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The Economic and Technological Resilience in the European Union: Geopolitical Fragmentation, Economic Security and the Future of Competitiveness

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Abstract

The European Union operates in a highly fragmented international environment shaped by geopolitical rivalry, geoeconomic competition, technological disruption, and growing uncertainty regarding critical external dependencies. These developments have elevated economic security and resilience to the centre of European policymaking, challenging assumptions that traditionally linked economic openness with stability, prosperity, and sustainable development. The purpose of this article is to examine how geopolitical and geoeconomic fragmentation is reshaping the European Union's approach to economic and technological resilience and to analyse the implications of this transformation for long-term competitiveness and sustainable development. Employing a qualitative research design based on policy analysis and systematic document analysis, supported by secondary statistical evidence from European and international institutional sources, the study investigates three interconnected dimensions of resilience: technological resilience, resource resilience, and competitiveness resilience. The findings indicate that the European Union is moving from an efficiency-oriented model of globalisation towards a resilience-oriented governance framework focused on managing sensitive dependencies in critical technologies, strategic resources, and supply chains. The analysis further demonstrates that resilience cannot be sustained through risk reduction measures alone. Its long-term effectiveness depends on productivity growth, innovation performance, technological capabilities, industrial strength, and investment capacity. The article concludes that competitiveness constitutes a foundational condition for durable resilience and that economic security increasingly functions as an enabling factor for sustainable development in a more contested global economic environment.



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1. Introduction

The international environment in which the European Union operates has changed profoundly over the past decade [1,2]. The COVID-19 pandemic exposed vulnerabilities in global supply chains [3], Russia's invasion of Ukraine revealed the risks associated with external dependencies, and intensifying rivalry between the United States and China has intensified geoeconomic competition [4]. Together, these developments have challenged

the assumptions that long underpinned European prosperity, including stable geopolitical conditions, predictable trade relations, and reliable access to global markets, technologies, and resources.

As geopolitical and economic fragmentation deepens, economic interdependence is now viewed not only as a source of efficiency and growth but also as a potential source of vulnerability [5]. Export controls, investment restrictions, industrial subsidies, sanctions, and technological barriers have become important instruments of statecraft, blurring the distinction between economic and security policy [6]. This shift has encouraged a reassessment of concentrated dependencies in critical technologies, digital infrastructures, advanced manufacturing, energy systems, and critical raw materials.

In response, the European Union has placed economic security and technological resilience at the centre of its policy agenda [7,8]. Initiatives such as the European Economic Security Strategy, the European Chips Act, and the Critical Raw Materials Act reflect an ongoing effort to reduce systemic vulnerabilities while preserving the benefits of openness [7,9,10]. This approach departs from earlier assumptions that market integration and economic interdependence would automatically promote prosperity, stability, and security.

The shift towards resilience nevertheless creates a policy dilemma. Measures aimed at reducing dependencies may strengthen security but can increase costs, constrain innovation, and weaken competitiveness. The challenge is particularly significant for the European Union, which faces mounting concerns regarding productivity growth, investment performance, technological leadership, and innovation capacity relative to major global competitors [11,12]. Resilience and competitiveness are not separate objectives; the long-term success of the European economic security agenda depends on their ability to reinforce one another.

Although the concepts of economic security, technological sovereignty and resilience have attracted growing scholarly attention, their relationship with long-term competitiveness remains insufficiently integrated within a single analytical framework. Existing research has generally examined these dimensions separately or focused primarily on individual policy instruments, leaving limited understanding of how they interact in shaping the European Union's evolving approach to economic security.

The purpose of this article is to examine how geopolitical and geoeconomic fragmentation is reshaping the European Union's approach to economic and technological resilience and the implications of this transformation for long-term competitiveness and sustainable development. It argues that the emerging economic security agenda reflects a shift from efficiency-oriented globalisation towards resilience-oriented governance of sensitive dependencies. The long-term effectiveness of this transition depends on strengthening innovation capacity, industrial capabilities, productivity growth, and technological competitiveness alongside reducing structural vulnerabilities.

To fulfil this purpose, the study addresses the following research question: How is geopolitical fragmentation reshaping the European Union's approach to economic and technological resilience, and what implications does this transformation have for long-term competitiveness? To address this research question, the analysis focuses on three interconnected dimensions of resilience—technological resilience, resource resilience, and competitiveness resilience—through qualitative policy analysis and systematic document analysis supported by secondary statistical evidence. By integrating debates on economic security with innovation, productivity and sustainable development, the article contributes to current discussions on the future of European competitiveness in a fragmented international environment.

Unlike studies that examine technological resilience, critical raw materials, or competitiveness separately, this study integrates these dimensions within a single analytical framework. In doing so, it demonstrates how their interaction shapes the European Union's evolving approach to economic security and provides a more comprehensive explanation of resilience as a multidimensional governance challenge.

2. Theoretical Framework

2.1. Economic Security in an Era of Geoeconomic Competition

Economic security has become a central concept in both policy and academic debates as geopolitical tensions intersect more closely with international economic relations. While traditionally associated with safeguarding economic stability and access to essential resources, contemporary interpretations encompass supply-chain resilience, technological capabilities, critical infrastructure, investment flows, and exposure to economic coercion [13,14].

The renewed prominence of economic security reflects the rise in geoeconomic competition, where states use economic instruments—including trade restrictions, export controls, investment screening, industrial subsidies, and sanctions—to pursue geopolitical objectives. Under these conditions, economic interdependence is no longer viewed solely as a source of efficiency and prosperity but also as a potential source of vulnerability [15].

The European Union's Economic Security Strategy illustrates this shift. The European Union's Economic Security Strategy does not treat economic security as a narrow policy domain. It identifies interconnected risks linked to supply chains, critical infrastructure, technology leakage, and economic coercion [16]. Economic security thus emerges as a framework for managing the relationship between openness, resilience, and strategic autonomy in a highly contested international environment.

