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Geopolitics, Big Tech and the Future of European Security

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Discontent Is Europe's Main Threat

Sometimes films about Romans tell us much more about the current world than we would dare to admit. In Monty Python's *Life of Brian*, there is a scene where anti-Roman revolutionaries ask rhetorically: "What have the Romans ever done for us?" only to list, with increasing reluctance, the aqueducts, sanitation, roads, irrigation, medicine, education, wine, public baths and public safety.

For decades, the European Union has been cast – at least among its champions – as an undisputed force for good. Peace, prosperity, democracy, social progress – all wrapped up in a neat technocratic bow. But today, many European citizens are channelling their inner Judean People's Front, grumbling: "What has the EU ever done for us?" The grand project of unity and stability is now viewed in many quarters as an out-of-touch overseer, blind to the grievances of those who no longer feel they belong. The "Romani ite domum" moment of Monty Python fame is being transformed into a growing continental cry of "Eurocrati ite domum": Brussels bureaucrats, go home.

This discontent is not merely rhetorical. It is reshaping the European political landscape with alarming speed. The numbers tell their own story. Support for hard Eurosceptic parties – those proposing the demise of the EU or questioning basic European principles, such as the primacy of European law over national law – reached close to 15% of the vote in national legislative elections in 2023. If we add the softer Eurosceptic parties, the vote in that same year for parties opposed to further EU integration stood at 28.5%. Today it is very likely to be around one-third of the total vote. In four countries – Hungary, Italy, Poland and France – Eurosceptics command or approach an outright majority. They already govern or participate in government in Hungary, Italy, Slovakia and the Netherlands, play kingmaker in Sweden, and are the largest party in Austria and Poland. Given the current trend, they will soon be knocking at the doors of power in many other European countries. And the profile of their voters matters. The strongest surge of support for Euroscepticism is found in the hard right, whose electoral weight now stands at 25% of the electorate and exceeds that of the 1930s; a historical parallel that should give us pause.

What explains this widespread discontent? Traditionally, the rise of discontent has been based on cultural explanations (Norris & Inglehart, 2019); on the revolt of individuals – often men, often ageing, often white, often with low levels of education – who increasingly feel ill at ease with a Europe that is far more cosmopolitan and diverse than the one they grew up in. These are people who, according to sociologist Arlie Hochschild (2018), feel like strangers in their own land. Territorial explanations also abound. The battle lines pit thriving, globalised cities against stagnating towns, suburbs and rural areas (e.g. Rodden, 2019). However, one explanation that is gaining significant traction is that of long-term economic stagnation and decline. Many places in Europe are stuck in what is increasingly known as a development trap. As defined by my colleagues and myself (Diemer et al., 2022), a place is in a development trap when it is unable to retain its economic dynamism in terms of income, productivity and employment, while also underperforming its national and European peers on these same dimensions. There are 60 million Europeans living in places where the GDP per capita in real terms today is below that of the year 2000. About one-third of the EU population lives in places that have been falling slowly behind. The incidence of development traps is particularly strong in France, Italy, Greece and Croatia, though they can be found in virtually every country in the EU.

And, in contrast to what happens, for example, in the US, when a place in Europe falls into a development trap, it stays trapped for long periods of time. Economic stagnation has become a structural feature in many parts of Europe. People living in these places that increasingly "don't

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matter" (Rodríguez-Pose, 2018) are driving the rise of Euroscepticism. The Eurosceptic vote is a consequence of a reaction of communities in which individual losses are strongly identified with collective losses. It is fundamentally linked to the geography of decline (Rodríguez-Pose et al., 2024); to places that have witnessed considerable economic, employment and demographic decline over the long term. The Great Recession of 2008 may have ignited the fuse of their reaction, but the discontent has roots that are far deeper.

So, what is to be done? Can this growing Euroscepticism – the gravest threat to the European project since its inception – be stemmed? Many advocate that, if the driver is cultural, there is a need to engage in cultural wars. But engaging in *Kulturkampf* is a dangerous game; one that risks deepening the fractures already running through European societies.

A more pragmatic response lies in tackling long-term economic decline. Many of the voters that have shifted towards Eurosceptic positions live in places that have fallen through the policy cracks: too rich to attract the attention of the European cohesion policy; too static and unglamorous to be at the centre of national policies. Yet, these places still have significant economic potential that remains untapped (European Commission, 2024). It is not as if the drivers of the industrial revolution and of much of the prosperity during the 20th century have lost their economic mojo overnight. The problem is largely territorial and requires a response of equal ambition. If concentrated economic decline continues unchecked, the political consequences will be seismic. This is no longer a debate about economics. It is about the very survival of the EU.

Yet, our decision-makers wring their hands over declining global influence, about competitiveness, defence, climate change, the digital transition. All of these, of course, are highly pressing concerns. We certainly need a more competitive Europe, able to defend itself and lead the fight against climate change. But let us not delude ourselves. All these priorities will become academic if Euroscepticism continues its march towards outright dominance. Without an EU that can survive in its current form, there will be no more competitive, more secure or greener Europe; there will be no well-functioning single market. There will simply be a very different Europe from the one that has been built over the last 70 years. If Trump's acolytes seize even more power than they already have – or even just continue to reshape the political discourse, without even having to win – we will return to the fragmented continent of old; one involving national rivalries, illiberal regimes and greater economic irrelevance.

And so, we return to Rome. In Ridley Scott's *Gladiator*, a frail yet wise and triumphant emperor, Marcus Aurelius, asks his most trusted general, Maximus Decimus Meridius, why he fights for the Empire. Maximus replies "I've seen much of the rest of the world. It is brutal and cruel and dark. Rome is the light!" On the other side of the Atlantic, events are already proving just how brutal and cruel and dark the world can become. The EU is imperfect, certainly. It is flawed and in need of reform. But it is also the most successful attempt at peace, prosperity and democracy the continent has ever known. And all the alternatives on the table are far, far worse. So, we must fight for it. And we must act fast. Rome is the light! Europe is the light!

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Geopolitics, Big Tech and the Future of European Security

In just a few short months, the new government administration in the United States has thrown the world order into disarray. A potential global trade war, new global value chain configurations and shifting security alliances are reshaping geopolitics. Given the current uncertainty, access to developing technologies will be decisive, and technological sovereignty is more important for the European Union than ever before. How can the EU get up-to-speed? What steps can Europe take to ensure its technological sovereignty? How should it go about relations with China and the new Trump Administration with regards to its tech policy? What role does Big Tech play in European security?

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Francesco Crespi, Rosario Cerra and Francesco Zezza

Coopetitive Technological Sovereignty: A Strategy to Reconcile International Collaboration with Knowledge and Economic Security

In the next 20 years, we will witness the convergent development of a complex system of frontier technologies that, together, will profoundly revolutionise the economy and society. In this perspective, the ability to generate, access and utilise these "frontier" technologies will decisively contribute to defining the geostrategic role that various economies will be able to assume in the international context (Archibugi et al., 2025; UNCTAD, 2023; Cerra & Crespi, 2023).

International tensions, particularly between China and the US, extend beyond trade and are driven by fierce technological competition for technological and industrial dominance. This competition involves the configuration of global value chains and geostrategic concerns, including the security and resilience of digital networks, energy, space, marine domains and international financial infrastructure. In this context, the notion of technological sovereignty gained relevance in recent years, highlighting the role of autonomous technological capacities in shaping global strategic interactions (Crespi et al., 2021; Cerra & Crespi, 2021; Bellanova et al., 2022; Caravella et al., 2024; Edler et al., 2023). The recent appointment of an Executive Vice-President to the new European Commission for Technological Sovereignty, Security and Democracy, appears to be coherent with increasing attention on these issues.

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So far, the debate on technological sovereignty has mainly emphasised the dimensions of technological *competition* as a playing field for shaping global geostrategic dynamics. Doing so highlights the fact that industrial, research and innovation policies can no longer merely aim for a generic increase in national competitiveness. Instead, these policies must become tools to deliberately guide economic agents to act in ways that generate security externalities favourable to states' strategic interests (Staab et al., 2024).

The next step is to recognise that solving specific scientific and technological problems require going beyond the capacities and expertise available to individual companies or states. In particular, the great global challenges such as the development and governance of new digital technologies (especially artificial intelligence), climate change, the transition to sustainable energy and growth models, health, security, and demographic and migratory phenomena, can be addressed more effectively through *cooperative* efforts (Huang & Soete, 2025; UNCTAD, 2024).

In this respect, technological sovereignty does not imply the necessity of pursuing a complete technological autonomy that challenges the international division of labour and the search for autonomous technological capabilities in all fields deemed strategic. It does, however, suggest the need for a single country – or a federation of states, as in the case of the European Union – to develop or maintain, with regard to fundamental technologies, its own autonomy or the lowest level of dependency possible. This indicates, in particular, the importance of avoiding unilateral dependencies.

Achieving this goal through a techno-nationalist approach would be highly inefficient, as well as practically unfeasible. Hence, misinterpreting technological sovereignty as techno-nationalism leads to the development of closed research and innovation policies, which inherently fail to ensure the objective of technological sovereignty (Lee et al., 2024).

Building on these considerations, this contribution aims to highlight the potential of "coopetition" as a strategy to manage the tensions between competition and cooperation in a context of growing technological complexity and global rivalries for achieving technological, economic and military supremacy (Cerra & Crespi, 2024).

Following previous literature on coopetition (Brandenburger & Nalebuff, 1996; Corbo et al., 2023; Gernsheimer et al., 2021; Katsaliaki et al., 2024), we can define it as a strategy capable of simultaneously combining cooperative and competitive dynamics between two or more entities to achieve mutual and significant advantages, thereby increasing the ability to effectively respond to the complex challenges posed by technological innovation, markets and geostrategic processes.

In particular, the paper explores competition and cooperation activities in science and technology by analysing recent trends in international scientific collaborations, co-patenting among major global players and data from EU-funded research projects. Additionally, we propose the notion of coopetitive technological sovereignty as a framework strategy for managing international relations, particularly in science and technology. Finally, the policy implications for the EU with respect to its economic security and strategic autonomy objectives are discussed.

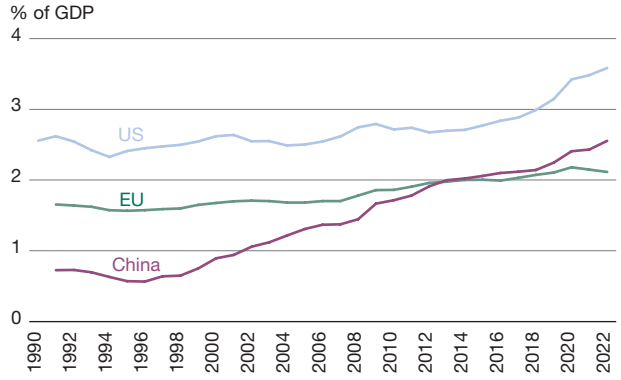
Competition and cooperation in science and technology in a changing world

The hyper-globalisation process that characterised recent decades has significantly increased the systemic interdependence of various countries, often through the promotion of commercial, technological and productive cooperation activities that have not always been conducted in a fully conscious way. On the one hand, these processes have facilitated international trade, productive specialisation, and thus the growth of the global economy. On the other hand, they have also triggered the emergence of major economic, financial, social, environmental and geopolitical imbalances (Guarascio et al., 2025; Reljic et al., 2021; Stamegna et al., 2024; Stiglitz, 2018a).

In this context, while the European economy faces prolonged stagnation, China continues to rise as a major economic and geopolitical power, and the global leadership role of the United States is increasingly in question (Kirshner, 2024; Streeck, 2024). Geopolitical tensions have fuelled protectionist policies, with growing political support for reshoring and friend-shoring initiatives (Draghi, 2024; Farrell & Newman, 2019, 2023; Laffan, 2018; Schwarzer, 2017).

In response to China's rapid ascent, the US has reoriented its strategy, treating China as a strategic rival rather than an economic partner (Ma et al., 2024). This shift is evident in legislative measures like the Innovation and Competition Act and Strategic Competition Act, economic sanctions on Chinese firms such as Huawei, and restricted high-tech exchanges in R&D and academia

Figure 1
Gross domestic expenditure on research and development, 1990-2022



Source: Authors elaboration on OECD data.

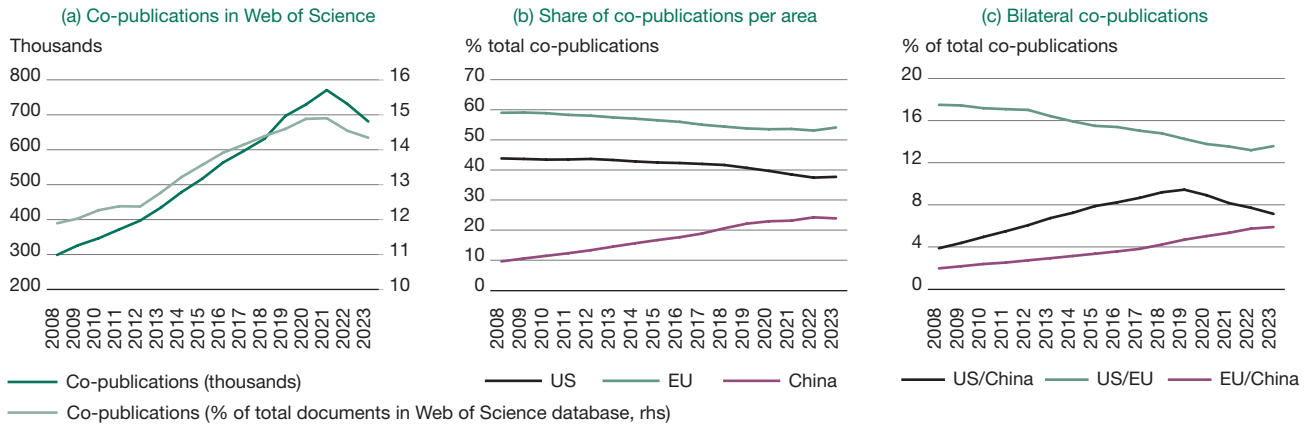
(Fajgelbaum & Khandelwal, 2022; Hopewell, 2021; Stiglitz, 2018b; Yuan, 2020).

International tensions, especially between China and the United States, go beyond trade disputes and are fueled by intense technological rivalry aimed at achieving dominance in technology and industry. This competition is shaped by geostrategic considerations and encompasses the structuring of global value chains, the security and resilience of digital networks, energy systems, space, maritime domains and the global financial infrastructure. Amid these developments, technological sovereignty has become a central theme in political discourse, reflecting a trend towards prioritising domestic production and forming closer ties with trusted partners to navigate global uncertainties (Crespi et al., 2021; Edler et al., 2023).

Currently, the landscape of technological competition is dominated by the US and China, while the European Union's competitive position has been declining (Archibugi et al., 2025). A straightforward illustration of this trend is provided in Figure 1, which shows the R&D investment intensity relative to GDP across these regions.

The US has consistently maintained the highest level of gross domestic R&D spending (GERD) as a percentage of GDP throughout the observed period, with recent growth fuelled by significant investments in digital technologies. Despite US leadership, China has made substantial progress, with GERD rising from 0.6% in 1996 to 2.6% in 2022, surpassing the EU by 2013. The EU lags, with a GERD-to-GDP ratio of 2.1% in 2022, trailing the US by 1.5 percentage points and China by 0.5 percentage points.

Figure 2
Scientific co-publications, 2008-2023



Source: Authors' elaborations on Clarivate Incites data, extracted in September 2024.

Unlike its competitors, the EU has not experienced the AI-driven GERD boom, with a decline in the post-pandemic period, raising concerns in Brussels (Draghi, 2024; European Commission, 2024a).

This trend partially explains the US's technological leadership in frontier technologies, China's extraordinary progress over the past decade, and the European research and innovation system's delays (Draghi, 2024).

International scientific collaborations

However, technological competition is not the only dynamic in international research and innovation activities. Cooperation in science and technology is crucial for achieving ambitious goals, such as, for instance, advancements in artificial intelligence (AI) and quantum technologies (UNCTAD, 2023, 2024). These require comprehensive knowledge integration, long-term projects and collaboration among specialised institutions and experts. In contrast, isolation poses a significant barrier, disrupting knowledge integration and collective learning that are essential for major scientific and technological advancements (Huang & Soete, 2025; Karplus et al., 2025).

Interestingly, the current phase is marked by a significant ambivalence. On the one hand, digital technology advances facilitate efficient data and knowledge transfer, while global challenges like climate change and pandemics demand stronger scientific collaboration and coordinated policies. On the other hand, escalating geopolitical tensions and conflicts drive policies that hinder cooperation, making it risky or costly.

The importance of research collaboration is evident in the substantial volume of multi-author publications from different countries, which often garner more citations and involve leading scientists in high-profile projects (National Science Board, 2021). Openness in the scientific system, including facilitating visits by foreign scholars and fostering international collaborations, enhances the development of a strong scientific foundation and cultivates "soft power" in international relations (Wagner & Jonkers, 2017). Moreover, research mobility and collaboration have brought widespread benefits to China and other participating countries (Lee & Haupt, 2021).

In this respect, Figure 2 shows the dynamics of international scientific co-publications indexed in the Web of Science database (2008-2023) for the EU, US and China. Co-publications, which account for about 15% of all publications, have more than doubled from 300,000 to over 770,000 between 2008 and 2021. However, this share declined from 15% in 2021 to 14.3% by 2023 (Figure 2a).

The increasing involvement of Chinese researchers in international scientific cooperation is reflected by China's share of global international collaborations, which rose from 9.6% in 2008 to 23.9% in 2023. Symmetrically, the US and EU saw slight decreases, from 43.6% to 37.7% and from 59% to 54.1%, respectively (Figure 2b).

Looking at bilateral collaborations, Figure 2c shows that in recent years China-US and China-EU collaborations have followed a diverging trend. While the former declined from 9.4% in 2019 to 7.1% in 2023, the latter increased from 4.7% to 5.9% over the same period. The decline in China-US collaborations can be partly attributed to pandemic-

related travel restrictions, visa denials and communication challenges due to blockages, illness and funding issues. However, if the decline was solely pandemic-driven, similar trends would be expected in China-EU relations, which is not the case.

This phenomenon reflects escalating political tensions between China and the US, particularly in science and technology. These tensions intensified with the US government's 2017 investigation into illicit technology transfers and the increased intensity of Federal Bureau of Investigation's scrutiny. The Department of Justice reported that 80% of economic espionage prosecutions involve conduct benefiting the Chinese state, with a China nexus in 60% of trade secret theft cases (Subbaraman, 2021). These political tensions have strained scientific cooperation, prompting increased restrictions on collaborative activities between universities on both sides of the Pacific (Gilbert, 2023). Following the investigation's conclusion in 2022, several Chinese scientists were arrested, and both the US and Chinese governments implemented measures to address technological security risks (Gilbert, 2023; Subbaraman, 2021). This led to a rise in "brain return" to China and a decline in China-US dual affiliations.

EU-funded research projects

In contrast, the EU's research system remains notably open, as further evidenced by data on EU-funded collaborative projects under the Framework Programmes for Research (FP) involving non-EU partners. Table 1 provides a detailed analysis of collaborations with the US, Russia, China, Japan and Korea.

The data indicates a significant rise in international collaborations during the FP7 and Horizon 2020 programmes, highlighting the EU's strong commitment to global scientific partnerships. The US emerged as the leading non-EU partner, participating in nearly 3,000 projects, followed by China and Russia, with Russia playing a prominent role prior to Horizon 2020. Collaborative projects increased across all partners, except Russia, over the three programming cycles (FP6 to Horizon 2020). For Horizon Europe (2021-2027), data are incomplete due to ongoing calls, but a notable absence of Russian collaborations is observed.

Co-patenting

International technology cooperation can also be examined through co-patenting activities. Figure 3 presents co-patenting trends for the US, China, India, France, Germany and Italy with other G7 and BRICS countries for the period 2000-2021. Figures show that US co-patenting activities with other G7 countries declined from 83% in 2000

Table 1
International collaborations of member states in EU-funded projects

	Framework Programme				
	FP6	FP7	Horizon 2020	Horizon Europe	Total
Period	2002-2006	2007-2013	2014-2020	2021-2027	
Budget, billion euro	16.3	50.5	77	95.5	283.3
Number of collaborative projects					
USA	337	437	1499	689	2962
Russia	291	326	137	..	754
China	198	232	282	77	789
Japan	27	103	176	87	393
Korea	18	54	84	43	199
EU contribution, million euro					
USA	811	2220	4430	1900	9361
Russia	1390	1560	631	..	3581
China	813	874	1200	221	3108
Japan	125	529	534	242	1430
Korea	96	284	821	426	1627

Source: Authors' elaborations on European Commission data, 2024.

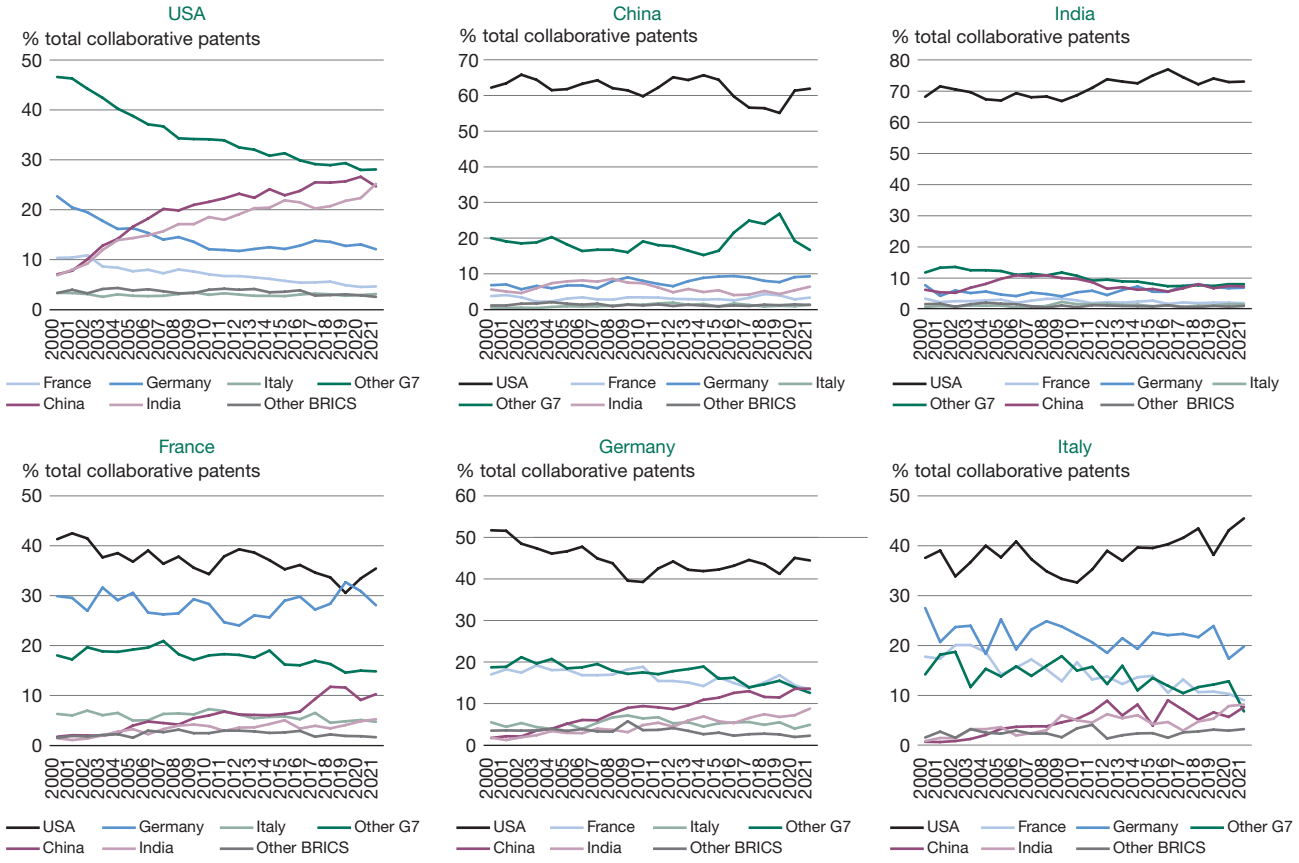
to 48% in 2021, while collaborations with China and India rose, globally, to 50%. Interestingly, unlike scientific publications, co-patenting with China shows no significant decline post-2016, except in 2021. This seems to indicate that the inertia in collaboration activities between the US and China in the technological field, which have been primarily carried out by companies, has been greater compared to the case of collaborations in scientific research.

China and India maintain the US as their leading partner, with over 60% and 70% collaboration shares, respectively. Notably, China's co-patenting with Germany grew from 6.8% in 2000 to 9.3% in 2021, reflecting strong technological ties. Among European countries, the US remains the main partner, although the share of co-patents decreased for France and Germany while increasing for Italy, from 37.5% to 45.4% between 2010 and 2021. Additionally, collaborations with China have grown significantly for France and Germany, reaching 10.2% and 13.6% respectively by 2021, while Italy's share stands at 7.7%. Italy's engagement with India is higher than France and Germany, at 8.1%.

Toward a European strategy for coopetitive technological sovereignty

The preceding analysis highlights the relevance of both competition and cooperation forces shaping international

Figure 3
Co-patenting activity of selected G7 and BRICS countries, 2000-2021



Notes: Figure shows the share of co-patents of USA, China, India, France, Germany, Italy along with other G7 and BRICS countries, as percent of total co-patents between G7 and BRICS countries.

Source: Authors' elaborations on OECD data.

relationships concerning the development of both scientific and technological knowledge.

Given increasing knowledge complexity involved in technological innovation activities, it is unrealistic for a country to maintain all technological and production capabilities, despite the political appeal of such an approach. This is especially true with the increasing integration of sectors and the growing importance of general-purpose technologies like AI and quantum technologies, which demand extensive knowledge integration (Guarascio et al., 2023).

For instance, the semiconductor industry involves globally distributed value chains from chip design to utilisation. Achieving technological sovereignty in semiconductors through isolated policies is impractical. National attempts to maintain all technological capabilities risk promoting inferior technologies, reducing international competitiveness. Moreover, unilateral pursuit of technological sovereignty could lead to redundant investments in innovation, stalling progress across multiple domains (Lee et al., 2024).

This implies that pursuing the development of stronger domestic technological capabilities while collaborating internationally to leverage complementary knowledge is essential. In a context marked by rising geopolitical tensions and intensifying competition for achieving technological, economic and military supremacy, the ability to strategically manage relationships at the international level becomes a fundamental element maintaining the benefits from cooperation without compromising the objectives in terms of technological sovereignty, economic security and strategic autonomy.

In this perspective, we claim that coopetition is the most suitable way to develop an effective approach to manage

international interdependences in science and technology and address current and future challenges. We hence define coopetitive technological sovereignty as a structural and longitudinal strategy in which states compete for technological leadership while deliberately collaborating, in an informed way, with other countries to generate essential critical technologies through the use of complementary knowledge.

Following this approach, selecting appropriate countries for cooperation is crucial. While any country contributing to technological innovation can be a potential partner, considerations of national security are essential.

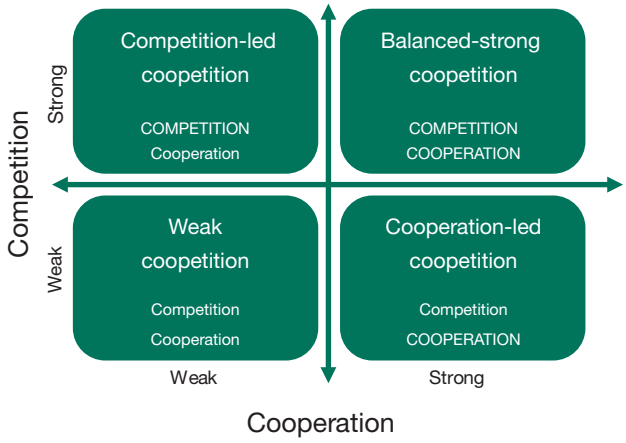
In this perspective, states must implement a coopetition governance system involving different organisations, i.e. governments, ministries, agencies, universities, research centres and companies. This system enables informed policy decisions that balance the benefits of collaboration with the risks, which vary by partner and technological field.

In particular, it is important for organisations to be able to dynamically assess where to place research/innovation international activity within the scheme shown in Figure 4 and, consequently, define the appropriate strategies. The following scheme outlines the case of cooperation-driven coopetition, where strong cooperation and weak competition occur; competition-driven coopetition, characterised by weak cooperation and strong competition; balanced-strong coopetition, which involves both strong cooperation and strong competition; and weak coopetition, where both are low. The positioning of each activity under scrutiny in one of the four quadrants will be the result of a thorough assessment of different elements, including the type of partners involved, the type of implied knowledge exchanges, the type of scientific/technological domains considered and the type of research activities (e.g. basic or applied) to be carried out. Subsequently, different coopetitive strategies to manage the relationships can be implemented in order to maximise cooperation opportunities while mitigating eventual risks.

