest threat facing the German automotive industry is not the obsolescence of existing core competencies, but rather the possibility that other companies might be quicker to build up new core competencies and thereby manage to compensate for any deficit in their capabilities. This does show a high level of awareness of the fact that digitalization necessitates new competencies, but the interviewees do not anticipate the disruption of their existing competencies and business areas. Respondents pointed to the inertia of the companies as the most important reason in this connection. The great mechanical and mechatronic complexity involved (see also Chapters 3.2 and 3.2.4) made for relatively long development cycles, they said, and required experience and corresponding competencies, neither of which could be acquired quickly.

> *"Software companies that actually have no idea about the automotive industry are suddenly appearing in the market. They already have the necessary skills in the software field – and software in particular will have a very important role to play."*

The experts stated that software-based functions are increasingly becoming one of the defining factors of the sector's product. This is not an entirely new trend, but the growing maturity of technologies such as continuous integration and continuous delivery means that the time it takes to improve and extend existing software functions and add new ones is falling all the time (see also Chapter 6.2). Software-based products also enable companies to expand into other areas more quickly than products born of the traditional longer development cycles. Newcomers to the market, especially those from a software environment, are able to adapt such products to customer wishes more rapidly or target customers more specifically, which is perceived as a threat. These factors have the potential overall to expand existing ecosystems and extend the trends emerging in these ecosystems across sectors.

Another factor regarded as relevant in this context is the ability to adapt organizational structures with respect to new competencies. There is, however, a lack of appropriate specialists with which to build up a digital skills base. According to the interviewees, newcomers to the market that already have a high level of ICT competence, especially those from the IT sector, are able to pick up automotive manufacturing skills or acquire them through alliances or takeovers relatively easily because these skills are available in the market anyway. Automakers looking to build up skills from the IT environment, in contrast, face rather more of a challenge, especially with IT resources thin on the ground and the required skills unavailable.

The second most serious threat in the opinion of the German experts is the possibility of other companies being able to move faster in occupying/shaping their role in the emerging virtual ecosystems. The inertia afflicting some companies in this context was here blamed on existing business models. Interviewees also reported a lack of flexibility among spin-offs from large corporate groups, which are hampered by the inertia of the parent company in areas such as strategy and path dependence (see Chapter 6.4) and pressure to protect data from the established business. Internal

processes involving user and usage data end up being too slow as a result and become a barrier to participation in ecosystems.

> *"Speed is of the essence when building up ecosystems: fall behind and the boat will have sailed already."*

The responses received indicate, furthermore, that there is a reluctance in Germany to release or share data because of concerns that it might be used to derive sensitive information that could be exploited by the competition. There is a fear too that the data could be utilized by other companies as a basis for business models without the source of the data managing to exploit the latent economic potential itself. Issues like data protection and privacy also play an important role in the context of personal data.

The third most prominent threat in the view of those surveyed was increased competition. ICT-induced change makes it easier for competitors, which in some cases are spread all over the world, to access the global market. Virtual marketplaces can be a particularly advantageous option for newcomers to the sector that do not have physical sales structures in place. The rise of electric vehicles is rendering the traditional skills in the areas of internal combustion, drive train and chassis increasingly irrelevant, which makes life much easier for new players in the market.

9.1.2 Mechanical engineering – the German perspective

The survey results indicate that the German mechanical equipment manufacturers, unlike their counterparts in the automotive industry, are most concerned about the erosion of existing core competencies. The main requirement for mechanical equipment manufacturers in terms of training has hitherto been developing and integrating skills in electrical engineering and electronics, but in future, thanks to Industry 4.0, they are also going to have to add IT and data analysis skills, pushing traditional pure engineering even further into the background. One interviewee offered the following explanation of this development:

> *"New participants will come to the market that perhaps already have professionals on board. There will be a need for more digital natives who are thoroughly comfortable with the mechanisms of digitalization and how it works."*

Another threat identified in the context of companies' own core competencies involves the effects of high-level integration and the spread and utilization of multifunctional devices such as 3D printers, which respondents believe could take the place of CNC milling machines and more complex work processes in future.

The second most commonly cited threat was inertia with regard to the development of new core competencies, for example in order to make good shortfalls in capabilities. German companies not only judge that they are slower to generate and implement new ideas than Silicon Valley companies, but also feel threatened by the speed with which Asian companies are able to copy and emulate innovations. One contributing factor of particular relevance to this view concerning the implementation of new ideas in the mechanical engineering sector is that the sector's products have a significantly longer service life than those of the automakers and are often highly customized (a machine is adapted individually and largely manually to the customer's requirements). Regarding the specialists required to build up new core competencies, respondents indicated that it would very much be possible to form alliances with companies from outside the sector in order to build up corresponding capabilities more rapidly.

Two threats shared third position in the rankings: increased competition and the possibility of other companies being able to move faster in occupying/shaping their role in the emerging virtual ecosystems. The Industry 4.0 campaign touched to an extent on the significance of data and data-based services and on integration and decentralization and the German mechanical equipment manufacturers consequently already have some awareness of how value creation potential is changing. Some product-centered companies though feel that they are still not capable of capturing and processing the production process data that would be needed to establish a corresponding ecosystem (in part too because of the associated competencies required). SMEs in particular lack the advice they need and it is very difficult to calculate the cost-benefit ratio for the necessary investment.

Turning to the matter of increased competition, some companies, especially companies from other sectors, are already experienced in data capture and processing and in offering services based thereon. Typical examples of such companies are Amazon and Facebook, which have the capacity to offer new product and service propositions based on data capture and processing. The data concerned in the case of these particular companies is user data, but the underlying principles could also be transferred to mechanical engineering and it is expected, against this backdrop, that new companies and companies from other sectors will be moving into this market. The respondents assume that these newcomers will be able to make headway quickly, will possess faster-moving decision-making processes and will often have more capital behind them. These strengths and the competencies referred to above will make them ideally placed to establish or extend digital ecosystems and assume a controlling position in this area.

9.1.3 Logistics – the German perspective

The declining share of value added due to marginalization, for example as a result of transparency or interchangeability, emerged as the greatest threat associated with digital disruption for the German logistics industry. Also mentioned prominently was the threat of competition from new players in the market that bring new concepts, a smaller and more versatile fleet, less infrastructure and/or the ability to exploit forecasting techniques. Technological developments too were regarded as a significant threat, with several interviewees pointing out the progress being made in 3D printing, which could potentially render the transport and/or storage of more complex components or products obsolete. One relatively simple example of this possibility are plastic spare parts for certain of its goods vehicles that Mercedes-Benz could print close to the intended point of use.[296] However there are as yet no certified providers for logistics services based on 3D printing that are capable of offering the high quality necessary in some cases or, even more significantly, supplying large numbers of units on competitive terms.

The second most serious threat as perceived by the respondents was the possibility of other companies being able to move faster in occupying/shaping their role in the emerging virtual ecosystems. Many logistics service providers feel that they lack the technical capabilities and business model competencies to develop their own platform-based ecosystems. Only relatively large providers like DHL (with Allyouneed[297]) are actively trying to develop such ecosystems. It is quite possible, however, that outsiders already in possession of the necessary expertise could come in and design an ecosystem of this nature and thereby create a level of transparency that would leave some providers marginalized and interchangeable.

One company from the mobility field is already making inroads into on-demand logistics with its business model: UberRUSH from Uber links users, who may also be providers of the personal transportation service, with an established software platform for ride arrangement. Companies participating in this ecosystem use the platform's APIs to offer delivery of their products via UberRUSH on their own sales platforms.

Third position in the ranking of threats based on responses for the logistics companies surveyed was the erosion of existing core competencies and the comparatively slower development of new core competencies.

> *"Our core competencies in transportation and storage will come under powerful attack – an Uber for logistics solutions."*

Amazon is a relative newcomer to the logistics market with Amazon Logistics. Using the data that accumulates from the utilization of its own platforms, the company is able to recognize trends, derive forecasts from these trends and then refine its own logistics process accordingly. The speed advantage this confers can potentially offset the effects of any shortcomings in terms of other capabilities, such as achieving optimal utilization of vehicle capacity or optimal route planning. The decrease in the value to be created out of the actual transportation of goods is compelling companies to tap into other sources of income. Examples of such sources of income include the provision of intermediary services for logistics taking in multiple companies, an activity for which ICT capabilities are essential. At least some of the experts surveyed believe that their current core competencies would enable them to become solution providers and advise other companies in matters of logistics, for example in relation to warehousing.

296) http://www.automobilwoche.de/article/20160808/HEFTARCHIV/160809960/3d-druck-mercedes-produziert-ersatzteile-%22on-demand%22
297) https://de.allyouneed.com

9.1.4 China

The greatest threat in the eyes of the Chinese experts is the possibility of other companies being able to move faster in occupying/shaping their role in the emerging virtual ecosystems. A large proportion of the companies attribute their concern about this possibility to a lack of the ability to think in terms of digital business models, although there are conspicuous examples – Alibaba and Tencent, for instance – of Chinese companies that have done just this very successfully.

The industrial companies making use of these concepts in China include a large number of major state-owned and partially state-owned businesses that contribute to employment and thus to general economic development in the country. Optimizing workflows at the expense of jobs would be problematic in this context. Many of these companies have expanded their capacity dramatically on the back of state investment. Massive change in these organizations is all but unthinkable, which is one of the reasons that the potential and possibilities of digitalization are not yet being recognized and exploited to the full.

A general lack of ICT skills is identified as the second most serious threat. This shortage turns companies with the necessary core competencies, especially IT companies, into competitors. As mentioned above, data processing and analysis capabilities are particularly important for companies wishing to participate in and help to shape digital ecosystems. The difficulty of finding suitable people is the main stumbling block in terms of building up capabilities in these areas and the companies surveyed certainly perceive this shortage as a threat.

Chinese companies are also unwilling or unable at the moment to bear the high costs involved in retaining big data experts to make up for their deficient capabilities. The automotive OEMs were especially concerned about the speed of development at other manufacturers too. The relatively young Chinese companies do have less historical baggage and can therefore afford to take risks, for example with developments in electromobility, but numerous established manufacturers are already working intensively on electric vehicles and even have corresponding products on the market. The capacity of the established manufacturers to overcome the speed issue by virtue of their great experience in development is seen as a particular threat by the Chinese manufacturers.

The erosion of existing core competencies appeared as the third most prominent threat among the interviewees. One of the key core competencies of Chinese companies in the past has been the ability to be a global cost leader. According to the experts surveyed, Chinese companies have yet to learn how to develop businesses with individualized products and demand models from the starting point of mass production and still maintain their original margins.

9.1.5 Japan

The Japanese interviewees regard increased international competition as the greatest threat. Although the new digital technologies simplify market access, neither small companies nor companies from the sectors surveyed that compete on the basis of lower prices (such as many Chinese companies, for example) were seen as potential competitors because industrial companies in Japan are very much focused on quality. Responses on the subject of increased competition related in most cases to the possibility of established companies catching up in the technological stakes and thereby becoming more competitive.

"Companies like Tesla and Google are viewed with concern and represent potential competitors."

Second in the ranking of prominent threats came the erosion of existing core competencies. Interviewees speaking for the mechanical engineering sector expect that machinery will in future serve as a business platform for supplementary IT-based services such as predictive analytics/predictive maintenance, customer service and flexible production. The Japanese component suppliers surveyed considered themselves to be

Background – Personal data in Japan

There is a general assumption in Japanese society that private information will be not be misused or otherwise exploited for commercial purposes. Companies seen to transgress against this unwritten law face widespread opprobrium. It became known a few years ago that one of the operators of the Tokyo urban rail and subway system wanted to sell anonymized usage profiles of its customers to a third party. Although it was demonstrably impossible to reverse the anonymization process, public pressure caused the planned deal to be abandoned.

Japanese companies are therefore likely to find it very difficult, at least in their home market, to establish digital business models and build up ecosystems that are based on the analysis and generation of knowledge from personal data. This may well go some way to explaining why such a large number of interviewees fear that foreign companies from other sectors will be better able to occupy the virtual ecosystems and that their industry will suffer as a result.

highly qualified in the development and implementation of highly efficient optimized processes for the production of parts and components, primarily hardware. The disclosures of the respondents also indicated in this connection that added value is now generated more by software than by hardware.

The experts suggest, however, that the Japanese component suppliers generally do not have the necessary qualifications in the software field. Japan, like Germany, has a much larger proportion of hardware-oriented companies than software-oriented companies. One interviewee blamed this focus on hardware and the concomitant lack of software capabilities on fear of the paradigm shift from hardware to software and the servitization of products (see Chapter 6). US companies, in contrast, are credited with great expertise in the area of business models based on software and services.

The third most serious threat as perceived by the interviewees is the possibility of other companies being able to move faster in occupying/shaping their role in the emerging virtual ecosystems. Respondents spoke specifically about the fear that companies from countries with lower labor costs might use the virtual marketplaces and ecosystems to break into the Japanese market and that customers might be prepared to turn their back on their domestic suppliers even if this meant accepting a reduction in quality as well. Customers would though, they stressed, expect these lower prices to be coupled with local service and a faster response to their wishes.

The interviewees see this threat coming mainly from companies with an established international presence and especially from Chinese industry, which has made cost-efficient mass production one of its core competencies. Companies are entering into alliances with foreign software companies though, for example in the area of autonomous vehicles, and doing so with the clear intention of, among other objectives, participating in the latter's ecosystems.

Another factor raised by the respondents is Japanese companies' tendency to prefer the role of fast follower to that of first mover. This, the respondents felt, could turn out to be a losing strategy in the context of ICT-based platforms. One of the reasons for this attitude, the interviewees suggested, is the central role quality plays for many Japanese companies.

> *"Industrial companies focus very strongly on quality: they rely on their quality to help them stand out in the marketplace."*

This quality-led approach stands at odds with the essence of ICT-based platform strategies, which are all about providing third parties with defined access to the outputs of the product in such a way that the product can be extended and enhanced on a continuous basis. What concerns the Japanese companies in practice is that the enhancements realized in this way might not satisfy the established very high expectations in respect of quality and that this could color perceptions of the quality of the product as a whole.

9.1.6 South Korea

The overwhelming majority of South Korean respondents identified increased competition as the greatest threat, a position they justified with reference to the possibilities opened up by digitalization. Their fear is that lower barriers to market entry will enable even smaller companies previously restricted to local markets to make an increasingly significant impact on the international stage.

The South Korean companies regarded their potential inability to match the speed of other companies in occupying/shaping their role in the emerging virtual ecosystems as the second most serious threat. One logistics services provider identified as a threat new companies such as Amazon that have comparatively little (old) logistics infrastructure – vehicle fleets, warehouses and cargo handling sites for example –

Chaebols

South Korea launched its first economic development plan designed to establish an industrial base in 1962. Unlike many other developing countries, South Korea chose to concentrate on methods such as licensing and reverse engineering rather than pursuing foreign direct investment. The government was quick to recognize the importance of investment in research and development and launched the National R&D Program all the way back in 1982. Among its aims were to prepare South Korean businesses for the global market and make them competitive in international marketplaces. This focus on exports benefited the big companies most of all, enabling them to grow even stronger. Thus arose the groups now referred to as chaebols, which are so large and have such substantial capital resources that they can invest in innovative fields in a way that small and midsize companies really cannot.

The interviews with decision makers in South Korea underlined the very active role played by the country's government in relation to digitalization. South Korean politicians are now trying to help develop the potential of SMEs with a "creative economy" program in order to reduce the country's dependence on the chaebols. The intention is to use ICT to create a link between science, culture, industry and technology with the ultimate objective of developing and marketing innovations with purely South Korean origins. The government has created for the purpose a "Ministry of the future" (the Ministry of Science, ICT and Future Planning), which is tasked with removing bureaucratic hurdles and simplifying and promoting the exchange of skilled personnel between different companies and the research sector. The creative economy agenda has seen the establishment over the last two years of 17 creative economy innovation centers (CEIC) spread all over South Korea. Activities at each center take account of the local context and local priorities.

and thus have much greater flexibility in the design and orientation of their ecosystem. Recent investment activity, it was suggested, was obviously intended to deliver complete control of the entire logistics chain so that speed and flexibility could be influenced directly.

> *"Our current logistics infrastructure no longer offers the best service. Local distribution centers and warehouses are inefficient and cannot be sustained. They represented an important competitive advantage in the past, but are increasingly becoming a liability."*

The respondents also raised the growing significance of the B2C area in logistics. This suggests that the customer interface and the analysis and forecasting of end customer wishes are going to become much more important, a development likely to help companies that already have good interfaces to end customers to consolidate their dominance in the relevant ecosystems.

The difficulty of making good shortfalls in capabilities and building up new core competencies required in the context of digitalization ranked third in the respondents' assessment of threats. Although the country's multinational conglomerates or "chaebols" (see box text) have proven very capable in the past, they said, there was a real danger that they would not be able to continue to support the South Korean economy on their own in the same way in future and that state investment in research and development would therefore be better directed to the SME level.

9.1.7 USA

US companies, like their counterparts in the other regions surveyed, identified the greatest threat to be the possibility that they would not be able to assume their role in the emerging virtual ecosystems as quickly as other companies or that they would not be able to help shape these ecosystems as they would wish. Automotive OEMs in particular face a strategic conundrum: invest in developing their own ecosystems so as not to be left hanging or join up with existing ecosystems, for example through alliances. Fiat Chrysler appears to have decided the latter is the better option in the case of autonomous vehicles[298] even if that does mean using an existing ecosystem that remains largely outside of its control. Another factor mentioned by an expert from the logistics sector is the increasing competition faced from micro-logistics companies.

> *"The micro-logistics companies will grow, because they don't have the typical legacy."*

The micro-logistics companies have made optimizing the flow of goods or information within a company their specialty. They usually have no expensive infrastructures of their own, instead just managing assets that were already in place or leasing assets of strategic value. The expertise thus obtained can also be offered as a service to other companies. Traditional logistics providers are hamstrung in comparison by their ties to their own infrastructure (warehouses, vehicle fleet) and their increasingly complex administrative burden. One expert indicated that this also diminishes the ability to take on risks of the type that would be involved in developing digital business models, for example, or creating a proprietary virtual ecosystem.

The erosion of existing core competencies was regarded as the second most serious of the perceived threats. The most commonly cited example of this process in the USA was the displacement of the internal combustion engine by the electric drive, which respondents mentioned in connection with fears that new young companies might displace the traditional automakers. Tesla was named repeatedly as an example and spearhead of this change and praised for the consistent and comprehensive approach of its solutions (power generation/storage with Tesla Powerwall, electromobility with Tesla vehicles, charging infrastructure with Tesla superchargers and so on). Interestingly the very same development was apparently not considered a threat at this time by most of the German automakers.

The third most prominent threat in the eyes of the US experts was the difficulty of making good shortfalls in capabilities. The traditional automakers, while not software companies as such, certainly consider methods such as scrum and agile to be usable or adaptable for their needs. One expert even went so far as to as-

298) http://www.reuters.com/article/us-fiatchrysler-google-idUSKCN0XU26K

sert that it will be difficult to retain the waterfall model[299] in future. How long it takes to build up this type of expertise of course depends to a certain extent on the availability of suitable IT specialists. The threat, according to the respondents from the automotive industry, lies in the fact that acquiring the right experts is difficult in the USA because they are mainly interested in joining world-renowned IT companies like Google or Apple. Much the same point was made previously in the context of the Chinese companies. Actively recruiting suitable graduates straight out of university in the same way as Uber,[300] for example, is an approach the automotive industry has yet to embrace according to the American experts.

9.2 | Weaknesses

This section presents the weaknesses identified by the companies in Germany in the sectors studied and provides an overview of the assessments from China, Japan, South Korea and the USA.

It was shown in Chapter 4 that the German experts understand digital disruption primarily in terms of a change to business models. The authors too believe that the chief prerequisite for mastering the digital transformation is the ability to develop digital business models. A lack of this ability was the most commonly cited principal weakness among the German experts. Japan is the only one of the regions studied that does not share this general opinion and consequently exhibits different priorities.

Another clearly identifiable weakness worldwide is the difficulty of coping with the pace of digital innovation cycles. Only the respondents from Japan and, to a limited extent, South Korea consider other weaknesses – integrating the IT mentality into the corporate culture, for example, or the investment risk associated with digitalization – to be more prominent. Also notable are the concerns voiced in South Korea and Germany about open interfaces, which are largely regarded as insignificant in the USA, Japan and China. The ability to develop of new business models depends to a significant extent on the availability of these very interfaces, but there are fears that the data they reveal could be exploited to derive information about production processes or production volumes and thus result in company know-how being compromised.

9.2.1 Automotive industry – the German perspective

The weakness referred to most frequently by respondents from the German automotive industry is a lack of the ability to think in terms of digital business models. The restructuring required for the shift to digital business models necessitates a change to the technology-/product-centered modes of thinking established across large parts of the companies. One of the experts surveyed said:

> *"Corporate policies would not allow a rapid shift to new business models, customers wouldn't tolerate it either and the corporate structure would prevent any sort of fast change in any case."*

The new capabilities needed are often unavailable, moreover, because the skills involved in exploiting the possibilities of digitalization are still relatively new and highly dynamic. Building up and expanding resources in this area will consequently take quite some time, which, in turn, creates more uncertainty and hampers efforts to plan the development of new structures.

The second most commonly cited weakness was a possible failure to cope with the pace of digital innovation cycles. While it is true that OEMs in some cases already expect agile methods such as scrum, these digital development cycles are still much faster-paced than the automakers' current cycles, which are designed to run for five to seven years.

