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Success Factors of Platform Business Models in Times of Artificial Intelligence

Daniel Maier, MSc

M.Sc., Technical University Ingolstadt, Esplanade 10, 85049 Ingolstadt, Germany

Prof. Günter Hofbauer

Professor, Technical University Ingolstadt, Esplanade 10, 85049 Ingolstadt, Germany

Abstract

The purpose of this article is to investigate if the success factors examined in previous studies regarding platform business models have been changed by new digital technologies at the example of artificial intelligence (AI). The question of research is to what extent and in which fields AI affects each success factor. The methodology contains a comprehensive literature review, whose findings are verified by means of a qualitative expert survey. In a first step, the existing literature is examined regarding success factors of platform business models and possible impacts of AI concerning the single factors. In a second step of the analysis, the findings are verified by interviewing experts with substantial AI background. As a result, it can be determined that AI has an impact on every single success factor. The core findings are a predicted reduction in transaction costs, a positive effect on multi-sided network effects and the contribution to evolving into a platform ecosystem. Key points in this context were process acceleration through AI-supported or entirely AI-adopted processes, as well as faster processing and effective usage of large amounts of data. These findings were also confirmed for the most parts by the qualitative expert interviews.

Keywords: platform business model; artificial intelligence (AI); digitalization; information technologies; digital technologies

1. Introduction

Due to the commercialization and continuous development of the Internet, business models have undergone massive changes in recent decades. As a result of increasing digitization, completely new digital models were formed or traditional ones fundamentally changed at the turn of the millennium (Timmers 1998). Massive growth rates were predicted for these new forms of digital, entrepreneurial value creation under the collective term e-

commerce. Particularly noteworthy are platform business models in the form of marketplaces and collaboration platforms (Timmers 1998).

Specifically, a platform is a place of value creation that connects various parties of interest with one another, primarily enabling them to exchange information and secondarily the consecutive exchange of goods and services (Srinivasan 2021). This form of value creation is therefore in stark contrast to classic value creation processes and has led to a rethinking of the success factors of business models.

This can be observed succinctly above all if one looks at the development of the highest-valued companies in recent years. For example, at the end of 2020, five platforms - Apple, Amazon, Microsoft, Facebook and Alphabet - were responsible for more than 20% of the market capitalization of the entire S&P 500 companies. Similarly, among the ten companies with the highest value globally, there were seven platforms, representing a 70% share (Kenney, Bearson & Zysman 2021).

Figure 1 shows this trend comparing 2018 and 2008. It is thus apparent that the most successful companies in recent years have been platforms, whereas 10 years earlier these places were still held by companies with traditional value creation processes (Kenney, Bearson & Zysman 2021).

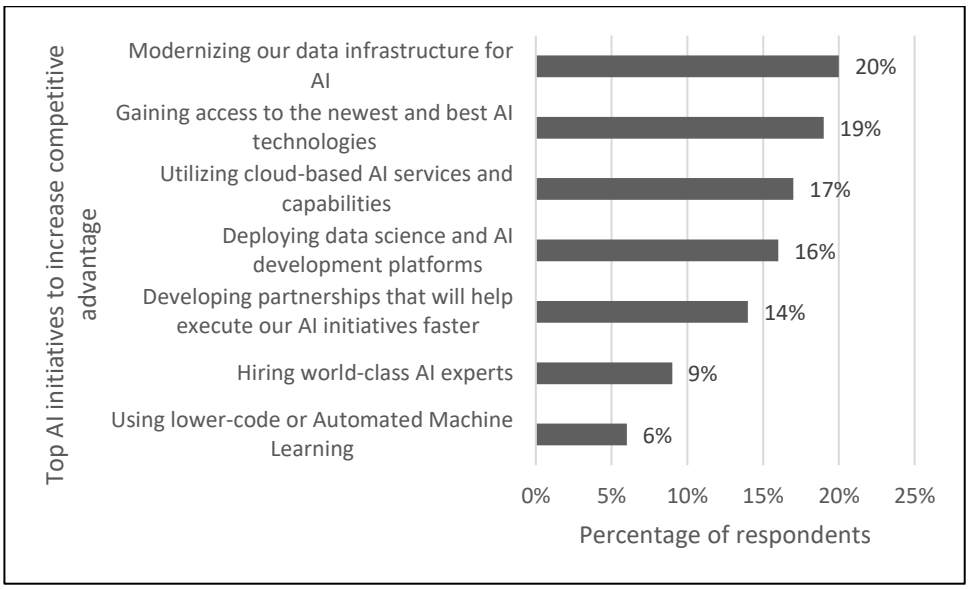
Figure 1: Highest valued companies 2018 vs. 2008