2.2. Technological Sovereignty and Strategic Autonomy

Technological sovereignty refers to the capacity to develop, access, and control critical technologies without excessive dependence on external actors. Unlike traditional notions of sovereignty, it does not imply self-sufficiency [17]. Instead, it emphasises the ability to make autonomous policy decisions while remaining integrated within global technological and economic networks.

The concept has gained importance as advanced technologies—including semiconductors, artificial intelligence, cloud computing, cybersecurity systems, and data infrastructures—have become essential drivers of competitiveness, innovation, and geopolitical influence. For the European Union, concerns over technological sovereignty stem from dependence on external suppliers, intensifying technological rivalry between major powers, and the concentration of technological capabilities among a limited number of global actors [18].

Technological sovereignty is closely linked to the concept of European security and strategic autonomy. Contemporary European approaches place greater emphasis on open strategic autonomy, seeking to strengthen critical capabilities without abandoning international trade, investment, and technological cooperation [19]. The objective is not autonomy from globalisation but the capacity to operate effectively within it while limiting excessive external dependencies.

2.3. Resilience and the Governance of Strategic Dependencies

Resilience provides the analytical bridge between economic security and technological sovereignty [20]. In economic governance, resilience refers to the capacity of economies and institutions to anticipate, absorb, adapt to, and recover from external shocks while maintaining core functions [21].

Recent disruptions—including the COVID-19 pandemic, the energy crisis triggered by Russia’s invasion of Ukraine, semiconductor shortages, and intensifying technological rivalries—have exposed vulnerabilities created by highly concentrated supply chains and production networks. These developments have highlighted the limitations of efficiency-oriented systems and increased the importance of adaptability, diversification, and redundancy.

Resilience offers a useful framework for understanding critical dependencies [22]. Dependencies become particularly consequential when they are highly concentrated, difficult to replace, and vulnerable to political manipulation [23]. The challenge for policymakers is not to eliminate interdependence but to identify and manage those dependencies capable of generating systemic risks [21].

This logic underpins the European Union’s emphasis on de-risking [24]. Unlike comprehensive decoupling, de-risking seeks to reduce excessive vulnerabilities in critical sectors while preserving the benefits of international economic integration [25]. The approach reflects the view that resilience and openness are not mutually exclusive but can be mutually reinforcing when supported by diversified economic and technological relationships [22].

Building on these theoretical foundations, the present study conceptualises economic and technological resilience as the European Union’s capacity to reduce major vulnerabilities while preserving competitiveness, innovation, and openness. The relationships and distinctions between the three core concepts underpinning the study—economic security, technological sovereignty, and resilience—are summarised in Table 1. Together, they provide the analytical framework for examining how geopolitical fragmentation is reshaping European economic security policies and influencing the future trajectory of European competitiveness.

Table 1. Conceptual Distinctions Between Economic Security, Technological Sovereignty and Resilience.

Concept	Primary Objective	Main Source of Vulnerability	Policy Focus
Economic Security	Protection against economic risks	Supply chain disruptions, coercion, external dependencies	Risk management and diversification
Technological Sovereignty	Strategic control over critical technologies	Technological dependence and innovation gaps	Domestic capabilities and innovation ecosystems
Resilience	Capacity to absorb and adapt to shocks	Systemic vulnerabilities and concentration risks	Adaptation, flexibility and recovery

Source: Author’s elaboration based on European Union [7,10,12].

As Table 1 illustrates, economic security, technological sovereignty, and resilience represent distinct but closely interconnected dimensions of the European Union’s response to contemporary geopolitical and geoeconomic challenges.

3. Methodology and Research Design

3.1. Research Design

This study adopts a qualitative research design based on policy analysis and systematic document analysis to examine how geopolitical fragmentation is reshaping the European Union’s approach to economic and technological resilience and how this transformation influences long-term competitiveness.

The research design is grounded in the concepts of economic security, technological sovereignty, strategic autonomy and resilience, which together provide the analytical framework for examining institutional change, policy adaptation and evolving governance arrangements in response to geopolitical and geoeconomic developments. The study adopts

an interpretative analytical approach combining qualitative policy analysis with systematic document analysis. Secondary statistical evidence is used exclusively to contextualise and support the qualitative interpretation of institutional developments and policy change; it does not constitute an independent quantitative method or statistical testing procedure. This research design is particularly suitable for examining complex policy processes that extend across political, economic and technological domains and cannot be understood solely through quantitative indicators.

The analysis focuses on identifying the principal drivers of policy change, the governance mechanisms adopted to reduce strategic dependencies and the implications of these developments for technological resilience, resource resilience and long-term competitiveness. Secondary statistical evidence complements the qualitative interpretation of institutional developments and policy responses by providing empirical context for the analysis, not serving as the basis for an independent quantitative assessment.

Accordingly, the statistical evidence serves a corroborative, not explanatory function, strengthening the interpretation derived from qualitative policy analysis without altering the qualitative character of the research design.

3.2. Data Sources and Document Selection

This study draws on qualitative and quantitative sources from authoritative institutional, policy, and academic works.

The qualitative component is based on document analysis of key European policy initiatives and strategic documents, including the European Economic Security Strategy, the European Chips Act, the Critical Raw Materials Act, the Data Act, the Data Governance Act, and the Draghi Report on the future of European competitiveness [7,9,10,26–28]. These sources are complemented by relevant academic literature and policy studies addressing economic security, technological sovereignty, resilience, and competitiveness.

The quantitative component draws on statistical evidence and indicators reported by the European Commission and other authoritative institutional sources [29–31]. These data are used to support the assessment of innovation performance, productivity dynamics, resource-related dependencies, and competitiveness challenges affecting the European Union.

Combining qualitative and quantitative material enables a more comprehensive assessment of the structural factors shaping European resilience and competitiveness.

