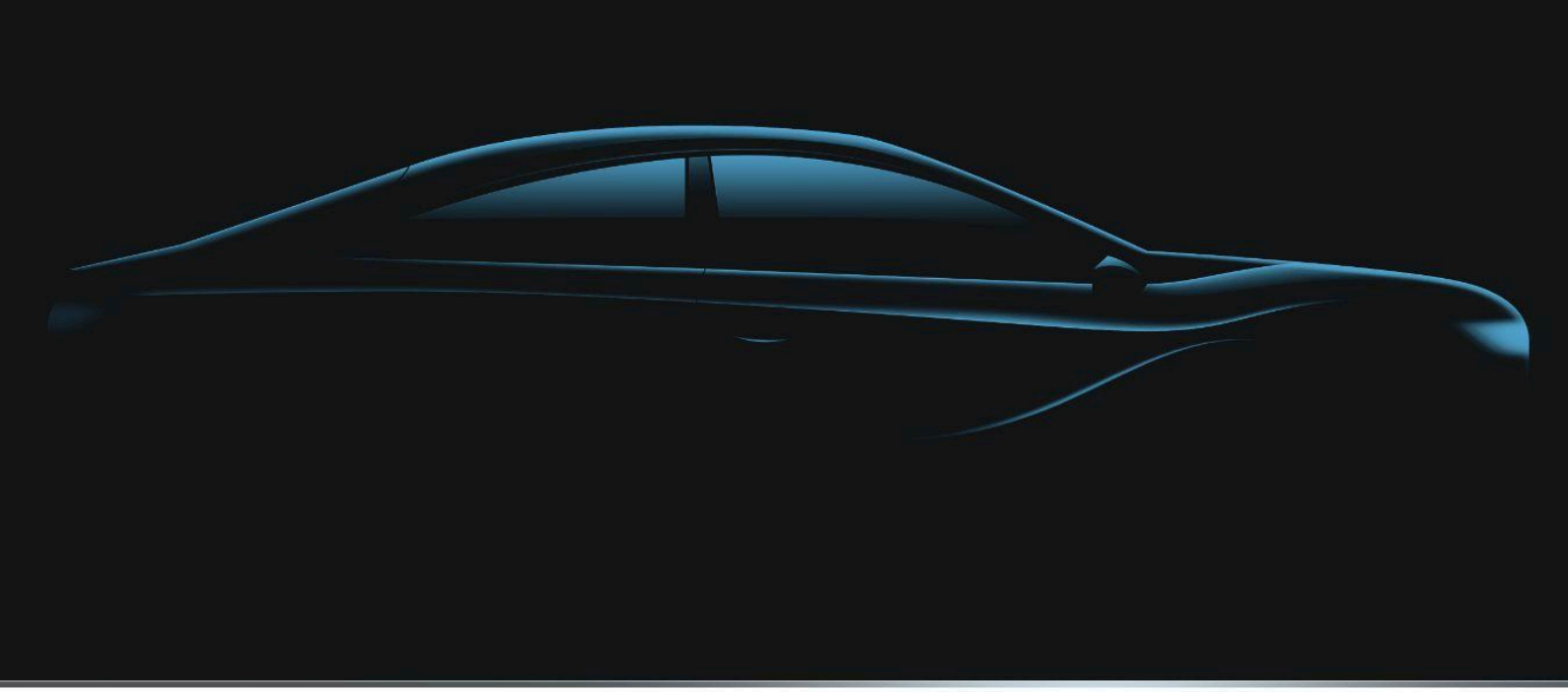

THE IMPACT OF TECHNOLOGICAL ADVANCEMENTS ON CORPORATE OPERATIONS, WITH A FOCUS ON BMW

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General Business Administration module

Task A

Date 22.05.2024

TABLE OF CONTENTS

1. INTRODUCTION

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"When the wind of change blows, some build walls
and the others windmills."

Chinese proverb

The Bayerische Motoren Werke AG, known as BMW, was founded on March 7, 1916. The company's origins can be traced back to Karl Rapp and Gustav Otto. Initially established as an aircraft engine manufacturer, BMW later expanded into motorcycles and automobiles. The first BMW motorcycle, the R 32, was introduced in 1923, marking a significant milestone in motorcycle history. Over the years, BMW grew its product range and became a successful automobile manufacturer, with models like the BMW 1500 and the BMW 501 being notable milestones. BMW's history is characterized by innovation and continuous growth across various vehicle segments, from motorcycles to luxury cars like the BMW 328[1]

- April 1917: Rapp Motorenwerke GmbH became BMW GmbH.
- 1917: Development of a supercharged aircraft engine, so successful that the military orders 2,000 models.
- 1918: BMW GmbH became BMW AG.
- 1918: End of World War I; Treaty of Versailles bans aircraft engine development for 5 years.
- 1922-1923: Introduction of the R32 motorcycle, marking BMW's entry into motorcycle manufacturing.
- From 1924: Production of numerous aircraft engines.
- 1930: The BMW VI engine sets a speed record with the Bahnzeppelin
- 1928: BMW acquires the Automobilfabrik Eisenach A.G.
- March 22, 1929: Production of the Dixi 3/15 PS, BMW's first car, a licensed version of the Austin Seven.
- From 1933: BMW is mainly known for its aircraft engines, while the automotive and motorcycle division is still small

[1] BMW Group Werke Berlin. "Historie." Abgerufen am 30. Januar 2024 von https://www.bmwgroup-werke.com/berlin/de/unser-werk/historie.html.

- ➢ 1933 to 1938: Increase in employees from 8,357 to 180,000 and revenue growth from 32.5 RM to 280 million RM
- ➢ 1941: 90 % of revenue comes from aircraft engines
- ➢ 1939 to 1945: Use of forced laborers at BMW[2]
- ➢ 1945: The Munich factory in Milbertshofen is almost completely destroyed; the Eisenach factory is taken over by Soviet forces and produces under the name EMW until 1951
- ➢ 1945 to 1948: BMW mainly produces motorcycles, cooking pots, and vehicle brakes.
- ➢ 1948: Introduction of the first motorcycle post-war (R24)
- ➢ 1951: Introduction of the first luxury car (BMW 501)
- ➢ Late 1950s/early 1960s: Financial crisis and near takeover of BMW
- ➢ From the 1960s onwards: Successful models like the BMW 1500 contribute to economic success
- ➢ From the 1970s to the early 1990s: Under Eberhard von Kuenheim's leadership, sales of cars and motorcycles increase significantly; Diversification attempts in areas like robotics, software, and aviation are made
- ➢ Around 1990, BMW acquires Rover (including MG, Mini, and Land Rover)
- ➢ In the early 2000s, BMW develops hydrogen-powered vehicles for everyday use as the first manufacturer worldwide. In 2019, BMW announces the production of a fuel cell vehicle using Toyota's fuel cell technology, set to be produced in limited series by late 2022 [3] [4]

Author (A): N.V.
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This work is dedicated to Task A, which examines the impact of technological progress on the business operations of BMW. We deliberately chose this topic as we consider it particularly engaging and relevant. The ongoing development of digital technologies has brought about profound changes in various aspects of business operations in recent decades. Particularly, companies in the automotive industry, such as the renowned brand BMW, are faced with the challenges and opportunities presented by technological advancements, including artificial intelligence, blockchain, and cloud computing.

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[2] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/
https://www.ifz-muenchen.de/heftarchiv/1986_4_2_grossmann.pdf

[3] Kulturgut Mobilität. "BMW Unternehmensgeschichte." Abgerufen am 5. Februar 2024 von https://www.kulturgut-mobilitaet.de/aktuell/hist-mobilitaet/2572-bmw-unternehmensgeschichte.

[4] Motorsport-Total. "Die Entwicklung der BMW-Niere von 1933 bis heute." Abgerufen am 5. Februar 2024 von https://www.motorsport-total.com/oldtimer/news/die-entwicklung-der-bmw-niere-von-1933-bis-heute-20042501.

The automotive sector, as one of the pillars of the global economy, not only represents the largest industry sector in manufacturing but is also the most significant industry sector in Germany in terms of revenue. In 2021, companies in this sector generated an impressive revenue of over 411 billion euros and directly employed nearly 786,000 individuals.[5] (January 2022: 509 billion).[6]

The automotive industry faces challenging and multifaceted obstacles that require a realignment to remain competitive. It is essential to integrate innovative technologies while simultaneously enhancing efficiency and productivity. Particularly, as highlighted in the official website of the Federal Ministry for Economic Affairs and Climate Action in the article "Economic Sectors and the Automotive Industry," predominantly medium-sized supplier companies, which now generate around 70 percent of the value creation in the automotive industry in Germany, play a crucial role in this process. China has a vast market where cars are increasingly popular, with half of the globally produced vehicles being driven on Chinese roads.[7]

Over the years, these supplier companies have developed outstanding system competencies. This enables them to meet the demands of increasing division of labor while collaborating more intensively in complex supply networks with vehicle manufacturers and suppliers from various industrial and service sectors. The close development and system landscape that emerges from this in the German automotive industry, along with the integration of external research institutions, is globally unique.

1.1. RELEVANCE OF TECHNOLOGICAL PROGRESS FOR THE AUTOMOTIVE INDUSTRY

The significance of the factor "mobility" extends beyond the social and economic development of a nation. In the past century, private car usage became the norm worldwide, and the automotive industry – from tier-n suppliers to globally operating Original Equipment Manufacturers (OEMs) - assumed a key position in many economies.[8]

[5] Bundesministerium für Wirtschaft und Energie. (2022). Die Automobilindustrie in Deutschland. Abgerufen von https://www.bmwk.de/Redaktion/DE/Textsammlungen/Branchenfokus/Industrie/branchenfokus-automobilindustrie.html#:~:text=Die%20Automobilindustrie%20ist,knapp%20786.000%20Personen

[6] Statista. (2022). Umsätze der wichtigsten Industriebranchen in Deutschland im Jahr 2021. Abgerufen von https://de.statista.com/statistik/daten/studie/241480/umfrage/umsaetze-der-wichtigsten-industriebranchen-in-deutschland/#:~:text=Die%20wichtigste%20Industriebranche%20Deutschlands%20%2D%20gemessen,Industrie%20und%20die%20Elektrotechnik%2DIndustrie.

[7] ZDF Heute Live (2019)Die Angaben beziehen sich auf den Zeitraum seit 2019 https://www.zdf.de/nachrichten/zdfheute-live/iaa-autoindustrie-e-mobilitaet-china-video-100.html

[8] Lempp, M., Siegfried, P. (2022). Einführung in die Automobilbranche im Umbruch und die urbane Mobilitätsrevolution. In: Automobile Disruption und die urbane Mobilitätsrevolution. Springer Gabler, Cham. https://doi.org/10.1007/978-3-031-19882-3_1

In the 21st century, the automotive industry is facing new technological and environmental developments that will fundamentally change its business models. Electrification of cars, Chinese competition, artificial intelligence, digitalization, and the Internet of Things are just a few of the key factors shaping the automotive industry.[9]

"Artificial intelligence is an essential part of the digital transformation at BMW Group and thus a key enabler for inspiring and intelligent customer experiences."

Peter Lehnert Vice
President New Technologies, Research, and Innovations Digital Car

Artificial Intelligence (AI), also known as Artificial Intelligence (AI), represents a central key technology and opens up significant perspectives for technology, society, and the modern working world. The integration of AI into business processes not only offers the opportunity to automate intelligent behavior but also creates unprecedented potential for data connectivity and processing, enhancing the efficiency of conventional operations and optimizing their quality. At BMW Group, AI is an integral part of digital transformation utilized across the entire value chain. This leads to clear added value for customers, products, employees, and internal processes. The Data & AI Initiative, focusing on Data Analytics and Machine Learning, ensures comprehensive connectivity and knowledge and technology transfer throughout the company.[10]

Artificial Intelligence (AI) finds diverse applications in everyday life, science, and especially in various areas of the automotive industry today. The use of AI enables intelligent functions in both products and processes throughout the entire automotive value chain. It is foreseeable that in the future, almost all critical applications in the automotive industry will rely on AI in some form.[11]

The development and implementation of AI applications in the industrial sector, however, pose a particular challenge due to several aspects. These include complex data flows, dependencies, and various infrastructure components distributed from the cloud to the

[9] Lempp, M., Siegfried, P. (2022). Einführung in die Automobilbranche im Umbruch und die urbane Mobilitätsrevolution. In: Automobile Disruption und die urbane Mobilitätsrevolution. Springer Gabler, Cham. https://doi.org/10.1007/978-3-031-19882-3_1

[10] BMW Group. (2022, [Datum der letzten Aktualisierung der Seite]). Fortschritt und Effizienz in neuer Vielfalt: Zusätzliche Antriebsvarianten und Innovationen für den neuen BMW 7er. Pressemitteilung. Abgerufen von https://www.press.bmwgroup.com/deutschland/article/detail/T0404080DE/fortschritt-und-effizienz-in-neuer-vielfalt:-zusaetzliche-antriebsvarianten-und-innovationen-fuer-den-neuen-bmw-7er?language=de

[11] Luckow, A., Eirich, J., Demtröder, K. (2023). Künstliche Intelligenz: Anwendungen und Werkzeuge in der Automobilindustrie. In: Gillhuber, A., Kauermann, G., Hauner, W. (Hrsg.) Künstliche Intelligenz und Data Science in Theorie und Praxis. Springer Spektrum, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-66278-6_11

edge, encompassing both hardware and software. The "Cloud" represents remote server farms that provide computing power and storage space, while the "Edge" refers to local devices or servers that process data near their point of origin.[12]

The integration of cloud and edge computing enables efficient processing and utilization of data. In the cloud, extensive datasets can be stored and analyzed, while the edge allows for fast processing of real-time data in close proximity to the data generation source. This holistic architecture not only ensures effective data utilization but also enables a flexible and scalable infrastructure that meets the demands of complex AI applications in the automotive industry. One of the prominent challenges lies in creating practical machine learning (ML) models, which not only require extensive datasets but also involve complex processes for data processing and labeling.[13]

Thus, it is clear that the innovative capacity of companies is significantly influenced by technological advancement. Investments in research and development enable companies to develop innovative products and services that meet the evolving needs of the market. This ability to innovate is not only a competitive advantage but also a key to accessing new markets and establishing a long-term position in the business environment.

