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Main Challenges Facing the European Defence Industry in Light of the Russo-Ukrainian War

The European defence industry faces significant challenges in light of the Russo-Ukrainian War, which has exposed critical vulnerabilities in its ability to meet the urgent demand for defence materiel and platforms. This paper examines the "defence industrial trilemma" – the delicate balance between technological excellence, economic competitiveness, and security of supply – as a key factor shaping the industry's future. It highlights the critical role of supporting sectors – namely the steel, chemical, semiconductor, and industrial robotics industries – in maintaining Europe's defence readiness. The analysis reveals that stringent EU regulations, soaring energy costs, and a heavy reliance on foreign suppliers hinder these industries' growth and competitiveness. For the EU, strengthening these sectors is essential to mitigate dependencies on external supply chains and ensure Europe's long-term defence capabilities in an increasingly volatile global landscape.

Keywords
European defence industry, defence industrial trilemma, defence innovation, security of supply, economic competitiveness Russo-Ukrainian War

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Introduction

The European defence industry stands at a critical crossroads, shaped by the complex interplay of geopolitical tensions, technological advancements, and economic pressures. The Russo-Ukrainian War has starkly exposed vulnerabilities within the European Defence Technological and Industrial Base (EDTIB), highlighting its struggles to meet urgent demands for ammunition, advanced weaponry, and critical materials. These challenges are compounded by the need to balance three competing priorities: technological excellence, economic competitiveness, and security of supply – a framework referred to as the "defence industrial trilemma".

Technological excellence remains a cornerstone of modern defence capabilities. European nations must equip their armed forces with state-of-the-art systems that are not only effective but also adaptable to rapidly evolving battlefield conditions. However, as recent conflicts have demonstrated, technological sophistication must be paired with usability and modularity to address the realities of high personnel turnover and prolonged platform lifecycles. At the same time, economic competitiveness is essential to ensure that defence spending delivers value for taxpayers while sustaining the industry's ability to innovate and export. Without cost efficiency, nations risk compromising either their security or their broader economic stability. Finally, security of supply has emerged as a paramount concern in an era of globalized supply chains. The ability to secure essential materials and equipment during both peacetime and crises is vital for operational readiness and long-term resilience.

The European Union's (EU) defence industry also relies heavily on key industrial sectors – steel, chemicals, semiconductors, and robotics – which form the backbone of its supply chain. These industries face their own distinct sets of challenges, ranging from high energy costs and regulatory burdens to global overcapacity and competition from less-regulated regions, particularly, Asia. For instance, the steel industry is grappling with ambitious decarbonization goals that strain profitability, while the semiconductor sector struggles with limited domestic production capacity and a deep reliance on foreign suppliers. Similarly, the chemical industry faces declining production volumes due to high costs and regulatory pressures, while the robotics sector contends with uneven adoption across EU member states.

This paper explores the main challenges facing EU member states' defence industries in light of these interconnected issues. By examining the defence industrial trilemma alongside the structural difficulties within key supporting sectors, it aims to provide a comprehensive analysis of European states' readiness to address emerging threats and maintain strategic autonomy. Strengthening these industries through targeted policies and investments is imperative to bolster European defence capabilities and reduce reliance on external supply chains in an increasingly volatile global landscape. The review of EU policies and industrial sectors is current as of April 2025.

1. Conceptual Framework

1.1. Methodology

This article employs a theory-informed, mixed-methods desk research design to analyse the EDTIB through the lens of defence economics regularities and the defence industrial trilemma. Building on an extensive review of academic literature, policy studies, and institutional documents, the study synthesises existing debates on technological excellence, economic competitiveness, and security of supply, situating them within the broader context of European value chains in the steel, chemical, semiconductor, and industrial robotics industries. The Russo-Ukrainian War is used as an empirical stress test to reveal structural vulnerabilities in these interlinked sectors.

Empirically, the study integrates value chain analysis, network analysis, and sectoral statistics. Value chain analysis is used to map the positions and functions of key European firms and industries along critical defence-related supply chains, from upstream raw materials to final defence products. Network analysis techniques are applied to public data on ownership structures, foreign direct investment, and cross-border industrial linkages to capture the density and direction of dependencies within the EDTIB and between internal and external actors. These qualitative insights are complemented by descriptive statistics from sectoral datasets – including steel output, chemical production indices, semiconductor capacity, robot density – as well as the systematic use of defence-industrial reports and official documents, which provide time-series information on production capacities, trade flows, and investment trends.

The study also incorporates price data for representative defence products – such as ammunition and armoured platforms – to illustrate characteristic patterns of defence inflation and cost dynamics in concentrated, high-fixed-cost industries. Triangulation across academic publications, policy reports, industrial statistics, and defence-industry analyses is employed to enhance the study's validity, while explicit distinctions are maintained between peer-reviewed sources, institutional reports, and media coverage, the latter of which do not carry the same evidentiary weight. The empirical coverage of EU policies and industrial indicators extends up to April 2025, ensuring that the assessment of EDTIB performance and supply-chain resilience reflects the most recent regulatory and market developments addressed in the article.

1.2. Literature Review

The European defence industry operates within a complex environment shaped by technological innovation, economic competitiveness, and security of supply, a constellation often conceptualised as the "defence industrial trilemma" in peer-reviewed literature (Blockmans, 2026). Scholars such as Fiott (2023) and Hartley (2017) highlight how efforts to maximise technological excellence, maintain cost efficiency and ensure resilient supply chains inevitably generate trade-offs that constrain the overall effectiveness of the EDTIB. Building on earlier research on defence innovation and military transformation, Addington (1994), and, more recently, Evron and Bitzinger (2023) emphasise the growing need for platforms that are both technologically sophisticated and operationally usable, underlining the increasing importance of dual-use technologies and civil-military synergies in modern warfare. Complementing these perspectives, Meng et al.'s (2020) treatment of the "smile curve" in global value chains provides an analytical lens for understanding why midstream manufacturing activities tend to migrate to low-cost economies, contributing to the gradual erosion of industrial capacity in advanced regions such as the EU.