Document selection followed a purposive sampling strategy. The analysis focused on official European Union policy documents, legislative acts, institutional reports, and internationally recognised statistical sources published between 2020 and 2025. Documents were selected according to four criteria: (1) direct relevance to economic security, technological resilience, or competitiveness; (2) institutional significance for European policymaking; (3) analytical relevance to the research question; and (4) availability of verifiable policy or statistical evidence. Documents unrelated to the analytical framework, duplicate institutional communications, and sources lacking direct relevance to the research objective were excluded.

The primary qualitative corpus consisted of eight core European Union policy and institutional documents, including six legislative and strategic EU documents (the European Economic Security Strategy, the European Chips Act, the Critical Raw Materials Act, the Data Act, the Data Governance Act, and the Net-Zero Industry Act) together with the Letta and Draghi Reports. These core documents were complemented by peer-reviewed academic literature and selected policy studies, which provided additional analytical context and supported the thematic interpretation of the findings.

The selected documents were analysed using qualitative thematic analysis. The objective of the thematic analysis was not to quantify policy content but to identify recurring governance patterns, institutional priorities, and policy responses across the selected documents.

The analytical process consisted of three stages. First, the documents were systematically reviewed to identify policy objectives, governance instruments, and institutional responses related to economic security and resilience. Second, the identified evidence was coded according to the three analytical dimensions adopted in this study: technological resilience, resource resilience, and competitiveness resilience. The coding framework mapped individual policy objectives, governance instruments, and implementation measures to each analytical dimension, providing the analytical basis for the comparative assessment presented in Tables 2–4. Third, coded themes were systematically compared across the analysed documents and subsequently synthesised into the comparative analytical framework presented in Tables 2–4, with secondary statistical evidence providing contextual support where appropriate.

Table 2. Key Dimensions of European Economic and Technological Resilience.

Key Dimension	Analytical Focus	Key Vulnerabilities	Main Indicators
Technological Resilience	Semiconductors, AI, cloud infrastructure, data governance	Technological dependence, innovation gaps	R&D expenditure, innovation performance, technological capabilities
Resource Resilience	Critical raw materials, supply chains, circular economy	Import concentration, supply disruptions	Import dependence, supply concentration, external dependencies
Competitiveness Resilience	Productivity, innovation, industrial performance	Productivity slowdown, investment gaps	Productivity growth, R&D intensity, investment levels

Source: Author's elaboration based on the analytical framework developed in this study.

Table 3. Strategic Dependencies and Resilience Responses in the European Union.

Strategic Area	Main Dependency	Strategic Risk	EU Response
Semiconductors	East Asian manufacturing capacity	Supply disruptions, technology restrictions	European Chips Act
Artificial Intelligence	Dominance of US and Chinese firms	Technological lag	AI strategy, innovation support
Cloud and Data Infrastructure	Non-European providers	Data and digital dependence	Data Act, Data Governance Act
Critical Raw Materials	External extraction and processing	Supply concentration	Critical Raw Materials Act
Clean Technologies	Imported components and materials	Industrial vulnerability	Net-Zero Industry Act and industrial policy

Source: Author's elaboration based on the European Union [7,9,10,25,26].

3.3. Analytical Framework

The analytical framework conceptualises economic and technological resilience as a multidimensional phenomenon shaped by the interaction of security, technological, industrial, and economic factors. The empirical examination is structured around three interconnected dimensions.

Table 4. Comparative Assessment of the Three Dimensions of European Economic and Technological Resilience.

Analytical Dimension	Principal Vulnerabilities	Main EU Policy Responses	Remaining Structural Weaknesses	Long-Term Implications
Technological resilience	Dependence on foreign digital technologies; limited commercialisation of innovation; investment gap in AI and advanced technologies	European Chips Act; Digital Europe Programme; Horizon Europe; AI Act; STEP	Fragmented innovation ecosystem; weak scale-up capacity; persistent investment deficit	Reduced technological sovereignty and lower capacity for innovation-driven growth
Resource resilience	Dependence on imports of critical raw materials; concentration of processing capacity outside the EU; supply-chain disruptions	Critical Raw Materials Act; Strategic Projects; diversification of suppliers; recycling initiatives	Limited domestic extraction and processing; long implementation periods; continued external dependence	Higher exposure to geopolitical coercion and supply shocks affecting industrial production
Competitiveness resilience	Productivity gap; lower private investment; declining industrial competitiveness; uneven innovation performance	Competitiveness Compass; Net-Zero Industry Act; Single Market initiatives; Industrial Strategy	Structural productivity differences; regulatory fragmentation; slow diffusion of innovation	Reduced long-term economic growth and weaker global competitive position

Source: Authors' own elaboration based on the analysis presented in Sections 4.2–4.4.

The first dimension, technological resilience, examines the European Union's capacity to develop and maintain critical technological capabilities in sectors such as semiconductors, artificial intelligence, cloud infrastructure, and data governance. The study evaluates the extent to which technological dependencies create structural vulnerabilities and assesses European efforts to strengthen technological capabilities.

The second dimension, resource resilience, focuses on critical raw materials and key supply chains. Particular attention is devoted to external dependencies, supply concentration, diversification strategies, industrial policy measures, and circular economy initiatives designed to reduce supply risks.

The third dimension, competitiveness resilience, explores the relationship between resilience and long-term economic performance. The assessment examines productivity, innovation, investment, industrial competitiveness, and technological leadership in order to assess whether resilience-oriented policies reinforce or constrain Europe's competitive position.

Together, these dimensions provide a framework for evaluating the interaction between security, openness, and competitiveness within the European Union's evolving resilience agenda. The key dimensions, analytical focus areas, vulnerabilities, and indicators applied in the study are summarised in Table 2. The analytical framework provides the basis for answering the research question by enabling a systematic assessment of how geopolitical fragmentation influences each resilience dimension individually and how their interaction shapes the European Union's long-term competitiveness.

As Table 2 illustrates, the framework integrates technological, resource, and competitiveness dimensions in order to assess resilience as a multidimensional component of long-term economic performance and strategic adaptation.