The proposed approach appears to have particular relevance for the EU, where a swift strategic response, particularly in industrial and innovation policy, is necessary to leverage existing competencies and technologies (European Commission, 2024a).

Addressing persistent disparities with global leaders requires EU countries to transcend both national and single-market boundaries to establish international collaborative networks. This is essential for accessing complementary knowledge and fostering joint technological development.

Figure 4
Coopetition modes



Source: Authors' adaptation from Park et al. (2014).

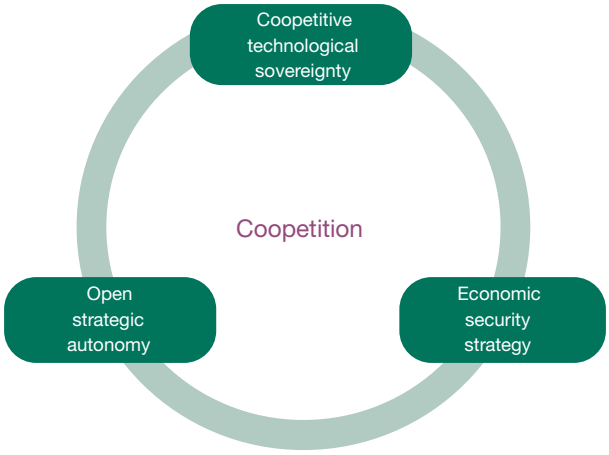
This shift offers a chance to propose a policy approach that integrates investment and industrial policies in high-tech sectors with strategic international collaborations. The dual focus on technological competitiveness and security – physical, digital, economic and social – necessitates the combined approach offered by a coopetitive technological sovereignty strategy. The European Commission's guiding principle for international research cooperation, "as open as possible, as closed as necessary," underscores this approach (European Commission, 2024b).

Moreover, coopetition could become a core paradigm for effectively implementing the broader EU strategies on economic security and open strategic autonomy.

Strategic autonomy reflects the EU's capacity to act independently in critical policy areas. The term "open" emphasises the EU's commitment to multilateral cooperation where feasible (Cagnin et al., 2021), balancing autonomy with interdependence to protect economic interests and European societal values. In parallel, the EU's economic security strategy focuses on revitalising domestic policies for strategic sectors and forming multilateral partnerships to enhance economic resilience and collective security (European Commission, 2023).

In any case, the implementation of European coopetitive technological sovereignty, open strategic autonomy and economic security must consider the delicate balance of competencies between European institutions and member states, alongside their varying priorities and interests (see Figure 5). Tensions between national and European sovereignty, competition among member

Figure 5
Coopetition as a core strategy for EU policies



Source: Authors' elaboration.

states, and disparities in technological and production capabilities further complicate this process. Indeed, the EU's role is limited in coordinating member states' actions, as economic security remains within the realm of national security, leaving responsibility to individual states. This decentralised authority presents coordination challenges that can, however, be at least partially addressed if we recognise that even member states interactions are characterised by coopetitive dynamics. In this respect, the development of a governance system for the strategic management of coopetition activities could also promote the reconciliation of different national interests.

Conclusions

The analysis presented in this article emphasises how, in the current historical phase, the dynamics characterising interactions among states have become intrinsically and structurally coopetitive. Hence, adopting a coopetitive technological sovereignty strategy is not only essential for the European Union but also a realistic pathway to navigating the complexities of the global technological and geostrategic landscape.

While the role of competition in the international technological race has been particularly stressed in the current debate, the provided analysis demonstrates that both competitive and collaborative forces are shaping international relationships related to the development of scientific and technological knowledge. In particular, bilateral collaborations in scientific publications show that a diverging trend has emerged in recent years between China-US and China-EU collaborations. While China-US collaborations have been declining, China-EU collaborations have been continuously increasing. This evidence suggests that the EU's research system remains notably open, as further evidenced by data on EU-funded collaborative projects under the Framework Programmes for Research involving non-EU partners.

Considering that the EU is lagging behind technological global leaders, the openness of the EU research system is essential for accessing complementary knowledge and fostering joint technological development. However, given the challenges related to increasing geopolitical tensions and economic security concerns, international relations in the sensitive field of scientific and technological activities should be carried out by adopting an informed and thorough approach.

To this end, it is necessary to build a governance system for coopetition that can involve, at various levels and in a coordinated manner, the institutions and organisations responsible for defining and implementing policies, to evaluate case by case and systematically the intensity of risks and opportunities arising from collaboration activities. This can be built by developing and spreading an organisational culture of coopetition within different public organisations. This goal can also be realised through the development of training activities for the acquisition of cross-disciplinary and advanced skills capable of enabling the comprehension and management of coopetitive-type relationships. In particular, training paths could be focused on advanced skills in strategy and management of coopetition, economic diplomacy, negotiations and conflict management, aimed at improving policy management in complex and multi-stakeholder scenarios.

In conclusion, pursuing a strategy of coopetitive technological sovereignty can be understood as a practical means to leverage the dual forces of competition and cooperation in science and technology. This would promote the benefits of cooperation without compromising economic security and strategic autonomy objectives.

Moreover, an effective management of coopetitive relationships among countries can help address the major challenges that global society is facing. Climate change, pandemics, population aging and digital transformation are difficult to tackle with the technological capabilities of a single country. Without concerted efforts within the international community, no single nation can effectively manage potentially catastrophic crises, as demonstrated by the collaborative international development of COVID-19 vaccines.

Given that the objectives related to major global challenges, in many cases, align with the interests of individual nations, this is precisely the area where it is possible to develop strategies for coopetitive technological sovereignty based on large-scale international cooperation. In so doing, such strategies could also reduce global security risks arising from the progressive decoupling processes between different regions of the world.

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Andrea Coveri, Claudio Cozza and Dario Guarascio

Big Tech and the US Digital-Military-Industrial Complex

Large digital platforms – Meta (Facebook), Amazon, Microsoft, Alphabet (Google) and Apple, the so-called Big Tech companies, which are compared to Chinese counterparts like Alibaba, JD or Tencent – dominate the world economy. Their market capitalisation has exceeded the GDP of large economies such as Germany or Japan.[1] They control a significant share of global research and development (R&D)[2] and patents related to frontier technologies, such as artificial intelligence (AI) (Fanti et al., 2022; Hötte et al., 2023). These figures reflect an unprecedented concentration of techno-economic power, with major implications for income distribution, access to knowledge and innovation, fragmentation and precarisation of labour, as well as on rising geopolitical tensions (Armoogum et al., 2022; Vasudevan, 2022).

At the root of this power is the control of knowledge, infrastructure (e.g. data centres, submarine cables) and, above all, dual-use technologies – i.e. cloud, AI, and new satellite navigation and communication systems – essential in both civilian and military spheres (Farrell & Newman, 2022; Coveri et al., 2024). Unsurprisingly, Big Tech companies are now key players in the clash between the two "digital-military-industrial complexes" (Guarascio & Pianta, 2025) – China and the United States – that are competing for global hegemony (Jia et al., 2018; Li & Qi, 2022; Rolf & Schindler, 2023). This is contributing to the blurring of the state-corporation boundaries even more than what was observed during the second half of the twentieth century with the rise of transnational corporations (Hymer, 1972; Cowling, 1982). In this respect, the ubiquitous role of Elon Musk within the new Trump Administration, or the loyalty shown by the other Big Tech CEOs during the swearing-in ceremony,[3] lend support to the hypothesis of a strategic convergence of interests (O'Mara, 2020; Coveri et al., 2024).

Military and intelligence apparatuses cannot do without Big Tech. The latter control tools (among them, cloud systems or AI algorithms aimed at image and sound recognition, behaviour prediction and military targeting) that are essential for surveilling adversaries (and "allies") and, if needed, to anticipate their moves on the battlefield. These corporations play a pivotal role in military-related innovation ecosystems, helping to mobilise the R&D efforts of start-ups and facilitating the transfer to the military sphere of technologies designed for the civilian domain (Gawer, 2022; Guarascio & Pianta, 2025). No less relevant, media platforms run by Big Tech – e.g. the social media platform X, owned by Elon Musk – are supportive in building political consensus and influencing public opinion, both at home and abroad.

On the other hand, public investments, particularly those aimed at buying and/or developing dual technologies, are a relevant source of accumulation for digital corporations; as well as a stimulus for their innovative activity (Coveri et al., 2022). Equally important may be government support when Big Tech internationalisation strategies are hampered by hostile governments and regulations (Kwet, 2019). In this context of "mutual dependence" (Coveri et al., 2024), the more intense the relationship between the state and Big Tech is, the less likely the former is to put restrictions in place – e.g. higher taxation, stricter antitrust measures or binding regulations aimed at limiting platforms' access to private information – that would seriously challenge the economic power of the platforms.

Building on Coveri et al. (2022, 2024), we focus on the US digital-military-industrial complex highlighting and empirically documenting the channels holding the two sides together. First, we identify the main elements shaping the interdependency between the state and Big Tech. Second, we explore military expenditures and procurement

1 See, for example, data reported by Visual Capitalist (2021) and Statista.com (2024).

2 By 2024, Big Tech's R&D investment was US $240 billion, more than a quarter of the total recorded in the United States. See Guarascio and Pianta (2025).

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3 After publicly expressing their support for the new administration, including through financial handouts, the CEOs of Alphabet, Amazon and Meta took part in the inauguration, marking a relative discontinuity from the attitude of distance from politics that has traditionally characterised Big Tech.

contracts, showing both the progressive militarisation of digital technologies, as well as the growing importance of Big Tech as military contractors. Third, we shed light on the "revolving doors" allowing former Big Tech officers to join military and intelligence agencies, and vice versa. Fourth, we document the active role of digital corporations in current war scenarios, contributing to dismantling the "don't be evil" rhetoric according to which Big Tech-controlled infrastructures and technologies are never used for malicious purposes.

Big Tech and the emergence of a digital-military-industrial complex

When John Hobson published *Imperialism* in 1902, military campaigns were crucial for opening new markets, securing the supply of raw materials and putting competitors out of business. With the consolidation of large transnational corporations, military expenditures have assumed a prominent role in sustaining capital accumulation, especially during periods of stagnation (Baran & Sweezy, 1966). Likewise, military-related R&D and procurement turn out to be important drivers of technology transfer, particularly for the development of radical innovations such as the Internet (Mowery, 2009). In the US, the linkage between military R&D agencies (e.g. the Defense Advanced Research Projects Agency, DARPA) and large private contractors is at the core of the "military-industrial complex", which was instrumental to the country's economic and technological growth during the Cold War (Galbraith, 2007).

The military sector is thus a domain where state-corporation boundaries may become significantly blurred (Pianta, 1989; Foster & McChesney, 2014; Roland, 2021). With the digitalisation of the world economy, this overlap becomes even stronger. Controlling digital networks and the "chokepoints" through which information flows from one continent to another allows for "weaponizing interdependencies" (Farrell & Newman, 2022), providing a substantial advantage over enemies and allies alike. Yet, this is virtually impossible without the support of Big Tech, as the latter controls knowledge (Rikap, 2024), technologies, such as cloud systems and AI (Van der Vlist et al., 2024), and physical infrastructures, e.g. data centres and submarine cables (Gjesvik, 2023), without which global networks can hardly be weaponised. No less relevant, contemporary wars are becoming increasingly "digital" (Merrin & Hoskins, 2020). AI-powered drones sold for less than US $100,000 can easily destroy aircrafts or tanks that are 100 times more expensive. Advanced cloud and satellite communications systems are essential for gathering information and preventing or executing attacks (physical and cyber). Even the performance of traditional weapons (e.g. aircrafts, tanks, anti-aircraft systems) is highly dependent on their digital components (Johnson, 2019; González, 2023; Zikusoka, 2024).

The digital-military-industrial complex is fairly different from the entanglement of public and private interests denounced by President Eisenhower in 1961, when the military-industrial complex was first defined. In the latter, traditional contractors (e.g. Lockheed Martin, Raytheon, Halliburton) were largely dependent on public demand and their innovative activity was closely linked to the needs of the military sector (Guarascio & Pianta, 2025). Accordingly, procurement relationships were (and to a good extent still are) characterised by large, long-term contracts; a strong focus on the performance of weapon systems (while less attention was devoted to efficiency or flexibility of use); and a high degree of bureaucratisation of processes (Pianta, 1989). This has biased technological trajectories and, in some cases, weakened the industry's ability to innovate (Kaldor, 1990). The digital-military-industrial complex operates in a rather different way. Despite owing their birth to a military project (the Internet), Big Tech earn most of their profits in the civilian domain; and a majoritarian share of the technologies that they develop for the military sector stem from applications initially designed for commercial purposes. This gives them greater bargaining power vis-à-vis government procurers, consolidating their role as exclusive providers of dual technologies and, more broadly, reducing the risk of being challenged by hostile regulations.

The interdependency between the state and Big Tech

First of all, there is an original linkage. As argued, the economic power of Big Tech stems from the appropriation of knowledge and technologies developed in the public (mostly military) sector and transferred at virtually no cost by the same governmental apparatuses that helped develop them (Mazzucato, 2013).[4] First movers, including soon-to-be Big Tech, have begun to push forward the technological frontier, introducing thousands of radical and incremental innovations, designed primarily for commercial

4 Major projects carried out by US federal agencies, such as DARPA (Mowery, 2010), contributed to the development of General Purpose Technologies (GPTs) – including semiconductors, the Transmission Control Protocol and the Internet Protocol (TCP/IP) (Greenstein, 2020) – and were crucial to the spread of computers and, later, the Internet itself (Mazzucato, 2018). In this context, close relationships between DARPA, private technology firms and the country's leading universities fostered technology transfer, incremental innovations, and forged the U.S. National Innovation System (NIS) (Freeman, 1995). With the "commercialization of the Internet" (Greenstein, 2015), few companies exploited the "first mover" advantage by gaining dominant positions in critical market segments such as search engines (Alphabet), social networks (Meta), digital marketplaces (Amazon) and cloud services (e.g. Amazon Web Services and Microsoft Azure).

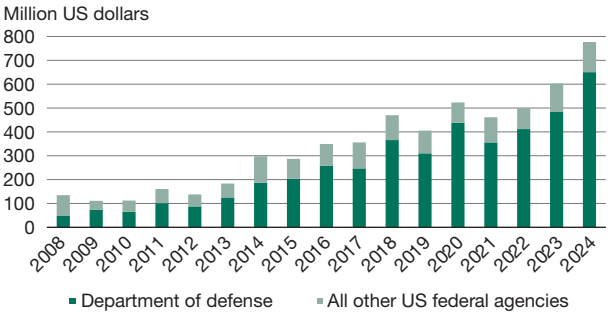
use. Although their growth takes place mainly in the civil-commercial sphere, the original linkage between Big Tech and the military apparatus never completely disappears. After the Twin Towers attack on 11 September 2001, US military and counter-terrorism policy recognised the value of digital infrastructures and technologies. As a result, Big Tech has been increasingly involved in intelligence- and military-related projects, including surveillance systems, secure communications and remote management of weapons and military equipment. The dual nature of applications designed, for instance to predict consumer behaviour (Zuboff, 2019) or optimise the functioning of logistics systems, is beginning to emerge (González, 2023).

At the same time, skills and competences stemming from the public sector are a crucial source of knowledge to develop Big Tech's R&D projects (Rikap & Lundvall, 2022). On the demand-side, the Department of Defense (DoD) budget for digital technologies kept growing. In the fiscal year 2024 budget, DoD requested US $315 billion for weapon systems acquisition, an increase from US $276 billion in 2023. This includes US $170 billion for procurement and US $145 billion for research, development, test and evaluation (R&DTE). Digital technologies play a central role in R&DTE efforts, with significant funding increases for cyberspace, spectrum, AI, 5G, and other digital-related programmes (Coveri et al., 2024). Moreover, investment in command, control, communications, computers and intelligence (C4I) – a field heavily reliant on digital technologies – has experienced the fastest growth among DoD budget components. Funding increased from US $7.4 billion in 2017 to US $12.8 billion in 2023 and is projected to reach US $21 billion in 2025.[5] This budget covers command centres, data processing, IT infrastructure, communication systems, air traffic control, night vision equipment and cyberspace operations. Additionally, science and technology (S&T) activities will receive US $18 billion in 2025, with priorities focusing on AI and machine learning applications, 5G, microelectronics, quantum sciences, cyberwarfare, hyper-sonics, directed energy weapons (such as lasers and particle beams), biotechnology and space technologies.

Regarding military-related procurement contracts awarded to Big Tech, we showed how the former increased about thirteenfold from 2008 to 2024. To illustrate, Figure 1 reports the value of contracts awarded to Big Tech, highlighting the share of resources stemming from the DoD.

Compared to the overall revenues of Big Tech, the value of these contracts is obviously small. Yet, these figures likely underestimate the real numbers, as many military and intelligence-related projects are classified (González, 2023). What truly matters, however, is the role that Big Tech play in managing critical infrastructure and technologies. Accordingly, Table 1 reports a selection of multi-year contracts that DoD, the Central Intelligence Agency (CIA) and National Security Agency (NSA) award Big Tech, providing details on the amounts, nature of the services delivered, and their intended military or intelligence applications.

Figure 1
US Federal procurement contracts awarded to Alphabet, Amazon, Meta and Microsoft, 2008-2024



Source: Adapted from Coveri et al. (2024).

In 2013, the CIA awarded Amazon Web Services (AWS) a 10-year contract, worth a total of US $600 million, to provide cloud computing services to all 17 US intelligence agencies. In 2014, AWS launched its first "Top Secret Region", called "Top Secret-East", which was followed by the launch of a second, known as "Top Secret-West", providing cloud services for US intelligence and defence agencies (including the NSA). Microsoft has been providing similar services under the "Azure Government Secret" projects, launched in 2017, and "Azure Government Top Secret", introduced in 2021.

Other relevant initiatives include: *Project Maven*, launched by the DoD in 2017 and involving first Google and later Amazon and Microsoft, aimed at developing surveillance software embedded in military drones; *Commercial Cloud Enterprise*, contracted in 2020 by the CIA with AWS, Alphabet, IBM, Microsoft and Oracle to provide cloud services; *Wild and Stormy* (worth US $10 billion), awarded by the National Security Agency (NSA) to AWS in 2022 and aimed at transferring US intelligence data from internal servers to Amazon's cloud infrastructure; *Joint Warfighting Cloud Capability (JWCC)*, awarded in 2022 by the DoD to Amazon, Google, Microsoft and Oracle (the economic value was disclosed to be about US $9 billion) for strengthening the military cloud.

5 Detailed information can be found at comptroller.defense.gov/Portals/45/Documents/defbudget/FY2024/FY2024_Budget_Request_Overview_Book.pdf.

Table 1
Selection of military contracts assigned by DoD, CIA and NSA to US digital corporations (2013-2024)

Year	Department	Contractor	Amount (million US $)	Nature of activities	Stated objective
2013	CIA	Amazon	600	Cloud	Data management aimed at preventing terrorist attacks
2019	DoD ("Project Maven")	Alphabet (withdrawn); Amazon and Microsoft	50	Drones	Acquisition of AI technologies to improve image recognition in military drones
2020	CIA ("Commercial Cloud Enterprise")	Alphabet, Amazon, Microsoft and Oracle	"Tens of billions"	Cloud	Cloud services centralised for 17 intelligence agencies
2021	DoD (HoloLens)	Microsoft	21,9	Augmented reality visors	HoloLens augmented reality headset for military activities in highly complex environments
2022	NSA ("Wild and Stormy" project)	Amazon	10	Cloud	NSA cloud infrastructures
2022	DoD	Microsoft	n.a.	Stryker armoured vehicles	Digital tools to be embedded into armed Army vehicles
2022	DoD	Alphabet (Google public sector division)	n.a.	Google workspace	Provision of Google Workspace to 250,000 DoD employees
2022	DoD ("Joint Warfighting Cloud Capability")	Alphabet, Amazon, Microsoft and Oracle	9	Cloud	Defense cloud infrastructure
2022	DoD ("Hybrid Space Architecture" program)	Amazon and Microsoft	n.a.	Satellites	Space and land infrastructure for national security
2022	DoD	Amazon	724	Cloud	Cloud services to process and store data for critical missions
2023	Space Systems Command / DoD	Microsoft	19.8	Cloud-based space simulation (viewable with Microsoft HoloLens headsets)	Space simulator aimed at gaining situational awareness and acting faster than adversaries
2024	DoD	Amazon	22	Cloud	Cloud services for the Army department of the US Special Operations Command

Source: Adapted from Coveri et al. (2024).

AWS also contributed to the development of the first permanent tactical cloud for the US Army's XVIII Airborne Corps, as well as the launch of AWS Modular Data Center and AWS Snowblade. The latter are devices made available to the DoD to enable the Army to collect, store and process data in remote or high-risk warfare contexts. Finally, in addition to cloud technologies and infrastructure, the Pentagon acquired 120,000 HoloLens augmented reality visors, developed by Microsoft – based on a 2021 contract worth nearly US $22 billion – that were aimed as much at equipping soldiers as at being incorporated into Stryker armoured vehicles.

Why is this evidence so relevant? By overseeing data centres, cloud services, submarine cables, AI systems designed to prevent cyberattacks and infrastructures that ensure connectivity in conflict zones, Big Tech has become the eyes and ears of governments both at home and abroad (Coveri et al., 2024). This allows them to access sensitive information and develop specific competences that may further strengthen their position vis-à-vis national governments. Moreover, the possibility of experimenting with new technologies in extreme and barely regulated contexts such as battlefields provides such corporations with a unique opportunity to perfect and refine new applications. In this respect, it is interesting to note that many companies producing AI technologies emphasise their role as military contractors as a way to highlight their reliability and technological ingenuity.[6]

6 A case in point is the war in Gaza, where digital companies – including many US Big Tech firms – have rushed to offer the Israeli military the latest advances in the field of AI. See, for example, https://www.washingtonpost.com/technology/2025/01/21/google-ai-israel-war-hamas-attack-gaza/.

Revolving doors

The increasingly close relationship between Big Tech and the military sector can also be highlighted by looking at the "revolving doors" already documented during the Cold War (Brunton, 1988; Etzion & Davis, 2008; Duncan & Coyne, 2015). This is about the movement of a growing number of senior Big Tech executives into military and intelligence agencies, while former members of the military apparatus are appointed to hold top roles in the same companies.

These movements allow the military sector to leverage skills and networks of relationships that can be crucial to monitor the technological frontier to identify, in a timely manner, the most promising applications (Lundvall & Rikap, 2022). By the same token, former military and intelligence personnel can help Big Tech to anticipate demand-side needs, better tailoring digital applications and circumventing the bureaucratic constraints that often slow down diffusion and technology transfer. Relatively recent examples include the former Apple Vice President Doug Beck, who was recently appointed as the new director of the Defense Innovation Unit;[7] and the Alphabet's former CEO Eric Schmidt, who served – along with former Secretary of State Henry Kissinger and former Deputy Secretary of Defense Robert Work – as Chairman of the Defense Innovation Advisory (DIA) Board and the National Security Commission on AI, namely advisory bodies aiming to counter China's growth in the development of dual (digital) technologies. As for the movements from the military apparatus to Big Tech, notable cases include former DIA Executive Director Josh Marcuse, who in 2020 took a management role within Google Public Sector, i.e. the Google's department that develops technologies for government agencies, including those related to the military; and General Keith Alexander, former director of the NSA from August 2005 to March 2014 and commander of US Cyber Command from May 2010 to March 2014, who joined Amazon's board of directors in September 2020.[8]

Big Tech goes to war

Finally, the digital-military-industrial complex manifests itself with the direct involvement of Big Tech in ongoing conflicts. In Ukraine, in addition to the major role played by Space-X, Elon Musk's company providing Internet connectivity to the Ukrainian army through its low-orbit satellite system, AWS and Microsoft have been managing the IT infrastructure of the Ukrainian public administration and banking system since the very early stages of the conflict (González, 2023; Coveri et al., 2024). Big Tech has been providing cloud and AI services to the Israeli army in its war in Gaza. More specifically, since 2021, the US $1.2 billion Nimbus project ties Alphabet and Amazon to the Israeli government for the provision of AI-based facial recognition and object tracking systems. The latter have played a prominent role in the military campaigns conducted in Gaza since October 2023. In 2024, Google agreed on an extension of the partnership to provide Israel's Ministry of Defence with additional cloud services.

As argued, access to conflict areas provides platforms with a unique test-bed for testing, evaluating and adapting new technologies. Accordingly, the battlefield becomes a peculiar laboratory that allows for experimentation, testing and refinement of military technologies that, in some cases, may prove transferable and profitable in the civilian domain as well (Fox & Probasco, 2022; Bergengruen, 2024). At the same time, as Big Tech becomes essential partners in conducting an increasing number of military activities, the government tends to build stable alliances with these companies. Again, the current Trump-Musk liaison could be considered a piece of evidence supporting such hypothesis.

Conclusions

The link between Big Tech and the military apparatus brings back traditions of economic thought too often forgotten or intentionally removed, such as the twentieth century theories of imperialism and monopoly capital (Hobson, 1902; Baran & Sweezy, 1966). The debate on the military-industrial complex, a concept associated with President Eisenhower's farewell address in 1961, also regains relevance. However, it seems to have been transformed into a digital-military-industrial complex where the key actor, Big Tech, share the peculiarity of being, at the same time, big market players, controllers of technologies essential to citizens' lives and indispensable partners of the military apparatus. This makes the integration of state and private capital even closer and more complex than in the past. It is in this context that the interdependence between the state and Big Tech is forged: a relationship in which the interests of the state prove at times indistinguishable from those of Big Tech, as the latter dominates the infrastructure, technologies and knowledge necessary for the economic, political and military survival of contemporary societies.

7 The Defense Innovation Unit – launched in 2015 by then Secretary of Defense Ash Carter – is a new US agency tasked with engaging digital corporations in the development of defence projects, narrowing the gap between the military and frontier commercial technologies (Kaplan, 2016).

8 Other notable cases involve revolving doors between defence-related government agencies and Google divisions, particularly Google Public Sector. According to the Tech Transparency Project, from 2006 to 2016, 258 such instances occurred between Google and US federal agencies, including the CIA and other security agencies. See Google's Revolving Door (2016).

The relationship between Big Tech and the military apparatus is not free of contradictions, however. Orienting an increasing part of R&D activities toward military objectives may negatively bias the innovative strategy of these corporations, reducing their interactions with the civilian domain, where a significant part of incremental innovations is developed; and weakening the organisational flexibility required by learning processes along the technological trajectory (Pianta, 1989). In the medium to long run, this may result in a weakening of the innovative capacity of Big Tech, which may find itself involved in extremely expensive but technologically unrealistic projects, as happened during the 1980s with the Strategic Defense Initiative (or Star Wars) launched by Ronald Reagan (Guarascio & Pianta, 2025).

Moreover, the close relationship with the military apparatus may give rise to conflicts between executives (inclined to meet the demands of their government counterparts) and workers, eventually unwilling to employ their skills to pursue military objectives. In April 2024, dozens of Alphabet engineers were fired for opposing the aforementioned Nimbus project, which involves the Israeli military's use of technologies developed by the company (similar protests took place within Amazon). Similarly, in 2018, more than 3,000 Google employees signed a petition against the company's involvement in the aforementioned Project Maven. This led to Google's abandonment of the project (quickly replaced by Microsoft and Amazon), although its venture capital wing (Google Ventures) retained stakes in at least two companies supplying military surveillance tools (Orbital Insight and Planet) to both the DoD and the National Geospatial-Intelligence Agency (NGA). The DoD "turned over" the management of Project Maven to the NGA in 2022.

The interdependence between the state and Big Tech that we have documented challenges the traditional distinction between the state and the market, blurring their boundaries and, most importantly, questioning the willingness (and ability) of the former to control (and discipline) the latter in the collective interest. This should not come as a surprise: as we have shown, Big Tech turns out to be increasingly important both for winning today's fierce intercapitalist competition, as well as for winning the wars that such competition continually threatens to trigger.

In such a framework, instruments such as antitrust policies can do little against the power of these large corporations, if only because the fines imposed on them are smoothed out with the turnover of a few days, if not hours. Rather, it would be necessary to question the private monopoly of knowledge and infrastructure that underlies this power, as well as the intermingling of interests that exists between them and the expansionist aims of their governments.

Europe faces considerable difficulties in this context. Its technological deficit in the digital domain makes it highly dependent on the US digital-military complex. Apart from the non-trivial attempts to curb the power of Big Tech through antitrust measures or via the introduction of regulations aimed at limiting the access to personal data (e.g. the General Data Protection Regulation, GDPR), European citizens, companies and member states do not yet have much of an alternative but to rely on the digital services offered by Big Tech. In this respect, the arms race that the EU is launching risks further strengthening the digital-military complex, thus increasing rather than reducing such dependency.