A second strand of academic research in defence economics and industrial organisation examines the structural features of defence markets, including defence-specific inflation (Dorn, 2024), high sunk R&D costs, and oligopolistic market structures (Bellais, 2024). Hartley and colleagues demonstrate that the fragmented procurement patterns,

national preferences for domestic suppliers, and limited export opportunities characteristic of EU member states weaken economies of scale and drive up unit costs relative to the more centralised systems of the United States and China. This literature also points to ownership structures – notably the predominance of publicly listed firms and the rise of foreign acquisitions in sectors such as steel, chemicals, semiconductors, and robotics – as a key factor shaping states' ability to align corporate strategies with national security objectives. Key cases, such as Liberty Steel and Midea's acquisition of KUKA, have raised wider concerns about industrial sovereignty (Kolisnichenko, 2023).

Policy and institutional documents further illuminate how the EU seeks to address these tensions through targeted initiatives. Instruments such as the European Defence Fund (EDF) (European Union, 2021) and Horizon Europe (Gabriel, 2021) aim to overcome fragmented defence R&D by fostering collaborative projects across member states, while the EU Chips Act (European Union, 2023b) represents an ambitious attempt to rebuild domestic semiconductor capacity and reduce strategic dependencies. At the same time, European Green Deal regulations and climate-policy frameworks impose stringent decarbonisation and environmental requirements on energy-intensive industries (Thormann et al., 2021) – a trend documented in detail by sector-specific reports from EUROFER (2023) and other industry associations. These policy sources highlight a persistent paradox, whereby measures designed to promote long-term sustainability and resilience can, in the short and medium term, undermine the cost competitiveness and investment capacity of industries that serve as critical suppliers to the defence sector (Dorakh, 2024).

Industrial statistics, sectoral reports, and online sources provide additional empirical evidence on how these dynamics play out in key supporting sectors. EUROFER data, Eurostat series, and company reports document declining output, rising input costs, and growing import penetration in European steel and chemical production, while industry analyses of the semiconductor and industrial robotics sectors point to capacity constraints, skill shortages, and intensifying competition from less-regulated regions (Huggins et al., 2023). At the same time, defence-industry reports and media accounts of the Russo-Ukrainian War illustrate the concrete consequences of these structural weaknesses, including shortages of ammunition, longer lead times for complex platforms, and increased exposure to bottlenecks in global value chains. Studies of military-civil fusion (MCF) in China

and the United States underscore how a more deliberate integration of civilian innovation ecosystems into defence planning can mitigate some of these vulnerabilities, whereas European states' comparatively limited experience with such arrangements is widely seen as a structural handicap (Gansler, 2011).

Despite this growing body of work, several gaps remain. First, existing studies rarely integrate value chain analysis, network analyses of ownership and control, and sectoral statistics into a single framework that links supporting industries – namely steel, chemicals, semiconductors, and industrial robotics – directly to EDTIB performance and security of supply under wartime stress. Second, there is limited research that systematically combines defence-economics regularities with empirical data on sectoral output, trade flows, and defence-related price dynamics to assess the affordability and scalability of European defence production. Third, while policy documents often describe individual EU initiatives in isolation, few analyses examine how their cumulative effects interact with structural vulnerabilities across multiple industrial sectors. This article addresses these gaps by applying value chain and network analysis, together with sectoral statistical indicators and defence-industrial reports, to explore how structural characteristics and recent policy and market developments in four key supporting sectors shape the EDTIB's ability to reconcile technological excellence, economic competitiveness and security of supply in the context of the Russo-Ukrainian War.

Accordingly, the guiding research question is: How do structural features and recent policy-driven changes in European steel, chemical, semiconductor, and industrial robotics industries affect the capacity of the EDTIB to balance technological excellence, economic competitiveness, and security of supply under the pressures revealed by the Russo-Ukrainian War?

2. The Conceptual Model: The Defence Industrial Trilemma

The analysis of the operation of the EU's defence industry based on a model we developed, which we call the "defence industrial trilemma" or the "iron triangle of the defence industry" (Taksás, 2019). The model is based on the requirements imposed on the defence industry by the armed forces both in the past and present. This concept encapsulates the necessity of balancing three critical criteria: technological excellence, economic competitiveness, and security of supply. These interconnected pillars dictate the effectiveness of the defence sector in supporting military operations, ensuring strategic autonomy, and maintaining economic sustainability. However, achieving equilibrium among these priorities is a persistent challenge, particularly in light of recent geopolitical, economic, and technological developments, such as globalisation and transnational value chains, the Fourth Industrial Revolution, and the fundamental shift in the nature of warfare presented by the Russo-Ukrainian War. This section explores these three dimensions in detail. Understanding these enduring requirements for the defence industry provides the foundation for a comprehensive overview of the factors influencing the defence readiness and strategic autonomy of EU member states.