3.4. Research Limitations

Several limitations should be acknowledged. First, the study relies primarily on secondary data and document analysis instead of primary empirical research. Second, the geopolitical and geoeconomic environment examined remains highly dynamic, meaning that policy frameworks, supply chains, and technological ecosystems continue to evolve. Third, resilience cannot be measured through a single indicator and must be assessed using a combination of proxy variables related to technological capabilities, diversification, innovation, and competitiveness [32].

Finally, the study focuses on the European Union as a whole and does not examine differences among individual Member States. Future comparative research at the level of individual Member States could provide additional insight into how different institutional capacities, industrial structures, and policy choices influence resilience outcomes under a common European policy framework.

An additional limitation concerns the predominance of official European Union policy documents and institutional reports among the analysed sources. Although these materials represent authoritative evidence for examining European policymaking, they may reflect institutional perspectives and policy priorities, which constitute an inherent limitation of the source base used in this study.

Despite these limitations, the qualitative research design, supported by secondary statistical evidence, provides a robust analytical framework for examining the relationship between economic security, technological resilience, and competitiveness in the context of contemporary geopolitical and geoeconomic transformation. The findings should be interpreted as analytically grounded rather than statistically generalisable. Their primary contribution lies in explaining institutional and policy dynamics, not in establishing causal relationships through quantitative inference.

4. Results

4.1. Geopolitical Fragmentation and the Emergence of Economic Security

The emergence of economic security within European policymaking reflects a fundamental transformation of the international environment [33]. Over the past decade, a series of geopolitical, economic, and technological disruptions has challenged assumptions that long underpinned the European model of economic openness. The COVID-19 pandemic exposed vulnerabilities in global supply chains, Russia's invasion of Ukraine highlighted the risks associated with strategic dependencies, and intensifying competition between the United States and China accelerated the geoeconomic fragmentation of the international system [2].

These developments have altered perceptions of economic interdependence. While globalisation delivered significant gains in productivity, efficiency, and consumer welfare, it generated concentrated dependencies in critical sectors, many of which were located outside Europe. Supply-chain disruptions during the pandemic revealed the fragility of highly specialised production networks, while the energy crisis following Russia's invasion of Ukraine demonstrated how economic dependencies can be transformed into instruments of political leverage [16].

At the same time, geopolitical competition between major powers has expanded beyond traditional trade disputes into technology, investment, data governance, and industrial policy. Semiconductors, artificial intelligence, advanced manufacturing, and critical raw materials have become central elements of geopolitical and geoeconomic competition [34]. Economic instruments once associated primarily with commercial policy are now used more frequently to pursue strategic objectives, blurring the boundary between economics and security [6].

These developments have encouraged a reassessment of critical dependencies within the European Union. Policymakers have become more concerned about vulnerabilities associated with critical technologies, supply chains, infrastructure, and access to essential resources. As a result, concepts such as economic security, strategic autonomy, technological sovereignty, and resilience have moved to the centre of European policy debates [32].

The European Economic Security Strategy represents the clearest institutional expression of this shift. The strategy identifies four principal categories of risk: supply-chain vulnerabilities, threats to critical infrastructure, risks related to technology leakage, and exposure to economic coercion [35]. Importantly, the strategy does not advocate economic isolation or comprehensive decoupling [36]. Instead, it seeks to preserve the benefits of openness while reducing excessive external dependencies through diversification, risk management, and capacity-building measures [37].

The evidence suggests that economic security has emerged as a response to the changing relationship between interdependence and power. Under conditions of geopolitical stability, interdependence was largely associated with efficiency and mutual gain [5]. In a more fragmented and competitive environment, it can generate vulnerabilities that expose states and institutions to disruption, coercion, or external influence. The European Union's evolving economic security agenda reflects an effort to manage these risks while maintaining openness, competitiveness, and long-term economic resilience [36]. The effectiveness of this approach depends largely on the Union's ability to strengthen technological capabilities, secure access to strategic resources, and sustain competitiveness in a highly contested global economy.

The analysis nevertheless suggests that institutional capacity alone is unlikely to guarantee successful implementation. The effectiveness of these policies will depend on sustained private investment, regulatory coordination across Member States, and the ability to adapt policy instruments to rapidly changing technological and geopolitical conditions.

4.2. *Technological Resilience and Strategic Dependencies*

Technological capabilities have become a key determinant of economic competitiveness, innovation, and geopolitical influence. As technological rivalry intensifies, access to critical technologies is viewed as a security issue affecting economic security and long-term resilience [38]. For the European Union, concerns about technological resilience stem from rising dependencies in sectors that are likely to shape future economic performance, including semiconductors, artificial intelligence, cloud infrastructure, and digital ecosystems.

4.2.1. *Semiconductor Dependencies and Systemic Vulnerabilities*

The semiconductor sector illustrates the systemic challenges facing the European Union. Semiconductors underpin digitalisation, artificial intelligence, telecommunications, advanced manufacturing, and defence systems. Disruptions during the COVID-19 pandemic exposed the vulnerability of highly concentrated semiconductor supply chains and highlighted Europe's dependence on external manufacturing capacities [39].

Although Europe maintains strong positions in selected segments of the semiconductor value chain, advanced chip fabrication remains concentrated in East Asia. This concentration creates systemic risks because disruptions arising from geopolitical tensions, trade restrictions, or military conflict can affect industrial production across multiple sectors. Semiconductor dependencies are not merely an industrial issue, but a systemic challenge linked to technological sovereignty, economic security, and competitiveness [9,17].

The European Chips Act seeks to reduce these vulnerabilities by strengthening domestic production, research, and innovation [9]. Its effectiveness, however, depends not

only on manufacturing capacity but also on ecosystem development, including research institutions, skilled labour, design capabilities, and access to global supply networks.

