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Digital Business Model Innovation: Empirical insights into the drivers and value of Artificial Intelligence

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Abstract

The business activities of traditional industrial companies have commonly focused on products and product-related services. Digital pioneers have evolved their offerings into product-service systems that are connected, intelligent, personalized, and adaptable. The speed at which business models must change continues to be underestimated by many market participants, especially when order books are well filled and the pressure to change appears to be low. Industrial and service companies need to adapt to the changes induced by new market players better today than tomorrow to secure future business success and remain competitive in the digital age. The aim of this article is to intensify the debate on digital business model innovation in industry and the service sector and to enrich it with practical examples of the successful implementation of artificial intelligence in products and services.

Keywords: Business Model Innovation, Business Process Reengineering, Artificial Intelligence, Data Analytics, Digital Transformation

1. INTRODUCTION TO DIGITAL BUSINESS MODEL INNOVATION

Successful business models have long been stressed by increasing competitive and cost pressures, breaking down silos, and commoditization of products and services. In the digital age, this is compounded by new entrants offering entirely new value propositions that will be data-driven and disruptive [4]. This is because once developed, software platforms have process costs that tend toward zero. This makes it easy to aggregate massive amounts of data, learn from data with artificial intelligence, and develop digital business models from it that can scale exponentially across domains and countries.

However, the business logic of traditional industry typically follows the linear value chain model [18]. Companies process goods in several stages to create higher-value end products and sell them to consumers. They generate value by managing the process of value creation activities that build on each other. Markets that function according to this principle are also referred to as one-sided or supply-driven markets. In contrast, platform markets are multi-sided markets characterized by the so-called network effect [19, 20]. That is, the more market participants of a certain group are on the platform, the more attractive a platform is for another group of market participants. However, once a critical mass is reached, a highly interconnected value creation system is formed, which significantly increases the opportunities for market transactions and significantly reduces transaction costs [3].

Platforms usually consist of two central components [21]: a platform core in terms of technical infrastructure with a business management layer. This platform core is controlled by the platform provider. The second part is the platform periphery, which sometimes combines several hundred thousand dependent service providers such as APP developers and e-commerce stores. Amazon and Alibaba have perfected this model. APP developers use platform technology made available to them through APIs (application programming interface) or SDKs (software developer kits) [23]. From the periphery, they dock onto the platform core via programming interfaces, without the externals maintaining business relationships with each other in the process. They co-exist and usually compete (co-evolution). Together, they make up a digital business or innovation ecosystem: the more apps are offered to consumers, the more consumers will use the platform, and the more the individual developer benefits from the demand. A self-reinforcing growth occurs [21].

If a company successfully positions itself as a platform provider and operates a platform business model, it can achieve a dominant position by acting as an intermediary between the producers and consumers of the market. This poses a serious risk for a lead company in the value chain, such as an automotive manufacturer, as it may lose the direct interface with its customers [06, 22].

Today, the traditional approach to business in industry is being disrupted by Internet giants and platform companies from primarily the United States and China [10]. A digital platform is a marketplace that connects providers and consumers, as well as any other providers, via the Internet and enables value-creating interactions between them [15]. This digital transformation of the marketplace and business model implies that a growing proportion of manufactured goods are now smart and refined through the collection, storage, analysis, and evaluation of data. In the process, smart product-service bundles are changing the business logic of entire industries and markets by being based on digital platforms, enabling data-driven services, and creating digital innovation ecosystems through networked value creation by complementary market players. On this basis, completely new business models can emerge in the industry. The starting point for these new business models is a radical focus on the customer with his or her individual needs. Instead of selling a physical product such as a medical device, an agricultural machine or a machine tool, platform companies and digital pioneers aim to offer customers an adequate range of product-service systems at any time and any place.

One example of how these ideas are being implemented in the automotive industry today, is "Mobility as a Service": to get from A to B, people can use an APP on their smartphone that combines different modes of transportation such as car sharing or public transport. The user can choose whether to take the fastest or the cheapest connection. These mobility services need data about the products, their usage and about consumers. In addition, they need data from other sources such as traffic data, movement data or weather data. They also need to be able to extract valuable information from it in real time using data analytics and machine learning [13]. Beyond the digitally augmented vehicle, mobile devices play a central role in collecting this information and data on how a particular service is used.

So, if data is the raw material of the 21st century [12], turning it into valuable knowledge becomes a significant manufacturing process. If everything-as-a-service is the preferred delivery model, highly automated cloud centers will become significant global manufacturing sites [08, 09]. The competitive question of the future will be: Will the smart product become the platform for innovative services, such as route optimization, infotainment, or automated parking in the case of the mobility provider? Or will intermediaries such as fleet operators offer users individually tailored mobility services that can also be used across different modes of transport?

