

OCCASIONAL PAPER – No. 02/2025

The 8 Percent Approach: A Big Bang in Resources and Capacity for Europe's Economy and Defence

By **Ismail Abdi, Andrea Dugo, Fredrik Erixon and Lauri Tähminen**

Author presentation: Ismail Abdi is a Research Assistant at ECIPE. Andrea Dugo is an Economist at ECIPE. Fredrik Erixon is the Director of ECIPE. Lauri Tähtinen is the CEO of Mission Grey and a non-resident Senior Associate at CSIS.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	4
1. INTRODUCTION	6
2. EUROPE AND GLOBAL TECHNOLOGY COMPETITION	18
2.1. The Tech Frontier	19
Figure 1: Total Patent Applications in the EU-27 and the US, 1990–2021	20
Figure 2: Number of Patents in Frontier Technologies in the EU-27, the US, and China, 2000 and 2021	22
Table 1: China's Rise as a Technology Giant (Patent Applications in 2000 and 2021)	23
2.2. Europe Trailing in Research and Development	23
Figure 3: Gross Domestic Expenditure on R&D (GERD) as a Share of GDP in Selected Economies, 1991–2021	24
Figure 4: Gross Domestic Expenditure on R&D (GERD) as a Share of GDP for EU-27 Member States, 2015 and 2023	25
2.3. Featherless 'BERD' – The Root of the R&D Difference	28
Table 2: Gross Domestic Expenditure on R&D (GERD) by Sector of Performance for Selected Countries and Regions, 2022 or Latest Available Year	28
Figure 5: Business R&D (BERD) as a Share of GDP for Selected Economies, 2015–2022	29
Figure 6: Business R&D Spending Distribution by R&D Intensity Level for Selected Economies, 2022	31
Figure 7: Business R&D Spending Distribution by Industrial Sector for Selected Economies, 2022	32
Figure 8: EU Giants' Business R&D (BERD), 2015 and 2022	34
2.4. Higher Education	34
2.5. Breaking Ground for Strategic Research Projects	36
3. EUROPE'S FALTERING MILITARY STRENGTH	38
Figure 9: Defence Spending as a Share of GDP in Selected Economies, 2016–2023	39
Figure 10: Defence Expenditure as a Share of GDP for EU-27 Member States, 2015 and 2024	42
3.1. The Home Front	43
3.2. Defending Global Order	48
3.3. The State of the EU Defence Industry and Technology	51

Figure 11: Share of Public R&D Allocated to Defence, Comparing the US and the EU-27, 2013–2022	53
Figure 12: Total Arms Exports and Imports for the EU-27 and US (in SIPRI 'TIV', Millions), 2015–2023	54
Table 3: Total Arms Revenues, US & Europe (EU-27 + UK, Norway), 2022	56
Figure 13: Top 5 EU and US Defence Companies by Arms Revenues, 2023 (Millions of US Dollars)	56
Figure 14: Top US and European Defence Companies' Combined R&D Expenditure, 2023 (Millions of US Dollars)	57
Figure 15: US Department of Defense's Total Obligational Authority (TOA) by Contract Spending, 2023	59
Figure 16: Military Equipment Purchases in the US and in the EU-27, mid-2022 to mid-2023	61
4. A DRIVE TO 8 PERCENT: A BIG BANG IN EUROPEAN RESOURCE ALLOCATION	64
4.1. Profiling the Resource Paths of EU Countries	66
Figure 17: EU-27 Member States with the Fastest Acceleration of Defence Expenditure	68
Figure 18: Evolution of Gross Budget Allocation for R&D (GBARD) of EU-27 Member States in Nominal Figures, 2015 and 2022 (Constant 2015 Prices)	69
Figure 19: Evolution of Gross Domestic Expenditure on R&D (GERD) for the for the EU-27, US, Japan, South Korea, and China, 2015–2022	70
Figure 20: Private R&D Incentives Combined (R&D Financing + Tax Incentives), 2015–2020 (Millions of US Dollars)	71
Table 4: Categorising the Spending Paths of EU-27 Countries for R&D and Defence, 2015 and 2024	72
4.2. The Big Bang Approach	73
Figure 21: Business R&D Spending Distribution by Industrial Sector for the US, the EU-27 and a "US-Like" EU-27, 2022 (Billions of Current US Dollars)	76
Figure 22: Gross Domestic Expenditure on R&D (GERD) for EU-27 countries in a Big Bang Scenario (Percentage of GDP)	78
Figure 23: Defence Spending for EU-27 Countries in a Big Bang Scenario (Percentage of GDP)	79
5. CONCLUSION	81
REFERENCES	84

EXECUTIVE SUMMARY

Europe has become a region of feeble economic performance and military frailty. Its share of the world economy is rapidly shrinking, and the region is struggling to keep up with economies at the modern technological frontier. Countries in the European Union have for decades talked about the importance of raising Research and Development (R&D) expenditure and allowing greater space for an entrepreneurial business sector that is prospering on the back of innovation. However, the results are poor. R&D expenditures as a share of GDP have largely been stagnant, and – in recent years – business investment and inward Foreign Direct Investment (FDI) have tanked. Rates of new business formation and growth are paltry, partly as a result of gross overregulation. Productivity growth has continued its decades-long path of deceleration, and the EU is increasingly behind international leaders.

Fortunately, Europe is beginning to wake up from its strategic slumber. Defence expenditures are now growing faster than in previous decades – and some countries, like Poland, are becoming serious powers. Yet, the region's own military capacity remains poor. Europe must rebuild core conventional capacities at a time when defence modernisation requires substantial resources and focus. Russia may be bogged down by its war against Ukraine, but it is rebuilding its capacities fast and is increasingly aided by partnerships with other countries that want to break down what remains of a liberal world order. Many European NATO-members are now hitting the 2-percent spending target but must spend vastly more to acquire sufficient capacities to defend themselves and their interests.

Europe is at a perilous strategic moment and its leaders must now take bold action. The EU needs a Big Bang in its allocation of resources for R&D and military capacity. Europe's total spending on R&D is way below comparative regions and drains the economy of long-term developmental strength. After decades of underspending on defence, Europe needs to vastly raise military spending to acquire the capacity needed to defend itself and the global order from which it prospers. On both accounts, Europe needs to overcorrect and discard its mentality of resource incrementalism, offering too little, too late out of a fear of overcommitting and overspending. Such an outlook is self-defeating. To be able to shape outcomes, Europe needs a Big Bang.

How much should Europe spend on R&D and defence? There is no correct answer to the question. However, it is easier to identify incorrect ones: it is simply inadequate to target R&D spending at the level of 3 percent of GDP (a target that suited the economy in the 1990s) or military spending at the same level, let alone the old peacetime NATO target of 2 percent of GDP. A basic formula is that R&D expenditures should be at a level and of a nature which can position the region at the global frontier of knowledge and technological change. In addition to adequate public resources, this also calls for a private sector that has the profile to lead in key areas of technological development. In the military realm, governments should spend what is necessary to defend their territories and assist allies as well as prevent such a need from arising: to deter enemies and aggressors from hostile and opportunistic behaviour. Europe is a long way from meeting this challenge: it does not only allocate insufficient resources but even

when pursuing the right policies, it remains stuck in a mindset of incremental change. At such a pace, the problems you are attempting to solve will continue to recede into the distance.

Thus, we are calling our Big Bang "the Eight Percent Approach": Europe's collective resources for R&D and defence should now be at 8 percent of GDP. A reasonable allocation of resources now should be the equivalent of 4 percent of GDP for R&D and defence, respectively. In nominal terms today for the European Union, this equals 720 billion EUR for R&D and 720 billion EUR for defence. This can be compared with the actual spending today (using data for 2023), which is 405 billion EUR in R&D and 340 billion EUR in defence. To get to the 8 percent Big Bang, EU countries need to increase spending by 695 billion EUR. An extra 315 billion for R&D, and an extra 380 billion for defence.

Capacity needs to be built for Europe to start shaping regional and contributing to global outcomes. New resources open up avenues for new actions, but they also need to be combined with many other initiatives to deliver on their objectives. Such policies include improving the competitiveness of the EU defence industry and discarding the old national champion model that has resulted in an EU defence sector that is fragmented, consisting of small and ineffective companies. Moreover, with battlefield contributions increasingly relying on modern data science and civilian technology, Brussels and other EU capitals need to radically improve the environment for innovation and technology experimentation.

Yet, as the challenge to the liberal order from which Europe has benefited is global, it must resist the temptations of a "Fortress Europe" mentality of allocating resources only to its own defence or, worse, to that of its individual Member States. Building stronger alliances and partnerships with other countries and regions is of fundamental importance. This includes finding a new balance between competition and cooperation with the United States in different arenas. However, managing transatlantic relations in this new era is not enough. A new international strategy must include deepening relations with other parts of the world, foremost amongst them the Indo-Pacific region.

1. INTRODUCTION

“Great men, great nations, have not been boasters and buffoons, but perceivers of the terror of life, and have manned themselves to face it.”

Ralph Waldo Emerson

Europe entered the new millennium in a buoyant mode. Many of its leaders had championed global multipolarity and even new checks on American unipolarity, assuming that such a world would give Europe more power to shape global outcomes. Rising economies, especially in Asia, and the birth of BRICs¹ were naturally going to equalise global economic prosperity, but Europe brought something else to the table. Its model of cooperation – based on rules and internationalism as well as a “social market economy” with strong welfare rights and other correctives to business capitalism – was billed as the future international compact. A popular book at the time summarised the ethos in the title: “Why Europe will run the 21st century”.²

While America suffered from militaristic centralisation, Europe's model, it was argued, made the EU agile and capable of responding to new global developments and threats in more holistic ways. It could even manage geopolitical frictions through its own economic power, particularly in a world where economic statecraft still sufficed to shape global results. This influence was also set to grow on the back of a strategy that would make the EU the most “competitive and knowledge-based dynamic economy in the world”.³ It would project authority in its neighbourhood and pull countries of the former-Soviet Union (FSU) into its orbit.

The world of the new millennium turned out to be quite different, in part due to the “Upstart” strategy pursued by China.⁴ As a result, in both Europe and America, the energising power of the BRICs has given way to the paralysing fear of the CRINKs (China, Russia, Iran, and North Korea) – a gradually emerging partnership of countries that are different but share the desire to make the world safe for dictators, authoritarians, human-rights violators, thugs, and corrupt oligarchs.⁵ They have in common the desire to destroy the liberal rules and norms that have powered the emerging post-World War II order, to undermine American leadership, and to prejudice the security and prosperity of US allies. The growing partnership between them gives them stronger capacities to do so.

Moreover, there is now a war on the European continent: it has devastated an EU ally, caused substantial disruption to energy supply, and exacerbated structural political frictions within the EU. Obviously, the war and European reactions have revealed how unprepared Europe is for an ever more serious war – ranging from depleted stocks and weak production capabilities of basic ammunition to illusory concepts of strategy and leadership. While political support to Ukraine

¹ BRIC began as an acronym for large and rising emerging economies (Brazil, Russia, India, and China) to which a capital S was soon added in the form of South Africa and the group keeps on growing.

² Mark Leonard (2005) *Why Europe will Run the 21st Century*.

³ The Lisbon Strategy was adopted by EU leaders at a summit in Lisbon in 2000.

⁴ Oriana Skylar Mastro (2024) *Upstart: How China Became a Great Power*

⁵ The same group of countries have also been called the Coalition of the Malevolent by scholar Eliot A Cohen and the Axis of Ill Will by historian Niall Ferguson.

has been resolute, Europe and the US have been intentionally failing to deliver necessary arms for Ukraine to stand a chance to push Russian troops out of its territory – partly out of fear that such arms deliveries would drag unprepared European nations into direct conflict. The Polish Prime Minister suggested that his Spanish counterpart argued against using the word “war” in EU summit communiques because people “do not want to feel threatened”.⁶ To paraphrase Aeschylus, the Greek father of tragedy, in war the ability to speak plainly is the first casualty and, it seems, that the faculty to think and act clearly is the second.

Worryingly, Europe does not command much power in its own neighbourhood anymore, with several opportunistic regimes in the Balkans and on the EU's eastern rim acting to undermine Europe's security with impunity. Most EU countries have spent the last two decades reducing their military capacities, imagining for a long time that a war in Europe had become – yet again – impossible. As a result, the state of Europe's own defence capacities is poor, with army, air-defence, and naval battle systems left in a desolate state. The European economy has moved sideways, and the zero-sum economics of the continent has gradually led to zero-sum politics. Many of the large and mature economies are trapped in low rates of economic growth and weak economic dynamism, and the region is ever more distant from the global frontier in many key technologies. Fiscal policy is constrained by deficits and debts, and a demographic shift is resulting in a surge in entitlement spending. As a result, both military and economic agility are distressed.

The Greeks of antiquity also warned against hubris and complacency, and that rulers and polities governed by these illusions would put themselves and others in danger. Unlike America's flirting with hubris in the form of military-led nation-building, Europe's strategic fault-line after the Cold War was to assume that the end of Pax Americana would usher in perpetual peace and a rules-based order – one that would imitate Europe's own post-World War II experience. Its current complacency is more worrying: faced with obvious threats that are creeping closer to the everyday reality of many Europeans, Europe struggles to come up with credible responses. Too many countries act as if they have the luxury to defer critical decisions about power and resources to the future – even long into the future, perhaps to a promising time that may not come anytime soon. The first half of the 2020s has been a time of crisis, first due to a global pandemic and second because of war in Europe. It is time to readjust expectations. The baseline for normalcy has shifted more permanently, and actions must adjust from the bottom-up, starting with the basic needs of innovation and defence.

Such a shift does not promise to be easy. EU institutions suffer from illusions of yesteryear, adding layer after layer of regulation on a depressed economy and developing a “Fortress Europe” mindset that does not make appropriate distinctions between friends and enemies. For example, discussions of Europe's strategic autonomy must account for those partnerships which may enhance European capabilities, and those engagements which promise to develop dangerous dependencies. Moreover, Europe must also, simply, accept and embrace the uncertainty which accompanies the breaking of new ground. “Economic progress in a capitalist society”, wrote Joseph Schumpeter – the doyen of entrepreneurial and innovation-

⁶ Rainsford and Kirby (2024) “War a Real Threat and Europe not Ready, Warns Poland's Tusk.” BBC News.

driven economics – “means turmoil”.⁷ Given a choice between raucous economic dynamism and courageous political leadership, on the one hand, and the safe preservation of a quiet economic status quo (or even decline) on the other, European leaders have preferred the latter.

In his report on European competitiveness, Mario Draghi warned that Europe faces an existential challenge. The EU is, in the first place, exhausted. Many would feel that the European project has been in crisis mode for 15 years. The financial crisis, the Eurozone crisis, the migrant crisis, Brexit, the pandemic, and now war (with its associated energy price spikes), have all worn power thin and caused political turbulence, not least manifested by the rise of political parties and leaders challenging the traditional centrist consensus and associating with enemies. Due to internal differences, the crisis responses have never been adequate⁸. Rather the EU has developed a “muddling through” mentality – one it has even come to celebrate. It is rarely responsible for crises: the responsibility for the war in Ukraine, to take the most obvious example, lays in Moscow. Yet it fails to understand that Europe’s own military, economic, and technological weakness causes instability. For authoritarians and bullies, the weakness of others is a provocation – and an invitation for hostile acts. Europe may not be interested in war, but war has yet again become interested in Europe.

In the second place, Europe is also economically and strategically challenged by the United States – its old ally. Like many others, Europe is trapped somewhere between moral panic and intellectual paralysis, fearing the consequences of a disruptive Trump administration but feeling incapable to do something about them. But there is a longer view that points to the same end point: weaker intimacy between America and Europe. It is remarkable how Europe’s economic power and strategic wherewithal have declined over the last three decades, leading successive US administrations and other major governments to neglect European views. Going beyond the war in Ukraine, Europe is largely absent in efforts to manage international conflicts and major strategic threats around the globe – in the Indo-Pacific, the Middle East, West Africa, and other hotspots. Faced with the risk of a tariff war with the US, it struggles to come up with a strategy or policy that could defuse tension and, in the long term, re-balance a strategic dependence that is fundamental to prosperity and security.

The EU has two major geopolitical tasks ahead of it: reviving the economy by moving back to the global technological and economic frontier and building up military strength to protect itself and make greater contributions to global peace, stability, and what remains of the liberal order. Both tasks have received greater urgency with a new US administration that obviously cares less about European security and Transatlantic unity, and that may be about to attempt a larger shift in global geopolitics that gives a stronger premium to raw power over rules and institutions that protect the integrity of smaller nations. As we will argue in this paper, they also hang together: economic and technological power are important for consequential statecraft, and if the war in Ukraine and the character of China’s rapid military build-up have taught us anything, it is that modern technological innovation and adaptation are central to battlefield

⁷ Joseph Schumpeter (1942) *Capitalism, Socialism, and Democracy*.

⁸ Alcaro & Dijkstra (2024) *Re-imagining EU Foreign and Security Policy in a Complex and Contested World*.

success. Technology and innovation have, of course, defined military capacity for a long time. Saddles and horseshoes once redefined battles – just as the longbow, muskets, cannons, and mechanised warfare later did.⁹ Now, it is data science and modern civil software technology that are revolutionising war – along with other new technologies powering weapons like hypersonic ballistic missiles.

War, it has been said, is a test to see who learns faster, and the developments from the battlefields in Ukraine have shown that technology and innovation capacity are a key element of defence and offence. War requires a defence industry that is extremely quick on its feet and that can work with technology platforms that need to change from one month to another – as enemies adapt and succeed in their own technology development. Notably, old alliances like NATO and new defence partnerships like AUKUS increasingly rely on integrating technology developments across members (what is known as Pillar 2) and spurring joint projects for advanced capabilities, like the AUKUS Quantum Arrangement. There is a growing sentiment that many large defence suppliers are stuck in their old ways. The vanguard of the defence sector integrates much more readily new technologies from different civilian sectors – the same technologies that are changing the structure of our broader economies and enhancing the performance of firms and entire sectors.

There is good news. Some leaders have accepted the fact that Europe is stuck, and that bold action is required. Following the provocations by the Trump administration in early 2025, there is new resolve to expand military spending and new ideas about how to finance rapid improvements in military capacity. In Brussels, for instance, the European Commission has released a Competitiveness Compass that acknowledges Europe's economic, technological, and military weaknesses. Generally, Europe has the resources and alliances needed to make itself stronger. Europe is far richer than the countries that pose the worst threats to its territorial and political integrity – and, spread over all countries, spend substantially more on the military than its main foe Russia does. The same goes for NATO and its allies across the world: their military spending outpace CRINKs by a very substantial margin, and NATO and its friends maintain a strong advantage in being more innovative and capable in delivering economic development. An "innovation coalition" consisting of free-market liberal democracies commands so much more economic power than the CRINKs that, on this score, it's not even a contest.¹⁰ Moreover, the CRINKs are on a declining path with rapid depopulation already happening and economic lassitude on the horizon in China and Russia. While China is moving very fast on drones, robotics, AI and supersonic missiles – and therefore building its military capacity – it is not on a path to outpace the West in gross economic size. As its ability to engage in battle grows, so do its own domestic political problems.

However, comparisons and pointers like these can be abstractions and, for Europe, hide some uncomfortable truths. The European Commission may acknowledge Europe's weaknesses, but it is not considering bold action. On Research and Development (R&D), the Commission's Competitiveness Compass only resurface an old target of spending 3 percent of GDP on R&D –

⁹ White Jr (1964) *Medieval Technology and Social Change*. Also, North (1981) *Structure and Change in Economic History*.

¹⁰ Barnett (2024) "Democracies' Advantage: Leveraging Innovation Coalitions to Meet the Autocratic Challenge." CSIS.

one that the region has failed to achieve ever since it was established decades ago. And even if our enemies may be on some paths of decline, this is at least equally true for Europe, whether we measure it by depopulation or military capacity. Moreover, the threats that exist now may be exacerbated by the recognition in Beijing and Moscow that they need to act while they can – sooner rather than later.

The opposite logic reigns in terms of international coalitions: while the partnership of CRINKs is in the ascendance, it is debatable whether the same can be said of the Western alliance. General Jim Mattis, the former US Secretary of Defence and Commander of the US Central Command, has said that "allies, allies, allies" remain the major advantage of Western powers; yet it is obvious that the broader alliance has been decaying. Both America and Europe have grown increasingly disillusioned with the international order that grew out of the experiences of World War II. They say, sometimes rightly, that this order has been exploited by opportunistic and revanchist countries. To defend themselves against the general erosion of order the United States and Europe also take confrontative economic, regulatory, and political action against each other. General Onno Eichelsheim, the Chief of Defence in the Netherlands, has observed that "the unity of autocracies is perhaps stronger than the unity of democracies at this moment." In the fight between democracies and autocracies, he suggests, "the autocracies have a winning hand".¹¹

Alliances need investments and, obviously, Europe has not invested in NATO for a very long time. In fact, Europe's commitment to defending itself, the West, and global order have all grown weaker, and this weakness has invited hostile acts. Europe has a vast territory and a big catalogue of global interests to defend; it is spread thin while enemies can concentrate resources to, so far, limited objectives. Importantly, inadequate military capacity and resource allocation erode trust in alliances and their ability to project and command power – a situation that opportunistic governments can exploit. The all-too-common European discourse regarding what the United States can do for Europe has too often crowded out what Europe can do for Europe. This has only served to highlight European weaknesses whether as a continent, Union, or as simply as a collection of countries.

To attain adequate power and resulting deterrence, Europe needs a Big Bang – a radical change in how it allocates resources to achieve scale and speed in the rebuilding of its military and technological capacities. Europe has made improvements in both arenas, but they remain small and incremental – and, unfortunately, fail to target the transversal technologies that define today's economic and military performance. This is the bad news: it is bleeding obvious that national governments and European institutions alike remain far-removed from providing adequate resources. It is equally obvious that few European countries intend to plug the resource gap anytime soon. If there is a strategy for losing a war against Russia and its partners in, say, 2030, this is it.

A case in point is the field of telecommunications – a sector that binds together R&D-infused innovation, technology-driven economic growth, and modern battlefield planning. Economists and military observers agree that improvements in telecommunication capacity are of central

¹¹ Trofimov (2024) "Has World War III Already Begun?" The Wall Street Journal.

importance, yet Europe is increasingly falling behind. Its deployment of 5G trails leading economies: investments are, for a variety of reasons, not being made. The EU has two of the global leaders in telecom – Ericsson and Nokia – but both companies have poor sales in Europe and struggle to make the case for themselves to EU policymakers. Remarkably, the European Commission proposed in 2023 a new policy for Standard Essential Patents that intended to reduce revenues for cellular technology developers, like these two Nordic firms, but in doing so it inaccurately argued that lower cellular patent royalties would make downstream sectors (e.g. automobile manufacturers) more competitive.¹² Ericsson is now talking openly about moving its headquarters to the United States – just as it has already moved investments there.¹³ With the new US administration the political pull factors for relocation should only increase, just as they did under the previous Trump presidency. Also, now that the home countries of these telecom giants, Finland and Sweden, have aligned not only culturally but also militarily with the United States, the fuller transatlantic integration of their economies should continue apace.¹⁴ Such integration has a strong security rationale but can also provide Europe with economic and other opportunities – but only if the Union is ready to seize them.

Obviously, a Big Bang in resources should be complemented with other policies that bolster capacity and greater interest in other parts of the world to become closer to the EU. The smooth ratification of the EU-Mercosur trade treaty is only one such imperative for broad strategic reasons. Simply, it should give direction to the development of the Union in coming years.¹⁵ Europe must also look to engage much deeper with other major economies such as Mexico and Indonesia¹⁶ and with the democracies of the Indo-Pacific with whom Europe converges on geopolitics but diverges on innovation output. This is why Europe's current woes cannot be solved by resources alone. Ideally, European governments and EU institutions would be capable to recover their strategic comportment and start confronting the world with a coherent view of themselves and their policies. Grand strategy is often an excuse to produce abstract concepts and obtuse theories – and Europeans aren't shy at playing that game; just consider the many exercises in long-term planning. The output of these exercises routinely becomes like Christmas wish-lists that have no real influence on policy conduct or decisions.

