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IMPACT OF AUGMENTED REALITY TECHNOLOGY ON FIRMS' COMPETITIVENESS

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Purpose: This study investigates how augmented reality (AR) technology contributes to firm-level competitiveness and through which mechanisms these effects arise.
Design/methodology/approach: We employ a qualitative multiple-case study of four leading Polish AR software developers with international client portfolios. Semi-structured interviews with managers provide insights into how client firms apply AR and what outcomes they achieve.
Findings: Results show that AR enhances competitiveness primarily in marketing and retail by improving product visualization, enabling customization, intensifying customer engagement, and creating a strong "wow effect" that elevates brand image. In some cases, AR supports new business models, as illustrated by customizable furniture or interactive cultural projects. While effects on cost reduction were less visible, AR's impact on sales, consumer experience, and innovation signaling was consistently reported.
Originality/value: The study extends AR research beyond consumer acceptance by examining competitiveness outcomes at the firm level. It highlights the supplier-side vantage point, which captures cross-industry adoption patterns and identifies both opportunities and constraints in AR deployment. The findings suggest that AR can become a source of sustainable advantage when paired with complementary resources such as product data, analytics, and organizational readiness.
Keywords: augmented reality, technology management, innovation management.
Category of the paper: Research paper.

1. Introduction

Augmented reality (AR) allows for the visual alignment of virtual content with real-world contexts (Scholz et al., 2016). Applications of AR technology are vast, the major fields are industry, e.g., aviation (Crescenzio et al., 2011), military, education, medicine and healthcare, travel and tourism (Jung et al., 2018), retail and marketing (Martinez et al., 2014).

Technology is an important driver of competitive advantage (Prahalad, Hamel, 1994; Eisenhardt, Sull, 2001; Mauborgne, Chan Kim, 2007; Christensen, Bower, 1995). While AR is gradually gaining public attention, technology advisory agencies (e.g., Gartner, Accenture) and researchers already publish on how to take advantage of this emerging technology (e.g., Berman, Pollack, 2021; Javornik et al., 2021, Rauschnabel et al., 2022). This confirms that AR may be mature enough to be a factor affecting enterprises' competitiveness.

We would like to focus on AR's potential of raising competitiveness of enterprises and answer the question if AR can increase the competitiveness of an enterprise which employs it. We define competitiveness as a firm's ability to achieve superior performance relative to its rivals. It is reflected in short-term commercial outcomes such as higher sales, stronger conversion rates, and reduced product returns. It also appears in process outcomes such as faster cycle times, lower error rates, and reduced service costs. Finally, it includes long-term strategic outcomes such as stronger brand equity, improved customer loyalty, enhanced dynamic capabilities, and the development of new business models.

The multiple-case study method was chosen, as a more generalizable method allowing deeper understanding of studied phenomenon. As a result, managers in four companies creating AR software applications were interviewed. However, in this paper we concentrate on their clients - companies which use this technology directly in their business undertakings.

We investigate what are the benefits of AR to them and how they use it. While previous studies have mostly examined AR from the consumer perspective—focusing on user experience or acceptance—there is little evidence on how AR contributes to firm-level competitiveness. Our study addresses this gap by analysing AR's impact from the supplier–client viewpoint, linking observable advantages to commercial, process, and strategic outcomes. This perspective is original in two ways: it focuses on business applications rather than consumer perceptions, and it integrates insights from technology management and strategic management theories to explain how AR becomes a source of competitive advantage.

2. Literature review

2.1. Augmented Reality's characteristics

AR gained recognition in recent years, however, its origins date back to 1950s and 1960s. The term was coined in 1990 and in the following years this technology gained application mainly in aircraft. The general idea behind it is to augment the view of a real environment (e.g., video feed from a camera or the view behind the glasses) with virtual input such as video and graphics in real time. AR users may interactively gain information about the real world surrounding. Technically this technology consists of software and hardware – a camera,

computing unit and surface to display the image (e.g., a screen) (Martinez et al., 2014). Each of these elements is becoming more and more technologically advanced. Moreover, AR cooperates well with other emerging technologies such as Virtual Reality, 3D, beacons, Internet of Things, image, and gesture recognition. Therefore, we believe it is the technology of the future, but it already may be beneficial to companies in the context of their competitiveness.

Javornik (2016) assembled the most representative media characteristics of interactive technologies: interactivity, hypertextuality, modality, connectivity, location-specificity, mobility, and virtuality. All these features are crucial for positive user evaluation and all of them are existent to some extent in AR technology.