2018				2008			
Rank	Company	Founded	USBn	Rank	Company	Founded	USBn
1	Apple	1976	890	1	PetroChina	1999	728
2	Google	1998	768	2	Exxon	1870	492
3	Microsoft	1975	680	3	General Electric	1892	358
4	Amazon	1994	592	4	China Mobile	1997	344
5	Facebook	2004	545	5	ICBC	1989	336
6	Tencent	1998	526	6	Gazprom	1989	332
7	Berkshire Hathaway	1955	496	7	Microsoft	1975	313
8	Alibaba	1999	488	8	AT&T	1885	238
9	Johnson & Johnson	1886	380	9	Royal Dutch Shell	1907	226
10	J.P.Morgan	1871	375	10	Procter & Gamble	1837	213

Source: Pergenz.de (no date)

Alongside this rise of platforms, another development can be observed: the increased emergence of artificial intelligence (AI). AI refers to complex algorithms which, on the basis of machine learning processes, carry out activities which previously could only be performed by humans (Chalmers, Mackenzie & Carter 2020). This circumstance has the potential to have a massive impact on corporate processes and value creation in general, as previous technologies have already done in the context of e-commerce (Chalmers, Mackenzie & Carter 2020). A transformation of companies is therefore to be expected, due to process and productivity optimizations, increased creativity and innovative capacity and an acceleration of decision-making (Mayer, Strich & Fiedler 2020). Companies are thus required to continuously adapt their processes and resources to the conditions created by new technologies, such as AI, and to respond to changing opportunities and possibilities (Akter et al. 2020). In practice, this is already being done by means of multiple approaches, such as modernizing their own information technology landscape, procuring AI technologies, using knowledge platforms and recruiting qualified personnel with an AI background (Ammanath, Hupfer & Jarvis 2020). Figure 2 summarizes these possible measures. It shows a survey of n=2,737 IT managers across diverse industrial sectors conducted by the international consulting company Deloitte.

Figure 2: Top AI initiatives to increase competitive advantage



Source: Ammanath, Hupfer & Jarvis 2020

2. Problem formulation and question of research

In general, it can be stated that the platform economy has experienced massive growth in recent years, which can be measured by various key figures (Maier & Hofbauer 2019). A practical example of this is the accommodation brokerage platform Airbnb, which has been able to achieve significant increases in terms of bookings, listings and ultimately also revenue. Figure 3 illustrates this development by showing individual key figures and an index measured in terms of bookings based on year 2016.

Figure 3: Airbnb key figures over time

Year	Revenue (in billions)	Listings (in millions)	Bookings (in millions)	Index (based on bookings)
2016	1,7	2,1	52	1,00
2017	2,6	4,0	115	2,21
2018	3,6	6,0	140	2,69
2019	4,7	7,0	272	5,23
2020	3,4	5,6	193	3,71
2021	5,9	6,0	300	5,77

Source: Business of Apps 2022

Due to this increase in importance, a tremendous number of research studies have already examined the factors that determine the success of platforms. For example, the success factors have already been analyzed when focusing the view to the sharing economy, which are, however, also applicable to platforms outside of peer-to-peer sharing (Maier & Hofbauer 2019). Furthermore, the architecture and culture of platforms were investigated and the digital value creation process was elicited (Rohn et al. 2021). Also, the individual success-determining mechanisms of platforms were put in direct comparison to traditional companies, leading to the discovery of multi-sided network effects, monetization mechanisms and disruptive approaches

(Parker, Alstyne & Choudary 2016). However, it should be noted that relatively young forms of value creation are subject to numerous, potential changes, which is due to the ongoing emergence of new technologies (Kraus et al. 2018). It can therefore be assumed that success factors defined in previous studies are no longer up to date and may have already changed through the development of new technologies. AI is just such a possible, technological innovation.