The European Union's *Strategic Compass* from 2022 – released after Russia's full invasion of Ukraine – is a 60-plus pages report on the world that packages some favoured phrases in the EU vocabulary (e.g. interoperability, observatory, resilience, "joint and inclusive", "strategic enablers", et cetera) into a "detailed plan" for European security.¹⁷ It is, of course, neither a compass nor a detailed plan, and fails to get to the heart of key security challenges. It even fails on the basics of strategy: convening a realistic account of challenges and resources, and the priorities and choices (trade-offs) that are needed to reach the desired destination.

¹² Erixon and Guinea (2023) Reforming Standard Essential Patents: Trade, Specialisation, and International Jurisprudence. ECIPE.

¹³ Deutsch (2024) "Ericsson CEO Says Weak Europe Market Forces Firm to Grow Abroad." Bloomberg.

¹⁴ O'Hanlon and Tähtinen (2022) "Yes to Finland and Sweden in NATO." The Hill.

¹⁵ Tähtinen (2024) "EU-Mercosur: So Much More Than a Dead Deal." CSIS.

¹⁶ Tähtinen (2024) "A Shared EU-US Economic Agenda for the World: Engagement as an Imperative." CSIS.

¹⁷ EEAS (2022) A Strategic Compass for Security and Defence.

The German government launched in the summer of 2023 its National Security Strategy – after its highly hyperbolised *Zeitenwende* – and, unfortunately, its quality is even worse. If there is anything notable about it, it is the faith that the German government invests in sustainability policies and its "inner strength" contributions to its national security.¹⁸ It fails to recognise the importance of a strong and fast-growing German economy at the vanguard of key technological change. Its appreciation of German military capacity sits awkwardly with the reality: decades of underspending have led to a dysfunctional army with huge capacity gaps¹⁹ – an army that has been ridiculed in the German debate as 'AINO' (Army in Name Only). In early 2024, seven months after the release of the National Security Strategy, a review of the Bundeswehr concluded that it has "too little of everything – ammunition, of spare parts, of radio devices; there is a lack of tanks, of ships and of aircraft".²⁰

Similarly, the German strategy fails to account for economic choices and trade-offs in strategy: for instance, that the policies chosen to achieve net zero have led the country to zero growth and shrinking economic and, therefore, military power. The Defence Ministry's Defence Policy Guidelines, which were released later the same year, are a bit more realistic but remain hopelessly over-ambitious given the poor state of Germany's military.²¹ In fact, the country's military capabilities are so lacking that German scholars have called for abandoning the use of the word *Zeitenwende* because the strategy "has failed" and German policies are "dangerously inadequate".²²

A central omission in many European broad strategies and long-term plans is the role of technology and innovation – also for military capacity. Everyone understands that rebuilding military capabilities after decades of cuts to defence budgets means purchases to modernise systems of war: fighter jets, air defence, tanks and kinetic battlefield capacity, submarines, and naval surface combatants. But there must be a parallel development in new war technology which requires vast resources too – including drones, new missile defence technology, and hypersonic weapons. To add to that: more civil capacities are needed in telecommunication, satellites, and space – areas in which Europe used to be comparatively strong but where it is now failing. Poor 5G capacity in Europe hinders digital economic growth but also limits military communication and the use of integrated technology solutions for several weapon systems. Similarly, ten years ago, Europe was a global power in space; now SpaceX is the leader in space satellites and by far the dominant actor in space cargo launches.²³ By contrast, Europe's former leaders struggle to remain relevant in the sector.

The Problem: Wrong Approaches to Dealing with Capacity Gaps

Building on current attitudes to resource allocation and capacity gaps in Europe, we can define several archetypical modes for how Europe has responded to stronger innovation competition and re-emerging security threats. Delineating them also helps to illustrate how Europe is failing

¹⁸ Die Bundesregierung (2023) National Security Strategy: Robust. Resilient. Sustainable. Integrated Security for Germany.

¹⁹ Leon Mangasarian and Jan Techau (2017) Führungsmacht Deutschland: Strategie ohne Angst und Anmassung.

²⁰ Deutsche Welle (2024) "Germany's Military is Aging and Shrinking, Says Report."

²¹ Bundesministerium der Verteidigung (2023) Defence Policy Guidelines 2023.

²² Tallis (2024) The End of Zeitenwende. Reflections After Two Years of Action Group Zeitenwende. DGAP.

²³ Lipton (2024) "Elon Musk Dominates Space. Rivals are Calling Foul." The New York Times.

on the central tasks of our age – and why a Big Bang is needed. We find three modes that are, to varying degrees, possible to identify in different countries and governments already today, and we will contrast this with a sketch of the approach that we set out in this paper: the Big Bang.

One mode is a Europe, sometimes blinded by the pursuit of its exclusive moral purity, that decides to go – metaphorically – over the cliff. It can be called the **Thelma & Louise** method, using the image of the 1991 movie when the two protagonists, played by Susan Sarandon and Geena Davis, decide to “let’s keep going”, even if it means taking their Thunderbird into mid-air. In Europe, this is the method for those who do not want to change and do not accept responsibility for past errors and omissions: they prefer to keep going just like they have done in the past, even if it means taking European capacity if not over it, at least, to the cliff’s edge. Perhaps this attitude is more prevalent in technology and innovation than in security policy. Faced with the manifest need to unleash the “animal spirits” of the capitalist economy, to quote John Maynard Keynes, European leaders rather decide to dull their economy and make it a virtuous but listless enclave in an otherwise chaotic world. Confronted with evidence that new regulations choke innovation, they decide to add more regulation. When evidence suggests that a mix of energy and climate regulations expand costs rather than reduce carbon emission, some politicians prefer more of the same whilst hoping for a different outcome.

A second mode can be labelled **Dante’s Inferno**, and its essence is already featured above: a paralysed Europe. In Dante’s famous poem, the main person finds himself “midway through life”, lost from the path that “does not stray” – an apt description of the type of midlife crisis from which the European project has been suffering for some time now. But the moral of the story is not the observer but what he finds as he passes through the circles of hell and gets to its core. The popular imagery of Satan and hell have often included fire and flames, but as Dante and Virgil tour the darkness and the barren lands of the inferno, and as they get further down the circles, they find less blaze and more of the “weeping and gnashing of teeth”.²⁴ And at the ninth and last circle of hell they meet Satan – his lower body frozen in ice. The image is clear: once the prideful centre of everything – self-important and occupied by willing himself into power and glory – he is now stuck and unable to move, even if that is what he wants.

The Dante’s Inferno method for European statecraft is about *paralysis*. In this iteration, the problem is not will and desire. European governments and institutions want to devote necessary resources to R&D and defence – and they want to be a region with corporate innovation powerhouses just as Europe was at the centre of the industrial revolution and the birth of science. But just like in Dante’s poem, they are stuck. Will and desire are not enough to shape outcomes, and the more they make failed efforts to move, the more they fall back into the mental habit which portends that their problems are someone else’s to fix. Confronted with many problems – e.g. soaring costs for healthcare and pensions, structural fiscal deficits, high energy costs, turbulent politics, failing performance of large and important companies – governments have little space to act and cannot build the political majorities necessary to get their desired policies accepted.

²⁴ The quote isn’t from Dante but from Matthew 13:42.

A third mode, and probably closer to how many European governments think about resource allocation, is the **Bean Counter method**. Europe knows it needs to change, and what should be changed, to gain more power over its own situation and command more influence globally. It also knows what cannot lead to desired outcomes. Still, it cannot generate the necessary resources and create the necessary reforms for shaping the outcome – at least not in the foreseeable future or on the timeline demanded by its adversaries – and rather approaches it as a matter of decimals and percentage points in spending: taking an accountancy approach to conflicts and innovation.

For instance, Europe knows its military capabilities must improve profoundly but many countries raise military spending with one or two decimal points of GDP every year, thinking that over time it will result in the currently agreed NATO spending target of 2 percent of GDP or a little more. However, Europe needs to shape immediate outcomes, and therefore resources are needed now. A similar approach is taken in spending on R&D: everyone admits the EU is spending far too little on R&D but only plans to achieve marginal annual increases until it reaches – in some decades – the target of an R&D expenditure equivalent to 3 percent of GDP. By then, of course, R&D needs will have grown even more, and other economies will have moved on to higher spending.

Our preferred approach, **Big Bang**, starts from what should be an obvious observation: the only way to deal with past omissions is to overcorrect now – and not defer responsibility for change to a distant future. Military capacity and R&D spending are real and observable variables: they can also be managed by governments. It is not a complex scientific endeavour to identify capacity gaps and problems in both areas and then design policy responses, including allocating necessary resources. For instance, Germany has grossly underspent on its military over the years: the gap between Germany's actual spending and the 2 percent defence-spending target since the end of the Cold War represents a "peace dividend" of EUR 1.8 trillion. The capacity gap now is estimated to represent, in money terms, more than EUR 600 billion.^{25, 26} This sum is vastly bigger than any already-decided resource allocation to the German military; the only way to plug the gap is to overcorrect now and provide necessary resources.

In other words, the Big Bang approach recognises that the outcome we desire to shape requires resource allocation and related decisions now. It should not be a derivative of gradual changes over time, leading to the desired outcome at some point long into the future. An overcorrection was necessary already yesterday; Europe had better get started today.

²⁵ Dorn, Potrafke, and Schlepper (2024) European Defence Spending in 2024 and Beyond: How to Provide Security in an Economically Challenging Environment.

²⁶ Gebauer and Korbaki (2024) "Vier Milliarden für Eurofighter sind eine gute Investition." Die Welt.

BOX 1: MODES AND POTENTIAL OUTCOMES

Mode 1 (**Thelma & Louise**): A Europe which fails to acknowledge its position and need to change, clinging in vain to the promise of its past, preferring to take us to the cliff rather than change course.

Mode 2 (**Dante's Inferno**): A Europe bound by its internal faults; despite its desire to remedy them it fails to take adequate action, thus finding itself "stuck" in a state of paralysis.

Mode 3 (**Bean Counter**): A Europe which tackles existing issues by making small contributions where required, to the effect that positive action is being taken but is unable to fundamentally change its position.

Mode 4 (**Big Bang**): A Europe that aspires to shape outcomes – via its economy and defence – and understands that a prerequisite for faster innovation and a strong military soon is to overcorrect for past failures in resource allocation now. It decides on a Big Bang in total spending on R&D and defence.

The Big Bang approach is also a strategy for Europe to deal with the United States, a relation that is obviously at risk of rapid deterioration. President Donald Trump may not be in favour of pulling the US out of NATO, and the US Congress would likely block him if he tried. However, he takes a transactional view on alliances and finds free riding on US security unacceptable. Trump's return to power is, in part, a reflection on how the US public increasingly shares in his concerns, while it is equally obvious that the US is on a long-term strategic trajectory that makes it less able and willing to support Europe. Its general outlook has moved away from the mix of liberal internationalism and neoconservatism that have been defining US foreign policy for decades, and the next destination seems more akin to a combination of Jeffersonian isolationism and Hamiltonian realism.²⁷ At worst, America and Europe may find themselves increasingly on a collision course.

The next NATO summit in Hague in mid-2025 may prompt a new spending target for members at 3 percent of GDP, reflecting new threat assessments and the postponement of a decision in mid-2024 to agree on a 2.5-percent target. It is also an opportunity to directly deal with shared security concerns that have been left unaddressed – like emerging threats in the North Atlantic. Of course, Europe remains profoundly dependent on US resources and technology for its defence. Notwithstanding the antics of Donald Trump and proclivities of different US administrations, it is sound policy for Europe to invest more in its own defence while allying with the US and other partners for the security of other geographies. If Europe gets serious about defence and R&D spending, it will likely find Washington to be a more reliable partner – also one that is keen to maintain open economic policies, so it too can prosper on the back of future European innovations.

²⁷ Mead (2024) "The Return of Hamiltonian Statecraft: A Grand Strategy for a Turbulent World." Foreign Affairs.

A full picture of Europe's current approaches to its failing economy and the new geopolitical situation mixes scenarios one, two and three. There are cohorts of governments and political leaders that have found common ground around different scenarios, and the reality of Europe's increasingly complex politics is that even each government may contain different forces subscribing to conflicting scenario positions. Brussels finds itself in the centre of this maelstrom, often asked to achieve results it has no power to deliver. It releases compasses, strategies, roadmaps, and agendas that promise a lot of activity but rarely deliver real achievement. Yet there are many governments with the capacity to act and do a lot more than they have so far done, either because they have resources to build on or because problems require more immediate management. Nor are there resources lacking across Europe. The current failure is rather one about imagination. War has surrounded us, but European leaders still think the risk of war in and against the EU is negligible. And if war were to happen, they seem to assume it would follow Europe's preference for how the war will develop. Worryingly, at the heart of this attitude is a failure to understand the potential for disaster and the severity of Europe's weakness: the remaining complacency and prevailing illusions are putting us in unnecessary danger. The more we delay important resource decisions into the future, the more we provoke hostile actors to move on us sooner rather than later. Europe is, to paraphrase a famous line about America's mid-war complacency, sacrificing future security for "fictitious normalcy".²⁸

Structure of the Paper

The purpose of this paper is to provide motivation for a Big Bang in Europe's defence and R&D spending: both are crucial for Europe to manage threats and command power in the world. The defence part is obviously more urgent. Russia has proven itself capable of rearming and changing strategy faster than expected, and a military confrontation with NATO could happen soon. Western leaders first operated with the assumption that it would take Russia a decade to re-build its capacity after its war on Ukraine ended. Western intelligence now suggests this time is more likely to be less than five years, and with a deeper CRINKs partnership it can be reduced even further. Equally notable, key Western intelligence services share the analysis that Russia is not going to stop with its war against Ukraine: in their view, new Russian aggression against other countries and NATO members is likely to come.²⁹

Importantly, in the Big Bang approach Europe will have a greater say over its own future, and it will invest to make the region – and the world – a place that is safer for freedom, liberal democracy, and free-market competition. Obviously, there are other necessary actions for Europe to revive its economy, including liberating capital markets, reducing regulation, and deepening economic relations with friends and allies. Without stronger defence and R&D capabilities, however, the EU will lack key parts of a broader economic and security strategy.

Governments in Europe need to become more capable of understanding resource needs and plan for them. For the moment, all European NATO governments – with the notable exception of Poland – struggle to have a realistic idea about how to plan resource needs for the military.

²⁸ Quote from Robert Patterson, the US Secretary of War 1940-45.

²⁹ See for instance the opening remarks by US Secretary of Defence Lloyd Austin III at the 20th Ukraine Defence Contact Group.

Remarkably, the UK government is currently going through its third strategic defence review in four years. Despite very recent decisions to increase defence budgets, countries like Denmark have concluded that they are not enough – and that more money is needed. Obviously, other countries will soon follow suit, not least considering the 2025 NATO summit and President Trump's new bid for European defence spending at the level of 5 percent of GDP. But constant revisions of long-term resource allocation imperil strategic planning and investment and make countries less capable to get the help of the market to reach the objective of improving capacity and, thus, deterrence. These revisions rather give the impression that governments are not on top of their briefs.

Chapter Two of this paper provides a deeper analysis of Europe's technologic and economic weakness, and describes its deep political roots across the EU. Chapter Three reviews capacity and resource allocation in the military. The purpose of these chapters is not to provide a full account of various capacity and resource weaknesses but to lay the ground for an estimate about what resources are needed now. Finally, Chapter Four outlines the Big Bang and what is required in actual spending for Europe to take care of itself.

Obviously, there are strategic elements connected to Big Bang spending – and they have grown more urgent as the second Trump administration seems intent to disrupt global affairs even more than President Trump did in his first term. In its efforts, Europe should develop a clear strategy that accounts for when and in which policy areas it views other countries, including the United States, as competitors and when as partners or allies. These categories are not mutually exclusive: the EU may in some realms manage to compete and, as a result, provide solutions that also benefit its ally. However, the old Transatlantic compact, built on free-market economic competition and a solid military alliance, should no longer be taken for granted, and Europe needs a broader strategy for avoiding a catastrophic break-up of the compact while it pursues its own interest, provided it can formulate one. No one knows at this point what will happen to the alliance in the future, and Europe had better prepare for different outcomes. One thing seems clear: Europe cannot rely on US military protection and at the same time be circumspect, or passive-aggressive, in its economic and regulatory policies vis-à-vis the US. At some point, America will lose its patience.³⁰

³⁰ It is notable that more liberal and "Atlanticist" voices in the US now are beginning to call for a much more aggressive economic diplomacy against Europe for its discrimination of US firms. See for instance, Robert D. Atkinson's (2024) "Go to the Mattresses: It's Time to Reset U.S.-EU Tech and Trade Relations." ITIF.

2. EUROPE AND GLOBAL TECHNOLOGY COMPETITION

"Everything is theoretically impossible, until it's done."

Robert A. Heinlein

Europe is a prosperous region. Whatever the metrics – the size of the economy, GDP per capita, standard of living, technological advancement³¹ – many EU countries rank high. The root of this advantage can be attributed to centuries of investment in and production of ground-breaking technology within these societies. Since the start of industrialisation, the cumulative effect of new productivity and growth has placed Europe and the "West" at the front of the economic development – initially in a global economic pattern that has been labelled the 'Great Divergence'.³² However, in the first two decades of the new millennium, regions such as the Yangtze and Indus River valleys, which had two centuries ago fallen behind, began to seriously catch up. This industrialisation led to unprecedented global economic equalisation. As a result, Europe's share of the global economy – and of new technology, innovation, patents, and R&D expenditure – has been declining. Moreover, the world's centre of economic gravity is moving from the Atlantic to the Pacific.

Worryingly for Europe, the 'Industrial Revolution' of today is being led elsewhere, and the EU's position at the global technological frontier – driving innovation change – has been seriously impaired.³³ Even technologically savvy countries in Europe, those who have been high up various rankings of innovation, are falling behind.³⁴ The next 'Great Divergence' will be centred around the new technologies – such as AI and Quantum, all powered by semi-conductors and requiring super-fast networks and other associated technologies – and those who develop them. The ones who pioneer the green transition – green energy and materials, and clean technology – at substantially lower costs than today will have a competitive edge. Although Europe is still somewhat keeping up at present, with some notable industry leaders and tech-driven entrepreneurs – as well as with some governments that take future technological change seriously – the trend is not encouraging. In fact, Europe is clearly trailing countries like the US and China in high-technology investment and R&D. As a region, the EU is also far behind smaller tech-powerhouses like Taiwan and South Korea in R&D and innovation intensity.

Europe's distance from the technological frontier – and the resulting risk of economic backwardness – is at the heart of Europe's geopolitical problem. No country, not even the United States, can be self-sufficient and rely only on the domestic supply of frontier technology. Obviously, in a world of more equal distribution of prosperity, all countries will become more dependent on others. However, countries with technological strength have something to offer other countries: they are natural attraction points and command economic power. This power can be used for strategic purposes: it is at the heart of economic statecraft.

³¹ World Population Review (2024).

³² Kenneth Pomeranz (2000) *The Great Divergence: China, Europe, and the Making of the Modern World Economy*.

³³ Erixon et. al. (2022) *A Compass to Guide EU Policy in Support of Business Competitiveness*. ECIPE.

³⁴ See for instance, the report on AI in Sweden released by a government review: AI-Kommissionen (2024) *Färdplan för Sverige*.

Poor rates of economic growth, low levels of investment, deteriorating R&D advantages, and a regulate-first attitude to new technology now pose geopolitical threats. Europe still has companies at the frontier of technological development, but they increasingly prosper despite rather than because of Europe. For example, Europe's telecom developers have become dependent on the US for margins and profits, especially as growth markets like China have become less open and profitable. Highly advanced semi-conductor companies share a similar experience: with strategic technology restrictions growing in scale and scope, they find themselves increasingly integrated in the North American world of business customers and regulation. Confronted with a US government less interested in Europe, calls may grow for these companies to relocate to America. It should be a central strategic task to rebuild the competitiveness and advantages for Europe for high-tech sectors. For this, a Big Bang in R&D expenditures is long overdue.

This chapter discusses the EU's competitiveness in transversal high-technologies and their commercialisation. We start by illustrating the extent to which Europe sits behind leading economies in technological development. We then move on to R&D expenditures, showing Europe's standing in its three main forms – Gross Expenditure on R&D (GERD), Business Expenditure on R&D (BERD), and Higher Education R&D (HERD). Lastly, we conclude with a subsection dedicated to the European Innovation Council (EIC), and how it could play a crucial role in the commercialisation of higher technology.

2.1. The Tech Frontier

Compared to leading innovation economies, the EU is a laggard. It is behind in those areas of development which are driving the future of technology, with broad potential applications, and those crucial for the green transition.³⁵ Patent growth, both overall and in key technologies, shows the US to be far ahead. Even worse is that the gap has been growing. Somewhat surprisingly, the EU is behind even on the green transition – in energy production as well as energy application. China and the US are the world's largest investors in the green transition. The US is ahead in AI with the largest proportion of leading companies, whilst China has a strong performance in, for example, EVs and lithium batteries, both increasing their market shares at the expense of EU manufacturers.³⁶ It is imperative that the EU takes action to make business and economic conditions for transversal technology sectors more hospitable – and allows for an easier transition for new technologies into the mainstream.

Figure 1 compares the total patent applications of the EU and the US between 1990 and 2021, while Figure 2 focuses on 'frontier technology' patents since 2000.³⁷ Per the latter graph, although the EU is not far behind in the year 2000, the EU's gap with the US has grown considerably over the past 20 years. This can be observed particularly in the business sector, in which the EU is comparatively limited, lacking as it does large innovative companies.³⁸ With new technology and innovation powering new sectors and services – and spearheading structural change

³⁵ Terzi, Sherwood, and Singh (2023) European industrial policy for the green and digital revolution.

³⁶ Ibid.

³⁷ The broad categories are Semiconductors, Computer technology, Digital communications, Audiovisual technology, Optics, and Telecommunications.

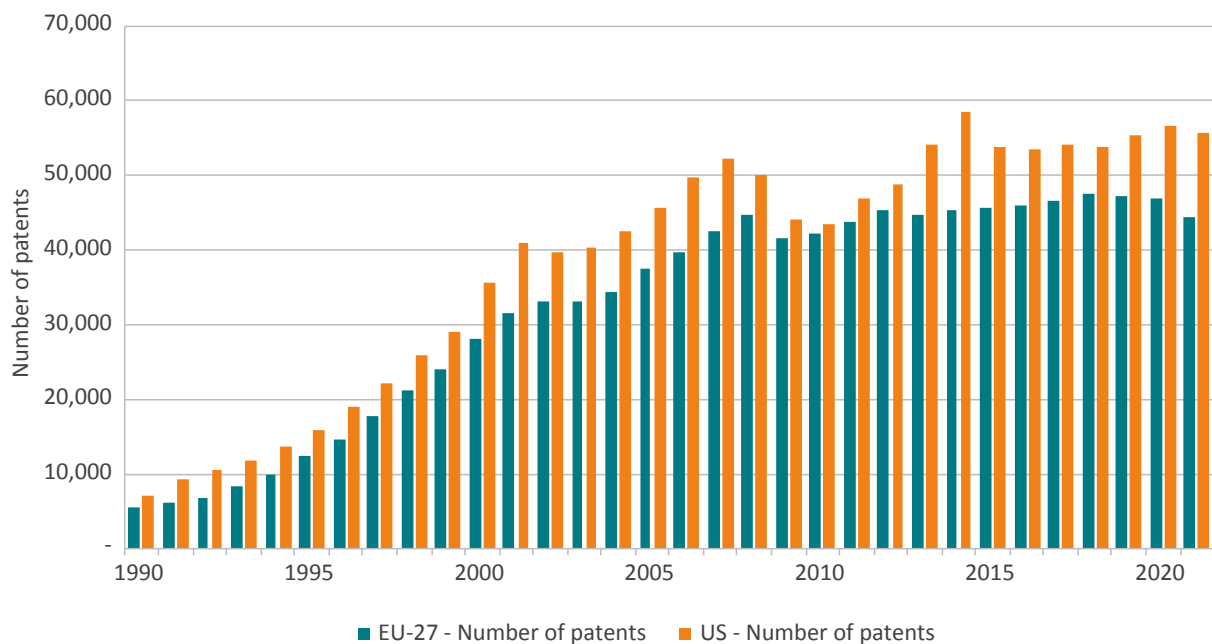
³⁸ Clarivate (2024) Top 100 Global Innovators List. The EU has only 17 companies as part of this list, while the US has over 70.

in the economy – the growing technology gap weighs down on Europe's general economic performance.