2.2. AR in various sectors of business

According to Porter and Heppelmann (2017) AR creates business value in two ways. Firstly, by becoming part of products themselves and creating better user interfaces and ergonomics. Secondly, by improving performance across the value chain - in product development, manufacturing, marketing, service, and many other areas. Berman and Pollack (2021) enumerate five benefits for companies implementing AR: increasing profits through higher sales; increasing profits through lower expenses; generating excitement for a brand, for retailers, or for a product; facilitating the consumer purchase process through increased product information; implementing and upgrading a firm's omnichannel strategy.

There is a variety of possible AR applications, ranging from industry and military, training and education, medicine and healthcare, travel and tourism (e.g., instantly translating text by pointing the smartphone's camera at the foreign text), retail and marketing (Martinez et al., 2014). AR can be a solution to "a wide range of problems (…), e.g., planning, design, ergonomics assessment, operation guidance and training" (Wang et al., 2016). Newer work confirms this direction: Marino et al. (2024) show that AR improves efficiency and reduces errors in industrial assembly tasks, while Treinen et al. (2024) document AR's effectiveness in quality inspection, assembly, and remote support. In healthcare, Lawson et al. (2023) demonstrate through a randomized controlled trial that AR/MR guidance lowers error rates during emergency medical care, highlighting the broader competitiveness benefits of immersive overlays for high-stakes tasks. Jetter et al. (2018) in their review noted that AR is gathering attention in various industrial areas, e.g., manufacturing in the aerospace industry (Frigo et al., 2016) and in shipbuilding (Fraga-Lamas et al., 2018), engineering analysis and simulation (Li et al., 2017) or architecture and construction (Chi et al., 2013). AR is "predicted to play a decisive role in the digital transformation of manufacturing" (Jetter et al., 2018). AR may also play an essential role in improving consumer experience in the restaurant sector (Batat, 2021).

The majority of AR business literature concentrates on consumers and factors influencing AR's acceptance, users' expectations, or experiences (e.g., Olsson et al., 2011; Martinez et al., 2014; Wojciechowski, Cellary 2016; Rese et al., 2017; Grzegorczyk et al., 2019; Kumar, 2021; Rauschnabel, 2021; Smink et al., 2020; Flavian et al., 2019; tom Dieck, Han, 2021).

The most important drivers of the AR adoption are reduction of costs, fast learning curve, curiosity, tangible 3D visualization and fun (Martinez et al., 2014). On the other hand, the most common bottlenecks are no common standard and little flexibility, limited computational power, inaccuracy of technology, social acceptance factor and excessive amount of information. Martinez et al. (2014) applied Roger's theory of diffusion of innovations to AR. According to them AR fulfills three out of five characteristics of Roger's technology acceptance model: relative advantage, ease of use and learning and trialability. Two characteristics that are missing are: conformity with social norms and observability (the degree to which the benefits of AR are evident).

Retail and marketing are often described as the "largest application opportunity for AR" (Gervautz, Schmalstieg, 2012). In retailing, the findings show that AR enables interactivity which improves shopping experience (Baier et al., 2015) and allows companies to provide additional product information (Adhani, Rambli, 2012). According to Baier et al. (2015) retailers may also use AR to engage consumers by "virtual trial and product education" and gamification to enhance the customer experience. Xu et al. (2024) provide evidence that specific AR features—such as vividness and interactivity—directly stimulate purchase intentions in e-commerce contexts. Moreover, AR allows firms to present additional product information which may support consumers in their product decisions (Rese et al., 2017). An example would be using the consumer's own image to interact with the product (Blazquez, 2014). Other marketing applications include navigation tools for locating stores and in-store navigation, as well as brand recognition and promotion (Gervautz, Schmalstieg, 2012).

Recent studies show that AR can impact various aspects related to the consumer retailing experience (Yang et al., 2020). Esch et al. (2019) studied how discomfort with AR affects attitude toward the brand. Rauschnabel et al. (2019) demonstrated how attitude toward the AR app and inspiration influence brand attitude, while Park and Yoo (2020) researched how controllability, responsiveness, and playfulness of AR relate to attitude toward a product.