In summary, the business activities of traditional industrial companies have traditionally focused on products and product-related services. Digital pioneers have already connected their "smart products" to the Internet and are collecting and evaluating the corresponding data. The speed with which business models must change is still underestimated by many market participants [10], especially when order books are well filled and the pressure to change appears to be low. However, industrial companies must adapt to the changes induced by new market players better today than tomorrow to secure future business success and remain competitive in the digital age.

The aim of this paper is to intensify the debate on business model innovation and digital transformation in industry and to provide concrete examples of successful implementation of the key technology of artificial intelligence based on practical examples.

2. METHODOLOGY

This paper is empirically grounded in primary data collected through 145 qualitative guided interviews with industry executives and experts in China, Germany, Japan, Korea, and the United States between September 2015 and October 2019. The data collection was conducted through exploratory semi-structured guided interviews based on existing studies, publications and projects on the relevant research and innovation areas in industry and services. The qualitative questionnaire and interview guide included guiding interview questions as well as quantitative elements.

The in-depth interviews were transcribed and analysed using the Qualitative Content Analysis-Method. The article is based on results from two research and accompanying projects conducted at acatech - German Academy of Science and Engineering and funded by the German Federal Ministry for Economic Affairs and Energy [01] and the German Federal Ministry of Education and Research [02], respectively.

The study consists of five main parts. The first and second parts deal with the problem definition and the methodological approach of the work. The third part highlights the rise of platform companies and the transformation of industry. The fourth part discusses what Europe needs to do to compete with platform companies and new entrants. Finally, some conclusions and an outlook follow.

3. KEY DRIVERS OF DIGITAL TRANSFORMATION IN INDUSTRY

The interviews conducted with representatives from industry and the service sector overwhelmingly reinforce the assumption that digital technology platforms are increasingly becoming the dominant marketplace for new business models. Digital platforms have a productivity-enhancing effect by creating transparency and networking actors, capital, and resources more efficiently - and with almost unlimited reach via the Internet [10].

Based on the empirical findings obtained, five trends can be derived that represent an increase in the importance of digital offerings in the industry and strengthen the transformation of this key industry:

3.1 ARTIFICIAL INTELIGENCE IMPROVES BUSINESS PROCESSES

Artificial intelligence (AI) has the potential to become a game changer and permanently change the rules of the game in our economy [07, 11]. The beginnings of AI date back more than half a century. However, the big breakthrough came only a few years ago. The Internet and sensor technology brought unimaginable amounts of data that could be used to train learning, adaptive software systems and increasingly achieve hit accuracy (accuracy) and robustness in use. Exponential growth in the IT industry, with huge advances in computing and storage power, now made it possible to process and understand this data by machine, in near real-time. For example, AI helps with speech and pattern recognition, image processing, machine vision, or human and (cognitive) machine interaction. This is driving new data-driven product and service innovations in almost all industries. Examples include real-time, adaptive, and intelligent production / Industry 4.0 [25, 01], or automated underwriting in the finance, legal and insurance industries.

As the expert survey shows, data is increasingly becoming an economic asset, has value and forms the basis of innovative and profitable business models. Intelligent products and machines are connected via the Internet even after they leave the factory and exchange huge amounts of data during their use. This Big Data is refined into Smart Data, which can then be used to control, maintain, or further develop and improve smart products and services. They generate the knowledge that forms the basis for new business models.

Consolidation and refinement by mean of real-time analytics and artificial intelligence usually takes place in data-intensive digital platforms, which, as explained at the beginning, are becoming the predominant marketplace. Industrial companies have already connected smart products to the Internet and started collecting and analysing data. However, many pilot projects do not yet make it from proof-of-concept to productive application and are rarely scalable [08]. Ideally, platforms combine, for example, device management with connectivity, data storage systems and an app store with digital services provided by an open digital ecosystem. Crucial to the successful implementation of new data-driven business models is how good the digital innovation ecosystem is and how quickly it can be built (see Fig. 1). In addition, various challenges regarding financing, reliability, data security, IPR (Intellectual Property Rights) protection and finally standardization must be answered.

Figure1: The architecture of data-driven business models [01]

3.2 SMART DATA ENABELS DISRUPTIVE BUSINESS MODELS

Following the principle of the circular economy, digital sharing platforms can contribute to greater efficiency and sustainability along the entire product lifecycle by making better use of the capacities of cars, machines, and homes. Some data-driven platforms have the potential to disrupt established business models. Examples include online brokerage services for passenger transportation, accommodation, or streaming services for music and movies.