2.1. Technological Excellence

Technological excellence dictates that the defence industry needs to equip soldiers with state-of-the-art weapon systems to fight successfully. However, it is not enough for these systems to be highly effective, they must also be relatively easy to use. This is because, as the ongoing Russo-Ukrainian War demonstrates, a significant proportion of the soldiers who go into combat will become casualties in the first phase of the war (Jones & McCabe, 2026) and those who replace them will not have the luxury of many years to learn the routine, yet effective use of these complex weapon systems. Technological excellence also means that equipment and weapon systems must be relatively easy to upgrade, since militaries typically maintain platforms in service for long periods, even decades (Baldwin & Clark, 2000). Meanwhile, the accelerating pace of technological development frequently renders certain battlefield solutions obsolete, unless they can be somehow integrated dynamically into existing platforms.

2.2. Competitiveness (Affordable Prices)

Second, the defence industry must be efficient and competitively viable. Taxpayers are far from indifferent to the costs of acquiring military defence. If a country's defence industry is not competitive – meaning it produces its products and services at a higher cost than foreign competitors – either the country will be forced to purchase less military equipment, thereby lowering its level of defence, or if it develops the same capability, it will cost much more and leave fewer resources for other important areas (such as education, healthcare, public transport, etc.). A third possibility is that the state, compared to other countries, will collect more revenue in the form of taxes from economic actors to finance these more expensive military procurements. This, in turn, undermines the market position, competitiveness, and employment rates of domestic companies and reduces household income for spending and saving. Thus, no matter which of the three scenarios unfolds, the direct consequence of an uncompetitive defence industry is either a compromise in national security or a decline in the population's living standards. In addition, the scarcity of resources caused by overspending on expensive equipment makes the broader economy and society less competitive, which ultimately erodes long-term defence industrial potential. The second reason why it is important for the defence industry to remain competitive is that the sector needs to be able to export its products and services in order to survive, since no country's armed forces can sustain their domestic defence industry on their own in the long term. Therefore, exports and competitive prices are essential to maintain operational capacity, especially in R&D and manufacturing, even if military procurement in the defence sector is often determined by political decisions.

2.3. Security of Supply

The third criterion, security of supply, dictates that the defence industry must be able to serve its customers both in peacetime and in times of crisis. This entails providing the materials and services needed to keep military platforms operational, as well as meeting surged demands in the event of a military conflict, to replace destroyed equipment and consumed stocks. If the defence industry is incapable of fulfilling this role, operational capability is compromised and, in the event of a protracted conflict, the country concerned will inevitably

face defeat. With global value chains now fully transnationalized, security of supply is perhaps the most critical factor in highly complex military technology systems. Because so many companies from various nations are involved in the production of the final product that the vulnerability of the supply chain is extremely high (Office of the Under Secretary of Defense for Acquisition and Sustainment & Office of the Deputy Assistant Secretary of Defense for Industrial Policy, 2018).

2.4. The Struggle for Maintaining Balance within the Trilemma

As noted at the outset of this chapter, it is becoming increasingly difficult to maintain a balance among the three requirements. This is because the internationalisation of knowledge and supply chains, the accelerating speed of technological development, and the specialization of national economies within the global division of labour are disrupting the framework of the trilemma. Technological progress during generational leaps significantly increases the complexity and intricacy of military platforms, as well as the vulnerability of their supply chains. This, in turn, drives significant cost increases that outpace inflation and requires the involvement of an increasing amount of foreign expertise. Therefore, pursuing technological excellence often compromises both affordable prices and security of supply. Meanwhile, strengthening the security of supply means forgoing foreign expertise in our equipment, which certainly reduces its technological excellence while increasing costs for two reasons. On the one hand, defence innovation synergy decreases, meaning we have to redevelop solutions that already exist or have been proven elsewhere. On the other hand, we give up foreign components and parts that are more cost-effective either because they were produced in countries with lower labour costs or due to greater economies of scale. As a consequence, security of supply can conflict with technological excellence and affordable prices. Third, although domestic development may be the cheapest solution in terms of lifecycle cost, this is only the case for countries with the most advanced defence innovation ecosystems. Therefore, in most countries, price reductions are associated with a loss of technological excellence and the integration of foreign expertise, i.e., a decrease in the security of supply.

3. Addressing European Union Defence Industrial Challenges in Light of the Russo-Ukrainian War

While globalization and technological developments in recent decades have created considerable tension between the three criteria (Gansler, 2011), the overall picture of the European defence industry has remained largely static (Alvarez-Couceiro Fernandez, 2023). Enjoying the peace dividend, the European nations have existed (still exist?) in a state closely resembling what the US academic literature terms a "battleship-building holiday" from the US interwar period (Addington, 1994). Crucially, even the Russian annexation of Crimea failed to trigger a substantial shift (Waszkiewicz & Taksás, 2023). Looking at the three criteria, it is questionable whether the European defence industry can compete with its global and regional rivals on any of them. However, it is indisputable that security of supply remains profoundly fragile. This vulnerability is starkly illustrated by current data and events; for instance, during periods of intense combat, Ukrainian artillery can deplete the entire European monthly production of 155 mm artillery ammunition in a single month (Alvarez-Couceiro, 2023). Furthermore, at the end of 2022, Nammo, one of the leading European ammunition producers, announced that a local TikTok data centre was consuming so much energy that it restricted the company's capacity to expand production – even as war raged on European soil (Yerushalmy, 2023).

Therefore, this analysis examines some of the most pressing questions, where implementing solutions is of the utmost urgency. While we do not claim to propose complete solutions to problems that have persisted for decades and continue to be investigated by groups of researchers and experts, we believe that highlighting and structurally presenting these elements of dysfunction can help shape common European thinking and pave the way for viable solutions.