> *"Shorter development cycles are a big issue – so far everything has happened on a seven-year timescale."*

Development periods need to become significantly shorter, with development moving in the direction of

299) The waterfall model is a linear phase model for application development that essentially comprises the sequential phases of requirement analysis, conceptual design, implementation, testing, commissioning and maintenance
300) http://www.wsj.com/articles/is-uber-a-friend-or-foe-of-carnegie-mellon-in-robotics-1433084582

Figure 46: Overview of the weaknesses identified by interviewees

The commonest responses are highlighted in color.

continuous delivery. This also means making full use of the required technical possibilities (see Chapter 6), however, in order to keep pace with digital innovation cycles. Not only that, but whereas in the past a long planning phase was followed by a long period of profiting from the results, today the up-front investment required is considerable even though the profitable phase is shrinking all the time.

Inhibitions about using open interfaces ranked third among the weaknesses addressed. The big question in this regard is which and how much information a manufacturer should release over such interfaces.

> *"The decision as to whether and, if so, what information is to be disclosed in the context of data exchange is absolutely fundamental."*

Respondents were troubled and discouraged by the risk of proprietary knowledge being compromised. This was especially true in relation to the idea of a

company making its own enhancements or adaptations available over interfaces or as open source even though this would open up the possibility of gaining from the solutions contributed by other users. Fears were also expressed about the state of dependency that could develop in these circumstances and the prospect of an excessive number of interfaces driving up complexity to the point at which it becomes very expensive to maintain and manage everything. Open interfaces are certainly viewed as a challenge, not least in respect of security with open standards, but the need for industry standards was acknowledged.

9.2.2 Mechanical engineering – the German perspective

The mechanical engineering sector tends to be dominated by engineers and a technology-centric way of thinking and it is therefore not surprising that the German mechanical equipment manufacturers too regard a lack of the ability to think in terms of digital business models as the most significant weakness. The fact that they have little prior experience in this area makes it difficult for companies in the mechanical engineering sector to quantify the level of IT investment necessary to create a basis for the servitization of their products. This means that in some cases at least there is simply no reason for companies to be thinking in terms of digital business models or that the opportunities presented by digital business models are still not fully understood. The authors believe that there are positive signs to be observed in the market nevertheless. Machine tool, laser and electrical and electronics specialist Trumpf, for example, has launched a digital Industry 4.0 platform solution called AXOOM that has already won a number of awards.

The second most significant weakness for the mechanical engineering sector was identified as the shortage of appropriate specialists available. The experts surveyed revealed that large teams of specialists can be required in some instances to progress the necessary technologies sufficiently quickly. Some companies question whether the right training – the training currently required to impart the capabilities sought – even exists.

> *"The current bachelor degree system offers little comfort because courses at this level give graduates no specialization and do not impart independent thinking skills. And it takes whole teams of specialists to move technology and business models forward."*

Experts report that skilled workers and specialists are needed at the interface between business models and IT. It is not easy though for the respondents to outline a career model matched to capabilities and salary expectations. A continuous further education and training model aligned with the requirements of the industry is required. Some specific training propositions available in the marketplace already fit this bill to an extent, but the respondents feel the universities are taking too long to respond. Companies from the software environment are accordingly going one step further and concluding that they need to be training suitable people themselves.

Concerns about open interfaces placed third in the ranking of weaknesses among the mechanical engineering industry experts surveyed. Standardized or open interfaces do pave the way for digital services that can provide a foundation for new business models, but the data made available could be targeted and used to derive details of specific production processes and other information relevant to the business. The respondents see a need for robust and secure uniform standards, for example for machine-to-machine communication or for cloud access and cloud use. There is a particular issue with smaller companies shying away from collaboration with large companies. Industry associations that could put forward and implement proposals for corresponding standards are regarded as too weak, however, and several of those interviewed made it clear they expected more support from government with the creation of industry standards.

9.2.3 Logistics – the German perspective

The principal weakness identified for the logistics sector, as for the automotive and mechanical engineering sectors, was a lack of the ability to think in terms of digital business models. The experts said that it was difficult at the moment to offer (purely) digital services in a sector so dominated by the physical. One of the companies surveyed was revealed to have two of four managing board members currently deeply involved in trying to change weaknesses in respect of digitalization into opportunities. This example illustrates the significance afforded this topic: having board members take the lead dramatically shortens strategic and organizational decision pathways.

The results of the interviews suggest that worries about the pace of digital innovation cycles are not as pronounced as the fear of lacking competence in digital business models. One interviewee remarked that their company had not yet advanced far enough on the software side to be worrying about the pace of innovation cycles. Some logistics companies are still not in a position to understand and ascertain the investment required in IT either, which is another reason why potential issues coping with the pace of innovation cycles remain a matter for the future among many of the companies surveyed.

Given the above it should be entirely unsurprising that the shortage of appropriate specialists available came next on the list of most frequently cited weaknesses. Not only do the type of specialists required usually prefer companies in the IT sector (a factor also raised in the context of threats for US companies), but companies often also have no internal job market through which to identify target capabilities that are already to be found with the company and, where applicable, transfer specialists into roles that will involve them in digitalization projects.

9.2.4 China

Like their counterparts in Germany, the sectors surveyed in China recognize a lack of the ability to think in terms of digital business models as the most significant weakness. It was noticeable that the mechanical equipment manufacturers did not even perceive a need to change their old processes and models because their current margins are more than adequate. The respondents understand overall that this amounts to a significant weakness but are not always working with the necessary consistency to rectify the situation. There are signs of ambition in this area, but no significant revenue has been raised on the basis of digital business models so far.

> *"We have begun to understand the mechanisms but have yet to generate any meaningful income."*

The picture in China as far as other weaknesses are concerned is very varied, with the possible failure to cope with the pace of digital innovation cycles, the shortage of appropriate specialists, reluctance to invest in technology, products and new business models and the failure thus far to integrate the IT mentality into the corporate culture all featuring in the weighted analysis. The point was made in relation to integrating the IT mentality that this can really only happen if corporate management wants to see innovation and is prepared to look beyond current margins. This requires that management itself take the lead in integrating the IT mentality and tackle the associated issues in a more organized, responsive and available manner.

9.2.5 Japan

The companies from Japan addressed in the survey differed from those in all of the other regions covered in that the most commonly mentioned weakness was the failure thus far to integrate the IT mentality into the corporate culture. Respondents were presumably referring here to methods such as agile development or options for structuring, for example the modular encapsulation of complexity. There is strong resistance in Japan to standardization and the idea of buying in electronics, as a result of which better systems "not made here" are often not adopted. This effect is exacerbated by the fact that IT products generally manufactured using agile methods or designed with the intention that they mature while in use with the customer are unacceptable to the companies surveyed because of the possibility such products may end up not achieving the high level of quality so central to the companies' priorities.

> *"Banana products that reach the customer before they are properly ready are not acceptable and nor is any reduction in quality."*

These companies strive to build and sell perfect products and not an unfinished version with software that has to be brought up to scratch retrospectively. Like the German automakers, Japanese OEMs consequently find it difficult to establish agile development methods.

The second most prominent weakness based on the interviewees' statements was the inability to agree on common standards. Regulatory authorities and industry associations are trying to introduce standards, but progress to bring about agreement between the established companies is slow. This stems in part from the fact that Japanese OEMs generally prefer de facto standards or separate (in some cases proprietary) standards of their own to the standards being proposed by the government and other agencies.

Third position in the ranking of weaknesses is shared by variations in the speed of action across different company units and reluctance to invest in technology, products and new business models. Different departments in the Japanese companies operate at different speeds too – and are not always pulling in the same direction either. The experts surveyed judge that marketing and sales move more slowly than research and development, for example, when it comes to adapting to changed circumstances, but feel poor integration between different processes in product lifecycle management is even more significant.

Differences in speeds between sites, moreover, make it difficult for global companies to implement major changes, among other drawbacks. Another challenge involves the problem of how to implement agile development approaches while still promising a high-quality product, as the pace of these methods can entail reductions in the quality of the result. The Japanese mechanical equipment manufacturers, like their counterparts elsewhere, are still also wrestling with the matter of what IT they need and how to acquire the requisite skills, for which reason the associated investment risks still appear to be impossible to predict.

9.2.6 South Korea

Interestingly South Korea is the only one of the regions considered in Asia to identify a reluctance to accept relatively high risks when investing in technology, products and new business models as the most serious weakness. Disclosures from the interviews indicate that past decisions have often turned out to be misguided, with companies either choosing an unfavorable moment to invest or putting their investment into the wrong technologies, and that there is now a marked uncertainty regarding investment in infrastructure, especially as it is more or less impossible to calculate the likely return.

The familiar concerns about open interfaces were very much in evidence in the responses too. One of the interviewees pointed out that Samsung's speech recognition system (Otto)[301] is very similar to Amazon's (Echo) except that it forgoes the latter's open interfaces. Amazon actually allows third parties to access its speech recognition system,[302] a feature that would en-

301) http://www.theregister.co.uk/2016/04/27/move_over_alexa_ottos_in_the_house/
302) http://www.computerbild.de/artikel/cb-News-Vernetztes-Wohnen-Amazon-Echo-Alexa-Drittanbieter-12059267.html

able Echo to process – and learn from – information from what could turn out to be quite a broad spectrum of third-party providers.

A lack of the ability to think in terms of digital business models was the third most commonly cited weakness among the South Korean interviewees, who tended to mention this concern in conjunction with their fears about failing to cope with the pace of digital innovation cycles. The logistics companies in particular were reported to be still much too closely bound to the old structures with regard to business models. This leaves them unable to imagine the potential of digitalization to revolutionize delivery, a process that appears on the surface to be rooted absolutely in the physical world, and most of the existing business models are consequently focused on the physical act of service provision.

9.2.7 USA

Failure to cope with the pace of digital innovation cycles was regarded as the greatest weakness in the USA. Respondents repeatedly singled out the slow pace of innovation (due to legacy issues and path dependence) as the main cause of companies' reluctance to take risks.

> *"Legacy slows us down and companies don't offer people enough training to cope with the digital transition."*

Other causes identified included the paucity of professional development opportunities companies provide in fields such as agile methods. The experts surveyed felt that helping personnel to enhance their skills in this way was essential if the move to shorter cycles was to be realized.

A lack of the ability to think in terms of digital business models was the second most frequently cited weakness. The respondents revealed that American companies, unlike their counterparts in Germany, are looking for new faces at management level as well as new specialist staff. American companies, they said, were concerned about organizational structures (management) as well as specialists at the functional level coming to terms with digitalization. The experts recognize that while IT is still focused mainly on supporting existing business models, it is also already regarded as an enabler for new business models. What future business models will look like remains uncertain at the moment, however, and the experts were clear that no more detailed plans can be drawn up until future revenue models and value creation architectures have been designed. Although the American mechanical equipment manufacturers are highly adaptable and very open to the idea of developing data-based business models, the responses provided by the interviewees indicate that this sector specifically (as in the other countries considered) is dominated by a mentality in which physical products come first.

The shortage of appropriate specialists available was the third most commonly mentioned weakness in this instance. The experts observe that education in the USA tends to be rather general in its approach and does not promote specialization in the way that the Japanese and, to an extent, German systems do.

> *"In the past, GM had an undergraduate scholarship. No one went to GM – all went to IT companies like Google or Amazon. For the IT domain GM is still an outside industry."*

The experts believe, moreover, that the best IT specialists prefer companies like Google and Amazon to established industrial groups like GM. The respondents expressly stated that the automotive industry in the USA remains a non-mainstream sector for IT specialists.

9.3 | Opportunities

The principal opportunity opened up for the German automotive and logistics industries by the digital transformation is the chance to access new markets and customers. The experts from South Korea and the USA expressed similar views. Hand-in-hand with access to customers go possibilities for customer retention, an area in which significant potential is identified across sectors not just in Germany but in China and South Korea as well. Chances to boost efficiency and cut costs are the main opportunities associated with the digital transformation in South Korea and Japan despite coming no higher than third in the ranking for the German logistics and mechanical engineering industries. The Chinese experts and the German mechanical equipment manufacturers agree that the most significant opportunity is the ease with which the portfolio can be extended and differentiated in a digitalized world. South Korea and the USA are the only countries surveyed to see opportunities in the new forms of scalability that are becoming available. Only the German automotive and logistics sectors recognize an opportunity in the possibility of joining/helping to shape emerging (virtual) ecosystems, although the authors would caution that a thorough understanding of the workings and mechanisms of these ecosystems is a prerequisite for their effective use.

Figure 47: Overview of the opportunities identified by the interviewees

The commonest responses are highlighted in color.

9.3.1 Automotive industry – the German perspective

Digitalization opens up new ways to access customers and it is this ability that the German experts from the automotive industry regard as the greatest opportunity. Sales need no longer be handled through dealers, for example, but can instead take place over the internet or through internet-based marketplaces, with customers able to select options, finish, prices, finance and so on from their own home via virtual channels. The internet thus creates new customizable dynamic options for targeting customers that are also cheaper to boot. The greatest opportunity presented in this context is the possibility of attracting and retaining new customers through the new customer access channels that become available.

The participants surveyed also believe, however, that it is important to retain customers within the ecosystem for the long term. Customer loyalty can be strengthened, the experts suggest, with new product functions or enhancements based on (digital) services. The convenience factor, for example only requiring customer details to be entered once (especially valuable for mobile payment options) or ensuring, like Uber, that it takes users no more than three clicks to reach their destination, is important for acceptance – and hence for customer retention – but poses a challenge in terms of data protection.

"We will achieve a good level of customer retention if we understand how our customers actually use our cars."

The automakers additionally believe that being able to find out more about actual vehicle use would give them a further opportunity to enhance customer retention, as more detailed information about driving behavior or infotainment use, for example, would allow them to deduce corresponding improvements.

No less important in terms of the opportunity it presents according to the study is the design and control of ecosystems. The interviewees see in ecosystems the opportunity to link and bundle – primarily digitally – previously discrete heterogeneous service activities that together make it possible to meet customer requirements in their entirety. The notion of initially linking together intermodal transport concepts (for example automobile, bus, rail and bike) and ultimately integrating services from other sectors as well (for example payment, insurance, entertainment and shopping) accordingly strikes them as both a challenge and an opportunity. It is anticipated that an ecosystem of this type would greatly increase the attractiveness of the automobile core product – as a platform for various service purchases – and thereby increase long-term demand and generate ecosystem-based customer loyalty. Finally, OEMs could use these ecosystems to consolidate their existing value creation position and expand their value creation activities into adjacent areas.

9.3.2 Mechanical engineering – the German perspective

The respondents for the German mechanical engineering industry regard the ease with which the portfolio of products and services can be extended and differentiated in a digitalized world as the principal opportunity. Expanding the portfolio, the interviewees anticipate, will bring a corresponding increase in revenue. Digitalization paves the way for companies to expand on their existing range of activities by, for example, offering a service instead of selling individual parts or, in the case of manufacturers, adding services to complement existing products. Examples of this might include IT-based services such as predictive analytics or predictive maintenance.

"Today I am a product manufacturer that supports a service in an ecosystem with my product. In future we will still manufacture products, but we intend to offer complementary services as well."

One way of implementing these changes, according to the experts, would be to enter into partnerships in order to improve usability, for example by means of involving prosumers or crowdsourcing. It has been established practice in the past to provide highly versatile software in exchange for a license fee and for this software then to be adapted to each customer's needs

by partners applying their own development and maintenance charges. The respondents believe that in order to address the fast-expanding prosumer market and reach every niche, however, it is now necessary to integrate assistants (wizards), user interfaces, templates, etc. that make use and adaptation extremely simple and intuitive.

New possibilities for customer retention created, for example, by the assumption of new roles were the second most common response to this question. One expert referred in this regard to the role of app supplier or even platform supplier after the manner of Android, but for programmable logic control systems. Digitalization can be used here to establish closer customer relationships between companies and to facilitate a deeper understanding of customer needs. Taken in conjunction with the differentiation of products, this capability makes it possible to develop a suitable ecosystem based on a software platform for the adaptation and sale of the user data and extracted knowledge in order to facilitate long-term customer retention.

Cost reductions due to efficiency gains ranked third among the opportunities mentioned. A company aiming to cut its costs, however, may first have to introduce new technologies or skills. Costs can be reduced by digitalizing processes as well as by simplifying them.

> *"The machine manufactures more efficiently, enabling the cost per product to be reduced while maintaining or even raising quality levels."*

Technologies from the field of digital engineering also have the potential to reduce the time taken to move from design to production. Some signs of production being brought back to companies' home countries can be observed in connection with these opportunities opened up by digitalization.

> *"Increased payroll costs in China are making our own products competitive again."*

These statements suggest that manufacturing abroad has now reached a similar price level but with poorer quality or a higher level of risk. On top of this there is a danger of the factories selling on the same products under a no-name brand at a fraction of the price.

9.3.3 Logistics – the German perspective

The chance to access new markets and customers is the most significant opportunity for the German logistics industry. Respondents made particular mention of access to the global markets, a factor that presents new possibilities in the context of digitalization. The possibility of offering services on a scalable basis using cloud technologies was also raised. Decision-makers credit the logistics sector with an increasing ability to set up and manage complex value creation networks in this connection. The development of cloud-based services for these value creation networks, for example for coordinating logistics chains for different companies, could represent a major opportunity here.

The second most important opportunity identified was the possibility of increasing share of value added by expanding an existing role and/or developing a new one. It is noticeable when discussing this subject that the logistics companies would like to take on a new role that goes beyond just transporting goods from a collection point to a delivery point. This would enable them to use their own value creation network to add the procurement function to their existing role and procurement could be optimized accordingly using the available data and information. The companies would need to be careful to make sure that this new role was not surrendered to other participants in the value chain.

Third place in the ranking of opportunities as determined by the responses of the companies surveyed was shared between new possibilities for customer retention, cost reductions due to efficiency gains and the possibility of cornering/helping to shape emerging (virtual) ecosystems. The services being created open up the possibility of reclaiming the interface to the customer and building customer loyalty. The companies surveyed recognize the potential for using data analyses of their own processes to generate information that can help them improve efficiency and further reduce costs and regard this as one of the opportunities of digitalization. Germany saw some very early efforts to corner/help to shape digital ecosystems with the development of online marketplaces such as eVITA.[303] Deutsche Post, a major player in the country's logistics sector, announced

303) http://www.heise.de/newsticker/meldung/Lycos-kauft-das-Shopping-Portal-der-Post-eVITA-70071.html

eVITA as a first mover in 1999, but the platform failed to gain traction and was sold just three years later.

> *"With eVITA we had a platform and opportunities just like Amazon's, but we didn't trust ourselves to scale it up."*

Now companies are bringing platforms of this type to the market with greater conviction and properly appreciate the opportunity presented by cost-reducing scale effects (see DHL's Allyouneed[304] platform, for example).

9.3.4 China

The Chinese interviewees indicated that for them, the ease with which the portfolio of products and services can be extended and differentiated in a digitalized world was the most significant opportunity. They referred to the fact that the Chinese automotive industry in particular is still relatively new and that legacy issues, including in terms of customer expectations, are not as dominant a factor as they are for European or American manufacturers. The industry can therefore entertain risks more readily and regards as a great opportunity the possibility of differentiating and expanding the product or service range on the basis of digital services. Its relative youth means the industry lacks experience, however, so there is also a corresponding risk of failure.

New possibilities for customer retention were the second most significant opportunity named. The Chinese market has met the digital propositions launched to date with a high level of acceptance and IT affinity, as already reported in Chapter 4. The potential harbored by digital propositions for improving customer retention is highly valued according to the experts in China. There is little in the way of customer loyalty in evidence at the moment and consumers are very sensitive to price, so they are quite happy to sacrifice factors such as convenience for a cheaper deal. One interviewee remarked that customer loyalty stood at less than 50 percent even for premium brands. China does not really have umbrella brands either, so there is definite potential for new brands to chase out established ones. The possibilities for building customer loyalty through digitalization are accordingly regarded as a great opportunity.

Chinese respondents see further new opportunities in the way that digitalization pressurizes organizations to develop new core competencies. As indicated by the experts from Japan (see Chapter 9.1.5), Japanese companies already view the cost-efficient production operations of their Chinese peers as a threat. A significant opportunity thus exists for any Chinese company that can successfully build up expertise in the creation of high-quality products. Several experts attached great significance in this context to the possibility of companies using digitalization to expand on their existing role as flexible and fast-moving manufacturers.

9.3.5 Japan

The Japanese experts judge cost reductions due to efficiency gains to be the most important of the opportunities associated with the digital transformation. Respondents saw Japan as being less enthusiastic about innovation and disruption with regard to new products and services (as already related in the survey analyses in Chapter 4). Japanese companies are much more likely to see themselves as the ones that perfect new developments in every respect, including costs and efficiency. Companies strive to manufacture the highest quality product with the lowest costs. According to the statements of the interviewees, innovations do not come directly from the SME level and only gain widespread acceptance if large corporations have a need for them. This stems from the close relationships between companies and the prevailing corporate culture (see box text "Japanese corporate culture").

The second most important opportunity in the opinion of the experts was the possibility of increasing share of value added by expanding an existing role and/or developing a new one. The experts expect increasing their interest in software to be the main way that companies will be able to boost their share of value added and expand or even redefine their role in the value creation process. It is anticipated that this will

304) https://de.allyouneed.com/de/home.html

Japanese corporate culture

The Japanese economy includes a strong SME segment, large companies and true multinationals. The primary objective for SMEs is to partner with the large companies – to become a part of the corporate family, in other words. There is little sign of SMEs endeavoring to remain independent, grow their business internationally and perhaps become one of the big fishes themselves. Even companies that have chosen this little-frequented path tend to align themselves closely with the practices of the sector's big beast, which means that the major conglomerates effectively call the tune for their entire industry.

