PLATTFORM INDUSTRIE 4.0

Value Networks as the Foundation for Digital Business Models

– Use Cases from Germany and China –

Sino-German Company Working Group on Industrie 4.0 and Intelligent Manufacturing (AGU)
Expert Group Digital Business Models

Published by

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CCID 赛迪

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This publication is a result of close cooperation between multiple entities in Germany and China including the Sino-German Company Working Group on Industrie 4.0 and Intelligent Manufacturing Expert Group Digital Business Models in support of the MoU signed in 2015 between BMWi and MIIT following the 2014 joint action plan "Shaping Innovation Together."

Since 2016, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, commissioned by BMWi, and the China Center for Information Industry Development (CCID) are the implementing bodies for the cooperation on the German and the Chinese side, respectively.

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Executive Summary

Industrial value creation is undergoing a major transformation on a global scale. Industrie 4.0 technologies enable enterprises to reinvent their traditional value propositions by utilising data in innovative ways. Value networks are emerging, horizontally connecting different industries and sectors across international borders, while vertically connecting raw material suppliers all the way to the consumers. Based on these networks, new digital business models provide innovative products and services that greatly improve customer experience. For the major global manufacturing hubs Germany and China, it is of utmost importance to understand the architecture of these new digital business models and to harness their potentials.

This study analysed 25 use cases from both countries, identifying six business model clusters:

1. **Efficiency** – An increase in efficiency results from reducing inputs while simultaneously producing similar or higher levels of output.
2. **Smart Product as Service** – Smart connected products can change product design and engineering. Making products smart can be offered as a service.
3. **Marketplace** – A marketplace coordinates supply and demand to facilitate transactions. Marketplace providers offer information and search functions, service provision, invoicing and assessment mechanisms.
4. **Data Trustee (Data Marketplace)** – The data trustee model enables data trading. Data trustees play a key role as a neutral platform.
5. **Mass Customisation** – Platforms allow for a mass customisation model focusing on the user experience and create demand to maximise the benefits for all parties to achieve win-win results.
6. **Value adding services in operation (As a service)** – Value adding services in operation describes the process of assessing the business model.

The following observations were made throughout the use-case analysis:

- Adaption and maturity level vary by size of company: Larger companies have higher levels of adoption of technology-led process and service innovation.
- Lack of innovation spill over in the economy: Spill over from larger to smaller companies is needed to realise value and productivity gains across the economy.
- Getting from data to value: Assessment of the value of date, pricing, trade and monetisation is in its infancy.
- Lack of talent: Technical, functional and managerial skills to harness the value of digital transformation are scarce.
- Security concerns: Concerns over the security of intellectual property are widespread.

Recommendations for enterprises and governments on how to facilitate the development and application of digital business models are elaborated in chapter 4.

1. Introduction

1.1 Background: Sino-German Cooperation on Intelligent Manufacturing

In July 2015, the German Federal Ministry for Economic Affairs and Energy (BMWi) and the Chinese Ministry of Industry and Information Technology (MIIT) signed a Memorandum of Understanding (MoU) with the objective of supporting German and Chinese enterprises in creating a favourable business environment for Intelligent Manufacturing and Industrie 4.0. This MoU emphasizes the importance of industry cooperation and highlights the shared interest in facilitating further dialogue at all levels between representatives from government, industry and academia.

BMWi and MIIT commissioned the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and the China Center for Information Industry Development (CCID) respectively to support the implementation of the MoU. Under the direction of BMWi and MIIT, GIZ and CCID jointly established the Sino-German Company Working Group on Industrie 4.0 and Intelligent Manufacturing (AGU)[1] as a platform for German and Chinese experts to discuss challenges and opportunities of Industrie 4.0 and Intelligent Manufacturing with the goal of better understanding the relevant business environment and policies, exchanging best practices and developing joint policy recommendations. These discussions directly inform the bilateral political dialogue.

The AGU expert groups focus on four Industrie 4.0 areas. These include:

- Digital Business Models
- Training 4.0
- Industrial Internet
- Artificial Intelligence

Specifically, the AGU Expert Group Digital Business Models seeks to understand the architecture of digital business models and develops guidelines for harnessing their potential to design dynamic value creation networks. The Expert Group Digital Business Models analyses and classifies the building blocks and mechanisms of digital business models with a specific focus on the needs and unique characteristics of German and Chinese enterprises of all kinds.

1.2 Objective of this Report

This report explores the nature of digital transformation in the manufacturing sector from the perspective of new business models and value chains. Use cases referenced in this paper may serve as examples to further establish digital business models in pursuit of further digitisation. The selection of use cases presented in this report is without claim to completeness, practical examples should be considered exemplary.

Based on industry use cases, this report compares digital business model architectures in China and Germany and analyses the impact of regulatory conditions on the success of digital business models. The study identifies patterns of value creation in production networks.

1.3 Impacts of COVID-19

Data for this study was collected from German and Chinese enterprises between May and November 2019. At the beginning of 2020, the COVID-19 epidemic has begun to drastically change the landscape and application rate of digital business models across the world by disrupting businesses' traditional modes of production and labour practices. These dynamics make the findings even more relevant. There

1 Deutsch-Chinesische Arbeitsgruppe Unternehmen in Industrie 4.0 und Intelligente Fertigung (AGU)

is evidence that the crisis will be both an accelerator and a catalyst of many of the business model trends discussed in this study. Facing public health concerns and corresponding government restrictions, remote capabilities for production processes have played a key role for enterprises in resuming business operations. Changing overall attitudes towards risk perception, value chain dependencies as well as financial benefits of digital operations can be observed across industries and indicate a long-term shift towards a more rapid application of digital business models in manufacturing.

In this sense, this report continues to provide highly relevant data and information supporting businesses in the development and application of digital business models in manufacturing.

1.4 Report Structure

The report opens with a description of key building blocks and mechanisms of digitally enabled business models in the manufacturing industry. The next section addresses the context in Germany and China before analysing the six value creation thematic clusters and their respective German-Chinese use cases. The report concludes with a discussion of opportunities and challenges for digitally enabled business models and joint recommendations for Germany and China to support the development of digital business models.

1.5 Characteristics and Enabling Technologies of Digital Business Models

Customer value and personalisation through "smart" services are at the heart of competitiveness today. Business models focusing on economies of scale have moved beyond a simple industrialisation and automation paradigm into one of mass customisation. Companies must evaluate their traditional business models and potentially reshape the production process to create value. Digital business models are a key factor in increasing an enterprise's competitive advantage.

This chapter identifies and describes key digital business model enabling technologies.

i. Cyber-physical system (CPS)

A cyber-physical system embeds software and sensors to record physical data in near real-time and actuators influence physical processes. A cyber-physical system is able to independently evaluate and save the acquired data and thus interact with both the physical and the virtual world.[2] In this context, physical components are mapped into realistic, digital models and the potential of the virtual world is transferred to the physical components.[3]

ii. Cloud computing

Cloud computing provides the necessary infrastructure to support near real-time control, maintenance and control of cyber-physical systems.[4] Cloud computing hosts the key characteristics of a shared resource pool as well as access via a network, flexible scalability, measurement of resource use and self-service.[5] Specifically, cloud computing is the process by which large data calculation processing programs are decomposed into countless small programs through the network "cloud". Through the cloud computing system composed of multiple servers, the small programs are processed and analysed to generate results for the user.

iii. Edge computing

Edge computing describes the process by which near real-time data processing and computation occurs closer to the source on the edge of the network with minimal network load, like on the shop floor. Analytics can be operated directly on the machine or device or at the plant.[6]

2 acatech–Deutsche Akademie der Technikwissenschaften, Hrsg. (2011): Cyber-Physical Systems: Innovationsmotor für Mobilität, Gesundheit, Energie und Produktion, Springer Berlin Heidelberg, p. 13.

3 Lee, Edward A. (2010): "CPS Foundations ". In: ACM, Hrsg. (2010): DAC '10 – Proceedings of the 47th Design Automation Conference. New York, p. 737–742.

4 Roth, Armin. Hrsg. (2016): Einführung und Umsetzung von Industrie 4.0: Grundlagen, Vorgehensmodell und Use Cases aus der Praxis. 1. Aufl. 2016. Berlin, Heidelberg: Springer Gabler.

5 Mell, Peter; Grance, Timothy (2011): The NIST definition of cloud computing – Recommendations of the National Institute of Standards and Technology. Hrsg. Von National Institute of Standards and Technology. Gaithersburg, MD.

6 RTInsights, Hrsg. (2017): Modernste Computertechnik: So setzen Sie das geschäftliche Potenzial des IoT frei; Gartner, Hrsg. (2018): Magic Quadrant for Industrial IoT Platforms.

iv. IIoT/industrial internet platforms

Industrial Internet of Things (IIoT) platforms refer to the more extensive and deeper application of computing and communication network technology in industrial systems. It describes the connection of entities (sensing/execution control devices, products and equipment, etc.), information systems, business processes and people to drive production and operations intelligently by analysing data and optimising decisions. Industrial Internet of Things (IIoT) platforms are also referred to as Cloud Manufacturing platforms or Industrial Internet Platforms. Such an industry platform creates a data-driven overall system that includes complementary products (hardware, software, data, and/or services). This overall system is also referred to as a digital ecosystem.[7]

v. Digital twin

The **Digital twin** is a virtual image of a physical object or system. It provides data about the current state of its physical object and creates the foundation for analytics solutions to predict future events.[8] Digital twins can be used to complete value chains and map out product life cycles. They also include dynamic status information of the individual workstation, the manufacturing environment or even the entire factory. Networking the digital twins of the means of production via software-defined manufacturing produces an image of the real factory.[9]

vi. Software-defined and service-oriented manufacturing

As part of cloud manufacturing, the production environment increasingly relies on the business model innovation "Manufacturing as a Service", which includes **software-defined and service-oriented manufacturing.** By using virtual companies, production networks become more flexible and production sites and facilities are networked on an order-specific basis. By sharing these networked production infrastructures over the Internet, customer-specific goods can be produced on demand without the need for costly equipment acquisition.[10]

Service-oriented manufacturing integrates data storage and analysis of equipment operation, maintenance and other types of services in a paradigm that allows for revenue sharing.

vii. Big data

Big data describes the vast amounts of data produced via the digitisation of processes. The ability to analyse these data with intelligent algorithms (Big Data Analytics) in combination with powerful hardware systems, such as in-memory databases, is an unprecedented source of information. All potentially relevant information can be recorded and applied to operational or strategic planning.[11]

viii. Artificial Intelligence

Artificial Intelligence (AI) describes the branch of research, design, and intelligent machine application in computer or intelligent science. AI is a technical science for simulating and extending the theory, methods, technologies, and applications of human intelligence.

1.6 Relevance for German and Chinese Economic Development

Germany's "Plattform Industrie 4.0" is a multistakeholder platform which brings together representatives from companies, academia, government, trade unions, and associations. Since the start of the initiative in its current form in 2015, "Plattform Industrie 4.0" discussions have primarily focused on the following components of a response to the digitisation of production: standardisation, technology, security, regulatory conditions and the future of work. The debate initially focused on the digitisation of companies' internal production processes ("smart factory"). Now, in the context of changing value creation, business model innovations are increasingly coming

7 Kraus, Tobias; Strauß, Oliver; Scheffler, Gabriele; Kett, Holger; Lehmann, Kristian; Renner, Thomas (2017): IT-Plattformen für das Internet der Dinge (IoT). Basis intelligenter Produkte und Services. Hrsg. von Fraunhofer-Institut für Arbeitswirtschaft und Organisation IAO; Hartmut Rauen; Glatz, Rainer; Schnittler, Volker; Peters, Kai; Zollenkop, Michael; Lüers, Martin; Becker, Lorenz; Schorak, Markus H. (2018): Plattformökonomie im Maschinenbau. Herausforderungen – Chancen – Handlungsoptionen. Hrsg. von Roland Berger GmbH.