One characteristic of platforms is network effects. The more players are connected via the platform, the more the participants benefit from using it and the more attractive the platform becomes for new customers and providers. The rapid and sustained growth of platforms is a decisive factor in their competitive success. In recent years, American and Chinese companies such as Amazon and Alibaba, Google, and Baidu, but also Facebook and Tencent, whose business models are based on digital platforms, have had enormous success in the B2C sector. Such platforms are now also emerging in the business-to-business (B2B) sector. With these platforms, the "winner takes all" principle is not equally inevitable, which is due to the importance of complexity and domain knowledge. In addition to the advantages mentioned, platform markets also have structural weaknesses, e.g., concentration tendencies toward monopolization due to scaling and networking effects, which pose problems for social networks such as Facebook. This also poses new challenges for competition law. If data power tends to reinforce existing market power, it must be clarified when the "abuse" of data power requires regulation.

3.3 THE RISE OF DIGITAL ECOSYSTEMS

The interviews showed that no company has the necessary know-how to be successful in the digital age in the long term. Through co-evolution and collaboration, companies can jointly offer complementary solutions to their customers and increase their competitiveness. When multiple innovators successfully collaborate in a platform environment, innovation ecosystems are created. Global competition will be transformed by the emergence of digital business models and platforms: It will take place primarily between digital innovation ecosystems - no longer just between individual companies. Here lie opportunities for start-ups and SMEs to contribute their highly specialized skills to these ecosystems without having to take a greater entrepreneurial risk by building their own platforms.

The move toward hyperconnectivity, autonomy, and increased human-machine interaction is inspiring companies to make their core processes more efficient and to finish products and services [10]. This development will take a rather evolutionary course. Data-driven business models, platform markets and digital ecosystems, on the other hand, have a disruptive effect. Current business models can be cannibalized within a very short time, regardless of the industry. This new view of business is unfamiliar to many "traditional" industrial companies [05]. Established business models and previously successful companies are being challenged by start-ups, but also by companies from outside the industry - especially large online corporations.

3.4 TOWARDS A PLATFORM COMPANY

The boundaries between manufacturing trades, service companies and the IT and Internet industries are blurring. Industrial companies need new skills, for example in the areas of IT security and artificial intelligence-supported data analysis. Even though many companies have already connected their "smart products" to the Internet - they also collect and evaluate relevant data. The speed and radicality with which current business models must change is often still underestimated.

Fig. 2 shows what such a process from optimized production to data-driven business model innovations might look like. Connectivity and real-time responses around the original product or service are followed by optimization and efficiency at the product and process level, including new after-sales services. Expanding the business model toward products as services and value-added services transforms the company into a service organization. Via the new digital business, the company ultimately develops into a platform company or participant in a digital ecosystem.

	Connect & operate live	Optimise & supply efficiently	Expand & boost sales	Innovate & develop ecosystem
Business model	**Products & support services**	**Product services & after-sales services**	**Product-as-a-service & value-added service**	**Data-driven digital business model**
Business driver	Product sales	Process optimisation	Service growth	Expanded ecosystems
IoT capacities	Embedded systems, augmented reality	Analytics, machine learning, optimisation	Service management (portfolio, product management)	Ecosystem business development
Integration & technology	Vertical integration (OT-IT), machine connectivity	Horizontal integration (planning to delivery)	Services platform, SLA management	Open data platforms, business networks
Standards	Connectivity (e.g. OPC-UA)	Semantic standards	Service interoperability	Cross-sectoral standards
	Optimised production		**Smart services**	**Innovation business**

Figure 2: From optimized production to data-driven business model innovations [own illustration, 10]

While the best networks today have latency times of ten to fifteen milliseconds, the upcoming mobile communications standard 5G will offer mobile Internet in near real time. Data latency, the time that elapses between data retrieval and data provision, will be reduced to just one millisecond in the future. 5G is fast, latency-free, energy-efficient, and reliable - a basic requirement for the next generation of products and services.

The interviews showed that there is a clear trend toward autonomous systems in the industry, even though the Corona crisis has led to more cost discipline and new strategic thinking. Autonomous vehicles reach a given destination autonomously and according to the situation, without human control or defined action plans. The key components of autonomous systems are sensors, self-regulation, and actuators. In this context, the self-regulation of autonomous systems is enabled by elements of perception and interpretation, planning and plan making, learning, and reasoning, and communication and collaboration [14]. Thanks to tremendous advances in AI, it is now possible to extract valuable information and insights in real time from data collected by sensors. This data also serves as training material for self-learning and autonomous systems, which recognize the structure of their environment themselves and generate their own knowledge base that can be continuously updated during operation. Self-driving shuttles in public transportation, mobile service robots in rehabilitation centres and in nursing care, and smart home technologies are just a few examples of autonomous, adaptive systems that are taking on increasingly complex tasks in all areas of work and life.