While Japan's SME segment is certainly innovative, the conventions described ensure that innovations need the backing of one of the large companies in order to break through. When a big company does pick up an SME's innovation, furthermore, the SME usually finds itself absorbed into the corporate family such that the innovation concerned is not then sold on to either competitors or companies from other sectors.

Once the SME has joined the family, of course, it is not going to push through disruptive innovations because these could harm the parent company. Even SMEs that have yet to tie-up with a large company will tend to encourage incremental rather than radical inventions.

require new employee roles to generate extra value added and deliver new products or services.

"The automotive industry has always featured traditional roles with engineers, salespeople and so on. Digitalization is going to necessitate new roles such as strategic planners, data scientists, market researchers and systems engineers. Large OEMs have begun to build up these areas, but there are still too few experts around."

A classic example of this would be the analysis of usage data to identify information about trends and patterns of behavior that can be exploited to improve the customer experience. Here too, however, conflict can be expected with regard to how this data is handled (see box text "Background – Personal data in Japan" in Chapter 9.1.5).

Possibilities for creating new cross-sectoral value creation networks emerged as the third most important opportunity for the Japanese interviewees. The respondents expect interaction between companies, customers and component suppliers to increase as a result of digitalization. Another expert anticipates that the automotive and logistics industries in Japan are going to begin to work even more closely together. According the interviewees, combining industry infrastructure/systems and IT will also make service ranges with cross-selling potential a possibility. The respondents include government initiatives among the possible initiating factors for these cross-sectoral value creation networks.

9.3.6 South Korea

Like their counterparts in Japan, the South Korean experts considered cost reductions due to efficiency gains to be the most significant opportunity. There is a pressing need to cut costs and the experts believe digitalization presents new possibilities for cost savings, not least by facilitating more affordable trial and error approaches.

"Costs need to come down and digitalization makes it possible to cut costs, for example by using simulations."

The chance to access new markets and customers was identified as the second most important opportunity. The shift toward B2C is very clear in South Korea,

mainly because South Korean society is highly digitalization-friendly and very curious about new developments. South Korea has considerable advantages over the German software industry in the B2C area because the latter, in the context of mechanical engineering and logistics at least, is still largely focused on B2B. The experts surveyed observed in this connection that collaboration between these two countries could substantially enhance and expand their respective existing strengths.

New possibilities for customer retention proved to be the third most important opportunity in the view of the companies surveyed, which felt that access to customer information and usage data would enable them to make better forecasts and thus understand and meet the needs and wishes of their customers more effectively. The companies regard this as an opportunity because they believe that satisfying customer requirements produces the elevated customer satisfaction they need to have a chance of building customer loyalty. The new forms of scalability for products and services opened up by digitalization shared third position in the ranking for the South Korean companies surveyed.

9.3.7 USA

When the experts in the USA were asked about the leading opportunities digital disruption harbored for their companies, the most common response was the new forms of scalability for products and services (a factor that generated relatively little excitement in virtually all of the other regions). The US respondents spoke in particular about the low cost of scaling and about how this makes it possible both to expand and to shrink the product range in response to demand. Companies need to be able to meet unexpected spikes in demand quickly and to trim back their offer just as quickly if demand begins to slide. Scaling provision in this way enables relatively small companies (Airbnb, Uber and Instagram, for example) in particular to make their proposition available worldwide in a short space of time at low cost. Software also facilitates greater flexibility by enabling new or supplementary hardware functionalities to be added (software-defined hardware).

> *"Integrating and configuring different features by software means is much more scalable and flexible than by means of physical products."*

Second position in the ranking of opportunities was occupied by the possibilities for accessing new markets and customers. The advance of digitalization is making it easier to test, simulate and purchase products and services. The ability to identify customer requirements that have not been met as well as those that have makes it possible for actual customer demand to drive development and innovation activities. This gives companies the opportunity to target their activities much more specifically. The experts also assume that new markets associated with the gathering and analysis of customer and usage data will emerge and that these will involve a variety of companies.

Possibilities for creating cross-sectoral value creation networks proved to be the third most commonly cited opportunity. Digitalization and the associated technologies enable niche providers in particular effectively to pool their organizations and their services virtually and offer their specialist skills as part of a broad range of products and/or services. The respondents see opportunities in the area of technology transfer between industries along the value chain on this basis. Features and developments from automation in areas such as aviation or robotics might be transferred to the automotive industry, for instance. One of the people interviewed referred in the context of cross-sectoral alliances to the collaborative arrangement between Fiat Chrysler and Google, which could facilitate the development of a completely new value creation network.

The respondents recognized the opportunity presented by the possibility of creating new ecosystems as well as the potential advantages of creating cross-sectoral value creation networks. Tesla has extended its own ecosystem by adding energy storage solutions for domestic applications, for example. From Tesla's point of view, the acquisition of SolarCity provides a gateway into the solar power sector that would open up attractive opportunities for what would be the world's only vertically integrated energy company in the renewables sector. [305]

305) https://www.teslamotors.com/de_DE/blog/tesla-makes-offer-to-acquire-solarcity

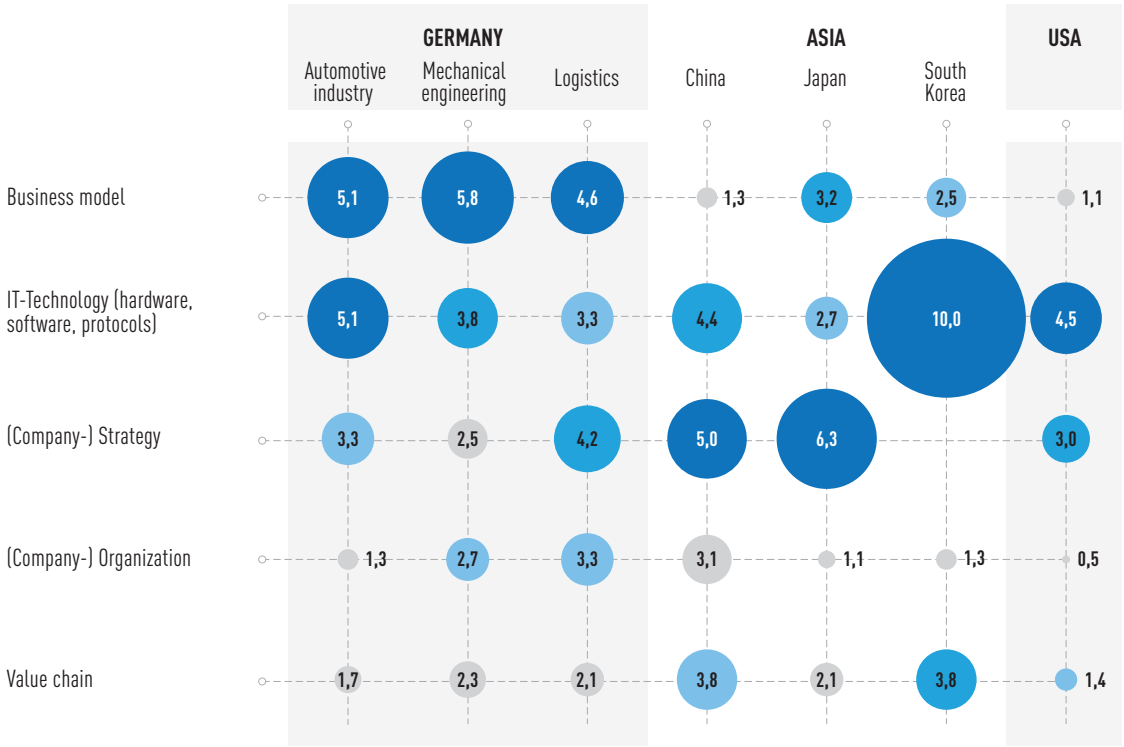
9.4 | Strengths to be established

The interviewees were asked about required strengths[306] that would need to be established or enhanced in order to make a success of the digital transformation. Changes to the business model are the main factor associated with this transformation by the German interviewees (see Chapter 4). This and the weaknesses indicated lead the German experts to regard the business models and associated skills as the most important strengths to be established. The ability to refine the corporate strategy ranked among the three most common responses for all of the sectors surveyed in Germany apart from mechanical engineering. IT and corresponding skills were cited the world over as a key strength that companies would have to establish in order to be able to make use of the opportunities opened up by the digital transformation.

Although the German companies expect digital disruption to transform value chains and value creation networks (see Chapter 4.2.1), they appear not to view changing these chains and networks as a priority. Their counterparts in China, South Korea and the USA, however, attach considerable importance to refining/altering value chains. The interviewees in just about every country recognize a need to build up skills in the field of corporate strategy development as well. The authors would suggest, however, that company organizational structures must also be refined with regard to digitalization in a parallel process so that the new and amended strategies developed can also be implemented (as highlighted most notably by the German logistics companies and mechanical equipment manufacturers).

Abbildung 48: Overview of the strengths to be established as identified by the interviewees

The priorities as regards the areas for action are presented aspect by aspect in graphic form to give a clearer idea of their respective relevance and to simplify comparisons. The commonest responses are highlighted in color.



306) The interviewees were not asked about companies' existing strengths.

9.4.1 Automotive industry – the German perspective

The most important competency to be established in the view of the German automakers is the ability to refine business models. The companies surveyed believe that acquiring skills relevant to digital business models is the most important priority as they seek to conquer the identified weakness of potentially being too slow to play a defining role in digital ecosystems. Decision-makers struggle with the risks associated with new digital business models though. Implementation is often judged to be problematic, with the established structures in relation to customers, dealers and component suppliers making it difficult to push developments through with the necessary consistency.

The current revenue model of the automakers revolves around selling cars. As already described in detail in Chapter 3, models based on use rather than ownership could give the automakers a new role. These models would be quite different to the defined revenue structure of the existing leasing models, however, because at the moment leasing serves primarily to stimulate vehicle sales. Data and data analysis are felt to be essential by the automakers so that they can evaluate and develop pay-per-use or pay-per-failure (a payment is made for every fault in customer products manufactured using machinery from the service provider) business models and assess their cost-effectiveness. Big data techniques can also help to establish a more complete overview of end customer usage behavior.

> *"Regarding big data, it is vital to know your customer. BMW only knows component suppliers and dealers."*

These factors are also seen as a basis for involving customers more closely in the development of vehicles and vehicle functions (open innovation), although it was stated that this would require a more active customer relationship with clearly defined interfaces. These issues are discussed in detail in Chapter 3. Data-driven business models present a good opportunity for German startups to break into the automotive market and are accordingly a matter of great interest. Many young companies are currently working to improve the value of their information, through various methods, and to refine their business models over time through a process of trial and error. These companies benefit from the flexibility that comes with having scarcely any path, customer or product dependencies and are able to adapt faster to desired requirements without the encumbrance of large historical investments.

The German automakers surveyed were as concerned about building up IT competence as they were about their capabilities in relation to business models, with the improvement and development of software and interfaces their main focus. Autonomous vehicles, for example, present new requirements for IT-based test systems, not least in order to manage the extremely large number of test scenarios needed. Investment is also required in the resources necessary to understand and use the data generated by the car (see Chapter 5.4.1).

Data ownership is an important issue for automakers in this respect, as while some strategic partners do (still) allow free access to data, large IT companies like Google do not (see Chapter 3). One expert remarked that companies with a large and productive existing customer base could find it more difficult to invest in new technologies, to bring in resources for this purpose or to build up new competencies. The development of new functions creates additional demands on IT and it is of course essential that the solutions developed remain profitable (see Chapter 6.4 regarding path dependence).

The second most important competency to be established involves corporate strategy. The respondents indicate that a rethink of corporate strategy has to be a particular priority for companies adapting to digitalization. Corporate strategies need to reflect the fact that the digital transformation represents one of the central strategic challenges for the coming years. It entails a wide range of transformation processes including both digital enrichment and expansion of companies' portfolios and significant organizational changes (see Chapter 5.4.1).

9.4.2 Mechanical engineering – the German perspective

Capabilities in relation to business models were also the most commonly cited strength to be established among the experts from the German mechanical equipment manufacturers. Respondents here felt that adapting business models was vital in order to capitalize on the potential of the new (digital) opportunities for value creation. The increasing number of additional services supplementary to the actual product too makes developing suitable new business models and extending existing ones a priority for this sector. The need to take a thorough look at business models involving multiple different elements was also mentioned in this connection. The experts are of the opinion that IT support will be required to realize the organizational changes regarded as going hand-in-hand with the changes to business models.

"A change in the business model changes the organization itself. This requires IT – and it requires creative ideas to guide value creation."

IT came second in the order of priority and is regarded by many of the experts surveyed as a key aspect, for example to augment production technology and facilitate the realization of "production as a service" approaches and the like (see Chapter 5.4.2). It is clear from the interviews that it is necessary to put in place not just the interfaces, protocols and communication infrastructure, but also the associated skills (data processing and analysis, software development). The difficulty of acquiring sufficient suitable, qualified personnel was raised in this connection.

"Data skills and, most of all, people – the supply is inadequate and existing resources are at full capacity."

The ability to adapt the organizational structure is regarded as the third most important strength to be established in the mechanical engineering industry. This sector is more or less dominated by small and midsize companies and the respondents emphasized the advantages with regard to corporate structure this confers over larger organizations in terms of leanness and efficiency in the promotion and implementation of innovative changes. The mechanical engineering sector generally has a more rounded picture of the competencies required than the other sectors. IT is needed as an enabler for the development and implementation of new business models. Changes in how companies are organized are an inevitable consequence of the growing success of innovative business models.

9.4.3 Logistics – the German perspective

The German logistics companies, like the German automakers and mechanical equipment manufacturers, referred most often to business model development as the most important strength to be established. Only with a suitable business model in place is it possible to generate additional revenues out of digitalization, so the ability to devise and refine business models is a key driver. The forecasts for this sector (see Chapter 5.4.3) make it clear that the deployment of new revenue models is a particular priority among the companies surveyed.

The ability to enhance corporate strategy came second in the ranking of strengths to be established. Despite assessments suggesting quite significant progress, the interviewees' disclosures indicate that some logistics companies still lack any kind of digital strategy and need to take urgent steps to rectify this. The logistics companies differ from the mechanical equipment manufacturers in that the former regard the customer interface as quite remote.

The expert responses rank IT third on the list of strengths to be established, but the logistics industry does not consider a lack of suitable specialists to be a problem. Most in demand are computer scientists who understand how to utilize IT. Making proper use of the results, however, requires data analysis specialists as well as people who know how to integrate IT, a factor that appears not yet to be a priority for the companies surveyed in this sector. Greater use of IT is also expected to yield efficiency gains. According to the experts, companies need to learn more about the use and significance of relevant technologies before adapting their corporate structures.

9.4.4 China

The ability to refine the corporate strategy is the most important strength to be established in China according to the experts. Senior managers in China are keeping a particularly close eye on developments in the area of Industry 4.0 in Germany, especially with regard to digital strategy in mechanical engineering. This relates not just to IT, but also to technology in general and in some cases to entire companies, as the Kuka[307] example demonstrates.

The second most important strength to be established in China according to the responses received is IT capability. It was reported that efforts are already underway to build up the necessary skills through in-house employee training.

> *"It is critical not simply to provide the technology, but to ensure that employees are trained in how to use it."*

According to the interviewees, companies intend, with this in mind, to develop their creative capabilities as well to increase output of inventions and promote innovation long term. Third in the ranking of strengths to be established according to the experts came the ability to develop suitable value chains and increase their efficiency.

9.4.5 Japan

The most commonly mentioned priority strength to be established among the experts in Japan was the ability to refine the corporate strategy to exploit the opportunities created by digitalization. Digitalization can affect all of a company's activities, so a comprehensive strategy is essential in order to make full use of the potential of ICT. Any gaps in the skillset in this area could otherwise become a clear weakness. The Japanese experts surveyed recognize strategic questions in relation to how best to use the new technologies and view decisions in this regard as a potential differentiating factor.

Business model development capabilities rank as the second most important strength to be established based on the survey results. Some experts identify developing a sustainable (digital) business model that shifts the focus of the business to other areas as a significant strategic objective. Putting strategy into practice appears problematic though.

> *"Strategy is a key issue for management and implementation is very difficult, but it is important in order to achieve the change necessary."*

There is still some uncertainty among those surveyed as to how IT can be used to create value within their particular company (for example how data can be utilized and monetized).

Third in the ranking of strengths to be established came IT capabilities. Respondents spoke of the need to acquire data processing and analysis skills, software development capabilities and expertise in the use of protocols and standards as well as the need for corresponding infrastructure. The prevailing corporate culture in Japan remains such, however, that proprietary standards without open interfaces are still very often the preferred option. Companies follow this path in an attempt to retain complete control of every single process step and thereby ensure that they live up to their own expectations in terms of quality. IT is, however, already highly regarded as an enabler of new business models.

> *"The technology will be the vehicle with which to implement the strategy and with it the business models."*

The companies surveyed view striking the right balance between control and openness to experimentation as a major challenge because IT is considered to be the most demanding and fast-moving field.

307) http://www.heise.de/newsticker/meldung/Midea-uebernimmt-Kuka-nach-stuermischen-Reaktionen-fast-geraeuschlos-3269844.html

9.4.6 South Korea

The experts surveyed in South Korea were most concerned about building up expertise in IT. IT infrastructure was felt to be very well developed in the country, but the experts were particularly troubled by the lack of IT-based services and skills, which they believe lag behind those of other countries. The reasons advanced to explain this situation included the strict regulatory environment. It was also posited that the education system largely fails to allow scope for creativity, which results in a shortage of innovative applications and services.

The value chain was the second most commonly cited area in the context of establishing strengths for the future. According to the interviews, the use of IT in this connection allows companies to gain a better understanding of customer processes and makes it easier to optimize the value chain, for example with regard to communication.

The responses received indicated that business model capabilities were the third most important strength to be established in the opinion of the experts. These experts expect that the logistics sector will see an even stronger move toward e-commerce in the future.

9.4.7 USA

The respondents in the USA regard IT capabilities as the most important strength for companies to establish in order to be able to make use of the opportunities opened up by the digital transformation. These capabilities furnish the basis for all of the other areas and the experts consider it absolutely necessary that they are understood at least to an extent.

> *"You have to understand what one can do to implement a strategy. Many companies have a nice strategy, but if the mindset does not change, it will not work."*

The ability to refine the corporate strategy ranked as the second most common response among the experts surveyed. The responses indicated in this connection that companies' mentality and culture (collectively referred to as "the organization") also need to change in order that new strategies can actually be implemented successfully. Strategy in this context is driven by data and findings pertaining to customer behavior.

> *"The strategy is of course driven by the data and the knowledge of what the customer does."*

One of the experts surveyed pointed out that sensors and communication systems, for example, were far more effective than any questionnaire. Digitalization has implications for just about every area of a company – from the question of how customers are targeted and products manufactured to the development process and other functions. Capabilities still need to be built up with this in mind so that new business models can be designed and properly integrated into the strategy.

The responses received to the survey showed that obtaining a better understanding of the opportunities associated with digitalization for improving and enhancing the value chain was the third priority in terms of strengths to be established. Awareness needs to be raised among customers of the capabilities, products and services companies are able to offer. This means creating greater understanding of the fact that providers in the manufacturing industry are able to offer services additional to the actual manufacture of products, such as problem-specific designs or proposals and recommendations concerning the choice of component suppliers. Digitalization paves the way to much greater flexibility and dynamism in this respect.

9.5 Summary of the key statements

The cross-sectoral factors for the German companies as per the survey responses described above are summarized in the following and the way that these factors relate across the areas considered is discussed. *Figure 49* revisits the key statements made in relation to the four areas considered: strengths to be established, opportunities, weaknesses and threats.

The specified strengths to be established can be analyzed to deduce relevant cross-domain priorities for Germany from the companies' perspective for the development of capabilities to counter the threats indicated. It appears to be critically important for the German industries to develop new or enhanced digital business models. Threats exist in this connection in the form of dependencies that inhibit radical change, but data is unquestionably going to play an ever more important role.

The experts, mindful of this fact, believe that it is also very important for companies to build up data handling capabilities (acquisition, analysis, ownership rights and rights of use). This also includes capabilities in relation to software (development) and interfaces, with the customer interface in particular being seen as an opportunity to build loyalty to the company and involve customers more actively in the development process. Organizations themselves also need to move forward (or digitalize) according to the experts in order to be able to respond effectively to the growing competition faced, most notably from the software field. Strategy too needs to be adapted, principally to accommodate the socioeconomic developments linked to digitalization.

Regarding the weaknesses identified, it is clear that German companies are often very restricted when it comes to thinking in terms of new digital business models. This is due partly to their large and productive existing customer base and partly to their technology-centric way of thinking and the corporate structures and guidelines that have evolved over time. The existing structures – and the bureaucracy and skepticism that go with them – are in some cases also apportioned a share of the blame for the inertia affecting the implementation of ideas and innovations and indeed are even viewed as a threat in some instances. Companies concerned about their lack of digital capabilities often mention that the specialists they need in this connection – not least in order to counter the identified threat of core competencies being eroded – are simply not available. Concerns about coping with short innovation and development cycles result in part from the fact that new development methods (scrum and agile, for example), have yet to be implemented. A further weakness identified by the experts is a reluctance to use open interfaces, which are one of the fundamental resources for implementing (data-driven) digital business models. The effort needed to build up the IT and related skills required for this purpose has already been mentioned in the context of strengths to be established.

The experts judge that the opportunities presented by digitalization essentially revolve around targeting customers and responding to their needs. Associated factors include new ways to reach customers and the growing prosumer markets. The (usage) data already mentioned in the context of strengths to be established plays an important role across the board in this connection.

