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Innovation in the Defence Industry from the End of the Cold War to the War in Ukraine

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Abstract: Since the end of the Cold War, the defence industry has emerged as a leader in innovative technologies, and the Russo-Ukrainian war has provided a unique opportunity to test these technologies in a real combat scenario. As a result of the geopolitical events of February 2022, the European defence industry has faced unprecedented political, economic, and technological changes. This study examines these transformations through semi-structured, open-ended, in-depth interviews with twenty-five experts across ten European countries, analysed using qualitative content analysis, with a focus on small and medium-sized enterprises (SMEs). While perspectives on the necessity of defence innovations vary, there is considerable market demand for both disruptive innovations and the advancement of conventional technologies. However, despite the theoretical benefits, the current uncertain environment leads policymakers to view international defence collaborations as insecure. Consequently, SMEs develop military technological innovations either independently or with domestic partners. This study's novelty lies in its foundation on real empirical data, contributing practically applicable insights to the existing literature on the subject.

Keywords: defence industry, innovation, disruptive technologies, international collaboration, small and medium-sized enterprises (SMEs)

Introduction

Since the end of the Cold War, European countries have been equipped for minor conflicts but not for wars involving major armies facing each other. Governments assumed that the era of peace had arrived, believing that wars would only happen far from Europe. Consequently, the accumulation of military assets ceased, and only a reduced amount of military equipment was maintained, insufficient for participating in a major war. With the beginning of the Russo-Ukrainian war, these military equipment stocks were quickly depleted. The armed conflict took European decision-makers by surprise, leading them to recognise the necessity of preparing for potential escalation. Subsequently, extensive defence industrial developments were initiated across Europe. This is the first time since

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the Cold War that European countries have initiated such development of the defence industry, which justifies researching the significance of military technological innovation.

Maintaining a local defence industry is crucial for every nation, and its significance has increased further due to the war on the border of Europe. Its importance stems from its critical role in national security, in maintaining global infrastructure, and in promoting economic growth. However, from the perspective of this research, its most important characteristic is that it can be classified among the most innovative industries. In the past few years, international trade, arms production, and the demand and supply of the defence market have dynamically increased for both military and civilian equipment. The increasing demand has only amplified due to the sudden outbreak of the Russo-Ukrainian war, creating a situation that modern societies have not yet experienced.

This research aims to analyse the political, economic, and technological changes in the European defence industry from a multidisciplinary perspective. It focuses on the significance of defence innovation and the factors supporting the development of new technologies, spanning from the end of the Cold War to the first year of the war in Ukraine. In this paper, special attention has been paid to the role of small and medium-sized enterprises (SMEs) in the defence innovation ecosystem.

After the extensive literature review, the following knowledge gaps have been identified. (1) According to the previous studies, the defence industry has undergone significant transformation in the past three decades, creating a conducive environment for the emergence of international defence collaborations (Reis 2021; Chin 2019; Kurç and Bitzinger 2018; Kurç and Neuman 2017; Struys 2004). However, empirical research has not yet examined how collaborations affect the development of innovations, nor how nations relate to these partnerships under the current geopolitical circumstances. (2) Researchers agree that demand is growing in the defence market (Durakovic and Trgo 2020), but there is limited scientific evidence about its specific nature, therefore this study also investigates this issue. (3) This situation has provided opportunities for private SMEs to enter the defence innovation ecosystem (Chin 2019; Leske 2018; Cheung et al. 2018), however, few studies have examined their potential in managing crisis situations arising from the effects of the Russo-Ukrainian war. (4) According to the literature, defence innovations are an important part of national strategy and economic development (Reis 2021; Harutyunyan and Davtyan 2019; Taksás 2019; Bellais 2018; Bitzinger 2009), but the user reception of these equipment has not been studied. This empirical research also investigates the direction and necessity of defence innovations, in a novel situation where new technologies were tested in real war conditions among opponents with nearly similar military technologies. The present study enriches the body of knowledge by filling these defined theoretical gaps, contributing practically applicable insights to the existing literature on the subject.

The key findings of this study highlight that, despite the theoretical advantages, in the current geopolitical environment policymakers view international collaboration as insecure and they attempt to address the defence market's emerging supply crises through

independent decisions. While perspectives on the necessity of defence innovations differ, there is a considerable market demand for both disruptive innovations and the advancement of conventional technologies, which provides opportunities for SMEs to operate within the defence innovation ecosystem.

The first section of this paper analyses the transformation of the defence industry since the end of the Cold War, focusing on how these changes have spurred innovation. This is based on a review of a body of scientific literature. The second section addresses the effects of the outbreak of the war in Ukraine on the defence industry, based on empirical data gathered through expert in-depth interviews with twenty-five respondents with outstanding professional experience in the field of innovation activity, using an inductive approach. The interviewees were primarily the CEOs, managers and engineers of European defence technology development companies, representing ten European countries.¹ This research was conducted in the first year following the outbreak of the Russo-Ukrainian war.