3.1. The Eternal Dilemma: Balancing Competition and Economies of Scale

The perennial question for the European defence industry is whether to increase competition or economies of scale (Di Paola et al., 2016). After all, the EU economy is fundamentally based on competition because of its positive economic effects, which underpin the success of integration, as demonstrated by the growth superiority

of Western European economic integration based on competition over Eastern European economic integration based on economies of scale during the Cold War. Competitive innovation and efficiency gains are thus the cornerstone of European industrial policy, which the EU is not prepared to abandon even when successful competition with global players might require European companies to do so (Szűcs, 2018). A good example of this is the prohibition of the merger between Siemens and Alstom, after a long debate (European Commission, 2019). The defence sector is in many respects an exception to EU rules, and therefore not necessarily subject to strict competition regulations (Gombos & Szűcs, 2019), meaning that the question has long been raised whether there is a need to promote greater economies of scale in this sector, either directly or indirectly. And if the answer is yes, the next question is: is there a realistic chance of achieving this in practice?

The defence industry is characterised by a high proportion of R&D costs relative to total costs, which, combined with low unit sales, results in a high unit cost of development within the overall price of the product (Hartley, 2023). Thus, economies of scale in this sector can help to mitigate the already huge defence (hyper)inflation, as illustrated by the fact that US economic policy, which is also sensitive to internal market competition, and Chinese defence policy, which is based on a vast internal market, typically only maintain two companies in the major defence platform markets. The much smaller European defence market has a much larger number of firms on the supply side, but the potential benefits of competition are not really felt, as there is no real competition because nations always prefer their own domestic defence industrial companies for procurement (Fiott, 2023). There are both security of supply and historical reasons for this. On the one hand, all armed forces prefer to have the shortest possible supply chains in the event of war, and by extension, the closest possible production and repair capacities. This remains at the forefront of the minds of politicians and military leaders, even if, due to the complexity of the platforms, a large number of important components will be imported, regardless of whether the assembly of the platform itself takes place geographically in the territory of the given country. On the other hand, the direct role of the state (and with it taxpayers' money) is always paramount in the defence equipment market, and the long and often bitter history of Europe lives on in the public consciousness to such an extent that it would be difficult for politicians to justify why significant German taxpayers' money is going directly or indirectly (e.g. through

procurement) to the development of French military equipment, or Polish taxpayers' money to German equipment, or Romanian taxpayers' money to Hungarian equipment, among numerous other examples. Consequently, we face a Catch-22 situation where a European defence industry capable of meeting these requirements (the trilemma) cannot develop through genuine competition and/or consolidation, while there is no realistic chance of either occurring. The second-best option is therefore cooperative programmes; however, their effectiveness and success rate remain very low for a number of reasons (Bellais, 2023). While most successful examples of joint European programmes can be found in the aviation industry (Hartley, 2023), but the Russo-Ukrainian War highlights that the Fourth Industrial Revolution has driven a new technological shift in warfare in favour of defensive technologies. This limits the role of conventional air and naval forces in combat, as their overly expensive platforms have simply become too vulnerable. Consequently, in addition to significantly modifying or even completely rewriting military doctrines, there is a pressing need to rebalance the distribution of defence R&D costs (Johnson, 2022), potentially favouring the development of land-based platforms within a much more fragmented European industrial base (Chinn et al., 2024) could be favoured.

3.2. Full Spectrum of Specialization

Another question that often arises is whether the European defence industry should cover the entire spectrum of warfare with its products or whether it should engage more deeply in global cooperative projects, thereby developing its comparative advantages in specific areas. The latter approach would provide an opportunity to export high value-added components in return for cheaper access to technology and complete platforms for the European defence sector (Jan, 2007). This niche industry model (Saputra et al., 2024) is typically the proposed development path for defence industries in smaller countries (Petkovics, 2016), and understandably, US partners tend to advocate this for the overall EDTIB (Burton, 2023). From a purely economic perspective, this would probably yield a higher return on taxpayers' euros, but the Russo-Ukrainian War has re-prioritized this aspect as well. The war highlights Europe's need for a sovereign self-defence capability, which in turn requires the widest possible spectrum of defence industrial products. The protection of 500 million people

simply cannot depend on the capacity of distant suppliers, especially when there are strategic threats in the immediate neighbourhood.

However, the transnationalization of industrial and service value chains means that even a European economy with huge economic potential cannot become entirely self-sufficient in defence, let alone at the highest technological level and at affordable prices. This inevitably brings us back to the defence industrial trilemma again. Indeed, if Europe cannot produce a wide range of cutting-edge platforms at affordable prices, it will have to consider a step back in technology. This shift would increase security of supply, lower prices, and allow European forces to equip themselves with a much wider spectrum of European equipment and in much larger quantities. Crucially, this approach would also facilitate the transfer of a significant portion of current stockpiles to Ukrainian forces. A step backwards in applied technology may, at first glance, seem counterintuitive, as it runs counter to economic and military evolution. However, the Warsaw Pact military doctrine demonstrates that although less advanced, systematically produced equipment was plentiful, quickly replaceable, and easily repairable. Furthermore, it could even be "cannibalized" – meaning the use of operational parts from a damaged vehicle to repair another – directly in the operational theatre. This streamlined not only production but also logistical efforts during wartime, a process further aided by the seamless interoperability resulting from Soviet dominance across the equipment pool. This is roughly the strategy currently employed by Russia in the Russo-Ukrainian War (Schwartz et al., 2023). In fact, US experts expect a significant technological setback in their own military in the event of a protracted war (C. Julie Kelly et al., 2020; Cancian, 2017). While this is not a panacea for the European defence industry or European defence capabilities, at least one of the requirements of the defence industrial trilemma must be compromised, as priorities between the three requirements naturally shift over time.