Another central aspect is customer orientation. By leveraging data analytics and digital platforms, companies can develop a deeper understanding of their customers, enabling personalized engagement and the provision of tailored solutions. This strengthens customer loyalty and solidifies market position.

The flexibility and adaptability of companies are crucial in a constantly changing economy. Technologically agile companies can better respond to unforeseen events and rapidly adjust their business models as needed, as was particularly evident during the COVID-19 pandemic.[14]

In addition to the strategic advantages, technological advancement also contributes to cost savings. By implementing modern technologies in production, energy management, and resource utilization, companies can increase their efficiency while simultaneously freeing up financial resources.[15]

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[12] Luckow, A., Eirich, J., Demtröder, K. (2023). Künstliche Intelligenz: Anwendungen und Werkzeuge in der Automobilindustrie. In: Gillhuber, A., Kauermann, G., Hauner, W. (Hrsg.) Künstliche Intelligenz und Data Science in Theorie und Praxis. Springer Spektrum, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-66278-6_11

[13] Helmrich, K. (2021). Wie die Cloud, Edge Computing und Künstliche Intelligenz zur Nachhaltigkeit in der Industrie beitragen. In: Hildebrandt, A., Landhäußer, W. (Hrsg.) CSR und Digitalisierung. Management-Reihe Corporate Social Responsibility. Springer Gabler, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-61836-3_11

[14] Puls, Thomas, et al. "Strukturwandel in der Automobilindustrie wirkt die Pandemie als Beschleuniger?" ifo Schnelldienst 74.05 (2021): 03-35.

[15] Hüttenrauch, Mathias, and Markus Baum. Effiziente Vielfalt: die dritte Revolution in der Automobilindustrie. Springer-Verlag, 2007.

Overall, the relevance of technological advancement for companies is extremely multifaceted. From competitiveness to innovation capacity, as well as customer orientation and flexibility, it influences all aspects of business operations and is therefore a central success factor for companies in the modern business world.

1.2. Formulation of the research question and objective of the work

Our investigation focuses on how new technologies such as artificial intelligence, blockchain, and cloud computing influence the business operations of BMW and the resulting impact on the company's efficiency, productivity, and decision-making processes. We specifically examine the challenges and potentials arising from the unique structure and collaboration within the German automotive industry.

We not only illuminate the theoretical foundations of these technologies but also contextualize them through concrete case studies and practical examples in the corporate setting. In doing so, we consider a broad spectrum of impacts, ranging from production and logistics processes to marketing strategies and the design of the customer experience.

The implementation of Artificial Intelligence (AI) and other modern technologies undoubtedly brings various challenges that need to be considered. These include concerns regarding data privacy and security in handling sensitive data, the complex integration of new technologies into existing infrastructures, the increasing demand for highly skilled professionals in the field of AI and data science, as well as ethical questions regarding the responsibility of AI systems. Additionally, it is crucial to gain the trust and acceptance of employees and customers.[16] These challenges require careful planning, effective resource allocation, and transparent communication from BMW to ensure successful integration of the new technologies.

Furthermore, we must consider the public debate surrounding Artificial Intelligence and robotics, which is often characterized by concerns about job loss. It is important to note that human potential and creativity are irreplaceable, despite the efficiency of AI and robotics. The discussion aims to create a working environment that acknowledges the unique abilities and social nature of humans, continuing to prioritize them.[17]

[16] Ralf Blessmann (03.08.2023). Wie generative KI die Automobilindustrie in eine Technologie-Revolution führt. https://www.capgemini.com/de-de/insights/blog/generative-ki-automobilindustrie-technologie-revolution/

[17] Wende, G.R. (2023). Miteinander arbeiten jenseits unserer Programmierungen. In: Wie halten Sie Ihre Gabel?. Springer, Wiesbaden. https://doi.org/10.1007/978-3-658-40045-3_7

Another focus lies on the critical assessment of the role of corporate leadership in this transformation process. How can executives drive the successful integration of new technologies and achieve a sustainable competitive advantage in the market?

Our work contributes to understanding the complex interplay between technological advancement and business operations of companies, with BMW serving as a representative example of the challenges and potentials of this development.

2. THEORETICAL FOUNDATIONS

2.1. DEFINITION AND EXPLANATION OF KEY TERMS

The theoretical foundations of this work encompass the definition and explanation of key terms in the context of Artificial Intelligence (AI), blockchain technology, and cloud computing. These technologies have garnered significant attention in recent years and play a crucial role in various industries:

Artificial Intelligence (AI)

Artificial Intelligence (AI) is a subfield of computer science that deals with the imitation of human cognitive abilities by processing information from input data.[18] AI enables the automation of intelligent behavior and the handling of complex processes and decisions.[19] Machine learning techniques enable the rapid and precise analysis of large datasets, offering significant potential in application areas such as autonomous driving, Industry 4.0, or medical technology.[20]

The BMW Group firmly integrates AI into its digital transformation to generate added value for customers, products, employees, and processes across the entire value chain.[21] The company's Data & AI Initiative focuses on data analytics and machine learning to promote rapid networking as well as knowledge and technology transfer.[22]

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[18] Wikipedia. "Künstliche Intelligenz." Abgerufen von https://de.wikipedia.org/wiki/K%C3%BCnstliche_Intelligenz.

[19] Fraunhofer-Institut für Kognitive Systeme IKS. "Künstliche Intelligenz". Verfügbar unter: https://www.iks.fraunhofer.de/de/themen/kuenstliche-intelligenz.html

[20] NetApp. "Was ist Künstliche Intelligenz?" Verfügbar unter: https://www.netapp.com/de/artificial-intelligence/what-is-artificial-intelligence/

[21] BMW Group. Artificial Intelligence. Abgerufen von https://www.bmwgroup.com/de/innovation/innovationen-und-mobilitaet/artificial-intelligence.html

[22] SAS. "Was ist Künstliche Intelligenz?" Verfügbar unter: https://www.sas.com/de_de/insights/analytics/what-is-artificial-intelligence.html

Overall, AI plays a crucial role in modern technology, society, and the workplace as it enhances the efficiency of traditional business processes and opens up new opportunities through intelligent data networking and processing.[23]
The automotive industry has recognized the transformative potential of artificial intelligence early on. Nowadays, AI technologies are used in nearly all areas of the industry, ranging from research and development to final assembly. They enable more precise manufacturing and more efficient quality control. Moreover, they are driving innovations in the field of autonomous driving. By utilizing artificial intelligence, manufacturers can also optimize the consumption and emissions of their vehicles. Overall, AI has fundamentally changed the way cars are designed, manufactured, and utilized.[24]

The main areas of Artificial Intelligence (AI) encompass various applications that are widely used across different industries and have evolved into indispensable tools for businesses. Some of these main areas include:

- **Machine Learning (ML):**
  - Supervised: Models are trained with labeled data, where the algorithm learns to make predictions or decisions based on existing examples.
  - Unsupervised: Models explore unlabeled data to identify structures or patterns, often used for segmentation or dimensionality reduction.
  - Reinforcement Learning: Agents learn to perform actions in an environment by maximizing a reward, with positive or negative feedback.

- **Neural Networks (Deep Learning):**
  - Deep neural networks, often referred to as Deep Learning, are a subset of machine learning that uses deep neural architectures to learn complex representations from data.

- **Natural Language Processing (NLP):**
  - AI systems that process and understand human language, including speech recognition, automatic translation, and text processing.

- **Computer Vision:**
  - AI systems capable of understanding and interpreting visual information from images or videos, used in object recognition, facial recognition, etc.

[23] IBM. "Künstliche Intelligenz." Verfügbar unter: https://www.ibm.com/de-de/topics/artificial-intelligence.

[24] ITPortal24. (ohne Datum). KI in der Automobilindustrie. Abgerufen von https://www.itportal24.de/ratgeber/ki-in-der-automobilindustrie

- ➢ **Expert Systems:**
    - Rule-based systems that use a knowledge base to perform specific tasks in a particular domain.
    -
- ➢ **Intelligente Robotik:**
    - Die Integration von KI-Algorithmen in Roboter, um ihnen zu ermöglichen, autonom mit ihrer Umgebung zu interagieren.

- ➢ **Intelligent Robotics:**
    - The integration of AI algorithms into robots to enable them to autonomously interact with their environment.

- ➢ **Recommendation Systems:**
    - Algorithms that analyze user preferences and behavior to recommend products, services, or content.[25]

- ➢ **Evolutionary AI:**
    - AI systems that can adapt and evolve, often inspired by biological evolutionary processes.

These applications have proven to be extremely useful in various industries from propulsion technology to production control. Companies utilize them to optimize processes, improve product quality, and increase efficiency in production.[26] [27]

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AIQX

Another major AI specific to BMW is the self-developed AI platform called AIQX, which stands for "Artificial Intelligence Quality Next." This platform integrates a set of sensors, cameras, and artificial intelligence, significantly enhancing the assembly process on the production line. In addition to optimizing assembly, it also includes advanced audio control of the vehicle.

[25] Fraunhofer-Institut für Gießerei-, Composite- und Verarbeitungstechnik IGCV. "Künstliche Intelligenz." Verfügbar unter: https://www.igcv.fraunhofer.de/de/forschung/kompetenzen/kuenstliche_intelligenz.html.

[26] EXB Solutions GmbH. "Arten von Künstlicher Intelligenz." Verfügbar unter: https://exb.de/blog/arten-von-kuenstlicher-intelligenz/.

[27] Audius AG. "KI: Ihr Wegweiser zu den 4 Arten der Künstlichen Intelligenz." Verfügbar unter: https://www.audius.de/de/blog/ki-ihr-wegweiser-zu-den-4-arten-der-kuenstlichen-intelligenz.

AR/VR

Augmented Reality, or AR, is a technology that overlays information or visual elements onto the real world. This results in a blend of virtual components integrated into a real environment, such as displaying route information during driving projected onto a vehicle's windshield.

On the other hand, Virtual Reality, or VR, provides complete immersion into a virtual world. Users can explore this world through virtual goggles, and beyond just observing, they can also interact with this environment. VR has been used for several years in various fields, including the automotive industry, where it allows for better visualization of a car's interior space.

AWS (Amazon Web Services)

The function of the AWS is cloud storage, computing power, data analysis, A.I. and video game development. Millions of companies use Cloud Computing to reduce costs, gain agility and innovate more quickly. A third of internet traffic passes through it. AWS has a partnership with BMW.

Blockchain-Technology

Blockchain technology was originally developed to transparently encrypt financial transactions without relying on a central financial system like a bank. This method allows for transferring money from one account to another without involving a third party such as banks. After a transaction is conducted, it is verified by miners who then relay the information to computers (nodes) to validate the transaction. If the transaction is confirmed by enough nodes, the block is added to the blockchain.[28] The advantage of this technology lies in its ability to provide high transparency in the supply chain, optimizing the traceability of a product, thanks to its distributed ledger. In summary, the following benefits of blockchain technology emerge:

1. Confidential data is anonymized and encrypted, making the application of blockchain attractive in various areas such as supply chains, financial transactions, and Industry 4.0 applications.
2. Access to the stored data is only possible with the correct key, ensuring the security of the data.

[28] YRILE. (2022, 4. Januar). LA BLOCKCHAIN EXPLIQUÉE SIMPLEMENT ! [Video]. YouTube. LA BLOCKCHAIN EXPLIQUÉE SIMPLEMENT ! (Smart Contracts, Hash..etc)

3. Companies can collect and analyze large amounts of data when using blockchain.
4. The involvement of various users enables rapid and reliable verification of the collected data.
5. Since all transactions are stored in a blockchain, comprehensive transparency is ensured, which is particularly helpful for error analysis.
6. The use of blockchain in payment processing can lead to cost reduction.
7. Blockchain also facilitates the optimization of transaction reporting.

In addition to the advantages, there are also some disadvantages to using blockchain technology:

1. The technology is not yet widely adopted, meaning that there are currently few ready-made solutions available. Therefore, implementation requires significant effort and expertise that may not be readily available.
2. The transaction speed of blockchain technology is often slow compared to conventional payment systems. In particular, the Bitcoin blockchain has experienced transaction backlogs, highlighting its unsuitability for traditional payment processing.
3. As a blockchain constantly grows with new transactions, it also requires more storage space. This can pose challenges, especially for public blockchains used by many participants.[29]
4. Blockchain technology exhibits a high level of energy intensity. In particular, the operation of cryptocurrencies like Bitcoin results in significant energy consumption, equivalent to the electricity needs of entire countries such as Denmark.[30]

These days, there are already second-generation blockchain systems (such as Ethereum, Core DAO) with the integration of smart contracts, which automatically fulfill the conditions of a contract.[31] The automotive manufacturer BMW is integrating a blockchain solution via the BNB Chain to offer loyalty programs to its customers.[32] [33]

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[29] Weissenberg Group. Blockchain-Technologie verständlich erklärt. Abgerufen von https://weissenberg-group.de/blockchain-technologie-verstaendlich-erklaert/

[30] YRILE. (2022, 4. Januar). LA BLOCKCHAIN EXPLIQUÉE SIMPLEMENT ! [Video]. YouTube. LA BLOCKCHAIN EXPLIQUÉE SIMPLEMENT ! (Smart Contracts, Hash..etc)

[31] Weissenberg Group. Blockchain-Technologie verständlich erklärt. Abgerufen von https://weissenberg-group.de/blockchain-technologie-verstaendlich-erklaert/

[32] BTC-Echo. "BMW will BNB-Chain für Blockchain-Treueprogramm nutzen." Verfügbar unter: https://www.btc-echo.de/schlagzeilen/bmw-will-bnb-chain-fuer-blockchain-treueprogramm-nutzen-157020/#:~:text=Der%20Automobilhersteller%20BMW%20integriert%20eine,des%20Blockchain%2DInfrastrukturunternehmens%20Coinweb%20hervor..