At present, there are already a few scientific contributions on AI in the economic sciences. Thematically, for example, it has already been dealt with unintended effects of AI on decision-making processes in companies and how these can be avoided if necessary (Frenzel et al. 2020). Furthermore, adaptation and willingness to buy when in contact with AI instead of a human has been investigated. The results here are quite ambivalent. For example, the use of intelligent chatbots has a negative impact on the success of sales calls (Luo 2019). In contrast, AI-generated content is received more positively than human-generated content under certain circumstances (Rix et al. 2022). In summary, current AI research is heavily concerned with the issues of acceptance and socioeconomic consequences. However, there are also a few case studies describing concrete applications at the process level (Mayer, Strich & Fiedler 2020). Though, these existing studies do not make a specific reference to today's platform economy or individual platforms at company level. This poses a research gap regarding possible changes in the success factors of platform business models through the use of AI. The question of research is thus whether the success factors may change because of AI and what consequences this has for the platform as a whole. Therefore, the underlying working hypothesis can be formulated: AI changes the success factors of platform business models.

3. Methodology

In order to answer the research question stated in the previous chapter, a two-part research will be conducted. First, the available information systems (IS) literature is examined with regard to the determinant factors for the success of platforms. The focus is on fundamental mechanisms and observations at the process level. In addition, the literature is examined for AI, specifically, what influence AI could have on the already known success factors. In a second step, the insights gained are verified by means of an expert interview. For this purpose, a telephone survey of four managers of big, internationally operating consulting agencies with strong points of contact with platforms and AI in their everyday professional life is conducted by means of a theory-generating expert interview (Döringer 2021). In this process, the interviewees were first asked an open-ended question about the impact of AI on platforms to elicit insights not found in the literature. Subsequently, they were confronted with insights already explored from theory in order to achieve a possible double-approval from theory and practice in each individual case. The results are included in chapter 5, individual findings confirmed from practice are specifically marked.

4. Success factors of platform business models

4.1 Reducing transaction costs

One success factor that is usually mentioned first in relation to platform business models is based on the value creation of platforms themselves. The platform's main task is to mediate a specific demand with a corresponding offer (Zhao et al. 2020). This is vehemently in contrast to a classic business model, often referred to as "pipeline" in the literature, which, unlike a platform, creates proprietary goods and services by deploying resources, handling a production process and leveraging customer-supplier relationships (Parker, Alstyne & Choudary 2016). Thus, value creation at platforms is not purposeful in one direction but occurs bilaterally. Whereas in a classic pipeline business model the company still has full control over the value creation process by transforming resources through internal activities into a value proposition, platforms only focus on the transactions that enable the exchange of these goods and services, created outside the platforms (Rohn et al. 2021). A massive advantage is therefore a much lower capital commitment due to the restriction to the intermediary role, while the creation of the physical and non-physical offer and associated risk lies at upstream or downstream stages (Zhao et al. 2020). Thus, they form a two-sided ecosystem within themselves, but are highly dependent on the parties operating on the environment (Kim 2016). The focus is therefore solely on connecting information exchange and how efficiently this exchange is designed. Key factor here are the transaction costs. Based on the transaction cost theory of Coase (1973), these reflect information asymmetries on the market, which make an economic exchange more difficult. This is largely due to a limited human perception and increasing modularization and diversity on the market (Henten & Windekilde 2016).

For this reason, the success factor of a platform is to reduce these information asymmetries by providing offers as precisely and quickly as possible and to enable the actual transaction (Maier & Hofbauer 2019). Compared to pipeline business models, platforms have the particular advantage that they can facilitate transactions more quickly. Key point here are the lowest possible search costs, which improves the customer experience and minimizes the effort for the buyer (Rohn 2021). In the competition between platforms, this success factor thus represents both a hurdle and an opportunity to differentiate oneself from competitors and to offer the customer added value. In this context, the task of the platform is to keep transaction costs as low as possible by bringing together supply and demand at a maximum of precision and quickly through real-time data processing. Whether the transaction content is ultimately a physical good or a service is irrelevant for the actual transaction. What is important on the part of the provider, however, is how his offer is presented in the form of descriptions and images (Täuscher & Laudien 2018).

The significance of this success factor becomes particularly apparent when one considers the rapid success of sharing economy platforms whose focus is primarily on reducing transaction costs. For example, the aforementioned example Airbnb was founded in 2008 and within the last few years has been able to achieve a reach and market capitalization that traditional pipeline companies could only gain over several decades under massive capital investment (Henten & Windekilde 2016).