Europe should put forth an alternative to such a dangerous convergence between the power of big corporations and the militarisation of digital technologies. It is not inevitable to use such technologies for conditioning consumers' behaviour, surveillance, or to make war. Nor is it inevitable that the control and development of digital technologies ends up in seemingly unbreakable private monopolies, contributing to the growth of inequalities and the weakening of democratic systems. On the contrary, in the context of a rediscovered industrial policy, the EU should work towards building public digital platforms that contribute to direct research and innovation efforts towards the pursuit of collective interests (e.g. expanding the supply of public goods such as health and education) and not towards strengthening systems of repression and war. Accordingly, the system of rules put in place by policies such as the GDPR or the AI Act[9] should be consolidated, not weakened in the name of competitiveness, as the Draghi report seems to suggest (Draghi, 2024).

Even more important, however, is the need to rethink the private nature of the Internet, which seems to have betrayed its initial promises: not the expected vector of widespread economic opportunities and democratic empowerment, but a driver of commodification, concentration of techno-economic power and geopolitical tensions.

9 https://digital-strategy.ec.europa.eu/en/policies/ai-pact

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The Missing Rocket: An Economic and Engineering Analysis of the Reusability Dilemma in the European Space Sector

In 2023, SpaceX's Falcon 9 completed 138 orbital flights, up from 96 in 2022 (Foust, 2025). In contrast, Ariane 6, Europe's long-awaited successor to Ariane 5, launched only once – for its inaugural flight. This stark contrast has sparked debate, with many advocating for Europe to develop its own reusable rocket, following SpaceX's model. The idea is that investing in reusability could boost Europe's competitiveness in the global market.

Europe and the US took extremely divergent paths between 2000 and 2014. The decision was not purely technical but driven by economic, political and strategic factors. While SpaceX's reusability model has reshaped the industry, its sustainability relies heavily on Starlink and the Low Earth Orbit (LEO) satellite market – a self-created internal demand that requires frequent, low-cost launches. Without a comparable market, Europe would need significant institutional investment and long-term political commitment to develop reusability, radically reshaping its rocket industry.

The current debate is often shaped by the dominance of SpaceX and frustrations over the delays of Ariane 6, rather than a more comprehensive European economic strategy. Blindly adopting the American approach may not be the best way for Europe to protect its sovereignty in space. Instead, Europe might be better served by carving out a distinct strategy for long-term growth and independence within the global space economy.

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This article examines overlooked data in the reusability debate, retraces key moments in American and European space policy and explores alternative strategies that align with Europe's strengths and interests. The article raises important questions: is reusability truly worth it? Why did the US invest in reusability while Europe did not? What alternative investments could Europe pursue? The answer depends on whether the market can support such an industry. With SpaceX's success tied to Starlink's demand, and the European market lacking high-frequency launches, Europe's decision is more complex than simply following SpaceX's lead.

Ultimately, the focus should shift from reusability versus expendability to a broader, strategic vision for Europe, leveraging space technology to achieve long-term goals.

Is reusability worth it?

The fundamental question in any exploratory endeavour, whether on Earth or in space, is: how do you get there, and at what cost? Rockets are the key to making space more accessible. Expendable rockets are costly to build, and unlike reusable ones, they can only be used once. This drives up launch costs, keeping space an exclusive domain for select institutional and private actors. Lowering rocket costs is essential for accessibility, and reusability has long been explored as the solution.

However, reusability is not inherently cheap. It requires a technological overhaul, heavy R&D investment and – most critically – a market with high demand to offset the costs. A reusable rocket that flies only three or four times a year is far from being more sustainable than an expendable one from an industrial policy standpoint. Additionally, reusability is only viable for "low-energy" spaceflights, hence for LEO and Geostationary Orbit (GEO) missions mainly. Indeed, the reusable propulsion stage, like the first stage of Falcon 9, requires fuel for return, limiting its capability to carry mass to orbit beyond Earth ("high-energy" spaceflights). To compensate, the launcher needs to increase in size, requiring more fuel: Starship, the fully reusable super heavy-lift launch vehicle currently in development, is nothing more than a large-scale application of Tsiolkovsky's equation.

This places reusability in a double dilemma: it is technologically sustainable for LEO missions and economi-

cally sustainable only with high-frequency LEO missions. Therefore, the question is not simply whether reusability is worth it, but rather in which context(s) reusability is worth it.

The engineering of reusability: A beyond-earth perspective

Is Europe truly facing a launch crisis, or is the issue one of competitiveness rather than capability? A genuine "launch problem" would imply a lack of technological expertise and infrastructure to develop, produce and operate space systems. That is not Europe's situation.

When it comes to competitiveness, several factors determine a launch system's edge. The foremost is payload capacity: the greater the payload a rocket can deliver to orbit, the stronger its market position. However, payload capacity must always be analysed in relation to mission type and target orbit. For example, SpaceX's Falcon 9 can lift nearly 23 tonnes to LEO in its expendable configuration and up to 18 tonnes when partially reusable. To GEO, Falcon 9 can carry a maximum of 8.5 tonnes.

Europe's heavy-lift launcher, Ariane 6, in its four-booster configuration (Ariane 64), has a lift capacity of about 22 tonnes to LEO and 11.5 tonnes to GEO. By these numbers, Ariane 6 is comparable to Falcon 9 in LEO and even superior in GEO. The reason for this design choice lies in Europe's historical strength in GEO missions, sensibly facilitated by its Kourou launch site in French Guiana. Located near the equator, Kourou enables launches that require minimal plane change manoeuvers to launchers, translating into fuel savings and increased European launchers' payload capacity. This strategic advantage allowed Europe, through Arianespace, to dominate up to 60% of the commercial geostationary launch market from the 1980s to the early 2010s (Arianespace, 2014).

However, this dominance has significantly eroded since 2015 due to SpaceX's introduction of reusable launchers, drastically lowering launch costs. While reusability has revolutionised LEO and GEO missions, its benefits for deep space exploration remain debatable.

The geographical challenge of Moon missions

Launch competitiveness varies with mission objectives. For Moon missions, the equation changes. The Kennedy Space Center, located at 28 degrees latitude, aligns well with the Moon's maximum orbital inclination, enabling US launchers to access the Moon with minimal fuel-intensive plane change manoeuvers. In contrast, Ariane 6 launches from Kourou at almost five degrees latitude. Consequently, to avoid the need for launchers to execute severe plane change manoeuvers (over 20 degrees), Europe must wait for the Moon to pass near the equator, limiting the lunar launch windows to every two weeks.

Despite this constraint, Ariane 6 demonstrates solid payload capabilities for Moon missions, rivalling Falcon 9 and other US rockets. Consequently, the efficiency and the competitiveness of a launcher cannot be reduced to a simple "mass-to-orbit" versus "cost" equation. The GEO and lunar mission examples illustrate how launchers with comparable LEO performance diverge in competitiveness when mission targets shift.

Reusability: A game changer or a limitation?

The ability of SpaceX to recover up to 75% of Falcon 9 – including the first stage and fairing – drastically lowers launch costs and increases flight frequency. This model works exceptionally well for LEO and, more recently, GEO missions, where relatively low energy is required to reach orbit.

However, for high-energy missions to the Moon, Mars or beyond, reusability introduces significant design challenges. A reusable propulsion stage must reserve fuel for its return journey, reducing payload capacity. To compensate, a larger rocket is needed, which in turn demands more fuel to stabilise during re-entry. This is why SpaceX frequently opts for expendable Falcon 9 versions for interplanetary missions and relies on the expendable Falcon Heavy when additional mass is required.

Recent US Moon missions under NASA's Commercial Lunar Payload Services (CLPS) programme, launched on reusable Falcon 9 rockets, have demonstrated limited payload capacities. While this constraint is currently masked by the small size of modern lunar landers (having a payload mass capability in the order of maximum 150 kg), the Artemis programme's needs extend far beyond, requiring payloads in the range of several tonnes. China's Chang'e missions already showcase superior capabilities in lunar logistics.

This limitation presents a challenge for commercialising lunar activities. Unlike LEO, where affordability drives demand, the lunar economy requires both cost-effectiveness and high payload capacity – something Falcon 9 cannot yet guarantee. This is why SpaceX is developing Starship.

Starship: The heavy-lift solution?

Deep space missions demand enormous fuel consumption because of the high energy levels that characterise such trajectory mission profiles. NASA's Space Launch

System (SLS), for example, burns over 720 tonnes of propellant – at a rate of six tonnes per second for 120 seconds – to place the 26.5-tonne Orion spacecraft on a direct lunar transfer trajectory.

Starship aims to scale up reusability for space exploration, promising over 100 tonnes of cargo delivery to the Moon and up to 150 tonnes to LEO (SpaceX, 2020). While this is revolutionary for LEO, deep-space missions remain unproven. A lunar Starship mission must:

- reach LEO
- execute a Lunar Transfer Injection (LTI) manoeuver
- perform multiple Trajectory Control Manoeuvers (TCMs)
- conduct a Moon orbit insertion (MOI) burn
- dock with the Gateway station
- land astronauts on the Moon's south pole
- ascend back to orbit
- return to Earth while surviving atmospheric re-entry.

A major challenge is refuelling: Starship requires approximately 5,500 tonnes of propellant, transferred in microgravity. Even assuming success, Starship would need multiple refuelling missions – possibly involving additional Starships – raising logistical concerns.

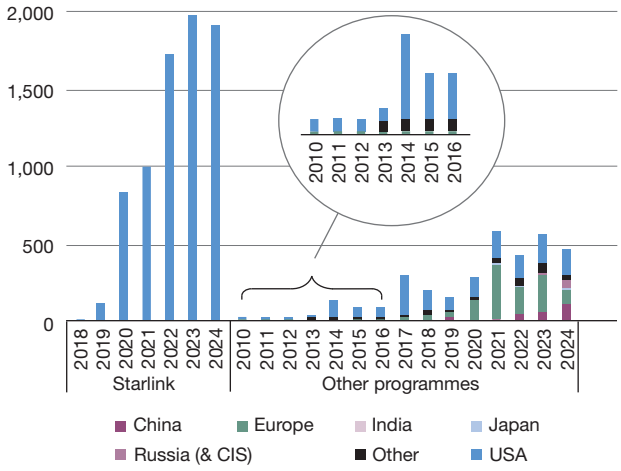
This underscores the paradox of reusability: while it simplifies architecture by consolidating functions into a single vehicle, it also introduces operational complexities. The Artemis programme, which currently lacks a reliable lunar lander solution beyond Starship, faces uncertainties. Can a Starship mission ultimately cost less than an expendable SLS mission? That remains to be seen.

The economics of reusability: A LEO perspective

For beyond-orbit missions focused on scientific discovery and planetary exploration, reusability often seems impractical and physically limiting. However, the equation changes when considering near-Earth objectives with a commercial purpose. In this dimension, cutting costs and achieving industrial-scale rocket production offers a clear advantage: large-scale manufacturing can reduce expenses enough to enable private customers to participate, fostering a broader economic system beyond institutional flights. However, even in this case, reusability has its limitations.

Reusability can cut costs only in the long run and if sufficient demand exists to sustain frequent launches. The key question from an economic perspective is: which markets can generate this demand. Do they already exist, or do they need to be created? And how large must demand be to make reusability financially viable?

Figure 1
Number of commercial spacecraft launched by customer region (Starlink shown separately)



Note: Disregarding Starlink, global space activity growth remains moderate.

Source: Eurospace LEAT database (2024).

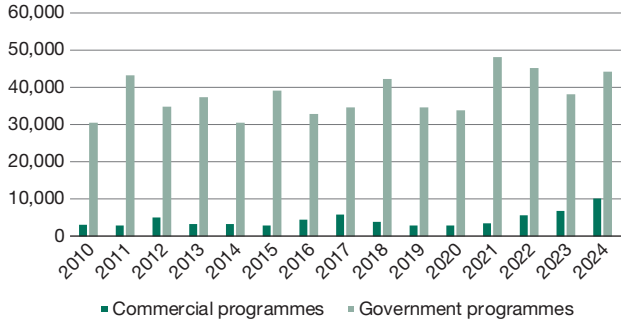
As of 2025, independent data remains scarce on whether reusability is definitively cost-effective. A study by Lionnet and Cuellar (2021) analysed the economics of Falcon 9 launch, revealing that profitability strongly correlates with launch frequency. The study concluded that a reusable rocket is economically viable only if it achieves at least six to nine launches per year, with contract prices ranging from US $50 million to US $110 million, depending on the customer.

The question of whether reusability is worth it therefore depends on a market demand that requires frequent, cost-effective launches to surpass the break-even threshold. Which market can create such demand?

In 2023, there were 212 successful orbital launches globally. The US led with 114, while Europe conducted only three (ESA, 2024). SpaceX accounted for 96 of the US launches – over 80%. However, 67 were for expanding its Starlink constellation, meaning 69% of SpaceX's missions were self-provisioned. Without Starlink, SpaceX conducted 30 launches – still far more than Europe's three but highlighting a crucial trend: SpaceX's high launch rate is driven primarily by Starlink, not overall commercial demand for LEO, Medium Earth Orbit or GEO launches (see Figure 1). In fact, a Eurospace (2024) study showed that in 2024, spacecraft market value was still dominated by governmental programmes (see Figure 2).

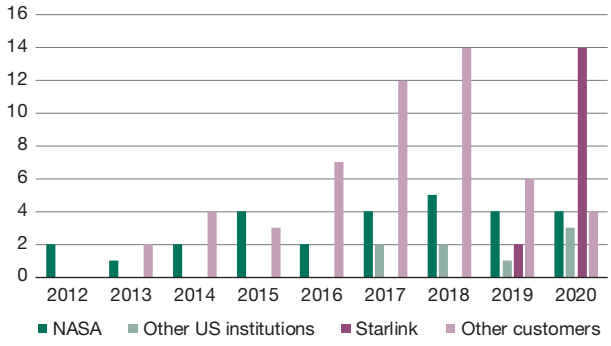
However, Lionnet and Cuellar (2021) demonstrated that even US governmental programmes – despite demand

Figure 2
Spacecraft market value
in million US dollars by market segment



Source: Data from Eurospace LEAT database (2024).

Figure 3
Falcon launches by main customer



Source: Data from Pierre and Cuellar (2021).

being higher than in Europe – are still insufficient to make reusability profitable in the long run. For example, in 2020, NASA provided stable launch opportunities for SpaceX, averaging four launches per year (Figure 3). Other US customers, mainly military and intelligence agencies, added two to four more. Yet, with only six to eight annual launches, reusability barely broke even. To sustain a reusable rocket production line, a much larger, consistent demand was needed. The only market capable of supporting such a cadence was that of LEO mega-constellations – a market that did not yet exist. So, SpaceX deliberately created it to serve its own economic goals.

The game-changing creation of Starlink

Reusability alone was not enough – SpaceX needed frequent launches to make Falcon 9 economically viable. As mentioned above, estimates suggest that reusability only becomes cost-effective after six to nine launches per year (Lionnet & Cuellar, 2021). In 2011-2012, Falcon 9 v1.1 had a lift capacity of 16 tonnes to LEO (Space Launch Report, 2017). Therefore, to sustain operations, SpaceX required at least 96 tonnes of annual payload (16 tonnes multiplied by a minimum of six launches), which was not covered by NASA and other US institutional operations until 2017 (Figure 3). The commercial sector lacked sufficient demand, forcing SpaceX to find new customers – or become its own.

In early 2014, Elon Musk and Greg Wyler explored launching a 640-satellite constellation called WorldVu (now Eutelsat OneWeb). Assuming the 16-tonne LEO capacity of Falcon 9, this could have secured six launches for SpaceX – helpful, but not financially sustainable. When discussions collapsed, SpaceX pivoted, filing an International Telecommunications Union (ITU) application through the Norwegian Communications Authority under the name STEAM. By 2016, it formally applied to the Federal Communications Commission (FCC) for what would become Starlink.

Since its first launch in 2019, SpaceX has deployed nearly 7,000 Starlink satellites, including 4,216 Gen1 units, and is now seeking approval for over 30,000 Gen2 satellites (Rainbow, 2024). SpaceX's industrial-scale launch and satellite production has dramatically cut costs. Each Starlink satellite costs approximately US $2,500/kg to produce, with data pricing below US $100/Mbps, compared to OneWeb's US $14,000/kg and US $200/Mbps (see Figure 4).

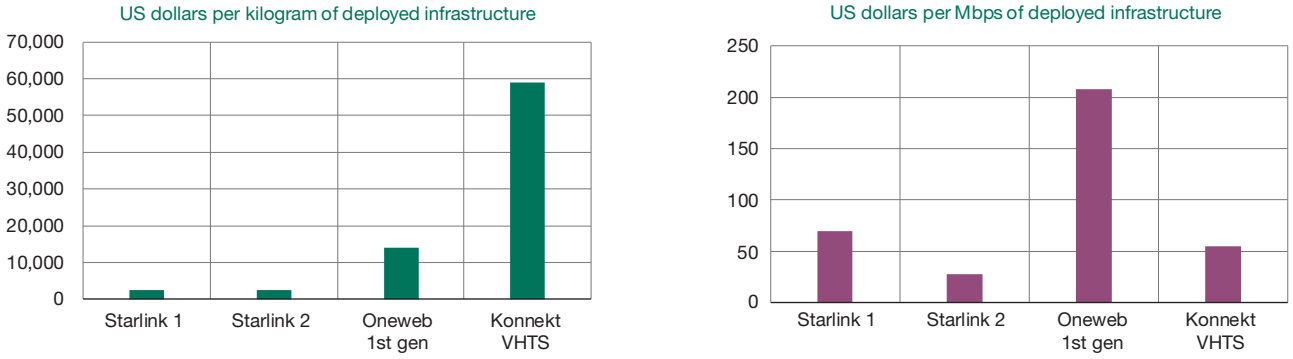
This vertically integrated approach – combining launch and satellite production – was a game-changer. While Teledesic and Iridium attempted similar models in the 1990s (Mellow, 2004; Polyakov, 2023), SpaceX was the first to successfully control both demand and supply, leveraging a reusable launch system and a mass-produced satellite constellation under one corporate umbrella.

Ultimately, Starlink and reusability became interdependent: reusability required high launch volumes, while satellite constellations provided the necessary demand. By solving this equation, SpaceX created a self-sustaining business model that no European competitor could replicate, as the European market followed a different, more fragmented trajectory.

The European trajectory: Why did Europe not go reusable?

Culturally, the commercialisation of space activities is a new concept within Europe's traditional space vision. Europe has historically seen major space activities driven by the European Space Agency (ESA), with public-private

Figure 4
Investment costs across companies



Notes: Broadband costs reflect bandwidth commercialisation potential. For example, Konnekt VHTS, a GEO satellite constellation operated by Eutelsat, costs more per kg than Starlink but lasts 3-4 times longer (15-20 years vs. 4-5 for Starlink) and commercialises 85% of available bandwidth (only 15% for Starlink), making cost per Mbps competitive.

Source: Data from Lionnet (2024).

partnerships emerging but still under significant government oversight. To understand Europe's approach, it is essential to go back to the 1990s when Europe made early attempts at reusability, forecasting what would later be realised by companies like SpaceX.

Early European efforts in reusability: The 1990s initiatives

From January 1988 to February 1994, ESA conducted the "Winged Launcher Configuration Study" (WLS), assessing seven reusable launch vehicle proposals. Among these, Vehicles 5a, 5b and 6a were considered viable for operation from the Kourou launch site. However, the outcome of the WLS was to choose to investigate only one solution, the one that best aligned with Europe's overall mission and operational needs. The technical feasibility of these proposals is detailed in Berry and Grallert (1996).

In 1994, ESA's Future European Space Transportation Investigations Programme (FESTIP) picked up from the WLS study, aiming to develop the next-generation launcher beyond Ariane 5. The primary goal was to dramatically reduce the cost of accessing space – what we now define as reusability. A 1995 ESA report highlighted the need to lower access costs to open new markets, and reusable launchers were identified as a key solution. However, reusability posed significant challenges in technology fields like materials, propulsion, avionics and aerothermodynamics. As a result, ESA projected that reusability would not be feasible until at least 2005, a timeline needed to develop such required technologies.

The FESTIP programme concluded in 1998, identifying the most promising reusable launch vehicle concepts but recognising that more technological advancements were necessary before reusability could become viable (Dujaric, 1999). This led to the creation of the Future Launchers Technologies Programme (FLTP) in May 1999. The FLTP aimed to assess partial or full reusability in launch systems, with a target of developing critical technologies by 2007. Unfortunately, the programme was put on hold due to disagreements over resource distribution among member states (Ackermann et al., 2005), highlighting how national interests played a role in Europe's hesitance towards reusability (in the past like at the present time).

Europe, however, was aware of the risks posed by not investing in reusability. As Caporicci (2000) noted, Europe risked losing its market share if a technological breakthrough occurred elsewhere, especially in the US. This is why in 2003, the FLTP evolved into the Future Launchers Preparatory Program (FLPP), which officially started in February 2004. The FLPP shifted focus to refining Europe's position in the global launcher sector, taking into account both technological and strategic factors. In 2006, FLPP Period-1 concluded successfully, while Period-2, though intended to conclude by 2015, lacked a clear finish date. The programme worked to define, design, analyse and test multiple reusable launcher concepts, with one notable success being the Intermediate eXperimental Vehicle (IXV), which successfully flew in space. The SpaceRider project, a modern evolution of IXV, illustrates Europe's ability to combine innovative technology with practical applications aimed at meeting future market demands.

The 2000s diverging strategies: Europe vs the US

Between 1998 and 2004, Europe conducted four major studies on reusable launchers but never reached a defini-

tive decision. This indecision stands in stark contrast to US developments during the same period.

In the early 1990s, NASA initiated programmes such as the Delta Clipper Experimental (DC-X), a prototype for single-stage reusable launch vehicles. By 2000, the US already had a strong internal demand for launch services – 16 launches that year, with 13 serving NASA, the Department of Defense, the National Reconnaissance Office and other government agencies. This demand provided a stable baseline for investing in a private sector-driven space economy.

As the "President's Commission on Implementation of United States Space Exploration Policy" outlined in 2004, the US vision was a space industry that would "contribute to national economic growth, produce new products and lead the world in invention and innovation" (Aldridge, 2004). Government contracts alone were not enough to revolutionise the industry, so the US actively fostered a private space economy built on reusable technology.

Europe, on the other hand, lacked similar demand. In 2000, Ariane 4 launched four times, and Ariane 5 only once. Arianespace studies in the early 2000s suggested that Europe would need only nine half-capacity Ariane 5 launches per year for a second-generation satellite constellation (Caporicci, 2000), and later studies projected that by 2025, European institutional needs would have been around 25 tonnes per year, requiring roughly 11 launches annually from Vega-C and Ariane 6 combined (Lionnet & Cuellar, 2021). Given these numbers, developing a reusable market from scratch made little sense for Europe. The ESA Space Economy Report (2024) reinforced this, noting that Europe nowadays still lacks the domestic demand base enjoyed by the US, China and Russia.

With limited institutional demand and no immediate commercial market, Europe opted to refine its existing expendable system rather than pioneer reusability. This reflects a fundamental difference in approach: the US saw reusability as a means to create new markets, while Europe focused on optimising known solutions.

The consequences of Europe's strategy

While Europe did not neglect space investment, its focus was directed elsewhere. The 1990s saw the foundation of Copernicus and Galileo, flagship satellite constellations that today provide extensive Earth observation and navigation capabilities. In the early 2000s, Ariane 5 was a competitive rocket dominating the commercial satellite market.

However, Europe's reluctance to invest in reusable launchers had long-term consequences. Between 2006 and 2015, Europe accounted for 10% of global launches, while China claimed 17.5% (Aliberti & Tugnoli, 2016). By 2023, the gap widened significantly: China launched 67 rockets, while Europe managed just three (ESA, 2024).

Europe's decision-making reflected budget constraints, technological risk aversion and national political interests. Unlike the US, which treated space as a disruptive economic sector, Europe approached it as a stable government-led industry. As a result, while other nations pursued growth, Europe maintained the status quo.

The US private sector boost: International Space Station as a critical factor

The US also had additional incentives to invest in private launch companies. Following the retirement of the Space Shuttle, the US faced a strategic dilemma: relying on Russian Soyuz rockets for International Space Station (ISS) access was politically and economically untenable. NASA, constrained by high costs, recognised that supporting private-sector development was the fastest and most cost-effective way to fill the gap. In 2005, NASA launched the Commercial Orbital Transportation Services (COTS) programme, a mix of government and private funds to develop space transport capabilities, and in 2010 it allocated US $50 million in stimulus funds under the Commercial Crew Development (CCDev) initiative to advance private crewed spaceflight to and from the ISS (NASA, 2010).

These programmes enabled companies like SpaceX to develop enough funding to invest in reusable rockets – though reusability itself was not initially a requirement. The first Falcon 1 and Falcon 9 iterations were expendable, proving that the shift to reusability was driven by private initiative rather than government mandates.

Europe, with no equivalent crisis or immediate demand, never faced similar pressures. Without urgent necessity or political will, the shift to reusability remained an unresolved debate.

The role of the European private sector

A notable exception in Europe's largely government-driven approach emerged in the early 2000s with the industry consortium "New Generation Launcher Prime Company" (NGL), formed by EADS (now Airbus) and Finmeccanica (now Leonardo). The NGL set out to design and develop a reusable launch vehicle and proposed a roadmap that began with on-ground demonstrations of critical technolo-

gies – especially in structure and propulsion – with the aim of progressing to in-flight tests. The underlying idea was that only a reusable launch vehicle could ultimately offer substantial long-term cost reductions beyond the incremental improvements achievable with traditional expendable launch vehicles like Ariane 5 evolving into Ariane 6.

The NGL marked the first time a private European consortium proposed a "private launcher" outside the direct control of national space agencies. The question remains: if the NGL had operated under an American model, might the outcome have been different? Europe's space sector has long been shaped by an ideological framework in which significant governmental oversight prevails, a stance that has often slowed technological advancement compared to the competitive, entrepreneurial spirit found in the US.

Today's condition: Ariane 6

By 2014, after 15 years of research, reports and studies, Europe made its decision: it would stick with expendability and proceed with the Ariane 5 successor, the Ariane 6 modular launcher. But is Europe trapped in a cycle with Ariane 6, or is it making genuine progress?

Ariane 6 was initially scheduled to replace Ariane 5 by 2020. However, a combination of global challenges – including the pandemic, geopolitical tensions, economic inflation and strategic planning issues – resulted in significant delays. These setbacks have hindered ESA's competitiveness, particularly for GEO missions, where Europe once led the world. Ariane 5, while proven, was technologically outdated and unable to meet ESA's ambitious goal of doubling its annual launch capacity from six to twelve.

Ariane 6 is not a radical departure from its predecessor. It features two main propulsion stages, with an increase in height of about 11 meters, but it retains the same width of 5.4 metres as Ariane 5. The first stage is powered by an updated version of the Vulcan engine used in Ariane 5, while the second stage is equipped with a new, single-engine system called "Vinci", replacing the dual-engine configuration of Ariane 5.

The Vinci engine

The Vinci engine was designed for greater flexibility, as it can perform multiple burns in space – enabling multiple satellite insertions into different orbits with a single launch. This was considered the key innovation for Ariane 6, enhancing mission flexibility and opening the door to servicing multiple customers at once. However, during its maiden flight, the Vinci engine failed on its second ignition, undermining its primary feature and leaving behind dangerous debris. The second burn in fact was meant to safely deorbit the second stage, but instead, it remains in LEO as debris.

This highlights a critical issue with Ariane 6: the launcher, while technically advanced, does not represent a significant departure from the past. Its two solid boosters configuration mirrors that of Ariane 5, with the only notable new feature being the Vinci engine. The payload capacity remains largely unchanged: about 22 tonnes to LEO, a slight improvement over 20 tonnes of Ariane 5, and similar for GEO missions. Ariane 6 has restored Europe's sovereign capability to access space autonomously, but in terms of pushing industry growth or introducing disruptive technology, it has not marked a breakthrough.

Ariane 6 cost efficiency and timing issues

From an economic standpoint, Ariane 6 introduces a more cost-effective approach. With a simplified manufacturing process, fewer components and a more efficient assembly line, it aims to cut costs by nearly 50% compared to Ariane 5. A new procurement model encourages competition among suppliers, further driving down costs. However, despite these advancements, the first flight of Ariane 6 occurred four years later than initially planned. Originally set for 2020, its maiden flight took place in July 2024 – one year after the retirement of Ariane 5. This delay, coupled with the loss of the Soyuz rocket due to the Russian invasion of Ukraine and the grounding of Vega C after a failed 2022 launch, left Europe without independent access to space for a year – a paradox considering the extensive ESA studies aimed at preventing such a scenario.

A future reusable rocket industry?