The chance to assume a role in or help to shape digital ecosystems is also regarded as a great opportunity, as these ecosystems make it possible to pool activities (including activities provided by different/complementary partners) and meet customer requirements more comprehensively. Appropriate services, moreover, enable companies to establish an interface to the customer – with all of the aforementioned possibilities (see Chapter 6). The experts identify new, more straightforward possibilities for product and service differentiation associated with the increasing use of software too, although the readily scalable nature of these new options appears not to strike them as important. The spread of IT across the production domain makes it possible to improve production efficiency and as a result to reduce unit costs and/or improve quality.

Some of the threats mentioned, such as the erosion of core competencies and the growing influence of large corporate groups from a software background that already have strong ICT capabilities, have been discussed previously and the potential options referred to by the experts for countering these threats have also been addressed.

Figure 49: Key statements from the interviews concerning strengths to be established, opportunities, weaknesses and threats

Suitable platforms and platform-based ecosystems additionally make it possible to identify trends that are spreading across domains. The ability to identify such trends and respond to them quickly can confer critical competitive advantages – and poses a corresponding threat for competitors.

CHAPTER 10

Conclusions and suggested next steps

Digitalization will impact on and fundamentally change all areas of the economy and of society. The changes it brings place a particular focus on the desire for self-determination with regard to the satisfaction of unmet needs of the individual as consumer and political actor (see Chapter 8).

The primary implication for companies is that integrating technical and organizational processes can open up new ways of delivering customer benefits in products and services. The market will see a shift from a sender-focused approach to a recipient-focused approach as this transformation progresses and it will become necessary to combine traditional technology-based functions with customer-centric business models as a result.

Achieving this shift will necessitate not only the widespread availability of powerful low-cost hardware, but also the development of a variety of different software solutions capable of being combined with each other as required – especially for tasks involving the automated extraction of information from large volumes of data. These technologies will make it possible to automate processes and, much more importantly, enable companies to bring previously unheard of levels of versatility and customization to individual business processes, products and services at very low cost and to adopt associated novel business models.

Cloud-based approaches have an important role to play, as do digital platforms, which are essential in terms of technical integration and bringing together value creation networks of users, suppliers and service providers. Opening platforms up to new players paves the way for more valuable services based on existing functions and increases the attractiveness of the platform for users. It also creates new revenue models for the platform operator and platform-based services offered by the operator itself or third parties.

Creating open ecosystems based on platforms can lead to companies cannibalizing their own market share, but this action can also safeguard the company's very existence in the longer term.

Making this step involves not only a strategic realignment of the company's existing portfolio, but also the development of elementary digital capabilities – changes that necessarily entail overhauling a company's established organizational structures and corporate culture as well. The resulting transition away from static, product-oriented value creation structures in favor of dynamic, service-oriented value creation networks increasingly requires companies to move away from the traditional customer/supplier, manufacturer/component supplier and partner/competitor relationships and think instead in terms of flexible platform ecosystems.

The creation of open ecosystems through the establishment of digital platforms can represent a quantum leap in cooperation for convened bodies in which multiple players work together. The authors believe that if Ger-

Illustration: © Mimi Potter – fotolia.de

many is to manage the digital transformation successfully, it urgently needs an ecosystem conducive to creativity to bring together and foster cooperation and discussion between the various stakeholders from politics, business, academia and society. All of the prerequisites for a transformation of the political system have been met too (see Chapter 8), so the political sphere should recognize that it is not beyond the reach of digitalization and make the digital transformation of the state a central element of its activities and processes.

It should be reiterated in this connection that digitalization is not a product in and of itself; it is merely an efficient technological basis for the demand-led ascertainment and satisfaction of citizens' specific requirements. Digitalization could be used negatively for the purposes of demagogues or positively to further the cause of freedom and democracy.

The descriptions and analyses reveal various areas to be targeted in seeking to assume a proactive and sustainable role in the shaping of these developments. Key factors in the spheres of "science and research", "business and industry" and "politics and society" that entail opportunities to shape developments are presented in the following (see *Table 4*).

Table 4: Summary of the opportunities for shaping developments in the spheres of "science and research", "business and industry" and "politics and society"

	Area of action	Brief description
Science and research	Development of new technologies for functional safety in autonomous systems	New technologies (development methods, agile system development, machine learning, etc.) cannot be deployed in the absence of verifiable inspection and testing procedures, which are required not least in connection with liability issues associated with the official approval of autonomous systems.
	Provision of mechanisms to increase the trustworthiness of data-intensive systems	The use of data by third parties – both private use and, in particular, industrial use – presupposes an adequate level of trust in how data will be handled.
	Creation of an information infrastructure for platform-centered ecosystems	Value creation networks for the provision of information-intensive services and products that span organizations and sectors require a homogeneous information infrastructure.
	Investigation and promotion of collaborative and distributed value creation structures	The ubiquitous availability of computing capacity and connectivity now enables individuals all over the world to work together and exchange services, for example on a peer-to-peer (P2P) basis.
	Development of a robust transformation strategy based on maturity	Relevant research activities are needed to assist and facilitate companies' progress through the "digital transformation" change process.
Business and industry	Evolution of products and services to create product-service systems (PSS)	PSS are a prerequisite for flexible customer-focused data-driven scaling and differentiation of the service range.
	Stronger focus on the end customer	The complex and highly fluid nature of performance relationships in value creation networks is blurring the boundaries between B2B and B2C business relationships.
	Establishment of shared platform ecosystems for digital products and services	Platforms stand at the heart of data-intensive digital products and services. They are the foundation on which ecosystems are raised.
	Digital forms of collaboration for open ecosystems	The innovative strength of startups, SMEs and industry associations must be mobilized in relation to digitalized products and services with heterogeneous (purely commercially oriented) organization forms.
Politics and society	Digitalization of the work of convened bodies – platforms, forums, working groups	An ecosystem based on methods and technology needs to be developed to support integrated, effective and efficient collaboration and decision making across the various players from politics, business, academia and society in and between the relevant convened bodies.
	Implementation of innovation projects for the political sphere and prominent positioning of the digital transformation of the state on the political agenda	Politicians should not overlook their own domain when considering innovation projects (they can only gain credibility by learning from their own experience). The political sphere has more scope than any other to shape the course of developments and the vital resource it represents should be made a priority and a focal point of innovation. There also needs to be a concerted effort to ascertain, discuss and tackle the challenges inherent in a digital transformation of the state, the implications of these challenges (in terms of content, structure and process) and related potential solutions for the „digital Federal Republic".
	Strengthening of digitalization skills in education, training and personal development	A basic understanding of the possibilities of information science and an elementary grasp of key informatization technologies are becoming essential core skills for disciplines within and beyond the traditional ICT field.
	Strengthening of public digital infrastructure	In the context of highly distributed processes, activities typical of private sector interactions, such as the processing of commercial transactions, should be mirrored by corresponding public services, such as the verification of organization identities or entry in official registers.
	Provision of a clear legal framework for digital ecosystems	Digital and data-driven ecosystems need clear regulations governing responsibilities between network partners due to their complex value creation relationships and information-based products and services.
	Encouraging the move into digitalization	Companies (especially SMEs) need to be supported with the strategic build-up of capabilities required to take advantage of the technical, organizational and, most significantly, commercial opportunities that come with digitalization.
	Encouraging open innovation	The definition of standardized interfaces and the open source development of functions that have no impact on competitive distinctions are vital cross-company innovations for ecosystems.

10.1 Science and research

Data-centered platform ecosystems are being created in the sectors studied, as described in Chapter 7. Emerging within these ecosystems are information-based products and services that open up the possibility of new business models with a differentiated and dynamically adaptable value proposition and that rely, in terms of the competitiveness of the companies involved, on access to relevant customer information. The recommendations with respect to research accordingly concentrate on investigations likely to yield results involving drivers of commercially attractive product and service ecosystems, in particular in technology-intensive sectors. These ecosystems are significantly affected by commercial and legal factors as well as technical factors, so the subject areas identified are intentionally interdisciplinary in nature.

10.1.1 Development of new technologies for the functional safety of autonomous systems

It is current convention when developing software-intensive systems with demanding functional safety requirements of the type found in the automotive and automation industries, for example, to prefer technologies that stick to well established, tried and tested procedures and methods. If new technologies – including development methods such as proper agile system development and technical software-based methods such as machine learning – are to be used, however, there must be a comprehensive and scientifically verifiable case for their reliability so that they can demonstrably be trusted in the context of official approval, including from the point of view of liability.

There is not as yet though any robust scientific assessment as to the applicability of many of these technologies, for example in the form of findings regarding the quality of statistical methods such as deep learning, outside of the training data space. Official approval procedures (for example ISO 26262 "Road vehicles – Functional safety") require an evidence base of this type (see Chapter 6.5). Also lacking are suitable approaches for embedding these new methods into the traditional development process, for example using appropriate architecture-based avenues with graded safety concepts. Most significantly, the distinction between the design and operation phases still remains and the development and runtime environments are not sufficiently integrated in the area of functional safety. These deficiencies are a particular problem in the context of adaptable automation and also in relation to the use of cloud-based technologies as required in the Industry 4.0 setting.

Countries including the USA[308] and others tend to be open to the introduction of new technologies even in safety-critical areas if there are evident advantages (see Chapters 5.2 and 6.5). The use of new technologies in software-intensive systems with demanding functional safety requirements in Germany, however, necessarily involves a very thorough examination of the issues involved, in large part due to the exacting national safety standards in force. The timely promotion of academic activities in the relevant areas of interest, in close cooperation with potential users in industry, could deliver advantages – in terms of quality and verifiable safety performance – significant enough to carve out a strong competitive position internationally.

The authors therefore recommend that a government support program be established for joint academic/industrial projects to put in place the engineering-specific necessary conditions for the industrial application of new technologies in software-intensive systems with demanding functional safety requirements. One particular objective of such a program should be to bridge the gap between the design and operation phases. This could be achieved through closer examination of machine learning methods, dynamic architectures (all the way to the cloud) or the use of run time models, for example.

308) cf. in this respect the USA's 15-point federal checklist for self-driving cars (http://www.nytimes.com/2016/09/21/technology/the-15-point-federal-checklist-for-self-driving-cars.html (accessed on September 20, 2016)

10.1.2 Provision of mechanisms to increase the trustworthiness of data-intensive systems

The realization of flexible and customizable processes using digital platforms, among other resources, depends to a high degree on the availability of suitable data. The use of data by third parties – both private use and, in particular, industrial use – presupposes an adequate level of trust in how data will be handled. Factors such as data confidentiality, integrity, availability and authenticity play a critical role in this respect.

Creating the environment required demands flexible management of access rights including the highly granular allocation and restriction of access rights on the basis of temporal, geographical or organizational parameters. Equally, it is essential in particular that the identity and reliability of data sinks, data sources and data aggregators and the availability of reliable information be assured, especially in the context of complex dynamic systems like the Internet of Things. Data-intensive systems are increasingly being used in the field of functional safety, so the quality of the information provided and its timely provision are very important alongside the fundamental aspects of information security. The issue of trustworthiness needs to be considered too, with particular attention paid to technologies for decentralized structures such as Distributed Ledger Technology (that is to say services based on blockchain technology). Also required is work to clarify relevant legal aspects including rights of use and liability as regards the quality of data made available.

The existing technical and legal conventions are adequate in a traditional product-oriented approach with clear system boundaries for a value creation architecture and system architecture dominated by the manufacturer as overall integrator. A lack of suitable methods is hampering the type of innovative activity needed to create new data-intensive services in open, complex and dynamic ecosystems (of which a distributed structure is a particular feature). This applies equally to the European private customer market, which is sensitive to privacy issues, and to the market for industrial customers, which is marked by tough competition and great pressure to enter into collaborative arrangements (in order to establish shared platforms/ecosystems). Promoting research into innovative mechanisms to increase the trustworthiness of data-intensive systems – including the definition of legally binding regulations – and providing such mechanisms fit for use in the industrial setting could help to establish German industry as a leading provider of reliability solutions for data-intensive systems and services. This would simultaneously remove one of the main barriers to innovation.

The authors therefore recommend that a government support program be established for joint academic/industrial projects to provide industry-ready mechanisms for the reliable use of data-intensive services in distributed and collaborative systems. Activities in this area should specifically include features of open, complex and dynamic ecosystems, the management of rights of use in varying temporal, geographical and organizational contexts, the reliability and quality of data used for systems with functional safety implications and trust management for systems such as the Internet of Things. Consideration must be given not only to the provision of the technical services, but also to the associated legal regulations and their application in practice, especially for small and midsize companies.

10.1.3 Creation of an information infrastructure for platform-centered ecosystems

Information-based products and services in technology-intensive sectors are reliant on trustworthy IT and legal mechanisms as regards data provision and use. The added value for users of such products and services, however, rises sharply when the data concerned is aggregated and processed to extract information (for example when measurement data from the manufacture of a product is combined with measurement data for the product in use to generate information about the predicted remaining service life). Inter-organizational and cross-sectoral value creation networks for the provision of information-intensive services and products require a homogeneous information infrastructure, key benefits of which include the ability to interpret information consistently by means of the standardized annotation of metadata as well as the provision of appropriate aggregation methods such as classification and correlation.

Creating an economically viable market model for information services or products in technology-intensive sectors using this infrastructure means taking particular account of how information affects competition in such an ecosystem: access to specific data that allows reliable aggregation generating more valuable information (for example for use in improving traffic safety) and sufficiently granular restrictions on interpretation that prevent the information obtained potentially becoming available to third parties (for example data and information of relevance to a specific business) are both key features of this type of infrastructure. The provision of a trustworthy infrastructure enables the providers of data-driven products and services to use third-party data to offer their customers innovative functions utilizing their domain competence without threatening the business model of third parties. This not only makes the providers concerned more competitive in the relevant application domains, but also creates opportunities for collaboration between companies. The possibility exists, moreover, to establish a dedicated market for such forms of information services.

Just as in the case of the mechanisms associated with the trustworthiness of data-intensive services, there is more to consider in the context of infrastructure for information ecosystems than the IT factors alone. Legal issues are again relevant, in this case with respect to the ownership and use of aggregated information in particular, and so are the value and added value of aggregated information in corresponding market models.

The authors therefore recommend that a government support program be established for interdisciplinary joint academic/industrial projects to provide an infrastructure, in the form of methods and technologies, for aggregation services in information ecosystems. Consideration must be given in this connection both to suitable aggregation methods for different aspects, such as real time or data quality, and to the mechanisms for consistent data interpretation, such as data ontologies. The development of technical solutions in comprehensive approaches should be included in the terms of reference as well and so should potential market models, especially for startups, and the legal ground rules for interactions between service providers and service users and their implementation in practice. The Industrial Data Space[2] research project, for example, is developing a reference architecture for open data platforms incorporating initial use cases. The joint projects recommended could potentially take this as a starting point.

309) https://www.fraunhofer.de/content/dam/zv/de/Forschungsfelder/industrial-data-space/Industrial-Data-Space_whitepaper.pdf

10.1.4 Investigation and promotion of collaborative and distributed value creation structures

Collaborative and distributed value creation structures form the basis for platform-centered ecosystems and other novel value creation models. The ubiquitous availability of computing capacity and connectivity now enables individuals all over the world to work together and exchange services on a peer-to-peer (P2P) basis.

The efficient and scalable technical mechanisms created to support financial transactions, most notably involving cryptocurrencies such as Bitcoin, also lend themselves to use in connection with collaborative and distributed value creation structures:

- traceable transactions where the identity of the implementing parties is protected;
- decentralized performance of transactions in large networks of nodes not organized according to any hierarchical structure; and
- a distributed, consistent and trustworthy register for transactions (a "ledger" based on blockchain technology).

The extension of these basic technologies, for example using smart contracts (machine-processable contracts whose performance can be automated) paves the way for the realization of distributed systems. These smart contracts orchestrate the physical and virtual processes, distribute them, in part fully automatically, across a large network of nodes and ensure that they are implemented. Cyber-physical systems realized using appropriate platforms (Ethereum in cooperation with Slock.it and RWE,[310] for example) thus open up the possibility not just of creating novel collaborative and distributed value creation structures, but also of realizing decentralized forms of organization extending all the way to decentralized autonomous organizations (DAO). DAOs are organizations that are able to offer services combining high scalability and very low marginal costs completely automatically by means of embedding functions of data-intensive and information-intensive systems in complex business processes.[311] The TransActive Grid platform in Brooklyn,[312] for example, automatically coordinates and optimizes energy supply and demand in an open network of participating prosumers on a P2P basis.

The creation of collaborative and distributed value creation structures all the way up to the level of DAOs appears to be technically feasible. Reliably implementing services that involve complex interactions between a large number of process steps described and automated by smart contracts, however, represents a significant challenge, as the hacking of one of the first DAO implementations recently demonstrated.[313] Scarcely any methods have been produced so far that facilitate and support the verification of properties of services provided in this way and there are questions to be answered regarding robustness in the face of potential problem scenarios and compliance with (for example legal) process specifications.

An ongoing decline in transaction costs for distributed and collaborative forms of value creation is increasing their appeal for certain tasks, but these organization forms have yet to make any real impact on the economy. Their (future) significance, from an economic and business administration perspective, has yet to become clear, moreover, and their legal position also remains to be clarified. Most notably, the associated questions regarding liability, taxation and governance have yet to be resolved.

Mindful of the very import role collaborative and distributed value creation structures are expected to play in the context of future data-driven and platform-centered ecosystems, the authors recommend that a further government support program covering highly interdisciplinary academically-oriented joint projects involving both industrial and public-sector organizations be established in this area to consider in the round the IT, economic and legal aspects of reliable collaborative and distributed value creation structures in different forms and technical realizations. This could potentially bring forth a beacon project for integrated working within industry, with public-sector administrative involvement, that could tap into different modes of functioning such as the blockchain infrastructure already up and running in Estonia.[314]

310) http://www.coindesk.com/german-utility-company-turns-to-blockchain-amid-shifting-energy-landscape/
311) cf. https://blog.ethereum.org/2014/05/06/daos-dacs-das-and-more-an-incomplete-terminology-guide/
312) http://transactivegrid.net/
313) Jentzsch, C. (2016): The History of the DAO and Lessons Learned. URL: https://blog.slock.it/the-history-of-the-dao-and-lessons-learned-d06740f8cfa5
314) cf. inter alia https://cointelegraph.com/news/estonian-government-adopts-blockchain-to-secure-1-mln-health-records; http://bravenewcoin.com/news/e-estonia-initiative-progresses-with-blockchain-partnerships/

10.1.5 Development of a robust transformation strategy based on maturity

ICT-induced change in established sectors demands equally fundamental change in established companies. Companies need to be assisted and encouraged through this digital transformation process.

It is known, for example, that companies' structures are reflected, at least to an extent (per Conway's law[315]), in the products and services they offer. This enables organizations to provide current products and services efficiently, but makes it more difficult for them to develop and offer new products or services that require development and provision processes incompatible with their existing organizational structure (for example agile software development, rapid prototyping and DevOps). A model for assessing the maturity of organizations that permits conclusions to be drawn regarding the extent to which the enterprises considered are prepared, in structural terms, for ICT-induced change was developed and implemented for this study's survey of enterprises (see Chapter 5). The model has demonstrated its value over the course of the study with the maturity assessment, but no systematic validation of the model using case studies of different companies has been completed and no recommendation system for organization transformation measures pitched according to the level of maturity determined has been developed.

The proper adaptation of organization structures, however, represents one of the main challenges to be overcome in seeking to exploit the potential of ICT-induced change and there is thus a clear need for a catalog of maturity-matched organization transformation measures drawn up to reflect the specific requirements of small, midsize and large companies and the public sector and including robust validation using case studies of successful and failed transformations. This would make it possible to recognize and eliminate any dependencies, whether organizational, financial or psychological, that stand in the way of ICT-driven change. Research into necessary approaches for creating ambidextrous organizational structures or cross-subsidizing future propositions that potentially conflict with the established business is also required. Such work would demonstrate both the need for what could be quite radical self-cannibalization and a willingness to accept the implications.

The authors therefore recommend the development, as part of a government-supported initiative, of a catalog of measures based on this study's maturity model for the operationalization of company digital transformation strategies. The development effort should be an interdisciplinary academic undertaking, completed in close cooperation with industrial partners, that pays particular attention to technical, economic and psychological aspects. One possible starting point for the design of a digital transformation strategy already exists in the form of a package of questions[316] for the media industry:

Use of technology:

1. Strategic role of IT: enablement or support?
2. Technological ambitions: innovator, early adopter or follower?

Business model changes:

3. Degree of digital diversification: electronic sales channels, cross-media, enriched media, content platform or business extension?
4. Revenue generation: paid-for content, freemium, advertising or complementary products?
5. Future business focus: content generation, content aggregation, content distribution, management of content platforms or more?

Organizational changes:

6. Responsibility for digital transformation strategy: company CEO, business unit CEOs, company CDO or company CIO?
7. Organizational assignment of new activities: integrated or separate?
8. Focus of operational changes: products and services, business processes or capabilities?
9. Establishment of capabilities: internal, partnerships, acquisitions or external recruitment?

Financial aspects:

10. Financial pressure on current core business: low, medium or high?
11. Financing of new activities: internal or external?

315) „Organizations which design systems […] are constrained to produce designs which are copies of the communication structures of these organizations." Melvin E. Conway: How Do Committees Invent? In: F. D. Thompson Publications, Inc. (Eds.): Datamation. Volume 14, No. 5, April 1968.

316) Hess, T.; Matt, C.; Wiesböck, F. & Benlian, A. (2016): Options for Formulating a Digital Transformation Strategy. MIS Quarterly Executive, Vol. 15, No. 2, pp. 83-96.