[33] IFP Energies Nouvelles. "Lithium & Energy Transition: More Than a Resource Issue." Consulté le [date de consultation]. URL: https://www.ifpenergiesnouvelles.com/article/lithium-energy-transition-more-resource-issue.

Car2X

One of BMW's two main AI technologies is "Car2X." As a cloud-based feature, Car2X enables real-time communication or interaction between the vehicle and BMW's production system during the manufacturing process.[34]

Cloud Computing

Large companies occasionally need to perform calculations of such enormous scale that they cannot rely solely on their internal computing resources. There arises a need for extensive data storage that these companies must cope with. In such cases, these companies turn to external providers to make their computing power available online, enabling collaborative workflows. This support is often monetized. Moreover, organizations like NASA also rely on external resources and therefore resort to cloud computing.[35]

Cloud Computing is a model that provides on-demand access to computer resources over the Internet and charges based on usage. It enables the rapid and easy provisioning of servers, data storage, and applications regardless of the device. The five essential characteristics according to the National Institute of Standards and Technology are: On-demand Self-Service, Broad Network Access, Resource Pooling, Rapid Elasticity, and Measured Service. These characteristics ensure flexible, scalable, and transparent use of computer resources. Cloud Computing goes beyond other approaches like virtualization and can be considered as a combination of Software as a Service (SaaS) and Utility Computing.[36]

The following sections will delve deeper into these concepts and elucidate their significance for the present investigation.

Cryptocurrencies:

It is a decentralized currency (does not depend on a centralized banking system) and as its name suggests, it is encrypted (therefore secure), operating on a computer system, the blockchain. Today there are around 6,000 of them, the best known of which are Bitcoin, Ethereum and Litecoin.

[34] Car-2-Car Communication Consortium. Verfügbar unter: https://www.car-2-car.org/.

[35] NASA. NASA turns to the cloud for help with next-generation Earth missions. Abgerufen von https://www.nasa.gov/centers-and-facilities/jpl/nasa-turns-to-the-cloud-for-help-with-next-generation-earth-missions/

[36] Wikipedia. (2023). Cloud Computing. Abgerufen von https://de.wikipedia.org/wiki/Cloud_Computing.

Cryptocurrencies are created through a process called “mining” which involves using the power of computers to solve complex mathematical problems.
The value of Cryptocurrencies is based on user trust in the blockchain system and not on states/banks.[37]

Implementation

Cédric Villani is a French mathematical physicist and mathematician, as well as a politician.[38]: In any field that is somewhat sophisticated, these can be found in several domains, such as propulsion change, work mode, and the use of artificial intelligence (AI) programs (ChatGPT, Mixtral, Starling, BMW's A.I.s...).[39]

These days, there are thousands of artificial intelligence systems, each specialized in specific domains. Indeed, every major company nowadays uses AI; some have developed their own in order to meet specific needs such as:

In the industrial sector, for example:

- Mechanical production: EMMA Tools (data collection), a data exploitation system that retrieves, for example, machining statistics and achievements during the assembly line
- In part design to optimize their mechanical characteristics and/or weight
- Prevention of future problems
- Quality control

In manufacturing, for example:

- Logistics
- Inventory management
- Maintenance prediction

KPI (Key performance indicator)

SMART (Specific, Measurable, Achievable, Relevant, Time-Bound) represents a set of criteria used to evaluate the success or failure of a business. This figure, or the calculation leading to it, varies considerably from one company to another as each defines its own success criteria. It can include measures such as click-through rate (CTR), assessing the success of an advertising campaign, improving work processes, sales figures, etc.[40]

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[37] Wikipedia. "Kryptowährung." Verfügbar unter: https://de.wikipedia.org/wiki/Kryptow%C3%A4hrung.

[38] Conférence L’intelligence artificielle 15-03.2019 an der EEMI (école européenne de smétiers de l’internet) https://www.youtube.com/watch?v=FnHHbpTYAG0

[39] Wikipedia. "Cédric Villani." Available at: https://en.wikipedia.org/wiki/C%C3%A9dric_Villani.

[40] Asana. "Key Performance Indicator (KPI)." Verfügbar unter: https://asana.com/de/resources/key-performance-indicator-kpi.

Machine-Learning (ML)-Modelle

Machine Learning is a subcategory of Artificial Intelligence (AI). What distinguishes it significantly is its ability to learn autonomously without requiring direct code modification. To do this, it is fed with large amounts of data, which also requires complex processes of preparation and labeling. When the volume of data becomes massive, it becomes imperative to facilitate decision-making and, consequently, to adjust Machine Learning accordingly.[41]

NFT (non fungible token)

A NFT is a unique digital asset that must be purchased in cryptocurrency and secured by the blockchain. It can be purchased on a purchasing platform like OpenSea.

Think Tank

This is a phrase used to describe a research institution or organization engaged in in-depth analysis and research on a variety of topics. It typically provides expertise and recommendations for addressing societal, economic, political, or scientific issues.

Third-party providers

It represents the opposite of OEM (Original Equipment Manufacturer), meaning the supplier markets products, whether they manufacture them or not, to a company responsible for adding value to the acquired products. For example, BMW may acquire tires for its cars and sell them with its vehicles. This supplier concept can also extend to multiple levels, with each supplier potentially having a supplier of its own, and so on. The variable "N" plays a similar role to that in mathematics, representing an indefinite number of suppliers in a supply chain.[42]

VAR (value added resellers):

Unlike third-party suppliers, Value-Added Resellers (VARs) add value to a company's products by providing additional services such as insurance or complementary services before reselling them to customers.

Web 3

Unlike Web 2.0, Web 3 decentralizes the flow of data and the power of big web technology companies. It replaces centralized servers and opts for a blockchain cryptographic network

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[41] Kai Demtröder, "Title of the Chapter." In: Book Title, edited by Editor Name, page range. Publisher, Year. DOI: 10.1007/978-3-662-66278-6_11

[42] Termly. "Third-Party Service Provider." Verfügbar unter: https://termly.io/legal-dictionary/third-party-service-provider/.

system, which allows data to be stored on distributed devices also called nodes (for example: computers, laptops, servers, etc.).

2.2. OVERVIEW OF THE CURRENT STATE OF TECHNOLOGIES AND POLITICS

Covid 19

Given the expansion of Covid-19, a global lockdown was declared, forcing the imposition of health rules including remote work (for those who could) or a prohibition on leaving home. These restrictions created a development delay in the automotive industry, especially among Western car brands. Despite Covid, China has taken a considerable lead in the automotive industry over Western counterparts both technologically and in terms of resources. The majority of automotive companies located in China (General Motors, Nissan (NSANF), Renault, Honda, and the owner of Peugeot, PSA Group)[43] near Wuhan (origin of Covid-19) were heavily affected by the production halt. Since then, thinking has changed in China. Individuals have seen the benefit of buying a vehicle to avoid taking public transportation and becoming ill.

"China is the world's largest factory but also the world's largest automotive market."

Why do without the electric motor?

Following an awareness of the increasingly serious issues of carbon levels in the atmosphere, which contribute to:

- Global temperature rise and climate change
- Alarming increase in ocean temperatures
- Depletion of fossil fuels
- More frequent occurrences of smog due to exhaust gases and fine particles
- Problems such as increasing traffic leading to the banning of the most polluting vehicles
- Slow depletion of oil

As a result of this accumulation of problems, policymakers have decided to turn to greener energies. The traditional automotive industry is, of course, heavily affected by this issue. For several decades, engineers and researchers have been trying to develop the perfect zero-emission engine.

[43] Beev. "Impact of the Coronavirus on Electric Car Dealerships." Beev Blog. Accessed [Date Accessed]. URL: https://www.beev.co/en/blog/concession-de-voiture-electrique/impact-coronavirus/.

Governments have decided to go green and have subsidized research to remain competitive in the zero-emission vehicle market. One technology that stands out strongly is electric vehicles with lithium-ion batteries. This technology has evolved significantly since its introduction to the market. However, there have also been many other technologies tested and some are still being tested.[44] Here is an overview of the main alternative technologies to the internal combustion engine:

Electric technologies:

When we think about electric technologies, we think about batteries, and by extension, lithium-ion batteries. This new technology (originating in 1979) is nowadays indispensable in all our portable/mobile electronic devices.

It offers numerous advantages:

- ➢ High energy efficiency (96%)
- ➢ Fast charging speed (2 hours)
- ➢ Ability for full and partial charges
- ➢ No maintenance required
- ➢ High energy density
- ➢ Long lifespan (thousands of charge cycles)
- ➢ Managed weight, approximately 5 times lighter than a lead-acid battery
- ➢ The possibility of choosing different lithium-based chemistries depending on the vehicle or device to be electrified.[45]

But also some disadvantages:

- ➢ Fires or explosions are possible, but not common.
- ➢ Overcharging and excessive discharging can lead to damage and reduced lifespan.
- ➢ Physical damage, such as punctures or impacts.

The production of batteries has become heavily centralized around lithium. Lithium is found in large quantities on Earth, mostly in Chile, Argentina, Australia, and China.[46] It is an abundant metal that unfortunately requires a somewhat environmentally unfriendly process to convert it into lithium ready for battery manufacturing. China has managed to

[44] Will a Viable Alternative to the Internal Combustion Engine Exist within the Next Decade?" Encyclopedia.com. Accessed. URL: https://www.encyclopedia.com/science/science-magazines/will-viable-alternative-internal-combustion-engine-exist-within-next-decade.

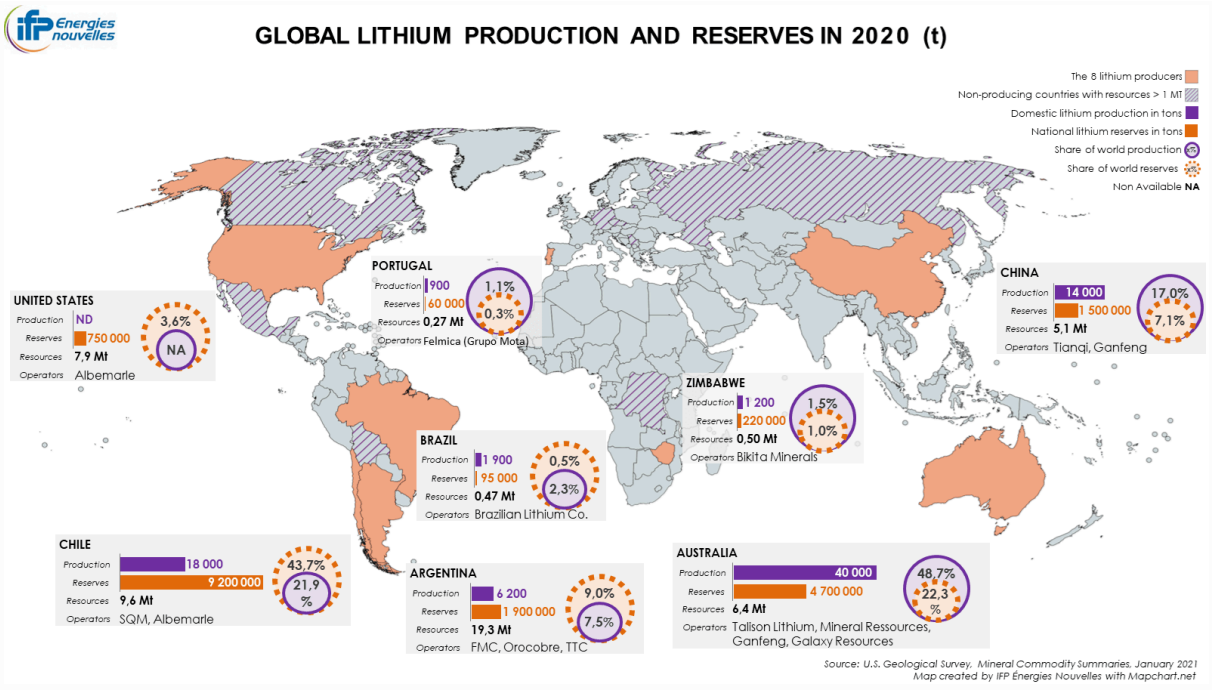
[45] Flash Battery. "Quels types de batteries au lithium utiliser ?" Flash Battery Tech. Consulté le. URL : https://www.flashbattery.tech/fr/types-batteries-lithium-quelle-chimie-utiliser/.