8 Sallaba, Milan; Gentner, Andreas; Esser, Ralf (2017): Grenzenlos vernetzt. Smarte Digitalisierung durch IoT, Digital Twins und die Supra-Plattform. Hrsg. von Deloitte.

9 Kagermann, Henning; Riemensperger, Frank; Leukert, Bernd; Wahlster, Wolfgang (2018): Smart Service Welt 2018. Wo stehen wir? Wohin gehen wir? Hrsg. von acatech – Deutsche Akademie der Technikwissenschaften.

10 Fraunhofer-Institut für Produktionstechnik und Automatisierung IPA (2019): Cloud-Plattformen.

11 Bauernhansl, T.; Hompel M.; Vogel-Heuser B.. Industrie 4.0 in Produktion, Automatisierung und Logistik. Wiesbaden: Springer Vieweg, 2014.

to the fore as key distinguishing features of competitiveness. The steering committee of "Plattform Industrie 4.0" therefore recommended the establishment of a new working group on "Digital Business Models in Industry 4.0", which was officially launched in March 2018.

In China, the integrative development of industrialisation and information technology is one of the characteristics of Chinese industrial economy development. Coupled with the rapid evolution of information and communication technology, new opportunities for upgrading manufacturing have emerged. To emphasise the research of new techniques, features and industrial formats during the progress of digital and intelligent manufacturing development, CCID has built a cooperation platform called Lingxi. This platform supports experts and companies in sharing their practical experience in intelligent manufacturing, digital enterprises and industrial internet applications. The Lingxi platform is also a service platform to provide practical tools and solutions for companies implementing digital transformation. More and more companies are finding incremental value and new business models to be the key topics before starting digital projects.

An overview of different approaches to upgrade industrial production in Germany and China:

How to connect the manufacturing industry

Different approaches to upgrade industrial production in Germany, China and US

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Initiative	Focus	Goals	Approach to data	Actors	Institutional bodies
Industrie 4.0	• Smart manufacturing & mechanical engineering • Hardware	• Industrial integration across entire value chains • Optimized, flexible (incl. personalized) production • Maintain Germany's traditionally strong position in manufacturing and mechanical engineering	"protect it"	• Government • R&D institutes • Business (large corporations & SMEs)	Plattform Industrie 4.0
Made in China 2025	• Smart manufacturing & consolidation of/across existing industries • Standard-setting	• Automized and digitalized (mass) production • From mere production to also design "made in China" • Advance manufacturing to catch up to the 3rd and lead the 4th Industrial Revolution	"control it"	• Government • Companies (large corporations) • R&D institutes	Alliance of Industrial Internet (AII)

Figure 1: Manufacturing Initiatives in Germany and China[12]

1.7 Status Quo in Germany and China

Business environment and regulation differ significantly by economic context. National governments help shape the enabling environment for innovation and new digital business models. In some areas, like data driven business models, there is a clear linkage between national regulation (e.g. data regulation) and possible business models.

Understanding how companies manage the interplay between external forces and internal capabilities is essential for the design of policy instruments that support innovation. This section first describes the status quo in Germany and its relation to the European Union before turning to the status quo in China.

1.7.1 Germany

In Germany, many organisations are facing increasing pressure to respond to the opportunities related to digital technologies. At the same time, many of these organisations lack the capabilities to do so successfully. To address this misalignment, the German government has established a variety of innovation policies summarised in this section.

European Union

The status quo in Germany must first be addressed within the broader context of the European Union. Germany, like other member

12 MERICS. "China's digital platform economy: Assessing developments towards Industry 4.0 – Challenges and opportunities for German actors". Content here are based on presentation of preliminary research results, which has been presented at BMWi. 26 September 2019, Berlin.

states, transferred broad competencies to the European Union, e.g. trade and currency. Based on the European Framework, the German government has an interest in developing a strong European position.

The European Union has expressed interest in further engagement with China. The European Commission, the executive branch of the EU, published a March 2019 "EU-China – A Strategic Outlook" outlining the EU's strategy for the European-Chinese relationship and connecting Europe with Asia. The outlook "provides a clear framework for confident engagement with our partners, enabling the Union to seek synergies between the EU and third countries, including China, in transport, energy and digital connectivity, on the basis of international norms and standards. The key principles of EU engagement on connectivity are financial, environmental and social sustainability, transparency, open procurement and level playing field."[13]

When it comes to the European Strategy for Artificial Intelligence,[14] the European Commission "sets out a number of operational measures aiming to maximise the impact of investments and to help Europe become the world-leading region for developing and deploying cutting-edge, ethical and secure Artificial Intelligence. These joint actions focus in particular on increasing investment, making more data available, fostering talent and ensuring trust. Such closer and more efficient cooperation is essential for implementing the EU's values-based approach of human-centric and trustworthy Artificial Intelligence, a key condition for wide acceptance."[15]

Germany

In recent years, the German government has passed various strategies and programs to set national policy targets for digital value addition.

- **Strategies (selection)**
  - Research and Innovation that benefit the People: The High-Tech Strategy 2025[16]
    (Forschung und Innovation für den Menschen: Die Hightech-Strategie 2025)
  - National Strategy for Artificial Intelligence[17]
    (Strategie Künstliche Intelligenz der Bundesregierung)
  - Shaping Digitisation: Implementation Strategy of the German Government[18]
    (Digitalisierung gestalten: Umsetzungsstrategie der Bundesregierung)

- **Programs (selection)**
  - "Microelectronics from Germany – Driving Digital Innovation" (BMBF)[19]
    (Rahmenprogramm "Mikroelektronik aus Deutschland – Innovationstreiber der Digitalisierung")
  - "Innovation for Production, Service and Work of tomorrow" (BMBF)[20]
    (Dachprogramm "Innovationen für die Produktion, Dienstleistung und Arbeit von morgen")
  - "Development of digital Technologies" (BMWi)[21]
    (Förderrahmen "Entwicklung digitaler Technologien")

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13 EC (2019): European Commission and HR/VP contribution to the European Council: EU-China – A strategic outlook. 12 March 2019, p. 5.

14 Communication from the Commission to the European Parliament, the European Council, the European Economic and Social Committee and the Committee of the Regions – Artificial Intelligence for Europe. COM (2018) 237 final, 25 April 2018.

15 EC (2019): European Commission and HR/VP contribution to the European Council: EU-China – A strategic outlook. 12 March 2019, p. 9.

16 BMBF. "Research and Innovation that benefit the People: The High-Tech Strategy 2025". September 2018. Accessed 29 May 2020. https://www.bmbf.de/upload_filestore/pub/Research_and_innovation_that_benefit_the_people.pdf

17 The Federal Government of Germany. "Strategie Künstliche Intelligenz der Bundesregierung". November 2018. Accessed 29 May 2020. https://www.bmbf.de/files/Nationale_KI-Strategie.pdf

18 The Federal Government of Germany. "Digitalisierung gestalten: Umsetzungsstrategie der Bundesregierung" September 2019. Accessed 29 May 2020. https://www.bundesregierung.de/resource/blob/992814/1605036/61c3db982d81ec0b4698548fd19e52f1/digitalisierung-gestalten-download-bpa-data.pdf?download=1

19 BMBF. "Mikroelektronik aus Deutschland – Innovationstreiber der Digitalisierung, Rahmenprogramm der Bundesregierung für Forschung und Innovation 2016-2020" November 2018. Accessed 29 May 2020. https://www.bmbf.de/upload_filestore/pub/Rahmenprogramm_Mikroelektronik.pdf

20 BMBF. "Innovationen für die Produktion, Dienstleistung und Arbeit von morgen". August 2014. Accessed 29 May 2020. https://www.bmbf.de/upload_filestore/pub/Innovationen_fuer_die_Arbeit_von_morgen.pdf

21 BMWi "Bekanntmachung zum Förderrahmen „Entwicklung digitaler Technologien" 2019 bis 2020". Accessed 29 May 2020. https://www.digitale-technologien.de/DT/Navigation/DE/Foerderaufrufe/Foerderrahmen/foerderrahmen.html

- Smart Service World I, Smart Service World II (BMWi)[22]
  (Smart Service Welt I, Smart Service Welt II)

In addition to the abovementioned strategies and programmes, the Federal Ministry for Economic Affairs and Energy (BMWi) and the Federal Ministry of Science and Higher Education (BMBF) have established multistakeholder platforms to share perspectives and develop new ideas.

- **Platforms (selection)**
  - Platform Industrie 4.0 (Plattform Industrie 4.0)
  - Platform Learning Systems (Plattform Lernende Systeme)

- **Instruments (selection)**

The following table[23] provides a systematic categorisation of policy instruments used by the German government to promote digital business models.

Category	Description	Example
Legislation/ regulation	Mandatory obligations or restrictions by governmental body	Law for digitisation of the renewable energy transition
Economic/ fiscal	Change of incentive structure of an individual or organisation	Taxes on digital business models
Agreement-based	Government body is contracting a private organisation for a certain task	German Federal Network Agency (Bundesnetzagentur)
Information- or communication-based	Influencing behaviour by provision of information	SME 4.0 Agencies (Mittelstand 4.0 Agenturen)
Co- or self-regulation	Regulatory initiatives by those who are to be regulated	Charta for digital connectivity (Charta der digitalen Vernetzung)
Support mechanisms and capacity building	Generating knowledge and research, demonstration projects, dissemination of knowledge, building networks	Support Programs; Mittelstand 4.0 Competence Centers; Digital Hubs Germany

Table 1: Categorisation of policy instruments[24]

1.7.2 China

The Chinese government cites innovation as key for digital economic development, especially for services and business models.[25] Innovations in different areas and accompanying business models impact industrial upgrades and the quality of economic growth.

22 BMWi. "Smart Service Welten". Accessed 29 May 2020. https://www.bmwi.de/Redaktion/DE/Artikel/Digitale-Welt/smart-service-welt.html

23 Sakao, T.; Wasserbaur, R. (2018): Analysing interplays between PSS business models and governmental policies towards a circular economy, in: Procedia CIRP 73 (2018) 130-136, p. 131.

24 Adapted from Sakao et. al.

25 MERICS. "China's digital platform economy: Assessing developments towards Industry 4.0 – Challenges and opportunities for German actors". Content here are based on presentation of preliminary research results, which has been presented at BMWi. 26 September 2019, Berlin.