3.3. The Issue of Military-Civil Fusion in Europe

Another major issue highlighted by the Russo-Ukrainian War is the question of MCF in Europe. It has long been recognized that civilian industries – due to their larger markets and consequent research and development capacities – have surpassed the defence sector in many areas of technological development. Consequently, the

involvement of civilian companies in enhancing defence capabilities has become essential. In terms of technology flow, the discourse has expanded beyond simple "spin-offs" to include "spin-ons" and even "spin-aparts" (Evron & Bitzinger, 2023). We also know that the very concept of MCF originated in China, where it is an important element of both economic and defence strategy, and we see the essential role that US civilian – especially technology – companies play in supporting the Ukrainian war effort. However, support for defence capabilities is far from clear and seamless from US tech firms, as seen in the Maven scandal (Crofts & Rijswijk, 2020) or the controversy surrounding the utilization of the Starlink system in the Russo-Ukrainian War. Nonetheless, the third offset strategy produced significant results in terms of attracting civilian technologies and knowledge and since then there have been further efforts in the field (Evron & Bitzinger, 2023).

Meanwhile, the EU has much less experience with MCF than its competitors, since it has never been given the same emphasis in state policies (neither at the member state nor at the EU level) as in other countries of the world with advanced defence industries. Therefore, one of the biggest challenges of the European defence innovation system is that civilian actors (civil companies, manufacturers, labs, research institutes, universities, joint ventures, business angels, etc.) and the defence actors (the military itself, military research centres and testing facilities, troops on the ground) barely know each other. Due to the decades-long peace, a new generation of scientists, researchers, and managers has grown up who has never had any link with the military, has never even served as conscripts, and has never seen any business opportunities in the defence industry. Because of budget constraints, the new generation of military commanders has barely had a genuine desire to participate in defence innovation, thus they have never had to understand how innovation and business management operate. This war is calling for a new level of defence innovation with ever-increasing civil participation, but as it is well known, changing behaviour and culture is by far the most difficult goal to achieve. The European Defence Innovation Scheme serves this purpose, though its effectiveness and efficiency can only be trusted for the time being.

4. The Struggle of Core Industries Supporting European Defence Supply Chains

As described in the conceptual model above, security of supply is one of the most challenging requirements in the defence industrial ecosystem. Data from the Russo-Ukrainian War shows that even the gradually more sanctioned and, at the same time, mobilized Russian economy and defence production are struggling with their disconnection from external supply chains (Bergmann et al., 2023; Boulègue, 2025). The increase in the EU's production capacity described in the preceding chapter can only be realized if companies providing components or raw materials for the defence industry are also able to enhance their production. Therefore, to gain a comprehensive understanding of the European defence industry, it is essential to analyse its entire supply chain. This undertaking requires substantial effort, but a brief review of four key sectors – the steel, chemical, semiconductor, and industrial robotics industries – provides crucial insights into the broader context of the current situation in European defence manufacturing.

It is important to emphasize that, unlike their Russian counterpart, both the EDTIB and its supply chains operate under a peacetime rhythm and regulation, so their capacities have not been mobilized to achieve higher production volumes. However, on the other hand, hand, it must also be taken into account that – based on the experiences of the COVID pandemic and the Russo-Ukrainian War – the mobilization of a modern economy is not nearly as simple and fast as, for example, during World War II. That is why examining peacetime data is important and also provides a comprehensive picture of European defence capabilities.

4.1. Steel Industry

The Russo-Ukrainian War has underscored the critical shortages in the EU's capacity to replenish ammunition stocks and produce new weaponry. The European steel industry is pivotal in providing the necessary foundation for these material-intensive products. Two of the most urgent challenges that have emerged in supporting Ukraine (Szőke & Kusica, 2023) are the production of 155 mm artillery shells and the manufacturing of armoured combat vehicles, such as main battle tanks (MBTs) and infantry fighting vehicles (IFVs) (Aries et al., 2023).

The EU's steel industry is grappling with numerous challenges. Ambitious decarbonization plans and climate goals set by the EU are placing additional strain on an already struggling sector, which is also dealing with high energy prices, low demand, and global overcapacity. This situation results in cheaper procurement alternatives from abroad, further compounding the industry's difficulties – as evidenced by a joint letter from European steel industry leaders to the heads of EU member states pleading for urgent action (EUROFER, 2024a).

Excess capacity in the global steel industry poses a significant challenge, with production volumes surpassing global demand by 543 million metric tons in 2023 and resulting in an industry operating at approximately 78% capacity. Despite this imbalance, investment – particularly in Asia – continues to expand rapidly. Global demand is projected to grow at a modest rate of about 1.9% annually until 2026, while an additional 157 million metric tons of capacity are either planned or under construction (EUROFER, 2024b). The current global overcapacity is largely driven by the downturn in the Chinese steel industry, which has left domestic steel producers without significant orders (The Economist, 2024). As a consequence, this overcapacity distorts the market by artificially depressing prices , thereby making imports from Asia more attractive and profitable for European companies (Masanobu, 2024).

The capacity building of European nations is constrained by self-imposed regulations aimed at reducing the industry's carbon footprint. These regulations, such as the Carbon Border Adjustment Mechanism (European Union, 2023a), the Emissions Trading System (ETS) (European Union, 2008), Foreign Direct Investment Screening (European Union, 2019), and trade defence instruments, hinder direct investment within the EU. Combined with low demand and the availability of cheaper alternatives, these factors make achieving carbon neutrality a formidable challenge. Consequently, from 2018 to 2023, the EU's production capacity declined by 6%, while global capacity increased by 2.3%, driven largely by Chinese investment.