3.5 RESULTS AND DISCUSSION

The study results raise some guiding questions that companies should pay more attention to in the future. After all, the extent to which traditional industrial companies can survive in the digital age and maintain their dominant position even against new market players and tech giants from the USA and China also depends on the following guiding questions.

- Business enterprises should permanently examine how they can further develop their existing business model and how they can fundamentally renew themselves.
- Does the company have the technical prerequisites such as connectivity and cloud infrastructure to optimise business processes, and to extend the company's products digitally?
- Does the analysis of real-time data bring new business insights that can be exploited or marketed?
- Customers wants customization. Are there opportunities to integrate artificial intelligence methods into business processes to increase personalization of the product as well as the service quality?
- Are there opportunities to form new partnerships with solution providers, customers, suppliers, and research institutions to offer expanded platform-based market services?

4. DIGITAL BUSINESS MODEL INNOVATION: EMPIRICAL INSIGHTS FROM DIFFERENT INDUSTRIES

What do productive examples of use by digital transformation pioneers look like, which companies can use as a guide in their transformation process? What are the success factors, where are the pitfalls, and what are the clear benefits of a specific business model innovation?

The following examples have been compiled and prepared by the national AI platform Learning Systems with partners from industry, the service sector and research [17]. All examples have in common that they rely on artificial intelligence methods in business model innovation. AI-based solutions require various competencies and system components that a single company rarely has. For the use of data analysis tools and AI, therefore, collaborations with software and hardware providers as well as platform companies that offer the required knowledge about value networks and support the development of digital ecosystems via them are a good idea [24]

4.1 SMART FARMING: NEW VALUE PROPOSITIONS BY AGRICULTURAL MACHINERY MANUFACTURERS

For farmers and contractors with mixed machinery fleets, the use of machine data in combination with different agricultural software products (APPs) is only partially possible, which has so far hampered or even prevented the efficient use of IT in agriculture. There are several approaches for cross-manufacturer data exchange. The web-based agrirouter, as a central instance, enables communication with products from currently 27 agricultural technology companies. The farmer accesses the data via the agrirouter and determines which data from different machine and agricultural software applications is shared with the platform (see Fig. 3).

Data Connect also pursues a decentralized approach - here, applications from the companies Claas, 365FarmNet and John Deere can communicate directly with each other (see Fig. 4). The farmer can work in one platform and access the data of the others from there. In general, digital solutions depend on trust in data security, a high-performance infrastructure, and a high level of user convenience. In the medium term, it is important to support farmers across manufacturers in optimizing their operations (standardization, interoperability) and to provide data-based recommendations for farming and harvesting operations.

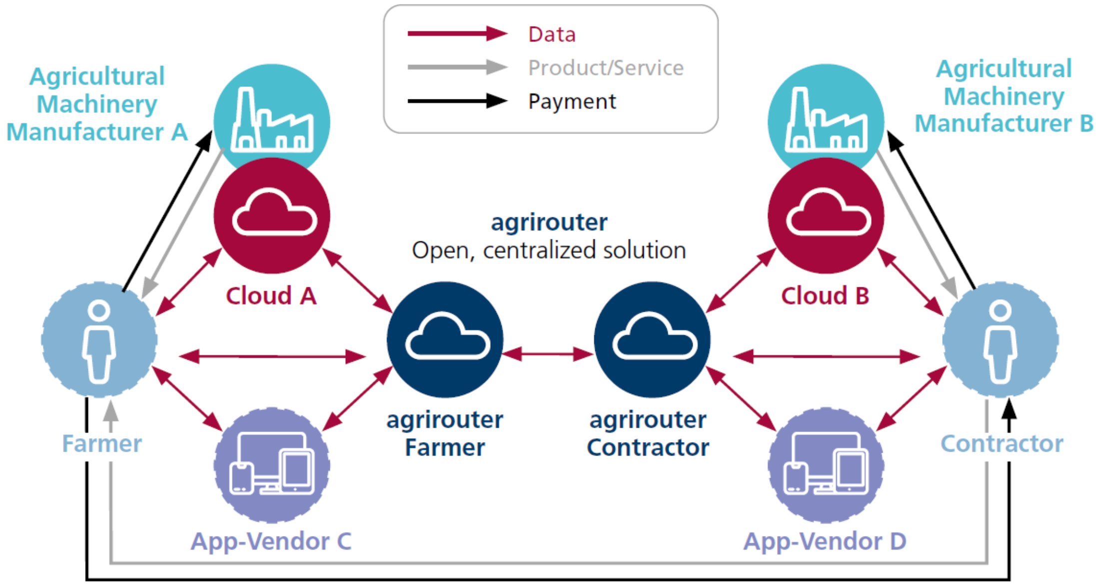

Fig. 3: Data exchange in smart agriculture – the case of agrirouter [own illustration, 16]