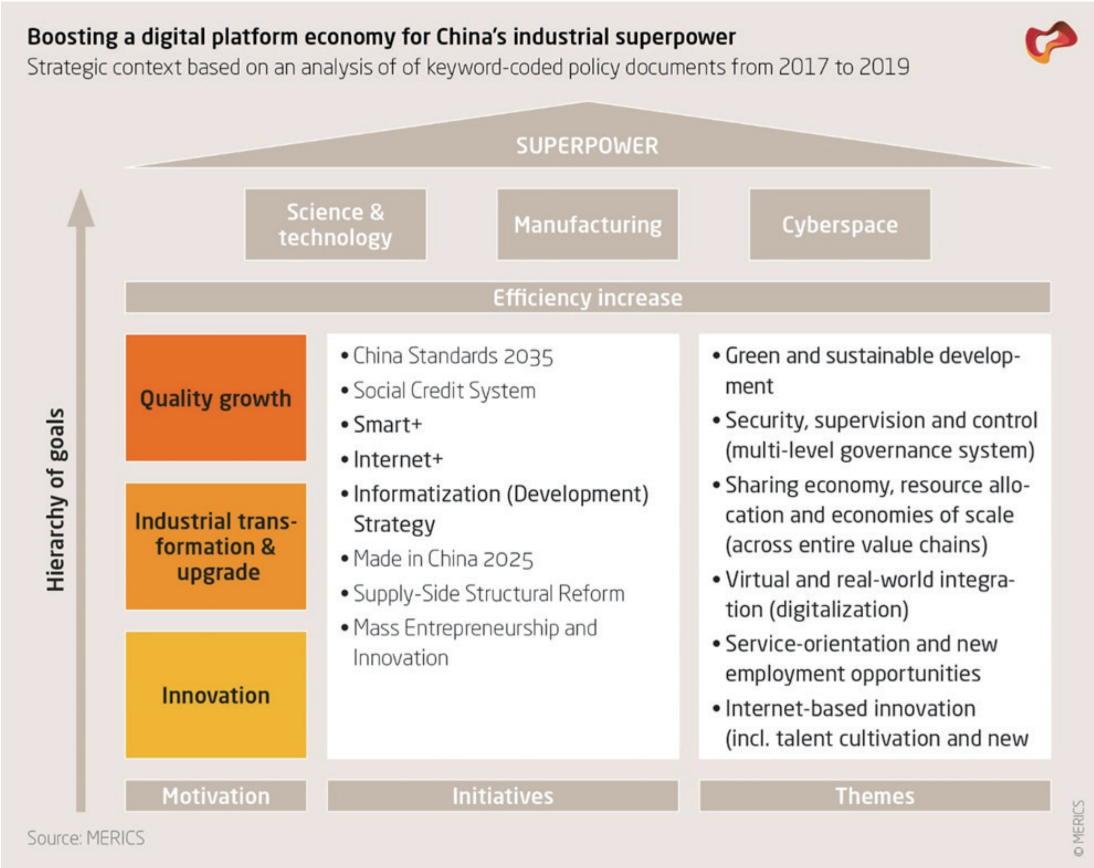

Figure 2: Boosting a digital platform economy for China's industrial superpower[2626]

The key motivation driving this development lies with the promotion of

- innovation (domestic capabilities and industrial application including commercialisation)
- industrial transformation and upgrading of China's economy, and
- quality growth – as opposed to quantitative growth.

The development dynamics in the industrial area revolve around supply-side structural reform and "Made in China 2025" as the "backbone". Combined with a digital platform economy, they are meant to increase efficiency in China's economic system while supporting the goal of turning China into a science and technology, manufacturing and cyber superpower. The development of China's digital platform economy thus thrives on other major initiatives, such as "Internet+". They seek to leverage big data and AI technologies, stressing a similar set of key themes (including win-win cooperation, service-orientation, and data/cyber security).

- **Strategies (selection):**
  - o Intelligent Manufacturing Development Plan (2016-2020)[27]
    （智能制造发展规划 2016-2020 年）
  - o Action Plan on Industrial Internet Development (2018-2020)[28]
    （工业互联网发展行动计划 2018-2020 年）

26 Arcesati, Rebecca; Holzmann, Anna; Mao, Yishu; Nyamdorj, Manlai; Shi-Kupfer, Kristin, von Carnap, Kai; Wessling, Claudia (2020): China's Digital Platform Economy: Assessing Developments Towards Industry 4.0. Challenges and Opportunities for German Actors. Mercator Institute for China Studies (MERICS), June 2020, P. 17.

27 MIIT; MOF. "Notice of the Intelligent Manufacturing Development Plan (2016-2020)". 21 July 2015. Accessed 29 May 2020. http://www.miit.gov.cn/n1146285/n1146352/n3054355/n3057585/n3057590/c5406038/content.html

28 MIIT. "Notice of the Action Plan on Industrial Internet Development (2018-2020) and Work Plan on Industrial Internet Task Force in 2018". 7 June 2018. Accessed 29 May 2020. http://www.miit.gov.cn/n1146295/n1652858/n1652930/n3757016/c6212005/content.html

  - o Work Plan on Industrial Internet Task Force in 2018[29]
    （工业互联网专项工作组 2018 年工作计划）
  - o Three-year action plan for developing platform of upgraded mass entrepreneurship and innovation in manufacturing industry[30]
    （制造业“双创”平台培育三年行动计划）

- **Programs (Selections):**
  - o Construction Guide to Standard System of National Intelligent Manufacturing (2018 Edition)[31]
    （国家智能制造标准体系建设指南 2018 年版）
  - o Construction and Promotion Guide on Industrial Internet Platform[32]
    （工业互联网平台建设及推广指南）
  - o Sino-German Lighthouse Cooperation Projects on Intelligent Manufacturing[33]
    （中德智能制造合作试点示范工作）

According to the United Nations' industry classification system International Standard Industrial Classification, China alone features each of the identified industrial categories.[34] China's economy hosts 41 industrial categories, 191 medium categories and 525 sub-categories. This constellation has formed a large and complete industrial system and became an important factor both in driving China's competitiveness as well as laying the foundation for upgrading the industry.

Since the inauguration of the 18th National Congress of the Communist Party of China, the deep integration of industrialisation and informatisation has further accelerated and the development of intelligent manufacturing has yielded positive results. As of June 2019, the penetration rate of digital research and design tools reached 69.3% and the numerical control rate of key processes reached 49.5%. At the same time, the proportion of enterprises engaged in networked collaboration, service-oriented manufacturing, and large-scale personalised customisation had reached 35.3%, 25.3%, and 8.1%, respectively.[35]

The rapid development of digital technology has narrowed the gap between the digitisation of various industries in China and developed economies. At present, a new round of scientific and technological revolution and industrial transformation is sweeping the world. Digitisation of industries have become the new trend and new driving force of China's economic development. China's leading digital service providers have played an important role in enabling SMEs to transform digitally. The application of digital technology represented by cloud computing, big data and mobile Internet is no longer limited to the economy but has been widely applied inall aspects of public services, social development and people's life.

In the Special Action of Smart Manufacturing Pilot Demonstration in 2015, China defined intelligent manufacturing as a new generation of information technology, which runs through all aspects of manufacturing activities such as design, production, management, and service.[36] Intelligent manufacturing can help shorten product development cycles, reduce resource and energy consumption, reduce operating costs,

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29 MIIT. "Notice of the Action Plan on Industrial Internet Development (2018-2020) and Work Plan on Industrial Internet Task Force in 2018". 7 June 2018. Accessed 29 May 2020. http://www.miit.gov.cn/n1146295/n1652858/n1652930/n3757016/c6212005/content.html

30 MIIT. "Notice of the Three-year action plan for developing platform of upgraded mass entrepreneurship and innovation in manufacturing industry". 14 August 2017. Accessed 29 May 2020. http://www.miit.gov.cn/n1146285/n1146352/n3054355/n3057656/n4699766/c5762100/content.html

31 MIIT; SAC. "Notice of the Construction Guide to Standard System of National Intelligent Manufacturing (2018 Edition)" 15 October 2018. Accessed 29 May 2020. http://www.miit.gov.cn/n1146295/n1652858/n1652930/n3757016/c6429243/content.html

32 MIIT. "Notice of the Construction and Promotion Guide on Industrial Internet Platform and the Evaluation Methodology on Industrial Internet Platform" 19 July 2018. Accessed 29 May 2020. http://www.miit.gov.cn/n1146295/n1652858/n1652930/n3757022/c6266074/content.html

33 The initiative was implemented from 2016 to 2019. An official announcement for 2020 has not yet been published as of May 2020. MIIT. "Notice of the Work on Sino-German Lighthouse Cooperation Projects on Intelligent Manufacturing 2017". 26 May 2017. Accessed 29 May 2020. http://www.miit.gov.cn/n1146295/n1652858/n1652930/n3757016/c5662967/content.html

34 The State Council of PRC. "Notice of the State Council on "Made in China 2025" (Guo Fa [2015] No. 28)". 19 May 2015. Accessed 3 November 2019. http://www.gov.cn/zhengce/content/2015-05/19/content_9784.htm.

35 Press office of the State Council of PRC. Press conference on the 8 October 2019. Accessed 3 November 2019. http://www.miit.gov.cn/n1146290/n1718621/c7457171/content.html.

36 MIIT. "Publication of the List of Pilot Demonstration Projects on Intelligent Manufacturing 2015". 21 July 2015. Accessed 3 November 2019. http://www.miit.gov.cn/n1146295/n1652858/n1652930/n4509627/c4510385/content.html.

increase production efficiency, and improve product quality. The 2018 central economic work conference firstly put forward the concept of "new type of infrastructure construction", in which the development of 5G commercial, artificial intelligence, industrial Internet, Internet of things and other new types of infrastructure are stressed. The 2019 government work report first proposed the concept of "smart +".[37] "Building an industrial Internet, expanding intelligence+ and empowering the transformation and upgrading of the manufacturing industry" were identified as important development steps for China to foster new kinetic energy for economic development.

- **Instruments**

Although the Chinese government did not set clear goals on the Digital Platform Economy level, a series of specific targets were set for the development of industrial internet platforms (as the main building blocks of the digital platform economy). At a basic level, for example, 1 million new companies are supposed to "go cloud" by 2020. On a more sophisticated level, China already wants to have 3-5 internationally competitive platforms by 2025, and 1 leading platform connecting 300.000 companies by 2035. The goal of having 10 cross-sectoral industrial platforms in place by 2020 was already reached by August 2019. In addition to the goals on the platform level, targets were also formulated at virtually all layers of the IoT stack:

- apps (300.000 by 2020),
- standards (upgrade to IPv6, push for NB-IoT, ≥10 security standards at various levels)
- and an ID resolution system (≥10 public service nodes and identification registration amount of 2 bn by 2020).[38]

Major implementation mechanisms are:

- State financing for tendered projects related strategic areas of industrial internet development
- Incentivising the set-up of cross-sectoral platforms as "national champions"
- Devising region-specific, sub-national pilot projects involving local governments, state-owned companies and private firms
- Devising a comprehensive industrial internet standardisation system by 2020.

These polices are supported with a wide spectrum of financial measures:

37 Premier Li Keqiang. "Government Working Report". At the second meeting of the 13th National People's Congress on 5 March 2019. Accessed 3 November 2019. http://www.gov.cn/premier/2019-03/16/content_5374314.htm.

38 Arcesati, Rebecca; Holzmann, Anna; Mao, Yishu; Nyamdorj, Manlai; Shi-Kupfer, Kristin, von Carnap, Kai; Wessling, Claudia (2020): China's Digital Platform Economy: Assessing Developments Towards Industry 4.0. Challenges and Opportunities for German Actors. Mercator Institute for China Studies (MERICS), June 2020.

China's wants to move towards market-driven funding mechanisms
Existing sources of funding for digital industrial platforms

State ↓ Market

Type of funding	Example
Regional cash subsidies (兑现补贴券)	About CNY 20,000 per company going cloud
National government procurement by the Ministry of Industry and Information Technology (MIIT)	More than CNY 3 billion for the strategic development of industrial internet layers and components such as identification resolution; cloud and edge, platforms standardization, security features
Subsidies for public tenders by provincial governments	Up to 20–30 percent of the applied funding, with a maximum sum of CNY 2–5 million
Partnerships between state-owned enterprises (SOEs) and local government funds	China Electronics Corporation plus Changsha City invested CNY 2 billion to set up China Electrics Industrial Internet Co.
Corporate funding: big companies develop and run platforms on their own expense, often by setting-up their own designated platform companies	China State Shipbuilding Corporation invested CNY 50 million to set up the China Shibuilding Industrial Internet Company
Attracting venture capital investment	Rootcloud got CNY 500 million (B round)
Going public: initial public offerings (IPOs) of Chinese platforms have not yet happened in the industrial realm, but have proven very successful with B2C platforms	Foxconn Industrial Internet Co Ltd IPO in Shanghai in May 2018

Source: MERICS

Figure 3: Chinese existing sources of funding for digital industrial platforms[39]

39 Arcesati, Rebecca; Holzmann, Anna; Mao, Yishu; Nyamdorj, Manlai; Shi-Kupfer, Kristin, von Carnap, Kai; Wessling, Claudia (2020): China's Digital Platform Economy: Assessing Developments Towards Industry 4.0. Challenges and Opportunities for German Actors. Mercator Institute for China Studies (MERICS), June 2020. Exihibit 7

2. Introduction of German-Chinese Use Cases

This report analyses company business models and value networks based on the St. Gallen Business Model Navigator.