Furthermore, Dacko (2017) enumerates benefits of AR shopping apps: improving conversion rates, reducing return rates, enlivening static retail inventories, providing a means to offer personalized pre-purchase evaluations. Dacko's findings show that AR shopping apps clearly add experiential value to retail settings. Tseng-Lung and Shuling (2015) confirmed that usefulness, ease of use, service excellence, aesthetics, and playfulness affect the adoption of AR. They set as an example IKEA's AR interactive catalogue, which by increasing playfulness and convenience can successfully inspire consumers to buy their products and improves a company's image. Another study confirms the usefulness of AR in brick-and-mortar shops as a tool to increase customer's satisfaction and present additional information about the shop's

offer (Spreer et al., 2012). However, for some shoppers, an AR app may be too slow or not dependable enough to use regularly (Ramakrishna et al., 2013). What is more, AR shopping app compatibility with the user's smartphone's operating system may be an issue (Dacko, 2017). Those issues, however, might have changed with time and technological progress.

As showed by Rauschnabel et al. (2022) AR is increasingly gaining in popularity among managers. According to their study 15% of managers are planning to use AR marketing in the foreseeable future, 17% already apply AR marketing in some areas, and 8% use it strategically. 60% are not using AR because of a lack of established AR Marketing tools within their specific industry (63%).

Eckert et al.'s (2019) review showed an increasing trend in the number of publications on benefits of introducing AR in the medical sector, not only in treatments but also training. AR also benefits consumers who may improve their health and fitness (Adapa et al., 2020). For instance, AR has the potential to engage its users more deeply in their healthcare, enhancing their commitment to treatments by increasing immersion, gamification and entertainment. AR tools offer individualized guidance on managing medications, practicing self-care, and performing exercises (Parekh et al., 2020). The bottlenecks for AR's diffusion are cost and privacy concerns. Finally, recent reviews emphasize AR's role in workforce training and Industry 4.0 assistance (Méndez, Velázquez, 2024), suggesting competitiveness gains may also arise through improved employee performance, knowledge transfer, and cost-efficient upskilling.

In summary, there still is little research on business applications of AR, whereas the strategic management theories indicate at direct link between new technology and firm's competitiveness. Some studies show that AR may be viable tool for increasing sales by influencing the consumers. Therefore, basing on above mentioned literature we believe that there is a research gap considering the use of AR technology by companies to increase its competitive advantage. We intend to address this gap by examining how client firms use AR and by identifying the mechanisms through which AR can enhance competitiveness.

3. Methods

To assess what are the benefits of using AR technology compared to standard solutions without it, we interviewed companies which create AR applications for companies directly using them to achieve their business goals. Those latter companies were of our foremost interest in this paper. We have selected a multiple case study approach from an array of other methods. It is not only regarded as the most suitable research method for theory testing (Yin, 2013), but also for the potential theory development (Eisenhardt, 1989; Merriam, 1998). This method allows for the conclusion to be drawn about a larger group of companies than a single case

study, resulting in a more reliable coverage of the researched area. Purposeful sampling was used to select the participating companies (LeCompte, Preissle, 1993; Maxwell, 2005), with the criteria being the company's portfolios.

The chosen companies had to meet following criteria:

a. leading portfolio of developed AR software applications among competitors,
b. at least three years of experience in professional development of augmented reality based applications,
c. providing their services to foreign international parties (no limit was set).

Three years of professional experience proves sufficient skills and knowledge of the researched field and secures a vast portfolio of finished projects. Features which were considered to evaluate the portfolio were as follows: quantity of realized projects, their level of technological advancement, their diversity and their clients' country of incorporation. This information was acquired from companies' websites and other mass media sources. Furthermore, providing services to foreign parties assures us that the company is competing on an international level which is the more demanding on various fields.

While we found twenty Polish companies which according to their websites develop AR applications, most of them had scarce experience, limited to creating either only single AR applications or more of them, but simple and repeatable. We excluded them from the study. Then, we filtered the companies without international or large clients listed in their "Clients" website section as well as those without their corporate websites available in English or other foreign language. This way we selected four Polish companies which outclass their rivals based on above-mentioned criteria. Especially, in terms of the quality and quantity of developed AR apps.

The research was conducted using either the direct interview method (Maxwell, 2005) or an online interview via Skype as well as the semi-structured interview method (Nikodemska-Wołowik, 2008) based on a prepared questionnaire. It was therefore possible to interact directly with the respondents and obtain accurate information about the factors which had the greatest impact on the studied phenomenon. Chosen form of interview allowed to identify the factors that the respondent would not determine alone thanks to broadening important issues. Additionally, this approach eliminated the possibility that some questions would be unclear to the respondent, potentially leading to unreliable and imprecise responses. The managers who were interviewed were either co-owners or sole owners of the company, and held CEO or management board positions. All participants provided informed consent for audio recording and analysis. The interviews took approx. 60-90 minutes.