Just as Mario Draghi pointed out in his report on European competitiveness, the EU's failing technology sector predominantly explains the growing performance differential between the EU and the US. Compared to the US, both productivity and economic growth have been lower in the EU than in the US in the past 20 years, and if the comparison is between mature European economies (such as core Eurozone members) and the US, the growth differential has been even bigger.³⁹ If the EU or, for that matter, a country like France, were a state in the United States, they would rank as the third poorest state, trailed only by Idaho and Mississippi.⁴⁰

The risks of having such a technology gap extends beyond the economy. At a time of heightened geopolitical conflicts, access to high-performing technology companies is of strategic importance and directly relevant for military capacity. The boundaries between civil and military technology are increasingly blurry. Battlefield agility and flexibility now draw on access to cadres of data engineers and other R&D intensive human capital, and the future of the European defence industry is crucially dependent on vastly expanded resources for R&D and innovation.

FIGURE 1: TOTAL PATENT APPLICATIONS IN THE EU-27 AND THE US, 1990–2021



Source: Erixon, Guinea, and du Roy (2024) Keeping Up with the US: Why Europe's Productivity Is Falling Behind (ECIPE)

³⁹ Dugo and Erixon (2024) A Strategy for a Competitive Europe: Boosting R&D, Unleashing Investment and Reducing Regulatory Burdens. ECIPE. See also Erixon, Guinea, and du Roy (2024) Keeping Up with the US: Why Europe's Productivity is Falling Behind. ECIPE.

⁴⁰ Erixon, Guinea, and du Roy (2023) If the EU was a State in the United States: Comparing Economic Growth Between EU and US States. ECIPE.

As can be observed in Figure 1, the gap is not written in stone: the EU is not too far behind in total patent applications, and it did manage to reduce the gap in the early 2010s. With the US having a faster pace of innovation creation and adoption, and a growing group of leading companies that significantly raised the country's business R&D spending, it has again become a much bigger source of new high-tech patents.⁴¹

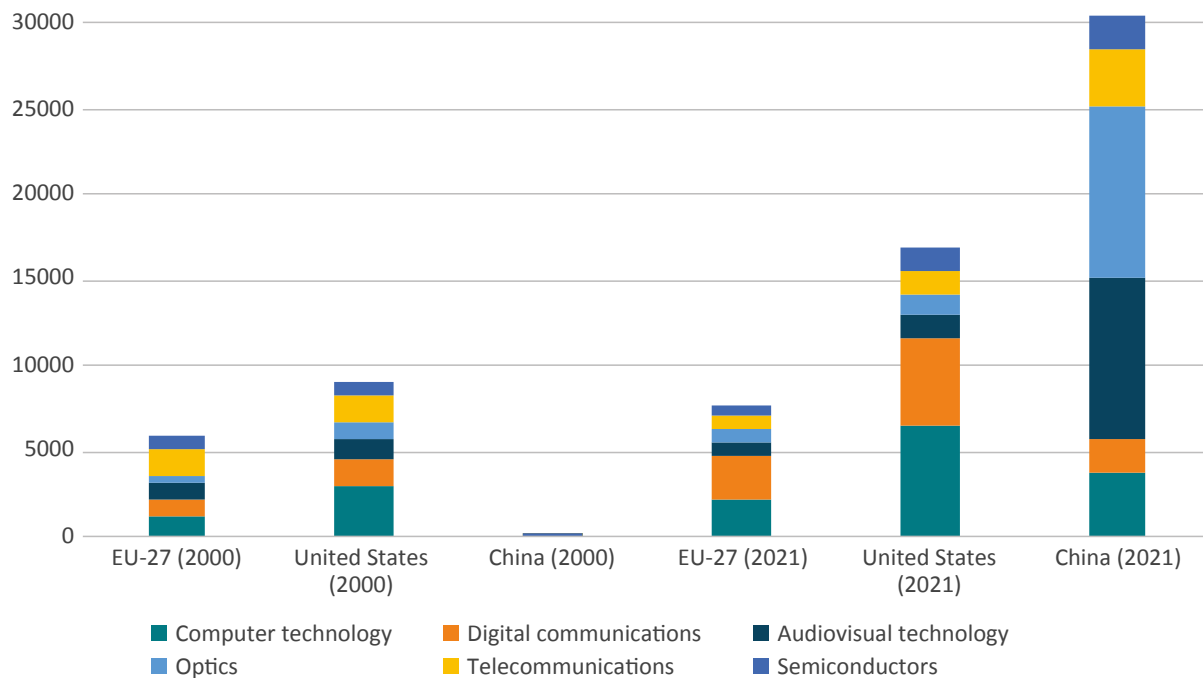
More critically today, the EU is particularly behind in patents for key technologies – those that will drive much of future economic development. Figure 2 breaks down the data on key technologies and shows how the gap between the US and the EU has grown significantly since the year 2000. The US started off ahead of the EU, with a greater proportion of patents in computer and digital communications technologies. While the EU has increased its proportion of computer technology and digital communications patents, the number filed has increased at a slower rate since 2000 (six thousand patents in 2000 versus eight thousand in 2021). In the meantime, the number of such patents in the US has surged to seventeen thousand by 2021. The absolute difference between the EU and the US has thus risen from three thousand in 2000 to ten thousand in 2021.

Considering China, a country the EU has labelled an "economic competitor and systemic rival", the EU's geoeconomic fragility becomes clear. China is an economic superpower with the ability to move markets and compete in frontier technologies. The EU's dependence on strategic technologies and goods from China has already become an issue in Brussels and European capitals. While the number of products in which the EU has a vulnerable import dependency may not be many, a greater concern for Europe is that this dependency may grow because of its own technological weakness.

Alongside these developments, China has established itself as the global leader in patents – albeit with concerns over their quality.⁴² As shown in Figure 2, China has grown from having a miniscule number of patents in frontier technologies in 2000 to being the global leader in 2021 with almost double the US figure and triple that of the EU. Table 1 further below illustrates this growth in total patents – a fifty-fold increase from 1300 patents filed in 2000, to 64000 in 2021. Not only is the EU losing sight of the US, its old sparring partner, the global benchmark is now being set by stronger and more fateful competition. It remains to be seen whether the EU can even develop the will to compete.

⁴¹ Ibid

⁴² Fuest et al. (2024, p.14.) EU Innovation Policy – How to Escape the Middle Technology Trap? IEP Bocconi.

FIGURE 2: NUMBER OF PATENTS IN FRONTIER TECHNOLOGIES IN THE EU-27, THE US, AND CHINA, 2000 AND 2021

Source: Erixon, Guinea, and du Roy (2024) Keeping Up with the US: Why Europe's Productivity Is Falling Behind (ECIPE); OECD-MSTI (China data).

China is an ascending power in R&D and leader and developer of new technologies (see below for data on Chinese R&D spending). As such, current dependencies may well be exacerbated and include strategic assets like human capital, knowledge, university infrastructure, and ideas.⁴³ Brussels already talks about applying technology transfer demands to Chinese firms – replicating policy methods that China has used to access superior technology from abroad.⁴⁴ What started as a deep trade partnership has spilled over into a relationship of growing frictions and hostility; a relationship with a rapidly shrinking number of meaningful contacts of economic diplomacy and with few institutions that provide structure and credibility, and clear opportunities to address obvious problems in predictable and market-friendly ways. The EU and China have imposed sanctions on each other and there are export controls on key inputs: the EU looks set to reduce its imports from the country while China looks for ways to expand sales in Europe amid worsening trade relations with the US.^{45, 46} China has also become an exporter of economic disorder through its use of state aid and other distortive mechanisms that defy the principle of market competition.⁴⁷

⁴³ Niklas Swanström, Fredrik Erixon, and Mittika Sarkar (2024) The US and EU, and the Emerging Supply Chain Network: Politics, Prospects, and Allies.

⁴⁴ Hancock, Bounds, and Russell (2024) "EU to Demand Technology Transfers from Chinese Companies." Financial Times.

⁴⁵ Vasselier and Chimits (2024) China and the EU, what to watch for in 2024. MERICS

⁴⁶ Arcesati, Chimits and Hmadi (2024) Keeping Value Chains at Home: How China controls foreign access to technology and what it means for Europe. MERICS

⁴⁷ In fairness, it should also be noted that the EU is a growing exporter of economic disorder and market fragmentation, not least through regulations like the GDPR and CBAM.

TABLE 1: CHINA'S RISE AS A TECHNOLOGY GIANT (PATENT APPLICATIONS IN 2000 AND 2021)

Year	Total Patents
2000	1,341
2021	64,158

Source: OECD MSTI

However, if the EU is to avoid dependence in strategic goods and technologies on a rival and potentially hostile country – all too costly, as observed in the case of weaning Europe off Russian energy – it must redouble its efforts of diversifying imports and, critically, regaining its position at the frontier of technology. China is not a threat to Europe's territorial integrity, but it is building stronger relations with Europe's enemies and – together with Russia, Iran, and North Korea – is already involved in hostile operations within Europe. It is also using technologies for strategic purposes, for instance, by denying access to critical technologies in the event of political frictions.

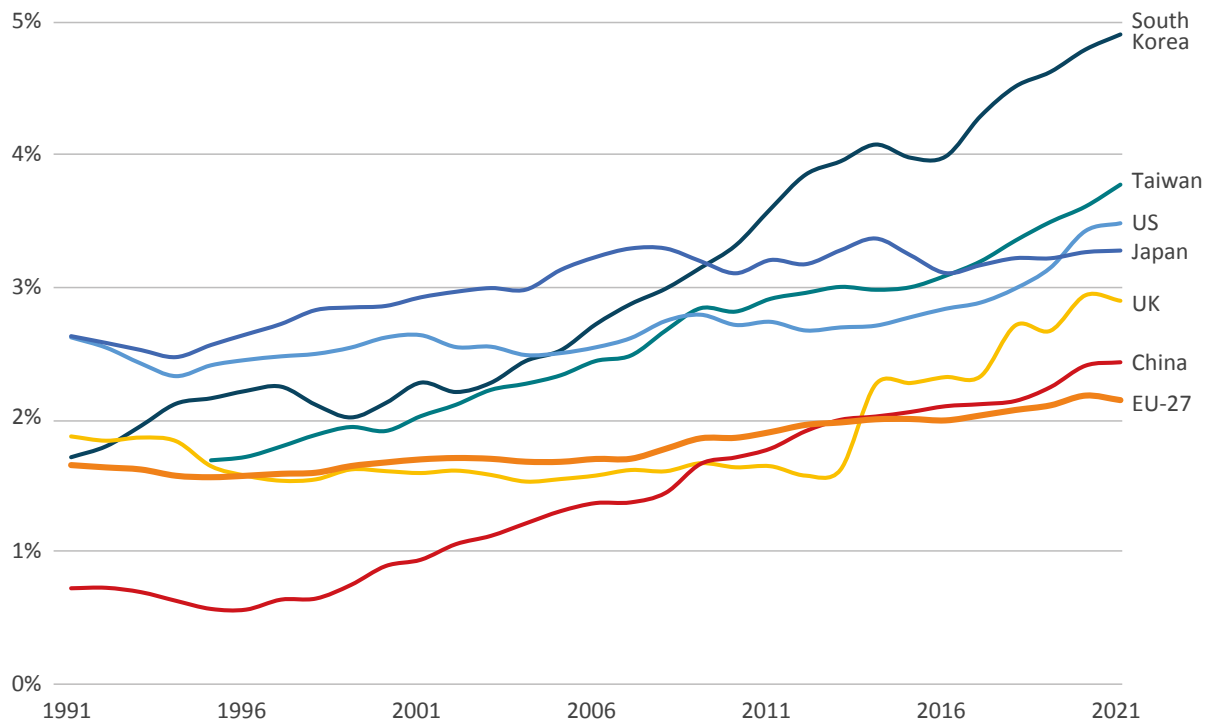
2.2. Europe Trailing in Research and Development

The EU is trailing leading innovation economies in R&D expenditures, and there are good reasons to link Europe's comparative R&D decline to its issues with technology capacity. Figure 3 shows the evolution of R&D spending as a share of GDP over a thirty-year span starting from 1991. Unequivocally, it points to the EU's failure to keep up with other major economies, and how this major divergence starts with the new millennium. The EU has been straddling below 2 percent of GDP for a long time while the US and Japan circled around 3 percent. In the meantime, China, starting as an R&D minnow, has now overtaken the EU at 2.4 percent. Taiwan and South Korea are notably ahead of other economies, the former combining high R&D intensity with growing innovation in sectors such as ICT and advanced semiconductors.^{48, 49, 50} A similar outlook characterises total patent applications and university rankings – a metric dominated by the US and the UK with new competition from Asian universities. This is not to declare a be-all-end-all relationship with these metrics, but they all form part of the picture of greater decline for the EU.

⁴⁸ Benson, Mouradian, and Alvarez-Aragones (2024) Evaluating Chip Over-Capacity. CSIS. Taiwan and China reportedly produce more than 70% of the world's microchips.

⁴⁹ Dirox (2023) Competitiveness in the ICT Sector of South Korea.

⁵⁰ Dugo (2024) South Korea Versus Japan: What Can the EU Learn from the Two Countries? ECIPE.

FIGURE 3: GROSS DOMESTIC EXPENDITURE ON R&D (GERD) AS A SHARE OF GDP IN SELECTED ECONOMIES, 1991–2021

Source: OECD

In the Lisbon Strategy, launched at the start of the new millennium, the EU agreed to bolster its R&D spend to 3 percent of GDP. However, aggregate EU R&D spending as a share of total GDP (GERD) has barely grown at all in the past two decades. Since 2015, it has only increased by a mere 0.1 percentage point. Spending now amounts to about 2.1 percent of GDP, which means the EU is trailing more than EUR 130 billion a year behind its own target set 25 years ago. If the trend continues, increasing the R&D spending (as share of GDP) by 0.5 percentage points in a period of 20 years, the EU would reach its 3 percent target a few years after 2050 – half a century after it was put forth.

However, a 3 percent target is likely to already be outdated: it reflected the structure of the economy in the 1990s, if not the 1980s, rather than the economy of today. It certainly does not reflect the economy of the future, which is becoming more R&D intensive. As observed in Figure 3, the leading innovation economies already allocate much bigger shares of GDP to R&D. The countries in Europe with the highest spending shares – e.g. Sweden and Belgium – are also behind the global R&D frontier countries (see Figure 4 for the individual EU Member States' GERD), and if their performance is compared to leading (and comparable) regions in the strong R&D economies, their lag appears even greater. For instance, the Commonwealth of Massachusetts, a US state, has an R&D spending just below 8 percent of its regional GDP. It is even higher in New Mexico.⁵¹

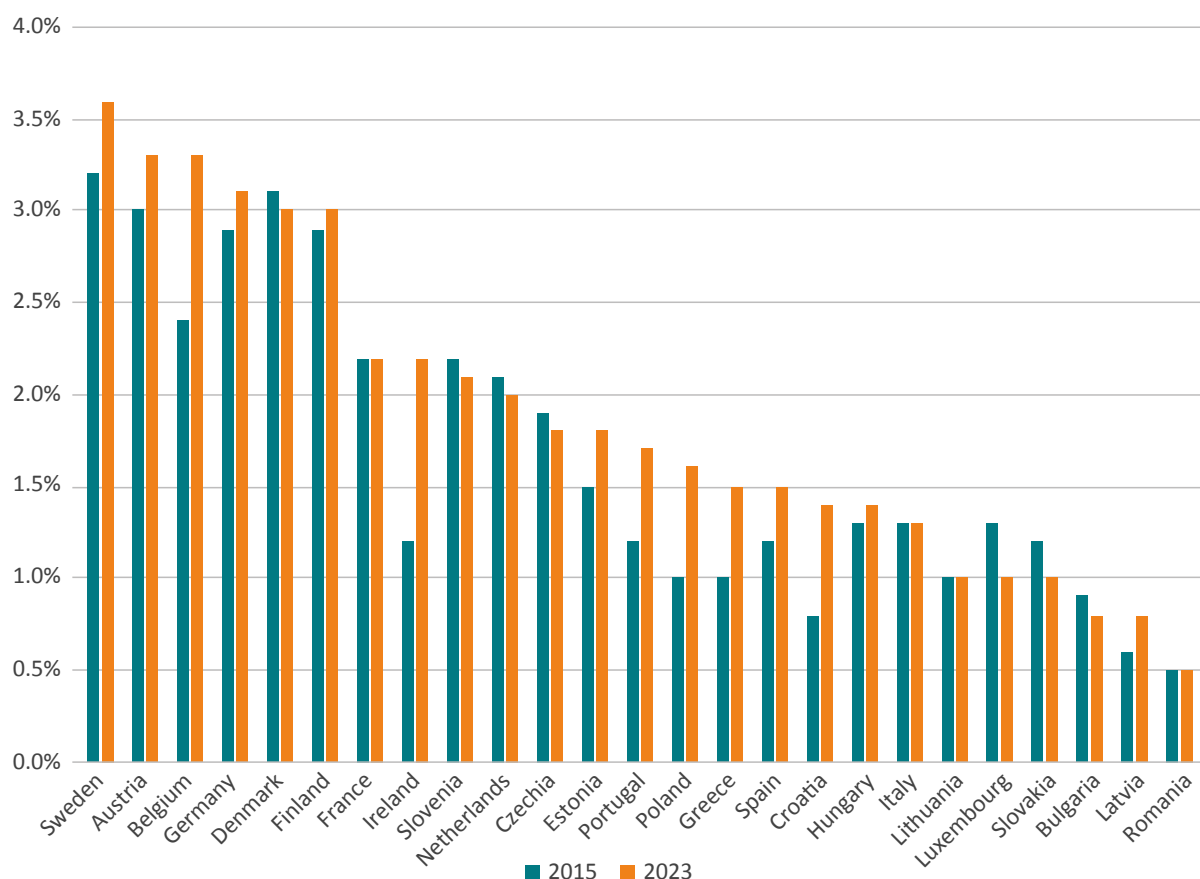
⁵¹ Dugo and Erixon (2024) A Strategy for a Competitive Europe: Boosting R&D, Unleashing Investment and Reducing Regulatory Burdens. ECIPE.

In response to R&D underperformance, some countries are increasing their spending shares. Brussels is also making some amendments, and the current annual spending on research and innovation in the EU budget stands just under 14 billion euros. Moreover, the EU is expanding facilities such as the European Innovation Council (EIC) to help make better use of these funds.

However, after the sustained period of underperformance, the need for an overcorrection looms large. The cumulative benefits accrued by those who have been investing more in R&D will make it difficult to attain parity, even if the EU was to suddenly meet its old target (3 percent). To make the EU more competitive in the future, both at the frontier of technology and in legacy industries, the moment calls for a rapid and substantial increase in R&D spending.

The need to increase R&D spending is a clear call; how this is achieved, however, is of course more complicated. As shown in Figure 4, which compares the GERD of EU states in 2015 and 2023, there are only four EU countries that meet the 3 percent Lisbon Agenda target – with two more just below it. Following this group, there is a sharp drop down with a handful of countries investing around 2 percent. The majority, per the graph, invests under 2 percent of GDP.

FIGURE 4: GROSS DOMESTIC EXPENDITURE ON R&D (GERD) AS A SHARE OF GDP FOR EU-27 MEMBER STATES, 2015 AND 2023



Source: ECIPE calculations, based on OECD and Eurostat (2023) data; does not include Cyprus and Malta

Despite these categorical differences, one element is constant. It is the fact that most EU countries' GERD has barely evolved since 2015. Excluding examples such as Belgium, Estonia, Portugal, Greece, Poland, and Croatia, many countries have made minimal increases while some countries have even decreased their spending share. Of course, there is a range of ways in which this issue may be remedied. At first glance, one might point towards the difference in expenditures amongst EU Members, a seemingly unsustainable gap between the smallest and largest (proportional) spenders. And it is correct to say that all countries cannot have the same R&D spending target: each Member State has different internal obligations and capacities. Setting an equal target for all states would simply negate the differences among the broad collection of EU countries, both in terms of their financial capacity and industrial profile. Reaching the 'GERD' target constant in the nearer term – an aggregate of 3 percent, placing the EU above China and nearer the US and Japan – requires a political achievement.

The technological "infrastructure" required for effective R&D is also an important factor. A high volume of research personnel, adequate facilities, the agglomeration of (multi-national, preferably higher tech) business, high quality education, and other factors are all key for R&D performance and for increased spending to generate desired outcomes. Evidence shows that, while spending on R&D yields GDP growth, the rate at which it does so is strongly linked to the level of 'absorptive capacity' – the ability to assimilate and practically apply new knowledge.^{52, 53} Some of the newer EU Member States, such as Estonia and Poland, have significantly increased their absorptive capacities relative to Northern and Western Europe.^{54, 55} However, others such as Romania and Bulgaria remain behind.⁵⁶

Thus, placing a heavy burden of R&D spending on states with lower capacity would not make sense as they need to first improve educational quality and modernise their business sector. Indeed, government-level R&D initiatives are less effective in low-absorptive capacity regions and they may prevent them (if too high) from making other structural investments which increase absorptive capacity.⁵⁷ Bearing this in mind, it is better for EU policy to push the more advanced members with a high absorptive capacity to increase R&D spending substantially, and hence push the bloc as a whole forward.⁵⁸

A similar pattern can be observed in the US where the R&D and innovation drive is carried along by a few superstar states (such as New Mexico, Massachusetts, Washington, and California).⁵⁹ On this basis, it would defeat the purpose to chase a low-absorptive capacity country such as Bulgaria for failing to meet, say, 2 percent of GDP in R&D. Rather, it is better to push highly

⁵² Celli, Cerqua and Pellegrini (2024) Does R&D expenditure boost economic growth in lagging regions?

⁵³ Cohen and Levinthal (1990) Absorptive Capacity: A New Perspective on Learning and Innovation.

⁵⁴ The New Economy (2019) "How Estonia became Europe's tech hotspot." The New Economy.

⁵⁵ Fowler et al. (2024) Quantifying public and private investment in European biopharmaceutical research and development. The paper details Poland's rise as a biopharmaceutical hub, with high access to educated labour, alongside its advancing defence industry.

⁵⁶ European Commission (2022) EU innovation performance continues to improve in spite of challenges. According to the report, innovation in the EU still lead by Western and Northern European countries.

⁵⁷ Foreman-Peck and Zhou (2022): R&D subsidies and productivity in eastern European countries.

⁵⁸ Radicic, Borovic, and Trivic (2023) Total factor productivity gap between the "New" and "Old" Europe: an industry-level perspective. Study of 8 CEE countries, show that 'TFP growth is higher where there is TFP growth at the frontier, and when the gap is "larger"'.
⁵⁹ BEA (2024) Experimental R&D Value Added Statistics for the U.S. and States.

absorptive countries like Sweden, Belgium, Germany, and the Netherlands towards a 5 percent R&D allocation in the near term. National-level R&D initiatives have proven more effective in such countries⁶⁰, and to achieve the collective aim of competing in the upper echelons of world technology, it is primarily the more advanced states of the EU that need to up their performance.