[46] IFP Energies Nouvelles. "Lithium & Energy Transition: More Than a Resource Issue." Consulté le [date de consultation]. URL: https://www.ifpenergiesnouvelles.com/article/lithium-energy-transition-more-resource-issue.

acquire a large portion of lithium and now holds a significant share of the monopoly. While not the largest owner, it holds stakes in the largest exporting countries (Guanfeng and Tianqi). Australia (the country with the largest production) exports 80 % of its lithium to China. It is then refined there and used to produce batteries.

Global lithium battery production:

- ➢ Germany in 2021: 1.6 % and 2025: 11.3 %
- ➢ China in 2021: 65 % and 2025: 79 % [47]



Emergence of Alternative Technologies

The emergence of lithium-ion batteries allows for much greater autonomy. This global focus on electric power accentuates competition in this new field. Those who manage to be the most competitive in terms of price/advantages of the vehicle, with access to secure materials and government subsidies for vehicle purchases, will be in a strong position in the automotive market. Politicians, well aware of this, see it as an opportunity for national pride and encourage the sale of electric vehicles. States support research and development and also subsidize vehicle purchases.

[47] BMW Deutschland. "Blockchain in der Automobilindustrie." Verfügbar unter: https://www.bmw.com/de/innovation/blockchain-automobilindustrie.html.

"The recovery is underway, but in an uneven manner. The growing gap between emerging and developing countries, on one hand, and advanced economies and China, on the other hand, is concerning."

Josep Borell

There are plenty of alternatives to the lithium-ion giant, but these are all still in the research stage and none have yet managed to stand out. Here, we will briefly look at the main ones:[48]

- Sodium-ion Batteries
- Lithium Sulfur Batteries
- Aluminum-Sulfur Batteries[49]
- Solid-State Batteries
- Liquid Metal Batteries that Sadoway and his students developed[50]
- Fuel cell[51]
- There are also some processes under study to replace lithium and cobalt with manganese. Others?...

Other types of energies:

- Algae-based gasoline[52]
- Porsche's clean gasoline
- Any others?

BMW is currently working on solid-state batteries: Solid Power with the American company Solid Power. This battery has a double advantage compared to conventional batteries: they are much safer and have a much better autonomy than the current Lithium/ion battery (800→1,000km). This battery could be applied in series within a few years (2025 for a prototype and 2030 for mass production).

"Parenthèse"

[48] Android Authority. "Lithium-ion battery alternatives." Available at: https://www.androidauthority.com/lithium-ion-battery-alternatives-3356834/.

[49] Trust My Science. "Une batterie basée sur des matériaux courants, sûre, efficace et peu coûteuse." Disponible sur : https://trustmyscience.com/batterie-base-materiaux-courants-sure-efficace-peu-couteuse/.

[50] Europäisches Patentamt (EPA). "Donald Sadoway - Finalist für den Europäischen Erfinderpreis." Verfügbar unter: https://www.epo.org/de/news-events/european-inventor-award/meet-the-finalists/donald-sadoway.

[51] Karkheck, Holger. "Tauschen statt tanken: Dieses SUV fährt mit Wasserstoff-Kapseln." Auto Bild, 30. Mai 2022, https://www.autobild.de/artikel/namx-huv-wasserstoff-suv-prototyp-21486459.html.

[52] National Center for Biotechnology Information (NCBI). "Title of the article." Verfügbar unter: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3152439/.

The theory of the rebound effect or paradox of energy efficiency: appears from the pen of the British economist William Stanley Jevons in his book On the Coal Question (1865). Once we observe the advanced techniques linked to the steam engine, it is not possible to consume charcoal, but the more efficient technologies are also constantly changing the functioning of the energy economy of the unit of production, augmented by the paradox of total energy consumption. energy consumed. In fact, the energy efficiency effect is offset by the wide diffusion of the technology. The rebound effect is the study of morals in the automobile and housing sectors.[53]

3. IMPACT ON BUSINESS OPERATIONS

3.1. Analysis of the impact of artificial intelligence, blockchain, and cloud computing on traditional business practices

Author (A): N.V.

Coauthor (CA): G.B.

BMW, as a pioneering company in the automotive industry, actively strives to address the changes brought about by digitalization and to use them as an opportunity to further solidify its position as one of the world's leading automobile manufacturers. In this era of technological advancement, innovations such as artificial intelligence (AI), blockchain, and cloud computing are gaining increasing importance, offering BMW a unique opportunity to fundamentally revolutionize its business practices.

The integration of these groundbreaking technologies into BMW's business operations promises not only an increase in efficiency but also opens up entirely new business opportunities and contributes to the improvement of the company's competitiveness. Our goal is to examine the impacts of AI, blockchain, and cloud computing on traditional business practices and to illustrate through practical case studies how BMW strategically employs these technologies to successfully meet the challenges of the digital era.

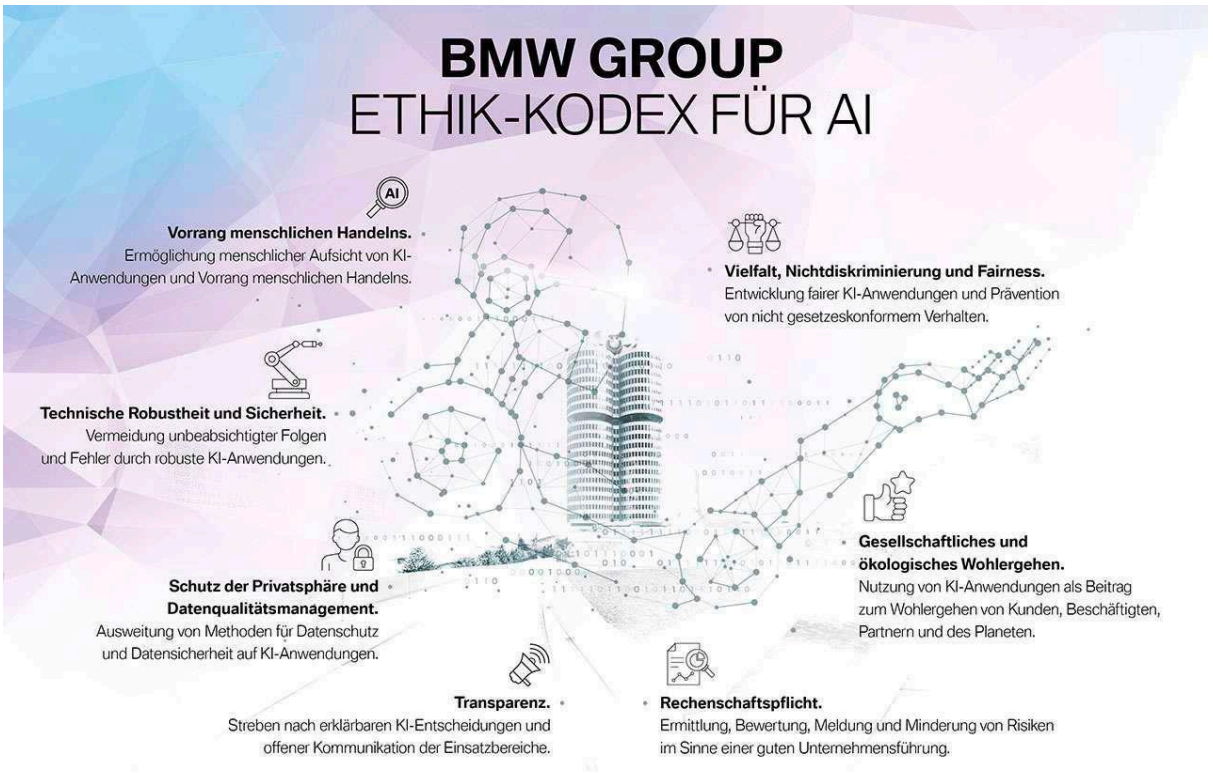
The BMW Group actively follows global developments in the area of technological advancements as well as regulatory and ethical issues. In collaboration with other companies and organizations, it participates in the development and further refinement of a framework for the responsible use of Artificial Intelligence (AI) and actively engages in the ongoing consultation process of the European Commission.

[53] OECD Forum Network. "The Jevons Paradox and Rebound Effect: Are We Implementing the Right Energy and Climate Change Policies?" Verfügbar unter: https://www.oecd-forum.org/posts/the-jevons-paradox-and-rebound-effect-are-we-implementing-the-right-energy-and-climate-change-policies.

Based on the basic requirements for trustworthy AI formulated by the EU, the BMW Group has developed seven fundamental principles for the use of AI within the company. These principles are continuously adapted to the diverse applications in all areas of the company and further developed accordingly. In this way, the company lays the foundation for an expanded use of AI and raises awareness among its employees for a responsible approach to this technology.[54]

"Correctly and responsibly applied, artificial intelligence has the enormous potential to create long-term benefits for all our stakeholders both inside and outside the company. We are therefore committed to the further development of artificial intelligence according to ethical principles, where the human being always comes first."

Carsten Sapia
Vice President Strategie, Governance & IT Security



Source: https://www.bmwgroup.com/de/innovation/innovationen-und-mobilitaet/artificial-intelligence.htm.

[54] BMW Group. (ohne Datum). Artificial Intelligence. Abgerufen von https://www.bmwgroup.com/de/innovation/innovationen-und-mobilitaet/artificial-intelligence.html.

3.1.1. Impacts of artificial intelligence on traditional business practices

In an era where the Internet of Things (IoT) and smart factories produce vast amounts of data daily, artificial intelligence (AI) opens up numerous promising applications in the manufacturing industry. Increasingly, manufacturers are leveraging AI solutions such as machine learning (ML) and deep learning neural networks to analyze data more precisely and make informed decisions.

Predictive maintenance is often regarded as a leading application of AI in manufacturing. By applying AI to production data, faults can be detected early, and maintenance schedules optimized, leading to significant savings in maintenance costs for production lines.

Furthermore, AI in manufacturing offers numerous other applications and benefits, including more accurate demand forecasting and the reduction of material waste. Artificial intelligence (AI) and manufacturing go hand in hand, as a close collaboration between humans and machines is essential in industrial manufacturing environments.[55]

According to Capgemini, the concept of artificial intelligence (AI) encompasses various learning system capabilities that are considered as intelligence, including image and video recognition, prescriptive modeling, intelligent automation, advanced simulation, and complex analytics. In terms of manufacturing processes, AI use cases revolve around technologies such as:

- **Machine Learning:** This involves using algorithms and data to automatically learn from underlying patterns without being explicitly programmed to do so.
- **Deep Learning:** This is a subset of machine learning that uses neural networks to analyze things like images and videos.
- **Autonomous Objects:** These are AI agents that perform tasks independently, such as collaborative robots or connected vehicles.

The global market for AI in manufacturing is expected to grow from 1.1 billion USD in 2020 to 16.7 billion USD by 2026, representing an astonishing annual growth rate of 57 percent. This growth is primarily attributed to the availability of big data, increasing industrial automation, improvements in computing power, and larger capital investments.[56]

[55] Simplilearn. (11.09.2023). Growing Role of AI in Manufacturing Industry. Abgerufen von https://www.simplilearn.com/growing-role-of-ai-in-manufacturing-industry-article.

[56] Simplilearn. (11.09.2023). Growing Role of AI in Manufacturing Industry. Abgerufen von https://www.simplilearn.com/growing-role-of-ai-in-manufacturing-industry-article.

The role of artificial intelligence (AI) in the industrial sector is diverse and ranges from preventive maintenance to process optimization. Below, various application areas of AI in the industry are explained in more detail:

1. **Preventing Future Issues:** AI solutions help manufacturers predict when or if functional equipment might fail, so maintenance and repair can be planned, and spare parts can be available before the actual failure occurs.
2. **Creative Generation:** In generative design, machine learning algorithms are used to mimic the design process of engineers. This allows manufacturers to quickly generate hundreds of design options for a single product.

3. **Forecasting Raw Material Prices:** AI-powered software can predict the prices of commodities more accurately than human analysts, and the accuracy improves over time.
4. **Edge Analytics:** Edge analytics utilizes data sets collected by machine sensors to deliver rapid, decentralized insights.
5. **Quality Controls:** AI systems can detect deviations from the norm by using image processing technology to identify defects in production and maintain the desired quality level.
6. **Robotics:** Industrial robots automate monotonous processes, reduce human error, and allow human workers to focus their attention on more profitable areas of the business.
7. **Process Improvement:** Companies can optimize their production processes and achieve a sustainable production level using AI-powered software.
8. **Enhancing Production Performance:** By using a digital twin, companies can track and investigate the entire production cycle to identify potential quality issues or areas where product performance can be improved.[57]

AI has significant impacts on the manufacturing industry as well, improving the manufacturing process in many ways. Some of the key applications of AI in manufacturing include:

[57] Simplilearn. (11.09.2023). Growing Role of AI in Manufacturing Industry. Abgerufen von https://www.simplilearn.com/growing-role-of-ai-in-manufacturing-industry-article.

1. **Artificial Intelligence in Logistics:** Through precise inventory management, companies can gain revenue, save money, and retain customers by appropriately storing products.
2. **AI Robots – Robotic Process Automation:** Industrial robots automate monotonous processes, reduce human error, and enable more efficient use of human resources.
3. **Artificial Intelligence in Supply Chain Management:** AI-powered software optimizes the entire supply chain from capacity forecasting to inventory management to increase efficiency and detect disruptions early.
4. **AI Autonomous Vehicles:** Self-driving vehicles automate transportation processes in factories, optimize deliveries, and improve safety on the roads.
5. **AI for Factory Automation:** Intelligent automation systems like AIOps enhance efficiency in the factory by automating data management, event analysis, and performance monitoring.
6. **Design and Production with AI:** By utilizing AI, companies can optimize production processes and generate innovative product ideas through generative design and machine learning.
7. **Internet of Things (IoT) and Artificial Intelligence:** The combination of AI and IoT enables more precise monitoring and control of production processes through real-time data collection and analysis.
8. **AI in Warehouse Management:** AI systems automate various aspects of warehouse management, including inventory control and quality inspection, to reduce costs and increase productivity.