Evolution of the Defence Industry

The Main Factors in the Transformation of the Defence Industry Since the Cold War

The end of the Cold War led to a significant change in the structure of the global defence industry. A succession of new challenges, such as governments reducing their participation in defence research, development, and innovation (RDI) due to budgetary restrictions and armament reductions, the increase in demand for innovative and highly accurate armaments instead of mass-produced conventional equipment, and geopolitical upheavals led to major transformation (Reis 2021; Chin 2019; Kurç and Bitzinger 2018; Kurç and Neuman 2017; Struys 2004). Besides the end of the Cold War, rapidly spreading globalisation also influenced the defence industry, which had to adapt to the new circumstances. Consequently, countries became less protectionist and relaxed entry to markets, creating new opportunities for a series of large mergers between defence contractors (Carril and Duggan 2020).

Earlier, defence innovation systems were more tightly bound by national borders. The transformation initiated a growing trend for multinational RDI collaboration that was partly designed to replace intergovernmental involvement (Cheung 2021; Kurç and Bitzinger 2018; Kurç and Neuman 2017) and has become the core component of defence innovation strategy over the last three decades (Briones-Peñalver et al. 2020). These strategic alliances among nations improve the ability to innovate and support knowledge transfer by decreasing the funds and resources required (Jianyu et al. 2018; Xie et al. 2018;

1 Austria, Bulgaria, Croatia, the Czech Republic, England, France, Germany, Hungary, Poland, and Serbia.

Martins et al. 2017; Panico 2017; Dornbusch and Neuhäusler 2015). Globalizing flows of knowledge are significant because innovative information is frequently located outside of national borders (Delgado-Marquez et al. 2018, Xie et al. 2018; Ardito and Petruzzelli 2017), and the ability to source and recombine external knowledge has resulted in better technological performance (Briones-Peñalver et al. 2020; Martínez-Noya and Narula 2020; Ardito and Petruzzelli 2017). However, the disadvantage of defence cooperation is that it may trap nations in conflicts that they would otherwise avoid and have no interest in, but if they avoid formal relations, they are in jeopardy of being left alone in a crisis (Radoman 2018).

The transformation of the defence industry has allowed SMEs from the private sector to play a more prominent role in the defence industry (Chin 2019). With the new participants in the field, the defence industry is no longer restricted to military institutions. New technologies developed by SMEs allow companies to diversify their commercial production, resulting in greater dependence on the civilian market and creating a larger consumer market for new products and services (Leske 2018). In many regions, defence innovation has become primarily the work of SMEs supported by civilian RDI and education, while components of the military work closely alongside this process (Cheung et al. 2018).

The government's buying power is crucial in the defence market, as it is the main and often the only customer (Carril and Duggan 2020). Despite the high level of innovation, emerging SMEs in the defence industry may struggle to develop the political relations that are required for their involvement in military procurement processes or may not be seen as reliable by potential clients (Dombrowski and Gholz 2009). Furthermore, political actors have the power to favour civilian firms by investing in them and squeezing out others by competing with them, preventing investment and exchange in competitive markets (Grimes 2021).

Small and Medium-sized Enterprises and Disruptive Innovation in the Defence Industry

The changing environment has resulted in the appearance of non-governmental actors in the defence market, whose number will multiply in the future (Bakos 2018). SMEs are the forerunners in developing defence innovation, much of the latter which is disruptive new technology (Frunzeti et al. 2021; Taksás 2019). New competitors are more willing to develop disruptive innovation (Chin 2019; Dombrowski and Gholz 2009), which creates opportunities in areas with no traditional suppliers (Leske 2018). Large defence enterprises are not interested in creating customized solutions for narrow markets (Duračovic and Trgo 2020), and competitiveness is no longer directly associated with power. Instead, technologically powered agility and the speed of movement matter, in addition to resources, which make SMEs successful in this field (Frunzeti et al. 2021). The defence industry is among the most knowledge-intensive industrial sectors, and innovation is crucial for companies to survive and improve their overall performance (Ardito and Petruz-

zelli 2017). While customer-driven designs can meet most defence needs, some applications require innovative custom design (potentially disruptive innovation) to operate in a defined environment (Desjardins and Hopper 2001).