The most critical components of the steel industry are iron ore mining and crude steel production capacity. The EU faces a global disadvantage in both areas due to its limited mineral resources compared to other regions, a factor which necessitates substantial imports to support its crude steel production. In 2023, the EU collectively produced 80.2 million metric tons (Mmt) of iron ore, representing less than 4% of global production. This output covers only 25% of the EU's

crude steel production input needs, with the remaining 75% being imported primarily from Canada, Brazil, and Ukraine. Concurrently, the EU27's annual crude steel output of 126 Mmt accounted for 6.8% of the global total of 1,850 Mmt in 2023 (EUROFER, 2023).

The EU may not currently dominate the global steel trade, but it has the potential to lead in green steel production through innovative technologies. European Commission regulations are steering investments towards sustainable segments. However, the steel industry can only reinvest its profits when it is financially healthy. Key demand drivers, such as the construction and automotive sectors, are facing economic difficulties. The construction industry is impacted by reduced government infrastructure spending, while the automotive sector struggles with increasing imports from China. Additionally, rising energy prices are slowing European economies and further squeezing industry profit margins. Without sufficient cash flow, investing in carbon-neutral technologies remains a distant goal for the steel industry. Furthermore, additional regulatory burdens imposed by the EU are further eroding profitability (Vögele et al., 2020).

Starting in 2025, steel demand is expected to rise due to increased investments in wind energy installations. However, without expanding production capacity, this could trigger a surge in imports into the EU. One potential solution is to invest in a circular economy, where steel scrap is recycled (Torres de Miranda Pinto & Diemer, 2020). Currently, the EU is a net exporter of steel scrap, meaning that such materials leave the continent and are replaced by fresh imports of iron ore and crude steel from external sources. This situation presents a paradox, as the steel industry urgently needs investment in green technologies, yet the push for renewable energy – often funded by government initiatives rather than market forces – could increase reliance on imported steel. Consequently, taxpayer money may flow out of the EU due to the rising imports of steel products (IIGCC, 2024).

The ownership landscape of European steel manufacturing companies presents a compelling topic for discussion. Non-EU companies, unencumbered by stringent environmental regulations, enjoy healthier profit margins, which enables them to invest in capacity expansion and the acquisition of smaller firms. European companies, struggling under these regulations, are not immune to such takeovers. A case in point is the acquisition of Hungary's Dunaferr by the British Liberty Steel Group Holdings, which is itself owned by the Singaporean Liberty House Group. This acquisition means a portion of European

steel capacity – including facilities in Ostrava (Czech Republic), Galati (Romania), Dunaújváros (Hungary), Magona (Italy), and Czestochowa (Poland) – is now controlled by a foreign entity. Plans for this plant include transitioning from coal-powered technology to modern electric arc furnace technology. However, the technology is expected to be sourced from CISDI Engineering, a Chinese firm, rather than a European provider (Kolisnichenko, 2023).

The ownership structure of major European steel companies is characteristically complex, as the majority are publicly traded, rendering it difficult to determine precise national ownership. Significant acquisitions remain subject to rigorous scrutiny by the European Commission in order to evaluate their impact on the internal market and competitiveness. However, if the industry's stagnation persists, these regulatory criteria may come under increasing pressure. Implementing initiatives like the EU Steel and Basic Metals Action Plan is crucial to maintaining the EU's independence within the steel industry (EUROFER & IndustriAll, 2024). With adequate investment, revolutionary breakthroughs in steel production are attainable, as demonstrated by China's rapid development of novel flash ironmaking technology (Sohn, 2023). This innovation has the potential to significantly reduce carbon dioxide emissions and energy consumption compared to traditional blast furnace smelting. As the European steel industry approaches a critical juncture, investing in next-generation technologies is more crucial than ever. However, this progress may depend entirely on China's willingness to share or sell this cutting-edge technology to the EU, thereby raising questions about the EU's ability to secure its own technological independence (Sohn & Mohassab, 2016).

4.2. Chemical Industry

The European chemical industry is a cornerstone of the continent's industrial base, supplying essential materials to sectors such as the automotive, healthcare, agriculture, and defence industries. However, the sector is currently facing one of its most challenging periods in decades. High energy and feedstock costs, weak demand, and regulatory pressures have severely impacted production and profitability. In 2023, chemical production volumes in the EU declined by 6.6%, following a 7.6% drop in 2022. This downturn has left the industry struggling to maintain its competitiveness on the global stage (EUROSTAT, 2023).

The European chemical sector is grappling with several structural impediments. The region's stringent environmental regulations, including REACH (European Union, 2006) and the ETS, impose significant compliance costs on companies, thereby making it difficult to compete with producers in regions like Asia and the Middle East, where regulatory burdens are lighter. High energy prices in the EU exacerbate this disadvantage, with gas costs remaining substantially higher than pre-2021 levels (Di Bella et al., 2024). These factors have prompted many companies to mothball or permanently close production facilities, as exemplified by BASF's ammonia and caprolactam plants in Germany (Hutson, 2023) and Ineos' polyester raw material unit in Belgium (INEOS Group, 2024).

Global overcapacity in key petrochemical value chains further compounds the industry's difficulties. While the EU remains the second-largest producer of chemicals on the world stage, accounting for €760 billion in annual sales, its share of global chemical sales contracted from 17% in 2012 to 14% in 2022. This decline reflects growing competition from countries like China, which has rapidly expanded its chemical production capacity and now dominates global markets (EUROSTAT, 2023).

Despite these headwinds, the European chemical industry is positioning itself as a leader in sustainability and innovation. Significant investments are being made in green technologies, such as carbon capture and storage (CCS), renewable energy integration, and advanced recycling methods for plastics (Lau et al., 2021). These efforts align closely with the European Green Deal and the goal of achieving net-zero emissions by 2050 (Thormann et al., 2021). However, the transition to green chemistry requires substantial capital investment – estimated at $550 billion by 2050 – which many companies are struggling to secure amidst declining profitability (Yilan et al., 2022).