10.2 Business and industry

10.2.1 Continuous evolution of products and services to create product-service systems (PSS)

Driven on by the rapid pace of digital innovation processes, user expectations in many branches of industry are changing at a rate significantly faster than can be met with traditional product cycles. Companies accordingly find themselves increasingly needing to develop "intelligent" products, which entail embedding digital components in traditional products. The effect of this trend on the automakers, for example, is that they have to deliver digital innovations over much shorter cycles and with a stronger customer focus (associated with direct customer feedback, for example concerning vehicle use). Such products must be designed so that changing and novel functionalities can be added by means of updates even after delivery to the customer in step with changing patterns of use and advancing technical possibilities (see Chapter 6.1).

The authors therefore recommend that industry take the steps necessary to ensure that its ICT-supported products are ready for future functions rather than concentrating principally on providing a wealth of preconfigured functions as at the moment. Essential steps in this connection include equipping physical hardware with digital interfaces, providing connectivity and replacing hardware-based functions with updatable software-based functions (mirroring the strategy of leading IT companies like Apple). Activities to market/raise the profile of preparatory technologies (such as Connected Car) or evolving functions based thereon (such as Tesla's Autopilot) are also required.

10.2.2 Increased focus on the end customer

The complex and highly fluid nature of performance relationships in value creation networks is blurring the boundaries in business relationships between company and end customer (Business-to-Consumer, B2C) and between company and company (Business-to-Business, B2B), in the process creating highly variable and individual customer requirements. Increasing ICT support and new approaches to product development are making it easier for companies today to develop products and services collaboratively with a strong focus on the customer and with the direct involvement of the (end) customer. Technologies such as crowdsourcing platforms, for example, make it possible to obtain global end customer feedback inexpensively through largely standardized modes of interaction and to channel this feedback into product development, for example. Other methods for the development of new products and services, such as design thinking and rapid prototyping, prioritize the user viewpoint and seek (end) customer feedback as quickly and as early on in the process as possible, making them inherently more customer-focused.

Companies that mainly have a B2B outlook (and therefore tend to be remote from the end customer) should pursue more intensive collaboration with end customers or the smaller companies operating between the producer and the consumer so as to be able to react faster to changing customer requirements and make optimal use of the opportunities thrown up by such changes (see Chapter 6.2). The authors therefore recommend that midsize and, especially, large German industrial companies with a definite focus on the B2B area adopt a more pronounced strategic focus on open forms of collaboration with their customers and end customers and invest in these forms for the long

term even if this means profitability taking a hit in the short term. Possible measures include using approaches such as design thinking, open innovation or crowdsourcing for the development of new products and services in collaboration with customers and end customers, opening up product or service interfaces and participating actively in open-source developments. The option of collaborating with partners in industrial countries that already focus more closely on the end customer, such as South Korea (see Chapter 9.3.6), should also be given serious consideration in this connection.

10.2.3 Establishment of shared platform ecosystems for digital products and services

The possibilities they provide for acquiring, aggregating and analyzing usage data make platforms an ideal tool for exploring customer requirements in detail in a manner highly conducive to the successful establishment of new or improved data-intensive products and services. US-based companies have seized a substantial advantage in this area, especially as regards the end customer field, and it is important that German companies close this gap, at least in the German core domain of qualitatively mature technical products and services, in order not least to safeguard the country's long-term competitiveness.

Major German companies like the traditional OEMs and technology companies (for example BMW, Daimler, VW and Siemens) and their component suppliers (Continental and Bosch, for example) in principle have the capacity, financially and in terms of their position in the market, to build up a corresponding platform and the associated data resources and basis for collaboration. Nevertheless the development of a shared ecosystem (as has already been seen with HERE, for example, or the Eclipse Foundation) organized sector-by-sector would bring considerable advantages in the pre-competitive setting. The operating costs for the technical platform then could be shared, for example, while a standardized interface for data storage and retrieval could massively reduce the time needed to build up and utilize the data resource.

Another useful feature of the platform might be a standardized interface for the preparation and management of function extensions (apps). Both standardized access to the data resources and a standardized developer interface would make the platform significantly more attractive for third-party developers (see Chapter 3) and thus act as a counterweight to the ecosystems already established by other providers. One particularly interesting evolution of this model would see each platform member relying on the same basic platform but having the option to differentiate its offering by adding its own individual services and apps and thereby tap into additional sources of revenue.

Such a model would also be a good fit with Germany's SME-dominated structure, as it would not be possible for every SME to develop and make a success of a platform of its own. This approach could, moreover, help to bring about the more rapid establishment of hybrid business models (revenue from digital services and the sale of products) in Germany. The authors of the present study consequently propose that work be carried out to identify possible ways of creating shared, mutually beneficial platform solutions, especially in highly competitive segments of industry with a marked preponderance of SMEs (for example joint ventures, co-operatives).

10.2.4 Digital forms of collaboration for open ecosystems

Decision-making processes should be tailored to individual circumstances in terms of content and process taking account of the criteria time, space, equality and cost/benefit position.

Straightforward and inexpensive forms of collaboration need to be identified in order to mobilize properly the innovative power of ecosystems for digitalized products and services with their heterogeneous organization forms across companies of all sizes, convened bodies and industry associations. Suitable forms of collaboration should in particular support fast and efficient ways of disseminating ideas and reaching decisions. One option here is to support communities on existing digital collaboration solutions to discuss problems, develop ideas and put forward or agree solution proposals.

The success of a collaboration platform depends to a significant extent in open ecosystems on the use of strong mechanisms to increase trustworthiness, for example by verifiably documenting decisions so that they cannot subsequently be repudiated. The properties of decentralized organization forms make it possible to combine functions such as the retrieval or provision of information with mechanisms for merit-based evaluation and the traceability of specific activities to incentivize individual contributions, which is of particular interest for the central processes of such ecosystems (especially consensus building, evaluating the significance of the contributions made by different members and the joint development of solutions).

The success of a platform depends on the extent to which the participants feel it belongs to them. Setting up successful platforms entails involving every participant from the outset according to their individual needs with regard to topics, structures, processes and expected results. Unilateral actions and decisions harm acceptance and reduce the probability of full participation.

The authors of the study therefore recommend that all of the relevant players from the political, business, academic and civil society spheres make use of collaboration mechanisms spanning companies, organizations, convened bodies and sectors in open ecosystems, gain experience with such systems and build up communities. This approach is similar to the regional digital hubs concept contained in the BMWi's recently published action plan for digitalization.[317] Communities with a shared interest, including convened bodies and industry associations, should make a particular effort to position themselves as pioneers in this connection, as such pilot applications not only provide a way to step up participation and collaboration (usually organized centrally at the moment), but can also open up new forms of direct collaboration for their members.

10.3 Politics and society

10.3.1 Digitalization of the work of convened bodies

The necessary conditions, in terms both of methodology (Mutual Gains Approach, MGA, Consensus Building Approach, CBA) and technology (collaboration software, Web 2.0), are in place to venture a quantum leap in collaboration within and between convened bodies. All of the potential for improvement identified in the functioning and, in particular, the comprehensive integration of SMEs and startups can be realized if the right methodology and the right technical platform are used (see Chapter 8).

When setting up a platform or forum or renovating or adapting one of the platforms mentioned, it is important that existing and potential participants be thor-

317) https://www.bmwi.de/BMWi/Redaktion/PDF/Publikationen/aktionsprogramm-digitalisierung,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf

oughly involved with regard to content and processes from the early stages of design and preparation. Each convened body stands in direct competition with day-to-day business and it is consequently important to analyze the criteria in detail from a participant perspective in order to avoid leaving the target cohort out of the planning train. The involvement of SMEs in particular requires a dedicated relevance analysis so as to preclude later disinterest.

The authors therefore recommend that existing platforms and/or forums such as the National IT Summit, NPE or others be adopted as examples of drivers of digitalization and that the digital integration of participants be driven forward using MGA/CBA and collaboration software. This should take place, by way of example,

- between the members of each group (project/focus/working group, platform, forum, relevant departments in Ministries),
- between project group leaders of a focus/working group,
- between focus/working group leaders in a platform,
- between platform and forum leaders,
- between the various Ministry departments involved,
- between the IT Summits and other convened bodies concerned with digitalization.

The transition from analog interface to digital platform would thus be realized. This is to be regarded as a basis for a learning, dynamic and creative ecosystem in the context of the successful shaping of the digital transformation through effective and efficient integrated collaboration and decision-making with actors from politics, business, science and civil society.

10.3.2 Implementation of innovation projects for the political sphere and prominent positioning of the digital transformation of the state on the political agenda

An expedient balance needs to be struck between the speed of decision making and the thoroughness of the decision-making process. Transparency, credibility and the needs of the citizen necessitate a fundamental rethink of the state system that has grown up over time. Parliamentary democracy as a community faces competition from unconstrained communities online and it needs to take action to defend its competitive advantages, but the political domain tends to exempt itself from innovation projects. It has more scope than any other to shape the course of developments, however, and the vital resource it represents must be made a priority and a focal point of innovation.

Political ideas, political institutions and political life will have to adapt to the digital age sooner or later. Digitalization provides a technological basis for the demand-led efficient ascertainment and satisfaction of citizens' needs. It is open to abuse by demagogues, but can just as well be used to positive ends by the elected representatives of the people. The authors therefore recommend that a concerted effort be made to ascertain and debate the challenges inherent in a digital transformation of the state, the implications of these challenges (in terms of content, structure and process) and related potential solutions for the "digital Federal Republic". This would include:

- Generating and prioritizing hypotheses with broad use of collaboration software. One possible approach would be to begin by obtaining ideas from recognized academics (for example experts in political science, constitutional law, social market economics), business leaders, thinkers and collaboration software developers, to discuss these ideas with representatives of the legislature, the executive and the judiciary using collaboration software, then to present them to wider stakeholder groups with the aim of gathering further new ideas on the subject of "politics 2.0" and finally to pool and prioritize the ideas using collaboration software.

- Creation of some form of strategic development department for politics:
  - o Joint fact analysis
  - o Derivation of solution spaces based on technical and organizational psychology factors
  - o Creation of initial implementation pilots

- Initiation of concrete pilots in self-contained departments of the political administration in order to demonstrate practical feasibility, methodologically (MGA/CBA) and technologically (collaboration software, Web 2.0), and simultaneously to learn from the manageability of the specific application and grow from there into other areas.

It is important to create awareness first within the political domain and then, gradually, across wider society. Communicating this awareness and showing a willingness to engage with the subject on different levels will on their own help to raise public confidence in politics.

10.3.3 Strengthening digital skills in education, training and personal development

A basic understanding of the possibilities of information science and an elementary grasp of key informatization technologies are increasingly becoming essential core skills for disciplines within and beyond the traditional ICT field across both academic and vocational pathways. A basic understanding of and, where applicable, the ability to create algorithms and program controllers are key skills for mechanical engineers and installation technicians alike, for example, while urban planners and farmers both have much to gain from the use of sensor networks and data analysis tools.

This makes it necessary to ensure that the teaching of these principles is enshrined in the various relevant education, training and personal development plans. The corresponding establishment of information science as a key discipline in the form of an interdisciplinary course module (going beyond programming alone) is very significant here, as is the strengthening of ICT skills in vocational training colleges and further and continuing education institutions. Career paths in logistics, installation engineering and healthcare-related fields are subject to an increasing level of change, but they also represent important agents of the digitalization of the economy and of society as a whole.

The authors of the study therefore recommend that education policy ensure such skills are widely incorporated into the relevant organizations. This will involve looking not just at public-sector institutions, but also, in particular, the professional bodies. Openness to lifelong learning must be strengthened and promoted too by providing corresponding opportunities (through the relevant organizations) and taking steps to make sure these opportunities are accepted. The specific changes called for in education, training and personal development must be underpinned by measures to ensure the related basic skills are taught across the core curriculum. This is essential not least in order to enable all stakeholders to deal maturely with the possibilities and risks of informatization.

10.3.4 Strengthening of public digital infrastructure

The implementation of a powerful broadband infrastructure is of course essential to maintain Germany's strength as a base for business, but there is much more to a modern digital infrastructure than this. Putting the necessary physical conditions in place is certainly a part of the equation, but there is also a need to open up the available data and processes to enable digital services based thereon and promote the emergence of novel and more efficient processes. In the context of highly distributed processes of the type that occur in the ecosystems described, activities typical of private sector interactions, such as the processing of commercial transactions, should be mirrored by corresponding public services, such as the verification of organization identities or entry in official registers. Keeping pace with the advance of digitalization across processes in business requires an expansion of public infrastructure as well (as in the case of the US government's Digital Service Initiative [318] and Estonia's "Country as a Service" [319] concept). This applies in particular to ar-

318) https://www.whitehouse.gov/participate/united-states-digital-service
319) http://www.computerworld.com/article/3071209/digital-transformation/country-as-a-service-estonia-s-new-model.html

eas in which commercial organizations using what are often highly innovative and as yet little-adopted technologies are competing with public-sector functions for identity, registration or certification services for digital processes.

The authors of the study therefore recommend that the political domain assume a leading role among the agents of the digital transformation in Germany by using digital approaches in developing and expanding infrastructure for the implementation of public-sector processes. The objective here should be to facilitate improved political and public administration processes through the technologies used in order thus to meet the more demanding expectations – in terms of speed or transparency, for example – that now apply. The comprehensive integration of important players such as SMEs and startups should also be ensured. The technologies involved can often be used in other areas besides the specific application intended, so this presents a way to realize and monetize new technologies developed with public institutions as application partners. Finally, the public sector can encourage the uptake of digital technologies in the private sector as well by being seen to play a pioneering role in their adoption. Examples of such beacon projects could include the creation of a "digital citizen's ID" or the digitalization of the IT Summit (as discussed in detail in Chapter 8).

10.3.5 Creation of a clear legal framework for digital ecosystems

Uncertainty as to the legal ground rules, especially with regard to matters of liability, represents a substantial barrier for small and midsize companies and startups in particular because they do not enjoy the same ready access to relevant expertise as big companies. The products and services enabled by new ways of processing information throw up all kind of questions not just in the often-discussed area of data protection, but also in terms of who is responsible for what among the network partners involved in the complex value creation networks typical of digital ecosystems. These responsibilities need to be clearly regulated.

Concerns in this area encompass fundamental aspects such as the use of open-source software, the transfer of data usage rights in services provided jointly, responsibilities in relation to the provision and use of highly-automated or autonomous procedures and liability in connection with the provision and use of critical data. One of the priorities for regulations implemented in this context must be to clarify where the burden of proof lies among the network partners. Existing legal norms in the areas of contract, employment, competition, tax and copyright law, among others, also need to be reviewed and, where necessary, adapted in light of their implications for the new organization forms emerging (especially in decentralized and collaborative organization forms, which may be making use of smart contracts in code form).

The authors of the study therefore recommend that the political domain help to establish a clear legal framework that balances the interests of users and providers in digital ecosystems. Account should be taken here of German strengths – like high expectations as to product maturity and self-determination in respect of information – without jeopardizing the country's innovative capability in order to create a competitive advantage for German and European solutions over American equivalents with this value proposition. Legal standards are increasingly established at a European level, so Germany should seek to assume a leading role in the preparation of European measures as well as putting the necessary national measures in place. The provision of recommendations equivalent to the German Federal Office for Information Security's "IT-Grundschutz" baseline IT protection methodology represents a key requirement for the clarification process for SMEs and startups in particular.

10.3.6 Encouraging the move into digitalization

Many small and midsize companies specializing in application fields like mechanical engineering, electrical engineering, electronics and logistics regard skills in the ever more important area of information and communication technology as digital terra nova. Most appreciate the essential significance of ICT, but the great uncertainty prevailing as regards the relevant barriers to entry tends to leave companies content to play a waiting game and eventually make the leap as part of a late majority or even as a straggler rather than as an early adopter. Measures are required to assist such companies with the strategic build-up of capabilities required to take advantage of the technical, organizational and, most significantly, commercial opportunities that come with digitalization. SMEs are unlikely to embark on the necessary strategic process to build up their capabilities in this area unless their owners are convinced of the logic of the associated strategic realignment, which makes tangible demonstrations of the new possibilities opened up with reference to products similar to those offered by SMEs critical for success. Innovative products and, especially, services in digital ecosystems rely on new market models and network partners, so support for the development of new business models is still required.

The authors of the study therefore recommend the targeted promotion of measures to make it easier for small and midsize companies to make a start with digitalization. This is not about the well-established strategic promotion of ICT-based innovations in other application fields in research or transfer alliances; the aim rather is to support measures that boost digitalization capabilities in general across those companies that are reluctant to take the first step. Support measures such as the provision of subsidized consulting services would be one way to promote the targeted development of capabilities. Consultations could be provided in this scenario by experts that have been checked by user associations. It is recommended that regional innovation centers established at existing research or transfer institutions, for example, be used to give tangible demonstrations of the possibilities of digitalization. Opportunities and capabilities could readily be showcased for third parties here by strategically promoting the dissemination by industry and the research institutions of the results from public joint projects.

10.3.7 Promotion of freely available innovations

The products and services realized in digital ecosystems require complex and constantly evolving value creation networks to implement their customer functions and as ICT penetrates ever more different application domains, so the number of areas in which they can be used continues to grow. Complex ecosystems now rely on innovations born out of the efforts of multiple companies and sectors, which presupposes not only the collaborative definition of interfaces, but also the open-source development of functions that do not impact on competitive distinctions. SMEs and start-ups, which have limited R&D and capital resources, are particularly dependent on such shared innovations and on the ability to use open-source software in their products. These very same companies, however, remain very uncertain about the legal consequences of an open innovation policy.

The authors of the study therefore recommend that the political domain take steps to encourage the development of open innovation and free access to results. These should specifically include advising companies on the basic factors to consider, for example in relation to intellectual property rights, in collaborative development efforts such as joint projects. Specimen cooperation agreements could provide concrete support in this connection.

Freely available reference implementation and more active distribution should be made mandatory for projects in receipt of public backing in the interests of promoting the free availability of results and open-source development. The demonstrators created could be made available to the public and, in particular, interested small and midsize companies at the regional digital hubs [320] for this agile alternative to standardization efforts. This would make it easy for them to take advantage of approaches and innovations developed outside of proprietary company settings (interfaces, reference architecture, methods) and integrate the results into their own developments.

320) cf. the BMWi action plan for digitalization (see above)

Annex

A Comparison of the forecasts made in the initial investigation with actual events

The prior project "Mehr Software (im) Wagen" (The Software Car) (2010) revealed that the information and communication technology architecture for electrical and electronic systems in automobiles needed to change and would change. An attempt was made as part of the project to describe a potential ICT architecture for the year 2030 and to forecast implementation scenarios for associated technologies. Consideration was given to both societal and technological trends with implications for the development of the ICT architecture and related innovation.

This section returns to the predictions made in the project and compares them with what has actually come to pass over the last five years. It also aims to provide an overview of current forecasts regarding the development of the ICT architecture and the associated factors and to align these with the statements made in the project. Particular attention is paid to the automotive sector, to related domains and areas affected by the technical developments concerned and to the changes in market structures, especially regarding the entry of relevant players (both newcomers and companies moving in from other sectors), the significance of alliances and changes in location policy.

The considerations below are limited to those forecasts that have yet to eventuate fully and whose realization accordingly still lies in the future (new forecast period).

Forecast 2: Fully or partially autonomous driving becomes possible

The market launch predictions for automated driving functions contained in the "Mehr Software (im) Wagen" project may have appeared optimistic when they were made in 2010, but they have been vindicated by events, which have in some cases moved even faster than predicted. Initial (semi)autonomous driving functions have become available, for example in the form of the capabilities of the Tesla Model S that can be activated using the OTA software update release on October 15, 2015. [321] The functions provided by Tesla include automatic lane changing and steering assist as well as self-parking. [322]

German OEMs also already had the ability to realize semi-autonomous functions. Examples include Driving Assistant Plus from BMW and Distronic Plus (with steering assistant) and Stop&Go pilot from Mercedes-Benz. Both systems maintain spacing with respect to the vehicle in front automatically, for example, and steer autonomously. [323] BMW's "BMW iNext" project, which also involves Intel and Israeli assistance system developer Mobileye, aims to develop a fully autonomous vehicle by 2021. [324]

Vehicles from Volkswagen and Daimler are expected to be traveling the German autobahn network autonomously by 2020 at the latest, [325] although Ralf Herrtwich, former head of Daimler's Autonomous Driving unit, thinks it will be 2030 before vehicles are capable of handling every driving situation autonomously. [326]

Expert opinion varies as to whether semi-autonomous functions will be available for small vehicles by 2020 [327] or if the pleasures of driver assistance systems will still be restricted to customers at the premium end at that time. [328] The models announced so far by the automakers suggest the latter is more likely to be the case, but there is as yet no clear indication of the intentions of newcomers like Google and Apple, which could choose to follow traditional sales models or could equally well launch into the mobility service provider market.