Scholars agree that the most consequential type of innovation is disruptive, which will lead to significant changes in the future and character of warfare (Frunzeti et al. 2021; Metea 2021; Zysk 2021; Pfaff 2020; Taksás 2019; Cheung et al. 2018) and the competitive dynamics of the defence market (Metea 2021; Pfaff 2020; Dombrowski and Gholz 2009). In the defence industry, the disruptive potential of an innovation depends on and is influenced by potentially catalytic factors, such as political goals and national strategy, the economic and social context, internal and external partners from different geographical locations, geopolitical relations, the growing complexity of technology, environmental threats, and the perception of strategic issues that require novel solutions (Horowitz and Pindyck 2023; Cheung et al. 2018; Delgado-Marquez et al. 2018; Leske 2018). Catalytic factors are powerful external elements in relation to the defence innovation system that occur at the ecological system's highest and most influential level and have the potential to produce the conditions that enable considerable transformation (Cheung 2021).

The Significance of Defence Innovation in National Strategies

Defence innovation has become crucial to national strategies, a fundamental component of strategic autonomy and genuine sovereignty (Reis 2021; Harutyunyan and Davtyan 2019; Taksás 2019; Bellais 2018; Bitzinger 2009). Scholars agree that a local defence industry is an indicator of political power positions; furthermore, the development and production of defence equipment are always motivated by the desire for power, wealth, and prestige (Metea 2021; Okun and Arun 2021; Reis 2021; Vladu and Popescu 2021; Kurç and Neuman 2017). In the current geopolitical environment, the defence industry has become an important area of public diplomacy, representing a means of gaining national advantages peacefully, without using force and causing resentment (Harutyunyan and Davtyan 2019; Muthana 2011).

Nations invest in defence RDI for economic reasons, as the industry has high profit-generating potential (Khalid and Razaq 2015). Additionally, investment in the sector is always aligned with government interests (Harutyunyan and Davtyan 2019). Nations export armaments because it strengthens global political positions (Kim and Kim 2021; Harutyunyan and Davtyan 2019), supports the formation of strategic allies, ensures national security (Pamp et al. 2018), and promotes national lobbying opportunities when large transactions are being implemented, thus increasing political influence and political ranking in the global community (Terziev and Nichev 2017).

The national defence innovation system is in constant transformation. Consequently, technological adaptation has become essential (DeVore 2021; Kytömäki 2014). Those companies that take action first to adopt new technologies that later become dominant

usually survive and prosper (Nair and Ahlstrom 2003). The militaries capable of the first adaptation of innovation gain a significant advantage, and those that do not adopt new technologies decline, often precipitously (Cheung et al. 2018). Strategic advantages are achieved by whichever side adapts faster to unexpected developments in technology (Devore 2021).

The transformation of the defence industry has led to a peculiar strategic posture in which the demonstration of military power is sometimes emphasised more than the physical application of violence. Thus, countries may push technological innovation to its limits to demonstrate their military superiority (Chin 2019). Also, global powers tend to collaborate now to respond to minor regional outbreaks of conflict for demonstrative purposes rather than prepare for conventional wars (Reis 2021). However, new technologies can have multiple, conditional, and even contradictory effects on different aspects of global political stability (Sechser et al. 2019), and the dominance of defence innovation may create vulnerability and instability that lead to war (Schneider 2019). The war in Ukraine showed that nations with large, innovative and sophisticated defence arsenals could view such geostrategic challenges as quickly resolvable, potentially increasing the risk of war. Disruptive innovation that removes humans from the battlefield will perpetuate this tendency (Carvin 2022).

Methodology

In the course of this research, interviewees were selected according to their experience in the defence industry to increase research validity, while the examination of different companies in ten diverse countries may contribute to transferability. Empirical data were collected through semi-structured, open-ended, expert, in-depth interviews that allowed respondents to reflect on their original perspectives on the recent changes in the defence industry. The selection criteria included the requirement of several years of experience in the field of defence innovation activities. Thus, the novelty of this research lies in not only examining the issue from a theoretical standpoint but also exploring the dynamics of the defence industry through the perspectives of respondents with practical experience. The interviewees gained professional expertise in areas such as military vehicles, satellites, arms manufacturing, and the aerospace industry. The interviews were undertaken with companies that operate in Austria, Bulgaria, Croatia, the Czech Republic, England, France, Germany, Hungary, Poland, and Serbia. Interviews lasted from forty-five to sixty minutes. The sample characteristics and profiles of the examined companies are illustrated in Table 1.

Interview	Country	Profile of the company	Position
1.	Austria	Defence equipment manufacturing	Sales Manager
2.	Austria	Armoured vehicles	Engineer
3.	Bulgaria	Defence wholesaler	Owner/CEO
4.	Bulgaria	Ammunition manufacturing	CEO
5.	Croatia	Metal engineering	Trader
6.	Croatia	Metal engineering	Trader
7.	Czech R.	Small arms manufacturing	Sales manager
8.	England	Aerospace	Engineer
9.	England	Aerospace	Engineer
10.	France	Defence investor	Investor
11.	Germany	Military vehicles	Engineer
12.	Germany	Arms manufacturing	Engineer
13.	Germany	Arms manufacturing	Engineer
14.	Germany	Optics	Trader
15.	Hungary	Defence investor	Investor
16.	Hungary	Arms manufacturing	Engineer
17.	Hungary	Arms manufacturing	CEO
18.	Hungary	Arms manufacturing	Trader
19.	Hungary	Arms and satellites manufacturing	CEO
20.	Hungary	Military vehicles	Engineer
21.	Poland	Arms manufacturing	Trader
22.	Poland	Metal parts manufacturer	Sales manager
23.	Serbia	Ammunition manufacturing	Sales manager
24.	Serbia	Firearms manufacturing	Sales manager
25.	Serbia	Optics	CEO