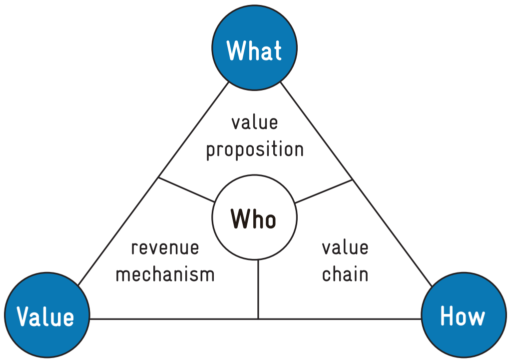

Figure 4: St. Gallen Business Model Navigator[40]

The business model analysis addresses the following four questions:
- Customer: Who are the target customers of the company?
- Value proposition: What does the company offer to customers?
- Value chain: How does the company, together with other partners, create this product or service?
- Revenue mechanism: How does the company create value in the form of revenue?

Use cases were provided by members of the Sino-German Expert Group on Digital Business Models.

The expert group analysed a total of 25 use cases which were grouped into six thematic clusters during a workshop in Shanghai: Efficiency, Smart Product as a Service, Marketplace, Data Trusteeship (Data Marketplace), Mass Customisation, and Value Adding Services in Operation (As a Service). One analytical perspective of the use cases is their degree of openness versus size of the ecosystem.

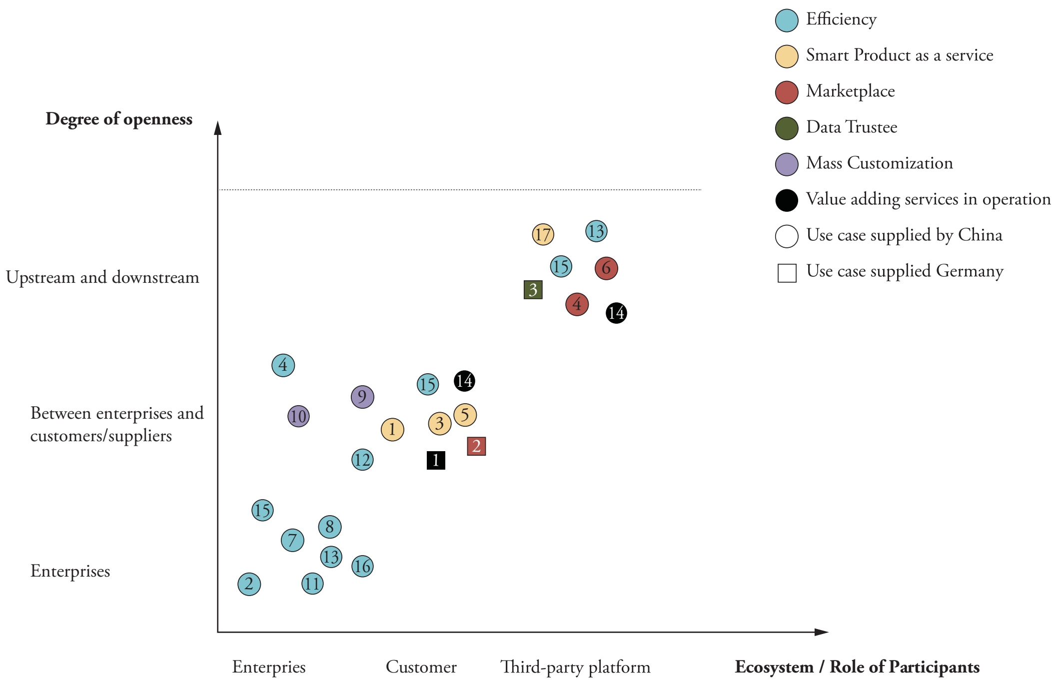

Figure 5: Use case clusters

40 Plattform Industrie 4.0. "Digitale Geschäftsmodelle für die Industrie 4.0". 27 March 2019. Accessed 09 June 2020. https://www.plattform-i40.de/PI40/Redaktion/DE/Downloads/Publikation/digitale-geschaeftsmodelle-fuer-industrie-40.html#:~:text=Digitale%20Gesch%C3%A4ftsmodelle%20f%C3%BCr%20die%20Industrie%204.0,-Einleitung&text=Die%20daraus%20gewonnenen%20Erkenntnisse%20sollen,der%20Organisation%20sowie%20rechtliche%20Rahmenbedingungen.

Use Case Clusters

2.1 Efficiency

An increase in efficiency results from reducing inputs while simultaneously producing similar or higher levels of output. These inputs include production resources like time, capital or human labour. Outputs include both products and services.

Companies can introduce new technologies or innovations into their production model to increase the efficiency of their existing inputs. Such efficiencies allow a company to cost-effectively scale the size of their operations and/or offer price reductions.

Value network

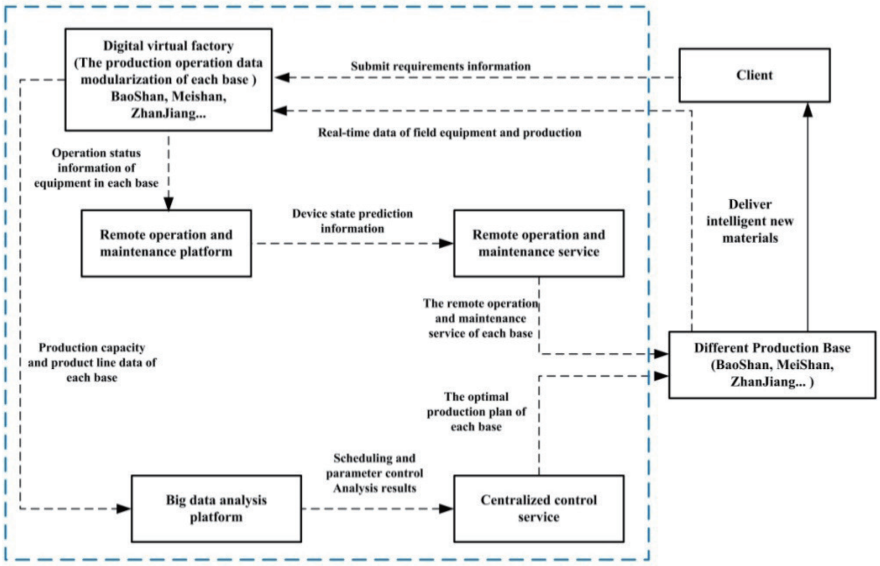

Figure 6: Efficiency value network

Practical example: BAOWU Carbon Materials & Technology Co., Ltd. (Baowu) and the digital virtual factory

Baowu constructed a digital virtual factory in Shanghai to remotely monitor their product network across China. The company connected their production bases across China with the newly established digital virtual factory featuring an Industrial Internet of Things (IIoT) platform. They equipped their production bases with sensors that feed real-time production data back to the digital virtual factory via the IIoT platform. The platform collects, processes and analyses the production base data and remotely manages all production schedules and maintenance.

By centralising control of the production network remotely at the digital virtual factory in Shanghai, Baowu optimises their production capacity and introduces predictive maintenance capabilities into their operations which reduces delays in the production process. Remotely analysing the data collected via the production base sensor allows Baowu to oversee production capacity within their entire production network. With this information, the company can allocate their production resources where most needed and avoid input disturbances. This results in a highly stabilised production operation and a reduction in needed labour resources at the individual production bases.

In addition to optimised production capacity, remote centralised control equips the digital virtual factory with predictive maintenance capabilities. Analysing the data collected from the production bases, the digital virtual factory can monitor the operation status of the production equipment and flag potential disruptions early. The centralised control centre determines the maintenance needed based on the received operation data. Depending on the nature of the prescribed maintenance, the control centre either remotely provides the respective production base with repair instructions or dispatches engineers to the location. Cumulatively, these actions lower maintenance and operation costs and allow the company to offer competitive pricing.

Changes in the business models

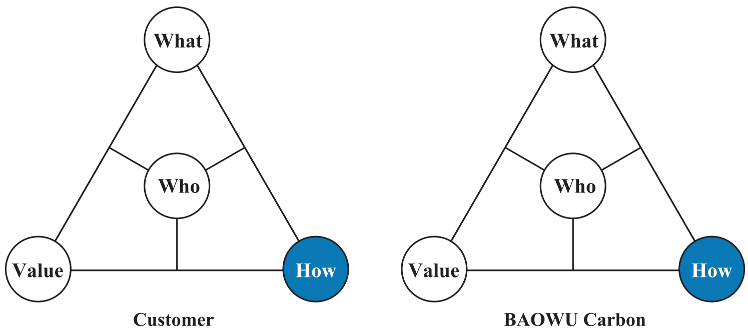

Figure 7: Changes in the business models related to efficiency

Summary

Within this increased efficiency model, the profit mechanism changes while both the products offered and value obtained remain the same. Overall, the modified profit mechanism primarily streamlines internal processes making the company more competitive while customers targeted and value obtained remain the same.

- **Value proposition:** The increased production efficiency decreases lead times for customer orders and lowers operation costs, thus increasing company competitiveness.

- **Value chain:** The IIoT platform connects the various production bases with the digital virtual factory. Real-time data sharing streamlines the production process and improves maintenance with the introduction of predictive maintenance.

- **Revenue mechanism:** The introduction of sensors and remote predictive maintenance between the production bases and the centralised platform at the digital virtual factory reduces the costs for internal processes. Centralising both production management as well as predictive maintenance reduces the need for labour resources at the individual production bases decreases the likelihood of equipment failure disrupting production. This reduction in needed labour resources and equipment failure translates into a reduction in overall production costs, thus increasing the profitability of the entire operation for the company. Customers may benefit from a minor price reduction but will likely not notice a significant change. Baowu's product portfolio also remains largely unchanged as a result of increased efficiency.

2.2 Smart Product as a Service

Smart Products are containers for reconfigurable software and digital intelligence. They are designed to interact with their producers, users and other products. Smart connected products can potentially change product design and engineering. Making products smart can be offered as a service.

Value network

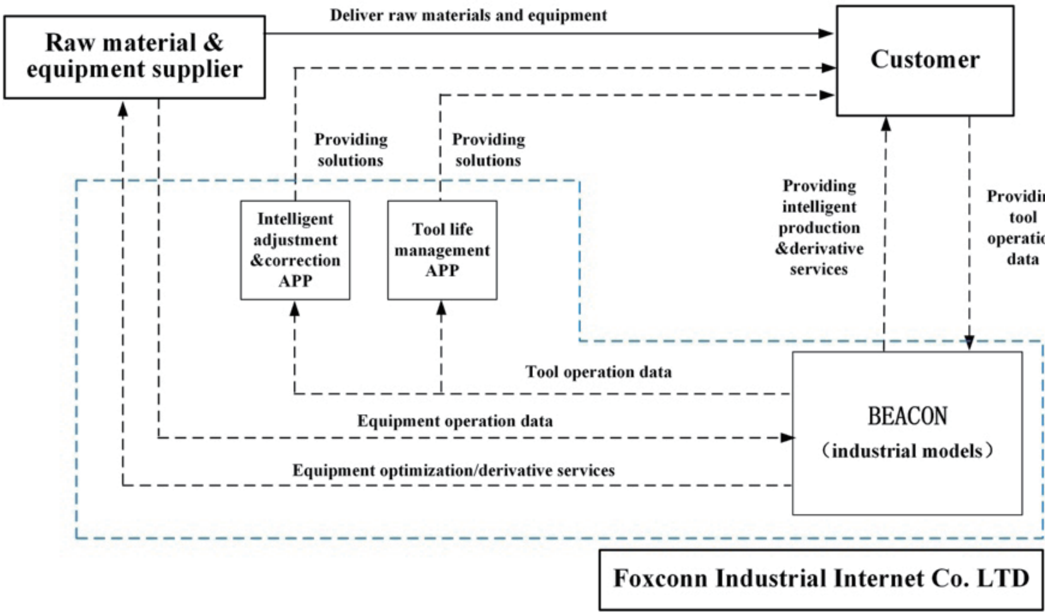

Figure 8: Smart product as a service value network

Practical example: Foxconn Industrial Internet Co. and the BEACON industrial Internet Platform

Foxconn Industrial Internet Co. LTD developed the industrial Internet platform BEACON, which stands for Big data, Everything, AI, Cloud, mObility, Networks, as a cloud platform technology combined with IoT. Although owned and developed by Foxconn for their internal processes, they also offer their suppliers and customers access to the BEACON platform. BEACON, which spans industries and sectors, provides enterprises with scenario-driven micro cloud solutions based on the collected data. The benefits are twofold. First, BEACON solutions help enterprises recalibrate machine movement to reduce it to the quintessential. This avoids machine overuse thus reducing the need for maintenance. Second, BEACON solutions help enterprises by reducing reliance on human labour by automating machine decision-making processes.