Poland as a research context offers a compelling case for studying AR's competitiveness effects. The country has become one of the fastest-growing IT hubs in Central and Eastern Europe, with a strong base of software houses serving global markets. Polish AR firms often compete internationally from the outset, working with foreign clients across industries. This environment creates a unique laboratory for examining AR's business value: companies

must meet demanding international standards while operating in an emerging but dynamic innovation ecosystem.

Equally important is the supplier-side vantage point adopted in this study. By focusing on AR developers rather than only client firms, we gain access to knowledge that spans multiple industries and use cases. Suppliers observe adoption patterns, common client challenges, and best practices across sectors, which makes their perspective especially valuable for identifying mechanisms of competitiveness and assessing where AR generates the strongest impact. This complements firm-level adoption studies and provides a more generalizable picture of AR's potential.

We analysed responses to six questions[1]:

1. What are the biggest advantages of AR applications?
2. What is the size category of your AR applications business clients?
3. What branches do your clients represent?
4. What are your clients' main objectives for AR applications?
5. Are your clients aware of advantages of AR applications? If yes, to what extent?
6. Does AR technology in your projects benefits your clients' competitiveness? If yes, in what way? Can you give any examples?

Questions were aimed at obtaining subjective opinions of interviewees, based on their professional experience and knowledge. During the interview the laddering technique was used which helped to deepen the answers.

4. Results

The respondents underlined that AR apps encourage greater user engagement which was claimed to be directly linked to applications' better efficiency. "In order to verify it, we measure the number, frequency and length of looks given to the AR display and the viewer's profile (e.g. sex, age) and compare with a standard solution." Accordingly, the longer and the more intensive was users' attention drawn to the display using AR, the more often the advertised product was bought. Consequently, this respondent highlighted that the main advantage of AR applications was the efficiency in promoting a product or service and increasing sales.

Another manager stated that key benefit of AR is visual impressiveness and the "wow effect" which grabs attention of consumers. This "wow effect" is then transferred from the application to the promoted product or company. Moreover, AR is claimed to provide a synergistic effect with other emerging technologies such as beacons, motion and gesture

[1] A small part of the same interview material has been used in a separate manuscript that analyses consumer preferences. That article addresses a different research question and focuses on the demand side, whereas the present paper examines firm-level competitiveness. The reference is omitted to preserve double-blind review.

control, virtual reality and 3D. According to three interviewees AR is a big step forward regarding presentation of 3D objects. An example given by them is a visualisation of a building in its real surrounding before the commencement of the construction. Furthermore, AR was claimed to be of great help in terms of customization of products, aiding and simplifying the shopping process (an example of Ferrari's AR app was given which allows visualisation of various models of alloy wheels on a real car,). Moreover, one answer underlined that AR boosts spatial imagination. Ease of use was also mentioned.

Table 1.
Influence of observed AR advantages

Observed advantage of applying AR	Mechanism / usability effect	Commercial / strategic outcome
More frequent and longer visual attention	Captures and holds customer focus on product displays	Higher purchase frequency and increased sales conversion
"Wow effect" and impressiveness	Creates novelty and positive emotional response	Stronger customer attraction to promoted products and improved brand image
Synergy with other emerging technologies (e.g., beacons, gesture control, VR, 3D)	Enhances visualization and supports interactive demonstrations	More persuasive presentation of new ideas, projects, and large or complex products; improved customer understanding
Product customization	Enables interactive configuration of products in real time	Simplifies shopping process, increases personalization, and makes purchase experience more engaging and enjoyable

Source: authors' own elaboration based.

90% of the clients of the first studied company represent the pharmaceutical branch while 10% are mainly museums. In the case of the second respondent it was a full range of possible branches e.g., furniture manufacturing, car industry and European Space Agency. The third CEO pointed at technological companies (Nokia, Orange), real estate developers, car industry (Fiat, Peugeot), e-commerce and media industry (AMC Networks, Viacom, NC+). The last manager mentioned manufacturing business, education (publishing house, museum) and services branch (logistics and a shopping centre).