321) http://www.golem.de/news/elektroauto-tesla-s-erhaelt-autopilot-per-software-update-1510-116848.html
322) https://www.tesla.com/de_DE/presskit/autopilot
323) http://www.welt.de/motor/article145747004/Der-neue-BMW-7er-lenkt-besser-als-sein-Chauffeur.html
324) http://www.heise.de/autos/artikel/Bis-2021-soll-autonomer-BMW-iNext-kommen-3252955.html
325) http://www.heise.de/newsticker/meldung/Volkswagen-Autonome-Autos-auf-Autobahn-bis-spaetestens-2020-3226804.html
326) http://www.welt.de/wirtschaft/article137958214/Schon-in-fuenf-Jahren-gibt-es-das-fahrerlose-Auto.html
327) http://www.2bahead.com/de/analyse/trendanalyse/detail/trendanalyse-warum-selbstfahrende-autos-kein-lenkrad-haben-werden/ 8) http://www.presseportal.de/pm/103296/2909138
328) http://www.presseportal.de/pm/103296/2909138

Table 5: Forecasts made in the 2010 “Mehr Software (im) Wagen” (The Software Car) project and status of those predictions in 2015

No.	Forecast/hypothesis	Time frame per old forecast	Source: "Mehr Software (im) Wagen"	Time frame per new forecast	Technology available?	Market in place?
1	Amendment of legislation, in particular revocation of the Vienna Convention on Road Traffic	no specific time frame	page 36	*occurred*		
2	Fully or partially autonomous driving becomes possible	2030	page 56	2030	partially	emerging
3	Standardized hardware and software components facilitate the entry into the automotive market of ICT suppliers from other sectors	2030	page 56	2025	partially	signs of development
4	Trend for hardware to replace software	no specific time frame	Page 18 and page 39	*occurred*	yes	yes
5	Separation of hardware and software with middleware (intermediate software layer) as the basis for "mixed criticality systems"	no specific time frame	page 41	*occurred*	yes	yes
6	Open source technologies increasingly replace proprietary technologies in the automotive segment and in embedded systems	no specific time frame	page 42	2030	partially	partially
7	The vehicle becomes a permanent element of infrastructure and is embedded in the Internet of Things	no specific time frame	page 37	2030	yes	emerging
8	Safety-critical functions are controlled at an inter-vehicle level (for example coordinated accident avoidance by means of communication between vehicles) or at least supported by near-field communication	no specific time frame	page 45	2030	partially	emerging
9	Trend favoring mobile networks with larger bandwidth, better coverage and higher transmission security; LTE 4G and Wi-MAX compete for superiority in the area of communication technology	2030	page 43	*occurred*	yes	yes
10	Ethernet becomes established for broadband communication within embedded systems, including in the automotive area	no specific time frame	page 43	2025	yes	emerging
11	Trend favoring systems with multiple processor cores, including in embedded systems	no specific time frame	page 40	2020	yes	emerging
12	Dramatic increase in the number of sensors both inside the automobile and outside	no specific time frame	page 42	*occurred*	yes	yes
13	Sensor technology becomes increasingly intelligent. Pre-processing takes place before data leaves the sensor	no specific time frame	page 42	*occurred*	yes	yes
14	Trend favoring model-based software development adapted to the vehicle domain	already established in 2010	page 43	*occurred*	yes	yes
15	Movement away from mechanical components in favor of fully integrated mechatronic components	2020	page 40	2020	yes	emerging

Forecast 3: Standardized hardware and software components facilitate the entry into the automotive market of ICT suppliers from other sectors

According to the most recent statements and forecasts, various ICT companies from outside the sector (such as Google and Apple) can be expected to enter the automotive market within the next five years as either component suppliers or full-fledged vehicle manufacturers.[329, 330] Online transport service intermediary Uber is known to be testing self-driving vehicles with LIDAR sensors in Pittsburgh, moreover, and has formed an alliance with the University of Arizona focusing on digital mapping and optical sensors.[331, 332] There is also speculation that Uber plans to bring its own highly automated vehicle, or at least its own mapping service, to market within the foreseeable future.

The entry into the market of these companies new to the automotive domain heralds a fundamental change in the automobile value chain – a change driven in significant measure by the increased relevance of ICT. The best example of this is the Google Car unveiled in 2014, which places the emphasis very much on the core aspects of vehicle technology. It features a simple battery-powered electric drive rather than an internal combustion engine and has no manual vehicle controls, instead relying on advanced sensor systems, complex IT architecture and connectivity. Google's direct contribution is limited to those areas falling within its own core competency, that is to say the operating system including sensor data fusion for the autopilot. The rest of the components are sourced from component suppliers while an engineering service provider looks after the final assembly of the vehicle.[333]

One other consequence of these developments is that content providers, network operators and integration specialists will in future assume a pivotal position in the automotive value chain and a more important role as drivers of innovation.[334] Technology companies are increasingly trying to establish themselves as automotive industry component suppliers too in recognition of the rising demand for their core competencies as the number of ICT-based functions in vehicles grows. Broadcom, for example, has developed an Ethernet-based data transmission technology – BroadR-Reach – that copes better with the higher transmission rates now required in automobiles than the CAN-based (Controller Area Network) solutions conventionally used for communication between controllers.[335]

Overall the original prediction that companies from outside the sector would manage to break into the automotive sector on the back of standardized hardware and software components and the concomitant reduction in complexity has been thoroughly vindicated; indeed these companies can be expected to have their own products accessible to the everyday consumer within the next five years.

Forecast 6: Open source technologies increasingly replace proprietary technologies in the automotive segment and in embedded systems

Automakers are particularly enthusiastic about open source technologies in the area of human machine interfaces. The entertainment system in the Tesla Model S unveiled in 2012, for example, is built around a variant of the freely available Linux operating system.

One of the advantages of Linux according to Tesla is that it is a stable solution well-suited to display and entertainment applications. The company nevertheless relies on in-house programs with no operating system for motor control and similar systems.[336]

The "Genivi" industry alliance launched by BMW, Delphi, GM, Intel, Magneti Marelli, PSA Peugeot Citroën, Visteon and Wind River Systems in 2009, which now has more than 170 members around the world, was created to produce the first open source development platform for in-vehicle-infotainment (IVI) to contain elementary functions such as connectivity with consumer devices, the ability to display internet content, the reproduction of audio and video material and the use of apps. Intended to simplify IVI development for automakers and component suppliers, it too is based on Linux. The "EntryNav" system, the first generation of the open infotainment platform developed through the Genivi alliance, was presented in fall 2013 and now features in almost all new BMW models.[337, 338]

Entertainment systems aside, however, open source software for automobiles is generally still in its infancy.

329) Milakis (2014): Automobiles; presentation at the Automated Vehicles Symposium 2014, Ancillary TRB Workshop "Envisioning Automated Vehicles within the Built Environment: 2020, 2035, 2050", July 18, 2014.
330) Farrell (2015): Project Titan: What We Know So Far About the Apple Car, in: Huffington Post, June 3, 2015.
331) Uber forscht mit US-Uni an selbstfahrenden Autos, in: futurezone Technology News, August 26, 2015.
332) Macadangdang (2015): Uber's Experimental, Self-Driving Car Spotted on Streets of Pittsburgh, in: Tech Times, May 22, 2015.
333) Automatisiertes Fahren – „The next big thing!?". Study published by Berylls Strategy Advisors, December 17, 2014.
334) Mosquet/Russo/Wagner/Zablit/Arora (2014): Accelerating Innovation. New Challenges for Automakers. Study published by Boston Consulting Group, January 2014.
335) Kindermann/Pieper/Leuchner (2014): BroadR-Reach®. Ein neuer physical layer für Ethernet Kommunikation. Presentation at KommA 2014; reproduced in: Jasperneite/Jumar (Eds.): Jahreskolloquium Kommunikation in der Automation (KommA 2014), Lemgo.
336) Feilner (2012): Linux inside: Elektrolimousine Tesla Model S bringt 17-Zoll-Monitor, in: Linux Magazin, August 24, 2012.
337) Cf. „The Open-Source Platform Genivi Compliant" on the Magneti Marelli website: http://www.magnetimarelli.com/excellence/technological-excellences/open-source-platform-genivi-compliant
338) BMW Zulieferer geehrt: BMW Supplier Innovation Award 2014, in: BimmerToday.de, October 4, 2014.

One exception is the "Visio.M" research project funded by the German Federal Ministry of Education and Research (BMBF), which was set up in 2012 to address the problem of the growing complexity of vehicle on-board systems. Researchers working as part of the project at Technische Universität München (TUM) developed a two-tier IT system that handles vehicle functions relating to driving and safety separately from functions that are concerned with convenience and communication so that it is possible simultaneously to ensure both the safety of the system and connectivity to the internet and the outside world. The associated software, the Automotive Service Bus, was unveiled in 2015 and is now available to developers worldwide under an open source license.[339]

The use of open source platforms generally opens up a wealth of opportunities to help automakers master the ever greater challenges posed by the advent of connected mobility. The availability of open source solutions spares companies the need to invest time and resources in proprietary systems and this, in turn, allows the development process to be made much simpler and more flexible, which means new products and services can be brought to market more quickly. Open source platforms also provide a way to cope with the heterogeneous nature of the mobile communication landscape and ensure a high level of device and hardware compatibility.[340]

Forecast 7: The vehicle becomes a permanent element of infrastructure and is embedded in the Internet of Things

It is apparent that the number of connected vehicles has risen sharply over the last five years: there were still no more than 45 million connected vehicles in total on the road around the world in 2011, but it is expected that 2015 alone will have seen some 54 million new connected cars sold.[341, 342] Forecasts suggest that there will already be 220 million connected vehicles in circulation by 2020. It is anticipated that vehicles will by then also be able, for the first time, to communicate directly with each other to exchange information about speed, road conditions and steering.[343, 344]

One current example is the Mercedes C-Class saloon that appeared at the end of 2015, which is intended to enable access to vehicle information, door locking and other functions, including block heater, via online remote services.[345] VW, for its part, announced in 2015 that it had succeeded in integrating the three most important standard technologies for smart phone connection, Apple CarPlay, Android Auto and MirrorLink, making it one of the first automakers to achieve this feat. The company intends that virtually all new VW models from 2016 onward support these interfaces, which should make it possible to access smart phone navigation, entertainment and messaging functions.[346]

The chief drivers of this development are ever more capable communication technologies, such as LTE, which are smoothing the way to the connected car. The steadily declining cost of integration too is helping to facilitate the accelerating transformation of vehicles into one more mobile terminal in the online world.

Customers have various expectations of this process including emergency call systems (for example eCall) for faster access to assistance in the event of accidents, new possibilities for vehicle location (for example in the event of theft), solutions for breakdown prediction and breakdown diagnosis, on-board mobile access to internet content and data consistency across different terminals (computer, smart phone and automobile). The manufacturers, on the other hand, face a range of serious challenges, the most significant of which is providing for safe and driver-friendly operation (a problem that has been taxing many automakers for years). Mobile service use also needs to be affordable for the customer and simultaneously profitable for the service provider – in this case the automaker – and it is therefore important for automakers to partner up with relevant technology companies promptly so that both can benefit from the provision of on-board internet use.

The prospect of a share of the growing market for connected services is surely an attractive one for automakers and technology companies alike at the moment. Expert forecasts predict that the value of the connected mobility market will grow from no more than around 32 billion euros in 2015 to between 115 and 130 billion euros by 2020 (with annual growth rates averaging 29 percent).[347]

The nature of the market is expected to change as it expands too, with safety features – currently still the most profitable area of connected services – being su-

339) Cf. "Visio.M Automotive Service Bus goes open source: The car becomes internet hardware" on the Technische Universität München website, March 10, 2015: https://www.tum.de/en/about-tum/news/press-releases/detail/article/32277/
340) Dressler/Kien (2015): Mit LTE zum vernetzten Auto, in: funkschau.de, May 28, 2015.
341) Mosquet/Russo/Wagner/Zablit/Arora (2014): Accelerating Innovation. New Challenges for Automakers. Study published by Boston Consulting Group, January 2014.
342) Connected Cars sind die Smartphones der Automobilindustrie. Oliver Wyman study concerning vehicle integration, September 2011.
343) Heck/Rogers (2014): Are You Ready for the Resource Revolution?, in: McKinsey Quarterly, March 2014.
344) Greenough (2015): The Car Is Becoming the Next Major Battleground for Digital Media Companies, in: Business Insider.com, July 13, 2015.
345) IAA-Neuheit: Mercedes C-Klasse Coupé, in: carIT.com, August 14, 2015.
346) Beiersmann (2015): Volkswagen zeigt PKWs mit Android Auto und Apple Car Play, in: ZDNet.de, July 30, 2015.
347) Bayern Innovativ GmbH (Ed.): perspektiven: Mobilität im Wandel, Nuremberg 2015; cf. http://www.bayern-innovativ.de/mediathek/kundenjournale/perspektiven

perseded in terms of market share by integrated driver assistance functions, which are predicted to be worth around 58 billion euros by 2020.

One essential for connected mobility and autonomous driving in general are mobile mapping services. The types of service discussed above cannot be realized without highly precise, context-sensitive and intelligent mapping systems capable of supplying information about a location in real time and with high availability. The recent eye-catching purchase of Nokia mapping service HERE by Audi, BMW and Daimler underlines the great strategic importance attached to mobile mapping services in a world of autonomous mobility. There are only three other providers worldwide: Google, Apple and TomTom. The German automakers' move for HERE also reveals an unprecedented willingness to manage or share important resources collectively in order not to give newcomers to the sector carte blanche to gain a foothold.

Forecast 8: Safety-critical functions are controlled at an inter-vehicle level (for example coordinated accident avoidance by means of communication between vehicles) or at least supported by near-field communication

The possibility of using vehicle-to-vehicle (V2V) communication to prevent accidents is a significant issue in the context of the introduction of highly-automated vehicles. This is especially true in the USA, where the number of people killed in traffic accidents every year is much higher than in Europe, and the US authorities are accordingly seeking an early roll-out of V2V communication. Legislation stipulating that new vehicles must have a V2V chip set installed has already been drawn up by the National Highway Traffic Safety Administration (NHTSA) and the U.S. Department of Transportation and the corresponding regulations could be approved by the US authorities in 2017.[348, 349]

General Motors would like to include V2V technology with its new Cadillac CTS model due to launch in 2017.[350] Communication between vehicles may well be regarded as a breakthrough in improving traffic safety in the US, but it is still generally understood in the country that the legislation represents no more than a first step and that it will be many years before the technology becomes ubiquitous.

There has as yet been no drive in Europe to make vehicle-to-vehicle communication mandatory for new vehicles. Plans are in place to roll out the eCall automatic emergency call system in 2018, but all this does is trigger an emergency message including location and time, direction of travel, number of occupants and fuel type in the event of an accident.

Germany has seen progress on other fronts, however, such as the "Ko-HAF – Cooperative Highly Automated Driving" research project launched by the German Federal Ministry for Economic Affairs and Energy in 2015. Led by Continental, this project is intended to investigate cooperative functions and communication between highly-automated vehicles and is specifically aiming to devise a back-end solution that would enable vehicles to communicate with each other via a server using the cellular network (LTE/UMTS) in order to improve traffic safety. Achieving this will require interfaces that permit environmental and location data to be exchanged between vehicles from different manufacturers plus improved vehicle position detection systems accurate down to the level of individual lanes.

The development of such standards is a vital step in enabling cross-platform communication. The venture, the 16 partners in which include BMW, Audi, Daimler, Opel and Bosch as well as Continental, will not, however, be completed until November 2018.[351]

Forecast 10: Ethernet becomes established for broadband communication within embedded systems, including in the automotive area

The messages sent via the automobile on-board network are going to become significantly larger and more complex as autonomous driving and highly-automated driver assistance systems become established. This makes the replacement of the traditional bus systems used in vehicles inevitable: MOST, FlexRay and CAN technologies, for example, will struggle with the transmission capacity requirements and are unsuitable for coping with the complexity involved in highly-automated driving functions in vehicle development.

Ethernet communication technology is generally regarded as the best solution for meeting current re-

348) DeMeis (2015): Automakers Lean on Silicon Valley, Electronics360.globalspec.com, June 4, 2015.
349) Beene (2015): U.S. Pledges to Speed up V2V Mandate, in: Automotive News (autonews.com), May 13, 2015.
350) Korosec (2015): Obama Administration to Fast-Track "Talking" Car Mandate, in: Fortune.com, May 14, 2015.
351) Continental heads research project "Ko-HAF – Cooperative Highly Automated Driving". Press release from Continental AG, August 6, 2015; cf. http://www.continental-corporation.com/www/presseportal_com_de/themen/pressemitteilungen

quirements due to its higher data transmission rates, lower costs for cabling in the vehicle and lighter weight than traditional bus systems, for example, the possibility of using inexpensive existing Ethernet tools and the greater flexibility in the network provided by Ethernet. Using Ethernet in this way will though require the introduction of new Ethernet communication protocols and a new physical transmission layer, different from traditional Ethernet, that is suitable for the automobile environment (resistance, etc.). [352]

Broadcom presented the first such physical layer – BroadR-Reach – to experts in the field in 2011. Its technology is compatible with standard Ethernet and permits data transmission rates of 100 megabits per second over an unshielded two-wire cable. Volkswagen and BMW, among others, announced plans in 2015 to roll BroadR-Reach out in their model series. [353, 354]

Audi uses time-controlled Ethernet communication from network specialist TTTech to connect the various hardware cores in the zFAS driver assistance system it unveiled in 2014. It cites the combination of data traffic with differing levels of criticality while maintaining a high data transfer rate as one of the main advantages of this solution. [355] Another example of Ethernet use in the automotive industry comes in the new S-Class from Mercedes, which incorporates MOST150, a vehicle-compatible physical layer for Ethernet developed from the established MOST bus. [356]

It is assumed, however, that the bandwidths of up to 100 megabits per second achieved in automobiles to date will not be sufficient in the long term and that data transmission rates of up to 10 gigabits per second over Ethernet will be needed to realize highly-automated driving. Significantly the changes to the on-board network provide companies entering the market from other sectors in particular the opportunity to establish themselves in tier 1 and tier 2 relationships with the automotive industry (as Broadcom and TTTech, for example, have already done).[357]

Forecast 11: Trend favoring systems with multiple processor cores, including in embedded systems

Several multicore systems for use in the automotive industry have been presented over the last five years. The Tegra K1 mobile processor unveiled by Nvidia, the world's largest manufacturer of graphics processors, in 2014, features four cores and is intended primarily for advanced and camera based driver assistance systems such as pedestrian detection, blind spot monitoring, lane departure warning and traffic sign recognition. The very substantial computing power is necessary to cope with processing the large quantity of real-time data from sensors and cameras. Nvidia claims the technology can help bring the autonomous vehicle to the mass market.

Audi uses this multicore processor for the zFAS driver assistance system it revealed in 2014. Mobileye's EyeQ3 multicore processor is also used in addition to the Tegra K1. The system is intended to bring together a large number of controllers (for example for parking aid displays, automotive night vision and lane keeping assistant) in one place and simultaneously combine all of the sensor information acquired so that the controllers have central access to all environmental information. Audi plans to launch its zFAS driver assistance system in a mass-produced automated vehicle before the end of this decade. [359, 360]

Forecast 15: Movement away from mechanical components in favor of fully integrated mechatronic components

Several companies now have highly-integrated wheel hub drives, which provide all of the components necessary for acceleration, braking and driving safety (electric motor, power electronics, controller, brake and cooling) within the wheel, in their technology portfolio as advanced prototypes approaching market maturity. "Highly-integrated wheel hub drives thus offer significant advantages in terms of maneuverability, vehicle dynamics and active safety as well as optimal use of space. This could prove to be very important in future, especially in the context of autonomous driving," explains Prof. Peter Gutzmer, Deputy CEO and Chief Technology Officer at Schaeffler AG,[361] who believes drives using hub motors could be in use in city cars after 2020. "We could have our development ready for series production in three to four years if a manufacturer were to come to us today and say let's do it."[362] The capabilities of hub motors have been forcefully demonstrated by the Swiss electric racing car "Grimsel", which set a new world record for 0-100 km/h acceleration of 1.513 seconds in June 2016.[363]

352) Kurzeinführung automobiles Ethernet, in: Eberspaecher-Electronics.com, January 7, 2014.
353) Lam (2015): A BroadR-Reach® for the Connected Car at CES 2015, in: Broadcom Connected Blog, January 7, 2015.
354) Holden (2011): Broadcom BroadR-Reach Ethernet Portfolio Brings Autos into Digital Age, in: Broadcom Connected Blog, December 7, 2011.
355) Audi zFAS driver assistance system (2015); cf.: TTTech.com.
356) Daimler Introduces MOST150 in the New Mercedes-Benz S-Class. MOST Cooperation press release, February 13, 2014.
357) Bayern Innovativ GmbH (Ed.): perspektiven: Mobilität im Wandel, Nuremberg 2015; cf. http://www.bayern-innovativ.de/mediathek/kundenjournale/perspektiven
358) NVIDIA Slides Supercomputing Technology Into the Car With Tegra K1, Nvidia Newsroom), January 6, 2014.
359) Nerreter (2015): Alles gemeinsam, alles in einem: das zentrale Fahrerassistenzsteuergerät; cf. Audi website: http://www.audi.ch/ch/web/de/vorsprung_durch_technik/content/2014/10/zentrales-fahrerassistenzsteuergeraet-zfas.html
360) Audi zFAS driver assistance system (2015); cf.: TTTech.com.
361) http://www.focus.de/auto/diverses/technik-der-antrieb-fuer-das-stadtauto-von-morgen-schaeffler-und-ford-zeigen-ideenauto-mit-e-wheel-drive-hochintegrierte-radnabenantriebe-sind-ein-schluessel-fuer-neue-fahrzeugkonzepte-bild_aid_958341.html
362) http://www.automobil-industrie.vogel.de/der-verbrennungsmotor-verliert-an-bedeutung-a-536542/
363) https://www.wired.de/collection/tech/e-auto-weltrekord-von-0-auf-100-eineinhalb-sekunden

The Immortus project created by EVX Ventures adds power generation to the highly-integrated drive train concept. A highly aerodynamic two-seater, the five-meter-long Immortus is propelled by two 20 kilowatt electric hub motors driving the rear wheels. The vehicle stands 1.1 meters tall and two meters wide and has seven square meters of solar cells on its roof, the energy from which is stored in a 10 kWh lithium ion battery. It is designed to accelerate from 0-100 km/h in less than seven seconds with a top speed of over 150 km/h and a combined battery and solar range of up to 550 kilometers. The range is theoretically unlimited in strong sunlight if the driver does not go above 60 km/h.[364]

Electric hub motors are still mainly used in electric bicycles, electric scooters/light motorcycles and electric wheelchairs at the moment, but they have also begun to appear in recent years on newly developed electric vehicles such as the battery-powered BYD ebus. Manufactured in China, the BYD ebus is already in use in several European cities and has been tested in Germany in the cities of Bonn and Bremen.[365]

The subject of high-level integration is considered more thoroughly in this final report in sections 3.2 and 6.5.1.