Changes in the business models

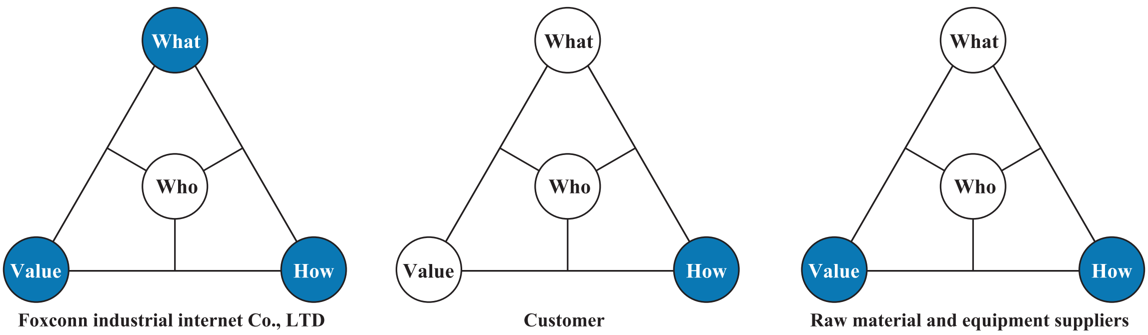

Figure 9: Changes in the business models related to smart products as a service

Customers who have purchased access to Foxconn's BEACON can selectively upload machine operation data to the platform. BEACON uses this data to communicate information about the production process back to the customer via an app. This includes information regarding necessary adjustments or corrections, improved equipment efficiency, or maintenance. Overall, this extends the service life of the equipment and reduces maintenance costs.

Through data collection, analysis and modelling on the BEACON platform, Foxconn Industrial Internet Co., Ltd. has developed more than 20 apps and 30 industrial models. These services support customer-oriented intelligent production, equipment optimisation for raw materials and equipment suppliers along with additional derivative services.

Summary

- **Value proposition:** In this scenario, customers, suppliers and Foxconn/BEACON benefit from the dynamic process of data sharing. Customers benefit from increased efficiency resulting from purchasing Foxconn's tailored app-based solutions using the BEACON platform while suppliers receive data to customise their machinery based on customer usage.

- **Value chain:** In this network, the Foxconn's BEACON platform operates in both directions: it communicates relevant information directly to customers and suppliers. Simultaneously, it also allows for customers and suppliers to communicate in a direct feedback loop. Based on the platform information, raw material and equipment suppliers are able to adjust and improve their machines per customer demands. Throughout this dynamic process, BEACON receives customer equipment operation data and communicates this back to both the suppliers and the customers along with information on equipment optimisation. This improves overall operation and production efficiency.

- **Revenue mechanism:** In addition to purchasing raw materials and equipment, customers now also purchase app-based supporting services using their uploaded data. Uploading their data and downloaded customised solutions changes the "how" of their operations. Similarly, suppliers can now also sell customised products based on customer data. In this model, suppliers change the "how" of their operations via uploaded and downloading data, as well as the "what" and "value" via customised raw materials and equipment and app-based services.

2.3 Marketplace

A marketplace coordinates supply and demand to facilitate transactions (two-sided market) and can be defined as "open" or "closed". As suggested by the name, open marketplaces are open to all service providers, while closed marketplaces are subject to a pre-selection of suppliers by the marketplace provider. In some cases, the provider might even be the only supplier on the platform.

A key success factor for a digital marketplace is critical mass on both sides of the market ("ecosystem"). It will only be worthwhile for the supplier to be active on the marketplace if there is sufficient demand. Alternatively, the marketplace will only be able to attract sufficient demand if there is a sufficient number of suppliers from which to choose. Once achieved, self-reinforcing network effects begin, and the market self-perpetuates.

Marketplace providers offer information and search functions, service provision, invoicing and assessment mechanisms. They provide these by themselves or via an external service provider. Access to and use of the services is subject to a fee.

Value network

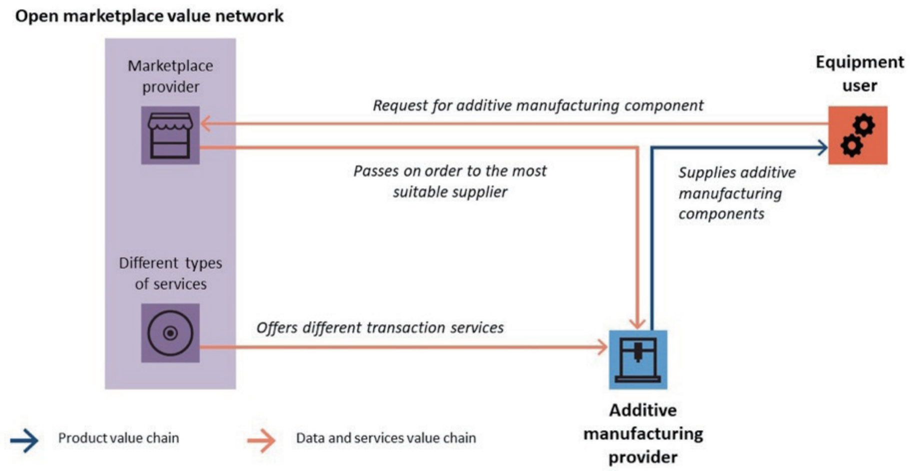

Figure 10: Open marketplace value network[41]

Practical example: 3YOURMIND[42]

Open marketplace

3YOURMIND is a start-up that offers software platforms to help companies and 3D service providers optimise additive manufacturing processes and harness the full potential of additive manufacturing. Digital workflows link teams and production sites optimise equipment utilisation rates and enable informed decisions on production-related issues. 3YOURMIND offers both a cloud-based platform as well as an in-house hosted platform. This allows the entire additive manufacturing process to be managed efficiently.

The enterprise platform gives users access to a network of (in-house and external) suppliers providing different types of additive manufacturing devices, allowing on-demand additive manufacturing. 3YOURMIND is positioning itself as an open additive manufacturing marketplace provider.

The ecommerce platform helps additive manufacturing service providers run their own shop that customers can use to order the 3D models they would like to have printed. Price calculations, feasibility assessments and printing optimisation can all be done via the platform. It also allows users to access information about orders and production status.

Changes in the business models

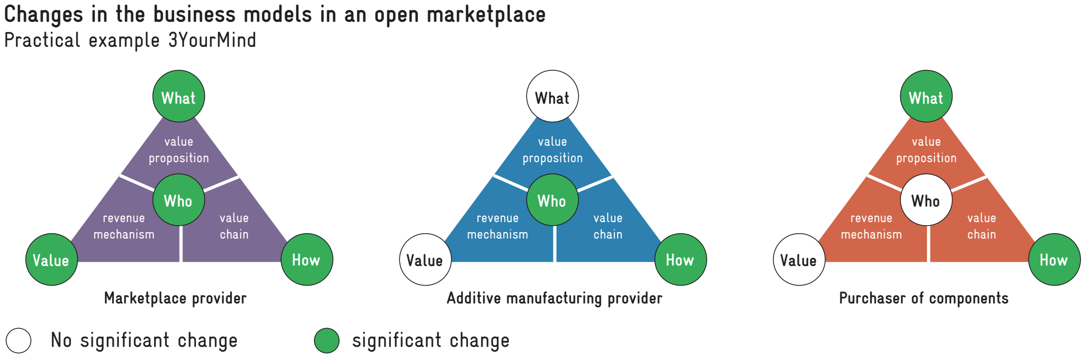

Figure 11: Changes in the business models in an open marketplace

41 Adapted from Plattform Industrie 4.0.

42 Plattform Industrie 4.0. "Digitale Geschäftsmodelle für die Industrie 4.0". 27 March 2019. Accessed 09 June 2020. https://www.plattform-i40.de/PI40/Redaktion/DE/Downloads/Publikation/digitale-geschaeftsmodelle-fuer-industrie-40.html#:~:text=Digitale%20Gesch%C3%A4ftsmodelle%20f%C3%BCr%20die%20Industrie%204.0,-Einleitung&text=Die%20daraus%20gewonnenen%20Erkenntnisse%20sollen,der%20Organisation%20sowie%20rechtliche%20Rahmenbedingungen.

Summary

- **Value proposition:** The marketplace helps to improve delivery times as well as the availability of parts, leads to better equipment utilisation rates and reduces transaction costs. In addition, those buying components in an open marketplace have a better opportunity to offer more 3D components and therefore position themselves in a market segment that had previously remained closed to them.

- **Value chain:** Marketplaces help match supply and demand. Open marketplaces also help further optimise network effects on the demand-side.

- **Revenue mechanism:** The marketplace provider can charge a fee for using the marketplace and/or market its software (e.g. as a pay-per-use model).

2.4 Data Trustee (Data Market Place)

The data trustee model enables data trading. Traditional value networks, which have predominantly been based on physical products, are enhanced to allow the aggregation, anonymisation and analysis of data from a wide range of sources and companies and the monetisation of this data. In these value networks, data trustees play a key role as a neutral platform. Companies that provide part of their data to a data trustee not only receive money for this as a customer of the data trustee but can also gain access to a more extensive database that may even contain pre-analysed data. In this model, companies providing part of their data to a data trustee can exchange data with other companies in a secure and standardised manner.

Generalised Value Network

This model features different value proposition and revenue models for a variety of business relationships.

- Manufacturing companies/OEMs: Customer, production, field and company data are secured through a neutral party and can at the same time be monetarised, enhanced by adding data from external sources, and used for the company's development or for other purposes. The manufacturing company supplies and monetarises the data. At the same time, it is a customer of the data trustee. This means that the same companies take on different roles in different situations.

- Data trustee: The data from one company is combined with additional data across supply chains, continents and existing business relations. The data trustee provides a neutral platform, assesses the quality of the data, addresses IT security, and ensures compliance with data use terms. The provider is thus paid a fee to ensure that companies maintain control over their data and that the data is anonymised. This means that the data trustee enables transactions and business models that would otherwise have been unprofitable or unfeasible and in doing so helps make the market more efficient.

- System integrator, smart sensor supplier, original equipment manufacturer: Data trustees help companies obtain data to optimise customer service, train AI systems, expand product portfolios, improve efficiency, optimise production and/or R&D in a cost-efficient manner as they no longer need to store and analyse the data themselves.