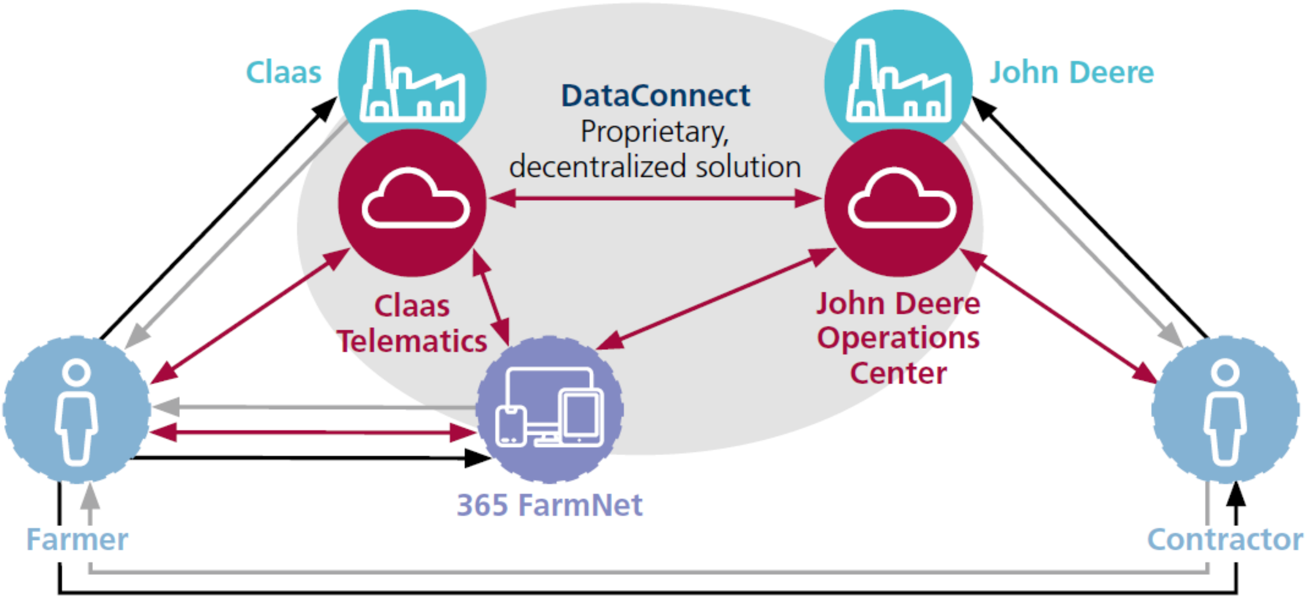

Figure 4: Data exchange in agriculture – the case of DataConnect [own illustration, 16]

Farmers and contractors usually use machines and equipment from different manufacturers and generations. In addition, there is the underlying operating system. The examples show that data transaction platforms can remedy this situation if operating equipment and software from different manufacturers can communicate and interact with each other in a uniform computer language.

Fig. 5 shows the potential of digital expansion from an economic, technical, and data-related perspective. In this context, process innovations go hand in hand with business model innovations, for example when agricultural machinery manufacturers can offer their customers improved performance promises such as optimized equipment availability and higher machine running times.

Network	Economic benefits	Technical benefits	Data-related benefits
Agricultural Machinery Manufacturer	- Generation of connectivity for the utilization of machine data in agricultural software products	- Creation of industry standards/multi-brand solutions through uniform interfaces	- Provision of machine data to optimize the overall production process
Farmers	- Increasing efficiency and effectiveness through holistic optimization of agricultural production processes	- Manufacturer-independent data exchange in near real time - Future application of AI methods to optimize the operation	- Cross-system integration of machine data into the documentation and optimization of production processes
Provider of Agriculture Apps	- Reduction of development efforts by using predefined interfaces	- Cross-manufacturer bidirectional data exchange with agricultural machinery and/or other agricultural software apps	- Partially automated documentation and the resulting analysis of weak points - AI process optimization

Figure 5: Potentials of digital process optimization and business model innovation in agribusiness [own illustration, 16]

4.2 SMART INSURANCE: INSURERS' TELEMATICS TARIFFS THROUGH AI ANALYSIS

Accident risk in traditional car insurance policies is only indirectly determined by past accidents and the type of car, among other factors. This potentially represents a disadvantageous policy design for drivers with low risk driving styles. Numerous insurers in Germany offer different variants of telematics tariffs. By collecting telemetry data while driving and pseudonymously evaluating the data into a score, this model can reward a low risk driving style with more favourable policies. The data is measured either by the smartphone or specific sensors and sent online to an AI service provider, where an anonymous evaluation into a score is performed (see Fig. 6). Based on this score, the insurer then determines the policyholder's premiums, which are more favourable than with conventional rates if the policyholder drives accordingly. An accident can be automatically detected and reported by the sensors and AI-based evaluation.