Amid what ESA's Director General Josef Aschbacher has called a "launcher crisis" in 2023, Europe feels the growing pressure to catch up with SpaceX's immense success. After 25 years of research, Europe is now eyeing a reusable rocket industry. However, creating such an industry requires specific market conditions – conditions that have not been nurtured in Europe. With SpaceX's Starlink already dominating the civilian satellite sector, it may now be too late for Europe to build a competitive reusable launcher infrastructure, especially in the absence of a strong commercial space market.

Several initiatives are underway to address this gap. The European Launcher Challenge, approved in 2023, aims to study the future of European space transportation.

Meanwhile, private efforts like Maya-Space, a spin-off of ArianeGroup, are also making strides. Maya-Space's development draws from ESA's Themis programme, which is focused on reusable technologies, specifically the vertical landing and reuse of first-stage boosters.

Yet, is this the right path for Europe? When we look at global trends, the US and China are the only two major powers investing heavily in reusable rockets – primarily because their large-scale demand justifies the R&D costs. In contrast, medium powers have chosen a different route.

The Japan case study: A strategic alternative

Japan presents a compelling example. Despite its prestigious space history, it has opted for expendable launchers for its future, as seen with the H3 rocket – a modular, expendable design similar to Ariane 6. Japan's strategic choice is based on its specific goals and resource constraints, distinguishing its approach from that of the US and China. Similarly, South Korea's KARI is developing its first fully expendable domestic launcher.

This comparison offers valuable insights for Europe. Like Japan and South Korea, Europe's strategic needs are different than those of the US or China. Medium powers with limited budgets can achieve significant progress with a focused, forward-thinking space strategy. The key is aligning technological development with clear, achievable goals, rather than chasing disruptive innovations simply for the sake of competition.

The path ahead

Europe's space strategy has been marked by technical excellence but lacks a disruptive vision. While ESA recognised the potential of reusability decades ago, limited institutional demand, political constraints and risk aversion led Europe to prioritise expendable launchers. By contrast, the US leveraged government demand to drive private investment, creating a thriving commercial space sector. Europe's decision to maintain the status quo worked for a time, but as global competition intensified, the consequences became clear. Now, with China and the US leading in reusable spaceflight, Europe faces a significant challenge in regaining its competitiveness in the launch market.

Although Europe has made strides in Earth Observation and navigation systems, such as Galileo and Copernicus, its approach to launchers has been more cautious. Europe's decision not to prioritise reusability stemmed from the correct assessment that such technology needs a robust LEO market, which it lacked. The US, recognising the same, chose to invest in developing that market, underscoring contrasting risk cultures between the two powers.

The real difference was not in developing reusable prototypes, but in the US's forward-thinking strategy, backed by a well-established institutional market. In contrast, Europe lacked both the market and the appetite for the long-term investments required for reusability. National political interests further shaped Europe's conservative approach.

Now, Europe faces a pivotal decision: in which infrastructures should it invest to compete globally? Countries like Japan and South Korea have chosen not to heavily invest in reusable infrastructure, aligning with their capabilities and ambitions. Europe's future in space depends on whether it chooses to redefine its ambitions, take risks and solidify its global position. Its next steps will determine whether Europe rises to the challenges ahead or remains constrained by its current trajectory.

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Margot Schüller

Mission Impossible? The EU's Search for an Independent Tech Policy Amid US-China Decoupling

Europe has become the battleground for the tech war between the United States and China. It started off with China's ambitious Made in China 2025 programme in 2015, perceived by the US as a threat to its technological leadership and global military dominance. Over the last ten years, US governments have tried to restrict China's further rise as an economic and technological power with a series of containment measures. During the first presidency of Donald Trump (2017-2021), China hawks became the drivers of US-China relations. They will have a stronger position in Trump's second term (2025-2029). They are now not only increasing tariffs and tech restrictions but aiming at complete decoupling. Without the participation of its allies in massive cutoffs from China, the US decoupling strategy will not be successful. Among US allies, member countries of the European Union play a crucial role. The EU single market offers huge marketing potential for US products and services.

In Europe, the geopolitical conflict between the US and China, with its strong focus on tech supremacy, triggered a discussion about how European countries could remain competitive and whether more tech sovereignty is needed. Due to Europe's high dependency on US technology and military security, the setting up of a regulatory environment that protects European values and improves industrial competitiveness might present a challenge for EU policymakers. Moreover, given the close economic and tech cooperation of many EU member countries with China, it is questionable whether they are willing to join an anti-tech alliance with the US against China and replace their current de-risking policy with complete decoupling.

This paper starts with a discussion of the differences between the EU and the US with respect to values and strategic interests. It then studies the EU's position in future technologies and the need for stronger competitiveness, followed by an analysis of the EU's quest for tech sovereignty and the reaction of the US. Finally, it covers the context of US-China decoupling.

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EU-US divides over values and strategic interests

With Trump's return in 2025 and his America First agenda, US-Europe divides over values and strategy have resurfaced. Leblond and Vannier (2024) point to major differences in three critical policy areas: defence and security, climate change, and trade and technology. To address the last of these, the EU-US Trade and Technology Council (TTC) was founded in 2021. It focused on five key fields of cooperation: export controls, foreign direct investment screening, secure supply chains (especially regarding semiconductors), technology standards, and cooperation on artificial intelligence (AI) and global trade challenges. Ten working groups were set up on the following topics: technology standards cooperation, climate and clean tech, secure supply chains, ICT security and competitiveness, data governance and technology platforms, misuse of technology threatening security and human rights, export controls cooperation, investment screening cooperation, promoting SME access to and use of digital technologies, and global trade challenges.[1]

The TTC was supposed to improve bilateral cooperation. Although it was the EU that took the initiative, both sides were motivated to team up with a long-term focus of promoting joint standards around emerging technologies to better meet the challenges of China's rise as a tech power. Following Scott and Barigazzi (2021), from the perspective of the US, the TTC was primarily an instrument for pushing back against China through transatlantic cooperation in the field of trade and technology standards. The comment by former White House national security adviser Jake Sullivan regarding the US's motivation confirms this view, emphasising that the TTC "will focus on aligning our approaches to trade and technology so that democracies and not anyone else, not China or other autocracies, are writing the rules for trade and technology for the 21st century" (Scott & Barigazzi, 2021).

Between 2021 and 2024, six ministerial TTC meetings were held, chaired by high level EU and US officials. In

1 https://commission.europa.eu/about/organisation/college-commissioners/henna-virkkunen_en

addition, the TTC's working groups served as channels of communication and diplomacy on a regular basis. Although the factsheet of the TTC's performance since 2021 shows an impressive list of bilateral activities and achievements (European Commission, 2024b), critics perceive a mixed record. The deterioration of the international political environment triggered by the impact of the COVID-19 pandemic and the Russian invasion of Ukraine led to a strong focus on security and resilience. Domestically, for example, changes in climate policy in both the EU and the US impeded the implementation of transatlantic green trade policy measures. That the TTC's ambitious goals were not met is also ascribed to the broad scope of topics and the inadequate organisational structure that failed to sufficiently engage stakeholders (Belton & Gruening, 2025).

Whether the TTC will continue its work under the Trump presidency remains unclear given recent US policy decisions on AI governance, deregulation and tariffs. An example of the latest policy measure on AI is Donald Trump's executive order (EO) on Removing Barriers to American Leadership in Artificial Intelligence published on 23 January 2025 (The White House, 2025), which replaced the EO of former president Biden of 30 October 2023, entitled Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence (The White House, 2023). Comparing the two policy documents, critics see a significant shift away from the Biden Administration's focus on oversight, risk mitigation and equity in favour of deregulation and support for AI innovation that should enable the US to maintain its global dominance. The Trump Administration's new deregulatory policy on AI governance contrasts sharply with the precautionary approach pursued by the EU. The EU's Artificial Intelligence Act of 2024 (EUAIACT) stresses safety, transparency, accountability and ethics. In principle, US companies that do not comply with EUAIACT standards will not have access to the European market (Carrillo et al., 2025).

At the AI Action Summit in Paris in February 2025, US Vice President JD Vance criticised that US business could not compete on the European market because of the restrictive regulatory framework for AI. He warned that "America cannot and will not accept" foreign governments "tightening the screws" on US tech companies (The American Presidency Project, 2025). At the summit, 62 countries and the EU signed a voluntary commitment to developing and making AI "open, inclusive, transparent, ethical, safe, secure and trustworthy" (Elysee, 2025). The US and the United Kingdom did not sign the document (Birchard, 2025). The president of the European Commission, Ursula von der Leyen, used the AI Action Summit in Paris to announce that the EU plans – after establishing a secure legal framework for AI – to support the commercial development of AI with increased funding over the coming years to catch up with the US and China (Birchard, 2025).

The EU has, however, fallen behind the US not just in AI but in most future technologies. This is one of the conclusions Mario Draghi, former president of the European Central Bank and Italian prime minister, presented in his report on The Future of European Competitiveness to the European Parliament in September 2024. The following section presents findings from various databases that show Europe's weakness in advanced and future technologies, underlining the urgent need for a new industrial strategy in Europe.

The EU's weak position in future technologies

Although Europe has several leading countries in science and technology, the EU has fallen behind the US and, in some fields of science and technology, behind China. According to data on innovation in 133 countries, the World Intellectual Property Organisation (WIPO) shows that five countries (Sweden, Finland, the Netherlands, Germany and Denmark) out of the EU27 belong to the top ten global leaders in the 2024 innovation index. The non-EU member countries Switzerland and the UK, rank first and fifth, respectively, among the top ten. The Global Innovation Index (GII) captures performance across four key stages of the innovation cycle – investment in science and innovation, technological progress, technological adoption and socioeconomic impact of innovation (WIPO, 2024).

The findings of the European Innovation Scoreboard (EIS) confirm the major challenges the EU is facing on science and technology development. In 2023, only 12 EU countries' performance in the digitalisation dimension was above average, while 15 countries performed below average, including Germany. From 2017 to 2024, the EIS recorded a decline in the EU's intellectual assets as a share of international patent and design applications. Compared to the EU's global competitors, the EIS found lower investment in research and innovation (R&I), especially by the private sector, in the EU (European Commission, 2024a).

When it comes to emerging technologies, the report on Weak Signals in Science and Technology 2024 finds that the US and China are the leaders in producing scientific knowledge across most clusters of twelve emerging technologies. The EU plays a strong role in research and related scientific publications for some of the twelve emerging technologies, namely, digital twins, AI and machine learning, therapeutics and biotechnologies, energy and environment, and agriculture. China and the US are

leading in patenting for all twelve categories of emerging technologies, which include advanced materials and advanced manufacturing, aerospace, mobility and transport, information and communication technologies, medical imaging, and quantum cryptography. The report also noted that the European research and development (R&D) ecosystem appears fragmented, with many strong but small-sized actors lacking critical mass. While China's R&D ecosystem exhibits specialisation across most of the twelve clusters of emerging technologies, the European ecosystem is assessed as focusing only on AI and machine learning (Eulaerts, 2025).

Against the background of the EU's weak position in emerging technologies and resulting low productivity, the Draghi report defines major areas for action. Out of this comprehensive study covering two volumes, only some points can be addressed in this contribution. The report represents a diagnosis of where Europe stands and recommendations for policymaking focusing on three policy actions. First, Europe needs to close the innovation gap with the US and China on advanced technologies. The Draghi report points to the problem that EU companies are mostly specialised in mature technologies that offer less opportunity for breakthroughs and spend less on R&I compared to US companies. To unlock their innovative potential, companies should not only invest more but also integrate AI into existing industries. Other challenges relate to inconsistent and restrictive EU regulations that hinder innovative companies from scaling up in Europe. Second, the Draghi report suggests a joint plan for decarbonisation and competitiveness given the interdependence of energy prices and the ability to compete internationally. Therefore, energy prices should be reduced and made less volatile. While decarbonisation offers commercial opportunities, EU companies face strong Chinese competition. Taking the various clean technologies into account, the report recommends a differentiated approach according to sectors and technologies. Third, the report sees a need to increase security and reduce dependencies. This action centres on secure supply chains of critical raw materials and technologies, as well as on developing the EU's defence capability. To better coordinate national policies among the EU member countries, the report advises introducing a factual EU foreign economic policy based on European values that considers the situations of middle- and low-income member countries (Draghi, 2024).

The Draghi report offers a wide range of in-depth analysis and recommendations that are designed to bring about the necessary changes to the EU. One of the underlying principles in the report is the quest for tech sovereignty, which is mentioned explicitly a few times. Although the EU faces a competitive disadvantage in some digital sectors, the report emphasises, for example, that "it is important that EU companies maintain a foothold in areas where technological sovereignty is required, such as security and encryption ('sovereign cloud' solutions)" (Draghi, 2024, p. 24). While the report acknowledges the dominance of US cloud providers, it states that "the EU must find a middle way between promoting its domestic cloud industry and ensuring access to the technologies it needs" (Draghi, 2024, p. 34). Everett et al. (2024) point to the report's suggestions of several regulatory initiatives that should bring about sovereignty objectives, especially for critical technologies. These include a new EU cloud and AI development act, better interplay between the General Data Protection Regulation (GDPR) and the AI Act, as well as recommendations around digital networks. It is not surprising that the discussion on EU tech sovereignty receives criticism from the US.

The EU's quest for tech sovereignty

The composition of the new European Commission demonstrates that the Draghi report's recommendations are being taken seriously. For the first time in the history of the EU, one of the six vice presidents in the European Commission has been tasked with responsibility for tech sovereignty together with security and democracy, as well as for the digital and frontier technologies portfolio (European Commission, 2024c). Over the next five years, Henna Virkkunen has to work through a long list of topics that have a direct impact on the EU's tech sovereignty, for example, development of an Apply AI Strategy that improves industrial uses and public services, development of an EU Cloud and AI Development Act together with an EU-wide cloud policy and a long-term EU quantum chips plan, and presenting a European Data Union Strategy.

Critics often equate tech sovereignty with protectionism. The way the Draghi report and the European Commission are embedding this principle into the overall industrial policy, however, works like a frame for innovation policy. In their paper on tech sovereignty as additional rationale for innovation policy, Edler et al. (2023) argue that "technology sovereignty should be conceived as state-level agency within the international system, i.e. as sovereignty of governmental action". The authors define tech sovereignty "not as an end in itself, but as a means to achieving the central objectives of innovation policy – sustaining national competitiveness and building capacities for transformative policies". For Edler et al. (2020), tech sovereignty encompasses "the ability of a state or a federation of states to provide the technologies it deems critical for its welfare, competitiveness, and ability to act, and to be able to develop these or source them from other economic ar-

eas without one-sided structural dependency". In sum, the main characteristic of tech sovereignty following Edler et al. is the ability of governments to act independently in the global tech system, not following an isolationist policy but cooperating with robust and reliable national, regional and international networks.

Comments by Foss (2025) from Think Tank Europa follow a similar line of argument, stressing that "a majority of planned tech initiatives focus on enabling innovation by building digital infrastructure". He expects that the Data Union Strategy, for example, will help the EU leverage high-quality data as a source of competitiveness. The Digital Network Act, too, will have the potential to improve connectivity and bring the EU closer to achieving its Digital Decade goals.

Building a EuroStack as a core technology infrastructure for Europe which covers semiconductors, networks, AI, cloud computing, the Internet of Things, data platforms and digital ID, is another concept discussed to increase the EU's digital sovereignty. According to the authors of the study "EuroStack – A European Alternative for Digital Sovereignty" (Bria et al., 2025), this initiative presents an ambitious vision for Europe's digital future, overcoming the bloc's heavy reliance on external technologies. Currently, more than 80% of Europe's digital infrastructure and technologies are imported and about 70% of foundational AI models are developed in the US (Borak, 2025; Bria et al., 2025).

The EU's focus on tech sovereignty is criticised by various experts and organisations in the US, such as the Information Technology and Innovation Foundation (ITIF), a think tank supported by many US tech companies, and increasingly from big tech companies directly (Meyers, 2025). Robert Atkinson, president of the ITIF, for example, argues that the EU's discriminatory regulations have led to a loss of revenue for US industries. He complained that "[i]n its bid for tech sovereignty, the EU has been aggressively targeting U.S. firms and industries, with unfair protectionist policies" (Atkinson, 2024). As counter measures, Atkinson suggests updating Section 301 of the Trade Act to address digital trade, using ICT service reviews against European companies, imposing taxes to offset the EU's digital service taxes and limiting US data flows to the EU. As defensive measures, he recommends, for example, limiting EU access to federal procurement opportunities, investigating critical exports and excluding European firms from the US defence industrial base. Although Atkinson's policy recommendations seem to be excessive, they demonstrate the range of potential sanctions the US government can apply against EU companies.

US anti-China tech alliance – What is Europe's role?

With Trump's sweeping tariffs on EU imports in March 2025 and his threat to escalate a global trade war with further tariffs on European goods, the US-EU bilateral economic relationship reached its lowest point. That Trump would withdraw from the World Health Organization and the Paris Climate Agreement once back in office had been expected by many observers in the EU. His bullish policies vis-à-vis Europe, other US NATO allies and Ukraine, however, came as a shock. It signaled to US allies that they can no longer rely on the US. Moreover, according to Steve Tsang (2025), Trump's foreign policy is also strengthening China's argument that the US "will use the liberal international order to put America first", establishing an order that is unfit for the twenty-first century and needs to be changed.

US policy on China under Trump 2.0 is expected to be even more aggressive than that of his first term, but also more transactional and less predictable (China Briefing, 2025). In The President's 2025 Trade Policy Agenda, China is addressed as "the single biggest source of our country's large and persistent trade deficit and a unique economic challenge" (United States Trade Representative [USTR], 2025). This document refers to the trade agreement Trump negotiated with China in his first term (Phase One Agreement) and announces that the USTR will assess China's compliance with this agreement, focusing on technology transfer, intellectual property and innovation, and other unfair practices. The assessment will also be used for discussion in the US Congress on China's Permanent Normal Trade Relation (PNTR) status.

The revocation of China's "most favored nation" status, followed by the phasing out of the import of essential goods, were listed as the first steps in decoupling from China in the Republican Party's 2024 platform. With the ambitious aim to "build the greatest economy in history", the platform also listed blocking Chinese investment in US real estate and industry, and encouraging US companies to leave China and bring critical supply chains back to the US. Additional goals include saving the US auto industry, the Buy American and Hire American concepts, and restoring the American Manufacturing Superpower (Kwan, 2025).

Given the growing frictions across the Atlantic over trade and technology on the one hand and the US decoupling approach vis-à-vis China on the other, Europe has little incentive to follow Trump's China policy. In contrast, a more pragmatic relationship with China offers not only better market conditions for European companies but also cooperation in areas of global importance such as

climate change and AI governance. China's rise as a science and technology power is one of the most important developments, contributing to the worldwide increase of knowledge (Xie et al., 2014). International data show that China has made tremendous progress in some specific fields of science and technology, making the country an attractive partner for the EU in future technologies. However, the relationship between the EU and China should be better balanced and Europe might be better off continuing its de-risking policy towards China, reducing overdependency on some Chinese imports, protecting the EU against unfair competition from China and strengthening Europe's technological and industrial capacities.

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Housing Markets

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JEL: G51, R21, R31

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Selected Macroeconomic and Social Aspects of Housing Affordability

Over the past decade, the housing market in the EU has been characterised by significant price growth, putting pressure on housing affordability. Despite a price moderation in 2022 and 2023 due to monetary tightening and increased mortgage interest rates, house prices remain historically high in approximately three-quarters of the EU, highlighting an underlying mismatch between demand and supply. On the demand side, urbanisation and demographic changes have driven up housing needs, while on the supply side, constraints in construction have hindered the market's ability to meet demand, leading to reduced affordability. To improve overall housing affordability, there is an urgent need to increase investments in new construction and in the renovation of existing stock as well as to review the role of regulation and to improve administrative capacity, which have been hindering the expansion of the housing supply in the recent decades.

Housing occupies a fundamental position in modern societies and economies. The housing market is economically, socially and politically significant. Housing-related expenses are a substantial share of household spending, and housing is a large share of the total assets in our economies. For many people, rental costs or mortgage repayments are the largest items in their monthly spending, and the purchase of a house is typically the largest purchase in people's lives. Consequently, home mortgages account for most of household indebtedness.

Access to safe and affordable housing is a fundamental human need, essential for individual dignity, health and well-being. It is critical for social cohesion, enabling people to build communities and participate in society. Unaffordable or unavailable housing can lead to social exclusion and poverty, and it aggravates the consequences of income inequality, in particular among younger households, undermining the societal fabric. It may hinder regional (and even intra-EU) mobility with damaging implications for economic dynamism and social progress.

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Policies affecting house prices

Housing is directly interconnected with the macroeconomy of the EU, both influencing and being influenced by the economic landscape. Residential construction and housing markets are pivotal to the economy, impacting employment, business cycles and overall economic activity.[1] Housing accounts for a sizeable share of output. In 2023, housing construction contributed approximately 6% to GDP, and investment in dwellings accounted for roughly 26% of gross fixed capital formation in the EU. Consequently, fluctuations in housing activities, house prices and rentals have substantial effects on the business cycle and GDP, ultimately affecting well-being. Additionally, housing market cycles have fiscal effects, impacting tax revenues and social expenditure.

Housing shortages can also harm long-term growth and competitiveness. Beyond the immediate social implications, issues of housing availability and affordability can discourage labour and residential mobility. This makes it more difficult to overcome interregional inequalities, improve job matching, and thereby enhance aggregate pro-

1 See also Valderrama et al. (2023) and OECD (2021).

ductivity and social mobility. These issues also raise the cost of land and labour, subsequently increasing the cost of premises and infrastructure for businesses and governments. The result is a mismatch in labour allocation and missed investment opportunities that stymie economic vitality in burgeoning regions, affecting not only national economies but also the euro area and the Union as a whole through diminished overall growth, productivity, and impaired international competitiveness (IMF, 2024).

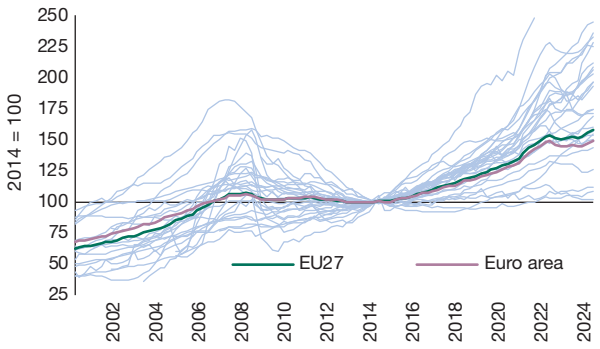
House prices are driven by various demand and supply factors that interact with diverse policies. Demand for housing is driven by factors that include household income, demographic developments (such as the total population, family structure and urbanisation), mortgage interest rates, the availability of credit, and investor and tourism demand. On the supply side, key factors include the housing stock and the amount of new construction, construction costs and land availability. Policies affect house prices, and consequently housing affordability, via their impact on either demand or supply. These include monetary and macroprudential policies, national and regional rules governing land use, urban planning, building regulations, public infrastructure and rental regulations, such as legal protection for tenants and landowners, rental subsidies and the availability of social housing.[2] Taxation, including property taxes, registration taxes, capital gains taxes, rental income taxes, inheritance taxes and notarial fees, may also affect house prices. While some policies, such as rent control, homebuyer subsidies or mortgage interest relief, can mitigate the negative consequences of unaffordable housing in the short term, they may have strong adverse effects in the long term because they support demand instead of supply.

Rising housing costs in the EU

House prices grew significantly across the EU between 2014 and 2022, moderated in 2022 and 2023 following monetary tightening, and started to increase again in 2024. Most EU countries during the pandemic and immediate post-pandemic period experienced strong increases in house prices (Figure 1), building on years of moderate growth. House prices were also increasing steadily in real terms.

Following monetary tightening and a significant increase in mortgage interest rates, house prices began to moderate in mid-2022, and this trend continued into 2023. In the EU, house prices decreased by 0.3% in 2023. The adjustment was strongest in countries like Luxembourg and Sweden, where prices were estimated to be most overvalued and household debt was and is highest (Figure 2). By the end of 2023, house prices were still estimated to be overvalued in three-quarters of the EU. In 2024, house prices began to recover, and in the third quarter of 2024, nominal house prices in the EU increased by 3.8% on a year-on-year basis.

Figure 1
Nominal house price evolution in EU countries



Sources: Eurostat and European Commission services.

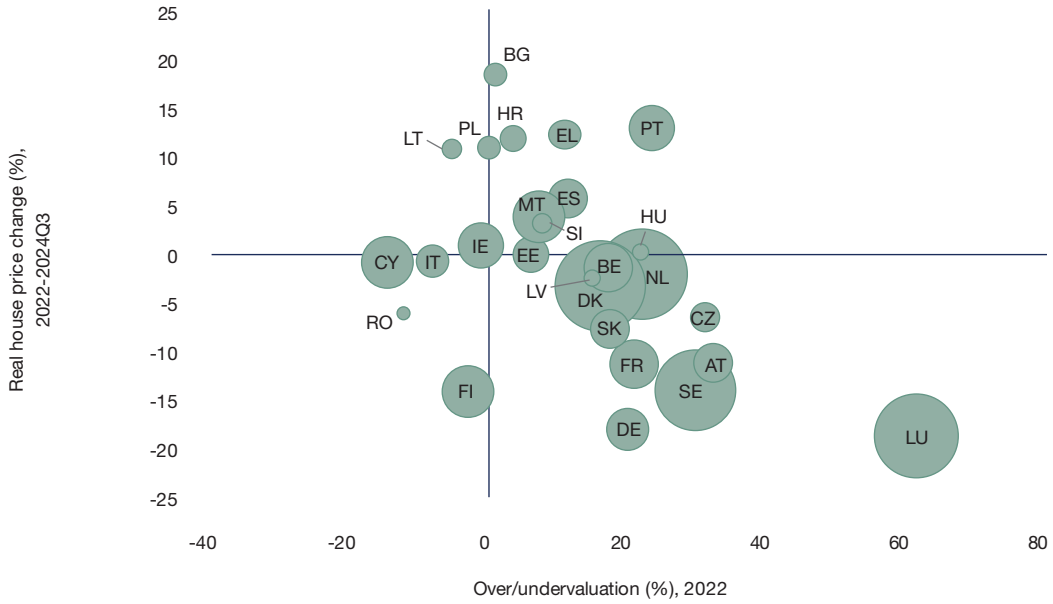
Over the last decade, house prices grew faster than incomes, putting pressure on housing affordability. Price-to-income ratios[3] increased by over 10% in the EU between 2014 and 2022 (Figure 3). Since 2022, most of this increase has been undone, but there are significant differences between member states (Figure 4), and within these, among regions and cities (Frayne et al., 2022). Moreover, the situation varies among income groups and age cohorts, with lower-income and younger groups being the most affected (Kouvavas & Rusinova, 2024).

Higher interest rates have decreased the borrowing capacity of households in recent years. The borrowing capacity of households is affected by incomes and mortgage interest rates, along with country-specific rules about how much of a home's value can be borrowed (see also Andrle and Plašil, 2019). While the decline in housing prices has improved price-to-income ratios, particularly given rising incomes, the increase in interest rates has raised monthly payments for loans of the same size. This reduces the bor-

2 Social and affordable housing both seek to meet the needs of those unable to afford market-rate housing but they do so through distinct methods and target different income levels. Social housing involves government or non-profit rental properties for low to moderate-income individuals and families. Affordable housing includes both rental and purchase options for those earning below the median income, ensuring housing costs do not exceed a set income percentage. Interpretations of these terms vary across EU countries.

3 The price-to-income ratio is the house price divided by gross disposable household income. However, price-to-income ratios do not consider the funding costs and therefore it reflects the affordability from a cash buyer perspective.

Figure 2
Real house price change vs over/undervaluation in EU countries



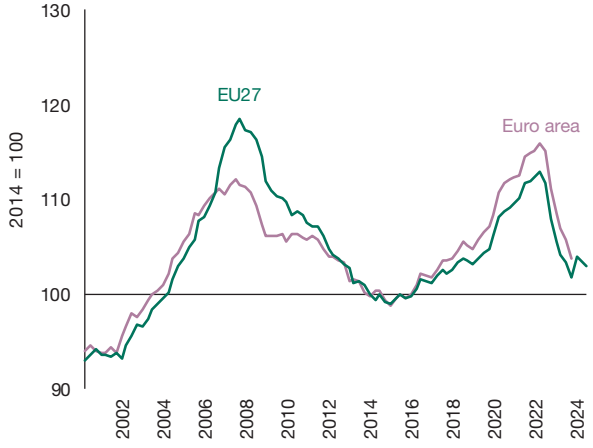
Notes: The size of the bubbles represents household debt in percentage of disposable income. Over/undervaluation is the difference in percentage points between observed house prices and house prices justified by fundamentals and is computed as an average of three metrics (model based, price-to-income ratio and price-to-rent ratio). See Philiponnet and Turrini (2017).

Sources: Eurostat and European Commission services.

rowing capacity of households as households can only afford the monthly payments associated with smaller loans.