4.2 Leveraging network-effects

A second success factor of platforms becomes apparent when considering the diffusion of new technologies and innovations. For example, the utility of the telephone increased

exponentially as the number of users grew, while this in turn led to a parallel growth of corresponding telephone providers (Rohn 2021). In the area of platforms, this phenomenon behaves similarly as a higher number of users increases the benefit of the platform for the individual one. In this context, one can speak about direct and indirect network effects.

Direct network effects relate directly to the value creation of the platform. Their core proposition is that the value and quality of the offer depends on the number of platform participants (Fehrer, Woratschek & Brodie 2018). This can be exemplified by the Airbnb example mentioned above. Thus, a higher number of providers leads to the achievement of a comprehensive and diverse offer, which covers the different needs of numerous demanders. At the same time, this enlarges the target group by increasing the attractiveness of the platform (Maier & Hofbauer 2019).

Indirect network effects, on the other hand, refer to the fact that market centralization of certain offers can result as a side effect of the increase in benefits of the platform due to the increasing numbers of participants. Thus, the value of the platform is increased by the fact that certain goods and services can only be purchased there. Exclusivity of some apps on app stores of certain smartphone manufacturers can be cited here as an example (Fehrer, Woratschek & Brodie 2018).

Network effects mostly lead to successful platforms attracting more and more users, which should inevitably lead to a monopoly. In fact, however, it is the case that different platforms with similar value propositions can also coexist if their offering differs in certain aspects. This can be achieved through targeted specialization and by actively limiting choice (Halaburda, Piskorski & Yldırım 2018).

The core task of the platform operator in terms of network effects is to maintain a certain proportionality between supply and demand, as disproportionality leads to a loss of value for at least one of the parties involved. In practice, this is achieved by analyzing the data and responding accordingly via incentives or demanding participation fees (Maier & Hofbauer 2019). For example, dating platforms often use the method of offering discounted or even free memberships to female users, while charging membership fees to male ones. In this way, platforms use their own monetization mechanism to regulate their user base (Parker, Alstyne & Choudary 2016).

Even though network effects represent a success factor and competitive advantage for platforms, they also give rise to two significant problems.

The first problem aims at the fact that network effects and especially the network mechanism are difficult to predict. This is because an analysis of individual design parameters can explain the growth of a platform or platform ecosystem, but not the complex interplay between the individual elements, which are interconnected through a significant number of transactions and touch points, making the actions within the platform environment a puzzle with countless pieces (Zhao et al. 2020).

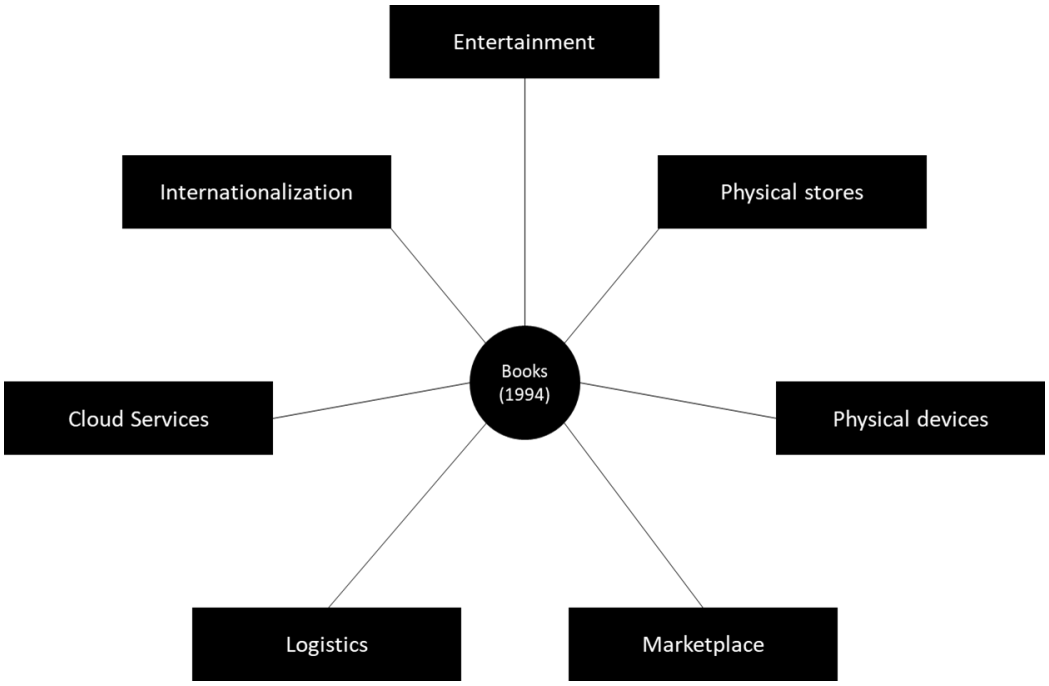
Second, network effects are not caused by individual parameters alone, but significantly by the platform architecture and the decision making of the platform operator (Zhao et al. 2020). The architecture in this context specifically implies the design of the information exchange, goods and/or services exchange and the financial exchange (Parker, Alstyne & Choudary 2016). Decision making, on the other hand, may include apparently trivial things, such as the introduction of a rating system. Especially the effects of taken measures are extremely difficult to track due to high interdependencies and thus unknown results (Zhao et al. 2020).