The applications of AI in manufacturing thus range from optimizing production processes to enhancing error detection through the use of complex image processing techniques. Through these technologies, errors can be automatically classified, regardless of the diversity of industrial objects.[58]

The integration of artificial intelligence (AI) into business practices at BMW has had a profound impact on various areas of the company. It has been recognized that AI has the potential to sustainably transform the manufacturing industry, opening up numerous potential benefits including increased productivity, cost reduction, quality improvement, and minimized downtime. While large factories are undoubtedly among the primary beneficiaries of this technology, many smaller companies should also recognize how accessible and cost-efficient high-quality AI solutions have become.

[58] Simplilearn. (11.09.2023). Growing Role of AI in Manufacturing Industry. Abgerufen von https://www.simplilearn.com/growing-role-of-ai-in-manufacturing-industry-article.

Especially in the premium segment, quality is indispensable, which previously led to high expenditures for quality inspections and rework. To ensure consistently high quality, daily routines in manufacturing are applied to optimize production processes and minimize rework. The immense variety of variants and complexity induced by integration push established process improvement methods to their limits.[59]

Data Analytics and Artificial Intelligence (AI) are considered key to managing complexity in production processes, but they are also subject to critical discussion. These technologies need to be accessible and operable for individuals outside of IT, while their impacts on jobs must be analyzed. The BMW Group views it as part of their Corporate Social Responsibility (CSR) to ensure responsible handling of these technologies and to promote sustainable applications.[60]

For customers, ensuring premium quality is paramount, while employees should benefit from innovations in the daily production routine. Management needs to understand the underlying processes, and society is interested in the impact on jobs and the democratization of innovations and algorithms.

The BMW Group aims for innovation leadership in its production system as well and examines the impacts of Data Analytics and AI on quality work within its CSR framework. This involves focusing on questions of corporate responsibility, handling potential risks, global value creation, and the requirements for executives.[61] The CSR of the BMW Group encompasses the responsible use of digital technologies and the promotion of sustainable applications of Data Analytics and AI. This concerns customers, employees, management, software developers, and society as a whole. The BMW Group aims to strengthen the division of labor between humans and IT systems, focusing on innovations that are understood by and beneficial to a wide range of users.[62]

The BMW production system is now facing the challenge of managing increasing variety and complexity. The principles of lean production form the basis for continuous

[59] Jochem R (2010) Was versteht man unter Wirtschaftlichkeit von Qualität? In: Jochem R (Hrsg) Was kostet Qualität? Hanser, München, S 27–54

[60] Zimmermann K (2017) Digitalisierung der Produktion durch Industrie 4.0 und ihr Einfluss auf das Arbeiten von morgen. In: Spieß B, Fabisch N (Hrsg) CSR und neue Arbeitswelten. Perspektivwechsel in Zeiten von Nachhaltigkeit, Digitalisierung und Industrie 4.0, Bd 84. Management-Reihe Corporate Social Responsibility. Springer Gabler, Berlin, S 53–72

[61] Schindler, M., Schmihing, F. (2021). Technik dient dem Menschen – Künstliche Intelligenz im BMW-Produktionssystem. In: Altenburger, R., Schmidpeter, R. (Hrsg.) CSR und Künstliche Intelligenz. Management-Reihe Corporate Social Responsibility. Springer Gabler, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-63223-9_11

[62] Knaut A (2017) Corporate Social Responsibility verpasst die Digitalisierung. In: Hildebrandt A, Landhäußer W (Hrsg) CSR und Digitalisierung. Der digitale Wandel als Chance und Herausforderung für Wirtschaft und Gesellschaft. Management-Reihe Corporate Social Responsibility. Springer Gabler, Berlin, S 51–59

improvements, while Data Analytics and Artificial Intelligence (AI) enable further optimizations. The BMW Group emphasizes the principle that technology should serve people. The focus is on the development of AI systems that are intuitive and adaptable, to make work in daily production more pleasant and attractive.[63]

In the premium segment of the automotive industry, there is intense competition that requires cost-effective production to ensure premium quality with maximum efficiency. Lean production principles are fundamental for continuously improving efficiency in production processes.[64] It involves systematically questioning processes and shaping them in a way that minimizes or ideally eliminates any form of waste.[65] The BMW Group follows the approach of "mixed mode production" to be able to flexibly respond to the demand development of global sales markets. The increasing hybridization and electrification lead to an increased variety of variants in the powertrain, which significantly increases the complexity for BMW production systems.[66]

BMW leverages advanced AI techniques to revolutionize vehicle manufacturing and optimize production processes. By integrating technologies like Car2X and AIQX, vehicles become interactive elements in the manufacturing process. Car2X enables vehicles to exchange real-time information during manufacturing and immediately report any deviations. This includes detecting and reporting faulty components or missing parts, for example. AIQX uses cameras and sensors to automate quality assurance by checking the completeness of components or identifying irregularities in the production process.[67]

In addition to optimizing production efficiency and quality, BMW also utilizes AI for more specific tasks, such as acoustically inspecting vehicles to identify quality defects before they are delivered to customers. Intelligent AI applications are deployed in various BMW Group plants to eliminate pseudo-defects in quality control and improve logistics processes, for example, by avoiding unnecessary transportation routes.[68]

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[63] Oeltjenbruns H (2000) Organisation der Produktion nach dem Vorbild Toyotas. Analyse, Vorteile und detaillierte Voraussetzungen sowie die Vorgehensweise zur erfolgreichen Einführung am Beispiel eines globalen Automobilkonzerns. Zugl.: Clausthal, Techn. Univ., Diss., 2000. Innovationen der Fabrikplanung und -organisation, 3. Shaker, Aachen

[64] Dombrowski U, Krenkel P, Mielke T (2015) Struktur Ganzheitlicher Produktionssysteme. In: Dombrowski U, Mielke T (Hrsg) Ganzheitliche Produktionssysteme. Aktueller Stand und zukünftige Entwicklungen. Springer Vieweg (VDI-Buch), Berlin, S 26–31

[65] Brunner FJ (2017) Japanische Erfolgskonzepte. KAIZEN, KVP, Lean Production Management, Total Productive Maintenance, Shopfloor Management, Toyota Production System, GD3 – Lean Development. 4., überarbeitete Auflage. Hanser, München (Praxisreihe Qualitätswissen)

[66] Majohr D (2008) Optimierung von Vorbehandlungsanlagen in der Automobilindustrie. Universität Rostock. https://rosdok.uni-rostock.de/resolve/id/rosdok_disshab_0000000103

[67] BWM Group, Presseinformation 15. Juli 2019, “Schnell, effizient, zuverlässig: Künstliche Intelligenz in der Produktion der BMW Group”, München

[68] BWM Group, Presseinformation 15. Juli 2019, “Schnell, effizient, zuverlässig:

BMW emphasizes that all employees have access to training to understand the basics of AI technology and develop simple AI applications independently. This promotes widespread acceptance and application of AI in production. The technology is specifically used where traditional methods reach their limits, such as in the detection of door entry strips, which has significantly reduced the error rate.[69]

Furthermore, BMW promotes open innovation by making its AI software available as an open-source project, enabling the continuous development and improvement of the technologies by a global community. These approaches are part of BMW's iFACTORY strategy, which aims to make production processes leaner, greener, and more digital, showcasing how the company is driving digital transformation while simultaneously enhancing efficiency and quality in vehicle production.

3.1.2. Case studies on artificial intelligence at BMW

The application of Artificial Intelligence (AI) at BMW spans across various areas and encompasses innovative solutions.

AI in production optimization:
BMW utilizes in-house technologies such as Car2X and AIQX (see 2.1. Definition and Explanation of Key Terms) to make production more efficient. These technologies enable connected production, where vehicles communicate autonomously during their assembly, check conditions, and report errors. These AI-based approaches enhance quality control through visual and acoustic monitoring, thereby contributing to the optimization of production processes. With these innovations, BMW aims to drive forward its digital transformation and future-proof production.[70]

A central aspect is the use of smart data analytics and AI algorithms in German plants to make processes more efficient. This includes combining technologies from the press shop

Künstliche Intelligenz in der Produktion der BMW Group", München

[69] Produktion. "BMW: Why Every Worker Can Use Artificial Intelligence." Accessed [date accessed]. URL: https://www.produktion.de/technik/zukunftstechnologien/kuenstliche-intelligenz/bmw-darum-kann-jeder-werker-kuenstliche-intelligenz-nutzen-231.html.

[70] BMW Group. "AIQX: Die BMW Group gründet Zentrum für angewandte KI-Forschung in Kooperation mit der Technischen Universität München." Verfügbar unter: https://www.bmwgroup.com/de/news/allgemein/2023/aiqx.html.

to final assembly to flexibly adjust parameters, save space, and minimize process stops.[71] [72] The precise adjustment of presses in the press shop through the use of data to adapt to individual sheet metal cuts. Furthermore, BMW has prepared around 100 "use cases" for AI in production, including the "BMW Labeling Tool Lite," an AI-powered software for object recognition that allows employees to take, mark, and upload photos to optimize the quality process.[73] These applications help to ensure quality, relieve employees from monotonous tasks, and implement flexible and cost-effective solutions in production.[74]

The increasing complexity in production also presents new challenges for quality work. Existing methods of error identification and resolution are often inefficient and costly. Data analytics and AI contribute to improving error detection and resolution but must be tailored to the specific requirements and needs of production employees. On one hand, the calculation and aggregation of KPIs are performed up to the factory level over a specified period. On the other hand, production employees, together with responsible foremen and supervisors, cyclically engage in a structured routine with these metrics to identify negative effects, investigate causes, and eliminate root causes of errors.[75]

The high level of customization and integration of various propulsion systems into the same production line initially increases the complexity in the BMW production system and leads to a higher risk of errors for production employees. For quality inspection, both manual and automatic checks are employed. In manual inspections, employees are deployed to verify, in a four-eye principle, whether other employees have worked correctly.[76] Automatic camera portals with conventional image processing are also used.[77] In these portals, there is a reference photo for each feature, against which the installed object is compared pixel by pixel. Deviations lead to error entries, which are reviewed by a supervisor. If the categorization of the camera is incorrect, it is referred to as a "false

[71] AutomotiveIT. "BMW forciert Künstliche Intelligenz auch in Krisenzeiten." Verfügbar unter: https://www.automotiveit.eu/konzern-it-bmw/bmw-forciert-kuenstliche-intelligenz-auch-in-krisenzeiten-357.html.

[72] BMW Group. "Wie die BMW iFactory die Produktion transformiert." Verfügbar unter: https://www.visit-bmwgroup.com/wie-die-bmw-ifactory-die-produktion-transformiert/.

[73] Automobil Industrie. "KI-App für alle sichert Qualität in der Produktion." Verfügbar unter: https://www.automobil-industrie.vogel.de/ki-app-fuer-alle-sichert-qualitaet-in-der-produktion-a-969656/.

[74] BMW Group PressClub Deutschland. "Schnell, effizient, zuverlässig: Künstliche Intelligenz in der Produktion der BMW Group." Verfügbar unter: https://www.press.bmwgroup.com/deutschland/article/detail/T0298650DE/schnell-effizient-zuverlaessig:-kuenstliche-intelligenz-in-der-produktion-der-bmw-group?language=de.