Table 1: *Characteristics and profile of respondents*

Conducting in-depth interviews is a scientific method used to gather personal opinions, as it allows individuals to talk about what they think is important and facilitates an understanding of context (Morris 2015). The interviews were digitally recorded, transcribed, and analysed using content analysis methodology. This method can be applied to qualitative data with the assumption that recorded forms of communication are a rich data source with great potential to reveal valuable information about a specific phenomenon (Kleinheksel et al. 2020). In the field of defence, content analysis is often used as opponents seek to extract data from each other’s communications that reveal latent content (i.e., that beyond the primary meaning of the text) (Nagy 2018).

In this research, the coding of the collected empirical data was implemented in three stages. During the coding process, the text was categorised and interpreted to explain

the consequences of the transformation of the defence industry. First, the relevant factors of the researched topic were identified and highlighted. Then, the identified factors were grouped into three main categories: rising demand in the defence industry, the role of SMEs and start-ups, and the factors related to defence innovation. After the main categories were identified, the sub-categories were organised and arranged in logical order, which are detailed in Table 2. Following this, further sub-categories were identified, which are detailed in the section on empirical results. Quotes used in this article were selected as representative of the accounts and viewpoints expressed by participants.

Main categories	Sub-categories
Rising demand in the defence industry	<ul style="list-style-type: none"> • Reasons for rising demand • Factors that lead to supply crisis • Means of solving the supply crisis • Defence industry development efforts • Defence collaborations
The role of small and medium-sized enterprises and start-ups	<ul style="list-style-type: none"> • Fields where SMEs and start-ups can succeed • Transformations of SMEs and start-ups • Obstacles to SMEs and start-ups in the defence industry
Defence innovation	<ul style="list-style-type: none"> • Factors that question the need for disruptive innovation • Issues related to engineers/the development process • Directions of defence innovation • Advantages of defence innovation • Catalytic factors that contribute to innovation • Factors in defence strategy that define the direction of innovation

Table 2: Identified main and sub-categories

Empirical results

Rising Demand and its Implications for the Defence Industry

Demand and supply in the defence industry have consistently grown for years, but the outbreak of the armed conflict on Ukrainian soil intensified demand and efforts to meet this. This phenomenon, partly caused by the war, is of industrial, economic, and geopolitical significance and has resulted in critical supply problems.

The sudden increase in demand is just one factor that has contributed to the critical supply problem in the European defence industry. As stated by the interviewees, the low level of investment in the defence sector,² the small number of collaborations,³ dependence on foreign suppliers, the dynamic increase in raw material and energy prices, an unpredictable environment, political pressure, geopolitical conflicts, public budget shortages, the earlier negligence of the sector, and the effects of the pandemic are all factors that have contributed to the challenges that the European defence industry has recently

² Compared to the USA.

³ Despite the initiatives, the level of international cooperation in the European defence industry is still low.

experienced. Due to the dynamic increase in costs and the unforeseeable environment, framework agreements have become inapplicable for use in public defence orders.⁴ There is no culture and adequate legal framework for handling this situation, which has not been experienced before in modern society. “There is a great need for a change of culture because, in the current situation, there is no future vision in the industry” (Interview 8). Under these conditions, suppliers face serious difficulties managing the sudden increase in demand.

The sudden outbreak of the armed conflict rapidly reduced defence stocks around Europe, highlighting the negligence of the industry and revealing the shortages of defence equipment. In response, most European countries significantly increased their defence spending. “All these events led to the conclusion that European decision-makers didn’t anticipate the emergence of a real war” (Interview 12). Decision-makers are pressuring industry to find a quick solution to this issue, but these challenges cannot be solved immediately. “It wasn’t the Ukrainian conflict that caused the problem, but the neglect of the defence sector, and this negligence cannot be resolved in just a few months; this idea is ridiculous” (Interview 11). Setting up local industrial production is not a short process, and considering the currently uncertain environment, saturated defence production capacities, the shortage of raw materials, and the European energy crisis, implementation is even more complicated.