However, other countries are not exempted from R&D responsibility. A lack of R&D spending can act against economic convergence and maintain less advanced countries in a position of low performance and technological weakness. It is also necessary for these countries to spend more on R&D for the purpose of having base capacity for higher education. In fact, increasing R&D expenditure has proven to increase absorptive capacity.⁶¹ Taking the example of Taiwan and South Korea again, despite their stark differences in system and circumstance, a central feature of their ascent was high R&D investment. Both countries started off seeking "technological catch up" and economic convergence with frontier countries, being far behind the developed world. With strong initiative from both governments to drive innovation in the private sector, their economies joined the ranks of the global innovators.⁶² To put this into context: even the least advanced EU states are in more advantageous positions than either South Korea or Taiwan were when they embarked on their high-tech journeys four decades ago.

A Big Bang approach thus requires a substantial increase in EU R&D spending soon. While aggregate EU R&D spending is now aimed at 3 percent of GDP, the overall target should be changed to 4 percent. In fact, this is where the EU should be now. Arithmetically, this means that high-absorption countries should spend more than 5 percent of GDP on R&D. This will help correct the compound losses from previous decades, and any technological spillovers which can be accrued from high R&D spending – from those higher up the ladder especially – help facilitate the increase.⁶³ Hence the more technologically advanced Member States should show their mettle.⁶⁴ Another crucial factor in both the Korean and Taiwanese cases was a significant broadening of their capital markets⁶⁵, without which neither could have grown. The EU should look to explore the expansion of capital for R&D through its Capital Markets Union targets, specifically for the kind of capital markets that help fund innovation growth.^{66, 67}

⁶⁰ Foreman-Peck and Zhou (2022): R&D subsidies and productivity in eastern European countries. According to the paper, "EU 15" states recorded higher marginal effects of policy innovation.

⁶¹ Griffith, Redding, and Reenen (2023) R&D and Absorptive Capacity: Theory and Empirical Evidence.

⁶² Wang (2007) From Technological Catch-Up to Innovation-based Economic Growth: South Korea and Taiwan Compared. As explained in the paper, while South Korea took an approach which empowered its national champions ("chaebols"), Taiwan kept its diverse SME driven economy. South Korea also adopted a high-debt, high-volume financing model driven by the state. Taiwan, in contrast, followed a low-debt, high-stability model, based on strong trans-national knowledge networks.

⁶³ Radicic, Borovic, and Trivic (2023) Total factor productivity gap between the "New" and "Old" Europe: an industry-level perspective.

⁶⁴ Celli, Cerqua, and Pellegrini (2024) Does R&D expenditure boost economic growth in lagging regions?

⁶⁵ Wang (2007) From Technological Catch-Up to Innovation-based Economic Growth: South Korea and Taiwan Compared. With its own caveats: Korea was driven to crisis in the late 1990s partly due to an explosion in debt.

⁶⁶ European Commission (2022) What is the capital markets union?

⁶⁷ Demertzis, M., M. Domínguez-Jiménez and L. Guetta-Jeanrenaud (2021) Europe should not neglect its Capital Markets Union. Bruegel. This paper argues for the CMU as it allows a greater concentration of equity-based financing, more preferable for high-tech investments.

2.3. Featherless ‘BERD’ – The Root of the R&D Difference

To get deeper into the R&D data and effectively understand the root of the EU's R&D underperformance, it is imperative to break down R&D spending into its sectoral components. Table 2 details Gross Domestic Expenditure on R&D by sector of performance for leading innovation economies. As shown, the EU has a comparatively large share of its gross R&D spending (or GERD) coming from public R&D and higher education R&D (HERD). In HERD, it also spends nominally more than the other economies. However, despite widely different economic structures, other economies have a significantly larger share of R&D coming from the business sector. Almost 80 percent of total R&D spending in the US, China, Japan, and South Korea derives from private firms. In Taiwan the figure goes up to 85 percent whereas it drops to a mere 66 percent for the EU. Remarkably, the US private sector devotes nearly two and a half times more resources in absolute terms to R&D than its European counterpart.

TABLE 2: GROSS DOMESTIC EXPENDITURE ON R&D (GERD) BY SECTOR OF PERFORMANCE FOR SELECTED COUNTRIES AND REGIONS, 2022 OR LATEST AVAILABLE YEAR (2015 US DOLLARS, BILLIONS, CONSTANT PRICES, PPP AND PERCENTAGE OF GDP)

Country, Region	Total R&D spending (Bn USD and % of GDP)		Business R&D spending (Bn USD and % of total R&D spending)		Government R&D spending (Bn USD and % of total R&D spending)		University R&D spending (Bn USD and % of total R&D spending)		Other R&D spending (Bn USD and % of total R&D spending)	
US	762	3.6%	601	79%	62	8%	75	10%	23	3%
China	671	2.6%	520	78%	98	15%	53	8%	–	–
EU-27	408	2.1%	269	66%	44	11%	89	22%	6	1%
Japan	180	3.4%	143	79%	14	8%	21	12%	2	1%
South Korea	120	5.2%	95	79%	11	9%	11	9%	2	2%
UK	84	2.9%	60	71%	4	5%	19	23%	1	1%
Taiwan	55	4%	47	85%	4	8%	4	6%	0.1	0.1%

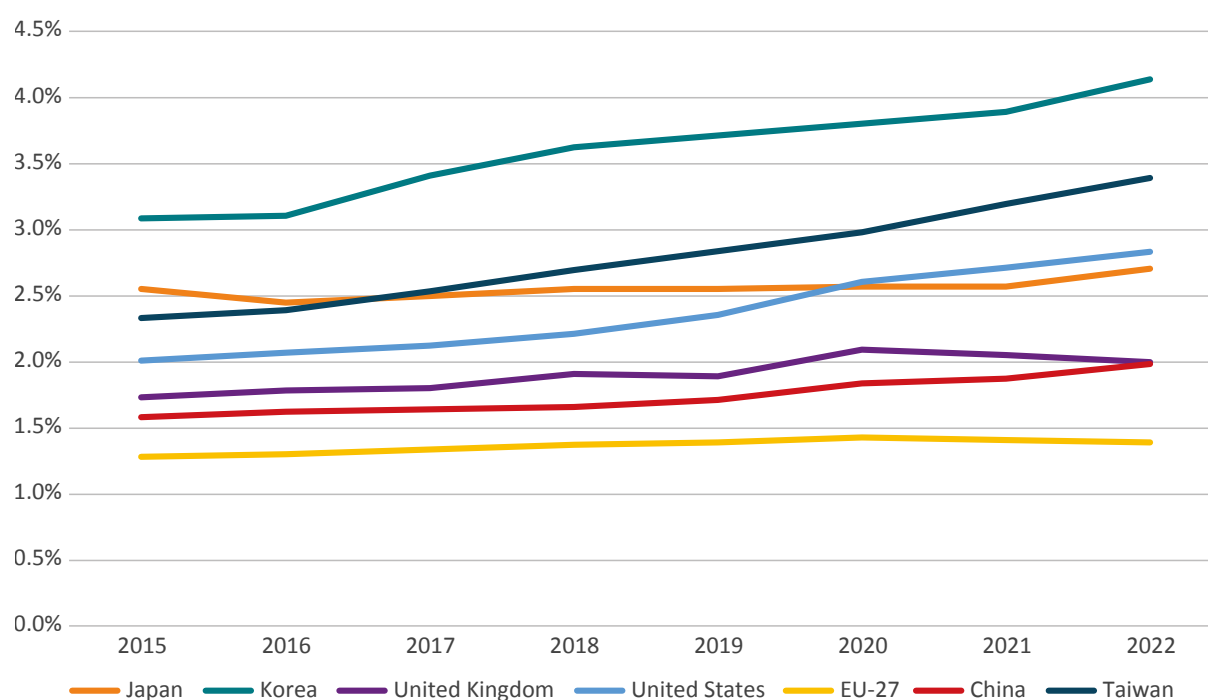
Source: ECIPE calculations based on OECD-MSTI data. Note: for the EU, data points for Cyprus and Malta were not included as they are unavailable. Data for the UK refers to calendar year 2021 as it is the latest year available.

Figure 5 tracks the business R&D – or ‘BERD’ – of these countries as a share of GDP from 2015 to 2022. A lack of data restricts the time period up to 2022. As highlighted, the EU sits plum last at 1.39 percent – a meagre increase of 0.09 percentage points since 2015. One could say the EU is somewhat of a “featherless BERD”. Korea and Taiwan are furthest ahead with 2.5 and 2 percentage points ahead of the EU, respectively. Japan has stayed consistently above 2.5 percent of GDP in BERD, standing at 2.7 percent in 2022, a feat which the US has come to surpass at 2.83 percent. China sits level with the UK at a flat 2 percent. A common feature of all other economies, the UK included, is a clear upswing in BERD expenditure since 2015. Among this world leading group, the EU remains the only one on a stagnating trend. Brexit will have had an undoubted impact, but it is equally clear that the EU and most European governments have not aptly responded to its trailing private sector R&D.

In other words, a first and unavoidable fact in the EU's R&D underperformance is that the bulk of underspending happens at the private sector level. Absent a radical increase in European corporate R&D expenditures, the EU will most likely fail to meet its own R&D spending target and to materialise any credible prospects of increased economic growth and revitalised competitiveness through innovation. Many studies have investigated the reasons behind private R&D underperformance in the EU. An influential analysis⁶⁸ identified two broad set of explanations, those that attribute private R&D underspending in the EU to peculiarly European framework conditions – the so-called intrinsic effect – and those that blame it on the very sectoral composition of the European economy – the so-called structural effect. Advocates of the intrinsic effect point to factors such as difficult access to financing, overregulation, and high taxation as the main drivers of poor R&D spending on the part of EU companies.⁶⁹

Proponents of the structural effect, instead, tend to privilege the idea that the technology profile of European economies – generally skewed towards middle technology sectors rather than high-tech ones – impacts the overall amount of corporate R&D spending in the EU far more greatly.⁷⁰ The truth is likely to be a combination of both factors.

FIGURE 5: BUSINESS R&D (BERD) AS A SHARE OF GDP FOR SELECTED ECONOMIES, 2015–2022



Source: ECIPE calculations based on OECD data.

⁶⁸ Moncada-Paternò-Castello et al. (2010) Does Europe perform too little corporate R&D? A comparison of EU and non-EU corporate R&D performance.

⁶⁹ Aghion (2006) A Primer on Innovation and Growth. Bruegel.

⁷⁰ Moncada-Paternò-Castello and Grassano (2022) The EU vs US corporate R&D intensity gap: investigating key sectors and firms.

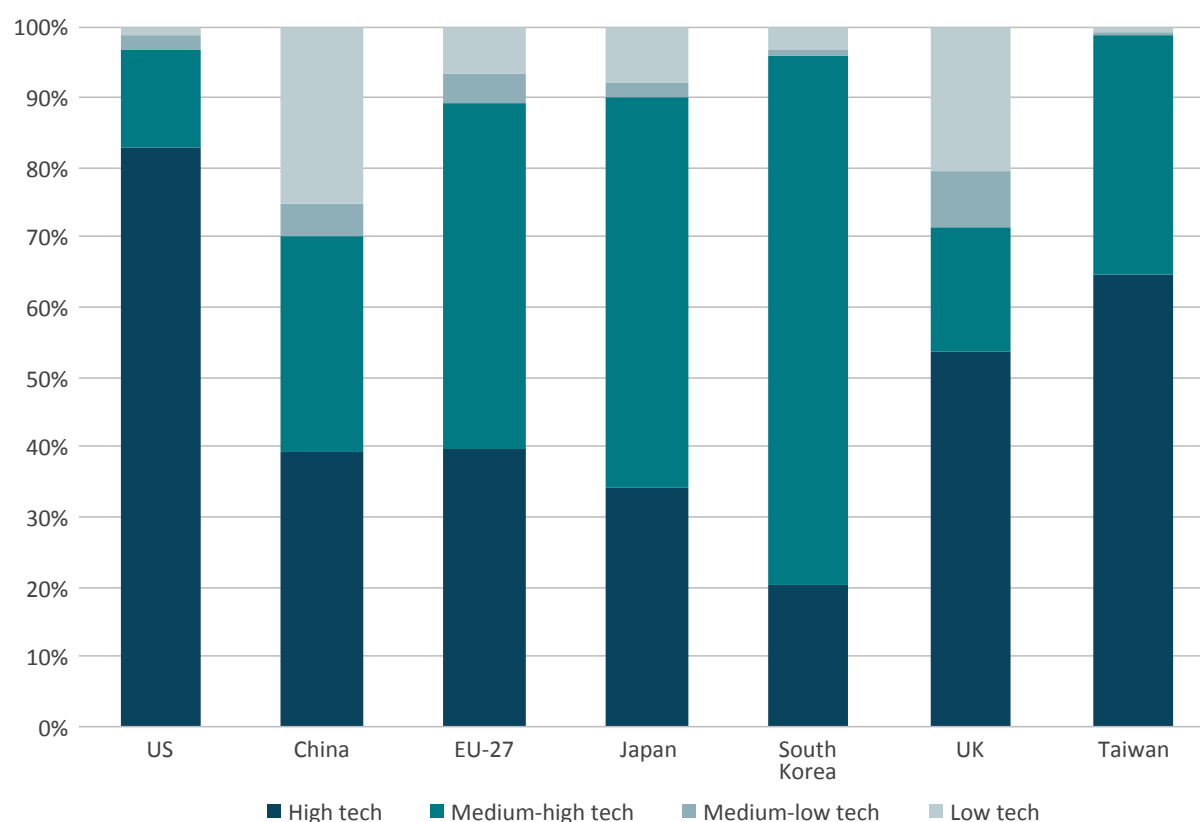
Intrinsic factors are certainly at play. For example, excessive regulation of the banking sector as well as the underdevelopment of capital markets in the EU have been proven to put brakes on the capacity of European firms (especially young and fast-growing companies), to finance themselves and invest in technological innovation.⁷¹ Concomitantly, however, the quantity of corporate R&D spending – how many resources are invested – appears to be inextricably tied to the sector of corporate R&D spending. As expected, many studies suggest that high technology sectors display higher R&D intensity – meaning a greater ratio of R&D investment to output or value added – than middle and low technology sectors.⁷² By this logic, a greater concentration of high-tech companies in an economy is likely to drive the overall private R&D spending upward.

Drawing on data from the 2023 EU Industrial R&D Investment Scoreboard, which provides detailed insights into the world's top 2500 companies by R&D spending in 2022, the picture gets clearer. Although it does not encompass all firms globally, the Scoreboard accounts for 80 to 90 percent of all business R&D spending worldwide.⁷³ Figure 6 shows the breakdown of private R&D spending based on R&D intensity by sectors – high tech, medium-high tech, medium-low tech and low tech – in the world's main frontier economies. What becomes immediately clear is that in the US over 80 percent of all corporate R&D spending is funded by companies active in highly technological sectors, a performance level that no other economy comes even close to matching. Taiwan ranks second, followed by the UK. In contrast, the EU exhibits a more balanced breakdown, with less than 40 percent of R&D spending funded by high tech companies and the largest portion concentrated in medium-high technology sectors. In line with expectations, the EU displays a sectoral breakdown that is much less skewed towards high tech than major R&D spenders like the US or Taiwan.

⁷¹ Dugo and Erixon (2024) A Strategy for a Competitive Europe: Boosting R&D, Unleashing Investment, and Reducing Regulatory Burdens. ECIPE. This reality was also a reason for the EU to establish the European Innovation Council and now informs discussions about launching a "DARPA" in the EU.

⁷² Fuest et al. (2024) EU Innovation Policy – How to Escape the Middle Technology Trap? IEP Bocconi.

⁷³ Nindl, Confraria, and Rentocchini (2023) The 2023 EU industrial R&D investment scoreboard. European Commission Joint Research Centre.

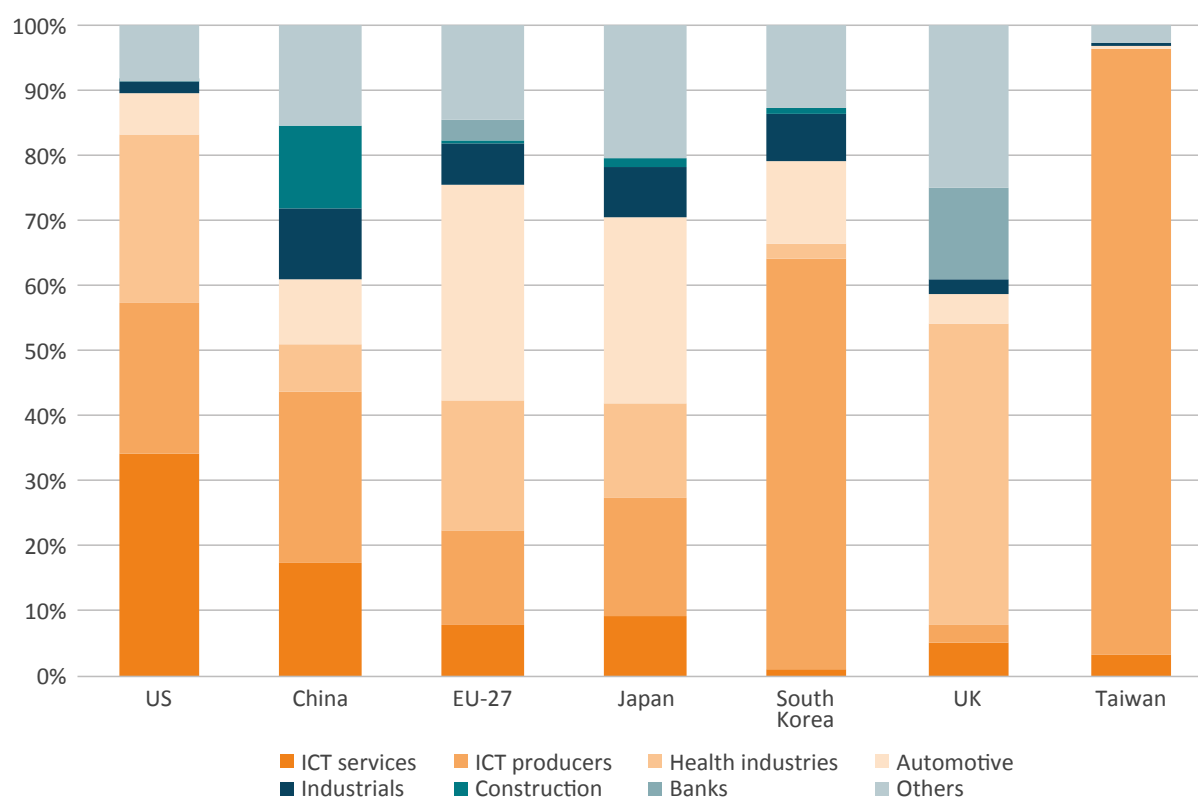
FIGURE 6: BUSINESS R&D SPENDING DISTRIBUTION BY R&D INTENSITY LEVEL FOR SELECTED ECONOMIES, 2022 (PERCENTAGE OF TOTAL)

Source: ECIPE calculations based on the 2023 EU Industrial R&D Investment Scoreboard.⁷⁴ Note: the sectoral classification takes into account the average R&D intensity of all companies aggregated by ICB 3-digits sectors using the OECD definition of technology intensity for manufacturing sectors.

However, an even more granular look at sectoral structure is needed to fully grasp cross-country differences in private R&D spending patterns. Figure 7 serves precisely this purpose: it presents the distribution of business R&D spending by industrial sector for the same set of countries under scrutiny.

In the US, ICT services and products together with pharmaceuticals and biotechnology cover over 80 percent of the whole distribution. Software and computer services alone account for roughly one third of all business R&D spending in the US, making it the only country to invest this large a share in perhaps the most cutting-edge of all industrial sectors. ICT production funds most of the R&D spending in both South Korea and Taiwan, with South Korea focusing largely on medium-high tech sectors such as electronic and electrical equipment and Taiwan also taking on the production of high-tech hardware and equipment. In the UK, high technology sectors like pharmaceuticals and biotechnology bear the brunt of R&D expenditures. Finally, in the EU, it is the automotive industry that singlehandedly contributes the most to R&D spending, whereas the ICT and health industries combined barely reach the 40 percent mark.

⁷⁴ Nindl, Confraria, and Rentocchini (2023) The 2023 EU industrial R&D investment scoreboard - Scoreboard panel 2003-2022. European Commission Joint Research Centre

FIGURE 7: BUSINESS R&D SPENDING DISTRIBUTION BY INDUSTRIAL SECTOR FOR SELECTED ECONOMIES, 2022 (PERCENTAGE OF TOTAL)

Source: ECIPE calculations based on the 2023 EU Industrial R&D Investment Scoreboard.

What lessons can the EU learn from this two-step analysis? First, European economies indeed appear to devote less resources to R&D in high technology industries like ICT or healthcare than some of its competitors worldwide, most notably the US. This difference likely accounts for a portion of the EU's chronic R&D underspending, as the average European company performing R&D spending usually operates in sectors with lower R&D intensity than the average company in the US. At an aggregate level, this results in a lower amount of business R&D spending. This points to the significance of the structural effect. However, the story does not end here.

An interesting counterexample to a purely structural explanation is that of Japan. The EU and Japan have virtually indistinguishable sectoral breakdowns both in terms of R&D intensity levels and industrial sectors – the dominance of the automotive industry in both economies is proverbial. However, Japan allocates roughly 3.4 percent of its annual GDP in R&D spending, while the EU settles for a mere 2.1 percent. Obviously, investing more resources in R&D is possible, even under the same economic structure. Intrinsic factors such as overregulation, hampering experimentation with new technologies, difficult access to business funding and others are likely behind the difference between the EU's and Japan's propensity to R&D spending.

Nevertheless, studies also suggest that R&D spending levels consistently above 3 percent in Japan over the last couple of decades have only marginally benefited the Asian nation when

it comes to productivity increases or economic growth.⁷⁵ A weaker relationship between R&D spending and economic growth points to a more generalised trend of declining R&D efficiency. As technological innovation advances, it takes more and more R&D input to generate a new unit of innovation-driven economic expansion.⁷⁶ This affects not only Japan, but also Europe and other countries. It also raises another problem. The bulk of R&D spending in these countries, in fact, happens in the automotive or other middle technology sectors, whose innovations are hardly applicable outside the sector of origin, in contrast with technological innovations in high-tech sectors like software or biotechnology, which fuse other industries far more easily.⁷⁷ Once again, structural factors seem to matter, especially for the purpose of R&D generating economic expansion. It is no coincidence that thanks to its largely developed high tech sectors, the US, despite also witnessing R&D efficiency decline, has experienced it on a much smaller scale.⁷⁸

There seems to be an interplay of intrinsic and structural factors behind the EU's business R&D underperformance. To put it simply, both the quantity and quality of R&D spending are crucial. Policies that intend to revert the EU's chronic R&D underperformance need to address both challenges if they are going to be successful.

Structural R&D approaches are also called for. The skewed technology profile of EU BERD suggests that governments may need to do more of the heavy lifting in the needed increase in EU R&D spending – either directly or indirectly through, for instance, very substantial R&D tax incentives – and that a greater part of R&D should be allocated to increase the size and competitiveness of transversal technology innovation in Europe. Considering Figure 8, it is notable that none of the EU's mature economies⁷⁹ exceed 2.5 percent in BERD, with France, Spain, and Italy doing especially poorly whilst most EU countries sit below 2 percent. There are also countries with smaller shares: Slovenia at 1.5 percent, Czechia at 1.3 percent, and Estonia, Hungary, Portugal and Poland all hovering around 1 percent. A sizeable shift such as the one observed in Belgium – which has substantially accelerated spending proportional to capacity – is key to the Big Bang philosophy and should be emulated in other countries.