4.2.2. Data Sovereignty and Digital Infrastructure

Data and digital infrastructure have become foundational assets underpinning economic activity, technological innovation, and regulatory influence. European concerns regarding data sovereignty extend beyond privacy protection and focus on dependence on foreign-controlled digital infrastructures, particularly cloud services and large-scale data-processing platforms [26,27].

The challenge is compounded by the concentration of digital ecosystems around a limited number of global actors. Dependence on non-European providers raises questions regarding resilience, innovation capacity, and strategic autonomy [25]. At the same time, the transnational character of digital technologies limits the feasibility of purely territorial approaches to governance. European policy consequently faces the dual challenge of strengthening control over critical digital infrastructures while remaining integrated within global technological networks.

4.2.3. Artificial Intelligence, Innovation and Technological Leadership

Artificial intelligence has emerged as a critical driver of productivity growth, industrial transformation, and technological competitiveness [40]. While Europe possesses strong scientific institutions and research capabilities, it continues to face difficulties in translating research excellence into commercial scale and global technological leadership [41].

Empirical data highlights the magnitude of this challenge. Draghi estimates that European expenditure on research and innovation remains approximately EUR 270 billion below that of the United States [12]. This gap constrains the ability of European firms to scale emerging technologies, attract investment, and compete in technologically important sectors. According to the same report, only four of the world's five largest technology companies are headquartered in Europe, underscoring the Union's limited presence among globally dominant technology firms. These findings point to the fact that Europe's principal weakness lies not in scientific capacity but in commercialisation, scale-up financing, and innovation ecosystem development.

The innovation gap is reflected in research and development performance. According to Eurostat, research and development expenditure in the European Union reached 2.24% of GDP in 2024, remaining below the long-standing European target of 3% and behind leading global innovation competitors [30]. This suggests that concerns regarding technological resilience are closely linked to the Union's ability to sustain long-term innovation and technological upgrading.

Taken together, these indicators reveal a consistent structural pattern. Europe's challenge is not limited to individual technological sectors but reflects structural weaknesses in innovation commercialisation, research intensity, and industrial scaling. The evidence suggests that technological resilience depends less on isolated policy interventions than on strengthening the overall innovation ecosystem capable of transforming scientific excellence into globally competitive technological capacity. This implies that fragmented implementation or insufficient coordination between innovation, industrial, and education policies could significantly reduce the long-term effectiveness of resilience-oriented strategies.

The overall pattern points to a structural competitiveness challenge. Technological resilience depends not only on protecting priority sectors but also on strengthening innovation performance, investment capacity, and industrial capabilities. Without these foundations, efforts to reduce technological dependencies are unlikely to produce durable resilience outcomes.

4.2.4. Technological Resilience as Managed Interdependence

Technological resilience should not be interpreted as technological self-sufficiency. For an economy as deeply integrated into global markets as the European Union, complete autonomy would be neither economically feasible nor strategically desirable [42]. Advanced technologies are developed through highly specialised international value chains that no major economy can replicate independently.

The emerging European approach is better understood as managed interdependence. The objective is to reduce excessive concentrations of risk, diversify technological partnerships, strengthen domestic innovation ecosystems, and secure access to critical technologies while preserving the benefits of openness [19]. In this context, technological resilience and competitiveness are mutually reinforcing. Stronger technological capabilities reduce systemic vulnerabilities, while innovation, investment, and productivity growth provide the foundations upon which long-term resilience depends.

4.3. Critical Raw Materials and Industrial Resilience

Critical raw materials have become a central component of economic resilience because the technologies underpinning digitalisation, decarbonisation, advanced manufacturing, and defence systems depend on a limited set of essential resources. Lithium, cobalt, nickel, graphite, and rare earth elements are essential inputs for batteries, renewable energy technologies, advanced electronics, and other sectors that shape economic competitiveness and technological development [43].

The European Union faces a particular challenge because demand for many of these materials is expected to rise sharply as the green and digital transitions accelerate [44]. European Commission projections indicate substantial growth in demand for lithium and other key materials associated with electrification, energy storage, and advanced technologies. At the same time, global extraction, processing, and refining capacities remain highly concentrated, creating vulnerabilities that extend beyond conventional market risks.

The strategic significance of critical raw materials derives not only from their scarcity but also from their position within global value chains [43]. In many cases, extraction, processing, and manufacturing are geographically separated, creating multiple potential bottlenecks. This is particularly evident in relation to China, which occupies a dominant position in the processing and refining of several materials essential for both the green and digital transitions. Such concentration increases exposure to geopolitical tensions, trade restrictions, and supply disruptions.

From an analytical perspective, these dependencies differ not only in magnitude but also in their strategic significance. Dependencies affecting upstream processing and refining create considerably higher systemic risks than those associated solely with extraction, because they influence multiple downstream industrial sectors simultaneously. This distinction explains why current European policy increasingly prioritises processing capacity and supply-chain diversification alongside resource access itself.

The degree of concentration is substantial. According to European institutional assessments, China supplies 100% of the European Union's heavy rare earth elements and approximately 93–97% of its magnesium imports, while Türkiye accounts for about 98–99% of European boron supplies. These figures illustrate the extent to which several industrial value chains remain dependent on a very limited number of external suppliers, increasing exposure to geopolitical and geoeconomic risks [10].

These vulnerabilities have elevated resource resilience to a central position within European economic security policy [10]. The Critical Raw Materials Act seeks to strengthen supply security through diversification, domestic production, expanded processing ca-

capacity, recycling initiatives, and strategic partnerships [10]. The objective is not simply to secure access to resources but to reduce vulnerabilities across the entire value chain.

4.3.1. Strategic Dependencies and Supply Chain Concentration

The principal challenge is not dependence itself but excessive concentration. Modern economies inevitably rely on international resource networks; vulnerabilities emerge when critical inputs originate from a limited number of suppliers and viable alternatives are scarce [23,44]. Under such conditions, supply disruptions may generate economic costs while simultaneously creating opportunities for geopolitical leverage.