According to the experiences of the respondents, in numerous cases, the solution to this issue is not to invest in the local defence industry as a long-term solution but to import defence equipment from outside Europe. Major defence-equipment manufacturing nations focus on developing complex, high-technology weaponry, which most countries cannot manufacture and can only procure by import at very high prices. The issue with the import of defence equipment is that it makes the importer nation politically, economically, and technologically dependent on another nation, making the supply chain vulnerable and hindering independent decision-making. Furthermore, defence equipment is designed to last for a decade or more, and if the exporter countries cannot continue to deliver (e.g., to Europe), this will lead to another supply crisis. Under the current circumstances, even reliable short-term forecasts are almost impossible to make. As described by the respondents, “the development of the defence industry based only on imports is not a sustainable long-term solution” (Interview 21), and “without the development of a local defence industry, the sovereignty of nations will be damaged, [making them] vulnerable” (Interview 2).

To ensure at least medium-term national security, every nation needs a local defence industry, as it is essential for economic growth, helps to build and maintain key industrial capabilities, supports technology transfer from the defence sector to other sectors of the economy, and contributes to strategic autonomy. International collaborations in

⁴ Metrics are available for predicting the evolution of raw material and energy prices, but there is currently no legal framework for the use of those in government procurement.

areas such as component and raw material acquisition, production, assembly, and development projects can provide support in the implementation of a competitive and sustainable defence industry. Decision-makers have an important role to play in the formation of successful international partnerships. However, in the current geopolitical environment, they view international collaboration as insecure and attempt to address the defence market's emerging supply crises through independent decisions. As one interviewee explained: "one of the main risks is that the supply chain can be obstructed at any time; even if production is domestic, the supply chain can still be disrupted if raw materials are sourced from abroad" (Interview 24). As stated by another respondent "two nations develop military technology together, and in the end, one does not transfer it to the other" (Interview 7). According to some interviewees, back in the post-Cold War era, despite attempts to develop defence innovations through international collaborations, few efforts concluded with tangible results.

The Role of Small and Medium-sized Enterprises and Start-ups in the Defence Innovation Ecosystem

During the twentieth century, defence-technology disruptive innovation was led by major public defence enterprises or other government-funded institutions, but recently, SMEs and start-ups have had an excellent opportunity to participate by taking a prominent role in addressing the emerging crisis. SMEs and start-ups are often more agile and flexible than larger defence companies and can quickly adapt to changing customer needs and market conditions. Although they cannot compete with big companies in manufacturing conventional equipment, they can provide specialised products and services that are not available from larger companies, develop new technologies that respond to specific needs, improve existing technologies, or develop dual-use technologies. They also can develop components and supply larger defence companies. Considering their smaller size and specialised focus, these companies are often better able to implement RDI projects that are considered too risky for larger defence companies.

In earlier times, the governmental sector pioneered disruptive new technologies, but recently, defence innovation has mainly occurred in the commercial sector. "When we are talking about disruptive new technologies, the focus is on small companies, and start-ups" (Interview 18) / "start-ups have vision" (Interview 12). The interviewees also explained that although start-ups used to be characterised by a philanthropic mindset, the increasing demand in the defence industry and the potential for significant profit have changed this philosophy. Many start-ups with strong innovation potential are starting to respond to commercial needs and may expand to meet the demands of defence and intelligence services. Recent circumstances indicate that the world may be approaching a recession, and the defence industry is recession-proof. Currently, governments have implemented policies and programs to support the growth of defence start-ups, which make investing in the defence sector more attractive to investors and help develop technological superiority against new threats. Portfolio companies whose products can be utilised as dual-use

technologies, such as unmanned system technologies (UST), satellite imagery systems, autonomous drones, robotics, artificial intelligence, and cybersecurity, are among the most alluring fields for investors. However, the risk of investing in defence-related start-ups as they develop new and unproven technologies is that the innovation may not meet the expectations of investors or will not be adopted by the market.

Developing military technology can be more competitive when implemented in collaboration with other domestic defence companies. Earlier, a single company may have been capable of supplying a nation with defence equipment or developing a new technology individually, and many companies still have this capability, but the changed circumstances have made collaboration with other companies a source of strength. As described by the respondents, in the past, if a company had existed for years, it was a sign of stability, reliability, and a precondition of cooperation. In contrast, companies are now being established for specific purposes and may exist for only months rather than years, with no history. In the defence industry, a significant number of new technologies and forms of disruptive innovation are now being developed by start-ups established for a single project. These innovations can later be sold to a large company that can reproduce the product(s) in large quantities.

SMEs and start-ups play an important role in the development of defence innovation and the defence industry as a whole, but they face many obstacles as they are not traditional parts of the defence industry. According to the experiences of the respondents, these obstacles may include the legal protection of innovation, difficult access to capital, complicated access to government contracts and tenders, bureaucracy and the hierarchical system of industry, corruption, industrial and economic espionage, and other forms of knowledge theft. They may also face issues arising from the heavily regulated nature of the industry, the long procurement cycle that makes budget planning complicated, the complex regularisation process of innovation, and a lack of interest from bigger companies in the industry. Governments have traditionally been cautious about contracting with new and unproven technology providers. However, this seems likely to change in the future, and SMEs and start-ups may experience fewer obstacles.