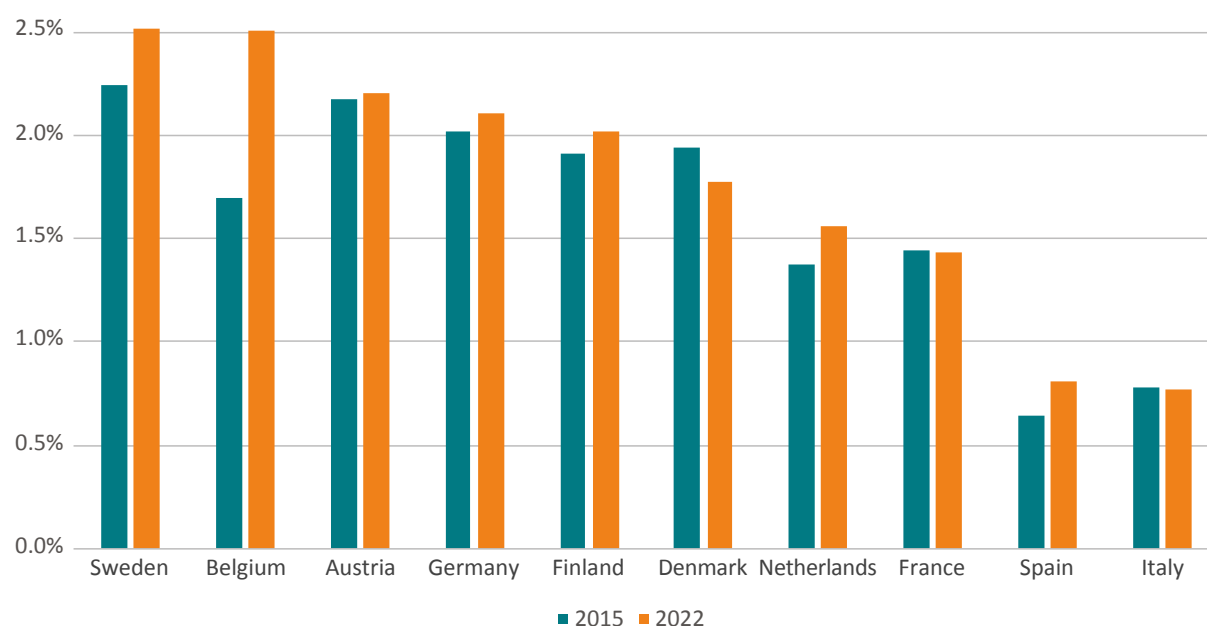
⁷⁵ Miyagawa and Ishikawa (2019) On the Decline of R&D Efficiency. Research Institute of Economy, Trade and Industry (RIETI).

⁷⁶ Ibid.

⁷⁷ Fuest et al. (2024, p.10-11.) EU Innovation Policy – How to Escape the Middle Technology Trap? IEP Bocconi.

⁷⁸ Bloom, Jones, Van Reenen, and Webb (2020) Are Ideas Getting Harder to Find?

⁷⁹ The EU's traditional business leaders such as Germany, France, Italy, Spain, Netherlands, and Sweden.

FIGURE 8: EU-27 GIANTS' BUSINESS R&D (BERD), 2015 AND 2022

Source: ECIPE calculations based on OECD data

2.4. Higher Education

Europe allocates a significant part of its total R&D expenditures to higher education R&D (HERD). Not only does it dwarf its peers in the number of researchers, but it also spends much more on HERD in both nominal terms and as a percentage of GDP. Once taken as individual states as well, the top HERD spenders in the EU (Sweden, the Netherlands, and Germany, for example) rank well above the US.⁸⁰ This is a strategic asset for Europe: it is equally vital for the EU to better utilise its HERD research capacity in the future.

The EU's higher education sector is well advanced, with a high volume of research into transversal technologies such as quantum technology⁸¹ and biotech. In quantum in particular, the EU has been a pioneer and is a leader in early research. However, there is a significant gap in commercialisation and patenting, with the EU being far behind the US and also surpassed by China. In Europe, there is a smaller number of large companies and "unicorns", start-ups valued over USD 1 billion, critical to provide the high-risk investment required in such a field. EU funding in quantum, for instance, is reportedly low risk, with a smaller emphasis on commercialisation.⁸² Since the European Commission itself sets the overall quantum research-funding agenda, it prompts a greater focus on commercialisation by ARPA-like mechanisms such as the European Innovation Council (EIC). A similar pattern can be observed in biopharmaceuticals. The EU has notable science capacity and performs far above both the US and China in HERD quantity and quality but underperforms on transition capacity and financing.⁸³ Several European countries

⁸⁰ OECD MSTI.

⁸¹ Räsänen et al. (2021) Path to European quantum unicorns.

⁸² Ibid.

⁸³ McKinsey & Co. (2021) Can European Biotechs achieve greater scale in a fragmented landscape. McKinsey & Co.

are considered hubs of biotechnology with significant R&D spending – Belgium, France, and Germany among them, and the UK, Switzerland, and Norway in the larger European family. Poland is rapidly rising as well.⁸⁴ What is common in both cases, however, is the inability to translate research-prowess into a significant commercial advantage on the world stage. Too much of talents and research output stay in academia.

EU countries struggle with the quality of universities and the ability to attract world-class talents to EU-based institutions of learning and research. Few universities in the EU rank high globally.^{85, 86} Of the reported (both Q.S. and Times Higher Education) top 100, the EU records a flat zero in the top 20 – a number unchanged since 2010. In contrast the US universities occupy 7 of the top 20 ranks – a dwindling number it should be said, down from 13 in 2010. Looking at the “Engineering and Technology” rankings the EU has only 2 universities in the top 20 (5 for the US). In the “Life Science” and “Natural Science” rankings, the EU has only 1 and 3 universities in the respective top 20's (compared with 12 and 8 for the US).

While it is true that university rankings are not an exact science – a more nuanced browse through the rankings will find more appreciative numbers for “research quality” in EU universities – it is obvious that European universities have not kept pace with US and UK universities overall. There are also many rapidly expanding and climbing Asian universities. One undoubted benefit of high rankings is the ability to attract and maintain high-quality international staff. Leading university hubs like the US, the UK, and Switzerland tend to have higher proportions of international academics (over 20 percent), as do those in the EU.⁸⁷ A less clear risk for the EU is the long-term loss of its academic talent to existing hubs (the UK and US) and to those emerging in East Asia (China, Singapore, India, etc.).

However, there is still a large pool – as large a pool as anywhere else – of academic and research potential which can be better utilised commercially. One way of taking advantage of this may be the creation of more University “Special Economic Zones”, academic bubbles with advantageous business circumstances like access to land, attracting private investment that depends on abundant talent. Dotted around Silicon Valley are several of the world's top universities, and other top specialist schools, which have contributed to its success in churning out high-tech start-ups. Both “attracting human capital to the local area and [...] stimulating entrepreneurial talent in the region” have been a recipe for success – one that has also been imitated in Cambridge, UK, in the field of biotechnology.⁸⁸ Several such centres around Europe's top (science) universities would allow the EU to better synthesise its higher education (R&D) prowess with its private and public investment as well as to strengthen those knowledge networks important for effective R&D. This may also act to complement innovation programmes like the EIC and help foster the future of entrepreneurial talent in Europe.

⁸⁴ Fowler et al. (2024) Quantifying public and private investment in European biopharmaceutical research and development.

⁸⁵ Q.S. Rankings 2024.

⁸⁶ Times Higher Education Rankings 2024.

⁸⁷ ETER (2019) Internationalisation of Academic Staff in European Higher Education. ETER.

⁸⁸ Huffmann & Quigley (2002) The role of the university in attracting high tech entrepreneurship: A Silicon Valley tale.

2.5. Breaking Ground for Strategic Research Projects

More funding towards R&D in Europe should also be combined with better-targeted strategic research initiatives and more efforts to help drive economic expansion on the back of R&D. The EU economy needs a shift in technology profile with a greater role for transversal high technologies. As covered in section 2.2., the EU's total public R&D spending (as a percentage of GDP) is proportionately high whilst it lacks in BERD compared to leading economies, and more public funding thus needs to go into BERD-like R&D – projects that target specific outcomes and seek to prompt a bigger change in the region's overall R&D and innovation profile. In other words, public resources should be used to spur more business research and attract more investment in sectors that have a higher R&D intensity, especially sectors like ICT and digital, deep-tech and quantum, biotechnology, and space.

For the EU's more advanced economies – those with the highest absorptive capacities – this would mean setting their sights on South Korea as an R&D benchmark whilst increasing their strategic support towards transversal high technologies. For those countries that have less absorptive capacity, the focus should be on building it and developing research collaboration with leading universities. In recent times, the EU has taken some steps to expand strategic R&D projects and push them towards greater integration with the business sector. After a successful trial period during the previous multi-year framework, the European Commission has launched the European Innovation Council (EIC) as its own rendition of DARPA – the US Defence Advanced Research Projects Agency, set up to fuel innovation outside the boundaries of state bureaucracy. The organisation itself is split into three departments – Pathfinder, Transition, and Accelerator – each designed to deal with particular technology-readiness phases, and funding is split into two categories with differing portions for each department. One is 'Challenge': projects that "build on new, cutting-edge directions in science and technology to disrupt a field and a market or create new opportunities by realising innovative technological solutions grounded in high-risk/high-gain research and development."⁸⁹ The rest is allocated as open funding.

The EIC is allocated EUR 10 billion across the duration of the framework, with the possibility of increased funding. Since its inception, the EIC has allocated resources to several projects that have delivered commercial outcomes. It has supported 22 'unicorns' with research and innovation resources. It is also trying to support the shift away from middle-tech towards high-tech, not least in the field of deep-tech.

In terms of structure, ARPA agencies place control in the hands of project managers. These are often seasoned experts – "geniuses" – taken from relevant fields, who are given a short-term, risk-friendly platform to build portfolios of various projects with the aim of meeting the administrations' set challenges.⁹⁰ Managers are supposed to be in complete control of funding and management of their portfolios, allowing them to quickly (re)allocate or divert funding in accordance with their targets.

⁸⁹ European Commission (2024) European Innovation Council.

⁹⁰ Azoulay et al. (2019) Funding Breakthrough Research: Promises and Challenges of the "ARPA Model".

The reality is a bit different than the model – ARPA agencies have also been trapped in the bureaucratic mindset of the US government – but the approach has been reasonably successful. DARPA, for instance, has been able to shift many critical innovations up the technology-readiness scale and onto the market over its lifetime. The EIC, in contrast, has a more comprehensive management structure which combines expert project managers (scientists and other distinguished technocrats) with experienced bureaucrats, business leaders and the like. Project managers reportedly manage only half of the total funds and must operate in tandem with their non-scientist colleagues. This system may prove to avoid DARPA's dependence on finding "genius" project managers every time; however, it carries with it the caveat of bureaucratisation, which the DARPA was designed to circumvent. On the other hand, the EIC's incorporation with the SME empowerment projects together into the 'EISMEA' may unduly influence the character of projects controlled.

Unfortunately, consortia requirements and the focus on SME empowerment included in the programme risk diluting the potential positives of the EIC.⁹¹ There is a general EU over-emphasis on seeking a "Union approach" and building "ecologies" and consortia – leading to an under-emphasis in supplying capital to a single company with the potential to grow very fast and lead the market with technology. While SMEs can be innovative, many of them are not and what is more important is to select targets that can achieve success. Obviously, such candidates also include large firms.

The EIC is still a novel initiative, and the major cases of success have yet to materialise. Still, it has shown good performance and could, after some changes, be expanded. It is evidently weighed down by "safety-play": it demands a lot of collaboration from recipients of funds, and it operates with caution, including too many criteria that are not directly tied to innovation-driven success. Combining a large cluster of elements, policies, requirements, and ambitions only serves to slow down the EIC and make it more bureaucratic and less like the DARPA.

Spurring intra-European collaboration is a core focus in EU policy and presents itself in the EIC programme in the form of multi-state consortia requirements. Though this can be beneficial in one sense, it also leads to administration-heavy projects that requires endless coordination – not a good foundation for technological advancement.⁹² This is especially true once capacity differences between partner countries are considered. As observed in several studies, it can also form another basis of undue political influence.⁹³ The development of new technologies in application-oriented fields, is mainly driven by firm and international best-in-class internal knowledge production conditions. The EU must therefore be more selective where it tries to connect the different Member States, and discard goals that are about intra-EU convergence. Strategic projects are rarely capable of delivering success when they are hamstrung by tangential or disassociated targets.

⁹¹ Fuest et al. (2024, p.24-25.) EU Innovation Policy – How to Escape the Middle Technology Trap? IEP Bocconi.

⁹² Wanzenböck, Neuländtner and Scherngell (2019) Impacts of EU funded R&D networks on the generation of key enabling technologies: Empirical evidence from a regional perspective. It was also found in the paper, that EU funded networks are higher in the "industrial core", or Western Europe.

⁹³ Fuest et al. (2024, p.26-30.) EU Innovation Policy – How to Escape the Middle Technology Trap? IEP Bocconi.

For the EU, funding must be matched with a strong sense of purpose. It must be linked to its ambitions of maintaining economic power that contributes to geopolitical stability and global liberalism. Europe should increase high-tech research funding and make sure the EIC continues to develop its independence from general R&D and policy bureaucracy. It should make decisions more as a strategic funder with proven experience of picking bold entrepreneurs than as an industrial policy actor. Furthermore, the EIC can develop its prize-funding approach and also make these awards more valuable, for instance in Grand Challenge innovation awards targeting transversal high technologies.⁹⁴ Much of the EIC's funding, in further contrast to DARPA, is allocated higher up the technology-readiness ladder, stoking fears that it is acting to fill a venture capital void.⁹⁵ Moreover, Europe suffers from decreased efficiency in its R&D expenditure.⁹⁶ Its ability to translate R&D spending (in the private sector) is less than that of the US and many other counterparts and competitors. Alongside an increase in spending, it is imperative that action is taken to increase the efficiency of R&D, paving the way for more effective incorporation of new technologies.

3. EUROPE'S FALTERING MILITARY STRENGTH

"The absence of alternatives clears the mind marvellously."

Henry Kissinger

Europe is a collection of middle-sized and small countries that, for the past 30 years, have failed to live up to their own small ambitions in defence and military capacity. In fact, as one observer puts it, European NATO members had the "luxury of pretending that the problem of defence had gone away altogether."⁹⁷ While a significant part of Europe is now determined to increase its defence expenditures, the grim reality is that all European countries start from low levels of nominal spending and with substantial capacity problems. These problems include dysfunctional systems (tanks and artillery that just do not work), absent stocks of arms and ammunition, inadequate staff counts, and weak ability to work with modern technology for battlefield power and adaptability. With an enemy that is already in a war economy, that can deliver new military technology and that is not shy of using it – in November 2024 Russia used an inter-continental ballistic missile against Ukraine⁹⁸ – European defence gaps become even more glaring.

Ultimately capacity must reflect that of the enemy – in Europe's case, an aggressive Russia benefitting from the CRINK partnership. Though EU combat vehicles and vessels, arms, and troop numbers are collectively higher⁹⁹, Russia's steep rate of growth means it is adding capacity even if significant equipment volumes are destroyed by Ukraine. Like China, it also has a strong home defence industry that is well coordinated with its public and private sector alike – all under the auspices of the Russian government – thus allowing it greater purchasing power as compared with the EU. Most recent reports comparing Russian defence spending in PPP terms,

⁹⁴ Azoulay et al. (2019) Funding Breakthrough Research: Promises and Challenges of the ARPA Model.

⁹⁵ Fuest et al. (2024, p.38-39) EU Innovation Policy – How to Escape the Middle Technology Trap? IEP Bocconi.

⁹⁶ Ortega-Argilés, Piva, and Vivarelli (2014) The Trans-Atlantic productivity gap: Is R&D the main culprit?

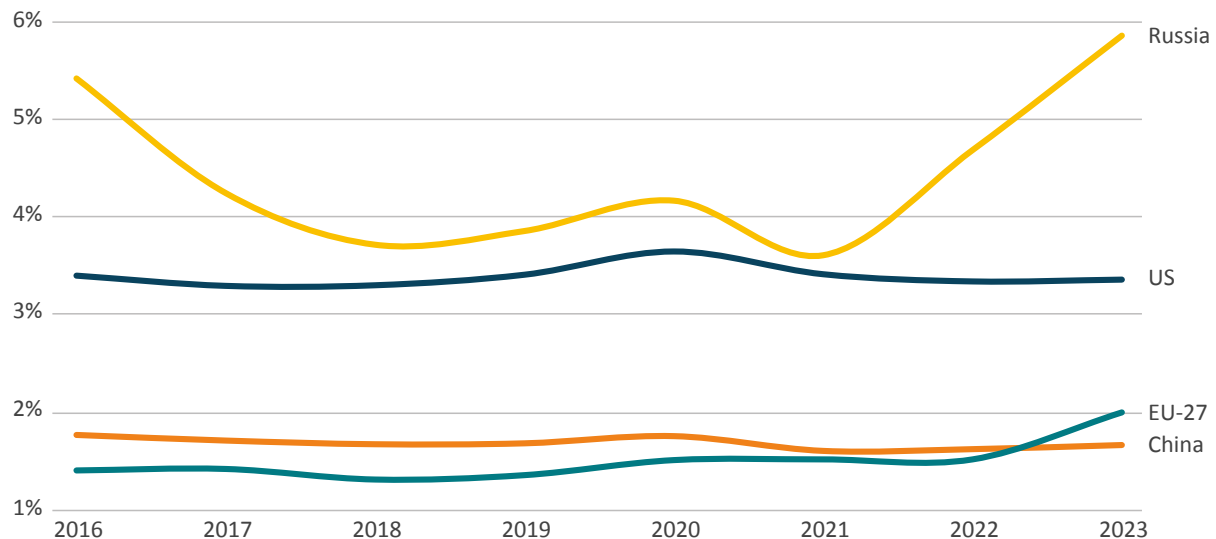
⁹⁷ Keir Giles (2024) Who Will Defend Europe? An Awakened Russia and a Sleeping Continent.

⁹⁸ Malenko, Balmforth, and Hunder (2024) "Russia fired new ballistic missile at Ukraine, Putin says." Reuters.

⁹⁹ Pfeiffer and Cannon (2024) "Why Europe is unprepared to defend itself." Bloomberg.

suggest it is surpassing the EU's collective defence spending¹⁰⁰. Figure 9 illustrates these trends, with the EU having spent 2 percent worth of GDP on its military for 2023 whilst Russia sits just under 6 percent – and counting.¹⁰¹ More importantly, it is enhancing its combat preparedness and advancing its logistical capacity for greater operations. Europe, however, lacks vital experience in large-scale coordinated operations.

FIGURE 9: DEFENCE SPENDING AS A SHARE OF GDP IN SELECTED ECONOMIES, 2016–2023



Source: ECIPE calculations based on SIPRI Military Expenditure Data

Compounding the issue, is the fact that Europe also suffers from a lack of standardisation with regards to its equipment, with modifications applied by different NATO members. Both have been underlined in the early part of the Ukraine war. In fact, a common story from the early days of the Ukraine war is of various 155mm shells not being compatible with donated artillery. These issues can be partly attributed to Europe's defence industry, which lacks a degree of coordination in comparison to that of the US. On the policy side, however, one finds an issue of procrastination in the face of growing animosity over the last decade. The military sector overall has faced significant cuts since the Cold War, and no more so than in the EU. Germany, for instance, went from peak Cold War military spending at about 4.5 percent of GDP to about 1 percent. Powerful Member States – the UK (at the time), France, and Germany leading amongst them – continued their cutting even after Russia's advance warnings in 2008 (Georgia) and 2014 (Crimea) about its revanchism. Of the leading group, only Italy responded to the latter with an increase in its defence budget. The number of combat vehicles and vessels also continued to fall in proportion to budget cuts¹⁰², with the industry thenceforth shifting to niche/high tech low-volume production. The consequences of this radical shift were made clear at the outbreak of the Ukraine war.

¹⁰⁰ Rathbone (2025) "Russian defence spending exceeds all of Europe combined, study finds." Financial Times.

¹⁰¹ Russia has substantially expanded its military spending in the past years. It is now running what amounts to a war economy. It is notoriously difficult to get a full appraisal of the levels of spending, given increasing secrecy and non-transparency in military accounting.

¹⁰² Though still ahead of Russia, the numbers do not incorporate the combined effectiveness, or interoperability of EU arms. As mentioned before, Russia is growing its logistical capacity and now has a larger air-transport fleet.

It is not surprising that European countries exploited the post-Cold War "peace dividend" – moving resources from the military to other areas. But most countries worked with a strategy pointing to higher spending rates to be prompted as soon as threats to security changed. However, this resource shift did not happen: the warning signs of the current world outlook were showing from 2014, if not already in 2008, and yet they did not prompt governments to change course. It is the inadequate responses to these warnings that need to be compensated for now – motivating a Big Bang rather than a softer scale up of resources and capacities. It is encouraging that more European governments are now prepared to allocate more resources for their own defence, but it is only one EU country that has responded adequately to the threat of war – Poland. It is the only country in Europe that has been adding necessary resources and capacities, amounting to very capable armed forces. Countries with active and reasonable resource and capacity planning – and they are fewer than one would think – seem still to be guided more by the available fiscal space than by what is needed to have a credible deterrence and capacity to act resolutely in the event of aggression.

In other words, Europe is still betting on the patience of the US to remain a very big net contributor to Europe's defence. Europe's leaders also take for granted that there is only one theatre of war they need strategy, capacity, and resources for: their own theatre. If asked to commit substantial resources for security in other parts of the world – say, East Asia and the Indo-Pacific – EU governments will come up painfully short. Even if Russia's war on Ukraine has been a strategic wake-up call from the doctrinal slumber of the "perpetual peace," Europe still ploughs the land of self-indulgence and egoism in defence. Other powers should come to Europe's rescue when Europe's freedoms are at peril while Europeans are avoiding pledging resources to the protection of their values and interests elsewhere in the world.

Some optimism is called for. Taken together, Europe has an accumulated nominal spending that is respectable in international comparison, provided that such comparisons do not include military leaders and big aggressors with the ability and wherewithal to concentrate substantial resources and pursue an all-out war with huge casualties. Moreover, there is a structure to build on. Among Europe's ranks are former major military powers like France and the United Kingdom: two countries with nuclear weapons and extensive combat and technical experience – including their navies. The state of their military is poor, but they have foundations to build on. There is another group of high-potential nations such as Poland, the Nordics, and the Baltics – and that group can include Italy and Germany who have advanced defence industries, significant air, land, or naval powers, or that are on a path to improve their defence capacity, albeit from a low level. A third group of capable nations such as the Netherlands and Greece are also raising their ambitions.

The resource challenge for all these groups of countries is big. Defence spending by EU countries for long hovered around EUR 200 billion but has gone up after Russia's full-scale invasion of Ukraine. Defence spending was just under EUR 240 billion in 2022.¹⁰³ For 2023 this figure increased to EUR 280 billion, and in 2024 it is estimated to hit up to EUR 326 billion (using

¹⁰³ European Defence Agency (2022).

constant prices).¹⁰⁴ Still, this number is grossly inadequate, and even more so in light of America's strategic re-orientation towards Asia – and its own neighbourhood in the Western Hemisphere. Substantially more resources will be necessary just to aid Ukraine. While the US remains the key military supporter of Ukraine, providing far more military aid than EU countries,¹⁰⁵ the EU may soon have to take a bigger military burden – or pay for continued US deliveries. This includes the scenario of an end to the fighting in Ukraine, and resource commitments that Europe will have to make to fortify Ukraine to such a degree that Russia will be deterred from attacking again. US defence planning is increasingly moving to the Indo-Pacific, and the US Congress may soon accelerate the shift in resource allocation accordingly. After all, the US grossly underspends on its Asian strategy, and there is growing pressure from friends in the region to move faster.

For military spending, some form of percentage or nominal spending parity with the US is a benchmark for estimating where Europe needs to go. Given the position that Europe starts from, it should be higher than nominal US spending on the military. While greater pressure has pushed many NATO members to attain the agreed 2 percent of GDP, some countries remain unmoved.¹⁰⁶ The US defence spend has consistently remained above 3 percent of GDP over the past decade, whilst that of the EU has been a bit above 1 percent. Obviously, this gap amounts to a very significant difference in nominal spending, with the US at USD 968 billion and EU countries at USD 344 billion (using current prices) for 2024.