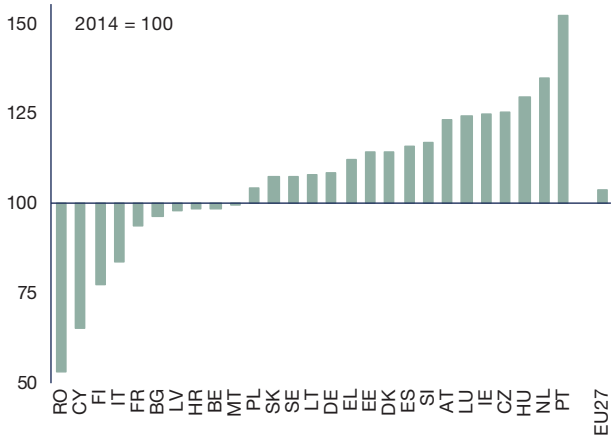
Figure 5 presents the first-year mortgage debt service cost (payment of interest and repayment of principal) as a percentage of median household income. First, it highlights significant differences in the borrowing capacity of a representative household across EU countries, with no distinct geographical pattern. Second, in most countries, the borrowing capacity of a representative household in 2024 was lower than a decade ago, as mortgage service represented a higher share of income. This is mainly due to house prices increasing more than median incomes, despite favourable financing conditions until 2022. In

Figure 3
House price-to-income ratio in the EU and the euro area



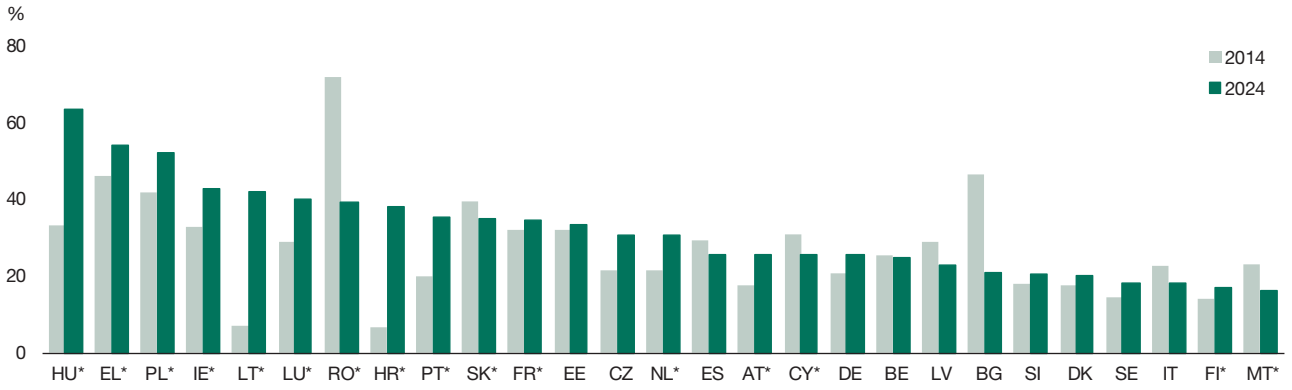
Sources: Eurostat and European Commission services.

Figure 4
House price-to-income ratio in EU countries, 2024Q3 vs 2014



Sources: Eurostat and European Commission services.

Figure 5
Mortgage service as percentage of income in EU countries



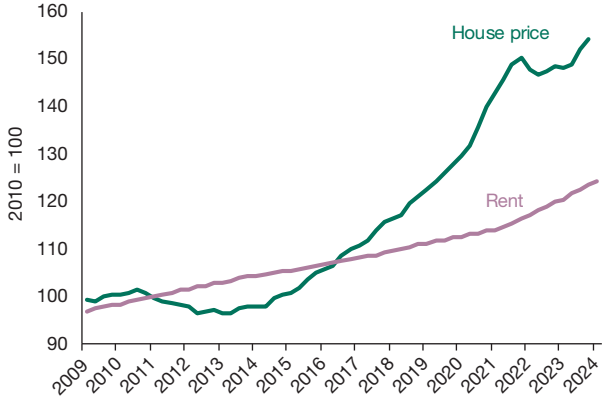
Notes: *As 2024 data is unavailable, 2023 data is used instead. The mortgage service as a percentage of income is calculated by dividing the annual cost of a mortgage (interest and principal amortisation) required to buy a 100 m² apartment by a family median income. The family median income is defined as two times the median equivalised income. The maximum maturity is used for the loan maturity, available in Grünberger et al. (2023). The loan-to-value ratio considered is 100%, and other variables, such as taxation, tax relief and transaction costs, were fixed to zero to capture only the impact of income and interest rates on borrowing capacity. The type of mortgage considered is full amortisation mortgages with constant payments.

Sources: Eurostat, JRC, ECB and European Commission services.

2024, the median-income family in many EU countries needed a significant share of its annual income to service mortgage debt, more than a decade ago. This makes home purchases unviable for many households, forcing them to seek alternatives.

While overall rents have grown at a significantly lower pace than house prices, rent levels in most capital cities are very high compared to incomes. At first glance, it appears that nominal rents have increased significantly less than house prices over the past decade, suggesting that rentals have become relatively less expensive and more affordable (Figure 6). However, the standard rent index, which is part of the harmonised index of consumer prices (HICP), considers existing rents (excluding new rents), which are adjusted at a significantly slower pace than rents faced by newcomers to the rental market, such as younger cohorts. Moreover, a more nuanced picture emerges when rents are adjusted for inflation or compared to income. In most countries, new rent levels in the cities are rather high compared to median incomes, namely a household of two people of median income spends more than 40% on rent (Figure 7). Additionally, the rental market's development in certain areas may be influenced by its relatively small size and regulatory framework, which can pose challenges in terms of responsiveness to evolving housing needs and affordability.

Figure 6
House and rental prices in the EU



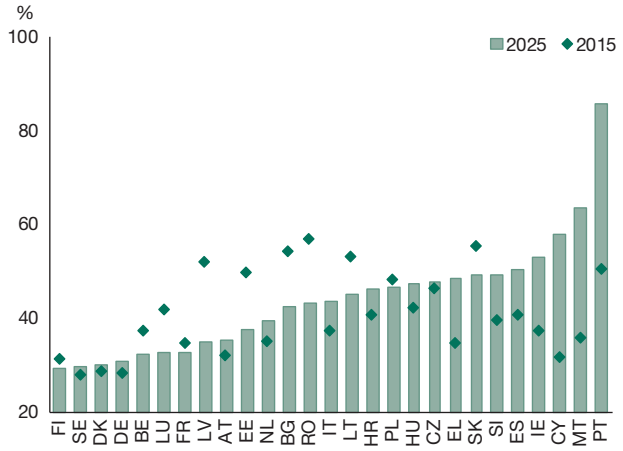
Sources: Eurostat.

Challenges in housing supply

Housing supply has been insufficient over the past decade in many member states, with numerous factors contributing to an increasing cost of new construction and renovations. Housing availability has often responded slowly and in an incomplete way to changes in demand because the processes of planning and building are time-consuming and subject to significant regulatory barriers and capacity constraints. This stickiness in supply leads to price pressures accumulating whenever there are increases in demand, such as when regional economies and populations grow.

In recent years, rising construction and refurbishment costs (Figure 8) – partly driven by stricter (sustainability) requirements and frequent disruptions in the supply of building materials – have increased the cost of new con-

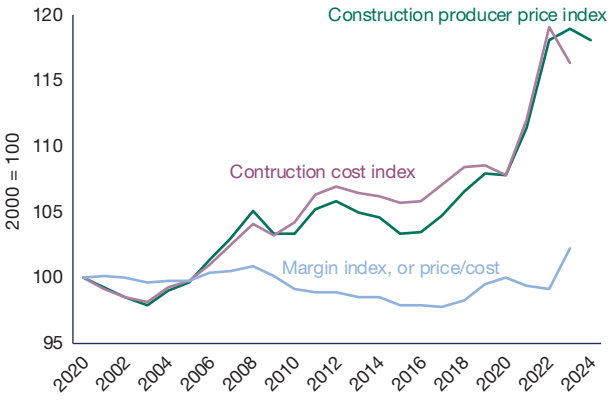
Figure 7
New rent in price locations as percentage of income



Notes: Annual rent of a two-bedroom apartment in prime locations of EU capitals (Eurostat file prc_colc_rents) divided by the median family income. The family median income is defined as two times the median household equivalised income.

Sources: Eurostat and European Commission services.

Figure 8
Construction cost and construction producer price, adjusted for inflation, EU27 aggregate



Sources: Eurostat and European Commission services.

struction. In most member states, high property prices and regulatory uncertainty have not provided sufficient incentive to invest in build-to-rent projects, exacerbating the supply shortage. Underlying factors include regulatory restrictions such as insufficient areas designated for brownfield investment and densification.

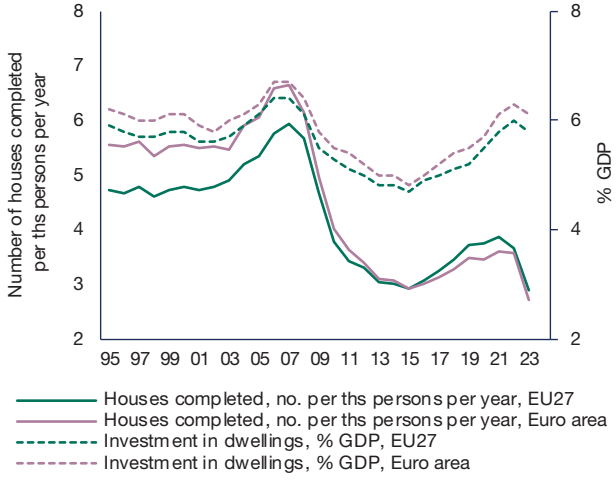
Additionally, the existing building stock has increasingly been purchased by institutional investors, which might contribute to rising rental prices and reduced housing affordability, as profit-driven strategies may prioritise high-income tenants (Banti & Phylaktis, 2024; Bandoni et al., 2025). Moreover, in some touristic areas long-term rents have been replaced by short-term tourist rentals (Cró & Martins, 2023). This has led to a potential supply contraction in the long-term rental market, resulting in higher rents. As shown in Figure 9, the number of houses completed in the EU (by thousand persons per year) significantly declined after the global financial crisis and has not yet recovered. In fact, housing completions in recent years have hit historical lows, partly due to rising funding costs for construction firms.

The situation is not expected to improve in the medium term, as building permits – typically a leading indicator of residential construction – are also at historical lows. Given this shortage, many policy interventions may have unintended consequences. For instance, rental subsidisation, while intended to support low-income households, may increase demand for rent, ultimately raising rents, effectively transferring resources to homeowners and further hampering housing affordability. In some countries, rental regulation may have reduced the incentive to build to rent, thus shrinking the size of the rental market. Additionally, generous mortgage interest rate relief in some countries not only drives up demand for home purchases in the face of staggered new construction but also favours home-ownership over renting, essentially providing a subsidy targeted at higher income groups.

Policies supporting affordable housing

The housing market is shaped by national and regional policies and regulations. National governments typically manage social housing strategies, rental regulations

Figure 9
Completion of houses and investment in dwellings, EU27 aggregate



Sources: Eurostat, ECB and European Commission services.

and the tax treatment of mortgages, while regional and local authorities control land use, zoning, and building permits and licensing, which affect urban development. The primary responsibility for housing policies, including investing in social housing, ultimately lies with the member states, which have adopted diverse approaches to meet their specific needs and preferences. EU-derived regulations, and the way they are implemented in member states, have an indirect impact on how complex, costly or time-consuming it is to deliver housing.

Policies supporting the supply of social and affordable housing are needed. Investment in social and affordable housing, including new construction, maintenance and refurbishment, should be part of the policy strategy. The supply of social housing has been very muted in most member states over the last decade. Investments in social and affordable housing initiatives can alleviate overall supply constraints while enhancing affordability, particularly for low-income and younger families. These programmes typically offer rental units at regulated prices or sell properties below market rates under specific conditions. Unlike housing allowances, which may increase demand and risk becoming counterproductive and costly for the public purse, the construction of social housing expands supply.

Policies aimed at reducing urban congestion can also help alleviate pressure on the housing market. By incentivising firms to relocate staff or move services away from congested areas, these policies can redistribute housing demand and ease supply constraints. This redistribution can enhance the effectiveness of policies supporting housing supply, such as social housing initiatives, allowing them to have a more significant impact. Investment in urban and suburban transport also plays an important role in this process.

At the European level, a supportive environment can be fostered through complementary funding mechanisms and strategic initiatives to promote affordable housing. Recognising the importance of affordable housing for social cohesion and economic stability, the European Commission is introducing a European Affordable Housing Plan, making this a key priority for the current term.[4] The plan will make proposals on how to offer technical assistance to cities and member states, and focus on investment and skills needed. A key component will be a European Strategy for Housing Construction to support housing supply, including measures to reduce building costs, increase the skills of the labour force, raise productivity and enhance the environmental performance of construction. Together with the European Investemnt Bank and other financial institutions, the aim is to attract more private and public investment for affordable and sustainable housing. Part of this will be allowing member states to inject liquidity into the housing market, including by reviewing state aid rules, and doubling the planned cohesion policy investments in affordable housing. It will also contain proposals on short-term accommodation rentals and how to tackle the inefficient use of the current housing stock.

By promoting deeper financial integration and attracting private investment, EU initiatives can improve financing conditions, including those for housing. As private financing remains dominant in real estate investment, integrated capital markets can attract private investment into long-term housing projects, thereby increasing liquidity and diversifying funding, particularly in underserved sectors like social housing.[5] The Banking Union reduces risks across the banking sector and better integrates financial institutions, enabling them to offer new and affordable mortgages. Future Union initiatives on banking and capital markets, under the Savings and Investments Union, could contribute to improving housing finance and boosting economic growth, providing a strong foundation for the targeted policies essential in tackling housing affordability.

4 Under this plan, member states will be allowed to double cohesion policy investments in affordable housing as an immediate first step. See political guidelines for the next European Commission (von der Leyen, 2024).

5 Fransen et al. (2018) identified a minimum annual investment gap of €57 billion.

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Benign Neglect or Institutionalisation? Dealing with de facto Euroisation in Candidate Countries

EU enlargement rounds have always been driven by political will of the parties concerned and administered through a comprehensive legal-bureaucratic procedure. There is strong political determination to carry on the accession process involving Western Balkan countries as well as Ukraine, Georgia and Moldova, but the standard enlargement procedures have proven time-inconsistent for recent applicants. This article scrutinises the specific historical, geopolitical and domestic characteristics of the Western Balkans and focuses on the unique currency situation of the region. Widespread spontaneous use of the euro in everyday life, and unilateral euroisation in two cases, should justify a non-standard monetary policy arrangement; not a shortcut to the euro area but providing an institutional framework and clear perspective for the parties concerned. These proposals align with recent accession practices and would strengthen political momentum.

The enlargement of the European Union is a par excellence *political act*: granting full membership to a candidate country must be approved by all incumbents, and the successful conclusion of negotiations ends with member state ratifications. At the same time, the accession process is a complex and time-consuming *bureaucratic procedure*, designed deliberately to be gradual and controllable, and it consists of numerous stages granting any incumbent the right to exercise politically motivated checks, if deemed necessary (European Commission, 2024a).

The long and demanding process thus has a dual logic: political and bureaucratic. This duality has been put to the test in various enlargement events in recent decades.

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* Note: the designation "Kosovo" is used without prejudice to positions on status and in line with UNSC 1244 and the opinion on the Kosovo Declaration of Independence.

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None has been simple; not even those involving economically advanced applicants who are potential net contributors to the common budget, as in the case of Austria, Finland and Sweden (accession accomplished in 1995). That round reminds us that enlargement has always been geopolitical: applications were submitted between 1989 (Austria) and 1992 (Finland), in a political window of opportunity, when global constellations and inner dynamics of Russian politics allowed the hitherto neutral states to apply for EU membership. The subsequent enlargement round was a "big bang" of ten new members in 2004, followed by Romania, Bulgaria and most recently Croatia.

Recent events highlight the primacy of politics: immediately after Russia's attack, Ukraine applied for EU membership on 28 February 2022. Days later, Georgia and Moldova submitted their applications. The European Council decided in less than four months to grant Ukraine and Moldova candidate status, and it recognised Georgia's "European perspective" – one notch short of formal candidacy. Their outlook is beyond the scope of the present study, which revisits the ongoing accession procedure of the West Balkans and highlights a somewhat neglected aspect: money.

Balkan countries have their own unique baggage of complicated history and nontrivial political conditions. They are also less advanced in economic terms than incumbents that entered EU between 2004 and 2013. The combination of complex politics and relative underdevelopment is a tough challenge in the bureaucratic merit-

based accession process. Still, EU institutions and member states have made biding promises to the applicants. Thus, unprecedented tension has evolved between the (geo)political will to enlarge, and the readiness of the applicants as well as incumbents to accomplish the customary legal-bureaucratic accession process.

This is the context in which the customary enlargement procedure is being scrutinised. The same European leaders who support the speedy eastern enlargement under the new geopolitical situation that emerged after Russia's aggression are also keen not to leave behind the six countries in the Western Balkans that aspire to membership: Serbia, Bosnia-Herzegovina, Montenegro, North Macedonia, Kosovo and Albania (also known as the WB6) have spent considerable time in the complex bureaucratic accession procedures. The authorities and peoples of the region worry now about being left behind and leapfrogged by eastern applicants.

It is logical, in such a situation, to search for some policy space, hitherto unused or non-existent, to further the WB6 accession procedure knowing, however, that the applicants are still far from meeting crucial entry conditions. That idea resonates in academic and political circles. One line of argument is that the accession process should be restructured so that some applicants may become partial or associate members, before acquiring full membership at a much later stage (Kribbe & van Middelaar, 2023). However, the concept of a new classification is controversial among key stakeholders who do not want to depart from the existing framework and main administrative rules of enlargement. Below, we argue for another possible direction of change: a non-standard sequencing of the existing process, involving a currency and payment affairs.

That changes should be made in the customary legal-institutional enlargement framework is not a novel concept, nor is it directly related to applicants in the EU's southern and eastern periphery. EU membership is strictly conditional on full acceptance of the four freedoms (free movement of goods, services, capital and labour) and core values (democracy and rule of law); but beyond that, it is imaginable that EU members could belong to "one or several clubs or partnerships, like the European monetary union or a future European defence union" (Sapir, 2022, p. 215). The concept of a flexible "club membership" is particularly justified by political realism: the EU may offer "visible and tangible benefits early on and immediate return for reform progress" (Kribbe & van Middelaar, 2023, p. 13).

Flexibility, far from being academic advice only, is present practice. Tailor-made bilateral agreements and programmes already exist, beyond the classical enlargement policy framework, as in the case of the Deep and Comprehensive Free Trade Agreements (DCFTAs) with Ukraine, Moldova and Georgia, or the Stabilisation and Association Agreements (SAAs) for the WB6.

A general policy dilemma for the EU in recent cases is still valid: how to incentivise candidates and strengthen their morale – without making political exceptions to the rules. There is no easy answer in the present situation. Domestic support for the needed reform measures will wane if the general mood is that the EU institutions only play for time by setting unattainable targets. It would be politically and managerially beneficial to identify specific areas where a candidate is well prepared to meet EU standards, allowing good performers to be accepted into a "club" based on real merits.

Going ahead in one area, not waiting for definite progress in other aspects, is already reality in the case of free trade agreements in manufacturing goods under DGFTAs: a sufficiently mature candidate is accepted for a specific agreement without becoming a member of the EU customs union yet. Full harmonisation with the EU's internal market regulations is, as history has shown, a long and hard process. Still, important progress in trade matters can be achieved when local conditions allow, to mutual benefit, at a time when the contours of full EU accession are vague. Similarly, an enhanced status or "club membership" could be established for certain services and the labour market for the people of the West Balkans.[1]

Could what is true for product markets and the labour market be true in a monetary aspect? Understandably, monetary issues are sensitive in the EU as they involve considerations of sovereignty and raise questions about whether applicants are really prepared in fiscal and monetary aspects, i.e. the Maastricht criteria. Still, the present research acknowledges the particular socio-economic conditions of this region, exploring whether the customary sequencing of the accession process could be modified and suitable administrative arrangements could be created for the legal use of the euro to the mutual benefit of well-prepared candidates and the euro area itself.

The issue of monetary preparedness is country specific and context dependent. Therefore, it is important to con-

1 The opening of labour markets of EU member states was not offered automatically for the entrants. Central and Eastern European countries learned in 2004 that key employment targets, primarily Germany and Austria, requested a seven-year derogation in order the protect domestic jobs in the face of an assumed inflow of low-pay workers from the East. The historical antecedents were different in ex-Yugoslavian countries, resulting in rather intensive cross-border flows of former Yugoslav nationals throughout the transition period until the very present.

sider the particularities of the given region before outlining the design of the recommended changes in the accession procedure.

Idiosyncrasies of the WB6 – History, legacies and options

Five of the WB6 countries – all but Albania – share common legacies as former republics of Yugoslavia until its dissolution. Socialist Yugoslavia maintained particular economic, labour and financial relations with Western states during the East-West political separation of Europe from the 1960s onwards, and this has consequences for the present.

Under the special relationship, large numbers of Yugoslavs found employment in the West as guest workers. As a result, use of parallel currencies became an everyday reality. Remittances in "hard currencies", especially in the West German mark, flowed to Yugoslavia legally. The West German mark gradually assumed currency functions alongside the Yugoslav dinar, the rather inflationary domestic legal tender. Yugoslav authorities did not hinder economic migration knowing that guest workers would repatriate their savings for consumption or real estate or small business investment purposes (Vidovic & Mara, 2015). Mass economic migration and remittances were negligible in other European socialist countries at that time.

The collapse and fragmentation of the Yugoslav state in the early 1990s led to suffering, years of hostility, wars and political instability. The new, emerging entities experienced severe economic and financial troubles, to varying degrees, but managed to remain economically connected with Western Europe.

In the turmoil, quite specific currency relations emerged. Take the case of Bosnia and Herzegovina: at the time of the establishment of its central bank (CBBH) in 1997, market transactions were settled in four currencies (Bosnian dinar, Yugoslav dinar, Croatian kuna, German mark). Given the antecedents and complex local conditions, the unilateral introduction of the so-called convertible mark was logical, however peculiar such a decision sounded at that time when Germany and other EU states were busy creating the common European currency. At the outset, the convertible mark was fixed at a 1:1 ratio to the value of the German mark. With the introduction of the euro in January 1999, the ratio was adjusted according to the Deutschmark/euro exchange rate (1.95583), and maintained permanently (BIS, 2003).

Economic and financial processes of the region have always been influenced by regional tensions and conflicts, as the fragile case of Kosovo indicates. Similarly, there are issues with North Macedonia, causing complications in the accession process: the country's aspirations had been blocked by Greece until a bilateral agreement was signed in 2018 concerning the official country name.[2] As for Bosnia and Herzegovina, it was constructed as a quasi-federal state consisting of two parts under the Dayton Agreement (1995), yet one entity called Republika Srpska seems to be oriented politically more towards Serbia than the Federation of Bosnia and Herzegovina, with its majority of Croats and Bosniaks.

Under these peculiar conditions, the emerging new entities needed instant solutions for vital issues including the currency regime. The case of Montenegro and Kosovo is unique: in their efforts to distance themselves from Serbia, and consequently from the Serbian dinar, authorities decided to institutionalise the de facto use of the euro. The de jure euroisation was, importantly, a unilateral decision without officially involving the ECB or other EU bodies. At present, this is the status quo. There is no incentive whatsoever for these countries to create their own currency, only to give it up in the final phase of the EU accession process for the euro.

All six countries strive to obtain EU membership. The degree of preparedness and their respective "maturity for the union", however, differ greatly. The speed of the progress hardly substantiates the hopes that these countries will fulfil all membership preconditions in the foreseeable future (Bourguignon et al., 2022). Strong political will might accelerate the process; still, under the dual logic of the enlargement process, as defined above, full EU integration of the WB6 is conceivable in the long term only.

This conclusion stems from area studies and comprehensive reports prepared by the European Commission on the level of integration maturity and preparedness of the countries concerned (Emerson & Blockmans, 2023). On a five-point scale of the average value of the qualifying aspects, Montenegro is in first place (3.11), followed by Serbia and North Macedonia (3.06; 3.04 respectively); the scores of the other applicants are lower (Mihajlović & Macek, 2024). In certain aspects, some countries perform far below average, especially with political issues (jurisdiction, basic rights, justice, freedom, security) while in other clusters, including economic criteria like competitiveness and the domestic market, the results are relatively good.

2 Previously, the country was referred to as the Former Yugoslav Republic of Macedonia in international documents. At present, the official reference is Republic of North Macedonia. Still, historical and ethnic problems with Bulgaria and Albania persist even after the conclusion of the denomination dispute.

Such a variability in preparedness has been recognised in academic circles as well as by policy-makers who are unsatisfied with the accepted accession process. The customary bureaucratic procedure – including the fulfilment of all criteria along the 35 acquis chapters – may only be attainable in the very long run in the Balkans case, or with Eastern candidates for that matter. What if, in the meantime, a particular applicant has achieved significant progress in a specific field? In this case, alternative concepts have emerged such as "Staged Accession", as a break with the present binary procedure of being either "in" or "out", recommending instead distinct stages defined by two criteria: applicant's readiness and incumbent's preparedness (Emerson et al., 2021).[3]

New definitions and unused phasing, however, can elicit political objections and justified concerns about procedural aspects, and those in the waiting line for membership may find any new definition suspicious and take "intermediate membership" as a substitution for the real thing. Maintaining a supportive political climate is key for the success of such a protracted process as defined by the conventional accession procedure. Further progress in the process, driven by the intentions of both the EU and the candidates, is assumed here, but the political mood may change.

The EU is the largest trading partner of the region as a whole (Vulović, 2023), although political actors and stakeholders are not limited to Europe. While all Western Balkan countries have a free trade agreement with the European Union, Serbia also has such an agreement with the United States and, more importantly, with Russia, and plans to conclude one with China. All WB6 countries have free trade agreements with Turkey.

A distinctive feature of the region is a high unemployment rate, especially among the youth, who tend to seek temporary or longer-term employment abroad – a continuation of the economic migration process that has characterised the region for a long time. Reverse labour force movements are also common. Cross-border money transfers, repatriation of wages and other incomes have become structural parts of economic life.

These are critical characteristics that set apart the WB6 from other nations that have accomplished accession in previous EU enlargement rounds. The idiosyncrasies raise an obvious question: why should this particular set of countries follow exactly the same path as others – free trade area, customs union, single market, full EU membership, and, once members, the fulfilment of the Maastricht criteria and the transition to the euro.

That pattern, tested in several recent accession events, assumes the existence of a national monetary system and a domestic currency. Then the member, with all conditions met, including a minimum of 24 months in the European Exchange Rate Mechanism, may apply for euro area membership. In contrast, the Balkans region has a critical feature: high level of de facto euroisation, with two countries having undergone a unilateral transition to the euro. This is a situation benignly neglected or tolerated by European institutions.

The above review of the region substantiates the claim made in this article that such a substantive feature would justify hitherto unused paths to the monetary union.

Currency considerations

The daily use of a parallel currency is not a unique Balkan phenomenon; hard currency in circulation has been a case in many emerging and developing markets. To give up volatile local currency for a strong anchor currency is justifiable under the logic of "institutions substitution" (Mendoza, 2002).

Similarly, for transition countries in Central and Eastern Europe (CEE), strong monetary policy arguments have been made to peg the local currency to the euro (currency board) or give it up altogether via unilateral euroisation (Buiter & Grafe, 2002). CEE candidates were, however, strongly discouraged by EU institutions in the membership preparatory phase and did not deviate from the textbook procedure: accession to the EU first, followed by preparation for entering the euro area.

The Balkans case is very different: secondary position or total lack of a local legal tender is, as we have seen it, an important peculiarity.[4] Currency and banking affairs therefore differ significantly from those of CEE countries that operated a sovereign monetary system with a domestic currency during the long preparatory period before EU

3 Four stages are proposed: initial, intermediate, new member state, and conventional membership. Second: retaining safeguards in relation to existing member states' concerns over further enlargement for which the EU's institutional structure is not yet adapted (Emerson et al., 2021).

4 The Austrian National Bank regularly monitors the use of euro in certain states outside the euro area. The euro substitution ratio in 2023 (i.e. the ratio of euro cash to national cash in circulation) is limited in present EU member states that have not yet joined the euro area (Bulgaria: 3.05%, Czechia 4.47%, Hungary 4.39%, Poland 3.63%, Romania 12.27%); the ratio is remarkably high in the Western Balkan countries (Bosnia and Herzegovina: 9.35%, North Macedonia 50.7%, Serbia 47.82). Data are not collected in Western Balkan countries with the euro as legal tender (Kosovo, Montenegro). For more information, see the OeNB Euro Survey.

accession. Once in the EU, some of them embarked on euro adoption immediately, while others had managed their own currency and monetary system for some time before authorities decided to make serious efforts to enter the euro area; again, some other governments retain derogation that allows them to stay out of the euro area.[5]

Country cases do not substantiate claims in favour of maintaining independent monetary policy regimes as an assumed crisis management tool (Bod et al., 2021a). What is more: whatever the monetary track records of CEE member states, they would have limited relevance for the WB6 group because of its particular financial conditions, as mentioned above.