One solution of these two problems could be the use of novel analysis technologies that allow traceability within a simultaneously high complexity.

4.3 Evolving into an ecosystem

The last success factor mentioned in this paper is a direct consequence of the previous two. One can see that the growth of platforms is largely due to transaction costs and network effects. However, this approach limits itself to the original core consideration of the platform in terms of its value proposition and ignores potential evolutionary opportunities. In recent years, due to numerous observable real-world phenomena, new views on the evolutionary direction of platforms have emerged: viewing them as platform ecosystems (Kenney, Bearson & Zysman 2021). The core of this consideration is that platforms are achieving an ever greater penetration through their tendency to market centralization, which allows them to establish collaborations and further offerings outside their original core business by opening up their platforms (Fehrer, Woratschek & Brodie 2018). The aim here is to find further segments in addition to the already penetrated market segment in which the platform can use its already existing infrastructure and database. Especially synergy effects can be exploited in this way (Kenney, Bearson & Zysman 2021). Amazon can be listed as an example in this context. Since its foundation in 1994, this platform company has developed into a platform ecosystem that combines numerous different business approaches. Examples include the streaming service Prime Video and the opening of its own physical retail stores (Kenney, Bearson & Zysman 2021). Figure 4 illustrates the individual business areas of Amazon.

Figure 4: Platform ecosystem Amazon



Source: Kenney, Bearson & Zysman 2021

To achieve such an expansion into an ecosystem, a platform must elicit precisely different approaches which may lead to new business opportunities. It also has to assess the possible prospect of success by analyzing the internal circumstances and market situation and to predict the readiness of the community for the new offering. The latter is of particular

relevance, as the value proposition may also differ from the previous one in an intersectoral way and thus be completely novel for existing users (Fehrer, Woratschek & Brodie 2018). A concise example at this point is Google, which has evolved from the Internet search environment to become a leading developer in autonomous driving (Kenney, Bearson & Zysman 2021). A holistic approach is crucial here, by breaking down the current business model into its individual building blocks and considering a potential application of the single components in other business areas (Fehrer, Woratschek & Brodie 2018). The hurdles here are once again the complexity of the individual interrelationships as well as an enormous amount of data.

5. Possible changes through AI

Now that the factors currently regarded as determining success have been presented, question arises if and how AI can influence them.

First of all, it can already be stated that AI leads to higher performance and capacity, particularly at the process level, since activities previously performed by humans can now be automated (Mucha & Seppala 2020). In doing so, AI controlled processes independently access available data, use analysis methods and are guided by observations from the past (Reim, Åström & Eriksson 2020). These activities are enabled by an increasing power of computer hardware and the perpetually easier availability of data (Brynjolfsson, Rock & Syverson 2017).