Europe needs to change course now – and radically too. First, decades of underspending have led to dilapidated kit and battle capacities, and a struggling defence industry. Many countries now need to rebuild a sufficient level of capacity at a very fast clip. In addition, they need to make very significant investments in new technology and capacities to work with modern data science for battlefield integration and adaptability. In Ukraine, Russia's war performance has been a multi-layered structure of several decades – if not centuries: ranging from old World War II tanks to 21st-century futuristic war technology. Russia's and the CRINK's ambition for space capacity is equally concerning.

Second, the war in Ukraine has made us alert to the fact that scenarios of war include those that are immediate, and Europe needs to be prepared for different types of military aggressions by enemies that collaborate on technology and that have the capacity to adapt as the conflict evolves. If anything, the war in Ukraine has shown the importance of artillery – in all its shapes and forms, from short-distance drones to long-distance air defence – and the devastating effect of Russia's ballistic missiles (which are difficult to defend against) and its capacity to just wear Ukraine's city defence positions down to what looks like garbage heaps.

Third, for the US to remain active in Europe and for Europe to be a net-contributor to security, it needs to start taking non-European resource commitments seriously. This is important – but a perspective that remains painfully absent in European discussion. Europe needs to invest in the global order, not just in its own defence, and this demands better resources

¹⁰⁴ European Defence Agency (2024) 2024 Coordinated Annual Review on Defence (CARD) report.

¹⁰⁵ Bomprezzi, Kharitinov, and Trebesch (2024) Ukraine Support Tracker. IFW Kiel.

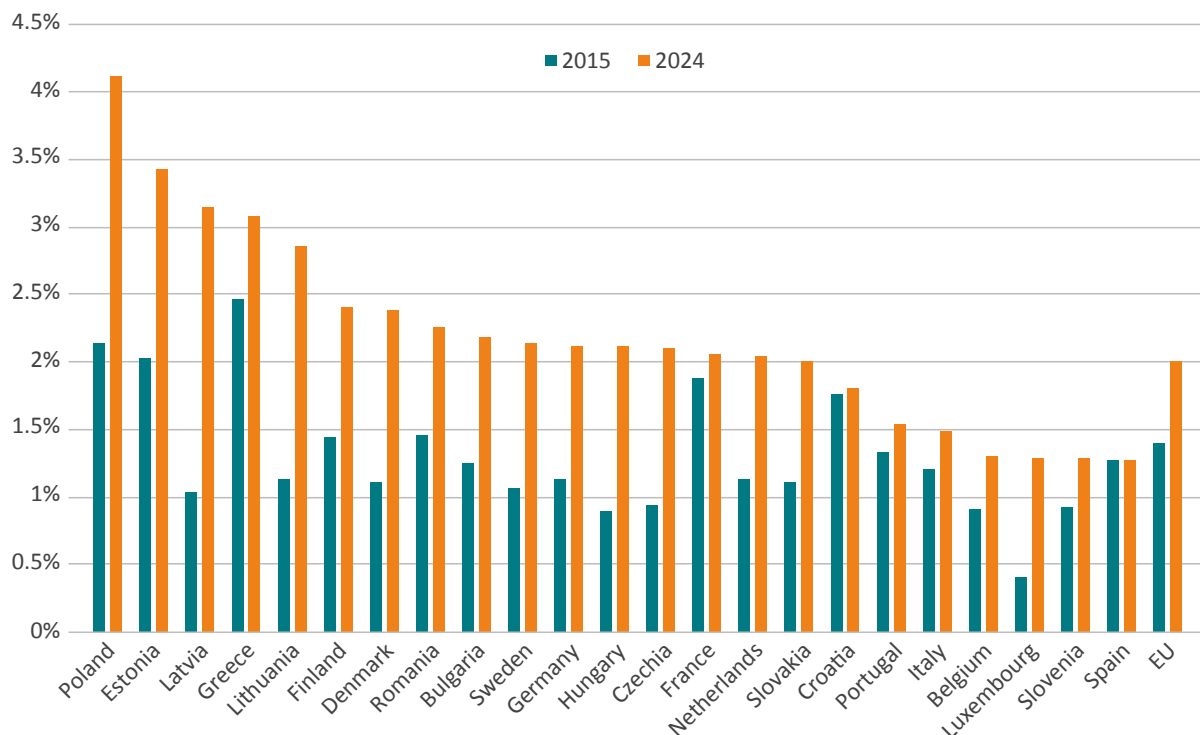
¹⁰⁶ NATO (2024) Defence Expenditure of NATO Countries (2014-2024).

for security in regions that are severely influenced by the CRINKs and their rapidly growing network of military collaborations.

These three factors point to different resource requirements. Europe's enemies are expanding their military spending much faster than we are – about 40 percent of Russia's federal budget is now allocated to military and security policy. America's build-up of deterring military capacity in the 1950s required average annual spending between 10 and 15 percent of GDP, and throughout the Cold War its annual military spending averaged at 7.5 percent. An EU that seriously hikes military spending would not be historically unprecedented.

So far, EU defence expenditure increases are rather a story of gradual change – the Bean Counter method – for most countries, with a few faster-growing outliers. Figure 10 compares EU members' defence spending in 2015 with expected spending for 2024 (as a share of GDP). As members of NATO, most EU countries (23 of the 27) have been pushed to increase their military spend to 2 percent, with 16 out of the 23 on target for 2024 per the latest NATO reports – a marked increase from just 7 in 2023. Although this proves stronger commitment to increasing defence spend in the long term, there is still a substantial amount of “creative accounting” in European defence spending figures. It remains the case that US spending makes up more than half of the total NATO spending for 2024.

FIGURE 10: DEFENCE EXPENDITURE AS A SHARE OF GDP FOR EU-27 MEMBER STATES, 2015 AND 2024



Source: ECIPE calculations based on SIPRI Military Expenditure Database and NATO data (2024). The EU bar represents the EU27 total for 2024 (inclusive of Austria, Cyprus, Ireland, and Malta), and EU28 total for 2015 (the current EU27 and the UK).

It is perfectly possible for countries to radically increase spending in the near term.¹⁰⁷ After all, they have already managed to commit substantially more resources to the military in the last two years. Understandably, those closest to the conflict in Ukraine have rapidly increased their defence expenditure. Poland's expenditure has risen to 4 percent (and climbing) – up from 2.1 percent in 2015, to 2.4 in 2022, 3.3 in 2023, and 4.1 expected for 2024. This equals a nominal increase of USD 8.5 billion from 2023 (current prices), and USD 16.3 billion from 2015 (constant 2015 prices). Estonia is already well above 3 percent of GDP in defence spending, and many countries have managed to go from about 1 percent to 2 percent in two years' time. Hence, it is a matter of setting priorities.

3.1. The Home Front

The EU faces two major security challenges – at home on its eastern border with Russia and a break-down of the current order in the Indo-Pacific driven by increasing aggressiveness from CRINK countries.¹⁰⁸ The more pressing of the two is, of course, Russia with its ongoing war in Ukraine, its long-term destabilisation of Europe's neighbourhood, and its active strategy to disturb political stability and economic development in Europe. This front calls for greater military expenditure in the short run reflecting many urgent needs in Europe's defence, ranging from artillery and armament to cybersecurity. Many EU Member States, the more powerful included, are incapable of defending themselves in the case of war in the foreseeable future.

Gaps and shortages include so many areas they are impossible to list. However, they are important to understand for the discussion about resources. Not even the UK, which has the most advanced army in Europe, has a military that is capable to defend the country: the UK's Minister of Defence, John Healey, recently observed, as others have done before him, that the British Army would not be able to stop an invasion.¹⁰⁹ Earlier in 2024, the National Audit Office of the UK observed in a report for the Ministry of Defence that military stockpiles were so small that the UK could not send equipment to Ukraine anymore.¹¹⁰

The inadequacies in the United Kingdom's defence are many.¹¹¹ Recruitment is a big problem.¹¹² The country does not have a proper ground-based air defence that can protect against long-distance missiles or drone-swarm attacks. It used to have a strong navy and still has two aircraft carriers in its fleet, but lacks navy staff, aircrafts, pilots, and supply ships for both carriers to be in operation at the same time. Stocks of ammunition and tanks have dried up, and the bureaucratic process of procuring new stocks is painstakingly slow. Similarly, the Royal Air Force is nominally strong, but it is stretched thin and lacks vital transport aircrafts. Embarrassingly, the UK had to limit its presence at the D-Day anniversary in France in the summer of 2024 because it could not

¹⁰⁷ For instance, central government spending, as share of GDP, increased by 4 percentage points in Germany and Spain between 2019 and 2023, and by 7 percentage points in Italy.

¹⁰⁸ There are obviously other threats too, including threats to maritime lanes.

¹⁰⁹ Brown (2024) "Armed forces could not stop an invasion, admits defence secretary," The Times.

¹¹⁰ NAO (2024) Investigation into Military Support for Ukraine. NAO.

¹¹¹ See the chapter by Albin Aronsson in Björn Ottosson and Krister Pallin (2024) Western Military Capability in Northern Europe 2023: Part I – National Capabilities. FOI.

¹¹² Rick Haythornthwaite (2023) Agency and Agility: Incentivising People in a New Era. UK Ministry of Defence.

divert parachute-capable aircraft from other missions.¹¹³ The country presents itself as having a world-class army but, like other countries, does not want to allocate resources to achieve the goals.

Germany is another big NATO member struggling with capacity and basic elements like arms-procurement.¹¹⁴ In fact, the state of the German military is so poor that many observers in Germany talk about it in the language of dark humour – including its problems of keeping internal conversations about strategy and capacity secret from its main enemy. Bureaucracy keeps Germany from quickly assuming necessary responsibility for its role as a central logistics hub for army movements for the entire alliance, leading partners to avoid German airspace. The head of the Germany Army, Alfons Mais, has been one of the more vocal critics. Just as he was taking up his position in 2022, he said that the army is “empty handed” and effectively amounted to “more or less nothing”. On Germany’s contribution to NATO and partner, he said that “the options that we can offer politicians to support the alliance are extremely limited”.¹¹⁵

His views are understandable. Decades of cuts and underspending mean there are critical gaps everywhere. For instance, Germany does not have a proper short-range air defence. Most of its kit is old, including its tanks. It is running short of critical weapons systems, including the famous Taurus missiles. The country has been the most ruthless in terms of equipment cuts since the mid-1990s. Its number of combat vehicles has decreased by 77 percent, combat aircraft by 69 percent, naval vessels by 69 percent, and its submarine fleet by 70 percent compared with 1994. Other NATO countries, though having cut down themselves, exercised greater prudence in their de-scaling.¹¹⁶

Not only are Germany’s ammunition stockpiles still critically low, but its industry (and that of Europe more broadly) is currently not able to produce in significant quantities in the short term.¹¹⁷ In fact, it was widely reported in late 2022, that its army only had two days’ worth of munitions sufficient for repelling an attack. This may have been an under-estimation of actual capacity, but it is undoubtedly the case that Germany cannot sustain a Russian attack if it were to arise.^{118, 119} Since the outbreak of the Ukraine war, Germany’s rearmament has been marred by struggle. *Zeitenwende* was met with relief and appreciation by alliance partners, but their growing frustration with its slow implementation is fuelling significant doubts about Germany’s reliability as a partner. Committed though its government has been on paper, it has failed to present a solid long-term plan to remobilise and increase its military capability. Its industry has also been unable to keep up with demand, whilst policymakers maintain their focus on national procurement.

¹¹³ Sky News (2024) “Urgent Review as D-Day Parachute Jump Scaled Back Due to Lack of RAF Aircraft.”

¹¹⁴ See the chapter by Alina Engström in Björn Ottosson and Krister Pallin (2024) *Western Military Capability in Northern Europe 2023: Part I – National Capabilities*. FOI.

¹¹⁵ Nette Nöstlinger (2022) “I am pissed off! German army official bemoans ‘bare’ forces as Russia invades Ukraine.” Politico.

¹¹⁶ Pfeiffer and Cannon (2024) “Why Europe Is Unprepared to Defend Itself.” Bloomberg.

¹¹⁷ Wolff et al. (2024) *Fit for war in decades: sluggish German rearmament versus surging Russian defence production*. Bruegel.

¹¹⁸ Reuters (2023) “Germany only has 20,000 high explosive artillery shells left, report says.”

¹¹⁹ Hofmann (2024) “Germany’s Bundeswehr: How ready is it to defend NATO?” Deutsche Welle.

The sad reality is that this is not news: the Bundeswehr's struggles have been apparent for quite some time. In 2015 there were widespread reports of it using painted broomsticks as guns in a joint-NATO exercise.¹²⁰ What is more shocking than Germany's military woes, is its lack of resolve in solving the issue. Since Chancellor Scholz' *Zeitenwende* speech, there has been little evidence of a change in times for Germany.

Let us consider also the case of Sweden – a country that has made a profound change in its security policy in the past two years and now joined the NATO alliance. As shown in Figure 9, the country has grown its defence spending in the past decade and is now in the 2-plus percent region. Expenditures will increase in 2025 and 2026 and thereafter plateau at 2.6 percent. This is an achievement in a country that a decade ago – after Russia's 2014 invasion of Crimea – still doubted the aggressiveness of Russia would mean anything to Sweden and its territorial integrity and sovereignty. Once Sweden has achieved its current desired for defence capabilities, it will be a significant contributor to security in the Baltic region and, perhaps, also the Arctic region.

But here is the problem: these are long-term ambitions, not reality. Even if new resources are added in its forthcoming plan for the military in 2030, Sweden is just not going to have the necessary defence capacities for a decade, at the least. At present, 2040 seems like a more reasonable period of time for when capacities will have improved to such a point that it has sufficient deterrence and capacity to adequately defend the country in a war.

Sweden's problems are an example of a wider European problem. Its disarmament policy purged its war organisation from capacity. It had 30 brigades during the Cold War, but now there is less than a handful. Air divisions were reduced from 42 to 6 and the number of surface combatants in the navy declined to 7 from 46. Artillery and coastal artillery regiments went to 1 and then 0. Its material is old. Its main jet fighters and tanks are from the mid-1990s. Submarines and navy surface combatants are equally old, even if they were delivered a little later. It is also coming up short on manpower, with far too few officers and soldiers and an air force and navy that have lost key human resources because of reduced pay over a long period of time. In other words, Sweden starts its new process of rebuilding capacity from a position of weakness.

Sweden's current capacity can be compared to Ukraine's capacity before Russia's full-scale invasion in 2022.¹²¹ Ukraine had 30 mechanised brigades; Sweden has – after a recent expansion – 2. Ukraine had 100 ground based mid and long-range air defence systems, Sweden has 4 – and the Nordic country is equally behind on artillery. Ukraine's 900 tanks can be compared to Sweden's 120. Sweden acquired Patriot system for its air defence but does not have enough to extend the defence beyond Stockholm and one other region (it only has two Patriot equipped air defence battalions). Its main artillery, Archer, has proven powerful in Ukraine, but Russia has also been capable to adapt and reduced their attacking power. The country's drone's capacity is small. Hence, Sweden will not be capable to fight a war anytime soon. Some of the new orders for key capacity have delivery dates in the first half of the 2030s. Many other required capacities have not even been ordered yet.

¹²⁰ Huggler (2015) "German army used broomsticks instead of guns during training." The Telegraph.

¹²¹ Data on Sweden's and Ukraine's military capacity come from Oscar Jonsson (2024) *Försvaret av Sverige*.

Add to this the very slow pace of building up technology capacities that mix military and civil technology and that incorporate the innovation capacity of the private technology sector. Like some other European countries, Sweden has taken some inspiration from American efforts – such as DARPA and the operations of “Unit X”¹²² – and understands the importance of civil technology innovation for battlefield capacity.

However, it has a long way to go. Sweden's Defence Research Agency has been operating on a shoe-string budget. Sweden has established its own Defence Innovation Board but, unlike the US equivalent, it is mostly occupied by agency bureaucrats. The US Defence Innovation Board has had chairmen like Eric Schmidt (former CEO and chairman of Google) and Michael Bloomberg (founder of Bloomberg) and includes notable innovators like Reid Hoffman (co-founder of LinkedIn and InflectionAI and founding investor in PayPal and OpenAI). By contrast, Sweden's board is chaired by the Minister of Defence and, apart from the CEO of Saab, features no member with experience of technology and innovation entrepreneurship. Moreover, defence organisations like the Defence Material Administration have launched a collaboration with the country's innovation agency, Vinnova, to boost civil-military technology cooperation but its budget for 2024 was just a bit more than 5 million euros and the tenders it invited bids for that year were all about abstract models for cooperation and partnerships – not about specific technologies and defined specific needs.¹²³

Accentuating these weaknesses in Germany, Sweden, and other parts of Europe is Russia's compounding military expenditure as seen in Figure 9. Russia's military purchasing power parity means its spending travels much further than nominal figures suggest.¹²⁴ It can rely on its growing national industry, but also cheaper imports from China. Obviously, EU countries in Russia's proximity are most at risk: many of them are Central and Eastern European states that previously were in the Soviet bloc. They have long held a more sceptical view of Russia and been far more sober about security risks than the Nordics and continental Europe.¹²⁵ Their threat perception has also put them at odds with EU cohesion over the years, in matter such as gas pipelines, energy-market regulations, and the type of submissive, if not defeatist, mercantilism that guided countries like France and Germany in their responses to Russia's invasion of Georgia in 2008 and Crimea in 2014. The reaction among these Eastern and Central European states has varied. Poland, for instance, had taken to building up its military industry during the peace-dividend and is now a beacon of European defence. Others such as Estonia have called on the EU titans to further drive support for Ukraine and a curbing of Russia.¹²⁶ Others have still taken to appeasement of the ‘other side’. This can be observed in the case of Hungary and Slovakia – with both countries' leaders taking a divergent approach to Russia.¹²⁷

¹²² Raj M. Shah and Christopher Kirchhoff (2024) Unit X: How the Pentagon and Silicon Valley are Transforming the Future of War.

¹²³ See Vinnova (2024) Civilia innovationer ska stärka Sveriges försvarsförmåga.

¹²⁴ Wolff et al. (2024) Fit for war in decades: sluggish German rearmament versus surging Russian defence production. Bruegel.

¹²⁵ Schilde (2017) European Military Capabilities: Enablers and Constraints on EU Power?

¹²⁶ Gardner (2024) “We have no Plan B if Ukraine falls, says Estonia.” BBC News.

¹²⁷ Reuters (2024) “Hungary's Orban says Russia stands to gain as ‘irrational’ West loses power.”

The disparity in military capacity between the EU and the US, China, and now Russia is at an alarming level. The US remains the superior world power both in terms of logistical capacity and technological advancement with its highly synchronised (yet bureaucratic) defence industry. Its capacity, however, is growing ever more thinly stretched with the sharp rise of China compounded by the refusal of the Middle East to fade into the background as a strategic theatre. This leaves Europe with the sole option of showing initiative in advancing its own military capacity in order to protect itself and its own neighbourhood. It is not just that military expenditure has fallen sharply across the board since the end of the Cold War; Europe has suffered particularly due to less coordination, less practice, less capacity maintenance, less technology investment – all wrapped up in a mismanaged process intended to replace bulk with efficiency, agility, and military tech savvy. One of the results has been a weakened defence industry and significant loss of buffer and resilience capacity in the emergency case – as experienced in 2022.

It is true that European NATO dominates Russia in terms of the number of armoured vehicles (i.e. tanks), combat aircrafts, and submarines, and it has a higher tally of warships and troop numbers.¹²⁸ Of course, the US and Russia maintain the world's largest nuclear arsenals, but on the conventional side, Europe has the numbers to compete. However, quantitative comparisons like these are often misguided. First, a good part of the European armed forces is just not battle ready. As noted above, generally and in the case of Germany and Sweden, much of the "kit" is just too old for modern warfare, some other has not been used for some time.

Second, wars are fought by systems that require substantial integration and organisations that many EU countries just do not have anymore. The EU's combined military capability may look impressive when aggregated, but it is inflated on paper. The battle-readiness remains surprisingly and even shockingly weak. Moreover, European NATO members rely upon the full suite of US hardware to protect themselves from Russian invasion, including missile defence systems which EU states do not maintain in sufficient quantity.

Third, potential scenarios of aggressions do not just include the attack on one country; a defence-oriented doctrine for Europe means you are stretching your defence thin over vast geographic zones with many potential choke points and places of battle. The aggressor can concentrate on specific locales that require a highly distributed defence operation, which means the NATO logic of amassing the resources of many countries against an aggressor at certain geographies remains better reflected in ambition statements than in observed capacity.

Take the Baltic states for example. Apart for the Suwalki corridor, a thin stretch of the Polish border, they sit completely encircled by Russia (Russia proper and Kaliningrad) and Belarus – from which Russia launched troops into Ukraine and where it stations nuclear weapons. A surprise attack here, whilst triggering a NATO-Russia war, would be difficult for EU-NATO to counter under the current circumstances. This is the case even in light of the notable improvements of Baltic security that have occurred in recent years, notably the establishment of the Enhanced Forward Presence battalions. Such a scenario could occur even after a surprise ending of the Ukraine war. In the coming years, Russia will most likely advance its military capacity far beyond

¹²⁸ Pfeiffer and Cannon (2024) "Why Europe is Unprepared to Defend Itself." Bloomberg.

the EU. The Baltic countries have responded and are now among the highest spenders as a share of GDP (Estonia, 3.4 percent; Latvia, 3.2 percent; Lithuania, 2.9 percent) but their security needs far more capacity than is currently mobilised. This is an issue which Europe must come together to mitigate.

Fourth, to win a war, and have a credible deterrence, means to have a plan for attacking your aggressor and take the war to its territory: Europe has inadequate capacities for such strategies and does not yet have a credible reaction function that communicates to potential aggressors. Much of its current efforts to improve battle capacity is fundamentally oriented at defence – not attack – and no war is going to be won only by defence. The existing capacity for attack basically relies on the supply of US weapons, systems coordination, and intelligence.

3.2. Defending Global Order

Europe also needs to start making serious military contributions to the global order, and the main region of big geopolitical risks is the Indo-Pacific. This is not the only region where Europe's presence, as a diplomatic and security actor, can help improve conditions for peace and stability – far from it. As a region, Europe has strong economic, political, cultural, and person-to-person connectivity across the world, and these connections are constituent parts of European interests. Defending them, and providing leadership and capacity for that defence, is important for Europe's international credibility. Obviously, this defence includes much more than military capacity but, given the challenges that now confront us, it is vitally important that Europe also adds stronger military capacity to its statecraft.

A stronger presence in the Indo-Pacific is important for two reasons. First, it is the centre of gravity in the world economy. European companies generate a lot of income from selling to the region and having investments there. Likewise, Europe imports a lot from the Indo-Pacific as well. It relies on the integrity of maritime shipping lanes and access to ports – namely, the freedom of the seas. A major war in the region would seriously destabilise the European economy too. Second, Europe has strategic partners in the region – like Japan and South Korea – that are part of the integration of a broader democratic East Asia into the economic and security arrangements of the old "West." Both countries make significant contributions to Ukraine now and are exposed to the global ramifications of the Ukraine war and the emerging partnership of the CRINKs (e.g. the consequences for South Korea following North Korea's active contribution to the war in Ukraine and Russia undermining UN Security Council monitoring of North Korea's nuclear and ballistic missiles programme). Equally important, Europe's most important ally, the United States, is increasingly pulled into the defence of regional allies and the overall Asian supply chain networks. Assisting allies and partners is a European interest and, equally obvious, conforms to values-driven motivations in Europe's foreign policy.