The high level of de facto euroisation has been the reality for some time, thus one may claim that there is no need for immediate action, and the Balkans case does not demand material changes in the customary accession procedure. The above review of the economic and social aspects, as well as the geopolitical conditions of the region, however, will not justify an easy acceptance of the status quo. Until EU accession takes place, the European Central Bank (ECB) has only limited influence on the monetary and macro-prudential policy of the countries concerned within present legal frameworks. The ECB and other regulatory bodies would be particularly important, however, in shaping longer-term processes, typically neglected by local politicians with short time horizons (Benczes, 2022).

There are strong monetary policy arguments for the general use of a strong anchor currency in an otherwise volatile business environment. Banking and finance are conducted in euro, thus prudential regulation is of utmost importance even if the entities concerned are far from passing all the tests needed for full EU membership.

What would, then, the alternative paths look like in the monetary respect? It is pointless to expect the government without national legal tender to retreat to where CEE candidates were at the time of their application and establish a floating national currency. No one expects these governments to go in reverse: the EU institutions have acknowledged the status quo with an attitude of benign neglect. Acceptance of the present situation may seem rational for both sides: the authorities of countries with legal or spontaneous use of euro are aware of the customary enlargement process; as for the EU institution, they have many more urgent issues to tackle. Still, the status quo does not serve the interests of either party.

Given the region's modest level of economic advancement, high unemployment and related social problems, along with the negative social consequences of the enhanced outflow of the working-age population, trade promotion and job creation/retention is a must. In order to serve the above goals, a Western Balkans Growth Plan was published by the European Commission in November 2023 aiming for, among other things, the creation of a common regional market (Jovanović, 2024). The issue of currency and banking is one of the priority areas, in particular, access to the single euro payment area (SEPA). The other aspects cover free movement of goods, services and workers, the promotion of road transport, the integration and decarbonisation of the digital single market, and integration into the industrial supply chain (European Commission, 2024b).

A large body of monetary literature underlines the fact that regional use of a stable common currency contributes to trade creation. Such currency is there for the WB6; what is needed is a clear framework and adequate monetary arrangements, under a modified sequencing of the accession process.

Modification, obviously, raises the feasibility issue, given the dual (political and bureaucratic) nature of the accession process. As for politics, aspirants and EU incumbents alike know all too well that a process with its numerous chapters is going to take a long time – longer than in the 2004, 2007 and 2013 enlargement cases – for two main reasons. One of them is the relative underdevelopment of the candidates, coupled with weaknesses in preparatory work.

The other – and more pertinent to the present research – reason is the time-inconsistency of the customary enlargement procedure. This is not surprising: the whole accession process had been designed for certain types of countries – not for those that had lived for decades, during the East/West separation, under political, economic, legal and social systems so different from those in the core EU. Such procedural time-inconsistency was felt profoundly by CEE states eventually admitted to the EU between 2004 and 2013. They somehow coped with the less-suited procedures – but at some unnecessarily high costs. At present, two decades after the largest enlargement round, the original enlargement rules seem to be less and less appropriate.

Yet, there does not seem to be an appetite among the incumbents for a watered-down version of the legal-administrative procedure for either WB6 or Eastern candi-

5 Bod et al. (2021a, 2021b) have discussed the euro introduction process of Slovakia, Hungary, Poland, Czechia, Croatia, Slovenia and the Baltic countries, pointing out that those that adopted the euro did that only after becoming EU members and subsequently fulfilling the Maastricht criteria. They also experienced spontaneous euroisation but to a lesser degree than in the WB6.

dates. Still, the political momentum for the promised enlargement process has to be maintained in order to retain supporters within the countries concerned and in the EU itself. Given that the traditional path seems to be excessively long, efforts have to be made to come up with alternatives. As recent special arrangements for product markets and (some) services indicate, new modalities can be found in areas where the candidate countries are prepared enough – and the EU is also ready to institutionalise the rules, conditions and framework. Based on the above analysis, monetary and currency issues should be tackled in the same fashion.

Concluding recommendations

Given the political and economic importance of the currency regime, it is understandable that the EU institutions and major actors are sensitive to any proposal concerning the legalisation of the status quo that had been created by the unilateral introduction of the euro. In reality, institutions always acknowledge non-customary cases as well. Interfaces between EU institutions and regional monetary and fiscal authorities are active. Experts from candidate countries participate regularly in technical as well as high-level events at the European Central Bank. Professional collaborations between monetary authorities cover important aspects of financial technology, anti-money laundering and payment settlements. These efforts are supported through events organised by the International Monetary Fund, the World Bank and, importantly, by the EU via the Western Balkans Payment System Modernization Project, under the administration of the Council for Regional Cooperation.[6]

It is thus important to realise that a kind of quasi-membership in expert teams already exists. Collaboration is all the more important between the EU and the WB6 as further financial convergence of the Western Balkans region would stimulate trade-creation effects and increase the region's ability to attract foreign direct investment.

A compelling geopolitical argument can also be put forward. Major non-European players, foremost China, entertain intentions to gain further influence in the region.[7] WB6 governments will consider geopolitical gains and immediate economic benefits. The mere fact of conducting accession negotiation is an asset of the EU in this competition for influence – but this should be underpinned by tangible progress. An ordered legalisation of the status quo for the two euroised country cases, and convenient framework for those using euro intensively as parallel currency, would replace the current attitude of benevolent indifference with a pragmatic business-like future.

What is not proposed here is immediate entry into the euro area with full membership rights. Incumbents have passed a complex and demanding, albeit somewhat arbitrary, process to earn entry. Those still staying out with derogation would have to go through the same or very similar procedures. From their perspective, it would be unfair to offer easier entry for others. But it is about more than fairness: it is logical that to have a seat at the ECB, the country must be member of the EU, and pass "Maastricht" or its potential upgrade by that time.

Also, a party to the proposed agreement will have no claim on the ECB's seigniorage (income from issue of euro currency) before EU membership and euro area membership. Still, what the recommended currency agreement offers to applicants and the EU, is important and useful. It will imply membership of the country's monetary authorities in all working groups of the ECB and the Eurosystem, and (non-voting) representation in policymaking forums. Being present in monetary workshops and decision-making bodies is justified in the case of countries where the euro is the legal tender, banks and financial enterprises conduct business in euro, and the common European currency is an organic factor in the economy and society.

Whether such a status promotion in the concerned two country cases would encourage a further step towards a full-fledged euroisation is not certain. Any important economic policy issue should be debated and agreed upon jointly during structured policy negotiations, and based on country-specific recommendations from EU institutions. Arguably, a currency regime of hard peg to euro is reason enough for the country's monetary institutions to be represented (obviously without voting power) in professional, regulatory and policy forums where issues of business and social consequences are debated. A structured policy dialogue between candidates and EU institutions would ease the transition to the euro, and the whole accession process, rather than perpetuating substandard monetary conditions.

6 EU-supported digitalisation has been progressing in the region, and national institutions have embarked on drafting EU-compatible regulations on cash operations as one of the basic criteria towards membership in the SEPA Payments Scheme and access to the EUs fast payments system (Target Instant Payment Settlement), as declared by the governor of Kosovo's central bank (Ismaili, 2024).

7 This appeal will increase unless the EU convincingly promises rapid progress within the accession framework (Steinbach, 2024).

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Differences in Economic Development in Central and Eastern Europe Over the Last 20 Years

The process of transition and growth in Central and Eastern Europe (CEE) provides interesting insights, considering the countries' historical relationship with the Soviet Union. The 20 years after the Eastern enlargement of the European Union show an integrative power within the Single Market. However, due to the complex development paths of CEE countries, the question regarding the factors influencing their economic performance arises. This paper considers the innovation and institutional factors, e.g. innovation system performance, institutional development and political practices, that influence the economic development of CEE countries. It also looks at the differences in the effects of these factors. The analysis is performed for 37 European countries for the period from 2000 to 2020. The results reveal the importance of innovation and institutional factors, which may have special implications for the development of non-EU CEE countries.

Economic growth and technological innovation have drawn the attention of economic literature for decades. The examination of the connection between innovation and economic growth goes back to the work of Schumpeter (1911, 1939) and Solow (1956), as highlighted by Pece et al. (2015). Schumpeter (1939) underlines the relationship between innovation and capitalist economic development as a process wherein capitalism fosters innovation, thereby generating new opportunities for economic growth necessary for its survival. Solow (1956) employs neoclassical models to depict economic growth as a function of capital and labour inputs, with technological innovation playing an important role in influencing the growth rate. Schumpeter (1939) considers the connection between entrepreneurial innovation and economic change as the main factor of economic development (Croitoru, 2017). Capitalism is creating innovation whereby new economic growth opportunities arise that sustain the core of capitalistic survival (Schumpeter, 1939). Romer (1986) and Lucas (1988) further develop the theories of Schumpeter (1939) and Solow (1956). They provide additional empirical evidence that innovation processes are a crucial factor influencing economic growth.

Discussing the relationship between economic development and innovation, Filippetti and Archibugi (2011) employ a concept of National Innovation Systems (NIS) to elucidate this relationship at the national level. This framework has been widely embraced in the literature on innovation economics (Freeman, 1995; Lundvall, 2016; Nelson, 1993). In essence, the NIS approach views innovation and technological development as outcomes of intricate interactions among various actors within a system. These actors include governmental institutions, firms, universities and other research organisations (Organisation for Economic Cooperation and Development [OECD], 1999), all engaged in collaborative efforts and knowledge exchange essential for developing new products and services (Freeman, 1995).

In addition to quantitative factors like the number of innovations introduced, the number of firms in the market, or the number of employees in high-tech sectors, norms and

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conventions within a specific country can also influence its economic growth, either directly or indirectly. These norms, often referred to as institutions, were introduced into economic analysis by North (1990), who states that institutions set the rules to govern human interactions and categorises these rules into formal institutions and informal institutions. In response, governments devise and implement policies aimed at influencing these innovation processes. The result is that the European Commission, the OECD and some European countries have adopted the NIS concept in their studies and policy efforts (López-Rubio et al., 2021; Lundvall et al., 2002).

Batrancea et al. (2022) further show the importance of financial institutions, for example, bank capital to assets ratio for developing countries' economic growth. Additionally, research has explored the relationship between different types of institutions. By analysing a sample of 50 countries, Holmes et al. (2013) find that informal institutions, like cultural dimensions of collectivism and future orientation, also impact formal institutions and influence economic growth.

Moreover, recent literature investigates how institutions interact with economic growth across specific country categories. Esfahani and Ramirez (2003) underscore differences in investment-to-GDP ratios between countries with stronger and weaker institutional frameworks. More recently, Dorożyński et al. (2020) highlight the impact of institutional variances (measured by the Global Competitiveness Index) among countries in Central and Eastern Europe (CEE) on investment attractiveness.

CEE countries exhibit distinct structural conditions and characteristics related to innovation. This can be attributed to the transition process from planned economies to market economies that these countries have undergone. This transition is described by the need to modify not only formal market conditions but also informal institutional frameworks, which requires significant time and effort from various actor groups (Gabrisch & Holscher, 2006). Kravtsova and Radosevic (2012) emphasise that eastern European countries face challenges related to inefficiencies in their national innovation systems, resulting in difficulties in generating R&D output. Nevertheless, CEE countries have gradually begun to close this gap in knowledge production capacity since the early 2000s (Kirankabes & Erkul, 2019). The relative success of certain countries, however, was influenced by numerous factors beyond the pace of transition, such as militarisation or over-industrialisation of the economy (Popov, 2007). Additionally, variations in institutional quality have significantly affected the development trajectories of countries (Dorożyński et al., 2020). Radosevic (2002) argues that in the post-socialist period, the development of regional innovation systems became crucial for sustainable growth in CEE. The article underscores the development of regional innovation systems across four levels: national, sectoral, micro and regional. It further highlights the role of network organisers in promoting regional innovation. While numerous studies on innovation in CEE economies exist (e.g. Scrieciu & Stringer, 2008; Stojčić, 2021; Stojčić & Orlić, 2019), Pece et al. (2015) specifically analyse the relationship between innovative characteristics and economic performance. They find a positive correlation between innovation and economic growth in several CEE countries, including Poland, Czechia and Hungary. Other articles focus on the convergence of EU enlargement (e.g. Niebuhr & Schlitte, 2009).

The literature gap for CEE countries

There exists extensive research on the role of innovation for economic development, as well as on the interaction between institutional arrangements and economic growth. However, the evidence on the impact of institutional variables, such as civil liberties and political freedom, in the analysis of economic growth remains limited. Here Henisz (2000) and Catrinescu et al. (2009) see a connection between economic growth and institutional quality, while Barro and Sala-i-Martin (2004) observed a partial relationship between growth rate and democracy. However, the specific evidence for the case of CEE countries, especially non-EU members, is still missing. Nevertheless, this evidence may be important, especially considering the potential future enlargement of the European Union (Dabrowski, 2022).

This paper advances the analysis by exploring innovative and institutional variables and their roles in the economic development of CEE countries. Unlike most of the existing research that focuses primarily on EU member states within the CEE region (Gherghina et al., 2019; Dorożyński et al., 2020; Havrylyshyn, 2007), this study includes both EU and non-EU members. Additionally, Western European countries are included in the analysis. This comparative approach aims to determine whether innovative and institutional variables exert different effects on country groups.

In summary, this paper investigates two main research questions:

- Which innovation and institutional factors influence the economic development of CEE countries?
- What differences in the effects of these factors can be measured between CEE countries that are EU or non-EU members, and Western European countries?

The research covers 37 European countries.[1] Out of these countries, 16 are categorised as CEE. Eight countries are members of the European Union: Bulgaria, Croatia, Czechia, Hungary, Poland, Romania, Slovakia and Slovenia. Another eight are neighbouring countries to the EU: Albania, Belarus, Bosnia and Herzegovina, North Macedonia, Montenegro, Moldova, Russia and Ukraine. Twenty-one are non-CEE countries that can be characterised as Western European countries. For the purposes of this research, non-EU countries that maintain significant ties to the European Union are included in this category. The UK was an EU member for a major part of the observation period; Norway and Iceland are part of the European Economic Area; and Switzerland has trade and political agreements with the EU, including the Schengen Agreement (EEAS, 2021; Eurostat, 2020).

GDP per capita is included in the analysis as a dependent variable as it is a key indicator in studies on regional development and convergence (e.g. Goecke & Hüther, 2016). Examining the evolution of GDP per capita over time enables us to observe the relative economic development of economies. To analyse the influence of institutional and innovation variables, the independent variables encompass macroeconomic indicators, innovation-related factors and institutional metrics. Drawing on prior studies by Pece et al. (2015), Petrariu et al. (2013) and Nistor (2015), the regressions also incorporate foreign direct investment (FDI) inflows as a determinant of economic development. To enhance comparability, FDI inflows are normalised by the GDP of the corresponding year.

The institutional variables are also included in the analysis. They reflect political freedoms, civil liberties and corruption within a country. Otáhal and Grochová (2012) and Svendsen (2003) have identified a notable negative correlation between corruption and economic growth in eastern European countries. Hence, building on Svendsen's (2003) research, this paper employs the Corruption Perceptions Index (CPI) to assess and quantify the impact of corruption on economic growth across the analysed countries. Furthermore, statistics on political liberties (PLF) in the respective countries provided by Freedom House are incorporated into the analysis.

Results of the path dependencies of development of CEE countries

The specifications are as follows: the relationship between log GDP, the innovation variables ($lag\_FDI\_pGDP_{i,t}$; $intlpEMTL_{i,t}$) and institutional variables ($lag\_PLF_{i,t}$; $lag\_CPI_{i,t}$) is calculated. Table 1 presents the results of these main findings. The analysis is first performed for all countries in column (1), followed by a separate calculation for CEE countries without EU membership in column (2), CEE countries with EU membership in column (3), and finally, non-CEE countries with EU membership in column (4).

Some of the results are in line with existing literature. Bogliacino and Pianta (2011) and Westmore (2013) un-

Table 1
Panel regression of log GDP per capita with innovation and institutional controls

	(1)	(2)	(3)	(4)
	All	CEE: Yes EU: No	CEE: Yes EU: Yes	CEE: No EU: Yes
	LogGDPpc	LogGDPpc	LogGDPpc	LogGDPpc
lag_FDIpGDP	0.007	1.684	0.024	0.013
	(0.015)	(0.976)	(0.187)	(0.013)
lag_intlpEMPL	3.221**	317.742***	46.953**	3.84***
	(-1.144)	(-70.564)	(-17.339)	(-1.246)
lag_CPI	0.005**	-0.006**	0.005	0.004**
	(0.002)	(0.003)	(0.003)	(0.002)
lag_PLF	0.047*	-0.053	0.006	0.301**
	(0.023)	(0.044)	(0.024)	(0.122)
rEMPL	3.743***	2.51***	2.944***	2.593***
	(-1.038)	(0.635)	(-1.007)	(0.83)
TOTL	-0.122***	-0.135***	-0.076***	-0.086***
	(0.027)	(0.014)	(0.019)	(0.023)
dPOP	-0.001	-0.094***	0.021	-0.001
	(0)	(0.023)	(0.012)	(0.001)
tPOP	0***	0	0***	0
	(0)	(0)	(0)	(0)
_cons	8.466***	15.254***	9.78***	8.287***
	(-1.077)	(-1.879)	(-1.245)	(0.821)
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	726	160	140	426
within-R^2	0.489	0.768	0.729	0.454
Pseudo R^2	.z	.z	.z	.z

Notes: Panel regression in a fixed effects model; strongly balanced panel; Driscoll and Kraay standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Dependent variable is the logarithm of the gross domestic product per capita (LogGDPpc). Including 1-year lag for the innovation and institutional (explanatory) variables: lag_FDIpGDP = Inward FDI financial flows as a percentage of GDP; lag_intlpEMPL = Patents and trademarks in relation to the number of persons employed; lag_CPI = Corruption Perceptions Index; lag_PLF = Scores for political liberties (PLF). Further control variables: rEMPL = Employment to population ratio, 15+, total (%); TOTL = Manufacturing sector (percentage, ISIC divisions 05-43); dPOP = Population density (people per square kilometre of land area); tPOP = Total (national) population.

Source: Authors' calculations.

1 EUR-Lex with EuroVoc (5892) definition.

derscore the critical role of innovation activity in fostering economic growth. This is also reflected in our result, specifically in the significance of *lag_intlpEMPL* variable across all model specifications. Thus, despite the lagging position of CEE countries in developing their technologies (Radošević, 2017), some positive trends may be observed. Nevertheless, here the results need to be taken with caution, considering patent offshoring and FDI-related patenting, especially occurring in CEE countries (Kadlec et al., 2023). Here the negative impact of manufacturing (TOTL variable) should be underlined.

Furthermore, the literature consistently supports the notion that higher levels of the CPI indicate that economies with less corruption have stronger economic performance (Svendsen, 2003). We observe this effect for all countries as well as EU members. This aligns with theoretical expectations as outlined by Svendsen (2003). Surprisingly, for non-EU countries, the negative effect is observed. Some previous research (Christos et al., 2018) failed to identify a significant impact of CPI on GDP for CEE countries. One of the explanations for this may be the limits of the indicator itself and the data sources used in its calculation (Budsaratragoon & Jitmaneeroj, 2020). Corruption hampers economic growth by distorting market incentives and weakening the effectiveness of public institutions. It leads to an inefficient use of resources and reduces investment in essential public goods. In addition, corruption harms innovation by lowering trust in institutions, reducing incentive to invest in research, and shifting resources away from productive and knowledge-driven activities (Gründler & Potrafke, 2019). The *lag_PLF* coefficient seems insignificant for CEE countries but positive when considering all countries or non-CEE countries, which may be explained by different levels of variation of this indicator for different country groups (Ahmed & Ahmad, 2020).

The panel model results do not indicate the impact of FDI as a percentage of GDP on the change of GDP per capita. This finding contributes to the ongoing discourse, given that Nistor (2014) previously identified a positive association between FDI inflows and GDP growth in CEE economies. Here Lefilleur and Maurel (2010) suggest that the impact of FDI investments can vary inside CEE countries. Enhanced market access in Central Europe can significantly boost FDI spending in CEE countries, specifically in some regions. Thus, a more detailed level of analysis, e.g. including NUTS2 regions, may be needed to obtain the significance in this case. Otherwise, these results can also be interpreted within the broader context of economic convergence between the selected regions.

Conclusion

The literature suggests that the enlargement reduced the gap and helped to integrate the CEE countries within the supply chains and market activities (Pasimeni, 2024). However, CEE countries continue to exhibit lower economic performance levels compared to western European countries. The reasons for this gap may stem from deficiencies in the innovation systems (Kravtsova & Radošević, 2012; Stojčić, 2021) or institutional frameworks, which are still transforming (Šimić Banović et al., 2018). This paper focuses on the role of innovation and institutional factors in the development of CEE countries (both EU and non-EU members) for the period 2000-2020, revealing the differences in the role of these factors in countries' transformation. When looking at the panel data, innovations show a positive impact on economic growth, suggesting that while CEE countries are still predominantly consumers rather than producers of innovation (Kravtsova & Radošević 2012), positive trends can be observed when looking at their development over 20 years. Conversely to Grela et al. (2017), who view FDI as a factor contributing to catching up, wherein countries with lower GDP experience faster growth, we do not observe such an effect at the national level for our sample. This may indicate a need to perform a more fine-grained analysis at the regional level.

Overall, the findings suggest that elevated levels of institutional and innovation variables play a crucial role in economic development. The research highlights behavioural differences between EU and non-EU countries. Nonetheless, the results also reveal distinctions between different country categories, particularly noticeable between EU and non-EU nations. The findings of this study affirm to policymakers and local stakeholders that prioritising the introduction of high-quality innovations and the development of institutions is crucial for promoting the convergence of CEE countries with Western European counterparts. These factors should also be integrated into EU-level policies, given empirical evidence suggesting that these policies can have a significant impact on the economic development of new EU member states and even candidate countries (Foreman-Peck & Zhou, 2022). In the long run, this could determine whether a state remains under Russian influence or develops independently within a stable institutional framework with access to the European market.

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Persistence in Consumption Across Europe: Evidence Using Fractional Integration

This paper employs fractional integration methods to investigate the degree of persistence in consumption in a group of 33 European countries using data on annual final consumption expenditure of households and non-profit institutions serving households for the period 1960-2021. The results show no evidence of mean reversion in consumption levels over time, as all the series are fractionally integrated. This indicates very high levels of persistence. Special attention should be paid to several southern European countries, which present some of the highest degrees of integration. This suggests that shocks or changes in the consumption levels in these economies, whether positive or negative, tend to have a more enduring impact compared to other parts of Europe.

Understanding the dynamics of consumption behaviour is of paramount importance for policymakers, economists and researchers aiming to unravel the complexities of macroeconomic fluctuations and long-term economic growth. Consumption, as a key component of aggregate demand, not only reflects households' purchasing power but also plays a pivotal role in shaping the overall economic performance of a country or region. Exploring the persistence of consumption patterns becomes crucial in capturing the underlying dynamics and identifying potential drivers of economic fluctuations (Christiano et al., 2018; Sergi, 2020).

This article investigates the persistence of consumption across Europe, a region characterised by diverse socioeconomic conditions, cultural influences and policy frameworks. By employing fractional integration techniques, we aim to shed light on the long-memory properties of consumption behaviour, providing valuable insights into the dynamics of household spending over time.

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To achieve comprehensive coverage and comparative analysis, we examine a vast dataset encompassing 33 European countries. The countries under examination are Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom as well as the European Union as a whole.

This extensive coverage enables us to capture a wide range of economic structures, cultural characteristics and policy environments, providing a rich empirical basis for investigating consumption persistence across the region. We can explore potential variations in consumption behaviour driven by country-specific factors, such as income levels, social preferences and institutional frameworks.

The concept of consumption is intrinsic to human nature. Since the beginning of commerce when goods were exchanged and valued, it has been emblematic of power and quality of life. Nowadays, it is no different. Purchasing power provides a reference in society and the economy, influencing policies (Workie et al., 2020). It is also related to savings: how much, how much more and how long the population can keep its earnings affect many other aspects of the market (Cox et al., 2019). Nationally, it is an important data point, but internationally it is also relevant because commerce and daily life are becoming more and

more global (Provornaya et al., 2020; Tacon, 2020; Xu et al., 2020).

The findings from our research carry significant implications for policymakers, as they provide insights into the durability and responsiveness of consumption patterns across Europe, and the effectiveness of policy interventions aimed at stimulating economic growth, addressing income inequality and fostering sustainable development (Rodrik, 2005; De Haan et al., 2006). Our goal is to understand possible future changes in consumption in Europe and whether there is persistence in the series under investigation.

Fractional integration

The utilisation of fractional integration, a statistical method that extends the traditional notion of stationarity, enables us to capture the inherent persistence embedded within consumption data. Traditional approaches assume that economic variables revert to a constant mean level, implying stationary behaviour. However, fractional integration accounts for the possibility of slowly decaying shocks and allows for more accurate modelling of long-term dependencies, common in economic time series data.

Fractional integration belongs to a broader class of long-memory models, so named because of the strong dependence between observations which are very distant in time. We say that a process is fractionally integrated or integrated of order d, and denoted as I(d), if it can be represented as:

$$(1 - B)^d x(t) = u(t), \qquad t = 0, \pm 1, \ldots, \qquad (1)$$

where B represents the backshift operator, i.e., Bx(t) = x(t-1) and with u(t) displaying a short memory or integrated of order 0 (I(0)) pattern described by:

$$\sum_{u=-\infty}^{u=\infty} | \gamma(u) | < \infty ,$$

where γ(u) refers to the autocovariance function of a stationary process, i.e. γ(u) = E[(x(t) - Ex(t)) (x(t+u) - Ex(t))]. In this context, the differencing parameter, d, becomes crucial since it indicates the degree of persistence or dependence in the data, as the higher its value is, the higher the level of association is between observations far apart in time. Moreover, it allows us to consider a large degree of flexibility in the dynamic specification of the model, including the specification of the following processes:

- anti-persistence, if d < 0
- short memory or I(0) behaviour, if d = 0
- covariance stationary long memory and mean reversion, if 0 < d < 0.5
- non stationarity though mean reverting processes, if 0.5 ≤ d < 1
- unit roots or I(1) processes, if d = 1
- I(d) processes, with d > 1.

Note that based on this specification in (1), if d < 1, it implies mean reversion while d ≥ 1 implies the lack of it. To see this, note that the polynomial on the left-hand side in Equation (1) can be expressed for any real value d in its Mc Laurin's form:

$$(1 - B)^d = \sum_{j=0}^{\infty} \binom{d}{j} (-1)^j B^j = 1 - dB + \frac{d(d-1)}{2} B^2 - \ldots,$$

and then, x(t) can be expressed in terms of both infinite autoregressive and moving average processes, in the latter case with the coefficients decaying hyperbolically to zero.

In the empirical application, the estimation is conducted via the Whittle function in the frequency domain, using a testing procedure developed by Robinson (1994) and widely used in empirical applications of the present model.

Data

The data used in this analysis refer to the final consumption expenditure of households and non-profit institutions serving households (NPISH), measured in current US dollars, sourced from the World Bank (2022). Households refer to groups of individuals living together and sharing a common residence, typically undertaking various economic and social activities as a collective unit. In the context of economics and demographics, households are fundamental units of analysis to understand consumption, savings, labour supply and other socio-economic behaviours.

Understanding households and their characteristics, such as income levels, expenditure patterns, demographic composition and socio-economic status, is important for policymakers, researchers and businesses in various fields, including economics, sociology, marketing and public policy.

NPISHs are entities that provide goods or services to households or communities. They are distinct from government organisations and for-profit businesses. Exam-

ples of NPISHs include non-governmental organisations (NGOs), charities, foundations, religious institutions, community centres and volunteer organisations. NPISHs play an important role in addressing social needs, promoting welfare and supporting community development.

Final consumption expenditure refers to the total spending by households on goods and services for their own use, encompassing various categories such as food, housing, transportation, healthcare, education and recreation. The expenditure is measured in US dollars and represents the value at current prices, meaning it is not adjusted for inflation or changes in purchasing power over time. The data provides an overview of household consumption patterns and expenditure trends across European Union countries, allowing for analysis of changes in consumer behaviour, economic growth and the overall well-being of households over the specified time period. The timeframe of the data collected stretches from 1960 to 2021. Some countries do not have data going back as far as 1960 and this is detailed in Table 1.