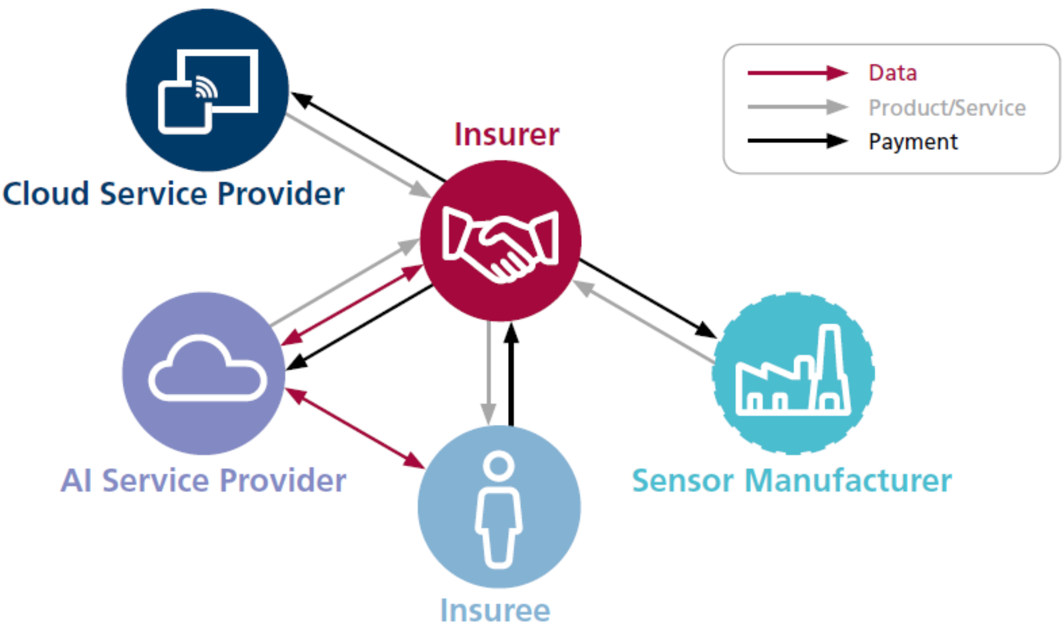

Figure 6: AI-based telematics tariffs in the insurance industry [own illustration, 16]

While the collection of position, speed, and acceleration data is not technically a problem, it is difficult to draw a clear correlation between specific telemetry data and claims and deliver on the promise of reduced accident risk. For example, it has been shown that a sporty driving style does not directly correlate with higher accident risk, but that most insurance claims occur in normal urban traffic, where telemetry-based prediction is difficult. Also, the most serious accidents in terms of bodily injury and amount of damage are those involving trucks on trunk roads, which can generally only be reduced to a limited extent by a telematics tariff. In addition, external factors, such as frequent cornering in rural areas or untypical driving times of shift workers, must not have a detrimental effect on the respective policyholders. Here, the development of further data sources, for example systems for fatigue detection, can be expected in the future.

Another important factor in Germany is the data protection requirements, which do not allow the insurer access to the data collected. In other countries, this data is used, for example, to reconstruct accidents. The protection of this personal data has so far been the biggest hurdle to this model, especially in the public perception. Nevertheless, telematics tariffs can be an interesting extension of existing service offerings for both the policyholder (cost reduction, etc.) and the insurer (business model innovation) (see Fig. 7) – in addition to a general increase in road safety

Network	Economic benefits	Technical benefit	Data-related benefits
Insurer	- Differentiated service provision and revenue generation through AI-based risk classification - Fewer claims	- Access to AI-based scoring of driving style	- Access to data-based score of driving style
AI Service Provider	- New customer for existing technology and infrastructure	- Application and context-specific adaptation of our own, scalable AI technology	- Access to telemetry data for training
Insuree	- Favorable, fair policy design for safety-conscious policyholders	- Functional extension of the own car with AI-based accident reporting on Edge	- Data-based feedback on driving behavior

Figure 7: Benefit potentials of AI-based telematics tariffs [own illustration, 16]

4.3 SMART MAINTENANCE IN THE AVIATION INDUSTRY

Unexpected failures of aircraft components such as turbines, electronics, or even on-board toilets result not only in risks but also in high costs due to potential consequential damage to the aircraft, waiting times for spare parts and technicians, additional space rental at the airport, delayed or cancelled flights, and missed connections.