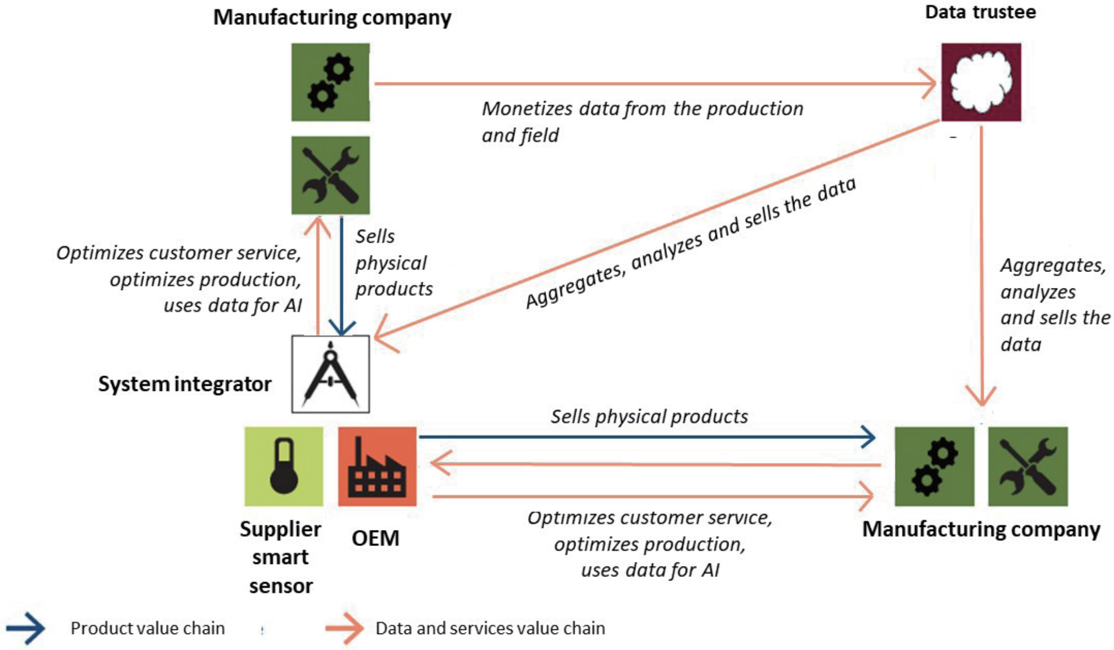

Figure 12: Data trustee value network[43]

Practical example: TÜV SÜD Data Trust Center[44]

A number of initial projects are currently being launched. One such project is at TÜV Süd, which launched the TÜV SÜD Data Trust Center – the first cooperation project between TÜV and IBM. "The Data Trust Center will serve as a data trustee providing secure, neutral and unbiased access to data on modern and highly automated vehicles," according to CEO of the Mobility Division at TÜV SÜD Patrick Fruth. For this purpose, data from different vehicle manufacturers can be collected on the platform neutrally and access to this data can be provided to other parties like service providers, insurance companies and authorities. Vehicle owners and/or vehicle manufacturers need to consent to or authorise the use of the data before it can be used. The Sealed-Cloud technology developed by Uniscon, which has been part of TÜV SÜD group since August 2017, ensures compliance with data protection rules and regulations and that the data is stored, processed and transmitted in a reliable and secure manner. Using this technology ensures that the unencrypted data that users store or process on the platform cannot be accessed by others, not even by the platform provider.

Other practical examples for this type of value creation scenario (or variations of it) are Munich Re's data trustee model for accident-related data, Deutsche Telekom's Data Intelligence Hub (DIH) and Airbus' Skywise Platform. The International Data Spaces Association (IDSA) is also worth mentioning; it has created a standardised reference architecture (of which several exist) for this type of value creation scenario which is used by the DIH.

Changes in the business models

The data trustee establishes itself as a new market player with an entirely new business model. The manufacturing company significantly changes the way it generates value as it combines existing physical products with services. The manufacturing company may even opt for a contracting model, selling not the product itself, but rather the value generated by the product. Capturing relevant data for optimising products or using additional data for research and development becomes even more important. These services are based on data, which help to not only broaden the value proposition, but also gain more knowledge about the customer base. In the past, many component manufacturers did not know where these components were installed or how they were used, but data trustees may be able to provide

43 Plattform Industrie 4.0. "Digitale Geschäftsmodelle für die Industrie 4.0". 27 March 2019. Accessed 09 June 2020. https://www.plattform-i40.de/PI40/Redaktion/DE/Downloads/Publikation/digitale-geschaeftsmodelle-fuer-industrie-40.html#:~:text=Digitale%20Gesch%C3%A4ftsmodelle%20f%C3%BCr%20die%20Industrie%204.0,-Einleitung&text=Die%20daraus%20gewonnenen%20Erkenntnisse%20sollen,der%20Organisation%20sowie%20rechtliche%20Rahmenbedingungen.

44 Plattform Industrie 4.0. "Digitale Geschäftsmodelle für die Industrie 4.0". 27 March 2019. Accessed 09 June 2020. https://www.plattform-i40.de/PI40/Redaktion/DE/Downloads/Publikation/digitale-geschaeftsmodelle-fuer-industrie-40.html#:~:text=Digitale%20Gesch%C3%A4ftsmodelle%20f%C3%BCr%20die%20Industrie%204.0,-Einleitung&text=Die%20daraus%20gewonnenen%20Erkenntnisse%20sollen,der%20Organisation%20sowie%20rechtliche%20Rahmenbedingungen.

component manufacturers with this kind of information. System integrators, original equipment manufacturers and smart sensor suppliers can broaden their value proposition towards customers and existing suppliers. Thus, the most significant change is an increased value proposition.

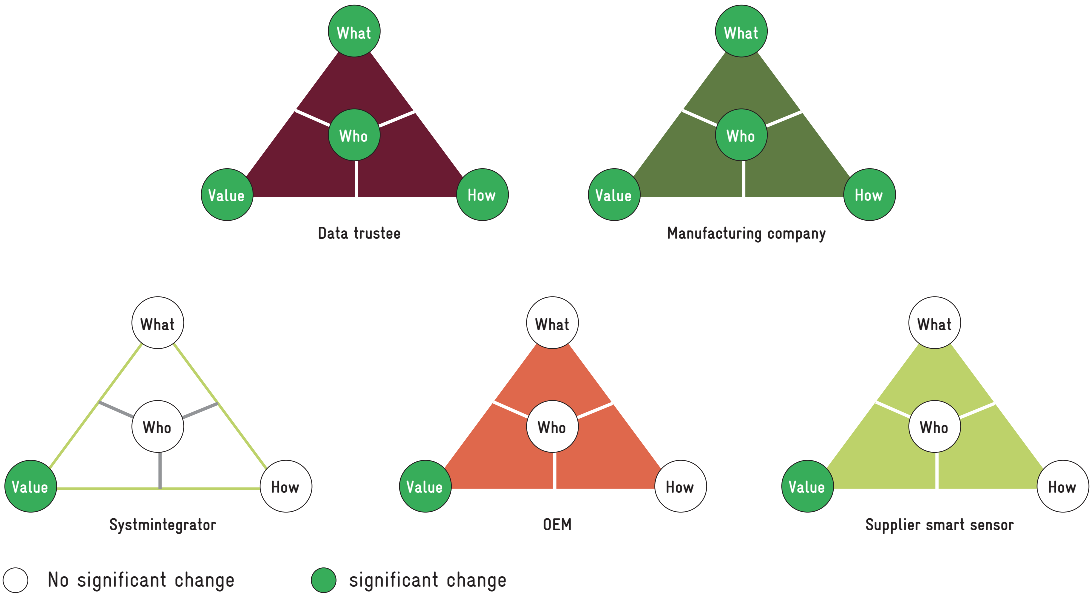

Figure 13: Changes in the business model related to data trustees

Summary

- **Value proposition:** In this type of value creation scenario, the key player will certainly be the data trustee. One question to be answered is whether a neutral monitoring body – like an auditor – is needed to monitor this process. It also remains to be seen whether and to what extent B2C platform trends can be transferred to this platform scenario and whether the success of B2C platforms can be repeated in the B2B area.

- **Value chain:** Taking a closer look at the new value creation models, products and services can no longer be clearly separated from one another. This is another key element of this type of value creation scenario. Data, and therefore to some extent services, are no longer solely by-products of a physical product but become products in themselves.

- **Revenue mechanism:** The question regarding the success of this value creation scenario hinges on data availability at fair and attractive prices. Do we need central or perhaps even government mechanisms to determine the value of data? How can SMEs in the manufacturing sector determine the price of data they generate – is there a base value or does it purely relate to use or value added? Most importantly, the value of data needs to be assessed systematically and extensively and monetised accordingly.

2.5 Mass Customisation

Platforms allow for a mass customisation model focusing on the user experience. Compared to traditional manufacturing models, the platform invites customers to engage in every step of the process to deliver products and services that best meet their needs. At the same time, the platform also creates demand to maximise the benefits for all parties to achieve win-win results. Digital feedback loops from the ecosystem and end user markets is the basis for a demand-driven approach to innovation.

Value network

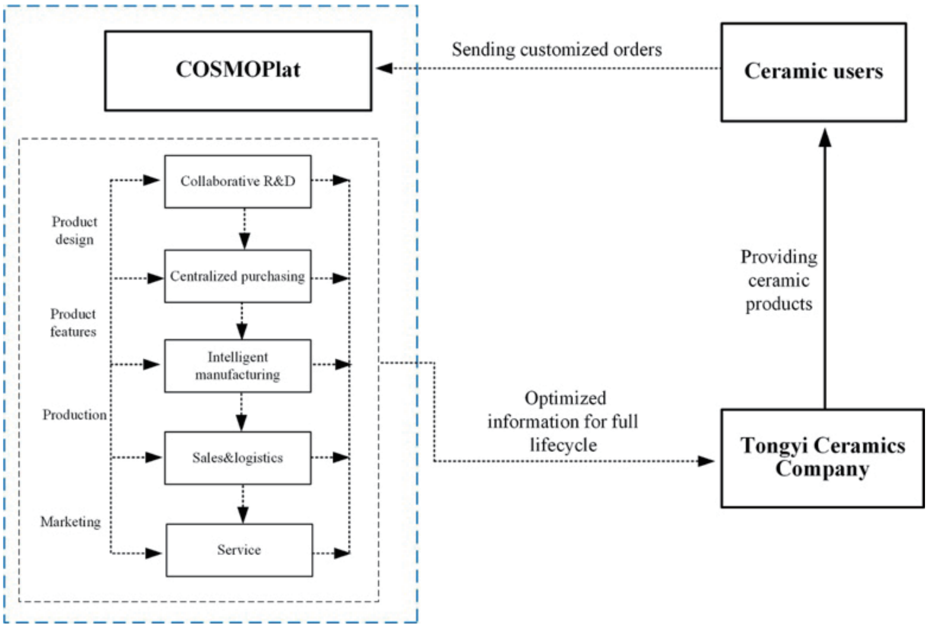

Figure 14: Mass customisation value network

Practical example: Haier, the COSMOPlat Industrial Internet Platform and Tongyi Ceramics

COSMOPlat is an industrial Internet platform developed by Haier as a mass customisation model. Specifically, it transforms the traditional industrial platform into an industrial internet platform that invites users to engage with the full production process. In this "mind to deliver" platform, users participate in the entire process from idea inception all the way until delivery.

The COSMOPlat platform features seven functional modules that can be used individually or in combination with other modules. These include:

- User interaction
- Research and development
- Marketing
- Procurement
- Manufacturing
- Logistics
- Service

Tongyi Ceramic, a company in the ceramic industry, purchased access to Haier's COSMOPlat platform to optimise the lifecycle of their production and provide customers with product customisation on a large scale.

Changes in the business models

In the case of Tongyi, COSMOPlat's collaborative R&D and intelligent manufacturing modules have streamlined the entire process from order and production to sales and delivery. This streamlining resulted in increased efficiency and overall cost reductions, thus allowing Tongyi to increase their order volume.