Every interviewee stated that all AR apps created by them are aimed either to promote or present a certain product, service or to improve firms' image in general. The most often declared final objective was to increase the sales. The second most often mentioned AR apps' aim was to deliver additional value to a product or service (e.g., a visualisation of building made for an architecture firm). Moreover, AR apps were also used to present information in a transparent and entertaining way, e.g. an exposition in a museum, an art project or statistical data.

The answers vary when it comes to the fifth question concerning clients' awareness of AR's advantages. One of the views is that clients underrate this technology viewing it only as a new trend, which needs to be implemented in order to stay up to date but is not of great practical importance. Another respondent stated that AR is regarded mainly as a useful addition to company's other (mainly promotional) undertakings, but still only an addition. In third company's opinion it depends on the client. Some of their clients are very fond of this

technology and aware of its benefits at the moment of their first contact and some are completely unaware of AR technology alone and need to be persuaded, if it is a more beneficial solution. Other view is that this situation has recently changed and companies directly using AR applications have become aware of its usefulness. The sources of this knowledge are their own experience and companies which create those applications, Internet sources and successful examples of AR applications of other companies. This may be indirectly confirmed by growing demand on such applications in the researched companies. In case of marketing agencies which often act as brokers between researched companies and their clients, they usually are fully aware of the potential of AR applications.

As far as the last question is concerned, every interviewee answered affirmatively that AR applications positively influence their clients' competitiveness. What varies is the extent of this influence. According to one CEO, it is small and limited to that of an innovative gadget. The reason for that is their client's unwillingness or inability to skilfully use this technology. "We must wait until the Polish market matures". Second interviewee agreed that this technology "makes sense not in simple, marketing appliances, but practical ones, because they do not reveal its full potential". Our respondent added that technical competences of the IT team are very valuable and hard to find. He and another CEO agreed that the business possibilities of AR technology are much bigger than current, typical ones, but they require innovativeness and creativity in their implementation. Two other respondents are much more positive about it. "Firstly, AR arouses curiosity. It shows that our client thinks about innovativeness and is up to date with new technologies. His customer's astonishment makes them look good. There are also clients who are more aware and sales oriented. For example, IKEA's AR application increased their sales. So, we have two possibilities: improving company's image and sales, although they often are combined". This correlated positively with a previous answer of other respondent concerning the increase of the sales as a result of bigger attention drawn to the promoted product. Another interviewee added that his clients use their AR applications to show a full spectrum of their offer at any place given, which would be impossible otherwise and in his opinion it must affect competitiveness. Same counts for very large products such as ships, cars and furniture, which can be presented so realistically and precisely only thanks to 3D and AR applications. "Wow effect" and impressiveness of this technology were mentioned as well. Additionally, the least tangible benefit for the client was improving their image by being identified with an innovative and impressive technology.

One of respondents is the cofounder of "tylko", a company which sells customizable furniture. Thanks to AR application it is possible to visualise a piece of furniture in your own house and basing on your preferences customize it so that it would fit perfectly and then order it online. AR application in this case is an inextricable element of whole business model and creates great value to its customers, contributing vitally to company's "tylko" competitive advantage. This was one of the main reasons it gained financial support from foreign investors.

Another example of successful implementation of AR was the project Operalab, an exhibition of competition entries held by The Polish National Opera and BMW. The core exposition was based on AR technology, which enabled to show different use-cases of each pavilion. The cofounder of "tylko" and "bridge", the latter company being responsible for this implementation, stated that thanks to AR the image of whole project and its participants was significantly improved and it gained tangible benefits. It positioned Operalab as one of the main cultural events in Poland, widely commented by the mass media.

A different success story of AR product was a three-dimensional visualisation in AR of a "New Warsaw" car with additional, transparent information on plans of reinventing well known Polish car brand. The CEO behind this project believes that thanks to skilful implementation of new technologies, especially AR, the car gained public attention and more importantly – convinced investors into it. The first car is currently under construction.

Another case provided by another interviewee was a mobile AR application, which allows consumers to scan a label of a product in a shop. For example, after scanning a label of spaghetti packaging, it shows us what dish can we make with it, what other ingredients we should buy and then automatically adds them to our shopping list. "This opens completely new perspectives for our clients. We wanted the application to be promoting sales. This concept seems unique. It is a bridge between online and offline, merging e-commerce with brick-and-mortar shops. (…) Interestingly, brief did not mention AR, but it perfectly fits our client's needs". He added that this will improve not only his client's image but also give him tangible increase in sales.

The fourth respondent could not think of a tangible situation but believes that their AR applications must be of noticeable benefit to their clients, as they often continue the cooperation, sometimes even quadrupling their orders.