The banking industry is playing a pioneering role here. Banks are increasingly using artificial intelligence to determine the creditworthiness of potential customers on the basis of historical data. The positive effects of this are above all a higher competitiveness due to faster data processing (Mayer, Strich & Fiedler 2020). In terms of platforms, this acceleration of data processing has a positive effect on transaction costs, which are minimized as a result. Faster data processing thus leads to lower transaction costs in terms of time, which further increases the added value of the platform. It should be noted at this point that this process automation through AI cannot be transferred holistically to the entire platform. There will still be processes that can only be executed by humans, while others will be taken over by AI. The characteristic term for this is human-AI hybrids (Rai, Constantinides & Sarker 2019). Platforms have three options with respect to the single task level: substitution of the task through AI, task augmentation via AI or task assemblage by combining human labor and AI, where human and an artificial unit are working together (Rai, Constantinides & Sarker 2019). The prerequisite for the adoption of processes by AI is that there are already totally digitized processes (Reim, Åström & Eriksson 2020). This shouldn’t pose a hurdle in the particular case of digital platforms. AI-supported speech recognition systems in conjunction with intelligent response finding can be cited as an already established example in this context. Such systems are already widely used in practice, as exemplified by the IBM Watson system. This system can answer 60-70% more customer questions than a classic call center through targeted pre-selection and more precise answer finding (Brynjolfsson, Rock & Syverson 2017). Such service hotlines can be found especially on marketplace platforms such as Amazon or Alibaba and can be an approach for faster processing and reduction of transaction costs for customer inquiries.

Faster data processing was also cited by the expert group as a core benefit of AI. For example, AI leads to an acceleration of the data flow and favors the management of tremendous volumes of data accumulating today. In today's platform world, this is necessary, because automated processing poses a basic requirement for the handling of daily incoming data at high volume platforms. According to the experts, manual processing of each individual transaction

would not be possible purely due to time reasons. The influence of AI on the success factor transaction costs can thus be confirmed both from theory and from practice. Due to these results, the influence on the transaction costs can be double-proved.

To a further extent, AI also has an indirect effect on network effects. This is since, as described in chapter 4.2, it is essential for the platform operator to identify the building blocks that lead to positive, multilateral network effects by analyzing its own platform infrastructure. However, because of the platform's complex programming, these building blocks are interconnected in a wide variety of ways in the code. A clear view on every single block is therefore extremely difficult. The characteristic term for this is platform opacity (Mackenzie 2019). AI now has the potential to reduce this opacity and make the platform more transparent. At the same time, AI-supported programming based on machine learning processes enables simplified handling of the platform in the future as well as predictability when changing individual platform elements. AI cannot change the fact that a platform remains a complex puzzle with countless pieces. However, this digital technology can help find the currently needed pieces faster and conditionally predict where the next ones will be to find (Mackenzie 2019). Proper decision making is also relevant to maintaining proportionality on the platform. This requires constant data analysis, which is complicated by an increasing velocity of data and ever-increasing interdependencies between single data sets (O'Leary 2013). AI can counteract this by allowing the system to make decisions in parallel with the data stream, as well as re-evaluate those already made. This is similar to a rolling horizon planning system that already exists as a standard in supply chain management. AI also transforms incoming unstructured data into structured data (O'Leary 2013). While this does not slow down the velocity of the data, it does allow a more focused analysis, which has a direct positive impact on decision making in terms of proportionality and predictability of future decisions. These factors in turn condition the management of network effects, allowing AI to indirectly influence network effects. This influence, which has been elaborated from the IS literature, could not be confirmed by the expert group. According to them, the network effects are a self-conditioning scaling mechanism, which in its basic form apparently has nothing to do with AI. AI does have an accelerating effect in the sense of faster data processing and automation, but the experts were unable to identify a connection to the number of participants due to AI. For this reason, the influence of AI on the success factor network effects cannot be double-proved by practice.

Another point is that AI technologies, in addition to improving processes, also offer the potential to expand business opportunities. By taking a look at some practical references over the recent years, a shift has taken place in which AI is not only seen as a tool to increase efficiency, but can also open up additional fields of business operation (Mucha & Seppala 2020). For example, Google used AI at an early stage to detect fraudulent links in advertisements, while later image recognition was added as an extension of Google Maps (Mucha & Seppala 2020). This enlarged the operation area of the application as it could be easily adopted by digital tourism guides and governmental institutions for providing information about tourist attractions and sights. For this reason, it can be stated that AI is quite capable of helping a platform to evolve into a platform ecosystem while simultaneously expanding the actual business. This can also affect the AI applications themselves if they are offered by the platforms as standardized applications, for example on their own app store. (Mucha & Seppala 2020). This finding was also confirmed by the experts interviewed, who referred in particular to Amazon's AI platform AWS, which has been developing and offering precisely such services for a long time. Furthermore, AI can be used not only as a tool for further development of the platform, but also directly as a promoter of business model innovation (BMI). In this context, AI acts primarily in the BMI building block value creation, which

significantly determines the platform's field of activity (Reim, Åström & Eriksson 2020). AI can contribute to the continuous improvement and development of the business model by finding new opportunities for innovations based on big data analysis. As a concise example, Amazon's business model transformations shown in figure 4 can be cited, which differ significantly from Amazon's original core business of selling print media (Kenney, Bearson & Zysman 2021).