The Applicability of Defence Innovation, Development Directions and Catalysing Factors

It was widely assumed that the next war would be fought by unmanned technologies supported by artificial intelligence. However, the production of conventional firearms is at full capacity, and the rising demand is creating continuous supply shortages. According to a respondent, “now the problem is that we are fighting a twentieth-century war with twenty-first-century technologies” (Interview 7). From a technological perspective, disruptive innovation is interesting, as it offers a new approach to solving defined problems, but its applicability is questionable as there are rarely occasions to test disruptive innovation in real circumstances. Moreover, if the degree of novelty of an innovation is significant, and

its utilisation differs substantially from that of equipment defined in military doctrines, its adaptation may involve a long and complex legal process. “Even if an innovation has a great technological advantage, if it differs significantly from the technologies that soldiers use, they will not be able to use it, as we have seen in Ukraine” (Interview 19). Moreover, in the absence of training for the utilisation of new types of equipment, users may not be able to operate it, so the latter will not be ready for immediate deployment, an issue which has caused numerous problems in the case of the Russo-Ukrainian armed conflict.

Engineers and military personnel with operational experience need to work together to develop technological innovations that can be deployed. “The ideal situation would be if a soldier who has experienced real war retires, graduates from engineering school, and starts designing, but this rarely happens” (Interview 16). Several companies have engineers with outstanding skills, but without any operational experience; thus, innovations do not always meet the needs of the armed forces, which can lead to severe problems with their application. “It is usually not military experience that contributes to the development of a new device, but the ability of engineers” (Interview 7). The purpose of the lengthy testing process for new defence equipment is to identify issues with its application, but due to bureaucratic reasons information useful for further product development usually gets lost among the actors or is not even conceived of. According to the experiences of the respondents, these reasons include the number of middlemen between the developer and the tester, the tester’s desire for compliance or obeying superiors, or soldiers’ training, which emphasises adapting to equipment that is available under every circumstance.

Recently, the further development of conventional equipment with a long history of use has been one of the forms of innovation in most demand on the market. The Russo-Ukrainian war has proven that certain capabilities, such as artillery which is responsible for a large portion of the casualties, are very crucial and their effectiveness can be enhanced with certain innovations. “To strike at the enemy’s hinterland, there is no longer a need for innovative and costly strategic bombers or ballistic missiles; often, their roles are replaced by inexpensive and easily accessible drones and improvised short-range missiles” (Interview 18). Furthermore, “with current technologies, technical solutions can make conventional arms more effective, like GPS or laser-guided munitions” (Interview 12). However, the motivation for innovation is often reputation-building and the potentially large profit. Also, from the perspective of citizens, implementing disruptive technology can lead to tangible economic growth, so decision-makers usually force the development of the latter kinds of projects instead of manufacturing conventional equipment. According to a respondent, “currently, the development of disruptive innovation is not necessarily the right direction” (Interview 22). From another perspective, “it is questionable how long the great aspiration for innovation is sustainable in the industry” (Interview 4).

Many arguments favour developing conventional arms, but the purpose of every war is to create an asymmetry, which can be achieved through innovation. The direction of defence innovation is also characterised by whether the nation adopts a defensive or offensive

strategy⁵ and is dependent on political, economic, and technological decisions. From a technological point of view, a defensive strategy is more expensive and requires more innovative technologies, so is challenging to sustain for a long period, while an offensive posture can be maintained with readily available, inexpensive equipment. Many states focus on new technologies and complex weapon systems because this is associated with several advantages for a nation, such as economic benefits, promoting strategic independence, and creating a significant advantage for the country's military, thus supporting national security. In one respondent's opinion, "when a state develops new technologies that offer strategic and tactical advantages, it contributes to the formation of strategic alliances and diplomatic relations through export activities" (Interview 14). Being a leader in defence innovation also makes a nation better equipped to face unknown threats.

In the defence industry, technological innovation occurs every day, placing great pressure on market actors. In the past, a technological innovation with a high level of novelty that could not have been produced economically, given the capabilities of the industry at the time, could have been shelved for a few years and later retrieved and presented to market. However, under the current market circumstances, innovations must be introduced immediately, even though they may not be ready.

One of the major directions of innovation in the defence industry is developing novel technologies that can reduce human casualties, such as unmanned autonomous systems. Satellite-based surveillance and global positioning systems that provide real-time images are also forms of innovation that have created significant tactical advantages and notably increased the effectiveness of artillery. "The soldier can see live data on his mobile phone and get a complex real-time picture of the current situation that gives him a huge advantage because from now [from that point on] it doesn't matter if the weaponry that is used was delivered two weeks ago or 30 years ago" (Interview 13). "Knowing in advance what is where and when is the biggest possible advantage" (Interview 17). Information-technology-based innovation, such as artificial intelligence and machine learning that support decision-making, cyber warfare prevention systems, quantum computing, and directed energy weapons, are the forms of innovation most demanded in the field of defence.