The critical points for Europe are exactly those that arose in Ukraine. A great economic dependency on China, as with oil and gas in Russia, is at risk of fundamental disruption in the event Beijing takes seriously hostile actions against Taiwan. The economic consequences of

such a scenario would be felt everywhere.¹²⁹ In fact, it would lead to a major global economic crisis, sending levels of prosperity across the world several notches down. The US has reshaped its strategic perception of China and taken a stronger attitude against Beijing, seeing it as less of a trade partner and more of a hostile rival.¹³⁰ As part of its Indo-Pacific policy, it has been preparing for potential scenarios of a Chinese invasion of Taiwan¹³¹ – from a full invasion to versions of a blockade – which notable US observers consider increasingly likely to happen. If not for other reasons, it is important for Europe, seeing how important both China and Taiwan are economically, to be able to add to the power of deterrence of the US and others in preventing an all-out war.

There is no unanimous voice on EU actions to contribute militarily to Indo-Pacific stability.¹³² The central EU line tends to be neither hawkish nor dovish: obviously, it wants to prevent a potential invasion of Taiwan but does not allocate many resources to this outcome.¹³³ Some leaders, like France's Emmanuel Macron, seem rather to speak with a split tongue, warning against Europe becoming a vassal to the US as, he has suggested, Washington is actively courting a conflict with China.¹³⁴ At the same time, Macron and others are arguing for defensive economic measures against China delivering the same type of outcome as America's more hawkish approach. Others are more passive or still seek intimacy with "fictitious normalcy," thinking that accommodation or appeasement of an aggressive Beijing will bring some trade gains – or, at least, avert the continent from having to cut sales and exports. The United Kingdom seems yet again to be intent on deepening its commercial relationship with China.

For most of the time, more mature perspectives are guiding the general EU stance in the Indo-Pacific. The realisation that China is not the regime it was a decade or two ago is now reflected in its attitude. The EU is moving closer to the US perception of China and treats it as an economic competitor and systemic rival: a country now subject to economic policies of "de-risking." China's support to Russia and its war on Ukraine has further exacerbated the risks of stronger economic conflicts with China. Whether it likes it or not, Europe is being pulled into strategic conflicts in the Indo-Pacific region, and the main question now is if it can muster the focus to put military deterrence capacity in the region to help moderate the risks of war and serious economic problems.

Europe currently has three large navies with some capacity that can be effectively utilised in the Indo-Pacific. They belong to France, the UK, and Italy. The former two are nuclear powers, and France is particularly active in the wider Indo-Pacific via its overseas territories and strategic partnerships. The UK's Royal Navy is in the middle of a reshaping process and, in the last few years, has been advancing its role in the region both through its AUKUS partnership and coordination with other partners, notably Japan. Italy, albeit in a smaller role, has also been increasing its

¹²⁹ Wintour (2023) "If China invaded Taiwan, it would destroy world trade, says James Cleverly." The Guardian.

¹³⁰ The White House (2022) US Indo-Pacific Strategy. The White House.

¹³¹ Stewart and Ali (2024) "How the US is preparing for a Chinese invasion of Taiwan." Reuters.

¹³² Schneider-Petsinger et al. (2022) Transatlantic cooperation on the Indo-Pacific European and US priorities, partners and platforms. Chatham House. According to the report, there are several EU states with Indo-Pacific strategies besides the 'large' power France, including Germany, Italy, and the Netherlands.

¹³³ Lau (2024) "Von der Leyen vows to stop China from invading Taiwan." Politico.

¹³⁴ Rankin (2023) "Macron sparks anger by saying Europe should not be 'vassal' in US-China clash." The Guardian.

activity in the Indo-Pacific, particularly in coordination with the UK, Australia, and Japan.¹³⁵ A few more countries, including Germany and the Netherlands, have produced Indo-Pacific strategies designed to augment the overall EU strategy.¹³⁶ They could add naval presence in the region. Other navies in the EU – Greece and Spain, for instance – could also be better utilised in support of the US in the Indo-Pacific. Nordic countries have navies too, but they are too occupied in the Baltic Sea and, increasingly, in the Arctic.

A greater role in the Indo-Pacific is also a good basis for the European defence industry to invest more in R&D and technology, and to collaborate with armies, navies, and air forces in the region – potentially netting export advantages. Steps have been taken with some close partners in terms of security engagement, namely Australia, Japan, and South Korea. France is also a large arms exporter to this region, with the majority of its arms exports heading to India, according to SIPRI. The EU relationship with ASEAN, however, is far from set in stone. China has invested heavily in these countries through its Belt and Road Initiative and relations with much of the bloc continue to grow stronger.^{137,138} The same can be observed on the military side, with Russia having recently engaged in naval exercises with Indonesia.¹³⁹ ASEAN's natural position, however, is one of staunchly pronounced neutrality. China is a strong ethno-cultural and economic partner and will always remain "close". For some nations, like the Philippines, it can also be a threat. Fostering stronger relations with these countries is important if the EU is to assume a greater role in the Indo-Pacific and will be necessary for cost and efficiency in the investment the EU needs to make in modern and future arms technology.

Coordinating the EU's defence industry with the future of Indo-Pacific stability will help to provide a high-tech edge in the long term. While quantity is more critical in the Ukraine case, the Indo-Pacific is a cold arena which will be shaped by technological superiority. China, with its rapidly advancing civilian and military technology, can only be countered on such terms. Greater coordination and cooperation in Europe's defence industry might allow it to obtain the desired increase in arms quantity needed to support private investment and rapidly increasing R&D spending in the industry.

This takes us back to the question of the relation with the US – and America's role in Europe. Underlying the shift in the US perception of Europe, alongside its political changes, is a substantiated imbalance in their relations. Thirty years after the Cold War ended, Europe still depends on the US for its fundamental security – to the extent that, without strong US military presence in Europe, Europe could be pacified and, in certain geographies, be overrun by a belligerent Russia. While nuclear dependence is a separate issue, Europe is critically under-equipped for conventional war and will have to draw on US support for more than a decade. In a changing world, with the Middle East heating up again and an increasingly confrontational China, prioritising European defence obviously comes into question for any US

¹³⁵ Patalano (2024) "Italy: The Globally Connected Mediterranean Power?" RUSI.

¹³⁶ Bergmann and Johnstone (2024) Europe's Security Role in the Indo-Pacific. CSIS.

¹³⁷ See ASEAN-China Joint Statement on Synergising the Master Plan on ASEAN Connectivity (MPAC) 2025 and the Belt and Road Initiative (BRI).

¹³⁸ Carnegie Endowment (2023) commentary by several regional experts titled "How Has China's Belt and Road Initiative Impacted Southeast Asian Countries?"

¹³⁹ Wardoyo (2024) "Indonesian, Russian navies hold first joint drills in Java Sea." Reuters.

administration – exacerbated by what some in America considers to be hostile economic acts by EU policymakers against US corporate interests.

For Europe's political priorities, it means taking the initiative on the home front but also to actively make more contributions outside immediate European theatres of conflict. Obviously, Europe does not have long-distance mission capability that can compare with the US navy, but the region is still made up of smaller actors with some naval capabilities.¹⁴⁰ In its war against Ukraine, Russia has been drawing the support of North Korea and Iran alongside China. The UK, France, Germany, Italy, Spain, and the Netherlands can add power in the Indo-Pacific, and this would boost "Western" coordination to secure its interests against an increasingly inter-connected adversary.

3.3. The State of the EU Defence Industry and Technology

Obviously, the defence industry is a critical part of any country or region's military capacity. It is needed to provide the weapons, ammunitions, and technology needed in order to fight a war. A healthy defence industry also leads on technology development by investing substantial amounts in R&D and innovation – creating capacities to fight in ways that enemies cannot do. This alone is a central part of deterrence power.

No area brings together the two strands of this paper – R&D/innovation and military capacity – as clearly as the defence-industrial sector. Decades of low military spending have purged especially EU defence companies of scale and innovative capacity. Many countries that host defence firms of decent size still insist on a "national champion" approach: the links between governments and industry will always remain strong in the defence sector but it is equally clear that Europe will fall short if many governments insist on maintaining the current industry structure. Likewise, as military capabilities blend with civil technological development, Europe needs to take new attitudes to issues of dual use and technology regulation. On many critical technologies involving telecommunication, structured data management, cloud, and AI, Europe has dug itself into a hole. Technologies and technology firms and markets are vastly overregulated, and all regulatory costs and uncertainties add new barriers to sectors that already have profound competitive disadvantages vis-à-vis the US and China. These disadvantages are not about inadequate human capital; nor are they anymore about high labour costs. In innovative technology sectors, Europe is rather becoming a low-cost region. The problems are about barriers to experimentation, innovation, and the vastly higher costs for companies that need to restructure because of technology and entrepreneurial failures.¹⁴¹

The difference between the EU and the US defence and technology industries, for example, is stark. America has a strong defence industry partly because its government spends much more on procurement. It is true that many of the large US defence companies have, as a result, developed complacent attitudes to technology and innovation,¹⁴² and that large

¹⁴⁰ Bergmann and Johnstone (2024) Europe's Security Role in the Indo-Pacific. CSIS.

¹⁴¹ Oliver Coste (2022) Europe, Tech, and War.

¹⁴² Raj M. Shah and Christopher Kirchoff (2024) Unit X: How the Pentagon and Silicon Valley are Transforming the Future of War.

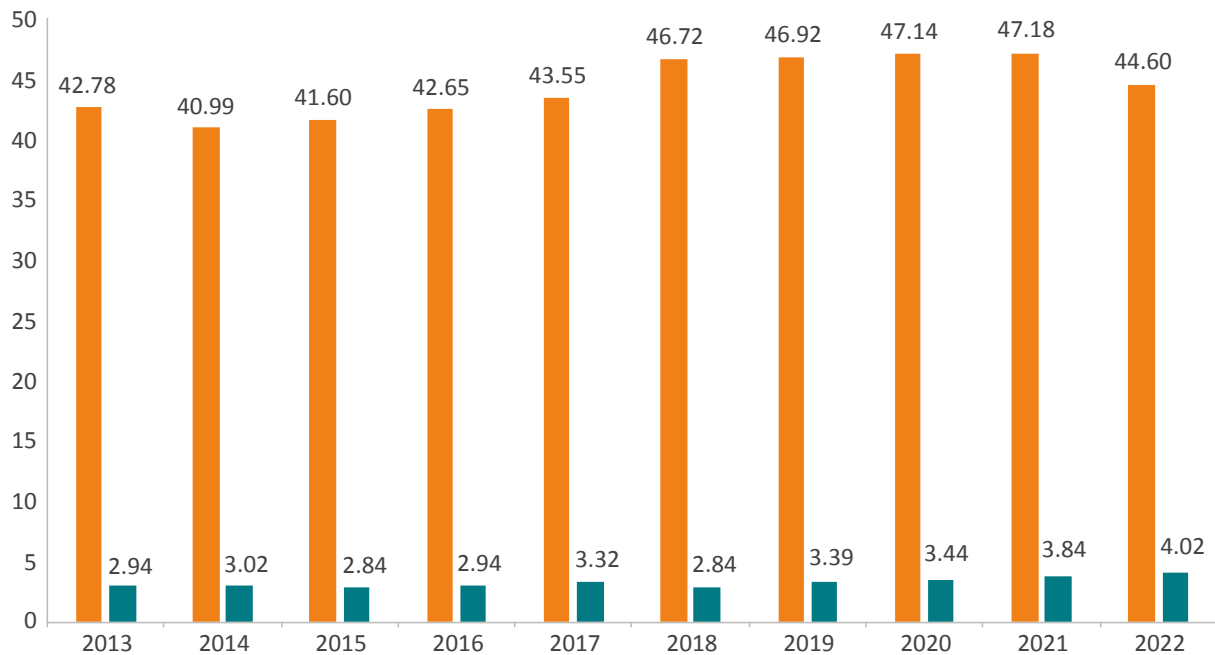
projects are invariably associated with huge cost overruns and delays – perhaps also too little competition.¹⁴³ Still, the US defence industry is a mighty force in capacity provision, technology development and global competition, and it is increasingly drawing on the broader civil technology sector and new companies like Palantir and SpaceX. Large technology firms are gradually pulled into the Pentagon orbit and the previously salient cultural conflict between Silicon Valley and Washington, DC has weakened.¹⁴⁴ Moreover, defence-related R&D represents roughly 40 percent of the country's public R&D spend, which has a clear impact on the innovation impulse in the defence sector. As a result, the external competitiveness of the US defence industry is also much stronger, with arms exports being far higher than arms imports.

Since the defence industry is dependent on few buyers, it is critical for the industry's health that governments are clear about available resources and how they plan for future procurement. No country nor any region's defence industry is going to grow its competitiveness if there are serious concerns about future spending and how it will develop. This is a major problem at present – damaging investments in production capacity for ammunition as well as the interest to contract on high-expensive and high-technology projects, like fighter jets. As a result, some recent modernisation programmes of fighter jets in Europe have so obviously favoured US suppliers – even at the expense of cost and efficiency – because they provide long-term stability, in addition to giving buyers a way to implicitly allying with America and tie Washington, DC closer to the defence of a certain geography. It is necessary for the industry and its investment planning that it is clear how governments plan for future procurement. Absent such plans, the industry will not make sufficient investments, and governments may ultimately have to pay for production investments as well just to get more production going.

Spending on R&D is critically reliant on what projections defence industries can make about future demand. Figure 11 shows the share of public R&D allocated to defence: the US dwarves the EU. It will take a long time for the EU to reach US levels, but it is obvious the Europe should look to synchronise the two sides of resource allocation covered in this paper (R&D/technology and military), and defence technology is one area where there is a very strong case to be made for substantially larger public spending.

¹⁴³ See Gould (2022) "Kathlene Hicks Warns of "Substantial Decline" in Defence-Industrial Base Competition." Defence News. Also, US Department of Defence (2022) State of Competition within the Defence-Industrial Base.

¹⁴⁴ Raj M Shah and Christopher Kirchhoff (2024) Unit X: How the Pentagon and Silicon Valley are Transforming the Future of War.

FIGURE 11: SHARE OF PUBLIC R&D ALLOCATED TO DEFENCE, COMPARING THE US AND THE EU-27, 2013–2022

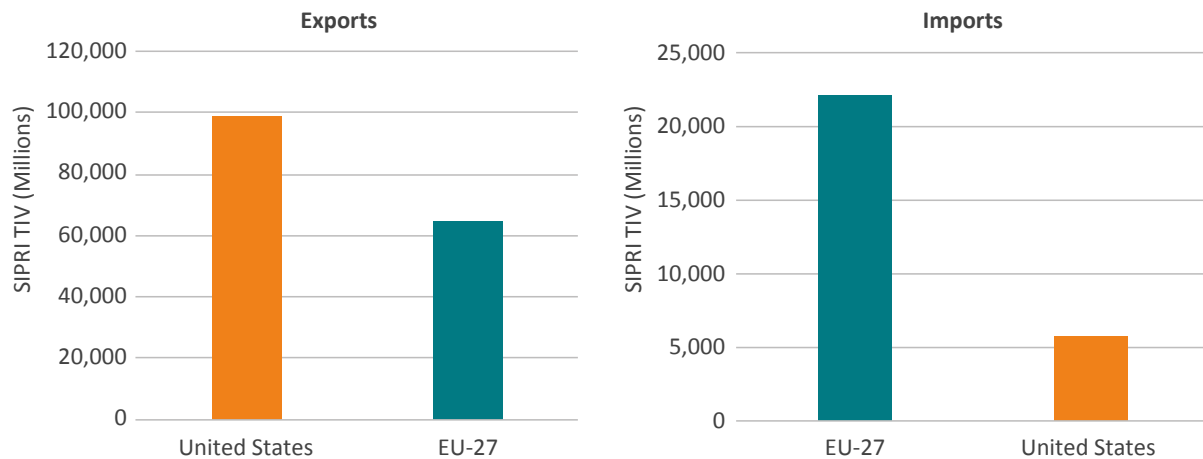
Source: ECIPE calculations based on OECD data

R&D intensity and other factors also have effects on the competitiveness of the defence industry – including the external competitiveness. Figure 12 compares the total major arms (combat aircraft, tanks, artillery, etc.) exports and imports of the US with those of the EU. Signifying the trend observed in EU countries, the US exports far more in arms than it imports, showing that its industry is way more capable of catering to its defence needs than is the case for the EU. According to SIPRI, European arms imports have nearly doubled between the period 2014-18 and 2019-23, with imports from the US increasing from 35 percent to 55 percent of the total, shadowing previous concerns about the EU's internal procurement capability. A reported 78 percent of 2022-2023 EU defence acquisitions were imports¹⁴⁵. Even European states such as Sweden and Germany (two countries with advanced defence industries) have tripled their imports.¹⁴⁶

¹⁴⁵ Maulny (2023) The impact of the war in Ukraine on the European defence market. IRIS – Institut de Relations Internationales et Stratégiques.

¹⁴⁶ Other states such as Czechia and Hungary, have recorded 30- and 7-fold increases in imports respectively. Although the report does not state the proportion imported from within the EU.

FIGURE 12: TOTAL ARMS EXPORTS AND IMPORTS FOR THE EU-27 AND US (IN SIPRI 'TIV', MILLIONS), 2015–2023



Source: ECIPE calculations based on the SIPRI Database. Notes: The graphs are Hungary not included in EU total for exports due to lack of data. 'TIV' stands for 'trend-indicator-value' and is a pricing system established by SIPRI which accounts the quality of the arms being sold.

The issue for the EU is that, for various reasons, it is both easier and at times more appealing to procure from abroad. The Netherlands, Norway, and Italy for example procure 90 percent of their imported arms from the US. Part of this can be attributed to the ease of the US Foreign Military Sales Programme which in essence provides a government-to-government interface, with the US government effectively guaranteeing a smooth delivery. On top of this, the quality of arms (defence systems in particularly) offered by the latter combined with its more dependable supply, makes it an easier choice.

BOX 2: FRAGMENTATION IN EU DEFENCE ILLUSTRATED (2018)

Total Number of Weapons Systems: 178 (compared with 30 for the US)

Main Battle Tanks: 17 (compared with 1 for the US)

Destroyers & Frigates: 29 (compared with 4 for the US)

Combat aircrafts: 20 (compared with 6 for the US)

Source: European Commission, EU Budget for the Future: The European Defence Fund (2018).

To illustrate this we can take the EU's "big" market success in the last decade, France. Though currently the world's second largest arms exporter, relatively few of its arms are purchased by fellow EU members, with most of its exports travelling outside the EU. It has struggled to break

ground in the European market amidst stronger US competition¹⁴⁷ According to SIPRI, Germany and France – the EU's largest arms exporters – have a combined 11 percent of the European arms market compared to the US' 55 percent (2019-2023). Furthermore, of the EU-to-EU export total, Germany holds approximately 50 percent of the market¹⁴⁸. An important side note in the face of this, is Russia's sharply falling exports (down 53 percent) as it concentrates its production on its own military.

The EU defence industry also suffers from insufficient size and investment power in comparison to the US (and China). Competition is a good thing but too much fragmentation leads to little real competition. Moreover, R&D and production costs can be wastefully duplicated¹⁴⁹. Current fragmentation is maintained at the expense of scale and is especially exacerbated by many governments favouring their own national champion. The result is that too many companies in the defence industry are too small to scale and attract the resources necessary to be long-term competitive, leading to growing non-EU imports. In terms of coordination, each country also maintains its own advanced technical specifications, further complicating joint procurement and EU industry empowerment.¹⁵⁰ As previously noted Russia's expansion in spending has pushed it above the EU in PPP terms – let us also not forget that it is one national industry, with the Russian government as its sole conductor. Combining these elements, the efficiency of its investment only increases relative to the EU. This is before considering the technical experience its is gaining in Ukraine (and the productivity gains for its defence industry), which heightens fear of Russia's ability to engage the rest of Europe even if said war were to conclude.¹⁵¹ Therefore, the EU must advance its defence industry coordination and cooperation.

Industry structure also plays a role. Europe's core defence industry is highly diffused on many small or mid-sized companies – all of whom, following the analysis in Mario Draghi's report on European competitiveness, have too little coordination and show relative inefficiency compared to other global industries.¹⁵² Most of the mid-sized companies have broad specialisations, leading to substantial fragmentation also in the various defence sub-sectors (e.g. tanks, submarines, fighter jets, etc.). It used to be different, however. While the EU is currently broadly limited in its defence capacity and sits particularly vulnerable in the event of a sudden war, its defence industry was strong in the Cold War era.¹⁵³ Since the mid-1990s there has been a stark shift away from volume production – and to a greater extent than in the US – which has left shortages in critical arms now that much of the existing stocks has been sent to Ukraine.¹⁵⁴

Comparing the European companies on the SIPRI Top 100 list of defence companies, of which there were 25, with their American counterparts prompts a few important observations (see Table 3).¹⁵⁵

¹⁴⁷ Many European air forces prefer US jets to their French (Rafale) and other European (Eurofighter) counterparts.

¹⁴⁸ Maulny (2023) The impact of the war in Ukraine on the European defence market. IRIS – Institut de Relations Internationales et Stratégiques.

¹⁴⁹ For defence the EU would better be taken as a single market.

¹⁵⁰ Ibid.

¹⁵¹ Mackenzie (2025) "Russian defense spending overtakes Europe, study finds." Politico.

¹⁵² Draghi (2024, p.165.) The future of European competitiveness: Part B | In-depth analysis and recommendations.

¹⁵³ Aries, Giegerich, and Lawrenson (2023) Guns of Europe. IISS.

¹⁵⁴ Ibid.

¹⁵⁵ The US had 42 companies (of varying defence portfolios) in the same list.

First, the top 5 US companies are vastly bigger than the top 5 European companies. This gap then recedes as we go down the ranking. Finally, there are many "civil" companies involved in defence in the US, and their arms revenues (though a small portion of their total revenues) are considerably large. In contrast, most of Europe's top companies are out-and-out defence companies.¹⁵⁶

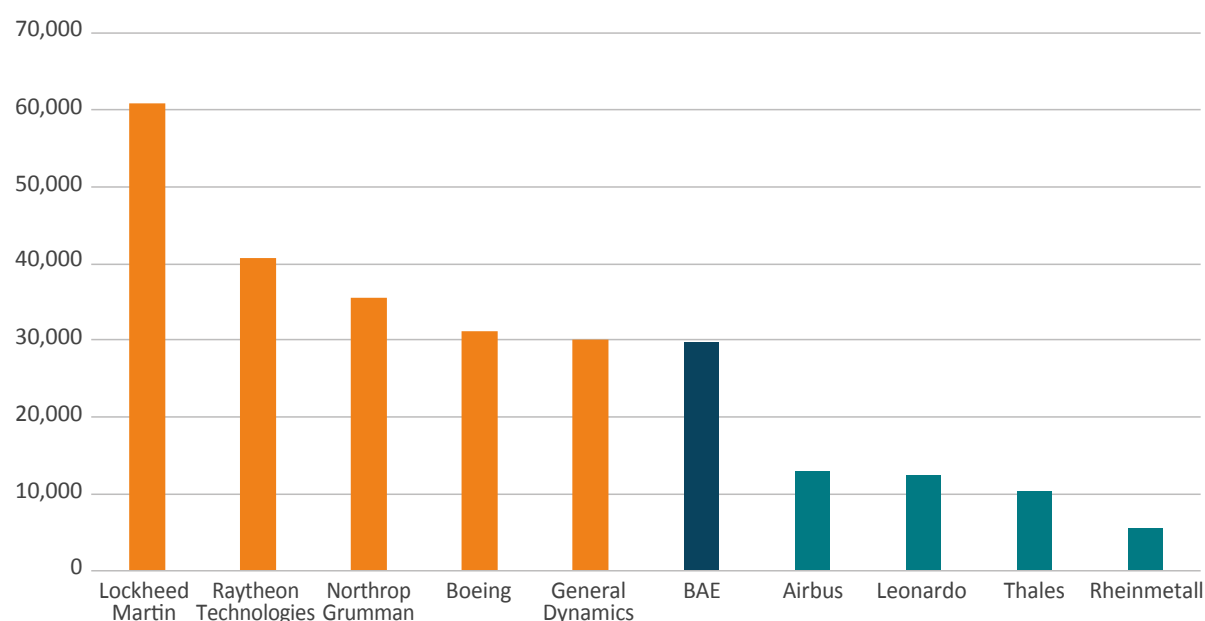
TABLE 3: TOTAL ARMS REVENUES, US & EUROPE (EU-27 + UK, NORWAY), 2022

Region	Total Revenues (USD Million)
US	302,380
Europe	119,400

Source: SIPRI Database (2022)

Figure 13 illustrates just how much larger the US' defence industry is compared to Europe's, with a focus on their respective top 5's. The 'Big 5' that dominate the US defence landscape are considerably larger than the top 5 of Europe. These companies – Lockheed Martin, RTX (formerly Raytheon Technologies), Boeing, Northrop-Grumman, and General Dynamics – are awarded the bulk of US defence contracts, and can in turn be relied upon to produce at scale and quality. Excluding the UK's BAE, the EU's Leonardo, Airbus, Thales, and Rheinmetall, pale in comparison to the 'Big 5'. Boeing has its equivalent in Airbus in the EU – both civil aviation companies with defence sections. However, the latter is not quite as integrated in defence, and records less than half the arms revenues of Boeing despite having roughly equal total revenues.