Results for consumption in Europe

The model examined is the following one:

$$\gamma_t = \beta_0 + \beta_1 t + x_t, \qquad (1 - L)^d x_t = u_t, \qquad t = 1, 2, \ldots$$

where γ_t refers to the observed time series; β_0 and β_1 are the coefficients corresponding respectively to the intercept and a linear time trend, and x_t is supposed to be I(d), where d is another parameter that is also estimated from the data; finally, u_t is a white noise process.

Table 2 shows the values of the differencing parameter, d, and their 95% confidence bands under the three classical assumptions in the unit root literature of: i) no deterministic terms, ii) an intercept and iii) an intercept with a linear time trend, with the selected model for each series presented in bold in the table. Table 3 reports the estimated coefficients for the selected specification for each series. The first thing we observe in this table is that the time trend is required in the majority of the cases. In fact, there are only five countries where the time trend coefficient is found to be statistically insignificant. These are Croatia, Greece, Hungary, Romania, Russia and Latvia. Focussing on the trend coefficient for the rest of the countries, the highest values are obtained for Spain (0.0394), followed by Cyprus (0.0365), Luxembourg (0.0365) and Portugal (0.0354).

All of the estimated values of d are high, implying high levels of persistence. In fact, all countries can be grouped into two categories: those where the unit root null hypothesis cannot be rejected (18) and those where this hypothesis is rejected in favour of d > 1 (16). Within the first group, there are four countries where the orders of integration are smaller than 1 (Serbia, 0.60; Bulgaria, 0.88; Slovenia, 0.93; Poland, 0.96); however, in the four countries the unit root null cannot be rejected. The same evidence of d = 1 is found in Czechia (1.05), Malta (1.11), Cyprus (1.14), Island (1.16), Lithuania (1.17), Romania (1.20), Russia (1.21), Hun-

Table 1
Descriptive statistics

Series	Start date	Max.	Min.	Mean	Std. dev.
Austria	1970	11.379	9.929	10.934	0.405
Belgium	1970	11.463	10.135	11.030	0.364
Bulgaria	1980	10.690	9.772	10.208	0.288
Croatia	1995	10.630	10.133	10.422	0.169
Cyprus	1975	10.269	8.600	9.699	0.493
Czechia	1990	11.107	10.151	10.751	0.297
Denmark	1966	11.259	9.840	10.760	0.423
Estonia	1993	10.253	9.369	9.857	0.305
Finland	1970	11.181	9.791	10.729	0.392
France	1960	12.203	10.552	11.625	0.519
Germany	1970	12.322	11.079	11.955	0.347
Greece	1960	11.380	9.506	10.634	0.568
Hungary	1991	10.944	10.281	10.674	0.226
Iceland	1970	10.121	8.500	9.563	0.425
Ireland	1970	11.125	9.486	10.511	0.491
Italy	1970	12.156	10.825	11.725	0.389
Latvia	1995	10.357	9.579	10.048	0.274
Lithuania	1995	10.588	9.701	10.235	0.292
Luxembourg	1970	10.413	8.837	9.828	0.449
Malta	1970	9.870	8.299	9.257	0.470
Netherlands	1969	11.638	10.260	11.197	0.388
Norway	1970	11.322	9.824	10.792	0.420
Poland	1995	11.583	10.926	11.320	0.218
Portugal	1970	11.242	9.727	10.72	0.445
Romania	1990	11.248	10.198	10.769	0.359
Russia	1988	12.086	11.021	11.593	0.330
Serbia	1995	10.619	9.721	10.367	0.223
Slovakia	1990	10.824	9.848	10.449	0.321
Slovenia	1990	10.499	9.851	10.242	0.209
Spain	1970	11.972	10.419	11.456	0.435
Sweden	1960	11.446	9.946	10.887	0.460
Switzerland	1970	11.602	10.133	11.127	0.398
UK	1960	12.297	10.735	11.680	0.533
EU	1970	12.952	11.612	12.524	0.381

Source: Authors' elaboration.

Table 2
Estimates of d under three different scenarios, logged series

Series	No terms	With an intercept	With a time trend
Austria	0.94 (0.76, 1.19)	1.33 (1.09, 1.66)	1.25 (1.07, 1.53)
Belgium	0.94 (0.76, 1.19)	1.40 (1.12, 1.80)	1.32 (1.09, 1.68)
Bulgaria	0.90 (0.70, 1.20)	0.90 (0.76, 1.13)	0.88 (0.71, 1.13)
Croatia	0.85 (0.56, 1.25)	1.30 (0.97, 1.86)	1.28 (0.98, 1.83)
Cyprus	0.93 (0.72, 1.20)	1.19 (0.93, 1.50)	1.14 (0.97, 1.40)
Czechia	0.86 (0.60, 1.22)	1.09 (0.84, 1.62)	1.05 (0.76, 1.72)
Denmark	0.94 (0.77, 1.18)	1.31 (1.08, 1.65)	1.26 (1.06, 1.59)
Estonia	0.86 (0.56, 1.24)	1.29 (0.93, 1.91)	1.25 (0.93, 1.87)
Finland	0.93 (0.76, 1.19)	1.37 (1.09, 1.82)	1.29 (1.06, 1.71)
France	0.94 (0.78, 1.17)	1.29 (1.09, 1.58)	1.24 (1.07, 1.51)
Germany	0.94 (0.76, 1.19)	1.32 (1.07, 1.67)	1.25 (1.05, 1.56)
Greece	0.94 (0.77, 1.17)	1.48 (1.28, 1.80)	1.43 (1.23, 1.75)
Hungary	0.88 (0.62, 1.24)	1.25 (0.90, 1.79)	1.23 (0.94, 1.72)
Iceland	0.95 (0.77, 1.20)	1.21 (0.84, 1.68)	1.16 (0.94, 1.56)
Ireland	0.93 (0.75, 1.19)	1.33 (1.04, 1.75)	1.25 (1.03, 1.62)
Italy	0.92 (0.75, 1.19)	1.24 (1.02, 1.61)	1.19 (1.02, 1.48)
Latvia	0.85 (0.55, 1.25)	1.35 (0.95, 2.07)	1.29 (0.96, 2.00)
Lithuania	0.85 (0.56, 1.25)	1.22 (0.83, 1.79)	1.17 (0.92, 1.66)
Luxembourg	0.94 (0.76, 1.19)	1.38 (1.06, 1.81)	1.29 (1.05, 1.68)
Malta	0.93 (0.75, 1.19)	1.17 (0.84, 1.51)	1.11 (0.93, 1.39)
Netherlands	0.94 (0.76, 1.19)	1.33 (1.09, 1.68)	1.26 (1.07, 1.58)
Norway	0.94 (0.76, 1.18)	1.35 (1.09, 1.76)	1.25 (1.07, 1.57)
Poland	0.86 (0.56, 1.25)	0.93 (0.68, 1.36)	0.96 (0.74, 1.30)
Portugal	0.94 (0.76, 1.19)	1.39 (1.12, 1.78)	1.31 (1.09, 1.67)
Romania	0.86 (0.60, 1.21)	1.20 (0.92, 1.68)	1.20 (0.84, 1.78)
Russia	0.87 (0.62, 1.21)	1.21 (0.98, 1.58)	1.21 (0.98, 1.58)
Serbia	0.86 (0.56, 1.26)	0.65 (0.46, 1.04)	0.60 (0.29, 1.04)
Slovakia	0.88 (0.62, 1.23)	1.38 (1.08, 1.34)	1.31 (1.06, 1.77)
Slovenia	0.87 (0.62, 1.22)	0.97 (0.72, 1.50)	0.93 (0.61, 1.53)
Spain	0.94 (0.76, 1.19)	1.45 (1.18, 1.87)	1.37 (1.14, 1.75)
Sweden	0.94 (0.75, 1.18)	1.27 (1.02, 1.67)	1.23 (1.02, 1.61)
Switzerland	0.94 (0.74, 1.19)	1.28 (1.03, 1.62)	1.21 (1.03, 1.58)
UK	0.94 (0.77, 1.17)	1.29 (1.05, 1.72)	1.25 (1.04, 1.66)
EU	0.93 (0.76, 1.19)	1.33 (1.07, 1.70)	1.26 (1.05, 1.58)

Notes: The values in parenthesis are the 95% confidence intervals and those marked in green refer to the selected specification for each country.

Source: Authors' elaboration.

Table 3
Estimated coefficients for the selected specifications in Table 2

Series	d	Intercept (tvalue)	Time trend (tvalue)
Austria	1.25 (1.07, 1.53)	9.879 (234.15)	0.0333 (2.32)
Belgium	1.32 (1.09, 1.68)	10.089 (240.27)	0.0335 (1.84)
Bulgaria	0.88 (0.71, 1.13)	10.008 (124.64)	0.0162 (1.92)
Croatia	1.30 (0.97, 1.86)	10.168 (255.40)	---
Cyprus	1.14 (0.97, 1.40)	8.554 (161.33)	0.0365 (288)
Czechia	1.05 (0.76, 1.72)	10.283 (184.11)	0.0240 (2.05)
Denmark	1.26 (1.06, 1.59)	9.808 (244.25)	0.0278 (2.00)
Estonia	1.25 (0.93, 1.87)	9.341 (217.06)	0.0307 (1.80)
Finland	1.29 (1.06, 1.71)	9.741 (228.53)	0.0321 (1.92)
France	1.24 (1.07, 1.51)	10.518 (269.96)	0.0281 (2.30)
Germany	1.25 (1.05, 1.56)	11.034 (261.86)	0.0290 (2.02)
Greece	1.48 (1.28, 1.80)	9.428 (277.79)	---
Hungary	1.25 (0.90, 1.79)	10.263 (252.60)	---
Iceland	1.16 (0.94, 1.56)	8.448 (140.31)	0.0347 (2.33)
Ireland	1.25 (1.03, 1.62)	9.442 (228.12)	0.0338 (2.40)
Italy	1.19 (1.02, 1.48)	10.789 (243.14)	0.0264 (2.16)
Latvia	1.35 (0.95, 2.07)	9.564 (206.85)	---
Lithuania	1.17 (0.92, 1.66)	9.664 (212.54)	0.0346 (2.40)
Luxembourg	1.29 (1.05, 1.68)	8.790 (216.45)	0.0359 (2.26)
Malta	1.11 (0.93, 1.39)	8.266 (232.15)	0.0310 (4.23)
Netherlands	1.26 (1.07, 1.58)	10.219 (242.53)	0.0306 (2.07)
Norway	1.25 (1.07, 1.57)	9.779 (257.77)	0.0323 (2.50)
Poland	0.96 (0.74, 1.30)	10.902 (259.79)	0.0252 (3.50)
Portugal	1.31 (1.09, 1.67)	9.676 (224.52)	0.0354 (1.96)
Romania	1.20 (0.84, 1.78)	10.432 (158.23)	---
Russia	1.21 (0.98, 1.58)	11.500 (137.23)	---
Serbia	0.60 (0.29, 1.04)	10.073 (96.89)	0.0203 (2.58)
Slovakia	1.31 (1.06, 1.77)	9.814 (269.92)	0.0325 (1.93)
Slovenia	0.93 (0.61, 1.53)	9.952 (186.04)	0.0173 (2.25)
Spain	1.37 (1.14, 1.75)	10.366 (226.64)	0.0394 (1.69)
Sweden	1.23 (1.02, 1.61)	9.917 (249.17)	0.0256 (2.11)
Switzerland	1.21 (1.03, 1.58)	10.085 (217.85)	0.0323 (2.58)
UK	1.25 (1.04, 1.66)	10.709 (283.34)	0.0247 (2.01)
EU	1.26 (1.05, 1.58)	11.569 (281.43)	0.0304 (2.10)

Notes: The values in parenthesis in column 2 are the 95% confidence bands for d; those in columns 3 and 4 are the t-values of the estimated coefficients.

Source: Authors' elaboration.

gary (1.25), Estonia (1.25), Croatia (1.30) and Latvia (1.35). In the rest of the cases, d is significatively higher than 1, and the highest values of d correspond to Portugal (1.31), Belgium (1.32), and particularly, Spain (1.37) and Greece (1.48).

Conclusions and policy recommendations

This paper examines the degree of persistence in consumption expenditure in 33 European countries using fractional integration methods. The results indicate very

high levels of persistence with no evidence of mean reversion in any single case since the series are all I(1) or I(d), with d > 1. Consequently, the general conclusion is that there is no mean reversion in the series of consumption and shocks are expected to be permanent. In the event of a negative shock such as an abrupt reduction in consumption, strong measures must be adopted by the authorities to recover the original trends. Moreover, special attention should be paid to some southern European countries such as Greece, Portugal and Spain, which present some of the highest degrees of integration. This suggests that shocks or changes in the consumption levels in these economies, whether positive or negative, tend to have a more enduring and long-lasting impact compared to other parts of Europe. The higher persistence in southern European consumption patterns stems from various factors that set them apart from other countries, including: political processes (Gough, 1996); socio-demographic characteristics, dominant values about private life and the way in which laws are produced (Martin, 1996); the vulnerable position of young people in the labour market (Madsen et al., 2013); the widening North-South gap within Europe, stemming from the euro area crisis, which began in 2010 (Matthijs, 2014); the underdevelopment of child and family policy (Jurado-Guerrero & Naldini, 2018); and even vulnerabilities in water security and the corresponding strong impact on strategic parts of these Mediterranean economies (Ludwig et al., 2011).

In the case of an adverse shock that leads to a sudden decrease in consumption, authorities should implement robust measures to restore the initial patterns or trends (Maćkowiak, 2006). The reasons for a decrease in consumption can be very diverse. We propose consideration of the following general suggestions and policy implications to improve consumption.

Revision of tax for essential products

This can involve reducing or eliminating VAT on essential goods and services, such as food (water, rice, milk, meat and vegetables), health (medicines and cleaning products), clothes (basic ones according to the climate), dwelling (electricity, water and gas), education, communication and transport. By lowering the tax burden on these essential items, households can have increased purchasing power and affordability, which would stimulate consumption (Dallongeville et al., 2011; Lyssiotou & Savva, 2021).

Also, implementing expansionary fiscal policies, such as tax rebates and lowering direct taxes can boost disposable income and encourage consumer spending (Kaplan & Violante, 2014; Stoilova & Todorov, 2021).

Several authors have analysed the opposite effect – how an increase in taxes leads to a decrease in consumption (Alm & El-Ganainy, 2013; Buettner & Madzharova, 2021; Colchero et al., 2017). Undoubtedly, taxes have an impact on the final consumer price, which in turn affects household spending and, consequently, corporate profits.

On the other hand, meeting the basic needs of the first two levels (out of five) of Maslow's hierarchy of needs: basic and safety needs is crucial. In European countries with a certain level of development, this should not pose a significant challenge. Thus, it becomes possible to foster consumerism that extends to fulfilling the higher levels of the pyramid (Ganassali & Matysiewicz, 2021; Wikansari et al., 2023).

Employment measures to increase hiring

The previous subsection is directly related to this one, since taxes should be in line with the purchasing power of the population, which is closely linked to their salary and savings capacity. Employment measures are an effective policy approach to boost consumption and stimulate economic growth. To enhance disposable income, policies that focus on improving wages, reducing unemployment rates and promoting job creation can increase household income, leading to higher consumption levels (Banker et al., 2013; Yasar, 2017). Also, it is beneficial for companies to foster a favourable business environment. Policies that support entrepreneurship, innovation and a favourable business environment can lead to economic growth, job creation and increased consumer spending (Wüstenhagen et al., 2008). Another way to improve income is facilitating access to credit for households that can stimulate consumption by enabling them to make larger purchases and investments (Kus, 2013).

A reference point is the national minimum wage. According to the 2024 data (Expansión, 2025), the following groups are found:[1]

Less than 1,000€: Russia (€194), Bulgaria (€477), Serbia (€544), Hungary (€686), Latvia (€700), Romania (€743), Slovakia (€750), Czechia (€765), Estonia (€820), Croatia (€840), Lithuania (€924), Malta (€925), Portugal (€957) and Greece (€968).

Between €1,000 and €2,000: Cyprus (€1,000), Poland (€1,008), Slovenia (€1,254), Spain (€1,323) and France (€1,767).

1 Austria, Denmark, Finland, Italy, Norway and Sweden have no data.

More than €2,000: Germany (€2,054), Belgium (€2,070), the Netherlands (€2,134), Ireland (€2,146), the UK (€2,231), Luxembourg (€2,571), Iceland (€2.830) and Switzerland (€4,549).

Not all countries have the same situation and need the same policies. It can be observed that Group A consists mainly of Eastern European countries (except for Portugal), Group B includes a diverse set of countries (predominantly from Western Europe), and Group C comprises Central European countries that include the original founding members of the European Union. Within the policy of improving purchasing power through employment, countries in Group A should take into account the aspects that influence the calculation of the minimum interprofessional wage, such as the consumer price index, average national productivity achieved, an increase in the share of labour in national income and the general economic situation.

Infrastructure investment

Investing in infrastructure projects can have a positive impact on consumption by creating jobs, improving transportation networks and enhancing overall economic activity (Ramey, 2020; Yan et al., 2024). Infrastructure support is not only a fundamental component of a country's development but also an integral part of the consumption chain, as it facilitates the distribution of goods (Skender et al., 2019).

Considering that the European Union and the Schengen Area constitute a free movement zone for goods and people, infrastructure development among countries fosters overall economic growth (Butkus et al., 2023), which in turn impacts consumption. Collaborative efforts are essential for the development and improvement of all nations.

All the above suggestions are simply recommendations in the event of an exogenous shock based on the high degree of persistence shown in the series across all countries, especially Greece, Portugal and Spain. To our knowledge, there is no other analysis of our topic using this specific methodology. This makes our study on the persistence of consumption behaviour in Europe, using fractional integration techniques, a potentially valuable contribution to this field.

For future analysis, various topics can be proposed. For example, various events have impacted the European economy, with some, particularly in southern European countries, having a deeper and more negative effect. Further research and analysis are needed to understand the underlying causes and mechanisms behind the observed persistence and its association with southern European countries.

From a methodological viewpoint, the analysis can be extended to a longer time series, which will reduce the width of the intervals, producing therefore more precise estimates of the order of integration of the series of interest. In addition, there are several issues that may deserve further attention, including, for instance, the presence of non-linearities/breaks or even outliers in the data that may have biased the results reported in this paper. Work in this direction is now in progress.

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Spatial Disparities in Economic Structural Change in Central and Eastern Europe During Integration

Understanding the structural change in catching-up regions and the spatial distribution of economic sectors is essential for designing comprehensive policy strategies to promote balanced economic development. This study examines the economic restructuring of the 11 central and eastern European EU member states as they catch up with the more developed EU14. The study applies productivity metrics and the Theil index to assess geographical concentrations and explore spatial patterns of centre-(semi)periphery features. The results reveal significant structural changes in central and eastern European economies, with variations across different region types. The diversity of economic sectors in central and eastern European countries differs markedly from that in the EU14, influenced by market- and policy-related factors. Addressing these inequalities requires targeted efforts to mitigate territorial disparities in the age of twin transition challenges and geopolitical conflicts.

Studying economic structural changes, especially in regions striving to catch up, distinguishing their development trajectories and characterising sectoral spatial concentrations is key to developing comprehensive strategies that promote balanced economic growth. This process involves understanding development trajectories and sectoral spatial concentrations. Todaro and Smith (2020) offer valuable insights, highlighting four paradigms of economic development: the linear-stages-of-growth model, structural change theories, the international dependence revolution and the neoclassical, free-market counter-revolution. These paradigms emphasise the importance of transforming economic structures, particularly shifting resources from low-productivity to high-productivity sectors (McMillan et al., 2017). This aligns with the European Union's regional policy, which aims to reduce economic disparities, enhance effective structural changes and foster convergence regions (Alcidi, 2019; Chakraborty & Mandel, 2024).

Analysing central and eastern European countries is crucial for understanding their economic restructuring and development trajectories, which can inform EU regional policies aimed at reducing disparities and promoting spatial inclusive growth. Following the market liberalisation (after 1990) and EU accession (2004, 2007, 2013), these countries have been modernising and integrating their economies, with foreign direct investment (FDI) playing a key role (Capello & Perucca, 2015; Lengyel et al., 2017). Additionally, substantial European funding, including allocations from the Cohesion Fund, has been directed towards the region with clearly defined goals and practices (Gorzelak, 2021).

The economic integration brought significant structural changes, though the impacts were uneven across regions due to factors such as proximity to western Europe, industrialisation patterns, urbanisation, and local cultural and creative assets. Urban-rural polarisation has also emerged as a key issue in recent years, prompting further analysis of urbanisation at the European level (Annoni et al., 2019; Bodnár, 2021). Moreover, during the period of

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regional convergence after 2010, one of the key elements was the issue of reindustrialisation in more rural areas, alongside the concentration of the service sector in metropolitan regions (Vas et al., 2024).

Reindustrialisation, discussed in literature since the 1990s (Cristopherson et al., 2014), gained importance in EU policies after the 2008 crisis (European Commission, 2021). Nonetheless, factors like globalisation, modernisation, technological changes, economies of scale, supply chain expansion, increasing importance of services, etc. also contributed to deindustrialisation (Cristopherson et al., 2014; Wolman et al., 2015). In the European Union, calls for economic transformation focused on industrial transition or reindustrialisation (Cimoli et al., 2015; Landesman, 2015). These efforts are supported by policy frameworks such as "An Integrated Industrial Policy for the Globalisation Era" (COM (2010) 0614) and the "European Industrial Renaissance" (COM (2014) 14 final), the latter aiming to increase the share of manufacturing from 15% to 20%. Alongside the industrial transition, regions have also adopted smart specialisation strategies (European Commission, 2021).

Central and eastern European countries have prioritised reindustrialisation by encouraging foreign investments, offering incentives and fostering favourable institutional conditions (Nagy et al., 2021). This reindustrialisation coincides with Industry 4.0 and reflects a division between the EU's advanced western regions and less developed central and eastern ones, where activities with low added value dominate (Kiss & Páger, 2023). These regions must focus on transitioning to knowledge-based economies, enhancing productivity and business sophistication (Dobrzański et al., 2024).

Currently, the European Union faces many significant challenges in economic competitiveness in the age of the twin transition and geopolitical conflicts (Draghi, 2024; European Commission, 2024). However, if the change is not appropriately managed by the European Union's cohesion policy, a "regional development trap" may emerge, hindering Europe's economic dynamism (Diemer et al., 2022). Additionally, it is crucial to analyse spatial disparities, as spatial inequalities can lead to serious political consequences (Rodríguez-Pose, 2018; Dobrzanski et al., 2024; Wolf, 2024).

Our research examines the structural changes in the NUTS3 regions of 11 central and eastern EU member states (CEE11): Bulgaria, Czechia, Estonia, Croatia, Poland, Latvia, Lithuania, Hungary, Romania, Slovakia and Slovenia, to understand their development trajectories and explore the spatial concentration of industries. We address three key questions: How did economic restructuring and productivity growth in CEE11 NUTS3 regions compare to the EU14 from 2010 to 2020? Are CEE11 regions converging with EU14 regions in terms of productivity? Which regions had the highest concentration of the key manufacturing and business service sectors between 2010 and 2020?

The article first outlines the methodology, including the distinction between urban and rural spaces. It then presents the results using descriptive statistics and Theil indices based on location quotients. Finally, the study concludes with a summary and policy recommendations.

Delimitation, data and methodology

In our study, we analyse the catching-up of the CEE11 countries' 239 NUTS3 regions with the EU14, focusing on their economic restructuring between 2010 and 2020. Due to regional boundary changes in some countries, comparable data on gross value added (GVA) and employment at the NUTS3 level is only available from 2010. We use annual data from seven sector groups for each region based on EU typologies. For comparison, we evaluate the economic structure of the 898 NUTS3 regions in the EU14.

In the EU, comparative regional studies typically focus on NUTS2 regions, with statistical offices primarily providing data at this level (Dauderstädt, 2021; Chakraborty & Mandel, 2024). However, spatial peculiarities have shown more detailed trends at the NUTS3 level. Eurostat has categorised the NUTS3 regions based on 1 km^2 cells and refined them with urban cluster data (cells neighbouring each other), balancing statistical reporting and spatial concentration. Eurostat (2018, p. 74) defines three types for regions corresponding to NUTS3 regions:

- Predominantly urban region (URB): NUTS level 3 regions where more than 80% of the population live in urban clusters;
- Intermediate region (INT): NUTS level 3 regions where more than 50% and up to 80% of the population live in urban clusters;
- Predominantly rural region (RUR): NUTS level 3 regions where at least 50% of the population live in rural grid cells.

Another typology has been developed for NUTS3 regions using the results of grid cells and the delineation of functional urban areas (Eurostat, 2018, p. 83):

- Metropolitan region (INT-M): a single NUTS level 3 region or an aggregation of NUTS level 3 regions in which 50% or more of the population live in a functional urban area that is composed of at least 250,000 inhabitants;

Table 1
Number and population of NUTS3 regions by type in EU14 and CEE11

	EU14			CEE11		
	Number of regions	Population, million people		Number of regions	Population, million people	
Type	2020	2000	2020	2020	2000	2020
CAP	14	27.4	32.1	11	11.9	12.0
URB	192	112.7	123.5	16	9.8	9.9
INT-M	164	56.2	61.6	37	23.7	23.4
INT-N	231	59.3	61.6	66	24.5	22.1
RUR	297	56.1	57.0	109	38.5	35.2
Total	898	311.8	335.8	239	108.5	102.6

Notes: CAP: capital city; URB: predominantly urban region; INT-M: intermediate-metropolitan region; INT-N: intermediate-nonmetropolitan region; RUR: predominantly rural region.

Source: Authors' own calculation based on Eurostat.

Table 2
Analysed sectors and sector groups

Code	NACE activities
A	Agriculture, forestry and fishing
B-D-E	Industry (except manufacturing and construction)
C	Manufacturing
F	Construction
G-H-I-J	Wholesale and retail trade; transport; accommodation and food service activities; information and communication
K-L-M-N	Financial and insurance activities; real estate activities; professional, scientific and technical activities; administrative and support service activities
O-P-Q-R-S-T	Public administration and defence; compulsory social security; education; human health and social work activities; arts, entertainment and recreation, repair of household goods and other services

Source: Authors' own construction based on Eurostat.

- Nonmetropolitan region (INT-N): NUTS level 3 regions that are not metropolitan.

In our study, we combine both typologies to create a hybrid approach. The data is sourced from Eurostat (2018, pp. 116–126).

The regional composition differs between the two country groups, partly due to differences in settlement structures (Table 1). In the CEE11, the population declined from 108.5 million in 2000 to 102.6 million in 2020, driven by emigration and lower birth rates. While population changes in capitals, predominantly urban regions and intermediate-metropolitan regions were minimal, intermediate-nonmetropolitan and rural regions saw significant declines. In contrast, the population of the EU14 grew from 311.8 million in 2000 to 335.8 million in 2020, partly due to immigration from eastern Europe. Thus, the two groups experienced opposite demographic trends. Population distribution is similar for capitals, intermediate-metropolitan and intermediate-nonmetropolitan regions in both groups, but differences are evident in urban and rural regions. In the EU14, 37% live in urban and 17% in rural regions, whereas in the CEE11, only 10% live in urban and 34% in rural regions.

We use seven sector groups from the Eurostat database to analyse the economic structure of region types, with data available for each NUTS3 unit (Table 2). Eurostat provides annual data on employed persons and GVA at current prices for these sectors based on the ESA2010 classification.

Various methodologies measure the spatial concentration of economic activities, typically distinguishing between absolute and relative perspectives (McCann, 2013). In this study, we adopt the framework and methodology of Thissen et al. (2013) to examine the smart specialisation of EU regions. Spatial concentration occurs when companies in a sector cluster in specific areas, deviating from the overall distribution of the economy, while spatial dispersion refers to the opposite.

Thissen et al. (2013) used the normalised Theil index to measure the spatial concentration of industries. Based on entropy, the Theil index reflects the orderliness of the phenomenon, acting as a reversed entropy indicator. To calculate Theil indices for spatial concentration, location quotients (LQs) based on employee numbers and GVA are used:

$$LQ_{ij} = \frac{e_{ij} / \sum_i e_{ij}}{\sum_j e_{ij} / \sum_{ij} e_{ij}} = \frac{s_{ij}}{x_i} = \frac{e_{ij} / E_{.j}}{E_{i.} / E_{..}}$$

where

e_{ij} denotes the number of employees or value of GVA in region i and sector j; $E_{.j} = \sum_i e_{ij}$ is the number of employees or value of GVA in sector j of the aggregated territory (EU14 or CEE11); $E_{i.} = \sum_j e_{ij}$ is the number of employees or value of GVA in region i; $E_{..} = \sum_{ij} e_{ij}$ is the number of employees or value of GVA of the whole aggregated territory (EU14 or CEE11); s_{ij} is the share of region i within the number of employees or value of GVA in sector j of the aggregated territory (EU14 or CEE11); x_i is the share of region i within the number of employees or value of GVA of the aggregated territory (EU14 or CEE11).