The EU chemical industry also faces a paradoxical situation: while it leads in developing sustainable solutions, such as high-tech plastics and safe chemicals, these innovations often fail to translate into competitive advantages due to high production costs and regulatory hurdles. Moreover, the sector's reliance on imports for raw materials and cheaper finished products from Asia undermines the EU's self-sufficiency and economic resilience. Looking ahead, demand for chemicals was projected to recover modestly, with a forecasted growth rate of 1.9% in 2024. Key drivers included increased investments in renewable energy technologies and a gradual normalization of demand

across customer industries such as the construction and automotive sectors. However, elevated interest rates and inflation continued to weigh on these sectors, limiting their capacity to stimulate significant growth (Chamier-Gliszczyński et al., 2023).

The ownership structure of European chemical companies adds another layer of complexity. Major players like BASF (Germany), INEOS (UK), Solvay (Belgium), and LyondellBasell (Netherlands) are publicly traded entities with diverse shareholder bases that complicate national oversight or strategic alignment within the EU's industrial policy framework. A case in point is the Hungarian MOL Group's acquisitions in Poland, which faced political opposition due to concerns regarding indirect Russian influence within the Hungarian company's ownership structure. Furthermore, some companies are increasingly shifting their investments abroad to regions with lower costs and fewer regulatory constraints. BASF's $10 billion production complex in China serves as a notable example (BASF, 2024), while the Dutch OCI has situated its new blue ammonia project in Texas instead of Europe.

To sustain its position as a global leader while navigating these impediments, the European chemical industry must strike a delicate balance between competitiveness and sustainability. Initiatives such as the Transition Pathway for the Chemical Industry aim to guide this transformation by fostering collaboration between governments, industry stakeholders, and research institutions. However, without targeted support – such as subsidies for green investments or relief from excessive regulatory burdens – the industry's ability to remain competitive on the global stage is increasingly uncertain. The European chemical industry stands at a crossroads: it can either seize the opportunity to lead the global transition towards sustainable chemistry or risk further decline under the weight of external competition and internal constraints (Darkow & von der Gracht, 2013).

4.3. Semiconductor Industry

The European semiconductor industry is a critical enabler of modern technologies, underpinning sectors such as the automotive, telecommunications, and defence industries. However, the industry's limited production capacity has become a strategic vulnerability, particularly in light of global supply chain disruptions and geopolitical tensions. European nations currently account for less than 10% of global semiconductor manufacturing, a sharp decline from their 24%

share in 2000. This dependency on external suppliers, primarily from Asia and the United States, has highlighted the need for significant investment in domestic production capabilities.

The semiconductor sector in Europe faces several impediments that hinder its competitiveness and growth. High production costs, stringent environmental regulations, and a lack of economies of scale make it difficult for European manufacturers to compete with their Asian counterparts. The region's reliance on imports for raw materials such as silicon wafers and rare earth elements further exacerbates its vulnerability. Additionally, the high capital intensity of semiconductor manufacturing – where building a single advanced fabrication plant (fab) can cost upwards of $10 billion – deters private investment (Huggins et al., 2023).

In response to these challenges, the EU has launched the EU Chips Act, a €43 billion initiative aimed at doubling European nations' share of global semiconductor production to 20% by 2030. This ambitious plan encompasses funding for research and development, subsidies for new fabs, and measures to strengthen supply chain resilience. Key projects highlighted under this framework include Intel's planned €30 billion investment in Germany and STMicroelectronics' expansion in France and Italy. However, critics argue that achieving such goals will require not only financial support but also a coordinated strategy to address workforce shortages and streamline regulatory processes (Dachs, 2023).

Despite these efforts, the EU's semiconductor industry remains heavily reliant on foreign technology and expertise. In Europe, advanced chip-making equipment markets are dominated by a few global players like ASML (Netherlands), which produces the world's most advanced lithography machines. While this gives EU member states a niche advantage, it also underscores the industry's dependence on global supply chains for other critical components (Tian, 2023).

Looking ahead, demand for semiconductors was projected to grow significantly due to advancements in artificial intelligence, electric vehicles, and renewable energy technologies; furthermore, they constitute key components of modern military armaments. However, meeting this demand will require overcoming structural barriers and fostering greater collaboration between industry stakeholders and governments. Without substantial progress in scaling up domestic production, the EU risks falling further behind in this strategically vital sector (Dorakh, 2024).

4.4. Industrial Robotics Industry

The European industrial robotics industry is a key driver of automation and productivity across sectors such as the manufacturing, logistics, and healthcare industries. Europe is home to some of the world's leading robotics companies, including ABB (Switzerland), Siemens (Germany), KUKA (Germany), and FANUC Europe (Luxembourg). These firms have been instrumental in advancing robotics technologies that enhance efficiency and competitiveness in industries ranging from automotive assembly to pharmaceutical production (Haidegger et al., 2023). However, FANUC is a subsidiary of its Japanese parent company, while KUKA was purchased by the Chinese Midea Group in 2016.

Despite its strong foundation, the European robotics sector faces mounting headwinds. Global competition is intensifying as countries like China rapidly expand their robotics capabilities through heavy investment and government support. In 2023 alone, China accounted for over half of global robot installations, significantly dwarfing the EU's share. Furthermore, high energy costs and supply chain disruptions have increased production expenses for European manufacturers, making it harder to compete on price with Asian producers (Reshetnikova & Pugacheva, 2022).