B Project method and project procedure

The present study is highly complex in nature. The necessary investigation of the different facets – business models, strategy, organization and technology – was broken down using the Future of Business method[366] so that essential work packages could more easily be tackled in parallel within the consortium. This approach did, however, involve investing a large amount of time at the outset in the examination of current developments and an intensive trend analysis. It was necessary to establish a firm understanding of the principle aspects of digitalization in line with current developments before proceeding with the global survey. .

Drawing on this background work it was possible, by combining the results of Venkatraman (IT-Enabled Business Transformation: From Automation to Business Scope Redefinition)[367] and Buss (IT Maturity and the Road to Responsive IT[368] and the ICT architecture evolution model from the Software Car study,[369] to develop a five-stage maturity model to underpin the field investigations and assessments. *Figure 50* summarizes the procedure model described above.

This maturity model forms the link between the actual position and the future vision, for the purposes of the consortium, and provides a way to perform a sector-neutral comparison of maturity in the context of the international expert survey.

The survey extended to a total of 199 interviews across Germany and five other countries/regions (see *Figure 51*). The survey comprised a series of general questions exploring understandings of digitalization, technical and socioeconomic maturity under the maturity model and the risks and opportunities created by related developments. It was conducted interactively using maps showing different variations.

The personal interviews were conducted according to a structured procedure using set questions and defined response options (on which respondents were free to expand). Some of the questions were of a general nature and intended to probe understandings of the possibilities associated with digitalization, while others requested an estimate of a company's specific readiness according to the maturity model defined for the purpose (see Section B) and an overview of the risks and opportunities of digitalization from the company's own perspective in the manner of a traditional SWOT (strengths, weaknesses, opportunities, threats) analysis.

Both the general questions and those concerned with risks and opportunities invited interviewees to rank up to three of the defined response options in order of importance. The questions investigating maturity asked interviewees to estimate the maturity level of their own company (see Section B) and specify how long they thought it would be before their company reached the next stage.

When analyzing responses to both the general questions and the questions concerning risks and opportu-

364) http://www.auto-motor-und-sport.de/news/evx-ventures-immortus-solarsportwagen-659289.html
365) http://www.rp-online.de/leben/auto/ratgeber/der-radnabenmotor-antrieb-direkt-im-rad-aid-1.5165316
366) Cf. Döricht (2013): Strategic Visioning – Future of Business, in: Moehrle/Isenmann/Phaal (Eds.):Technology Roadmapping for Strategy and Innovation. Charting the Route to Success, Berlin/Heidelberg, p. 257–265.
367) Cf. Venkatraman (1994): IT-Enabled Business Transformation: From Automation to Business Scope Redefinition, in: Sloan Management Review 35, 2, p. 73–87.
368) Cf. Andrew Buss: Getting IT to Fire on All Cylinders, presentation at Data Centre World, ExCeL Exhibition Centre, London, February 27, 2014.
369) Cf. the final report of the German Federal Ministry of Economic Affairs and Energy-funded joint "eCar-IKT Systemarchitektur für Elektromobilität": Mehr Software (im) Wagen. Informations- und Kommunikationstechnik (IKT) als Motor der Elektromobilität der Zukunft, 2010 study, p. 48 et seq.

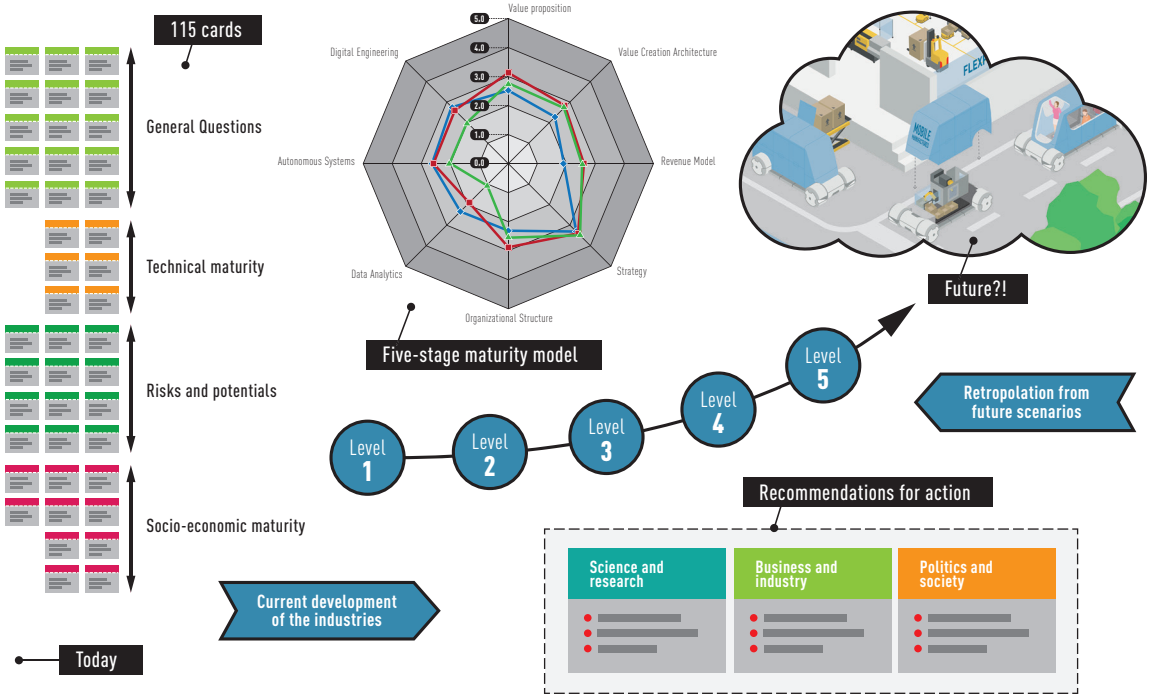
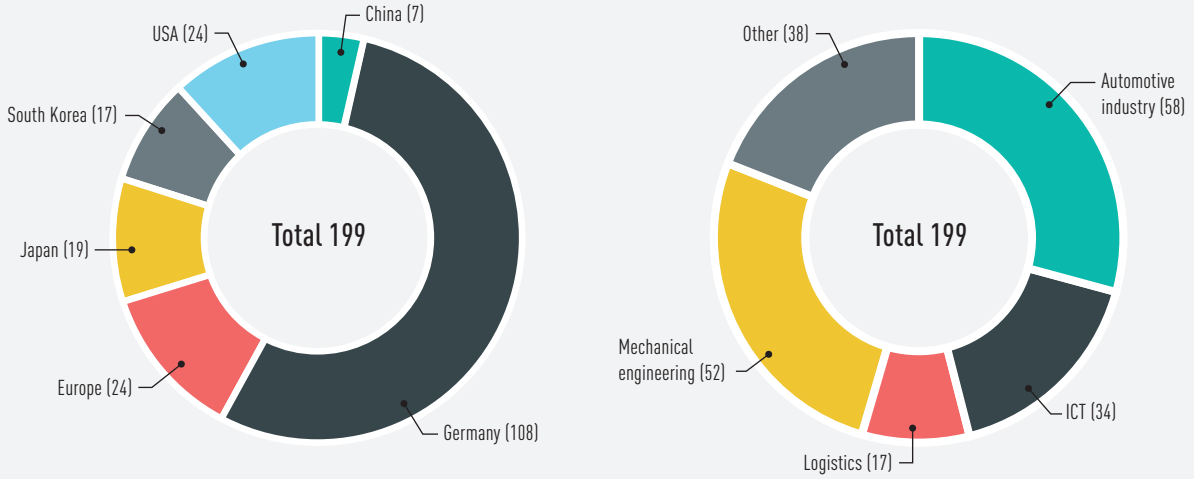


Figure 50: Combination of the Future of Business method with the maturity model per Venkatraman

Figure 51: Composition of the 199 companies surveyed by country respectively by industry domain

The survey concentrated on the automobile manufacturing, mechanical engineering and logistics sectors. The figures in each case represent the companies surveyed in the respective sectors.



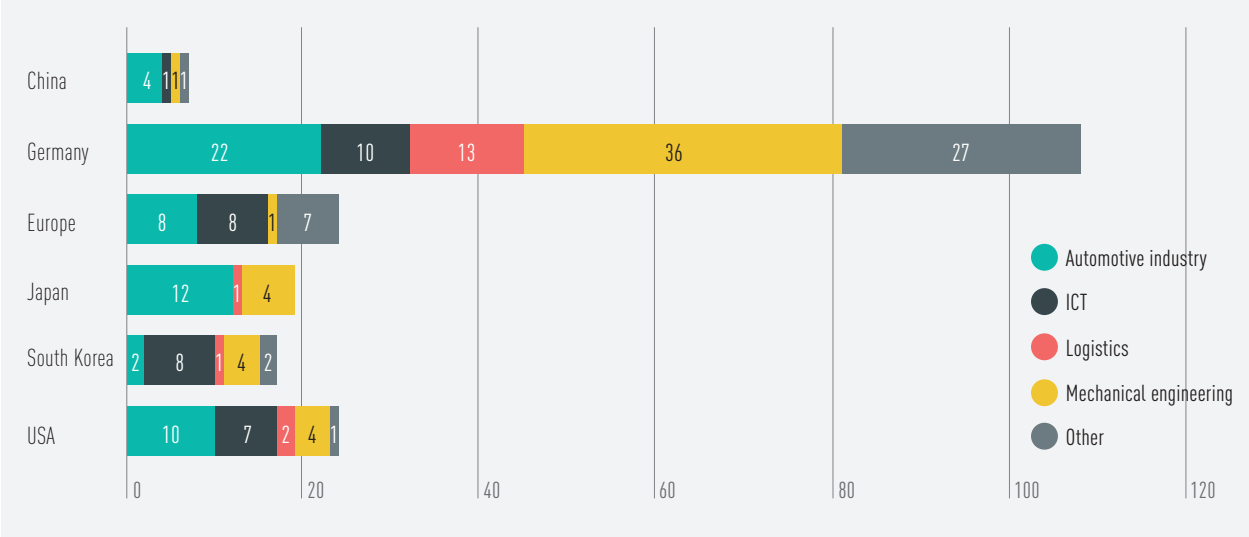


Figure 52: Composition of the 199 companies surveyed by industry domains within each country

The survey concentrated on the automobile manufacturing, mechanical engineering and logistics sectors. The figures in each case represent the companies surveyed in the respective sectors.

nities, the order of priority indicated by the interviewee was taken into account by assigning the highest-ranked response a weighting of four and the second highest-ranked response a weighting of two to ensure the factors considered most important by the interviewees were similarly emphasized in the analysis.

C Object and conceptual design of the maturity model

The maturity model was developed in a series of workshops making use of expert input and experience and information from scientific publications. The final maturity model was presented to a selected group of relevant specialists for validation.

The object of the model and the associated dimensions described (see Section 5.1) was to make it possible to compare different sectors in connection with the introduction and use of technologies, approaches and structures relating to digitalization. A maturity stage in the model is considered to have been reached for the dimension concerned if the corresponding implementation activities have been completed in at least 50 percent of the affected areas or 50 percent of the company.

D Features of the maturity model taking the automotive industry as an example

The maturity model designed as part of the project permits a multi-dimensional assessment of the maturity of the sectors considered in terms of digital transformation and in the socioeconomic and technical context. The socioeconomic domain is subdivided into three dimensions – business model (itself subdivided into the fundamental components of value proposition, value creation architecture and revenue model), strategy and organization – while maturity in the technical context is established with reference to the position in data analysis, autonomous systems and digital engineering. The individual dimensions are assigned to one of five predefined maturity stages. These are described below and illustrated with reference to examples drawn principally from the automotive sector.

a) Socioeconomic dimensions

Value proposition: What influence does digitalization have on your company's value proposition (product/service)?

Stage 1: Unchanged value proposition supplemented with additional digital offerings (that do not affect core functionality)
The position at this first stage is that there has effectively been no change to the actual value proposition, with rudimentary additions featuring digital functionalities the only evidence of any effect. An example of this stage of maturity in the automotive context would be the vehicle manufacturer making a manual for the vehicle available as a PDF (in addition to the traditional printed copy).

Stage 2: Largely unchanged value proposition with minor integrated digital functionalities
This maturity stage would be considered to have been reached if error codes were to be transmitted (automatically) from the entertainment systems installed in customer vehicles to a service center and if corresponding personalized service calls could then be made from this service center.

Stage 3: Changed value proposition with partially integrated digital functionalities
This third stage is considered to have been reached if different physical objects and data resources have been connected up and integrated for process purposes in a way that enables the customer to interact with the environment while using the vehicle – for example for automated payment transactions at service stations or in order to optimize route planning and navigation in accordance with personal preferences.

Stage 4: Substantially changed value proposition with almost fully integrated digital functionalities
A vehicle manufacturer at this stage has reached the point of offering the customer mobility as a service rather than just an automobile as a physical means of transport. Not only is the vehicle connected, but additional mobility services (such as automated parking with corresponding management of the available parking spaces, suggestions regarding the use of alternative means of transport) that factor in customer preferences, expectations and the results of real time data analysis are offered and integrated into the mobility service.

Stage 5: New value proposition with thorough and comprehensive integration of digital functionalities
The fifth stage entails a fundamental ICT-based realignment of the products and services of the vehicle manufacturer (OEM) such that the manufacturer assumes the role of a platform orchestrator to which the customer merely submits its destination and timing requirements, for example. The OEM configures and offers an optimized journey option, using all of the available means of transport (bus, rail, air, etc.), based on the customer's personal travel preferences. The value proposition has thus been transformed into a seamless mobility as a service proposition.

Value creation architecture: What influence does digitalization have on your company's value creation architecture?

Stage 1: Unchanged value creation architecture with isolated adaptations
The first maturity stage, at which the potential for change in the internal and external value creation architecture is low, might involve activities such as the optimization of processes in customer support that are based in part on automated self-selection or classification systems, for example.

Stage 2: Largely unchanged value creation architecture with increasing integration of internal value creation activities
This maturity stage involves developments such as the integration of procurement and sales data to allow just in time inventory management.

Stgae 3: Changed value creation architecture based on changed business processes
The changed value creation architecture at the third maturity stage makes it possible, for example, to optimize processes strategically across different functional departments using digital capabilities and resources so as to maximize efficiency and flexibility.

Stage 4: Substantially changed value creation architecture based on a changed external value creation network
The fourth maturity stage moves away from the notion of just changing the internal value creation architecture in favor of enabling the integration of external (third-party) value creation activities that permit the flexible and efficient interaction of value creation activities across industry/sector boundaries.

Stage 5: Transformed internal and external value creation architecture
The transformed value creation architecture of the fifth maturity stage is reflected, by way of example, in the flexible orchestration of internal and external value creation activities as a function of changes in supply or demand across different sectors/industries.

Revenue model: What influence does digitalization have on your company's revenue model?

Stage 1: Unchanged revenue model with direct monetary payment and no option for a combination of direct and indirect revenues
The unchanged revenue model at the first maturity stage could be illustrated for the purposes of providing an example by an automobile purchase process involving just a static digital payment.

Stage 2: Slightly changed revenue model with a few options for a combination of direct and indirect revenues
A company that has reached the second maturity stage in this case might, for example, be prepared to vary the purchase price for vehicles, perhaps by reducing the price in exchange for usage-related data generated by the vehicle.

Stage 3: Changed revenue model with a number of options for a combination of direct and indirect revenues
One example of a changed OEM revenue model is Uber's surge pricing model, which replaces an approach centered on the sale of a vehicle at a fixed, calculable selling price with one that responds flexibly to changes in supply (drivers) and demand (customers).

Stage 4: Substantially changed revenue model with many options for a combination of direct and indirect revenues
Stage 4 would be considered to have been reached as soon as, by way of example, different forms of fixed price and pay-per-use revenue models (for example based on the customer's mobility preferences or on variations in demand) are combined with different direct and indirect revenue sources. The revenue sources in this case depend on the willingness of customers to share personal data or accept reduced quality.

Stage 5: New revenue model with a sharply differentiated and flexibly selectable combination of direct and indirect revenues
One example of a completely new style of revenue model for a traditional OEM exhibiting a high level of potential differentiation with direct and/or indirect revenue components would be a mobility service in which multiple passengers use one vehicle jointly (for example UberPOOL) and the journey is financed by the activation of personalized advertising automatically tailored to the users' specific preferences.

Strategy: Has the digital transformation been taken up in the corporate strategy?

Stage 1: The digital transformation has not been taken up in the corporate strategy and is not considered in the functional units
The first maturity stage covers situations in which the digital transformation has not (yet) been factored into the corporate strategy and there are consequently no implementation activities in the functional units, for example. The company therefore has no strategic roadmap for the digital transformation. IT is essentially regarded as useful only in terms of the deployment of computers and the use of software to manage business processes.

Stage 2: The digital transformation is a fringe element of the corporate strategy and is barely given any thought in the functional units

The second maturity stage covers organizations that are factoring in the digital transformation at a strategic level but have not taken centrally coordinated steps to implement associated practical actions at the functional level, for example.

Stage 3: The digital transformation forms part of the corporate strategy and is factored into activities by a few functional units
The third maturity stage is considered to have been reached as soon as the digital transformation becomes one of the established elements of the business strategy and has been translated into operational actions across a variety of functional units – in particular actions targeting low hanging fruits such the use of digital channels for marketing purposes, for customer support via digital media, etc.

Stage 4: The digital transformation is completely integrated into the corporate strategy and is factored into activities by most functional units
Organizations that have reached maturity stage 4 regard the digital transformation as an integral part of their corporate strategy, have adopted coordinated actions to implement the associated activities and are explicitly putting the necessary steps into practice across most functional units.

Stage 5: The digital transformation sits at the heart of the corporate strategy and is factored into activities by all functional units
The highest maturity stage denotes a situation in which the digital transformation is the cornerstone and the most pressing factor in strategic planning. Organizations at this stage will have adopted an integrated roadmap for putting the associated actions into practice and implementation activities will extend to all functional units.

Organization: What influence does digitalization have on your company's organizational structure?

Stage 1: Organizational structure with centralized decision-making authority, independently operating functional silos and very limited capacity to adapt
The digital capabilities and resources in evidence at the first maturity stage are not conducive to any far-reaching redesign of the organizational structure. Companies at this stage are concerned much more with achieving targeted efficiency gains in isolated functional units – for example a faster response in customer support.

Stage 2: Organizational structure with a limited measure of distributed decision-making authority, mostly independently operating functional silos and the capacity to adapt only slowly
The second maturity stage covers companies that have begun to utilize digital capabilities and resources to redesign their existing organizational structure and have implemented initial actions to introduce cross-functional collaboration and coordinated change management practices.

Stage 3: Organizational structure with partially distributed decision-making authority, some cross-unit teams and a moderate ability to adapt
Digital capabilities and resources at companies occupying the third maturity stage are increasingly used to decentralize decision-making authority and facilitate cross-functional collaboration (for example through the use of digital collaboration tools). Change processes are firmly anchored in the organizational structure and slowly incorporated into the corporate culture.

Stage 4: Organizational structure with substantially distributed decision-making authority, many cross-unit teams and a strong ability to adapt
The organizational structure at the fourth maturity stage is completely adapted to the digital capabilities and resources. It has a high capacity to learn and can move quickly and adapt flexibly.

Stage 5: Organizational structure with highly distributed decision-making authority, cross-unit teams and optimal adaptability
The elements of rigidity characteristic of traditional organizational structures are completely eliminated at maturity stage five. The (in part virtual) structure is instead flexible and problem-oriented and conducive to the dynamic development of digital capabilities and resources. Decision-making authority is decentralized, cross-unit teams are able to collaborate without hindrance and the organizational structure supports quick action, effective learning and ready adaptation (for example the holacracy approach at Zappos).

b) Technical dimensions

Data analysis: What expertise does your company have in the area of data analytics?

Stage 1: Static, statistical models based on ex-post data (exact description of problem, objective, inputs known)

Objectives, necessary inputs and problems are known and can be examined. Data (virtually without change) is used to trigger events (transactions, working processes, automation tasks). Data is only stored for documentation purposes. Error messages in a vehicle are logged, for example, and the fault memory is retrieved at a later point in time at a workshop or during an inspection. The retrieved data is then analyzed in order to identify the fault and, where applicable, the cause.

Stage 2: Statistically determined (physical/causal) models based on continuous data (objective, inputs known, pattern recognition and forecasts)
Use of a (statistically determined) physical/causal model (in place of the exact problem description) with permanently defined inputs in order to achieve the defined objectives. Data from different sources is acquired, changed or adapted in order to trigger events (with better quality, efficiency, etc.). Data is stored for continuous optimization. This involves analyzing data continuously and checking it for patterns that diverge from the normal status. The system is able to suggest alternatives within a defined framework. Appropriate maintenance intervals might be defined as a function of the telemetry data and/or driving behavior, for example. Certain telemetry data might also be sent to the cloud, for example so that the behavior of multiple users can be analyzed to help optimize motor control.