[75] Schindler, M., Schmihing, F. (2021). Technik dient dem Menschen – Künstliche Intelligenz im BMW-Produktionssystem. In: Altenburger, R., Schmidpeter, R. (Hrsg.) CSR und Künstliche Intelligenz. Management-Reihe Corporate Social Responsibility. Springer Gabler, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-63223-9_11

[76] Regber H, Zimmermann K (2009) Change-Management in der Produktion. Prozesse effizient verbessern im Team. 1. Aufl. mi-Wirtschaftsbuch, München

[77] Demant C, Streicher-Abel B, Springhoff A (2011) Industrielle Bildverarbeitung. Wie optische Qualitätskontrolle wirklich funktioniert. 3. Aufl. Springer, Berlin

positive" or pseudo-error. All actual errors must be corrected before the vehicle leaves the factory.[78]

Camera portals are set very sensitively to avoid overlooking actual errors, which, however, leads to frequent false positives. Consistent environmental conditions are crucial for pixel-based image comparison, which is why the portals are specially designed. They are integrated into a box that shields ambient light and contain multiple cameras and lighting units. Each camera is oriented to capture a specific feature optimally. The lighting is synchronized with each camera, using red light to minimize reflections. To ensure that all photos look similar and can be compared to the reference photo, vehicles are stopped in production for the photos to be taken in the camera portal. However, this contradicts the principle of lean production flow.[79]

Due to limited space, especially at the main plant of the BMW Group in Munich, the number of camera portals in production is limited. This results in long quality control cycles with only a few portals per production line. This leads to increased rework, where components need to be disassembled to replace faulty parts. Additionally, this approach results in initially faulty assembly of parts, requiring correction later. Fluctuating environmental conditions further complicate error detection. The high rate of false positives entails considerable effort for supervisors, who must review and potentially correct all errors.[80]

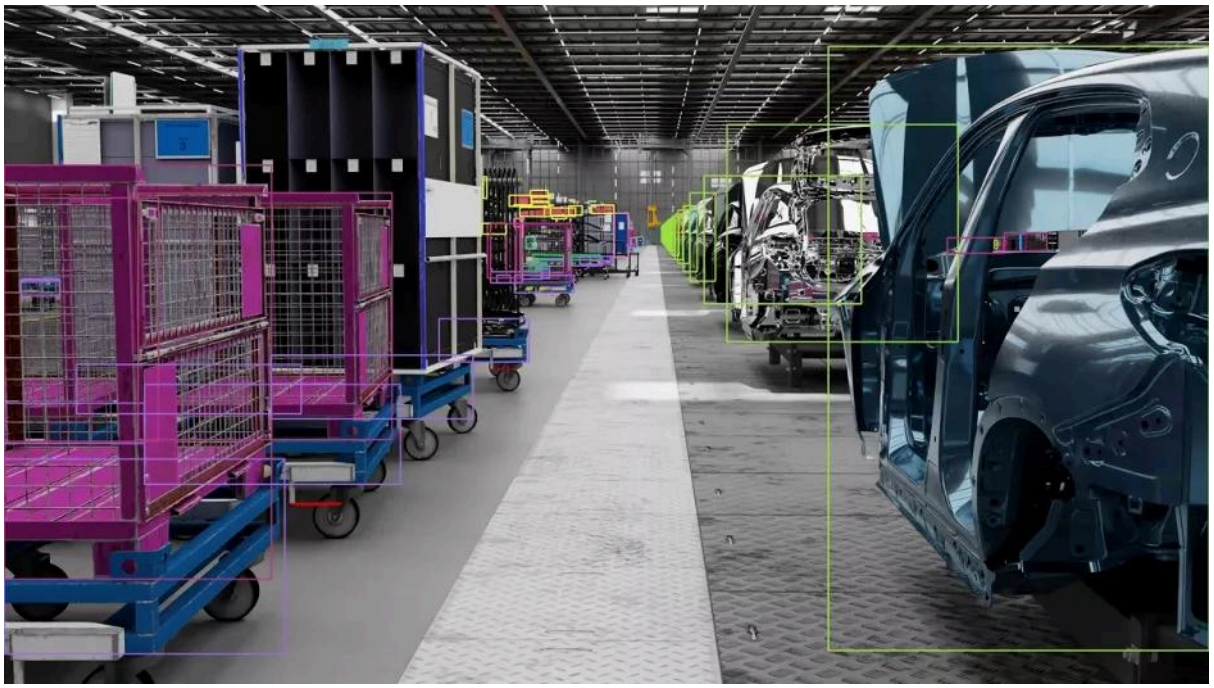
BMW, among others, has jointly with Microsoft, Nvidia, and Idealworks released the world's largest dataset for AI applications to accelerate AI training in production. The synthesized AI dataset (SORDI) comprises over 800,000 photorealistic images and production resources in 80 classes, including objects such as pallets, grid boxes, and forklifts, which are of particular importance in the core technologies of automotive manufacturing and logistics. This dataset enables fundamental tasks of image processing such as classification, object detection, and segmentation. BMW has been using artificial intelligence in various quality assurance applications in its plants since 2019. Integrating SORDI into the robotics simulation environment and the digital twin of the production system enables the creation

[78] Deuse J, Schmitt J, Stolpe M, Wiegand M, Morik K (2017) Qualitätsprognosen zur Engpassentlastung in der Injektorfertigung unter Einsatz von Data Mining. In: Gronau N (Hrsg) Industrial Internet of Things in der Arbeits- und Betriebsorganisation. GITO Verlag, Berlin (Schriftenreihe der Wissenschaftlichen Gesellschaft für Arbeits- und Betriebsorganisation (WGAB) e.V), S 47–61

[79] Schindler, M., Schmihing, F. (2021). Technik dient dem Menschen – Künstliche Intelligenz im BMW-Produktionssystem. In: Altenburger, R., Schmidpeter, R. (Hrsg.) CSR und Künstliche Intelligenz. Management-Reihe Corporate Social Responsibility. Springer Gabler, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-63223-9_11

[80] Schindler, M., Schmihing, F. (2021). Technik dient dem Menschen – Künstliche Intelligenz im BMW-Produktionssystem. In: Altenburger, R., Schmidpeter, R. (Hrsg.) CSR und Künstliche Intelligenz. Management-Reihe Corporate Social Responsibility. Springer Gabler, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-63223-9_11

of robust AI models based on synthesized HD photos without manual effort. This step aims to assist IT experts in developing tailor-made AI solutions for production.[81]



Source: https://www.automotiveit.eu/technology/bmw-veroeffentlicht-datensatz-fuer-ki-anwendungen-755.html.

By releasing the source code, software developers worldwide can view, modify, use, and further develop it. "With the algorithms we are now publishing, BMW Group has significantly reduced the development time for neural networks for autonomous transport systems and robots," says Dirk Dreher, Head of Logistics Planning. Neural networks autonomously compare live images in production and logistics with image databases to detect any deviations from the target.[82]

Artificial Intelligence and Design at BMW

The BMW design team has delved into the creative potential of transformation, blending new technologies with centuries-old techniques. They reimagined the BMW i Vision Circular[83], focusing on sustainability and inspiring aesthetics. Additionally, BMW designers have experimented with artificial intelligence (AI) to enhance design processes, achieving relatively good results in specific tasks like wheel design. AI can provide interesting approaches when given precise specifications. However, according to Adrian van

[81] AutomotiveIT. "BMW veröffentlicht Datensatz für KI-Anwendungen." Verfügbar unter: https://www.automotiveit.eu/technology/bmw-veroeffentlicht-datensatz-fuer-ki-anwendungen-755.html.

[82] K-Zeitung. "BMW forciert Künstliche Intelligenz in der Produktion." Verfügbar unter: https://www.k-zeitung.de/bmw-forciert-kuenstliche-intelligenz-in-der-produktion.

[83] BMW Deutschland. "BMW i Vision Circular Überblick." Verfügbar unter: https://www.bmw.de/de/topics/faszination-bmw/bmw-concept-cars/bmw-i-vision-circular-ueberblick.html.

Hooydonk, human creativity and responsibility remain irreplaceable, as AI generates numerous suggestions that require further development by human designers. AI proves to be a valuable assistant, yet its application in creating entirely new vehicle designs is challenging due to its reliance on existing knowledge.[84]

Source: https://www.bimmertoday.de/2023/06/02/ki-design-bmw-experimentiert-mit-kunstlicher-intelligenz-aber/

Artificial Intelligence and Marketing at BMW

Die BMW Group setzt künstliche Intelligenz im Marketing ein, um innovative Ansätze zu verfolgen und die Automobilindustrie zu transformieren. Dies beinhaltet die Nutzung von KI-Technologien, um das Marketing zu optimieren und anzupassen. Expertenrunden mit Vertretern der BMW Group und dem Karlsruher Institut für Technologie (KIT) diskutieren, wie KI-Technologien das Marketing und die Automobilbranche verändern. Diese Veranstaltungen bieten Einblicke in die Anwendung von KI im Marketingbereich, um die Effizienz zu steigern und neue Möglichkeiten für die Kundenansprache zu schaffen.[85]

[84] Bimmertoday. "KI-Design: BMW experimentiert mit künstlicher Intelligenz." Verfügbar unter: https://www.bimmertoday.de/2023/06/02/ki-design-bmw-experimentiert-mit-kunstlicher-intelligenz-aber/.

[85] Marketing Club Karlsruhe. "KI im Marketing." Verfügbar unter: https://marketingclub-karlsruhe.de/events/ki-im-marketing-bmw-kit/.

BMW has ventured into digital art by transforming the BMW 8 Series into a digital artwork using AI technology, showcasing the integration of art and technology in the automotive industry.

Source: https://www.bmw.com/de/innovation/kreative-ai-bmw-8er-gran-coupe-kunstwerk-mit-kuenstlicher-intelligenz.html

How does one create artwork from over 50,000 motifs and innovative ideas? Key to the process was the careful selection by art expert Gary Yeh. He explains that while individual artworks can be impressive, he finds the greatest value in art when drawing connections between different artworks and, more broadly, different aspects of culture. Curating helps connect the dots to reveal the bigger picture.[86]

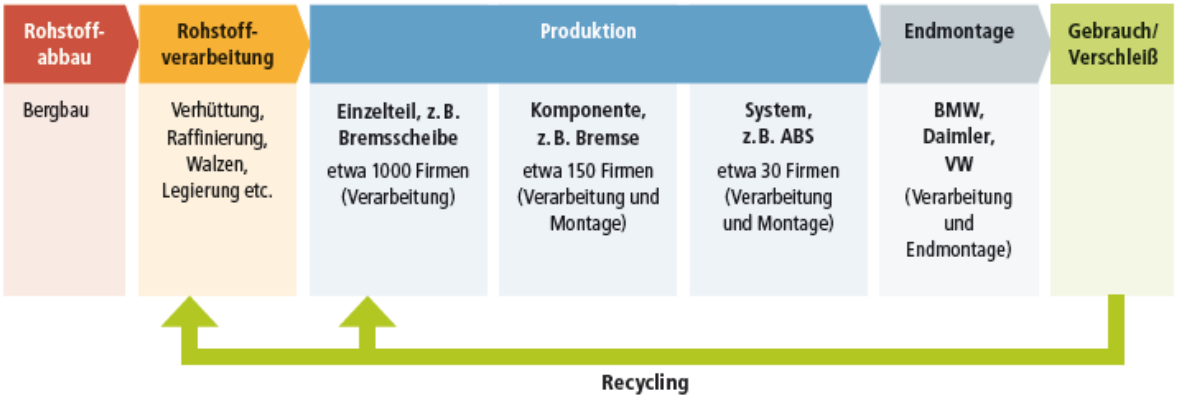
Nathan Shipley explains that AI assembles the bigger picture from existing datasets in a way similar to how our brain operates. “The project utilized artificial neural networks, modeled on the human brain's structure, which processes information through a network

[86] BMW Deutschland. "Kreative AI: BMW 8er Gran Coupé - Kunstwerk mit künstlicher Intelligenz." Verfügbar unter: https://www.bmw.com/de/innovation/kreative-ai-bmw-8er-gran-coupe-kunstwerk-mit-kuenstlicher-intelligenz.html.

of neurons. This algorithm generates outcomes for each input, refining its accuracy with every training session. Through processing, categorizing, and classifying the input data into patterns, AI creates a comprehensive and nuanced model that integrates all information and characteristics of art knowledge and datasets."[87]

3.2.1. Analyzing the impact of blockchain on traditional business practices

Vereinfachte Darstellung des Materialflusses in der Automobilindustrie:



Source: Report (09.2012). Vom Erz zum Auto. Abbaubedingungen und Lieferketten im Rohstoffsektor und die Verantwortung der deutschen Automobilindustrie. ISBN: 978-3-943126-07-5

Automobile companies share a responsibility for human rights violations in the extraction and processing of raw materials such as bauxite, aluminum, iron, and copper. This responsibility includes verifying the origin of the raw materials and complying with supplier standards. German car manufacturers like BMW, Daimler, and Volkswagen, along with their suppliers, play a crucial role in the global production and supply chain. The auto industry has increasingly specialized in assembling parts and systems, with actual production handled by numerous suppliers. The supply industry's structure is complex, involving companies of various sizes and specializations. Despite consolidation in the auto industry, many small suppliers play a vital role in the cost-effective manufacturing of parts.[88]

The number of individual parts in a modern car is astonishing, ranging between 10,000 and 40,000. These parts are predominantly not produced by automobile companies themselves, resulting in each of the major car manufacturers having thousands of suppliers. BMW estimates that around 12,000 direct suppliers worldwide are involved in

[87] BMW Deutschland. "Kreative AI: BMW 8er Gran Coupé - Kunstwerk mit künstlicher Intelligenz." Verfügbar unter: https://www.bmw.com/de/innovation/kreative-ai-bmw-8er-gran-coupe-kunstwerk-mit-kuenstlicher-intelligenz.html.

[88] Report (09.2012). Vom Erz zum Auto. Abbaubedingungen und Lieferketten im Rohstoffsektor und die Verantwortung der deutschen Automobilindustrie. ISBN: 978-3-943126-07-5

the production of their entire range of models. These suppliers, in turn, may have numerous sub-suppliers, making the automotive supply chain incredibly complex.[89]

The number of parts in a modern car is staggering, ranging from 10,000 to 40,000. Notably, automotive companies don't manufacture these parts themselves, leading each major automaker to rely on thousands of suppliers. BMW, for example, has around 12,000 direct suppliers globally, contributing to the complexity of the automotive supply chain.

Blockchain represents the evolution of Web 2.0, introducing data decentralization, which simplifies use and enhances transparency. Almost all car brands have started working with this technology. In the automotive industry, blockchain provides supplier transparency, facilitates charging at any station, manages personal data, simplifies car rentals, and supports smart contracts and insurance.

3.2.2. Case studies on blockchain at BMW

Author (A): G.B.
Coauthor (CA): N.V.

"The blockchain provides us with the technical foundation to create helpful and effective solutions."