Prerequisite for this is that capacities are created accordingly in the form of AI-versed employees and the creation of organizational adaptability (Reim, Åström & Eriksson 2020). A core advantage of AI is also that, in addition to internal conditions, it also takes the platform's environment into focus. For example, AI not only looks at internal data when eliciting new business opportunities, but can also process market data and integrate it when searching for innovations, which means that the result is thus related to the platform environment (Wamba-Taguimdje et al. 2020). One hurdle here is the data itself. While data from internal data processing can already be structured and categorized by AI as part of process automation, market data represents unstructured data, which makes analysis more difficult. The characteristic term for structured, analyzable data in this context is rich data (Wamba-Taguimdje et al. 2020).

In addition to mentioning Amazon's AI platform AWS, the experts also confirmed that AI can lead to authoritative and transformative innovations. AI has the potential to transform entire industries, just like other technologies before it. The Internet was cited as a prime example, which has driven entire industries to ruin, while at the same time offering endless opportunities for other companies. The experts believe that this will be also true for AI, offering countless opportunities to innovate and expand their own businesses. The influence of AI on evolving into a platform ecosystem can thus also be confirmed by practice and can therefore been double-proven. Figure 5 summarizes the results for each success factor separately.

Figure 5: Summary of key results

	Transaction costs	**Network effects**	**Evolving into ecosystem**
Key contribution of AI	Faster data processing	Decision making support	Effective data usage
Double-proved	Yes	No	Yes

Source: Own illustration

From a subordinate perspective, AI also impacts the platform as a whole. For example, due to their immense data volumes, platforms require computing centers that are characterized by massive power consumption depending on the size of the platform. AI has already proven that it can be able to achieve efficiency gains through the use of artificial neural networks. For example, a team at Google DeepMind managed to develop an AI that could reduce a data center's energy consumption by 40% based on temperature data, power flow and pump speed (Brynjolfsson, Rock & Syverson 2017). The application areas of AI for platforms are thus not only at the process level, but in many cases also in higher-level matters, such as maintenance and servicing. From the experts' point of view, there is also still potential through AI in error prevention in processes as well as in the recruiting process, for example in the pre-selection of candidates. This shows that the impact of AI is not limited to individual processes or areas, but affects the business model in many ways.

6. Conclusion

In summary, the most relevant factors for platform business models are a maximum reduction in transaction costs, maximization of network effects and the development of a platform ecosystem. This is largely due to the reduction of information asymmetries via data processing, decision-making under complex conditions and the discovery of new business opportunities. Through this research, it can be proven that every success factor is influenced by AI. For example, AI holds the potential of faster data processing, which has a positive impact on process speed and process efficiency. This minimizes transaction costs, which adds value to the user and thus directly conditions the success of the platform. From a network effects perspective, AI supports decision making and enables continuous analysis of data, which is essential due to the complexity of platforms. While AI cannot reduce the velocity of data in this regard, it can have a positive impact on predictability, which has a positive impact on managing the proportionality of the platform. Lastly, AI offers the possibility of new business opportunities. For example, in the context of BMI, AI contributes to the search for new innovations by analyzing internal data and market data. A key hurdle here is data quality. Two of the three success factors have been confirmed by experts, while the effect on network effects cannot be considered double-proven. Subordinate advantages for platforms can be seen in an improvement in maintenance and in error prevention. In summary, AI influences every single success factor of platform business models.

It is important to note that this research only drew on the underlying literature and a qualitative survey with a limited number of participants. For next research, conducting a survey with a representative number of respondents would be advisable. Also, this study considers platform business models holistically as an umbrella term, while specific platform models still need to be analyzed individually. These could be peer-to-peer models, marketplaces or B-to-B platforms, for example. Added value of this approach would be a investigation of the various specifics and peculiarities of the individual platform subtypes. If data regarding AI and metrics of platforms are available, a quantitative research would also be conceivable to verify the success of platform models taken as given in this study.

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