From the perspective of defence innovation, catalytic factors are often armed conflicts that happen geographically close by or involve allies, such as the Russo-Ukrainian armed conflict. However, changes in the warfare environment are only one of the factors that highlight the importance of developing technologies to protect critical national infrastructure and prevent hostile attacks. The need to protect a country from threats such as terrorism, advances in technologies, innovation developed for civilian use, international competition, or the transformation of the legal environment are all catalytic factors. Several technological innovations applied in Ukraine were developed based on experience obtained during deployment in Iraq and Afghanistan. However,

⁵ The purpose of a defensive strategy is to maintain the *status quo*; an offensive strategy aims to change it.

as reported by the interviewees, many forms of innovation developed for operations in desert climates cannot operate well during a European winter, and problems have emerged during their deployment.

Discussion

In the current geopolitical environment, the importance of maintaining a local defence industry is increasing. Based on the literature, an effective defence industry can be achieved only through international collaboration for most nations. The respondents also described how these alliances play a significant role in component and raw material acquisition, production, and ameliorating the impacts of the supply crisis. On the contrary, the results of this research lead to the conclusion that, under the current circumstances, European decision-makers are hesitant to engage in cooperation with other nations. Despite the theoretical advantages, there is only limited cross-border cooperation within the European defence industry, due to the fact that these alliances pose numerous national security risks for nations. Given the current unpredictable geopolitical circumstances, shifting national interests may interrupt joint developments, disrupt supply chains or trap nations in conflicts that they have no interest in. Taking into account the geographical proximity of the Russo-Ukrainian war, countries primarily aim to enhance their own defence capabilities, treating the interests of other nations as secondary. The strongest strategic position for a country is achieved when its national defence industry is independent of any foreign entities for raw material acquisition, armament production and RDI. However, complete independence is not feasible for most European countries.

The conclusion that can be drawn from the interpretation of international collaborations is that theoretical research related to the operation of the defence industry generally describes an ideal state. However, when examined from an empirical approach, in reality, under the current circumstances, the industry does not function in an idealized scenario.

According to the collected empirical data, the development of innovative technologies can provide strategic and tactical advantages through export activities, contributing to the formation of alliances and the support of diplomatic relations. Furthermore, offering military technological innovations to other nations, or refusing to supply defence equipment, is frequently employed as a strategy for asserting political interests.

Based on the results of this study, SMEs and start-ups are the pioneers in defence innovation and play a prominent role in addressing the emerging crisis in the industry. SMEs and start-ups can operate profitably in the defence industry if they focus on improving conventional arms, developing new technologies in response to a specific need, or supplying customer demand. Many innovations are developed through domestic collaborations between SMEs. These companies, with professional knowledge, may be able to identify and supply market niches, generating significant profit. This becomes more feasible if an individual with battlefield experience is employed and if the state's strategic objectives are

considered during the RDI projects. SMEs and start-ups can also develop components and supply larger defence companies.

Currently, the biggest issue for SMEs is to acquire the capital for developments. As investor culture has shifted towards sustainable, ethical, and pacifist directions over the past decade, neither large investment firms nor banks provide capital for defence technology development. To develop a long-term sustainable local defence industry, it would be necessary to rapidly transform the investment culture, considering the war at Europe's borders. Although there is already a willingness among private investors to finance the development of dual-use or military technologies, this is not sufficient at a national level.

The collected empirical data shows that although the defence industry is one of the most innovative sectors, there has recently been strong demand for conventional equipment and the further development of conventional technologies. Some respondents argue that disruptive innovations can be effective in practical deployments, while others contend that they are only technologically interesting and otherwise unnecessary. Numerous military technologies deployed in the Russo-Ukrainian war have been mistakenly labelled as innovations (e.g., the military use of civilian drones, or reconnaissance and electronic warfare equipment), despite existing for several years, but were only employed for the first time in a real armed conflict where the opposing parties possess almost identical technological capabilities.

Innovation is important for maintaining national security and staying competitive, but the current geopolitical situation may change the direction of technological development. From a technological viewpoint, disruptive innovation is interesting, but its battlefield applicability is questionable. The catalytic factor for defence innovation is frequently an armed conflict that happens geographically nearby or involves allies, and the direction of defence innovation always depends on whether the nation adopts a defensive or offensive strategy. The interviewees agreed that the Russo-Ukrainian war has been a significant catalytic factor in the field of military technological innovations.