This challenge is particularly significant for sectors associated with renewable energy, batteries, advanced electronics, digital infrastructure, and defence technologies. These industries occupy a central position within Europe's green and digital transitions and are widely viewed as key determinants of future competitiveness. Resource security has become closely linked to industrial strategy, technological development, and long-term economic performance.

4.3.2. Circular Economy as a Resilience Strategy

One distinctive feature of the European approach is the integration of circular economy principles into resilience policy. Beyond their environmental benefits, recycling, reuse, and resource recovery can reduce dependence on external suppliers and improve supply security [45]. Critical raw materials embedded in batteries, electronic devices, and industrial equipment represent a potentially important domestic source of essential resources.

Circularity contributes to sustainable development by improving resource efficiency and reducing environmental pressures. By retaining materials within economic cycles, circular economy initiatives support both resilience and long-term sustainability objectives [46]. However, circularity cannot eliminate external dependencies entirely. The scale of demand associated with electrification, digitalisation, and decarbonisation is likely to exceed recoverable volumes for the foreseeable future, meaning that access to primary raw materials will remain economically important.

4.3.3. Industrial Resilience and Productive Capacity

The evidence highlights the close relationship between resource resilience and industrial capability. Access to essential resources alone provides limited value without the capacity to process, transform, and utilise those resources within competitive industrial ecosystems [47]. Resource security and industrial capability represent complementary dimensions of resilience [48].

This relationship is now clearly reflected in European industrial policy. Efforts to strengthen domestic manufacturing in sectors such as batteries, renewable energy technologies, semiconductors, and advanced materials are closely connected to long-term objectives related to economic security and technological sovereignty. The findings show that resilience depends on maintaining capabilities across multiple stages of industrial value chains, not focusing exclusively on resource acquisition [48].

Table 3 summarises the principal strategic dependencies identified in the study and the corresponding policy responses adopted by the European Union. Together, these measures illustrate how technological, resource, and industrial resilience have become closely interconnected components of the economic security agenda.

As Table 3 demonstrates, the European Union's resilience agenda extends across multiple strategic sectors and combines diversification, industrial policy, innovation support, and regulatory measures aimed at reducing critical vulnerabilities while preserving long-term competitiveness.

4.4. Competitiveness as a Precondition of Resilience

The preceding sections examined technological and resource dimensions of resilience. The final dimension concerns competitiveness, which provides the economic foundation upon which long-term resilience ultimately depends. Reducing major vulnerabilities may strengthen security, but resilience cannot be sustained without the productive, innovative, and financial capacities required to support adaptation and long-term growth.

Recent assessments point to a widening competitiveness challenge within the European Union. According to Draghi, real disposable income per capita has grown almost twice as fast in the United States as in the European Union since 2000 [12]. This divergence reflects deeper differences in productivity growth, innovation performance, investment dynamics, and technological leadership that play a greater role in shaping long-term economic resilience.

4.4.1. Productivity and the Competitiveness Gap

Productivity remains the most important structural determinant of long-term competitiveness. Draghi estimates that approximately 70% of the gap in GDP per capita between the European Union and the United States can be explained by productivity differences [12]. OECD evidence points to a similar trend. Since 2000, labour productivity growth in the European Union has been on average around 0.5 percentage points lower per year than in the United States, contributing to a widening competitiveness gap between the two economies. In 2023, labour productivity increased by 1.6% in the United States, while productivity in the euro area declined by 0.9%, illustrating the persistence of divergent productivity trajectories [31].

This finding highlights the central role of productivity not only in generating economic growth but also in financing innovation, industrial transformation, defence capabilities, and resilience-enhancing investments.

The challenge is amplified by demographic trends. As labour force growth slows across much of Europe, future prosperity will depend primarily on productivity improvements, technological progress, and innovation [31]. Competitiveness should be viewed not as a separate policy objective but as a prerequisite for durable resilience [12].

4.4.2. Innovation Capacity and Technological Leadership

Innovation represents a second pillar of competitiveness resilience. Although Europe maintains strong scientific institutions and advanced industrial capabilities, persistent weaknesses remain in commercialisation, scale-up financing, venture capital availability, and the development of globally dominant technology firms [49].

These weaknesses have important implications. Technological leadership exerts substantial influence over economic security, industrial competitiveness, and geopolitical influence. Resilience policies that focus primarily on protection may prove counterproductive if they discourage innovation, investment, or participation in global knowledge networks [50]. Long-term resilience depends less on shielding economies from competition than on strengthening their ability to compete successfully.

4.4.3. Investment and Productive Capacity

The relationship between competitiveness and resilience is equally visible in investment dynamics. Strengthening technological capabilities, securing supply chains, expanding renewable energy systems, and modernising infrastructure require substantial long-term investment [11].

Draghi estimates that achieving Europe's objectives in digital transformation, decarbonisation, technological upgrading, and long-term resilience will require additional

annual investment equivalent to approximately 5% of EU GDP. This finding demonstrates that resilience is not simply a regulatory challenge but also a question of economic capacity and investment performance [12].

Viewed together, the productivity, innovation, and investment indicators presented throughout this section point to a common conclusion: competitiveness functions as the enabling condition through which resilience policies can generate durable long-term effects. Without sufficient productive capacity and sustained innovation performance, resilience measures risk addressing immediate vulnerabilities without strengthening the structural foundations of future economic security.

Many resilience-related objectives are highly capital intensive, including semiconductor manufacturing, battery production, critical raw material processing, advanced research infrastructure, and next-generation energy systems [50]. Their successful development requires sustained coordination between industrial policy, innovation systems, financial markets, education, and regulatory frameworks.

4.4.4. Resilience Through Competitiveness

Resilience and competitiveness are mutually reinforcing, not competing objectives. Technological sovereignty requires innovation, resource security requires industrial capability, and strategic autonomy requires economic strength. Economic security measures may reduce vulnerabilities, but their long-term effectiveness depends on the productive capacities that competitiveness generates.