5. Discussion

We interpret our results with a simple, integrated lens: AR only creates advantage when its visuals and interactivity are paired with basic complements such as clean product data, 3D assets, analytics, omnichannel IT, and trained staff. Our findings suggest that AR technology has a positive impact on company's competitive advantage. Unique features of this technology allow a company to outrun the competitors in respective fields, especially retail and marketing. Main advantages of this technology over standard solutions are intensification of user's experience, impressiveness, engaging character, ease of use and transparency of presented information. This is directly linked with increased attention towards promoted product or company, measured by one of our respondents and reported increased sales in comparison to standard solutions. Such findings are similar to the previous ones stating that attitude toward the AR app and inspiration influence brand attitude (Rauschnabel et al., 2019)

or attitude toward a product (Park, Yoo, 2020). In a head-to-head experiment, AR outperformed VR when persuasion relied on rational, information-rich appeals, whereas VR worked better for purely emotional appeals (Wu et al., 2025). Contrary to Berman's and Pollack's (2021) conclusion our study does not highlight lowering firm's expenses by AR's introduction, mainly because our cases are marketing-heavy and supplier-side. In operations and service settings, AR-based guidance and remote assistance could be where cost effects are most evident.

Table 1 captures the main advantages of AR reported in our interviews, but these remain case-specific. To generalize, we integrated our findings with prior research, highlighting how AR features translate into commercial, process, and strategic outcomes. Table 2 presents this synthesis as a broader framework of the pathways through which AR enhances competitiveness.

Table 2.
Pathways from AR features to competitiveness outcomes

AR feature / characteristic	Mechanism / usability effect	Underlying capability (RBV / DC lens)	Competitiveness outcome
Enhanced visualization & 3D spatial overlays	Clarifies product attributes; enables realistic product and environment simulation	**Sensing** – improves recognition and understanding of product attributes	Increased sales conversion; reduced product returns; stronger decision confidence
Customer engagement & "wow effect"	Captures and sustains consumer attention; creates novelty and emotional response	**Seizing** – turns attention into purchase and brand attachment	Improved brand image; stronger customer attraction; higher purchase frequency
Product customization & interactivity	Allows real-time configuration; personalizes shopping experience	**Seizing** – converts user input into tailored value	Greater customer satisfaction; higher willingness-to-pay; differentiation from rivals
Synergy with other technologies (VR, beacons, gesture control, IoT)	Expands functionality and immersion; supports omnichannel integration	**Reconfiguring** – enables integration and new workflows	New business models; enhanced omnichannel strategies; competitive edge in innovation signaling
Ease of use & transparency of information	Simplifies complex decision-making; presents data in intuitive ways	**Sensing + Seizing** – lowers cognitive load and improves decision accuracy	Faster purchase process; reduced cognitive load; enhanced customer loyalty
Experiential & marketing applications	Provides memorable experiences; signals innovativeness	**Resource-based** – builds unique and hard-to-imitate brand resource	Stronger brand equity; improved firm reputation; attraction of investors/partners
Potential in operations & services (guidance, remote assistance)	Supports training, error reduction, knowledge transfer	**Reconfiguring** – introduces new service routines and learning loops	Process efficiencies; lower error rates; cost reductions (future potential)

Source: Authors' elaboration based on own survey and reviewed literature.

AR helps to create a new type of experience for the customer, becoming an innovative form of experiential marketing (Haumer et al., 2020). Moreover, it was claimed that there is no other comparable solution in presenting customizable products in 3D or very large objects. Accurate 3D and spatial overlays make choices clearer and reduce user effort, which raises decision confidence. The use of AR results in improved (innovative) image of company. Another important advantage of this technology is the ability to deliver additional value to company or

a product, which in our opinion is of crucial significance, as those additional, completely novel features are what differs companies implementing AR from their competitors and what their clients may be looking for.

These findings are reinforced by recent controlled studies: Marino et al. (2024) found that AR improves assembly accuracy and reduces errors, while Treinen et al. (2024) show that AR in inspection and remote support enhances efficiency. Pitzalis et al. (2025) present a digital twin with AR interface for a gearbox assembly, using AR overlays to detect and inspect mechanical deviations in real time. Souza et al. (2025) review nineteen industrial assembly-task AR studies, documenting improvements in error reduction, operator guidance, and process alignment. Haider et al. (2025) examine advanced industrial manufacturing use cases, including spatial AR for force feedback visualization, safety alerts, and posture assessments in smart factories. In adjacent domains, Fathi et al. (2025) provide evidence from AEC and facility management operations, showing that AR/VR applications are used in maintenance, design coordination, and operation phases — giving insight into non-retail operational deployments.