Dr. Andre Luckow
Head of Distributed Ledger and Emerging Technologies bei der BMW Group

Using blockchain for a digital vehicle passport.
To secure the vehicle history for resale, the blockchain technology, in conjunction with the VerifyCar app, provides a solution. Users can trace and verify the entire history of a vehicle, including mileage and maintenance records. During a sales discussion, a simple scan of a QR code through the app enables quick verification of the vehicle data, with a green checkmark confirming the verification, as explained by Dr. Luckow.[90]

According to Dr. Luckow, blockchain technology offers significantly higher security against manipulations compared to traditional methods of recording vehicle data. A physical stamp in the maintenance book could easily be replicated with a color printer. However, blockchain records are currently secure against manipulations. The VerifyCar app utilizes this technology to reliably record events such as accidents or the number of previous

[89] Report (09.2012). Vom Erz zum Auto. Abbaubedingungen und Lieferketten im Rohstoffsektor und die Verantwortung der deutschen Automobilindustrie. ISBN: 978-3-943126-07-5

[90] BMW Deutschland. "Blockchain in der Automobilindustrie." Verfügbar unter: https://www.bmw.com/de/innovation/blockchain-automobilindustrie.html.

owners. Furthermore, blockchain simplifies the exchange of data between individuals and enables vehicle owners to submit their verified mileage to insurance companies to claim any potential discounts. Previously, this was only possible through access to isolated databases, but the decentralized nature of blockchain allows secure access without compromising security.[91]

Secure Raw Material Sources

Blockchain can be used as a means for a company to demonstrate transparency to its customers. Potential customers are increasingly concerned about the origins of their purchases, such as the source of their chocolate, its journey to them, and increasingly, who was involved in its harvest or extraction. Blockchain offers a suitable solution for this, allowing everyone to be informed about the product's origin due to its transparency.[92]

German car manufacturers like BMW, Daimler, and Volkswagen, and their suppliers, play a significant role in the global production and supply chain. The complexity of the automotive supply chain is highlighted by the vast number of parts in a modern car, ranging from 10,000 to 12,000, most of which are not manufactured by the automakers themselves, involving thousands of suppliers. BMW estimates about 12,000 direct suppliers worldwide are involved in producing their full range of models, each of which may also have numerous suppliers, making the car's value chain extremely complex.[93]

One prominent example of supply chain issues is the Cobalt scandal in Congo (end of 2018, beginning of 2019)[94] as in Marocco (11.2023)[95], which underlines the need for transparency in the sourcing of materials. Implementing blockchain could address these issues if all parties are willing to be fully transparent, which is not straightforward to achieve.

The concept of "Supply Chain Verification" focuses on tracking and documenting supply chains, which is essential not only for parts but also for raw materials. Raw materials like cobalt or tungsten, often sourced from hard-to-monitor locations, can be manipulated

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[91] BMW Deutschland. "Blockchain in der Automobilindustrie." Verfügbar unter: https://www.bmw.com/de/innovation/blockchain-automobilindustrie.html.

[92] Usine Digitale. "BMW veut généraliser la blockchain pour améliorer la traçabilité tout au long de sa supply chain." Disponible sur : https://www.usine-digitale.fr/article/bmw-veut-generaliser-la-blockchain-pour-ameliorer-la-tracabilite-tout-au-long-de-sa-supply-chain.N948286.

[93] Investopedia. "Who Are BMW's Main Suppliers?" Available at: https://www.investopedia.com/ask/answers/060115/who-are-bmws-main-suppliers.asp.

[94] Spiegel Online. "Kobalt aus dem Kongo: Hier sterben Menschen für unsere E-Autos." Verfügbar unter: https://www.spiegel.de/wissenschaft/mensch/kobalt-aus-dem-kongo-hier-sterben-menschen-fuer-unsere-e-autos-a-1291533.html.

[95] Tagesschau. "Kobalt aus Marokko: BMW-Zulieferer unter Druck." Verfügbar unter: https://www.tagesschau.de/investigativ/ndr-wdr/umweltstandards-bmw-zulieferer-kobalt-marokko-100.html.

through long and complex supply paths. Therefore, the BMW Group relies on blockchain projects to make the origin of minerals transparent. In addition to traditional methods like barcodes or seals, innovative techniques such as chemical tracers are used to uniquely identify materials and ensure their authenticity.[96]

Linking the physical and digital world by documenting every step in the supply chain on a blockchain offers multiple benefits: it enables tamper-proof and transparent proof of the origin of raw materials, simplifies certification processes, and speeds up customs procedures. For end customers, this means, among other things, protection against counterfeit spare parts and the assurance that the raw materials used for their car were ethically sourced.[97]

In the automotive industry, blockchain enables supplier transparency, the ability to charge vehicles at any station, the storage of personal data such as seat adjustments and vehicle configurations, simplification of car rentals, and the use of smart contracts and insurance.

The ability to charge the car at all "stations"

We see a variety of charging stations for cars with different contracts and various power suppliers as well as different energy sources (nuclear, coal, green, etc.), which poses a challenge for users as it comes with varying prices. This multitude of charging stations presents a problem for drivers. Therefore, users are forced to plan their trips carefully.

One of the reasons why car buyers opt for electric vehicles is their environmentally friendly aspect. Hence, it is crucial that they can choose their desired energy source.

The pilot project "Charge Chain" promoted by the BMW Group aims to make charging electric vehicles as easy as possible for the user. As soon as the customer initiates the charging process by connecting the charging cable to the charging station and their vehicle, blockchain technology takes over all further steps. These include selecting the service provider, authentication, which previously required a customer card, and choosing the most cost-effective tariff at the respective charging station. All these processes are regulated automatically and in the background by the blockchain.[98]

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[96] BMW Deutschland. "Blockchain in der Automobilindustrie." Verfügbar unter: https://www.bmw.com/de/innovation/blockchain-automobilindustrie.html.

[97] BMW Deutschland. "Blockchain in der Automobilindustrie." Verfügbar unter: https://www.bmw.com/de/innovation/blockchain-automobilindustrie.html.

[98] BMW Deutschland. "Blockchain in der Automobilindustrie." Verfügbar unter: https://www.bmw.com/de/innovation/blockchain-automobilindustrie.html.

This project impressively demonstrates one of the main strengths of blockchain technology: the verification and secure execution of transactions without the need for an intermediary financial institution. Thus, energy suppliers and operators of charging stations can carry out financial transactions directly and securely among themselves, supported by the efficiency and security of blockchain technology.[99]

Recording personal data (seat adjustment, vehicle configuration, etc.)

As mentioned earlier, blockchain also allows for the recording of driver information/preferences. This data is stored in a blockchain (thus securely stored) and is downloaded to the car by activating it with a fingerprint on the steering wheel. These options can be activated for both private cars and rental vehicles.[100]

Private Cars:

Typically, a car is used by 2 drivers (or more), often by the husband and wife. Driver preferences are then activated, such as seat position, mirrors, music, temperatures, destinations, etc.

Rental Cars:

Rental vehicles are used by many users who cannot be provided with a key. These drivers then have access to their customer account where all their data is securely stored. Like with private cars, the driver can also access all their preferences.

The simplification of car rentals

When booking a rental car, blockchain significantly simplifies the contract process. It is much easier to access a vehicle, check maintenance work, and obtain cheaper rental prices by being directly connected to providers (for example: BTU Protocol).[101]

Smart Contracts and Insurance

Based on the provided sources, the combination of Smart Contracts (SC) with insurance, particularly auto insurance, offers significant advantages:

- ➢ Simplification of procedures
- ➢ Acceleration of verification and contract execution processes, including reimbursements

[99] BMW Deutschland. "Blockchain in der Automobilindustrie." Verfügbar unter: https://www.bmw.com/de/innovation/blockchain-automobilindustrie.html.

[100] IBM Institute for Business Value. "Blockchain in Mobility: A New Road Ahead." Verfügbar unter: https://www.ibm.com/thought-leadership/institute-business-value/en-us/report/blockchainmobility

[101] Capital. "À Paris, on peut louer une voiture via la blockchain et ça coûte beaucoup moins cher." Disponible sur : https://www.capital.fr/crypto/a-paris-on-peut-louer-une-voiture-via-la-blockchain-et-ca-coute-beaucoup-moins-cher-1312394.

- ➢ Reduction of insurance costs
- ➢ Lowering contract expenses

The integration of Smart Contracts with auto insurance can streamline operations, expedite processes, and lead to cost efficiencies in the insurance sector. This integration leverages interconnected products to facilitate faster data transmission to insurers, reducing reliance on experts for tasks like accident assessments.[102]

"We cannot yet foresee the possibilities that blockchain will offer us in the future."

Dr. Andre Luckow

Head of Distributed Ledger and Emerging Technologies bei der BMW Group

Author (A): N.V.

Coauthor (CA): G.B.

In conclusion, it can be stated that blockchain technology in the automotive industry has already enabled significant advancements and continues to hold immense potential for future applications. The transparent and secure nature of blockchain promises a revolution in how data is managed in the industry, from supply chains to customer interactions. With the ongoing development of blockchain platforms and the increasing acceptance of this technology, the future of the automotive industry will benefit from innovative applications that enhance efficiency, strengthen trust, and enable new business models. It is evident that blockchain will have a lasting impact on the automotive sector, serving as a driving force for positive change and progress in the years to come.

3.3.1. Analyzing the impact of cloud computing on traditional business practices

Cloud computing has proven to be a transformative force in the business world by fundamentally changing how companies access, use, and manage IT resources. It offers a range of benefits, including cost savings, increased flexibility, and improved collaboration, but also introduces new challenges.

The adoption of cloud computing enables significant cost reductions for businesses. Traditionally, companies had to invest in expensive hardware and infrastructure to meet their IT needs. With cloud services, they can now pay on a pay-as-you-go basis, eliminating the need for large upfront investments and allowing small businesses access to

[102] Assuralib. "La blockchain : à quoi pourrait-elle servir dans l'assurance ?" Disponible sur : https://assuralib.com/actualites/la-blockchain-a-quoi-pourrait-elle-servir-dans-l-assurance.

technologies that were previously unaffordable. This shift leads to a significant reduction in barriers to market entry and promotes a more dynamic and competitive market.[103]
In addition to cost savings, cloud computing offers unprecedented agility and flexibility. Companies can quickly adjust their capacities to respond to fluctuations in demand, enabling faster market introduction of products and services. This advantage is particularly important in a rapidly changing business environment, where the ability to quickly respond to market changes can be crucial for success.[104]

The cloud also promotes innovation by simplifying companies' access to advanced technologies such as artificial intelligence, machine learning, and big data analytics. These tools can be used to develop new business models, enhance customer service, and increase operational efficiency.[105]

However, moving data and applications to the cloud also poses challenges, particularly in terms of security and compliance. Storing sensitive information on external servers raises concerns about data privacy and security. Companies must ensure that their cloud service providers implement robust security measures and that compliance with relevant data protection laws is maintained.[106]

Another critical issue is the dependence on cloud providers. Outages or data losses at these services can have significant impacts on business operations. Moreover, migrating existing systems and data to the cloud is a complex and potentially costly task.[107]

Despite these challenges, the potential of cloud computing to transform traditional business practices remains immense. Companies that effectively utilize cloud services can not only reduce their operating costs but also expand their market presence, foster innovation, and enhance collaboration. Therefore, the decision to adopt cloud computing is not just about technological upgrading but a strategic move that can secure competitiveness in the digital economy.

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[103] SUSO Academy. "Nachhaltiges Cloud-Computing: Wie Softwareunternehmen durch Cloud-Lösungen effizienter und umweltfreundlicher werden können." Verfügbar unter: Suso Academy. (2023, 6. März). Nachhaltiges Cloud Computing: Wie Softwareunternehmen durch Cloud-Lösungen effizienter und umweltfreundlicher werden können. Abgerufen am von https://www.suso.academy/2023/03/06/nachhaltiges-cloud-computing-wie-softwareunternehmen-durch-cloud-losungen-effizienter-und-umweltfreundlicher-werden-konnen/.

[104] BITKOM. "Leitfaden Cloud Computing." Verfügbar unter: https://www.bitkom.org/sites/default/files/file/import/090921-BITKOM-Leitfaden-CloudComputing-Web.pdf.

[105] BITKOM. "Leitfaden Cloud Computing." Verfügbar unter: https://www.bitkom.org/sites/default/files/file/import/090921-BITKOM-Leitfaden-CloudComputing-Web.pdf.

[106] Checkpoint. "Was ist Cloud-Sicherheit?" Verfügbar unter: https://www.checkpoint.com/de/cyber-hub/cloud-security/what-is-cloud-security/.

[107] Checkpoint. "Was ist Cloud-Sicherheit?" Verfügbar unter: https://www.checkpoint.com/de/cyber-hub/cloud-security/what-is-cloud-security/.