This relationship is particularly important for the European Union, whose prosperity remains closely linked to international trade, investment, technological cooperation, and participation in global value chains. Under such conditions, resilience cannot be achieved through isolation. Sustainable resilience depends on the ability to combine openness with innovation, productivity growth, and economic capability.

From this perspective, competitiveness should not be interpreted solely in terms of market performance or economic efficiency [48]. It constitutes a prerequisite for sustaining the financial, technological, and institutional capacities required to support long-term sustainable development. In the absence of competitive and innovative economic structures, the ability to finance the green transition, digital transformation, and resilience objectives may gradually weaken [51].

The evidence points to a clear conclusion. The future success of the European Union's economic security agenda will depend not only on reducing strategic dependencies but also on strengthening productivity, innovation, investment, and technological leadership. Competitiveness is not simply an economic objective; it is a strategic asset that underpins resilience, sustainable development, and long-term prosperity in a fragmented international environment. However, sustaining this relationship will require policy coherence across industrial, technological, research, fiscal, and trade policies. Without such coordination, individual resilience measures may generate only limited systemic effects.

5. Discussion

The results indicate that the emergence of economic security within the European Union reflects a structural transformation of the international environment, not merely a temporary response to recent crises. Geopolitical fragmentation, technological rivalry, and geoeconomic competition have altered the relationship between openness, interdependence, and security [33], creating new forms of vulnerability that exert substantial influence on economic performance, technological development, and strategic autonomy [35].

Although the findings indicate that the European Union has significantly strengthened its policy framework for economic and technological resilience, the effectiveness of these

initiatives will ultimately depend on their implementation across the Member States. Differences in institutional capacity, industrial structure, fiscal resources, and national political priorities may lead to uneven outcomes, potentially limiting the coherence of the Union's resilience strategy.

These implementation challenges suggest that resilience should be understood as a dynamic governance process, not a fixed policy outcome. The capacity to adjust policy instruments in response to changing geopolitical, technological, and economic conditions may prove as important as the measures themselves.

From a theoretical perspective, the findings support the view that economic security has evolved into a governance framework for managing sensitive dependencies generated by contemporary forms of interdependence.

This interpretation is consistent with the empirical evidence presented in the Results section. Across all three analytical dimensions, the findings demonstrate that technological resilience, resource resilience, and competitiveness resilience do not operate independently but reinforce one another as complementary components of an integrated economic security framework.

Vulnerabilities associated with critical technologies, essential resources, and concentrated supply chains extend beyond purely economic concerns because they affect the capacity of states and institutions to preserve autonomy and sustain long-term competitiveness [6,35].

5.1. Reassessing Openness and Security

One of the principal findings concerns the changing relationship between openness and security. The results show that economic interdependence remains a source of prosperity and innovation, yet highly concentrated dependencies may generate systemic risks. The challenge is not interdependence itself but the governance of critical vulnerabilities.

This conclusion provides support for the European Union's preference for de-risking over decoupling [24]. Selective efforts to reduce excessive dependencies appear more compatible with the Union's economic structure than broad strategies of economic disengagement. The evidence indicates that resilience is most effectively strengthened through diversification, adaptability, and institutional capacity-building, whereas isolation offers limited long-term benefits.

Nevertheless, resilience-oriented policies may generate important trade-offs. Measures aimed at reducing strategic dependencies can increase production costs, require substantial public and private investment, and create additional regulatory burdens for businesses. The long-term success of the European Union's economic security agenda will depend not only on reducing vulnerabilities but also on maintaining an appropriate balance between resilience, openness, and economic efficiency.

An additional challenge concerns the compatibility of resilience-oriented industrial policies with the rules of the multilateral trading system. As the European Union expands the use of industrial policy instruments to strengthen economic security and reduce excessive strategic dependencies, it must ensure that such measures remain consistent with World Trade Organization (WTO) principles concerning non-discrimination and fair competition. The European Union has consistently presented initiatives such as the European Chips Act and the Critical Raw Materials Act as proportionate and targeted measures designed to strengthen supply security while preserving its broader commitment to an open, rules-based international trading system.

Beyond questions of WTO compatibility, the academic literature has highlighted potential risks associated with extensive industrial policy interventions, subsidy programmes, and strategic support measures. Such policies may reduce market efficiency, distort com-

petition, or contribute to subsidy races among major economies [36,47]. Others question whether initiatives such as the European Chips Act and the Critical Raw Materials Act will achieve their intended objectives within the planned timeframes, given the scale of investment required, implementation challenges, and the complexity of global supply chains [38,42,44].

5.2. *Technological Sovereignty as Managed Interdependence*

The study contributes to debates concerning technological sovereignty. The examination suggests that technological resilience depends primarily on the ability to participate effectively in global technological ecosystems while maintaining capabilities in technologically important sectors. Under conditions of extensive cross-border technological interdependence, complete autonomy would be both economically costly and difficult to sustain.

Technological sovereignty emerges as a form of managed interdependence. Its effectiveness depends on the robustness, diversity, and adaptability of technological ecosystems, not on economic isolation [17]. This interpretation is consistent with contemporary understandings of open strategic autonomy and reflects the realities of globally integrated innovation networks [19].

This interpretation should not, however, be understood as implying that the appropriate balance between openness and strategic autonomy has already been achieved. Determining which technological dependencies should be reduced, preserved, or even strengthened remains a political and economic judgement that may evolve as geopolitical conditions, technological capabilities, and global market structures continue to change.

5.3. *Competitiveness as the Foundation of Resilience*

The most important finding concerns the relationship between resilience and competitiveness. Across all dimensions examined in this study, resilience ultimately depends on capabilities commonly associated with competitiveness, including productivity growth, innovation performance, technological leadership, investment capacity, and industrial strength.