The adoption rate of industrial robots in the EU also varies significantly between countries. While Germany leads with one of the highest robot densities globally (397 robots per 10,000 workers in manufacturing), other EU nations lag behind due to limited access to capital and slower digital transformation efforts among small- and medium-sized enterprises (SMEs). This uneven adoption creates notable disparities in productivity across the region (Statista.com, 2024).

To address these structural impediments, the European Commission has introduced initiatives such as Horizon Europe (Gabriel, 2021) to fund research into advanced robotics technologies, including collaborative robots (cobots) and AI-driven automation systems (Nobile, 2023). Additionally, programmes like Digital Europe aim to support SMEs in adopting robotics solutions by providing training and financial assistance (European Commission, 2024).

Looking forward, demand for industrial robots was anticipated to grow as industries increasingly prioritized automation to offset labour shortages and enhance efficiency. However, the EU's ability

to maintain its leadership in robotics will depend on its capacity to innovate while addressing structural issues such as high energy costs and fragmented adoption rates across member states. Strengthening collaboration between academia, industry leaders, and policymakers will be crucial to ensuring the sector's long-term competitiveness on the global stage (Licardo et al., 2024).

4.5. Summary

The steel, chemical, semiconductor, and industrial robotics industries are vital to European nations' defence capabilities, forming the backbone of their defence supply chains. The steel industry provides essential materials for ammunition and armoured vehicles but faces challenges such as high energy costs, global overcapacity, and stringent EU regulations that hinder investment and profitability. Similarly, the chemical industry supplies critical inputs for defence technologies but struggles with declining production, high energy prices, and competition from less-regulated regions like Asia.

The semiconductor industry is indispensable for modern military technologies but suffers from limited domestic production capacity, reliance on foreign suppliers, and high capital requirements. Despite initiatives like the EU Chips Act to boost production, European nations remain dependent on external technology. Meanwhile, the industrial robotics sector supports automation in defence manufacturing but faces stiff competition from China and uneven adoption across EU member states.

Together, these industries are crucial to ensuring the Old Continent's strategic autonomy in defence. However, they are constrained by regulatory burdens, external competition, and insufficient investment in innovation. Strengthening these sectors through targeted policies and investments is essential to bolster European nations' defence readiness and reduce reliance on foreign supply chains. Achieving this goal requires, among other things, serious changes to European regulations that prevent the occurrence of carbon leakage. Otherwise, strict European sustainability rules will only contribute to the downfall of the bloc's industry, rather than to the reduction of global pollutant emissions.

Conclusions

The analysis clearly demonstrates that the Russo-Ukrainian War has acted as a stress test, exposing critical capability gaps within the EDTIB and its key supporting sectors. Unless these gaps are addressed, the current industrial structure will remain fundamentally vulnerable; it will be incapable of sustaining the volume, tempo and diversity of output required to match emerging threats, as well as to provide credible strategic autonomy in a protracted crisis. At the core of this vulnerability lies the defence industrial trilemma: EU member states are simultaneously attempting to maintain high technological standards, keep equipment affordable, and ensure robust security of supply, but in practice, they fail to fully deliver across all three dimensions.

The findings highlight a combination of structural deficiencies that inhibit innovation, scale, and genuine market discipline. Fragmented national procurement, limited cross-border consolidation, and the persistent protection of domestic champions prevent the emergence of a truly competitive European defence market with the economies of scale needed to contain costs and support sustained R&D. In this environment, a fully functioning internal market for defence equipment does not exist in the economic sense of the term, as prices are heavily shaped by politics, scale effects remain under-exploited, and firms face weak incentives to innovate beyond national demand. Without fundamental changes to this market structure, Europe will continue to lag behind American and Asian competitors in production costs, output volumes, and the speed at which new capabilities can be fielded.

At the same time, the war has underlined that European nations cannot rely on "niche specialisation" alone; they need an industrial base capable of delivering a broad spectrum of critical military equipment from their own territory if they are to ensure security of supply under crisis conditions. Yet member states also face the simultaneous need to replenish depleted stocks and invest in new capabilities, making affordability and economic competitiveness at least as important as supply security. This creates a sharp paradox within the trilemma, as in the short to medium term, it may be necessary to accept a relative step back in technological sophistication in some capability areas in order to expand production volumes and improve resilience of supply at sustainable cost levels. The article does not present this as a desirable outcome, but rather as the logical consequence of trying to reconcile

finite resources with higher operational demands and a more hostile security environment.

From a supply-chain perspective, the steel, chemical, semiconductor, and industrial robotics sectors emerge as systemic bottlenecks that shape what the defence industry can realistically deliver. High energy prices, overcapacity, and stringent environmental regulations in steel, declining output and intense external competition in chemicals, persistent import dependence in semiconductors; and asymmetric competition in industrial robotics collectively erode the EU's ability to control critical nodes in defence-relevant value chains. Current EU-level policy instruments – such as the EDF, Horizon Europe and the EU Chips Act – are important steps, but the research suggests that their impact will remain limited if they are not complemented by more coherent industrial, competition and energy policies that explicitly recognise defence as a strategic priority and enable deeper MCF.

Overall, the evidence points to a European defence industrial system in which more obstacles than accelerators currently stand between political ambition and industrial reality. The core contribution of this article is to demonstrate, through a value-chain and network-oriented analysis of four key supporting sectors, that the capability gaps exposed by the Russo-Ukrainian War are rooted not only in defence-specific choices but also in broader industrial and regulatory structures. Without targeted reforms that tackle the absence of a genuine competitive market, the lack of scale and the misalignment between sustainability objectives and security of supply, the defence industries of European nations will remain structurally ill-equipped to confront the scale and nature of the threats they face.

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