In healthcare training, a randomized trial found that AR plus haptics increased student comfort and some self-rated performance measures, with a trend toward shorter procedure time (Felten et al., 2025). On the consumer side, Xu et al. (2024) confirm that interactivity and vividness drive e-commerce conversion. Together, these outcomes indicate that AR contributes to competitiveness through both revenue-enhancing and cost-reducing mechanisms, consistent with our three-horizon definition (commercial, process, and strategic).

We believe that those additional features delivered to products and services are the source of competitive advantage rendered by this technology. An example may be Google Translate, which allows consumers to instantly translate text by pointing the smartphone's camera at the text in the foreign language. It is much quicker and easier to use than standard online translators which require the user to type the translated phrase. Just those two traits are completely game-changing, as they allow not only to take over the users of competitive solutions, but also attract new users who are interested in translating text on the go (e.g. tourists), which previously was too time-consuming or uncomfortable. In the analysed case of "tylko", AR allows the process of customizing and ordering furniture to be quicker, easier, more fun and accurate than their competitors.

The standing question is if AR will be the next disruptive technology, as defined by Christensen (1995, 2015)? It needs to be highlighted that technology is not disruptive from the very beginning. At first it is inferior in some aspects but provides some new performance attributes. With its development, it becomes disruptive, when it starts dominating the market and disrupting old technologies, products or services. We believe that AR is in the first stage of this process. It has some predispositions revealed by this study such as fun factor, visual attractiveness, convenience, synergistic effect with other emerging technologies, additional value for customer and its effectiveness. However, it is still underdeveloped on some fields to become a mass technology, both in the software and hardware field.

Compared to AR adoption drivers in the study of Martinez et al. (2014) our research confirms fun factor, curiosity and tangible 3D visualisation as positive traits of this technology leading to its popularization, but our respondents do not mention reduction of costs and fast learning curve in contrast to the mentioned article. No possible drawbacks of AR adoption were mentioned in our research. This may mean they are either insignificant or our respondents could have been biased in this matter, due to their profession as AR applications developers.

As presumed, every respondent stated that AR applications improve their clients' competitiveness because of aforementioned positive traits, which was the key issue of this research. Only one of them regards it as not significant yet (but still having undiscovered potential). This means that some companies are not yet prepared to skilfully implement this technology and it may be the reason for its partial undervaluation (in the sixth question). But it is claimed to be a matter of time. Our interviewees' clients are also becoming more aware of AR's potential. This finding corresponds with other authors' conclusion that sole technology is not enough to create competitive advantage and other factors are needed, such as organizational skills as underlined in dynamic capabilities theory, as well as ability to create value innovation (Mauborgne, Chan Kim, 2007). Our study results confirm the outcomes of Spreer et al. (2012) that AR influences positively user satisfaction and is helpful in information presentation. Moreover, Zabel (2024) demonstrates that AR technologies can strengthen dynamic capabilities—sensing, seizing, and reconfiguring—thus reinforcing the theoretical claim that AR, when properly embedded, can be a source of sustained competitive advantage.

Interestingly, AR-implementing companies had specific business-oriented aims for AR applications, which was increasing the sales by promoting the company or its product and (to a lesser extent) delivering additional value to their products and services. This contrasts with two responses that companies view AR mainly as an innovative gadget and addition to other company's undertakings. The reason behind those opinions may be higher cost of such applications which limits their usage and the fact that their scope is limited to certain group of customers. Additionally, we observed that visualising information with AR was an often-cited purpose chose only by non-commercial clients like museums or art projects. Research shows AR's excellent capability of improving visitors' immersive experiences in this sector (Allal-Cherif, 2022). However, recent studies caution that AR's novelty effects may erode with repeated exposure, reducing consumer responses over time (Söderström et al., 2024).