By integrating heterogeneous data from different sources and using machine learning, predictive models for machine and component failures are automatically generated that predict problems even before they occur, enabling their prevention and more predictive, load-dependent, component-specific maintenance planning. In addition to reducing risks from in-flight failures, there are significant cost savings in aircraft downtime, material, and labour costs. Instead of standard maintenance intervals, load- and wear-dependent, component-specific measures are possible, so that maintenance can be carried out earlier or later as required and can be planned more easily. Ideally, spare parts and technicians are already available at the airport when the aircraft lands, and maintenance is carried out in parallel with off- and on-boarding (see Fig. 8).

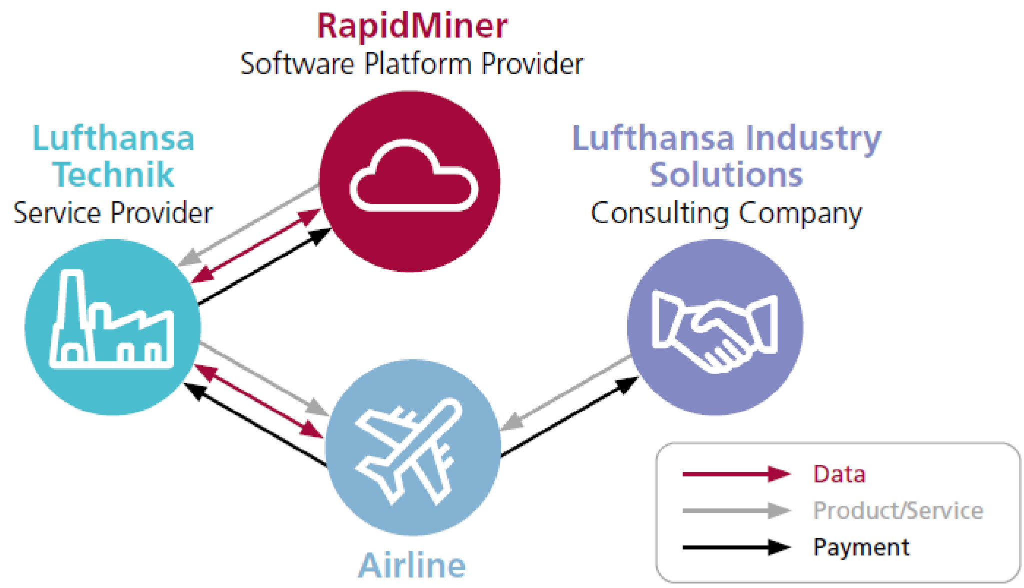

Figure 8: Optimized deployment times through predictive maintenance [own illustration, 16]

Challenges exist in the integration of large amounts of heterogeneous data. However, patterns in failure, usage and maintenance data can often only be identified and used by combining the different data sources. By integrating heterogeneous data from a wide variety of sources (e.g., current, and historical sensor readings and load data from the aircraft, operational and weather data from flight plans, textual repair and maintenance reports, or audio and image data) and using machine learning techniques, predictive models are automatically generated even for complex failure patterns of machines and components. This allows problems to be predicted even before they occur (see Fig. 9). The method can also be transferred to other technology areas such as automotive and rail traffic or production machinery.

Network	Economic benefits	Technical benefit	Data-related benefits
RapidMiner	- Development of new applications & industries for Machine Learning - OEM Partnerships	- Improved know-how about ML & AI technologies and the application domain of the value network	- No need to handle sensitive data, since algorithms are applied directly by Lufthansa Technik for the airlines
Lufthansa Industry Solutions	- Sale of consultancy services	- Development of an ML platform for the own portfolio	- Increased control over data flows and use - Compliance with European data protection standards (GAIA-X)
Lufthansa Technik	- Sale of predictive maintenance services	- Development of an ML platform for the own portfolio	- More precise forecasts by combining data from several airlines (if desired)
Airline	- Increased safety - Higher customer satisfaction and reduced costs due to fewer delays & failures	- Access to ML platform - Service from a single source	- More accurate forecasting models through a broader data basis - No use of personal customer data

Figure 9: Potential benefits of predictive maintenance in aviation [own illustration, 16]

Further examples of AI-based product and process innovations as well as digital business model innovations can be found on the German AI map [18; see Fig. 10), which lists and explains more than 1,100 examples from Germany alone.