Based on the calculated LQ values for each year between 2010 and 2020 and each sector or sector group (j=1, …, 7), a spatial concentration index was computed using the nor-

malised[1] Theil index applied to LQ values (Thissen et al., 2013, pp. 63-64; Lengyel et al., 2017):

$$Conc_j = \left[\frac{1}{I}\frac{1}{\ln(I)}\right]\sum_{i=1}^{I}\left[\left(\frac{LQ_{ij}}{\frac{1}{I}\sum_{i=1}^{I}LQ_{ij}}\right)\cdot ln\left(\frac{LQ_{ij}}{\frac{1}{I}\sum_{i=1}^{I}LQ_{ij}}\right)\right]$$

where I is the number of regions. The values close to 1 for these indices indicate a high spatial concentration of the respective sector, while values close to 0 suggest a more dispersed distribution.

To measure social and regional inequalities, we use the weighted inverse entropy, a reversed entropy indicator that generalises the Theil index, referred to as the generalised Theil index (*GE*).

If we have a specific variable (Y_i) expressed as the ratio of two absolute variables (X_i and F_i), then the inequality in the specific variable can be expressed using the generalised Theil index (*GE*) as follows (Frenken, 2007):

$$GE = \sum_{i=1}^{N} x_i log \frac{x_i}{f_i},$$

where x_i and f_i are the distribution ratios formed from the absolute variables. The generalised Theil index measures the inequality among the observed units. The closer it is to 0, the greater the order, indicating more balance.

The generalised Theil index is also suitable for providing an answer, through spatial level aggregation, to how much of the inequality comes from inequalities within and between the aggregated spatial units. In other words, the *GE* value can be decomposed into the sum of two values (Frenken, 2007):

$$GE = \sum_{i=1}^{n} x_i \, log \frac{x_i}{f_i} = GE_{within} + GE_{between}$$

$$GE_{within} = \sum_{k=1}^{m} p_k GE_k \qquad GE_{between} = \sum_{k=1}^{m} p_k log \frac{p_k}{q_k}$$

where GE_{within} is the average of the *GE* values of the aggregated spatial units (countries or region groups); $GE_{between}$ is the entropy between the aggregated spatial units (countries or region groups); GE_k the entropy within the aggregated spatial unit *k* (country or region group); p_k and q_k representing the distribution ratios of the absolute variables *X* and *F* for the aggregated spatial units (countries or region groups), respectively.

Characteristics of the economic structure of country groups between 2000 and 2020

We analyse the economic structure and transformation of the CEE11 and their regions using two key indicators: employment and productivity (GVA per employed person). National data on hours worked and GVA since 2000 are used to calculate productivity for country groups. The sectoral distribution of employees serves as an indicator of economic structure and can be partially aligned with the hours worked. Over the past two decades, both country groups have seen similar trends, though with notable differences (Table 3). For example, the agricultural sector in the CEE11 has declined by half but remains more than twice as large as that of the EU14. In manufacturing, the EU14 experienced a decline due to deindustrialisation, which slowed after 2010 with the EU's reindustrialisation efforts, while the CEE11 saw only a slight decrease and still has a larger manufacturing share. Business services increased in both country groups, but in 2020, their share was over 1.5 times higher in the EU14 than in the CEE11. Services related to households, like trade and accommodation (G-H-I-J and O-P-Q-R-S-T) remain high in both regions.

Table 3
Distribution of hours worked across sectors (%)

	EU14			CEE11		
Sectors	2000	2010	2020	2000	2011	2020
A	5.8	4.5	4.1	20.8	13.7	9.9
B-D-E	1.3	1.3	1.3	3.4	3.1	3.0
C	17.3	13.7	13.1	21.0	19.2	19.6
F	8.6	8.3	7.6	6.3	8.3	8.2
G-H-I-J	28.3	28.8	27.6	23.2	26.0	26.8
K-L-M-N	13.1	15.7	17.3	6.7	9.1	10.4
O-P-Q-R-S-T	25.7	27.7	29.0	18.5	20.6	22.1
Total	100	100	100	100	100	100

Notes: See Table 2 for more details about the analysed sectors.

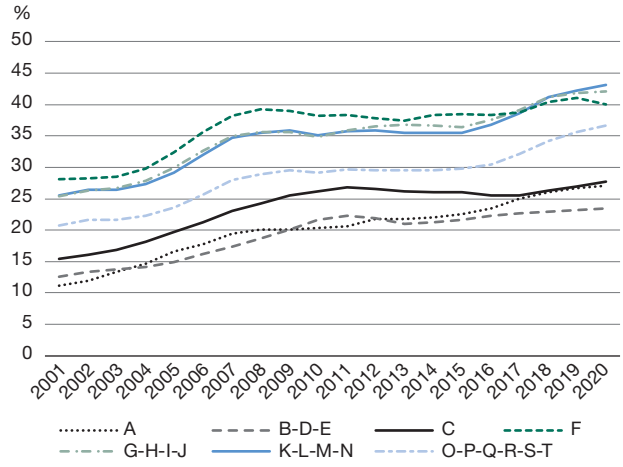
Source: Authors' own calculation based on Eurostat.

In four sectors (B-D-E, F, G-H-I-J, O-P-Q-R-S-T), the share of hours worked is similar in both groups, as they align with population distribution and are non-tradeable, while significant differences exist in agriculture, manufacturing and business services.

Productivity, measured by GVA per hour worked, highlights the role of restructuring in the catching-up process of CEE11. For the CEE11 group, productivity improved in each sector, but notable differences compared to EU14 sectoral productivity are observed (Figure 1). From 2000 to 2008, in CEE11, productivity improved across all sectors at a similar rate. After 2015, changes were minimal until 2016, when trends diverged. Business services saw rapid productivity growth, reaching 43% of EU14 levels by 2020. Similarly, sectors like construction and

1 The maximum value of the Theil-index is ln(*I*). To normalise it onto the interval [0;1], division by ln(*I*) was applied.

Figure 1
Sectoral productivity in CEE11 relative to EU14
Gross value added per hour worked



Notes: The figure shows a three-year moving average, which allows for the filtering out of occasional outliers when showing long-term trends. See Table 2 for more details about the analysed sectors.

Source: Authors' own calculation based on Eurostat.

services (G-H-I-J, O-P-Q-R-S-T) also saw gains. However, manufacturing and agriculture sectors, both major employers, saw slower productivity growth, with manufacturing reaching just 28% of EU14 levels by 2020.

Both key indicators of restructuring – hours worked and productivity – show positive changes in the CEE11 from 2000, with employment increasing in higher-productivity sectors. However, the catching-up process slowed after 2008, only resuming in 2016. Business services and household service sectors saw rapid productivity growth after 2017, reaching 37%-43% of the EU14 average. In contrast, productivity in the manufacturing sector has remained stagnant, fluctuating between 26% and 28% of the EU14 since 2009, indicating a lack of catching-up in this sector.

The changes in the sectoral structure of urban-rural regions

We identified five regional types based on employment and productivity changes. Over a decade, employment grew at a similar rate across all regional types in both groups, with slightly higher growth in capitals. However, by 2020, employment distribution differed significantly: in the EU14, 38% were employed in urban regions and 15.3% in rural, while in the CEE11, 10.4% were employed in urban regions and 30.4% in rural.

Both country groups show changes in the economic structure by region type, with distinct features based on the share of employed persons (Table 4). The shift in labour specialisation within the EU is evident in manufacturing and business services.

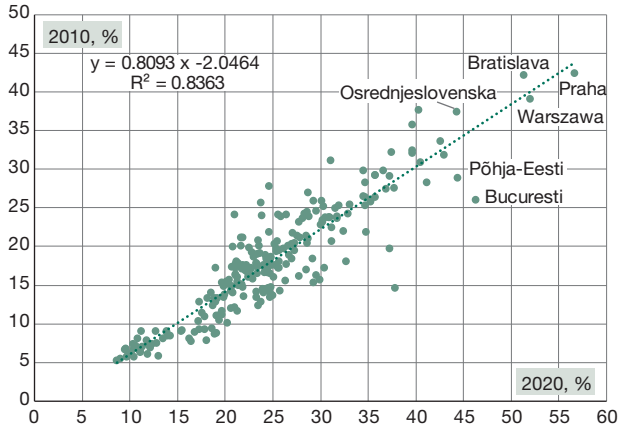
Table 4
Share of employed workers in CEE11 and EU14 (%)

		CAP		URB		INT-M		INT-N		RUR	
		2010	2020	2010	2020	2010	2020	2010	2020	2010	2020
A	CEE11	0.8	0.7	2.2	1.8	14.6	9.7	12.3	9.4	27.2	19.7
	EU14	0.4	0.3	1.7	1.4	2.7	2.4	5.2	4.7	8.2	6.9
B-D-E	CEE11	1.8	1.7	5.6	4.7	2.8	2.7	3.4	3.3	2.8	2.8
	EU14	1.1	1.0	1.2	1.2	1.2	1.2	1.4	1.4	1.3	1.4
C	CEE11	10.0	8.7	18.7	18.4	19.9	20.8	24.4	25.9	19.6	21.5
	EU14	6.0	4.9	13.0	11.9	15.4	14.6	17.3	16.7	16.0	16.0
F	CEE11	7.5	6.8	8.2	6.7	8.4	8.5	7.8	7.5	7.2	8.4
	EU14	5.3	4.9	6.2	5.6	6.9	6.5	7.8	6.8	8.0	7.4
G-H-I-J	CEE11	34.5	34.4	28.8	29.4	25.8	27.5	23.5	23.8	19.2	21.5
	EU14	30.6	30.7	28.9	28.8	26.1	26.0	25.6	25.7	24.1	24.4
K-L-M-N	CEE11	20.0	22.5	12.4	14.0	7.7	8.6	6.7	7.3	5.0	5.6
	EU14	23.3	25.1	18.6	19.9	15.1	16.0	12.4	13.3	10.8	11.8
O-P-Q-R-S-T	CEE11	25.4	25.2	24.1	24.9	20.6	22.1	21.9	22.9	19.1	20.6
	EU14	33.4	33.2	30.4	31.1	32.6	33.2	30.3	31.3	31.6	32.1

Notes: CAP: capitals; URB: predominantly urban regions; INT-M: intermediate-metropolitan regions; INT-N: intermediate-nonmetropolitan regions; RUR: predominantly rural regions. See Table 2 for more details about the analysed sectors.

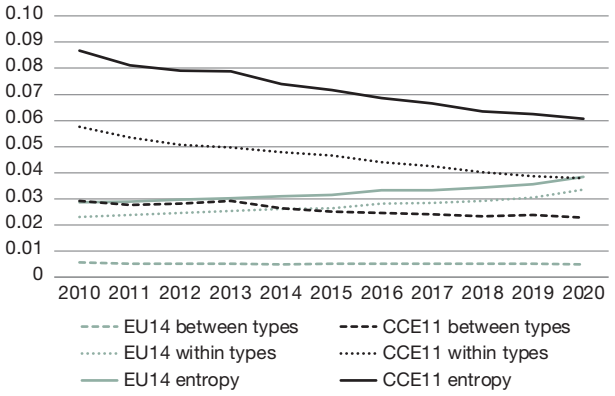
Source: Authors' own calculation based on Eurostat.

Figure 2
Gross value added per employee in the CEE11 compared to the EU14



Source: Authors' own calculation based on Eurostat.

Figure 3
Inequalities of gross value added per employee based on the generalised Theil index



Source: Authors' own calculation based on Eurostat.

Manufacturing has been playing a prominent role in the CEE11, with a decline mainly in capital regions due to deindustrialisation. For urban regions in the CEE11, minimal change indicates stagnation but the employment share remains 1.5 times higher than the EU14 in 2020. In other CEE11 region types, manufacturing employment is about 1.5 times the EU14 average, showing international specialisation within the EU. Meanwhile, the EU14 saw a decline in manufacturing employment across all regions, with rural areas stabilising.

In business services (K-L-M-N), the share of employed persons increased across all regions in both groups. Capitals have significantly higher shares, while urban regions in both groups are similar. However, other CEE11 regions have much lower shares than their EU14 counterparts. In rural CEE11 regions, agriculture still has a high share, though it is steadily declining due to sectoral transformation.

As noted in the theoretical overview, successful structural transformation is marked by rising productivity. In nearly all 239 CEE11 regions, productivity increased from 2010 to 2020, with a strong correlation (R^2=0.8363; Figure 2). Capital regions saw dynamic productivity growth, though they still reached only 55%-70% of the EU14 average in 2020, with the highest ratios in Czechia, Poland, Slovakia, Romania, Slovenia and Estonia.

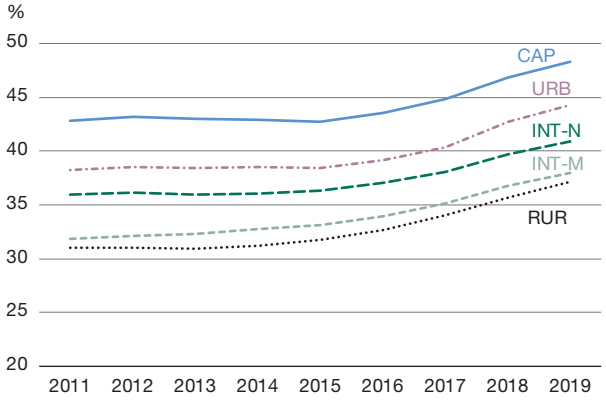
The generalised Theil index reveals different patterns of inequality between regions as well as among and within region types based on the GVA per employed person. Regarding disparities among regions, there were different patterns for the two country groups. In the EU14 (entropy), inequality starts low and gradually increases, while in the CEE11 (entropy), it begins higher and decreases, remaining about 1.5 times higher in 2020 (Figure 3). Inequalities among region types remain stable but are nearly five times higher in the CEE11 than in the EU14. Inequalities within region types in the CEE11 start high and decrease, while in the EU14, they begin lower and increase, reaching similar levels by 2020, indicating comparable dispersion within types for both groups.

Inequalities among region types remain essentially unchanged for both country groups, but in the EU14, they are almost negligible, whereas, in the CEE11, they are nearly five times higher. Inequalities within types of regions in the CEE11 start from a high value and gradually decrease, while in the EU14, inequalities within types of regions start from a much lower value and gradually increase, becoming nearly equal in 2020. Inequalities within types are similar for both country groups, indicating a comparable level of dispersion within types.

Examining the productivity trends of CEE11 regions, it can be observed that the capitals and urban regions surpass the other three region types and gradually approach 45%-50% of the values of EU14 region types from 2016 onwards (Figure 4). The catching-up process of the two intermediate and the rural regions is also noticeable, but they lag behind the urban regions.

The data raises important questions related to our research, such as how regions with improving productivity and employment are distributed across different region types in the EU14 and CEE11. It also prompts an analysis of whether traditional centre-periphery relationships persist and how labour division is evolving between the two groups. A closer look at the spatial concentration of

Figure 4
Productivity gross value added per employee relative to EU14, euro



Notes:CAP: capitals; URB: predominantly urban regions; INT-M: intermediate-metropolitan regions; INT-N: intermediate-nonmetropolitan regions; RUR: predominantly rural regions.

Source: Authors' own calculation based on Eurostat.

Table 5
Distribution of the employed workers in manufacturing and business services

	Manufacturing				Business services			
	CEE11		EU14		CEE11		EU14	
	2010	2020	2010	2020	2010	2020	2010	2020
CAP	8.8	8.1	4.9	4.4	36.3	38.9	16.3	17.1
URB	9.9	9.8	35.3	34.8	13.5	13.8	43.2	43.3
INT-M	22.2	22.7	19.6	20.1	17.9	17.5	16.5	16.4
INT-N	26.3	26.2	22.0	21.8	15.0	13.7	13.4	12.9
RUR	32.9	33.3	18.2	18.8	17.3	16.1	10.6	10.4
Total	100	100	100	100	100	100	100	100

Notes: CAP: capitals; URB: predominantly urban regions; INT-M: intermediate-metropolitan regions; INT-N: intermediate-nonmetropolitan regions; RUR: predominantly rural regions. See Table 2 for more details about the analysed sectors. Business services consist of financial and insurance activities; real estate activities; professional, scientific and technical activities; administrative and support service activities.

Source: Authors' own calculation based on Eurostat.

manufacturing and business services will provide deeper insights into these dynamics.

Spatial concentration of manufacturing and business services

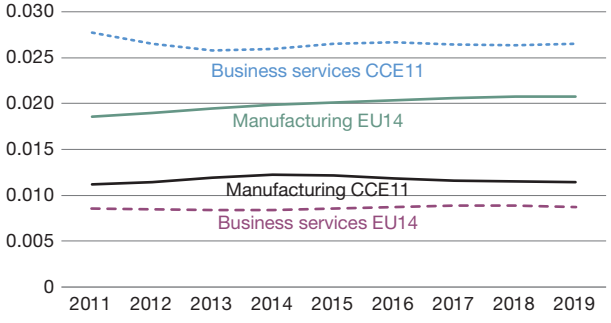
Recent literature highlights the growing importance of agglomeration advantages linked to the spatial concentration of strategic tradeable industries. The spatial concentration of employment and GVA reveals similar trends, with differences tied to productivity levels. From 2010 to 2020, we examine the spatial concentration of manufacturing and business services (Table 5). Significant differences in employment distribution are evident: in the CEE11, manufacturing is concentrated in intermediate and rural regions, while in the EU14, it is focused in urban and both intermediate regions. Business services are concentrated in capital cities in the CEE11 and urban regions in the EU14, with regional population and employment distribution playing a key role in these patterns.

In the CEE11, business services are highly concentrated based on the number of employed persons, while manufacturing is more dispersed. In contrast, the EU14 shows a moderate concentration in manufacturing and a more dispersed distribution of business services (Figure 5). Thus, while the CEE11 sees strong concentration in business services, the EU14 experiences less concentration in manufacturing.

When measured by GVA, the spatial concentration of sectors differs from that based on employment (Figure 6). Manufacturing is highly concentrated in both country groups, especially in the EU14, while business services are more dispersed. This pattern mirrors the employment-based distribution, with manufacturing concentrated and business services dispersed in the EU14.

During the analysed period, diverse regional development paths emerge, reflecting regional characteristics. In the capital regions of CEE11, higher-productivity activities are concentrated, with urbanisation agglomeration advantages likely emerging. Like urban areas in the EU14, deindus-

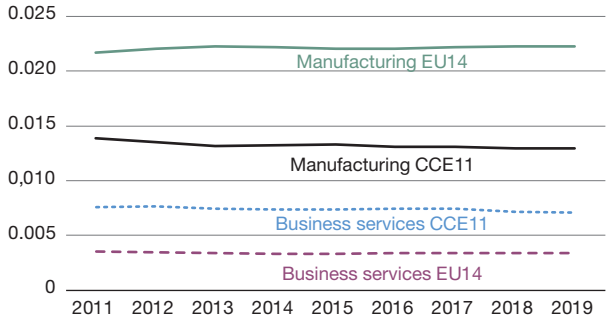
Figure 5
Spatial concentration of key sectors based on the number of employed workers calculated by the Theil index



Notes: A three-year moving average is used. Business services consist of financial and insurance activities; real estate activities; professional, scientific and technical activities; administrative and support service activities.

Source: Authors' own calculation based on Eurostat.

Figure 6
Spatial concentration of key sectors based on gross value added calculated by the Theil index



Notes: A three-year moving average was used. Business services consist of financial and insurance activities; real estate activities; professional, scientific and technical activities; administrative and support service activities.

Source: Authors' own calculation based on Eurostat.

trialisation is occurring, with manufacturing declining and business services strengthening. Outside the capitals in the CEE11, however, manufacturing is growing, indicating reindustrialisation, while similar regions in the EU14 continue deindustrialising. These trends are important for developing regional strategies and understanding regional inequalities and economic dynamics.

Conclusion

The analysis of regional economic processes and inequalities in the CEE11 has long been a key topic in both regional policy and scientific discourse. The current economic and environmental crises further highlight the importance of understanding the development paths of less developed regions. This study explores how the CEE11 countries' catching-up process with the EU14 unfolded, focusing on economic restructuring by sector.

The empirical analysis shows that while economic transformation and modernisation are evident across all CEE11 regions, the pace of change varies. Diverse regional development paths emerged, and the economic structures of CEE11 regions differ from those of the EU14.

The capital and urban regions in both country groups show deindustrialisation, but in CEE11, manufacturing remains slightly higher, and business services are lower than in the EU14. The intermediate metropolitan type of regions in CEE11 have a higher share of manufacturing and a lower share of services compared to the EU14. Intermediate-non-metropolitan regions in CEE11 have a high share of agriculture and manufacturing, while services lag behind the EU14. Rural CEE11 regions are dominated by agriculture and manufacturing, with minimal services.

In the CEE11, reindustrialisation is mainly seen outside the capital regions, unlike in the EU14, where services dominate not only in capitals but also in non-capital areas. A centre-periphery pattern emerges within the CEE11, contrary to the EU14, where high-value services support manufacturing in urban areas, while in the CEE11, low-value industrial activities shift to intermediate and rural regions. Similarly, within the CEE11, higher-productivity services concentrate in capitals, limiting the growth of business services elsewhere, where only low-productivity manufacturing or agriculture, along with local services, remain.

In CEE11 capital regions, higher productivity activities are emerging due to globalisation and urban agglomeration. Outside the capitals, manufacturing is increasing, signalling reindustrialisation, while EU14 regions are experiencing deindustrialisation. However, manufacturing productivity in CEE11 regions remains low at 26%-28% of the EU14 average. Services in these regions are limited, and the role of agriculture is declining, though the sector still employs a third of the workforce. Notably, no link was found between the share of agriculture in employment and the productivity of lagging areas, indicating that improving productivity in agriculture and manufacturing will be crucial for rural regions' future development.

In summary, the differences in sectoral concentration can be attributed to two key factors.

Urban network. In CEE11 countries, the urban network is generally more monocentric than in western Europe, with few urban regions outside the capitals, only 16 in the 11 countries. The first-tier cities, especially the capitals, have an increasingly concentrated population, providing business services for the entire country. Furthermore, governments support capital regions disproportionately more than their size would justify, which has been creating bias between places and people (Parkinson et al.; 2015, Cardoso & Meijers, 2016). Due to this dominance and bias towards capital cities, second-tier cities are comparatively marginalised, and their economies develop relatively slower. Hence, there is a lack of second-tier urban regions that have taken on the "engine" role, as observed in the EU14 (Camagni et al., 2015).

Reindustrialisation effect. Economic policies in CEE11 countries focus predominantly on manufacturing and financing reindustrialisation programmes, partly out of necessity. However, data indicates that the productivity of the manufacturing sector in CEE11 is low: it has been stagnating for years and is not approaching the EU14 countries' average. Many processing industries in non-metropolitan, rural regions operate with low productivity

with standardised activities. This situation will likely result in a "development trap" for most of these regions (Diemer et al., 2022), and the enduring centre-(semi)periphery division between older and newer EU member states and between CEE capitals and rural regions.

Our analysis highlights key processes for regional economic development policies. Over the past decade, the CEE11 region benefited from manufacturing growth driven by low wages. However, increasing sectoral value added is crucial to addressing the challenges of the digital and green transition. Without place-sensitive policies (Laursen & Lange, 2024), inequalities are likely to widen, especially as urban areas gain more advantages in the service sector. Moreover, the twin transition is likely to amplify the spatial inequalities and worrisome future tendency of economic divergence (Maucorps et al., 2023). The EU and member states must implement policies beyond current cohesion mechanisms to counter these trends.

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China-Russia Cooperation: Economic Linkages and Sanctions Evasion

Since Russia's full-scale invasion of Ukraine and the subsequent imposition of sanctions by the coalition of countries supporting Ukraine's independence and territorial integrity, the economic relationship between Russia and China has evolved significantly. The partnership is characterized as symbiotic but highly asymmetrical, with China becoming an essential partner for Russia. China provides crucial markets for Russian exports, as well as access to critical inputs, while Russia, in turn, plays a secondary role. For China, Russia is a beneficial, yet non-essential partner, as it capitalizes on commercial ties without committing to a deep, full partnership. For China, Russia is an ideological ally to challenge US primacy and the current international order.

Both Russia and China are discontent with the current multilateral order (Gabuev, 2024), though with different motives. Russia has long been advocating for a multipolar world and increasingly isolationist policies, seeking to reduce its reliance on the West. In contrast, China, which has benefited significantly from the existing multilateral system, aims to claim a greater role on the global stage, rather than seeking to dismantle it entirely. China continues to engage actively in trade with the EU, the US and other global powers, while Russia's global presence has been significantly scaled down, particularly by sanctions following its invasion of Ukraine in 2022.

Russia's ability to sustain its war effort against Ukraine and challenge the international order depends largely on Chinese support, especially in evading sanctions and accessing critical technology. Without China's assistance, Russia would struggle to finance the war or secure the resources necessary for military operations (Bunzel & Ribakova, 2024). However, this dependence comes with risks. Although China does not formally endorse Western sanctions, it is cautious about transactions that might expose Chinese businesses to penalties or damage broader commercial interests, particularly its access to the EU and US markets.

Since Russia's full-scale invasion of Ukraine in 2022, bilateral trade between Russia and China has surged to record levels (Perry, 2025). Both nations benefit from their new "no limits" partnership (Joint Statement, 2022), though not equally so. For Russia, China has become an essential trading partner, overtaking Europe in importance, while for China, Russia remains a relatively unimportant market. In exchange for its energy and commodities (Hilgenstock et al., 2023),[1] which are critical to Russia, but not indispensable for China, Russia receives Chinese consumer goods, cars and technological imports (Leahy et al., 2024).

While trade flows are booming, investment from China to Russia remains modest. Chinese companies have opportunistically capitalized on the withdrawal of Western competitors from Russia. However, despite bold announcements of planned investments totaling US $200 billion (Skan, 2024), most cooperation projects, including large-scale ventures like the Power of Siberia 2 pipeline, exist only on paper. While there has been some progress in areas of financial and payment system linkages, cooperation in these sectors, and even trade transactions, has been significantly hindered by the US's threat of secondary sanctions.

With Russia's ability to transact in dollars and euros severely restricted by sanctions, the Chinese yuan has steadily grown in prominence in the Russian economy. The combined share of curren-

1 Russia's energy exports to China are just as necessary for Russia as they are for China, if not more so.

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cies of countries "unfriendly" to Russia declined from 87% to 18% for exports and from 67% to 18% for imports between January 2022 and December 2024. Nearly 90% of the transactions are reportedly settled in yuan and rubles, as President Putin announced in December 2024. Nonetheless, the threat of US secondary sanctions on Chinese banks, as outlined in an executive order issued in December 2023, resulted in a slowdown in Russia-China trade in 2024. Exports from China to Russia decreased by approximately 1% in the first half of 2024, while Russian exports to China grew only modestly.

The Russia-China relationship, though strategically important, is fraught with tensions. Russia feels like a junior partner, frustrated by its shift from being a major exporter of high-value goods to China to primarily exporting energy and commodities. This dissatisfaction is compounded by China's reluctance to invest in Russia and its hesitancy to challenge Western sanctions. Russia is also concerned about the growing influence of the yuan. Meanwhile, China faces its own challenges in the relationship. Russia is a relatively small market for China, and China's diversified energy strategy reduces its reliance on Russian exports. Leading Chinese companies are cautious about risking global market access by deepening ties with Russia, especially given Western sanctions. China is also wary of Russia's growing ties with North Korea, which could complicate its regional strategy, and historical border issues between the two nations remain unresolved.

Sanctions are a crucial tool in economic statecraft but are not a guaranteed solution for geopolitical conflicts (Itskhoki & Ribakova, 2024). Their effectiveness depends on clear objectives, comprehensive enforcement and realistic goals. Sanctions are more impactful when applied decisively and comprehensively, as gradual implementation allows target countries to adapt. The sanctions imposed on Russia since 2014, particularly after its 2022 invasion of Ukraine, highlight these complexities. While they caused significant costs, the continued energy exports and the gradual timing of sanctions, along with enforcement gaps, limited their effectiveness. Russia's economic size and global commodity market integration further diluted their impact, showing that larger, economically integrated nations can mitigate sanctions better than smaller ones.

The involvement of nations like China, but also Turkey and the United Arab Emirates, which helped Russia circumvent sanctions, underscores the difficulty of maintaining a unified sanctions regime. This reveals the trade-off between vague sanctions designed to signal intent and those with clear objectives and strict enforcement. In the context of an all-out conflict, sanctions with specific targets, firm enforcement and secondary sanctions on third-party nations are likely to be more effective. Ultimately, sanctions must be carefully tailored to achieve specific, attainable outcomes to maximize their impact.

The Russia-China relationship is symbiotic but asymmetrical – essential for Russia, but only a secondary concern for China, which takes advantage of Russia's vulnerabilities. While China currently acts as Russia's lifeline, after a potential settlement in Ukraine and the removal of sanctions, Russia may find itself deeply indebted to China, compelled to offer support in return.

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