Despite claims of increasing industrial application of AR (e.g., Jetter et al., 2018) we were not able to to confirm it. However, our findings confirm previous research (e.g., Gervautz, Schmalstieg, 2012; Martinez et al., 2014) which identified retail and marketing as one the five most popular fields of AR applications. Surprisingly, our findings almost completely omit other four areas. We believe that the lower cost and risk of implementing AR in this industry, as well as tangible benefits like increased sales, may be contributing factors, as well as the growing number of visible success stories and relative ease of implementation. On the other hand, other areas of implementation of this technology are much more demanding in the context of above-

mentioned terms and connected with pioneering costs (Porter, 1985) but may be more profitable. This suggests a potential niche for innovators, as these areas are likely to be explored next. Our study confirms Rauschnabel et al.'s (2018) findings that companies may still lack the know-how concerning AR's implementation in a specific branch. Surprisingly, our respondents did not mention AR application in the healthcare and fitness sectors, despite claims concerning its benefits for businesses and patients (consumers) (e.g., Parekh et al., 2020). This gap reflects our sampling and vantage point; the strongest and most durable effects should surface in assembly, inspection, and service where procedural guidance and remote help are core work.

AR is a part of third wave of IT-driven transformation: Internet of Things and "smart, connected products" (Porter and Heppelmann, 2014, 2015 and 2017). Similarly to AR, Internet of Things allows merging real and virtual words. According to the authors it will transform the competition and companies, especially in the field of manufacturing, but also the services. Smart, connected products reshape almost every function in company's value chain, including product development, IT, manufacturing, logistics, marketing, sales, and after-sale service. Our conclusion is coherent with claims of Porter and Heppelmann (2015) who predict that AR will be a great improvement in terms of efficiency and effectiveness of services e.g., when AR overlays are used to provide step-by-step repair instructions to the technician in the after sale service.

Our study makes three main contributions. First, it shifts the focus from consumer acceptance of AR to firm-level competitiveness, showing how AR applications create tangible commercial, process, and strategic outcomes. Second, it connects AR's core media characteristics with resource-based and dynamic capabilities perspectives, explaining how interactivity, visualization, and data overlay become sources of advantage when embedded in firm processes. Third, it identifies boundary conditions by demonstrating that AR effects are strongest when products are tangible or complex, when firms possess complementary technological readiness, and when industry contexts support omnichannel or experiential strategies.

6. Conclusions

Our findings confirm that AR can increase the competitiveness of an enterprise which employs it. The purpose of this article was to show in what way AR may influence company's competitiveness. The findings point that companies use AR mainly as a marketing tool, mainly to improve their sales or in order to upgrade their products or services to outrun their rivals. This technology proved to have numerous advantages over standard solutions in respective fields. Due to better spatial presentation and tangible 3D visualization it helps to project and then present large objects like buildings or ships to clients. AR renders a competitive advantage

in the presentation of data and introducing new sales methods to companies. Moreover, AR enables new business models which could not be implemented without it, e.g. an AR application allowing to sell customizable furniture on the internet, which is intuitive, fast, accurate and fun. One should be aware that a broader study may show other ways in which AR can improve the competitiveness of enterprises.

7. Limitations and Future Research

This study has several important limitations that should be acknowledged. The interviews were conducted with managers of AR development companies rather than with the adopting firms themselves. This supplier-side perspective offers breadth across industries but carries the risk of optimism bias and partial knowledge of client performance. The study also did not include objective performance indicators such as conversion rates, product return rates, or cost savings, and therefore relies on perceived outcomes reported by interviewees. The small sample of four Polish AR developers further limits generalizability, especially because the cases were concentrated in retail and marketing contexts. Another limitation is the positive skew of responses: none of the participants described unsuccessful projects or client dissatisfaction, which may reflect selection effects, social desirability bias, or the commercial interests of the interviewees. Finally, the findings are situated in a technological environment that is still evolving, and they may not fully apply once AR hardware and software reach greater maturity and standardization.

Future research can address these limitations in several ways. Studies should investigate the perspectives of adopting firms directly and complement qualitative interviews with objective key performance indicators such as sales uplift, error reduction, or cost-to-serve improvements. Research in additional industries such as manufacturing, logistics, healthcare, and education would clarify where AR generates the most significant competitiveness effects. Longitudinal studies could follow firms before and after implementation to test whether benefits persist, fade with novelty, or intensify as integration deepens. Experimental and survey research could examine boundary conditions, for example the role of product tangibility, firm readiness, or industry context, and could also test the durability of the “wow effect” over time. Further work is also needed to explore how AR interacts with other technologies such as the Internet of Things, artificial intelligence, or virtual reality to create synergistic competitiveness outcomes. Finally, future studies should investigate how AR enables entirely new value propositions and revenue models rather than only enhancing marketing or product presentation.

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