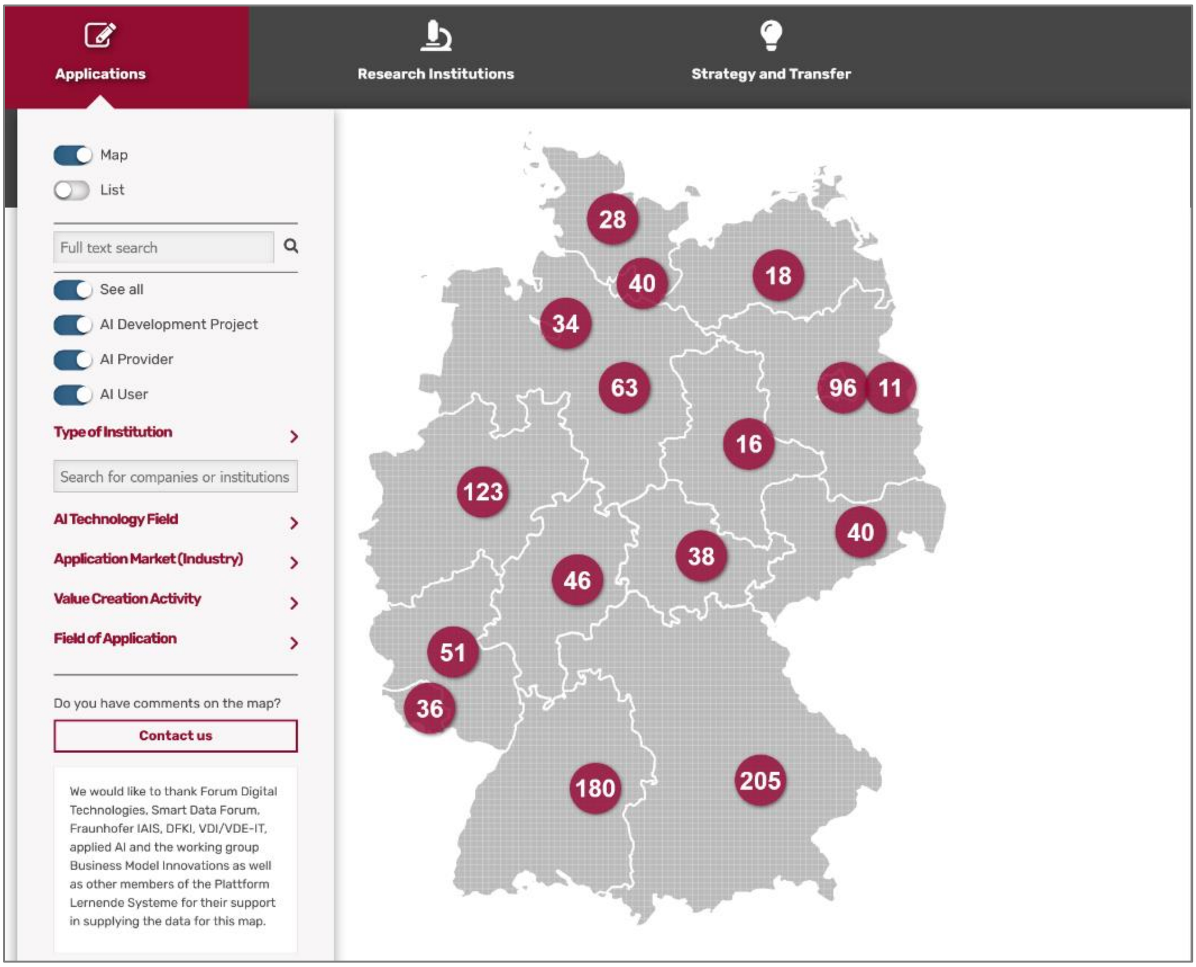

Figure 10: The AI map shows the status quo for AI implementation in Germany [17]

5. CONCLUSIONS: NO COMPETITIVNESS WITHOUT DIGITAL TRANSFORMATION

In summary, the business activities of traditional industrial and service companies have traditionally been focused on products and product-related services. Data-driven providers have already connected their "smart products" to the Internet and are systematically collecting and evaluating the corresponding data.

On the other hand, the speed at which business models must change is still underestimated [10]. Therefore, industrial companies must adapt to the changes induced by new market players to secure future business success and remain competitive.

The study results including the practical examples have shown how this can be done in an ideal way. But for each company, its own roadmap looks somewhat different. It is important to take these examples as an opportunity to define your own path and follow it consistently. Because without digital transformation, there can be no sustainable market success and, in the medium term, no competitiveness in the digital age.

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CONFLICTS OF INTEREST

The author declares that there is no conflict of interest.