3.3.2. Case studies on cloud computing at BMW

BMW extensively utilizes cloud computing in cooperation with Amazon Web Services (AWS) to advance its automotive technologies. Cloud computing enables the processing of large amounts of data without the costs and effort associated with owning and managing servers. This is particularly important given the enormous data generated during the car manufacturing process by AI, blockchain, and sensors. This data can be efficiently stored and processed in the cloud by providers such as Amazon, Microsoft, Alibaba, or Google. The partnership with AWS covers several key areas:

1. Development of Automated Driving Systems: BMW uses AWS for its platform to develop automated driving systems. This involves managing large data volumes generated by advanced driver-assistance systems (ADAS). These systems are fundamental in developing features such as adaptive cruise control, parking assistance, and automated lane changing. The cloud infrastructure supports the development, testing, and deployment of these systems and contributes to accelerating innovation and enhancing the safety and reliability of BMW vehicles.[108]

2. Integration of AI and IoT: In collaboration with AWS, BMW is expanding its capabilities in the Internet of Things (IoT) and Artificial Intelligence (AI). This includes the use of cloud-based computing and storage resources to manage data from BMW's connected vehicles and to deploy complex AI algorithms that enhance vehicle functionality and the driving experience.[109]

3. Data Management and Analytics: BMW has established a Cloud Data Hub on AWS, where large volumes of data from vehicle sensors and other sources are processed and analyzed. This hub enables BMW to optimize its operations in production, sales, and vehicle performance, thereby enhancing overall efficiency and customer satisfaction.[110] [111]

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[108] BMW Group. "The BMW Group selects AWS to power next generation automated driving platform." Verfügbar unter: https://www.press.bmwgroup.com/global/article/detail/T0436780EN/the-bmw-group-selects-aws-to-power-next-generation-automated-driving-platform

[109] RCR Wireless News. "BMW and AWS sign cloud deal to drive IoT and AI smarts in new-gen autos." Verfügbar unter: https://www.rcrwireless.com/20230906/internet-of-things-4/bmw-and-aws-sign-cloud-deal-to-drive-iot-and-ai-smarts-in-new-gen-autos

[110] BMW Group Press Release. "AWS and BMW Group team up to accelerate data-driven innovation." Verfügbar unter: https://www.press.bmwgroup.com/global/article/detail/T0322118EN/aws-and-bmw-group-team-up-to-accelerate-data-driven-innovation

[111] Amazon Web Services. "BMW Group Case Study." Verfügbar unter: https://aws.amazon.com/de/solutions/case-studies/bmw-group-case-study/

4. Schulung und Kompetenzentwicklung: BMW investiert auch in die Schulung seiner Mitarbeiter im Bereich Cloud-Technologien. Bis zu 5.000 Software-Ingenieure weltweit werden geschult, wovon etwa 2.000 eine AWS-Zertifizierung erlangen sollen. Diese Schulungen konzentrieren sich auf Bereiche wie maschinelles Lernen und Datenanalytik, um sicherzustellen, dass die Teams von BMW effektiv Cloud-Technologien nutzen können.[112]

5. Training and Skill Development: BMW is also investing in training its employees in cloud technologies. Up to 5,000 software engineers worldwide are being trained, with about 2,000 expected to achieve AWS certification. These trainings focus on areas such as machine learning and data analytics to ensure that BMW teams can effectively utilize cloud technologies.[113]

Cloud computing is crucial for BMW as it enables the company to develop innovative and data-driven solutions in the automotive sector. The use of cloud technologies allows BMW to efficiently process and analyze extensive data volumes, which is essential for the development of advanced driver-assistance systems and other technologies. These technologies significantly enhance the safety and efficiency of the vehicles.[114] [115]

The cloud also provides BMW with the necessary agility and flexibility to quickly respond to market demands and efficiently develop and implement new features. This accelerates innovation cycles and shortens the time to market for new technologies. Moreover, the scalable and flexible nature of the cloud allows for optimization of IT costs by reducing expensive hardware investments and adjusting capacities as needed.[116]

By analyzing data stored and processed in the cloud, BMW can make data-driven decisions that enhance production planning and the strategic alignment of the company. This

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[112] BMW Group. "AWS and BMW Group team up to accelerate data-driven innovation." Verfügbar unter: https://www.press.bmwgroup.com/global/article/detail/T0322118EN/aws-and-bmw-group-team-up-to-accelerate-data-driven-innovation

[113] BMW Group. "BMW Group collaborates with AWS to bring new cloud technologies for fast and reliable availability of digital innovations." Verfügbar unter: https://www.press.bmwgroup.com/global/article/detail/T0404359EN/bmw-group-collaborates-with-aws-to-bring-new-cloud-technologies-for-fast-and-reliable-availability-of-digital-innovations

[114] BMW Group. "AWS and BMW Group team up to accelerate data-driven innovation." Verfügbar unter: https://www.press.bmwgroup.com/global/article/detail/T0322118EN/aws-and-bmw-group-team-up-to-accelerate-data-driven-innovation

[115] Amazon Web Services. "BMW Group Case Study." Verfügbar unter: https://aws.amazon.com/de/solutions/case-studies/bmw-group-case-study/

[116] RCR Wireless News. "BMW and AWS sign cloud deal to drive IoT and AI smarts in new-gen autos." Verfügbar unter: https://www.rcrwireless.com/20230906/internet-of-things-4/bmw-and-aws-sign-cloud-deal-to-drive-iot-and-ai-smarts-in-new-gen-autos

enables more accurate forecasts about vehicle performance and customer preferences, which in turn boosts customer satisfaction.[117] [118]

Cloud technologies also facilitate global collaboration within BMW. Software updates and new features can be seamlessly deployed through the cloud, enhancing efficiency and ensuring consistent technology worldwide.[119] Overall, cloud computing enables BMW to remain at the forefront of the automotive industry by fostering innovation, increasing efficiency, and providing a solid foundation for the future development of vehicle technologies.

4. ADVANTAGES AND CHALLENGES

In considering the adoption and integration of new technologies such as Artificial Intelligence, Blockchain, and Cloud Computing into BMW's business processes, numerous advantages as well as significant challenges arise that the company must manage strategically.

4.1.Advantages

One of the greatest advantages of this technology integration is the significant increase in efficiency. By using Artificial Intelligence, BMW can reduce maintenance costs and minimize downtime. This leads not only to a reduction in costs but also to an improvement in service quality. Furthermore, precise data analysis enabled by AI tools allows for more effective control of production processes and a reduction in waste.

Additionally, the use of Artificial Intelligence improves product quality. AI-supported systems assist in quality control by detecting errors more quickly and increasing accuracy in the manufacturing process. This contributes to BMW's ability to continue offering products of the highest quality, which is a central part of the brand identity.

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[117] BMW Group. "AWS and BMW Group team up to accelerate data-driven innovation." Verfügbar unter: https://www.press.bmwgroup.com/global/article/detail/T0322118EN/aws-and-bmw-group-team-up-to-accelerate-data-driven-innovation

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[119] BMW Group. "AWS and BMW Group team up to accelerate data-driven innovation." Verfügbar unter: https://www.press.bmwgroup.com/global/article/detail/T0322118EN/aws-and-bmw-group-team-up-to-accelerate-data-driven-innovation

Another important advantage is the increased transparency in the supply chain made possible by Blockchain technology. This technology ensures that all components and materials are verified and traceable, contributing to the adherence to ethical standards and strengthening consumer trust.

Cloud computing also offers significant benefits in terms of scalability and flexibility. BMW can quickly adjust IT resources based on current needs, which is particularly advantageous in a volatile market environment. This flexibility supports the company in responding quickly to changes and bringing innovations to market swiftly.

4.2.Challenges

However, these advantages are also met with significant challenges. The introduction of these advanced technologies requires considerable initial investments. These investments are not only financial but also include time and resources for training employees and integrating the systems into existing infrastructures.

Data privacy and security are further critical challenges. With increasing connectivity and the collection of large amounts of data, stringent security measures must be implemented to protect sensitive information and ensure compliance with global data protection standards.

The complexity of technology integration also poses a challenge. The successful introduction and use of new technologies require careful planning and often extensive changes in operational processes. This can lead to initial operational disruptions and requires ongoing adjustment and optimization.

Dependence on external technology providers, especially in the area of cloud computing, carries risks. Disruptions or performance fluctuations of these services can have direct negative impacts on operations, underscoring the need for careful selection and management of service providers.

Finally, digital transformation also requires cultural and organizational adjustments. The introduction of technologies like AI and blockchain changes work processes and often necessitates a rethinking and new competencies among employees.

While the strategic implementation of new technologies is essential for strengthening BMW's position as an industry leader, similar dynamics can also be observed in other sectors. In industries like healthcare and retail, the impacts and requirements of

technology integration differ, yet the potential and challenges are considerable. A differentiated view of these technology implementations highlights the specific impacts and requirements in each sector.

In healthcare, AI-powered systems like IBM Watson Health enable faster and often more accurate analysis of medical data, which is particularly helpful in diagnosing complex diseases like cancer. Technologies such as telemedicine and mobile health apps also improve the accessibility and efficiency of medical care by allowing patients to be cared for regardless of location. However, these technological advances are accompanied by challenges such as stringent data protection regulations and resistance to change from medical personnel. Therefore, the implementation of new systems must be carefully planned to both protect patients' privacy and promote acceptance among users.

Retail also benefits greatly from technology integration. Large retailers like Amazon use AI and data analytics to create personalized shopping experiences and improve customer service through automation. Blockchain technology promotes a more transparent supply chain, which is particularly advantageous in times of global supply shortages. Yet, here too, challenges arise such as the technological integration into existing systems and the associated high costs, especially for smaller retailers.

5. CLOSING REMARKS

5.1. SUMMARY OF KEY FINDINGS

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In our study, we thoroughly examined the impact of new technologies on business operations at BMW, with a special focus on artificial intelligence, blockchain, and cloud computing. Our analysis has shown that these technologies have significant effects on the efficiency, productivity, and strategic alignment of the company.

The Automotive Industry at a Crossroads

Our work initially focused on various engine technologies, with an emphasis on batteries and their economic, technical, and safety efficiency. We quickly realized that the automotive market is already saturated and that governments are heavily promoting exports to support their economies. The coming months and years will show which automotive companies will successfully navigate these challenges and which will fail.

The Importance of Technological Advances and Services in the IT Sector

While technological advancements are essential, progress in computers and services also represents a significant milestone. With the emergence of an increasingly efficient and faster global internet network (Web3), new technologies have emerged that offer more interesting tools for use.

Artificial Intelligence (AI), Blockchain, and Cloud Computing were at the heart of our work, and we could see how important their interest is for companies. These technologies help to streamline processes, improve security, transparency, and efficiency, while simultaneously providing a better user experience.

By leveraging these technological advancements, automotive companies will be better equipped to meet future challenges and stand out in a highly competitive market.

Artificial Intelligence has proven particularly valuable by enabling BMW to optimize manufacturing processes, make more precise demand forecasts, and predict maintenance, leading to significant cost savings. Additionally, AI contributes to quality improvement by enabling advanced quality controls and error detection, which enhances BMW's reputation for outstanding quality.

The application of Blockchain technology offers increased transparency and security in the supply chain, which is particularly important in the automotive industry. Through Blockchain, BMW can verify the origin of materials and ensure that all components meet company standards and ethical guidelines. This not only strengthens consumer trust in the brand but also helps to meet regulatory requirements more effectively.

Cloud Computing has proven to be a key technology for scaling the IT resources needed to process large amounts of data and quickly deliver innovative services and products worldwide. The cloud enables flexible and efficient data processing, which is crucial to respond to the rapid changes in the global automotive market.

5.2. CRITICAL DISCUSSION OF THE FINDINGS

The Digital Transformation at BMW

In summary, the integration of technologies such as Artificial Intelligence, Blockchain, and Cloud Computing not only enables BMW to increase operational efficiency and reduce costs but also to better respond to changing customer needs and expectations. For the automotive industry in general and for BMW in particular, it is crucial to continue investing

in these technologies and to advance digital transformation in order to ensure competitiveness in an increasingly connected and technology-driven world.

Complex Factors in the Automotive Industry

Our study has shown how many factors play a crucial role in the automotive industry. Political issues and partnerships, economic aspects, societal trends, environmental concerns, competitive landscape, customer expectations, financial considerations, and brand image are all critical. We have observed a strong trend towards digitization in the industry and in customer service.

Proactive Adaptation to Technological Innovations

This study clearly demonstrates that proactive adaptation to technological innovations and their integration into existing business models are not only necessary to maintain market position but also significantly contribute to sustainable value creation. BMW exemplifies the transformation of traditional industries through the use of modern technologies, shaping and defining the landscape of the global economy.

Outlook for the Future

To remain competitive in an increasingly interconnected and technology-driven world, it is essential for companies like BMW to continuously invest in new technologies and drive their integration into existing business models. Only by doing so can they efficiently respond to changing customer needs and expectations and strengthen their market position.

Digital transformation is an ongoing process that requires proactive adaptation to technological innovations. Companies that recognize and implement this change early on will be able to generate sustainable value and thrive in an increasingly digital economic landscape.

5.3. OUTLOOK ON FUTURE DEVELOPMENTS RELATED TO TECHNOLOGICAL PROGRESS IN BUSINESS OPERATIONS

New Technologies: a Promising Future with Energy Challenges

In our research, we have found that IT technologies and services such as artificial intelligence (AI), blockchain, and cloud computing are the technologies of the future. Although we are still in the early stages of their adoption beyond cryptocurrencies, these

technologies offer tremendous potential for companies looking to enhance their transparency and better protect the private data of their users.

Artificial Intelligence (AI)

Consumer AI emerged about a year ago and caused a stir on the internet. The applications are diverse, and we can imagine them being used in all usable areas. Despite the significant advantage of these aids available to us, we must not forget that this technology is extremely energy-intensive. Although many efforts are being made to reduce energy consumption, it is likely that the electricity demand will not decrease.

Blockchain

Blockchain is a technology that has proven its reliability in cryptocurrencies. It appears to be the solution to Web 2.0 problems, such as unencrypted data. This technology seems very promising to us, but like AI, it incurs very high environmental costs as it is also very energy-intensive.

Cloud Computing Combined with Blockchain

Cloud Computing combined with Blockchain seemed to us to be the ideal solution for the storage and computing power required for the operation of the system. However, this technology also requires significant electrical resources.

The Energy Challenge

These techniques certainly have a promising future, but a major issue still needs to be addressed: the high energy consumption. Will we be able to find a solution to reduce the energy demand of these new technologies? This is a crucial challenge that needs to be addressed to enable their sustainable development and widespread adoption.

In summary, while AI, Blockchain, and Cloud Computing offer exciting prospects for businesses and users, their environmental impact in terms of energy consumption must be considered, and solutions to reduce their energy footprint need to be found.