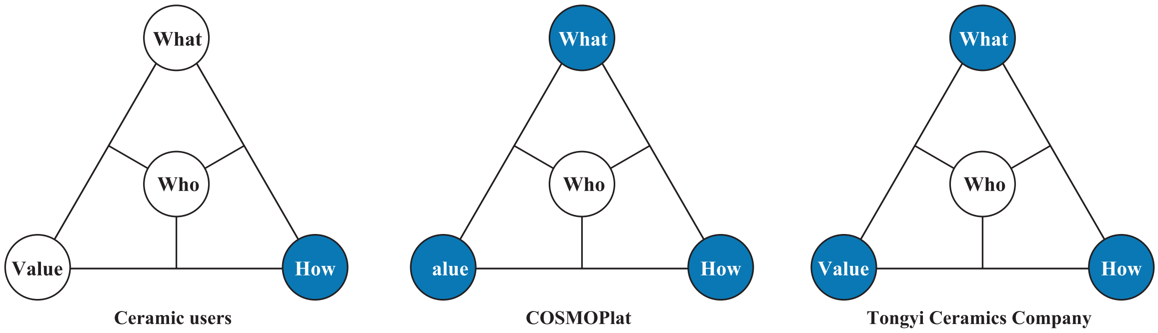

Figure 15: Changes in the business model related to mass customisation

Summary

- **Value proposition:** Haier offers a new mass customisation service via the COSMOPlat platform. Customers enjoy increased satisfaction with their customised products.
- **Value chain:** The COSMOPlat platform invites customers and suppliers to engage in the production process from customised orders to status tracking.
- **Revenue mechanism:** Tongyi purchases mass customisation services from Haier via the COSMOPlat platform. Ceramic users can now purchase a higher quality, customised product

2.6 Value adding services in operation (As a service)

The concept value adding services in operation describes the process of assessing the business model from the perspective of the customer. A manufacturer sells a product (generating one-off revenue for the manufacturer) to a third party (who becomes the owner of the product). The owner allows another company (service provider) to generate value through this product. The service provider ensures that the end customer (user of the product) can use the product at all times. The end customer's main benefit is the ability to outsource activities not part of the core business.

Value network

In the following table, two practical examples are explained in terms of the underlying value networks. The value networks include several roles, all of which contribute to and benefit the network:

Roles	Practical example 1 – Tire as a Service	Practical example 2 – Equipment as a Service
Product user	Fleet operator	Producer
Service provider (orchestrates the service)	Service provider (Michelin Solutions)	Equipment manufacturer (Bosch)
Product manufacturer	Tire manufacturer (Michelin, Continental)	Equipment manufacturer (Bosch)
Maintenance network for the product	(Manufacturer's or external) maintenance network	Equipment manufacturer (Bosch) or external maintenance service providers
Owner (buys and leases)	Service provider (Michelin Solutions)	Finance company (Munich Re)
LoT hardware integrator	Telematics provider	LoT platform provider (Bosch and others)
LoT solution provider	Software firm + cloud provider	LoT platform provider (Bosch and others)

Table 2: Roles within the value network[45]

45 Plattform Industrie 4.0. "Digitale Geschäftsmodelle für die Industrie 4.0". 27 March 2019. Accessed 09 June 2020. https://www.plattform-i40.de/PI40/Redaktion/DE/Downloads/Publikation/digitale-geschaeftsmodelle-fuer-industrie-40.html#:~:text=Digitale%20Gesch%C3%A4ftsmodelle%20f%C3%BCr%20die%20Industrie%20 4.0,-Einleitung&text=Die%20daraus%20gewonnenen%20Erkenntnisse%20sollen,der%20Organisation%20sowie%20rechtliche%20Rahmenbedingungen.

Practical examples[46]

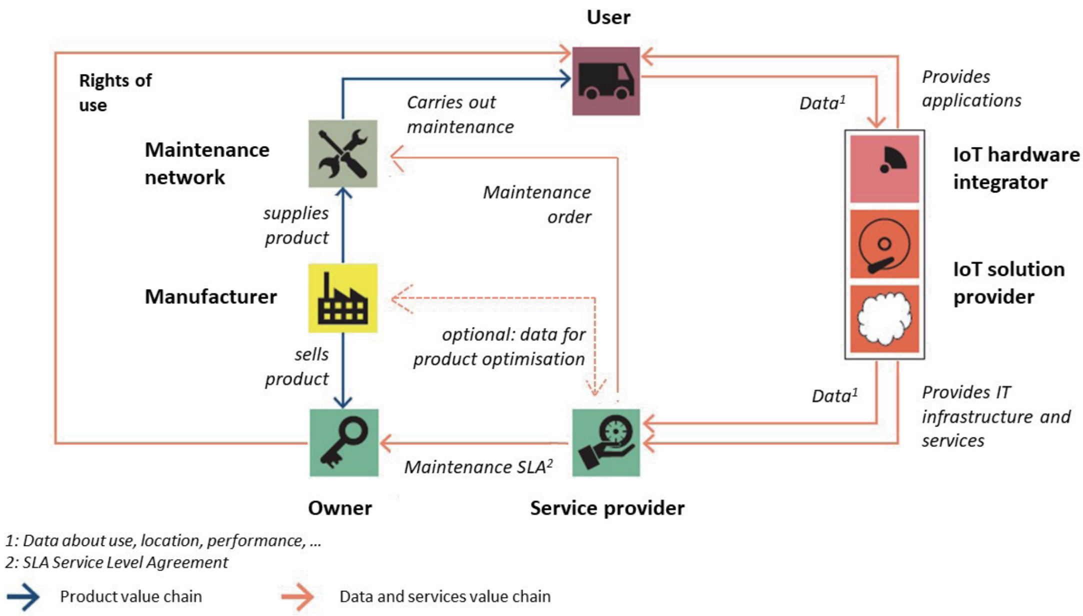

Figure 16: Value network for practical example 1 – Tire as a Service

Practical example 1 – Tire as a Service

A tire manufacturer sells tires to a service provider, who leases these to a fleet operator. In contrast to practical example 2, the company who is the owner also serves as the service provider. The service provider ensures that the fleet operator (user) is provided with fully functional tires as a service and with extensive tire management services. The owner and service provider coordinate the procurement and installation of the tires from several different manufacturers. In addition to procurement and installation, this network allows the owner and service provider to remotely monitor the condition of the tires via an IoT platform and provide maintenance service as needed. The data on the cloud based IoT platform is analysed by the owner and service provider and used for invoicing and coordinating needed services.

Practical example 2 – Equipment as a Service

The equipment manufacturer sells the product to a finance company (owner) who leases the equipment to the producer, charging a fee. The equipment is linked to an IoT platform to ensure that the service is used and priced in line with the terms of the contract and that the equipment is properly maintained and repaired. The service provider is responsible for carrying out maintenance and repair work and for providing spare parts. The finance company can access the data that is stored on the IoT platform remotely, which allows it to better assess the extent to which the equipment is being used. This allows a pay-per-use pricing model to be used, whereby the user only pays for the time the equipment is actually used. It also gives the user access to additional financial and warranty services.

Changes in the business models

In cases where a company serves both as the owner and the service provider (as in practical example 1), the changes in the companies' business models can be summarised as follows:

46 Plattform Industrie 4.0. "Digitale Geschäftsmodelle für die Industrie 4.0". 27 March 2019. Accessed 09 June 2020. https://www.plattform-i40.de/PI40/Redaktion/DE/Downloads/Publikation/digitale-geschaeftsmodelle-fuer-industrie-40.html#:~:text=Digitale%20Gesch%C3%A4ftsmodelle%20f%C3%BCr%20die%20Industrie%204.0,-Einleitung&text=Die%20daraus%20gewonnenen%20Erkenntnisse%20sollen,der%20Organisation%20sowie%20rechtliche%20Rahmenbedingungen.

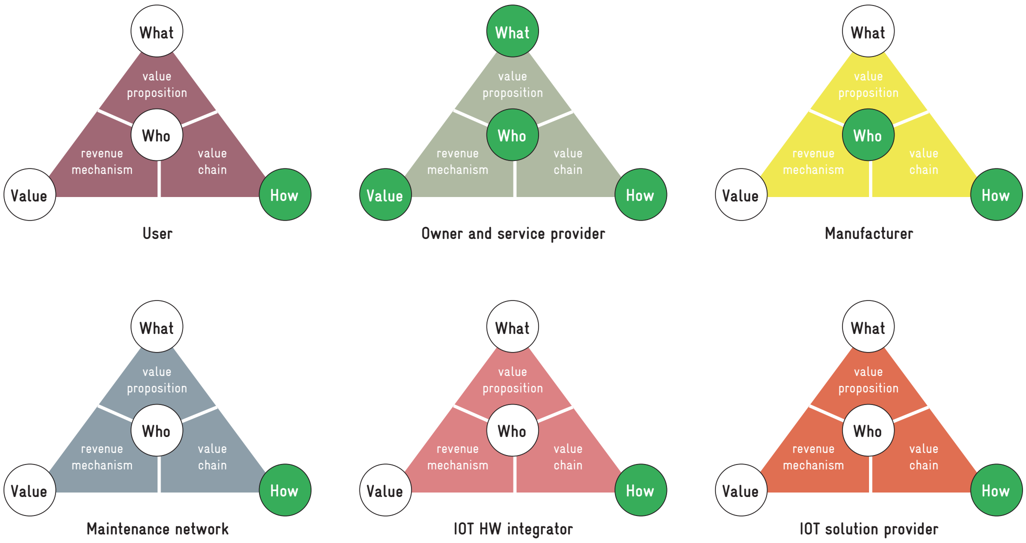

Figure 17: Changes in the business models for practical example 1 – Tire as a Service

- The user (fleet operator) is integrated into a new value chain. Instead of buying the actual tires for the fleet, the fleet operator acquires a value proposition promising fully functional tires.
- The owner and service provider position itself as a new player in the market and includes additional companies in a value chain he coordinates.
- The service provider becomes the manufacturer's main customer.
- The service provider commissions all workshop services, which are provided via the maintenance network.
- The IoT hardware integrator and the IoT solution provider allow data about the use of the tires to be exchanged between the user and the service provider.

Summary

In the practical example Tire as a Service, the role played by the owner and service provider – who is providing the added value in use – can be summarised as follows:

- **Value proposition:** The owner and service provider provide the user with added value in use by providing it with a wide range of tire management services.
- **Value chain:** The owner and service provider position itself as a new player in the market and creates a new value network for companies that are already active in this market. He orchestrates both the physical activities and the data flow.
- **Revenue mechanism:** The owner and service provider charge the user a fee that is based on the actual use of the service. The revenue generated from this is used to pay the other player in the value network.

3. Analysis of the Use Cases

3.1 Characteristics of Digital Business Models

Platform economy building by interconnecting everything

New technologies like 5G and AI allow people, machines and data to be interconnected with the "Internet of Everything" (IoE). The flows of information, capital, people, logistics, traffic, etc. form an IoE network structure across the economy. The dependence among these flows has increased since the introduction of new technologies.

Reshaping the value network by focusing on user needs

The simple, linear industrial chain of the past is unsuitable to the digital age and is being replaced by more efficient ecosystems. In these new ecosystems, which have gradually gained dominance, consumers are at the core.

Information asymmetry is disappearing with customer value becoming the focus of business competition. How enterprises use digital technology to create a better customer experience has become a pivotal business issue both on and offline.

The key challenge here is governance between partners.

Data as a source of value

Data is emerging as a new production factor that is both a basic strategic resource as well as an important productive force in the digital economy. Pricing, trading and monetising data is just the beginning.

Mass Customisation

Consumer preference is shifting from mass produced products to customised and/or personalised products and services. The production of personalised products is possible via data analytics and digital feedback loops. The challenge with mass customisation is creating ecosystems of scale.

3.2 The Maturity Model

Deep Dive Case Study

In search of dynamic consistency: Business model evolution of Haier as a response to a changing business environment

Business models change over time. Companies are anticipating and reacting to changes in their external environment by altering the core components of their business model accordingly. This section illustrates the dynamic interplay of the external environment and the configurations of the business model following the case of Haier over the last three major business model changes. The dynamic interplay begins with the discussion of external forces leading to the efficiency business model in phase 1. Next, this section shifts its focus from efficiency to the combination of marketplace and data trustee and the role of external forces. This section concludes with the introduction of mass customisation to the business model.