Stage 3: Dynamic use of models (the system decides which model is used) or use of dynamic parameterization
Dynamic use either of different models (the system decides which model is used) or employing dynamic parameterization. Data is aggregated and combined to support other dimensions. This makes it possible to respond faster and more effectively to changes in the ecosystem and to develop new USPs (predictive maintenance, customer loyalty etc.). It is possible, for example, to have different models parameterized and then selected dynamically during operation. This approach might be used in order, for instance, to enable different motor control software maps to be selected dynamically, where applicable as a function of current driving behavior.

Stage 4: The system decides for itself (input space is permanently defined, for example due to physical constraints) on the input for the model and the model can be adapted dynamically building on base models
The data may also be sourced from external partners. A vehicle recognizes, for example, that the sensor information available requires it to reduce the confidence level (due to contaminated or failed sensors or a dramatic environmental change, for example) and it then attempts instead to access other sources of information, according to a dynamically adapted model, so as to be able to continue performing its function safely.

Stage 5: Only the objective is known. The resulting problem is automatically captured in a dedicated "model" and the data required for the purpose (the input space is not permanently defined) is derived and acquired
A base model is created in an initial iterative process based on all of the information available (relating to the objective). The second step involves the system searching for the necessary input and improving the base model in a continuous process. The system also performs self-diagnosis using a process monitoring routine, which intervenes predictively, and independently develops alternative solution strategies. Potential causation patterns for faults are sought in both directions (ex-post and ex-ante) and suitable solution strategies are developed. The associated process knowledge – in abstracted form – can also be reused in similar situations (abstraction and generalization).

Autonomy: How far has your company progressed in the area of autonomous systems?

Stage 1: Simple processing and response
Recognition of simple signals (own sensors), execution of predetermined actions, simple actuator control loops. In the automotive sector this could amount to the processing of signals from a tire pressure sensor, for example. The sensors generate and display a message if the tire pressure falls below a previously defined threshold value.

Stage 2: Responsive behavior
Possibilities for capturing information about the environment (for example driver characteristics, obstacles), actuator coordination, coordinated execution of movement. One example characteristic of this stage is an active braking assistant that independently initiates a braking maneuver, based on information about the environment captured by sensors, if the driver is too slow to respond.

Stage 3: Semi-autonomous capabilities
Recognition of objects and planning of complex actions (human specifies task elements) in defined but

dynamic environments. Examples of such capabilities might include a parking assistant or the combination of lane keeping, automatic distance keeping and braking assistant.

Stage 4: Fully autonomous capabilities (sector-specific)
Recognition of objects and situations and planning of complex actions in undefined dynamic environments. Vehicles typical of this stage are able to recognize and assess any given situation without human interaction or detailed programming and independently develop, plan and implement solution strategies based on available resources. An example would be a vehicle that can collect its occupants autonomously from any given address.

Stage 5: Full autonomy (not sector-specific)
Adaptation to unknown challenges on the basis of own physical capabilities, establishment of new connections between different contexts. An entity is able to make its functionality available to third parties (for example other sectors or areas of industry) autonomously and has a detailed knowledge of its own capabilities. This scope of capabilities can also be expanded dynamically based on experiences accumulated, so an electric vehicle might make its sensors available to a house (such as rain sensors for window control) for example. Energy, computing power or lessons learned could also be exchanged in order to solve problems or give an indication of future problems.

Digital engineering: How highly developed is your company in digital engineering?

Stage 1: Digitalization of the design and production process
The company understands how to manage data and information and has an appropriate IT infrastructure in place. Paper has (essentially) been replaced by data capture including the structuring of data and information, their rendering available for use and their actual use. This is achieved with a comprehensive computerized product data management (cPDM) system for a specific product, for example. cPDM involves the capture of all product data and process data – bills of material, work schedules, drawings, etc. – digitally in a compatible form. One example from the automotive sector are CAD/CAM models of individual parts that can also be processed by production machines.

Stage 2: Data-driven design support and simulation-based design verification (product design, production engineering)
Simulation is used to verify the properties of the product and plan the production processes. Starting with an existing model of a vehicle body, the existing differential, for example, is replaced with a heavier model. The software tool subsequently indicates that shock absorbers, springs and brakes will also need to be adapted to the new vehicle weight (and, where applicable, suggests suitable products).

Stage 3: Linking of the design process and the production process
Dynamic adjustments to the production process as a function of design decisions and vice versa. For example when vehicle components are being designed, their properties are defined as well. When changes are made, the production processes available in-house are automatically checked for compatibility and modification of the design or of the production process is suggested where applicable. Necessary component supplies, costs, potential volume and delivery times are also determined.

Stage 4: Semi-automated (semi-intelligent) design support (sub-module design in real time for standard modules)
Takes account of entire development and production chain across company boundaries within a sector (dynamic selection/amendment of suppliers and cooperation partners). Taking the example described for stage 3, in this case not just in-house production capabilities but the production capabilities of component suppliers and partners are considered during the design process. Modifications are additionally suggested autonomously in the design process or the production process on the basis of design libraries.

Stage 5: Product requirements are described (in the abstract) and the design of the product and the production chain is suggested and optimized completely automatically across sector boundaries.
Additional features of the vehicle plus the target market and the delivery time are defined starting with a standard body. The tool then suggests possible designs (optics, price elasticity and preferred material) for the specified features and the target market. All of the necessary component suppliers and producers are automatically checked in this connection to verify their capabilities, costs and ability to deliver and the design proposals are optimized based on the results.

E The MGA/CBA process in detail

The full MGA/CBA process comprises the elements set out in the following.

I. Convening

I.1. Begin talks with potential convener
I.2. Start project evaluation (exploratory, confidential talks to sound out stakeholders)
I.3. Identify suitable stakeholders with reference to the project diagnosis
I.4. Involve suitable stakeholders
I.5. Decide, on the basis of the stakeholder response, whether the MGA/CBA approach should be used
I.6. Ensure that decision makers and leading officer support the process even if they are not themselves direct stakeholders

II. Assignment of roles and responsibilities (at first meeting)

II.1. Define responsibilities in respect of convening, support, recording and moderation/chairing of meetings and specify representation of stakeholder groups and expert advice for this purpose
II.2. Set out rules for the involvement of deputies and observers
II.3. Agree agenda, basic rules,[370] work schedule and budget in writing and approve them at the second meeting
II.4. Define options for communication with the stakeholder representative organizations and with the public at large (minutes, websites, mailing lists, etc.)

III. Joint solution finding

III.1. Strive for transparency (distribute minutes after every meeting, but avoid naming names)
III.2. Obtain expert opinion in joint fact-finding
III.3. Set up working groups where necessary
III.4. Invent mutually beneficial options and group into packages
III.5. Separate inventing from committing – a basic rule of MGA/CBA
III.6. Obtain support from qualified neutral process facilitators
III.7. Apply single text method
III.8. Amend agenda, basic rules and schedule as required

IV. Reaching agreement

V.1. Strive for full agreement on a written package of obligations. Questioning using the following scale can be useful in determining the extent of consensus:[371]
a) Wholeheartedly agree;
b) Good idea;
c) Supportive;
d) Reservations – would like to talk;
e) Serious concerns – must talk;
f) Cannot be part of the decision – must block it
IV.2. Use conditional obligations to deal with risks or uncertainty
IV.3. Stick to agreed decision-making procedures
IV.3.1. Ask who cannot live with the written package proposed
IV.3.2. Ask those who raise objections for suggestions as to how to improve the package without simultaneously rendering it unacceptable for others
IV.4. Retain records of all agreements
IV.5. Maintain communication with the stakeholder representative organizations and with the public

V. Compliance with the obligations

V.1. Obtain ratification of the draft agreement by the relevant organizations
V.2. Arrange for stakeholders to sign the Final Agreement
V.3. Present agreement to the powers that be (leading officer, authority) – the issue here is to couple informal agreements to a formal resolution by the office holders[372]
V.4. Reconvene if the powers that be raise objections
V.5. Follow up on changes in circumstances during implementation and reconvene if necessary

370) Susskind/Cruikshank (2006): Breaking Robert's Rules: The New Way to Run Your Meeting, Build Consensus and Get Results, New York, NY, Appendix B, p. 198 et seq.
371) Susskind/Cruikshank (2006): Breaking Robert's Rules: The New Way to Run Your Meeting, Build Consensus and Get Results, New York, NY, Appendix B, p. 199
372) Susskind/Cruikshank (1987): Breaking the Impasse: Consensual Approaches to Resolve Public Disputes, New York, NY, p. 95.

F Annex concerning EMS

Software according to number of participants:

- Up to 25 participants: ClickMeeting[373] (many-to-many solution); Mikogo;[374] GoMeetNow;[375] TeamViewer;[376] WebEx;[377] Spreed Meeting[378] (it is particularly important to emphasize that the participants must be able to create and use whiteboards and mindmaps together)
- Up to 100 participants: GoToMeeting;[379] FastViewer Instant Meeting;[380] Adobe Connect Meetings;[381] AnyMeeting;[382] GlobalMeet;[383] ReadyTalk;[384] IBM SmartCloud Meetings[385]
- Up to 250 participants: join.me[386]
- For conferences involving up to 1,000 participants: ClickWebinar;[387] Adobe Connect Webinar[388]
- Collaboration software: ClickMeeting;[389] Spreed Meeting;[390] Group Systems ThinkTank[391] (platform for collective intelligence); MeetingSphere;[392] Spilter;[393] for large groups: nextpractice and nextmoderator;[394] teambits:interactive[395] (spin-off from Fraunhofer Gesellschaft)

G Description of the IT Summit platforms

There is no publicly accessible list showing all of the companies and institutions involved in Germany's National IT Summit, so a variety of data sources have been analyzed for this overview. The members of the focus groups associated with each of the platforms have been added to the list of platform members where known.

The presentation makes no claim to be complete because lists of members were not publicly available for all platforms, focus groups and project groups. The companies and institutions involved with the various platforms were counted only once even if multiple representatives were present. The total figure avoids any duplication and counts all of the companies and institutions involved in the German National IT Summit once only.

The list of members for each platform is based on the document "Nationaler IT-Gipfel" published by the German Federal Ministry for Economic Affairs and Energy (BMWi).[396]

Lists of members from publicly available platform documents were also assessed. The various documents and the associated platform are listed in the following.

Digital Networks and Mobility platform

The list of member companies of the platform is additionally informed by the following documents:

Network Convergence focus group:
Abschlussdokument der Fokusgruppe Konvergenz der Netze, Published by: Nationaler IT-Gipfel Berlin 2015 – Plattform "Digitale Netze und Mobilität", available at: *http://www.bmvi.de/SharedDocs/DE/Anlage/Digitales/it-gipfel-fg-konvergenz-1.pdf?__blob=publicationFile* (version of October 2015), most recently accessed on April 8, 2016.

Smart Data for Intelligent Mobility focus group:
Ergebnisdokument der Fokusgruppe Smart Data für intelligente Mobilität, Published by: Nationaler IT-

373) http://www.clickmeeting.com/?utm_source=affiliate-ink&utm_medium=affiliates&utm_campaign=publicare
374) https://www.mikogo.de/
375) http://www.gomeetnow.com/web-conferencing/learn.html#FastestCollaborate
376) http://www.teamviewer.com/de/
377) http://www.webex.de/
378) http://www.spreed.com/eu/?set_language=de
379) http://www.gotomeeting.com/
380) https://fastviewer.com/de/online-meeting/
381) http://www.adobe.com/de/products/adobeconnect/meetings.html
382) https://www.anymeeting.com/ways-to-use/Web-Conferencing.aspx
383) https://www.pgi.com/globalmeet/
384) https://www.readytalk.com/
385) http://www.ibm.com/cloud-computing/social/de/de/webmeetings/
386) https://www.join.me/de
387) http://www.clickwebinar.com/?&_ga=1.115198471.1268378132.1460195635
388) http://www.adobe.com/de/products/adobeconnect.html
389) http://www.clickmeeting.com/?utm_source=affiliate-link&utm_medium=affiliates&utm_campaign=publicare
390) http://www.spreed.com/eu/?set_language=de1
391) http://thinktank.net/
392) https://www.meetingsphere.com/
393) http://www.spilter.nl/
394) http://www.nextpractice.de/nextmoderator.html
395) http://www.teambits.de
396) Available at: https://www.bmwi.de/BMWi/Redaktion/PDF/M-O/nationaler-it-gipfel-2015,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf (version of November 2015); most recently accessed on April 8, 2016.

Gipfel Berlin 2015 – Plattform "Digitale Netze und Mobilität", available at: *http://www.bmvi.de/SharedDocs/DE/Anlage/Digitales/it-gipfel-fg-smartdata.pdf?__blob=publicationFile* (version of October 2015), most recently accessed on April 8, 2016.

5G focus group:
Ergebnisdokument der Fokusgruppe 5G, Published by: Nationaler IT-Gipfel Berlin 2015 – Plattform "Digitale Netze und Mobilität", available at: *http://www.bmvi.de/SharedDocs/DE/Anlage/Digitales/it-gipfel-fg-5g-vision.pdf?__blob=publicationFile* (version of October 2015), most recently accessed on April 8, 2016.

Innovative Digitalization of the Economy platform

The list of member companies of the platform is additionally informed by the following documents:

Digital Sovereignty in a Connected World focus group:
Leitplanken Digitaler Souveränität, Published by: German Federal Ministry for Economic Affairs and Energy (BMWi). [397]

Intelligent Networking focus group:
Stakeholder Peer Review, Deutschland intelligent vernetzt, Status- und Fortschrittsbericht 2015, Published by: Nationaler IT-Gipfel – Plattform "Innovative Digitalisierung der Wirtschaft" –Fokusgruppe "Intelligente Vernetzung". [398]

Industry 4.0 platform

The list of companies and institutions represented in the platform is taken from the following document:

Zusammensetzung der Leitung der Plattform sowie eine Übersicht der in der Plattform vertretenen Unternehmen und Organisationen, Published by: Industry 4.0. platform. [399]

Digital Work Environment platform

The list of member companies of the platform is additionally informed by the following document:

Flexible Working Time and Location focus group:
MONITOR Mobiles und entgrenztes Arbeiten. Aktuelle Ergebnisse einer Betriebs- und Beschäftigtenbefragung, Published by: German Federal Ministry of Labor and Social Affairs. [400]

It was not possible to include the members of the Protection Standards in the Digital Work Environment focus group in the dataset as this focus group will not commence activities until the end of 2016 and the participants had yet to be finalized at the time of publication.

The kickoff meeting for the Employment and Training focus group is scheduled to take place shortly. No documentation on results or conclusions has been published so far and nor is there a publicly accessible list of participants for this platform, so it has not been possible to include the members of this focus group in this dataset.

Digital Administration and Public IT platform

The list of members of the six focus groups is based on

IT-Gipfel Fokusgruppen der Plattform "Digitale Verwaltung und öffentliche IT", Prepared by: TB´e Radtke. [401]

Observations regarding the presiding German federal ministries:
The presiding German federal ministries for the various platforms and forums have been taken from the following document:
http://www.bmwi.de/BMWi/Redaktion/PDF/I/infopapier-neuausrichtung-it-gipfel-digitale-agenda,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf

The Culture and Media platform is chaired by Minister of State Prof. Monika Grütters, Federal Government Commissioner for Culture and the Media.

397) Available at: https://www.bmwi.de/BMWi/Redaktion/PDF/IT-Gipfel/it-gipfel-2015-leitplanken-digitaler-souveraenitaet,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf; most recently accessed on April 8, 2016.
398) Available at: https://www.bmwi.de/BMWi/Redaktion/PDF/IT-Gipfel/it-gipfel-2015-intelligente-vernetzung,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf (version of November 2015); most recently accessed on April 8, 2016.
399) Available at: http://www.plattform-i40.de/I40/Redaktion/DE/Downloads/Publikation/zusammensetzung-industrie-4-0.pdf;jsessionid=8D09358D526B59589D3A0CBAC9D3FA76?__blob=publicationFile&v=2 (version of January 2016); most recently accessed on April 8, 2016.
400) Available at: http://www.bmas.de/SharedDocs/Downloads/DE/PDF-Publikationen/a873.pdf?__blob=publicationFile&v=2 (version of November 2015); most recently accessed on April 8, 2016.
401) Verfügbar unter: http://www.cio.bund.de/SharedDocs/Publikationen/DE/Politische-Aufgaben/fokusgruppen_der_plattform_digitale_verwaltung_und_oeffentliche_it.pdf?__blob=publicationFile (Stand Juni 2015); letzter Zugriff am 08.04.2016.

H Data sources for other platforms considered

Commission of Experts for Research and Innovation:

The Commission of Experts for Research and Innovation is a scientific advisory body to the German federal government in the area of research and innovation policy.

http://www.e-fi.de/

National Platform for Electric Mobility:

The German National Platform for Electric Mobility is an advisory body to the German federal government in the area of electric mobility.

http://nationale-plattform-elektromobilitaet.de/

Network Alliance for a Digital Germany:

The Network Alliance for a Digital Germany is a forum concerned with comprehensive high-speed data network coverage.

http://www.bmvi.de/DE/DigitalesUndRaumentwicklung/DigitaleInfrastrukturen/Netzallianz/netzallianz_node.html

Cars and Data and the Automated Driving round table:

Cars and Data and the Automated Driving round table are platforms established under the auspices of the German Federal Ministry of Transport and Digital Infrastructure and are actively supporting the advance to Mobility 4.0.

https://www.bmvi.de/SharedDocs/DE/Anlage/VerkehrUndMobilitaet/rede-dobrindt-bundestag-haushalt-2015.pdf?__blob=publicationFile

https://www.cducsu.de/sites/default/files/150324_positionspapier_automatisierung_des_fahrens.pdf

Innovation Dialog:

The Innovation Dialog is a dialog and specialist advisory body to the German federal government in the area of future issues pertinent to innovation policy. The third Innovation Dialog of the 18th legislative period concerns the subject of "Innovation potential in human-machine interaction".

http://innovationsdialog.acatech.de/

https://www.bundeskanzlerin.de/Content/DE/Pressemitteilungen/BPA/2015/11/2015-11-11-dritter-innovationsdialog.html

High-Tech Forum:

The High-Tech Forum is an expert committee that advises the German federal government on all high-tech strategy matters.

http://www.hightech-forum.de/

Three-level industry dialogs of the German Federal Ministry for Economic Affairs and Energy (BMWi):

The BMWi's industry dialogs, which are organized over three levels, draw up recommended actions on various issues, in conjunction with representatives of the relevant sectors, to make German industry more competitive.

Relevance in the context of digitalization:

Trades industry dialog

The Trades ("Handwerk") industry dialog identified three domains of particular importance for the future of this area: investment/finance; ensuring availability of specialists and employment opportunities; and digitalization.

http://www.bmwi.de/BMWi/Redaktion/PDF/B/branchendialog-handwerk-gemeinsame-erklaerung,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf

http://www.bmwi.de/DE/Themen/industrie,did=705266.html

Mechanical Engineering and Plant Engineering and Construction industry dialog

A public online consultation conducted as part of the Mechanical Engineering and Plant Engineering and Construction ("Maschinen- und Anlagenbau") industry dialog found the following issues to be the sector's most pressing concerns: Industry 4.0, internationalization/export and employment policy.

http://www.bmwi.de/DE/Themen/industrie,did=675632.html

Alliance for the Future of Industry:

The Alliance for the Future of Industry ("Bündnis Zukunft der Industrie") is a platform for consolidating and communicating the results of sector-specific dialogs and deriving recommendations for action.

Relevance in the context of digitalization:
Among the subjects addressed by the Alliance's working group 4, Value Creation Structures of the Future ("Wertschöpfungsstrukturen der Zukunft"), are:

- Digitalization and integration of industrial structures
- Industry 4.0 taking account of the German National IT Summit, the Industry 4.0 platform, the Innovative Digitalization of the Economy platform and other initiatives

http://www.bmwi.de/BMWi/Redaktion/PDF/B/buendnis-zukunft-der-industrie-struktur-und-arbeitsweise,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf
http://www.bmwi.de/DE/Themen/Industrie/buendnis-zukunft-der-industrie.html

I Categorization of terms used

Small and midsize companies (SME)
Small and midsize companies for the purposes of the present study are companies that employ fewer than 250 people. [402]

Start-up
The definition of a startup for the purposes of the present study is based on the criteria employed by the German Startups Association (BVDS), namely: [403]

- Less than ten years old
- Marked growth in employee numbers and/or other key indicators (for example sales revenue or customers)
- Strong innovative capability

Science and education
The "Science and education" category contains institutions whose activities center on scientific endeavors and/or research. These include state and private universities and their institutions and departments, non-university-sector research institutions (such as the Fraunhofer-Gesellschaft, Leibniz-Gemeinschaft and Max-Planck-Gesellschaft), research associations, scientific academies and private companies with a scientific focus. The German Research Foundation (DFG) and the German Aerospace Center (DLR) are also counted in this category.

Business associations and interest groups
This category comprises business associations and interest groups plus relevant trade associations, co-operatives and industry consortiums.

Trade unions
This category contains trade unions.

Politics
Governmental institutions such as ministries and agencies at European, national, state and municipal level fall into this category along with political parties and their members and government commissioners.

Society
This category contains associations and organizations that have a charitable mission and/or are active in social affairs and/or promote social projects.

402) Available at: https://www.kfw.de/Download-Center/F%C3%B6rderprogramme-%28Inlandsf%C3%B6rderung%29/PDF-Dokumente/6000000196-KMU-Definition.pdf
403) Available at: https://deutschestartups.org/wp-content/uploads/2013/07/DeutscherStartupMonitor2013.pdf

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