Conclusion

Since the end of the Cold War, the defence industry has been completely transformed. These changes, such as governments reducing their participation in sustaining the defence industry, have provided a great opportunity for SMEs and start-ups to obtain a share of the industry and supply the market with disruptive innovations. The war in Ukraine is the first modern, non-asymmetric war fought by opponents with an almost equal technological background since World War II. What makes this situation interesting is that this is the first real opportunity in modern times to test disruptive new technologies under real circumstances, as opponents can utilise their latest technologies. Under these conditions, the demand for conventional arms and new technologies has skyrocketed. To ensure that innovations are suitable for deployment, they need to be tested against other

advanced technologies, which is the key factor in this situation. For the researcher of war, this represents a great experiment during which theories can be tested, the consequences of which will reshape the warfare of the future.

This research suggests practical implications for SMEs and start-ups by providing an overview of the nature of the transformation of the industry and offering information on the current trends in the defence market. Recently, the market has demanded conventional equipment in significant quantities and the further development of conventional technologies. Interest in dual-use innovations and new technologies is also significant. The results of the research emphasize the importance of continuous analysis of the external environment because it supports SMEs in detecting demands, upon which they can develop innovations. SMEs are provided with opportunities to enter the defence innovation ecosystem through the industry development efforts across Europe; however, acquiring the necessary capital for development projects may be difficult.

The results also support policymakers in making long-term decisions related to the development of the defence industry capable of maintaining national security. This research draws attention to the necessity of cultural changes in this field. A long-term sustainable and effective industry cannot be achieved solely through the importation of armament and other equipment; it also requires the support of local SMEs through government programs and the provision of financial resources. To achieve this, it is crucial to eliminate ethical expectations towards banks and investors. From the perspective of strategic arms manufacturing, nations must make efforts to be as independent from foreign entities as possible to reduce the risk of supply crises. By developing the local defence industry, in which innovative SMEs play a crucial role, the nation will be able to protect its citizens in unexpected geopolitical situations.

An important element in developing the local defence industry is domestic ammunition manufacturing, because there is always a demand for ammunition, making it recession-proof. Furthermore, an ammunition manufacturing plant can be adapted quickly to meet new demands. Replenishing ammunition stocks and meeting the urgent needs arising from the war in Ukraine are also essential.

The development of defence innovation must be driven by increased attention to the external environment to help identify and understand catalytic elements, knowledge about what competitors are developing, which organisations fund what, and the ability to draw forward-looking conclusions from data that is collected. A new military technology may emerge as an innovation initially deemed unnecessary; however, as the market adapts, it becomes widely adopted, or it could represent a technological breakthrough developed specifically to address a long-standing issue. The findings indicate that the main direction of innovation is the development of technologies that reduce human intervention and human casualties (but from another perspective, these new technologies can cause more casualties for opponents). In addition, countless forms of advanced protective equipment

would significantly increase the protection of individuals, but the latter is often expensive, and defence budgets are usually limited.

Respondents' opinions about the necessity of disruptive defence innovation differ in the current circumstances. Some respondents state that innovation is critical for maintaining national security and staying competitive. Still others think that disruptive innovation is only interesting from a technological perspective but otherwise unnecessary. The decision to adopt an innovation is also influenced by individual emotional, cultural, and aesthetic factors, which are often more significant than rational arguments. Decision-makers frequently cling to traditional equipment and face difficulties integrating innovations into the existing arsenals and military tactics. Furthermore, since there is not always time to train soldiers on its use during an active armed conflict, the full potential of many new military technologies remains untapped. However, many nations still prefer to finance the development of disruptive innovation, as it promotes tangible economic development for citizens. Another issue with disruptive defence innovation is that some products are introduced when not fully operational, due to fierce competition and market pressure.

The absence of training associated with the utilisation of defence innovations has caused numerous issues during the Russo-Ukrainian armed conflict. The findings of this study emphasise the importance of educating soldiers on the utilisation of new technologies because their inability to use the latest equipment may have fatal consequences.

Despite rapid technological development, humans will always remain critical elements of strategic and tactical decision-making. Decision-making requires a large amount of up-to-date data that is too much for the human brain to process, and novel technologies can significantly help in this process, but final decisions are always made by the most crucial element of the system, the accountable humans. This emphasises the importance of the human factor in the defence sector and highlights that no nation can base its national security on technological innovation alone. To successfully defend a nation from threats, manpower is needed that follows orders when necessary. If there is no one to operate state-of-the-art defence technologies, the latter are useless.

Further research is needed to identify additional features associated with the complex field of the defence industry. In particular, more research should be conducted on how the culture of the defence industry should be transformed to prepare for and maintain national security in the event of unforeseeable crises. Further research could also explore how SMEs and start-ups can be better coordinated to decrease the fragmentation of the defence industry. The operational challenges that disruptive innovation leads to and their consequences for the warfare of the future can also be examined.

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