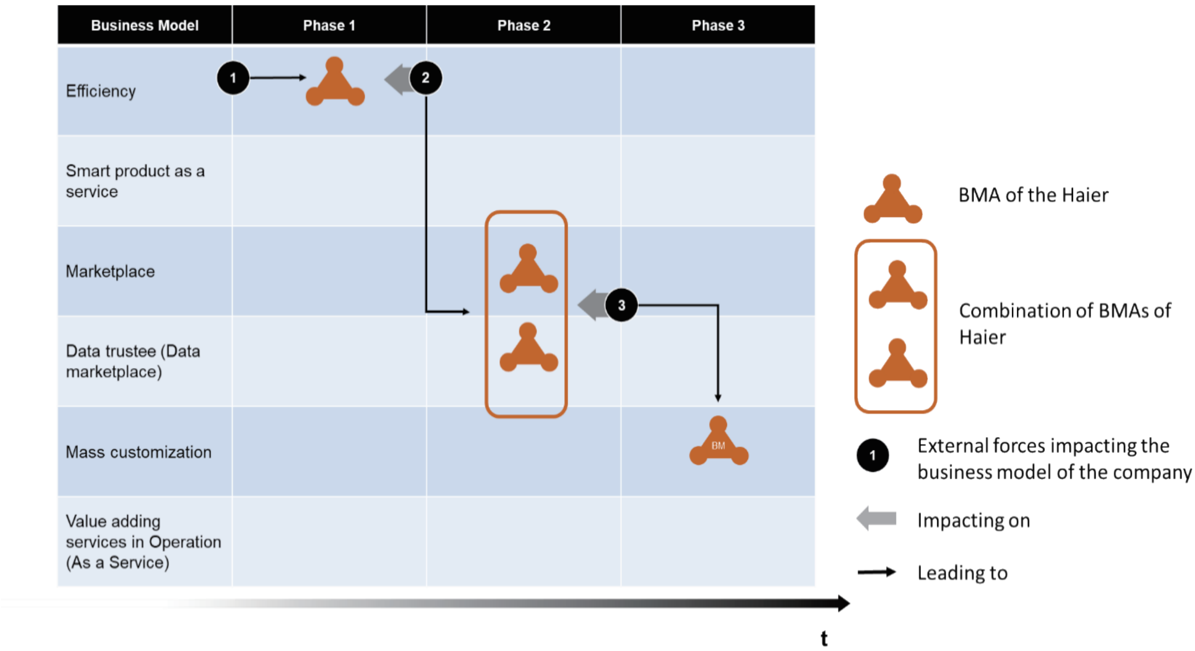

Figure 18: Recent business model evolution of Haier

Phase 1: Efficiency

As discussed in practical example six on Haier, the COSMOPlat Industrial Internet Platform and Tongyi Ceramics, the ceramics company receives raw materials from their suppliers based on their specific customer orders. This reduces both waste and the production timeline thus resulting in an overall increase in efficiency. Tongyi has achieved high quality products at a lower cost with faster delivery through the production phase.

In traditional manufacturing systems, the overall amount of data generated in this scenario would be relatively small. However, with the rapid application of IoT in the industrial field, a much larger amount of data could be generated from the same scenario. This increased data generation would require a powerful management tool, like an Industrial Internet platform.

	Force enabling change	Force constraining change
Key trends	Development of management	Level of manufacturing
Industry force	Increase of efficiency	Low management level of manufacturing
Market force	Need for lower price	High cost of upgrading
Macroeconomic force	Increased cost of human labour	Operation cost of factory is high

Table 3: Forces impacting on the establishment of the business model efficiency

Phase 2: Analysis of data in operation + Marketplace

With the help of COSMOPlat, Tongyi Ceramics is not only the producer or service provider but has also built a robust relationship directly with the customer. Tongyi Ceramics has now become a customer operator providing 24/7 around the clock service and predicting customer needs. The service now combines R&D, manufacturing, operation management, sales and maintenance with value creation present in each of these new services. Overall, COSMOPlat reduces both transaction and management costs for Tongyi Ceramics and its suppliers. This forms a larger network community where integrating resources replaces simple transactions, the benefits of which are shared by partners and suppliers.

	Force enabling change	Force constraining change
Key trends	Diverse needs of customer	High inventory
Industry force	Technology of intelligent manufacturing	System integration
Market force	Local consumer increase	Reliance on foreign suppliers
Macroeconomic force	Sino-US trade war	Environmental protection requirements

Table 4: Forces urging the change from efficiency to a combination of marketplace and data trustee

Phase 3: Mass customisation

Unlike the traditional production model in which enterprises first develop products before predicting market demand to then manufacture and sell on a large scale, Haier COSMOPlat is a user demand-driven production model. This model enables user participation from creativity to delivery known as Mind to Deliver where user engage at the beginning of the process from idea conception all the way until product delivery. On the COSMOPlat platform, customers can enter their order preferences and immediately access millions of global design resources and hundreds of companies to provide the physical design and production services. Through intelligent manufacturing, users can place an order and engage with the entire production process in real time.

	Force enabling change	Force constraining change
Key trends	Diverse needs of customer	High inventory
Industry force	Technology of intelligent manufacturing	System integration
Market force	Local consumer increase	Reliance on foreign suppliers
Macroeconomic force	Sino-US trade war	Environmental protection requirements

Table 5: Forces urging the change from the combination of marketplace and data trustee to mass customisation

4. Conclusion and Recommendations

4.1 Joint Recommendations for Germany and China

i. Adaption and maturity level vary by size of company: Larger companies have higher levels of adoption of technology-led process and service innovation.

Which are the right policies / measures to increase adoption and maturity?

- Formulate more concrete ambitions and goals for both countries' digitisation of industry, set targets and define corresponding interventions.

- Currently, Industrie 4.0/Intelligent Manufacturing is discussed in a broad brushed way, not factoring in size or sub-industry of the company. Furthermore, policy responses have to take into account the position and level of autonomy in the value chain.

- Provide personalised orientation to SMEs and create stronger synergies across SME support mechanisms
    - A report / performance analysis on SME initiatives is advised in order to formulate detailed supporting policies for SMEs. E.g. SME centres shall consider the international trends and opportunities.

- Provide "Digital Initiative for SME" especially on the back of the challenges associated with the COVID-19 pandemic which should
    - Offer services for SME with a focus on digitisation opportunities
        - Providing an accessible online match-making service platform for both supply and demand sides in order to improve the information transparency and operation efficiency as well as to minimise the negative impact of the bullwhip effect in the supply chain. Such a platform could create increased efficiency in the whole ecosystem.
        - Government measures and initiatives supporting digital transformation of SME vis-à-vis COVID-19, among others, specific subsidy and tax policies, as well as active (public) advisory services.
        - Pro-active communication activities/campaigns to raise awareness among SME
    - Create a sub-expert group with a research / advisory focus on digital business models exclusively for SME

ii. Lack of innovation spill over in the economy: Spill over from larger to smaller companies is needed to realise value and productivity gains across the economy.

How can spill over be incentivised?

- Spill overs are an important means to increase productivity and innovation in the whole economy. Supporting the establishment of value networks to increase cooperation competence in companies could foster this process.

- High opportunity costs of upgrading enabling technologies as well as insecurities on returns of investment play an important role in preventing SMEs from innovating their business models.
    - Exploration and launch of new funding schemes for all enterprises, especially SME, are recommended.
    - Scale is key for digital business model profitability. Further research is needed on how companies can be better supported in scaling up their digital business models.

iii. Getting from data to value: Assessment of the value of data, pricing, trade and monetisation is in its infancy.

<u>Which are the business models that enable top line value creation?</u>

- Overall discussion of Industrie 4.0 / Intelligent Manufacturing needs to shift further towards monetisation of digital business models and ecosystem requirements
  - Providing consulting / advisory services (especially to SME), centred on a digital business model perspective (how to identify new value propositions), not on technology upgrading alone. The latter should be understood as a means to increase value.

- Developing a policy framework that enables innovative data driven business models

- Providing a SME guideline addressing key questions, e.g.
  - Which types of data exist?
  - Examples of data use in digital business models within individual data categories

- Guidance on the evolving legal/ regulatory environment
  - The German Government is currently formulating its data strategy. At this time, Germany lacks a legal framework for companies to co-invest into building ecosystems. For example, the US enables the establishment of Joint Development Foundations. Ecosystem building activities in Germany have chosen that framework for set ups in Germany.
  - For China, the Big Data Strategy has become an important part of national policy making, focusing on building-up domestic cyber-capabilities to facilitate high quality economic development. The specification for the protection of personal information have just been implemented in 2018 and revised in 2020[47]. The legal framework of data management and security still requires further improvements.

- Overall, competition laws in both countries should be reviewed to enable cooperation in data marketplace ecosystems
  - Legal rights of users, owners and beneficiaries of generated data have to be clearly formulated with applicable standards and specifications.

iv. Lack of talent: Technical, functional and managerial skills to harness the value of digital transformation are scarce.

<u>Which are the right responses of educational institutions to address talent gaps?</u>

Demand for skills is arising much faster in the market than educational institutions can provide them.

- Use technology to close capability gaps

- Provide clarity on data professions of the future and workflow
  - Ongoing research is needed to better estimate required skillsets in the future.
  - Training programs and schemes need to be developed to further educate current workers, not just university students / trainees.
  - A framework for the development of future digital skills sets in companies is needed

- Develop training contents for digital business models
  - A theoretical module (e.g. study on use cases) including a technical/ practical session
    - Training should focus on value creation aspects via digital business models, not on efficiency gains through technological upgrades

47 China Electronics Standardization Institute. "Publication of the National Standards of the Specification for the Cyber Security Technology – Protection of Personal Information (2020 Edition) ". 16 March 2020. Accessed 19 May 2020. http://www.cesi.cn/202003/6213.html

  - o The training should be independent on industry sectors, products and services.

v. Security concerns: Concerns over the security of intellectual property are widespread.

What does it take for trust to increase?

- Establish Security-by-Design and Security-add-ons throughout the lifecycle as the foundation of trust in Industrie 4.0. This is expected to accelerate as COVID-19 changes work practices

- Improving quality of third-party supervision institutions to guarantee information security.

- Security must become a quality aspect and a part of the business continuity management. Security monitoring systems should be further developed and supported.
  - o Strengthening cooperation between business department staff and security personnel

- Support of security interoperability for technical and organisational security policies as well as regulatory and legal policy frameworks.

- Security is an essential part of trustworthiness and trustworthiness is a qualitative decision-making criteria for exchange of information between companies.
  - o Qualitative, transparent standards for evaluating the trustworthiness of companies / business partners and their products, systems and processes are required.
  - o Joining third-party networks (private and public) poses high security risks for enterprises. Trustworthy certification bodies are needed to establish trust.

4.2 Outlook

China and Germany are both important global manufacturing powers. They share strong industry complementarity and host great potential for cooperation. It is in line with the mutual interests of both sides to continue to strengthen cooperation between the two countries in the field of intelligent manufacturing and digital manufacturing transformation, including

- sharing typical cooperation experiences

- exploring opportunities and challenges in the cooperation process

- promoting more cooperation in fields with deep industrial bases such as talent, technologies and standards.

With regards to the recent impact of COVID-19, both countries evidence suggests a major push forward in the development and application rate of digital business models. Whereas a comprehensive understanding of mid-and long-term effects of COVID-19 on digital business models will require further research and analysis in the upcoming months and years, this report adheres to the assumption that COVID-19 has become a catalyst for the application of digital business models.

As the relevance of international/global value networks have become (painfully) apparent during the first months of 2020, further major developments in the application of digital business models are to be expected in the near future.

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