This observation has important implications for both theory and policy. From a theoretical perspective, the findings suggest that resilience should be conceptualised as an integrated governance framework linking security, industrial policy, innovation, and competitiveness, not as a collection of isolated policy measures.

Measures designed to reduce vulnerabilities may strengthen resilience in the short term, but their long-term effectiveness depends on the capacity to generate innovation, attract investment, and sustain economic growth. Resilience policies focused exclusively on protection risk addressing symptoms while leaving underlying structural weaknesses unresolved.

These findings indicate that resilience policies should be evaluated not only according to their capacity to reduce risks but also according to their contribution to long-term productivity growth, innovation performance, and industrial upgrading. This integrated perspective better reflects the multidimensional character of resilience identified throughout the analysis.

Resilience ultimately depends on more than reducing external dependencies. Its long-term effectiveness depends equally on the capacity to stimulate innovation, attract investment, strengthen productivity, and preserve the openness necessary for technological learning and international cooperation.

The discussion shows that competitiveness should be viewed as a foundational capability that extends beyond a purely economic objective. Economies characterised by strong innovation systems, advanced technological capacities, and sustained productivity

growth possess greater ability to absorb shocks, adapt to disruption, and preserve strategic autonomy over time.

Resilience and sustainable development are closely interconnected. The green and digital transitions require substantial investment, technological upgrading, and industrial adaptation. Consequently, the same capabilities that support competitiveness underpin long-term resilience and sustainable economic development.

5.4. Implications for the Core Arguments of the Study

The findings provide strong support for the three core arguments advanced in this study. First, the empirical material confirms that the European Union's economic security agenda reflects a shift from efficiency-oriented globalisation towards resilience-oriented governance of sensitive dependencies. Second, technological resilience appears to depend primarily on innovation capacity, industrial capabilities, and technological ecosystems, with protectionist measures playing only a secondary role. Third, the analysis demonstrates that durable economic security cannot be achieved without improvements in productivity, competitiveness, investment, and technological leadership.

Taken together, these findings show that the future success of European economic security policy will depend on the ability to reconcile resilience, openness, innovation, and competitiveness. The central challenge is not to choose between security and openness but to develop forms of resilience that strengthen Europe's capacity to innovate, compete, and sustain long-term prosperity within a highly fragmented international environment.

At the same time, the findings should be interpreted as reflecting an evolving policy agenda, not a completed institutional transformation. Many of the initiatives analysed in this study have only recently entered into force and their long-term effectiveness will depend on future implementation, political commitment, financial resources, technological progress, and developments in the wider geopolitical environment. Continued empirical research will be necessary to assess how these policies perform over time and whether they achieve their intended resilience objectives.

Across all three analytical dimensions, the evidence reveals a consistent pattern. Technological capabilities, secure access to strategic resources, and competitiveness should not be understood as independent policy objectives but as mutually reinforcing components of a resilience framework. Table 4 synthesises these findings by comparatively assessing the principal vulnerabilities, policy responses, remaining structural weaknesses, and long-term implications associated with each resilience dimension. This integrated assessment provides the basis for the discussion presented in the following section.

6. Conclusions

This article examined how geopolitical and geoeconomic fragmentation is reshaping the European Union's approach to economic and technological resilience and assessed the implications of this transformation for long-term competitiveness. The results demonstrate that the rising prominence of economic security reflects a structural response to changes in the international environment, not merely a temporary reaction to recent crises. Intensified geopolitical competition, technological rivalry, supply-chain vulnerabilities, and external dependencies have altered the conditions under which European prosperity and security are pursued.

The analysis showed that economic security has emerged as a new organising principle of European policymaking. The European approach does not seek to replace openness with protectionism; instead, it aims to reduce excessive vulnerabilities while preserving the benefits of international economic integration. Economic security, technological sovereignty, and

resilience should be understood as complementary components of a broader strategy aimed at strengthening the Union's capacity to adapt to external shocks and systemic disruptions.

The results further demonstrate that technological and resource resilience cannot be achieved through self-sufficiency or isolation. Both depend on diversified partnerships, robust innovation ecosystems, industrial capabilities, secure access to critical raw materials, and the effective governance of strategic dependencies. Resilience is best understood as the capacity to manage interdependence while limiting its systemic vulnerabilities.

The most important conclusion concerns the relationship between resilience and competitiveness. Across all dimensions examined in this study, resilience ultimately depends on productivity growth, innovation performance, investment capacity, technological leadership, and industrial strength. Measures designed to reduce vulnerabilities may enhance security in the short term, but their long-term effectiveness depends on the economic and technological capabilities that competitiveness generates. Competitiveness therefore emerges as a precondition for durable resilience and one of its principal foundations.

The article contributes to the literature by demonstrating that contemporary resilience strategies are fundamentally linked to the governance of complex interdependence. More specifically, the study contributes by developing an integrated analytical framework that connects technological resilience, resource resilience, and competitiveness resilience within a common conceptual perspective. This framework may provide a useful basis for future comparative analyses of resilience policies beyond the European Union. The European Union's transition from efficiency-oriented globalisation towards resilience-oriented governance does not imply a retreat from openness. Instead, it reflects an effort to reconcile security, competitiveness, and sustainable development within a highly fragmented international environment.

The long-term challenge facing the European Union is not simply to become more resilient, but to ensure that economic security strengthens innovation, competitiveness, and sustainable prosperity. For policymakers, this implies that resilience policies should be designed as integrated governance strategies combining industrial policy, innovation support, technological capability building, supply-chain diversification, and competitiveness-enhancing reforms rather than as isolated sectoral interventions. In this sense, economic security should be viewed not as an alternative to openness and development, but as an enabling condition for sustaining them in a highly contested global order.

Future research should examine how resilience-oriented policies are implemented across individual Member States and assess their long-term effects on innovation performance, industrial competitiveness, and economic security using comparative empirical evidence. Such analyses would help evaluate whether the institutional changes currently underway produce durable improvements in the European Union's resilience architecture.

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