FIGURE 13: TOP 5 US AND EUROPEAN DEFENCE COMPANIES BY ARMS REVENUES, 2023 (MILLIONS OF US DOLLARS)



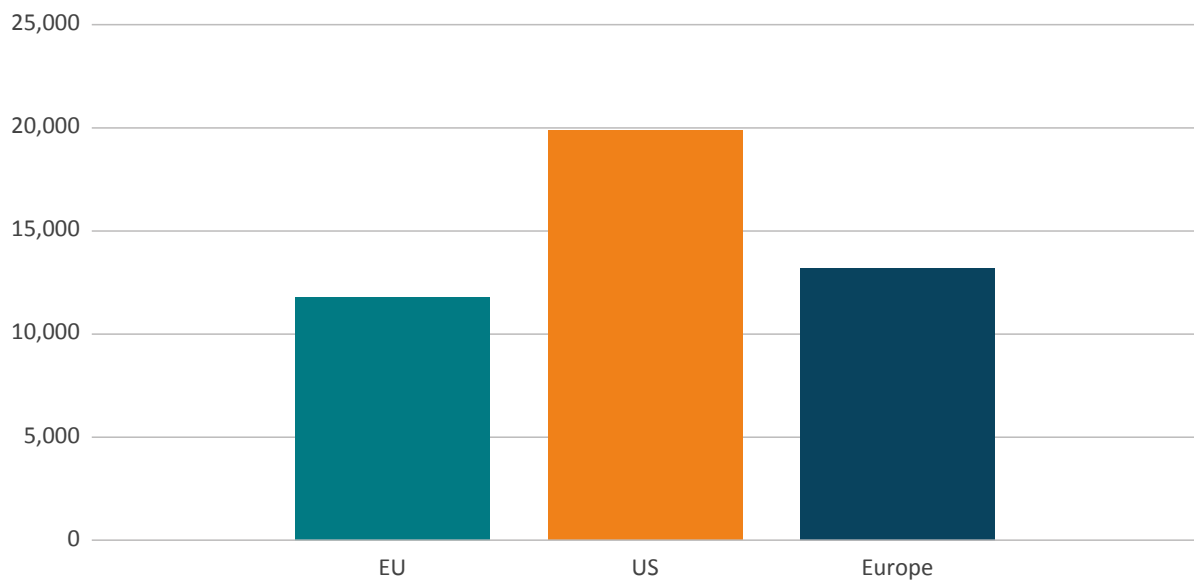
Source: ECIPE calculations, SIPRI Database (2023) Note: BAE Systems (British) is emphasised in Navy.

¹⁵⁶ See 'The SIPRI Top 100 arms-producing and military services companies in the world' list for 2023.

The US consolidated its defence industry, perhaps to a fault¹⁵⁷, since the end of the Cold War, while Europe, in turn, kept its collection of smaller national champions. Of course, the benefit here lay for the individual states, as they maintained an a la carte defence service whilst keeping jobs at home. Now, the numbers of European and US defence companies do match up overall, with various civil companies involved along with the pure defence companies, but the US spends far more than the EU and is thus able to maintain such a spread.

The long-term disadvantage both for the companies and for Europe's security is that European defence companies could not break much ground in the continental and international markets. The US government, though cutting down procurement from Cold War levels, was still an active client of the defence sector throughout the 1990s and the 2000s (spurred, obviously, by wars in Afghanistan and Iraq). EU governments need to develop a much better policy platform for defence companies to thrive, and this includes long-term planning on how it sets out to invest in new equipment and technology.¹⁵⁸

FIGURE 14: TOP US AND EUROPEAN DEFENCE COMPANIES' COMBINED R&D EXPENDITURE, 2023 (MILLIONS OF US DOLLARS)



Source: ECIPE calculations, SIPRI database, and company annual reports. Notes: "Europe" includes the United Kingdom (BAE) and Norway (Kongsberg Gruppen)

Figure 14 combines the company-reported R&D expenditure of US, EU, and 'European' (the EU, the UK, and Norway) companies on the SIPRI Top-100 list for 2022. US companies are spending nearly twice as much as EU companies, and 1.5 times the top 'European' companies.¹⁵⁹ The difference is also visible at firm level for the top 5 companies. The US Big 5 spent USD 1.5 (Lockheed Martin), 2.8 (RTX), 3 (Northrop-Grumman), 3.4 (Boeing), and 0.7 billion (General

¹⁵⁷ Allen and Berenson (2024) Why Is the U.S. Defense Industrial Base So Isolated from the U.S. Economy? CSIS.

¹⁵⁸ Bloom (2024) "Defence firms 'need reassuring' that big orders will be long-term." BBC News.

¹⁵⁹ Of the total, there were 12 US companies and 5 European companies for which R&D data could not be found.

Dynamics) in 2023, respectively. While Europe's top 5 spent USD 0.4 (BAE), 1.5 (Leonardo), 3.5 (Airbus), 1.2 (Thales), and 0.5 billion (Dassault) in the same year.¹⁶⁰

Much like in innovation spending, the private sector plays an indispensable role in military spending as well. In fact, defence is arguably the domain with the highest intimacy between governments and private firms.¹⁶¹ Governments rely on private companies not only for the development and supply of cutting-edge technologies and equipment, but also for maintaining the operational readiness of their armed forces. From advanced weapon systems to cybersecurity infrastructure, the private sector has become a key driver of military capability.¹⁶² Recognising the vital role of private companies in the realm of defence, some analysts have gone so far as to say that the ensemble of activities carried out by the private sector now represents a "sixth domain" of warfare, alongside NATO's five traditional operational domains – land, sea, air, space, and cyberspace.¹⁶³

BOX 3: PRODUCT PORTFOLIOS OF SELECT EUROPEAN DEFENCE COMPANIES

1. **BAE: Systems;** Fighter Jets (Eurofighter, F-35); Naval Vessels; Submarines; Cyber & Intelligence.
2. **Leonardo:** Helicopters; Defence Electronics (Systems); Fighter Jets (Eurofighter, F-35); Aerostructures.
3. **Airbus:** Helicopters; Defence Electronics (Systems); Logistics aircraft (C295, A400M, A330MRTT); Fighter Jets (Eurofighter).
4. **Thales:** Armoured Military Vehicles; Systems (Communications, Land & Air, Defence Mission Systems).
5. **Rheinmetall:** Heavy Munitions (Artillery Systems, Ammunition, Canon Systems, etc.); Main Battle Tanks (Panther KF51); Defence Systems (Air Defence, Radar, Command and Control, etc.)
6. **Saab:** Fighter Jets (Gripen); Systems (Advanced weapons systems, Radar, Command and Control, Naval Systems); Naval Vessels; Submarines.
7. **Dassault Aviation:** Fighter Jets (Rafale); Combat Aircraft (Neuron Combat UAV); Logistics Aircraft
8. **KNDS:** Main Battle Tanks (Leopard II, Leclerc); Combat Vehicles (IFVS, APVs); Heavy Munitions (Artillery systems, etc.).
9. **Naval Group:** Naval Vessels; Submarines; Systems (Naval); Heavy Munitions (Naval)
10. **Fincantieri:** Naval Vessels; Submarines.

¹⁶⁰ Airbus' defence R&D spend was USD 409 billion, while that of Boeing was USD 919 billion. Sourced from 2023 Annual Reports.

¹⁶¹ Heidenkamp (2024 p. 141–166.) The Private Sector's Role in Defence: Challenges and Opportunities for Government and Industry. Emirates Centre for Strategic Studies and Research.

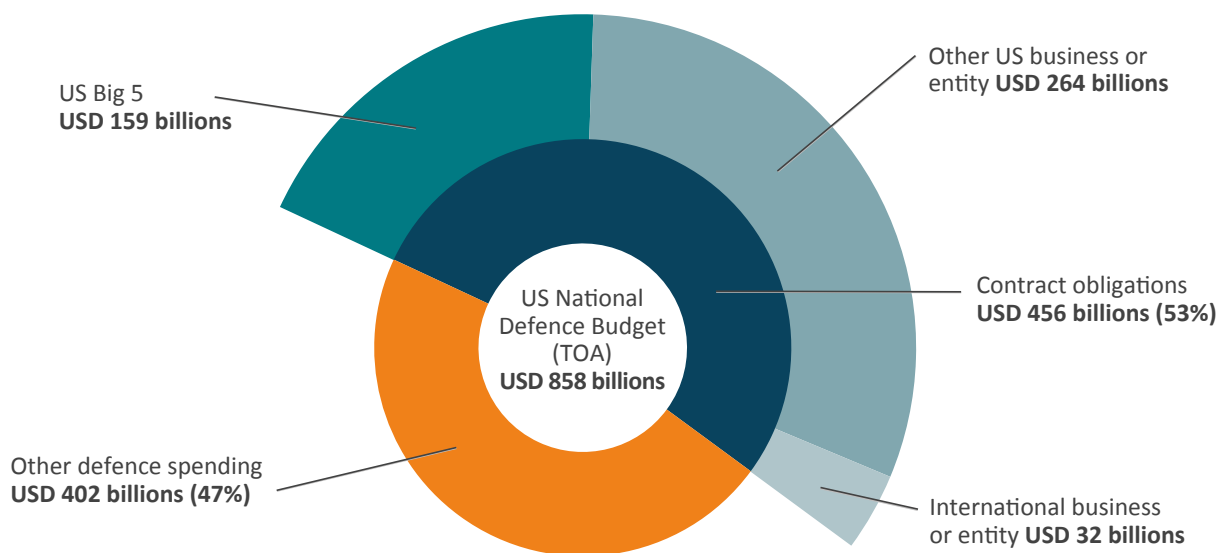
¹⁶² Ibid.

¹⁶³ Kramer (2023) The sixth domain: The role of the private sector in warfare. Atlantic Council.

Unsurprisingly, the one country where the relationship between the private sector, particularly defence companies, and the government is most crucial in shaping the national security landscape is the US. The US Department of Defense is heavily reliant on the private sector for the research, development, and production of advanced military technologies.¹⁶⁴ This partnership is not merely transactional but deeply intertwined, with the government incentivising significant portions of private R&D and often driving innovation through procurement.¹⁶⁵

The scale of this relationship is made evident by Figure 15, which shows that USD 456 billion – representing 53 percent of the US Department of Defence's total obligational authority for fiscal year 2023 – were allocated to contract obligations. While not all Pentagon contractors are private companies – some of them are federal agencies, academic institutions, local authorities, or foreign governments – the overwhelming majority are indeed businesses. This reinforces the argument of a special relationship between the Department of Defense and the private sector.

FIGURE 15: US DEPARTMENT OF DEFENSE' TOTAL OBLIGATIONAL AUTHORITY (TOA) BY CONTRACT SPENDING, 2023 (BILLIONS OF US DOLLARS)



Source: ECIPE calculations based on SAM.gov¹⁶⁶ and OUSD Comptroller¹⁶⁷.

Moreover, it is notable how dominant US-based contractors are. About 35 per cent of all contract spending – and 19 percent of the total US defence budget – goes to the Big 5. An additional 58 percent of contract obligations is awarded to other US companies or entities. By contrast, international contractors receive only USD 32 billion, which represents just 7 percent of overall contract spending and a mere 3.7 percent of the total US defence budget.

¹⁶⁴ Gholz and Sapolsky (2021) The defence innovation machine: Why the U.S. will remain on the cutting edge.

¹⁶⁵ Robertson (2024) "The Pentagon wants industry to transform again to meet demand. Can it?" Defence News.

¹⁶⁶ System for Award Management (2023) US Department of Defence IDV Award Information – Domestic or Foreign Entity (Customised report). SAM.gov.

¹⁶⁷ Office of the Under Secretary of Defence (Comptroller) (2024, p. 6.) National Defence Budget Estimates for FY 2025.

This distribution appears to underscore the claim made in the Draghi report on European competitiveness, that the US defence market remains largely impenetrable to European companies.¹⁶⁸ While technically they are involved, the US market is arranged such that they have little chance in breaking ground. This illustrates the genuine and strategic synergy between the US government and its domestic private sector – a partnership essential to maintaining the country's position as a global military leader.¹⁶⁹ Whereas in the European case, as highlighted previously, America is firmly inside the door.

How does the European defence-sector spending compare with the US? Broadly speaking, the involvement of the private sector in European defence is far less developed than in the US. While comprehensive and transparent data on private contractors, like that from the Department of Defence, is not readily available across Europe – either at the national or EU level – it is clear that European countries have weakened the procurement from their defence industry since the end of the Cold War.¹⁷⁰

While much remains to be done, things have started to change since 2022. European countries have ramped up their defence budgets and made concerted efforts to boost private sector engagement. Initiatives like the European Defence Industrial Strategy¹⁷¹ and partnerships such as the one between the European Investment Fund and the NATO Innovation Fund¹⁷² have been introduced to unlock private capital in the defence, security, and resilience sectors. However, it will take time for this new strategy to bear its fruits.

Obviously, the US is also confronted by headwinds, not least the fluctuations in procurement cycles that make it difficult for the defence industry to plan for its resource allocation.¹⁷³ As a result, the defence industry's ability to adapt and rapidly scale production in times of crisis has weakened.¹⁷⁴ The US Department of Defense does not publish data about its stockpiles, but serious warnings have been raised in recent years about certain munitions – for instance air-defence missiles used to intercept missiles and drones by aggressors.¹⁷⁵

Unpredictability, however, is far more pressing for European arms companies. While US defence firms have had a hard time ramping up production for Ukraine and other potential conflicts, their difficulties pale in comparison to the European defence industry's struggle to try and meet the continent's exploding demand, following years of underinvestment and inconsistent policy support.¹⁷⁶

¹⁶⁸ Draghi (2024, p. 165.) The future of European competitiveness: Part B | In-depth analysis and recommendations.

¹⁶⁹ Roland (2021) Delta of Power: The Military-Industrial Complex.

¹⁷⁰ Barna, Feldman, Bieńkowska, Reilly, Szewczyk, and Coget (2024) Mobilizing Greater Defence Capabilities in Europe: the EU's Defence Industrial Strategy. Global Policy Watch.

¹⁷¹ Directorate-General for Defence Industry and Space (2024) A new European Defence Industrial Strategy: Achieving EU readiness through a responsive and resilient European Defence Industry. European Commission.

¹⁷² European Investment Bank (2024) EIF and NATO Innovation Fund join forces to unlock private capital for Europe's defence and security future.

¹⁷³ Pettyjohn (2023) A discussion with Dr William LaPlante, Under Secretary of Defence for Acquisition and Sustainment.

¹⁷⁴ Ibid.

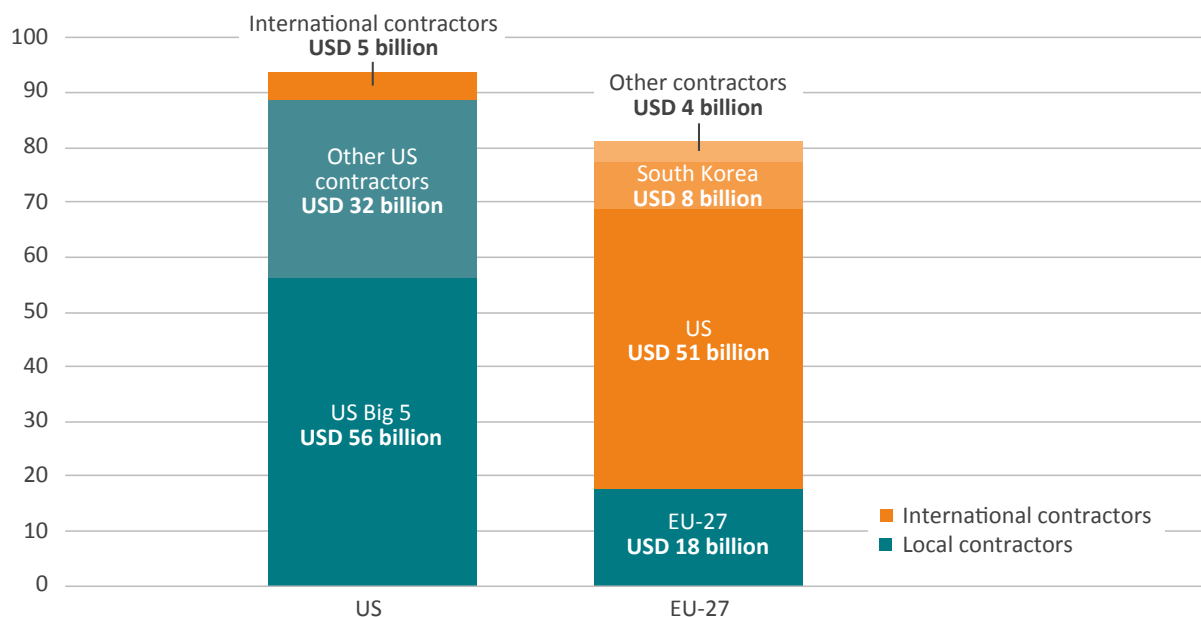
¹⁷⁵ Youssef and Lubold (2024) "Pentagon Runs Low on Air-Defense Missiles as Demand Surges." The Wall Street Journal.

¹⁷⁶ Wolff (2024) Fit for war in decades: sluggish German rearmament versus surging Russian defence production. Bruegel.

Since the start of the Russian invasion of Ukraine, the US has delivered over 3 million 155mm artillery shells to Ukraine, along with an additional million rounds of large-calibre ammunition. In comparison, Ukraine's Defence Ministry reports receiving just over half a million shells of varying calibres from the EU.¹⁷⁷ Despite EU leaders' pledges, European arms manufacturers have faced significant challenges meeting ammunition production targets to support Ukraine's defence needs.

Figure 16 illustrates the diverging purchasing patterns between the US and the EU. When comparing military equipment purchases in the US and in the EU for roughly similar periods – October 2022 to September 2023 for the US, and July 2022 to June 2023 for the EU – there is a stark difference. The first aspect worth pointing out is that, after Russia's all-out invasion of Ukraine, the total value of defence acquisitions between the two regions is not vastly different – USD 94 billion in the US versus USD 81 billion in the EU. This can be attributed largely to a sharp increase in defence equipment procurement across Europe. During this period, EU Member States collectively spent EUR 75 billion (or 81 billion in USD) on military equipment, up 44 percent from EUR 52 billion in 2021.¹⁷⁸

FIGURE 16: MILITARY EQUIPMENT PURCHASES IN THE US AND IN THE EU-27, MID-2022 TO MID-2023 (BILLIONS OF US DOLLARS)



Source: ECIPE calculations based on SAM.gov¹⁷⁹, USAspending.gov¹⁸⁰ and IRIS – Institut de Relations Internationales et Stratégiques¹⁸¹.

¹⁷⁷ Zuzana, Barca, and Flis (2024, July 25) Why the EU Fails to Deliver on Arms Pledges to Ukraine. VSquare | Investigating Central Europe.

¹⁷⁸ Maulny (2023, p. 15.) The impact of the war in Ukraine on the European defence market. IRIS – Institut de Relations Internationales et Stratégiques.

¹⁷⁹ System for Award Management (2023) US Department of Defence IDV Award Information – PIID (Customised report). SAM.gov.

¹⁸⁰ USA-Spending (2023) Federal Account Spending Profiles.

¹⁸¹ Maulny (2023, p. 15.) The impact of the war in Ukraine on the European defence market. IRIS – Institut de Relations Internationales et Stratégiques.

Obviously, the most notable element is the critical difference in the sourcing of defence equipment. In the US, most of the military equipment – 60 percent – is procured from the Big 5, with another 34 percent from other domestic companies, leaving little more than 5 percent of acquisitions for international suppliers. By contrast, Europe relies heavily on external sources, with 78 percent of its military equipment coming from outside the EU. Of these foreign acquisitions, the US accounts for a commanding 80 percent, comprising 63 percent of Europe's overall defence equipment procurement. Despite European defence companies having commendably expanded their production capacity – estimates suggest a 50 percent increase in production of artillery ammunition since the start of the Ukraine war¹⁸² – these firms have been able to meet only about a quarter of Europe's defence demand. To meet the self-set goal of procuring at least half of all defence investments from the European industrial base by 2030, EU countries need to step up their defence industry game.¹⁸³

Improving the performance of Europe's fragmented defence market requires structural measures. While the relationship between defence contractors and governments in Europe is not as deeply entrenched as in the US, it is still significant. However, much of this collaboration is confined within national borders, rarely trickling up to the EU level or leading to strong cross-border mergers or common European developments of critical weapons. European governments rather tend to maintain close ties with their national defence champions by pursuing independent procurement policies, which in turn leads to duplicated R&D efforts and programs, absence of scale, and inefficiencies in defence spending.

The cost of this fragmentation has been substantial. Throughout the early 2000s, estimates suggested that the inefficiencies associated to a lack of coordination between Europe's defence markets cost between EUR 26 billion¹⁸⁴ and EUR 90 billion¹⁸⁵ annually. More recently, the Letta report on renewing the EU's Single Market cited an even higher figure of EUR 100 billion.¹⁸⁶ Regardless of the exact amount, the underlying issue is clear: while Europe is home to many significant defence companies, it fails to capitalise on the benefits of a unified defence market and a fragmented industry leads to both economic losses and system inefficiencies when European armies collaborate. Much like the US, where the defence industry benefits from scale and unified procurement, the European defence market requires more consolidation, with fewer but larger contractors who can deliver solutions at scale.

Europe could draw lessons from the US model of pursuing stronger coordination in defence procurement. NATO, the EU, and national defence ministries can collaborate much more in industrial defence resources and, crucially, allow for much stronger natural market coordination – including mergers and acquisitions. In 2022, European collective procurement of military equipment accounted for only 18 percent of total equipment spending, far below the agreed-

¹⁸² Directorate-General for Defence Industry and Space. (2024, p.6.) A new European Defence Industrial Strategy: Achieving EU readiness through a responsive and resilient European Defence Industry. European Commission.

¹⁸³ Wolff (2024) The European defence industrial strategy: important but raising many questions. Bruegel.

¹⁸⁴ Ballester (2013 p. 78.) The Cost of Non-Europe in Common Security and Defence Policy. European Parliamentary Research Service.

¹⁸⁵ Briani (2013, p.28.) The Cost of Non-Europe in the Defence Field. Centre for Studies on Federalism and Istituto Affari Internazionali.

¹⁸⁶ Letta (2024, p.73.) Much more than a market: Speed, Security, Solidarity. Empowering the Single Market to deliver a sustainable future and prosperity for all EU Citizens. European Commission.

upon benchmark of 35 percent set in the European Defence Agency (EDA) frameworks¹⁸⁷, and light years away from the 50 percent target set for 2030 and the 60 percent one set for 2035 under the new European Defence Industrial Strategy.¹⁸⁸ Hence, the potential is certainly there for European countries – including the United Kingdom – to pool resources more effectively and engage in large-scale collaborative procurement that can drive consolidation and greater competitiveness for European defence companies. Coordinated procurement efforts would enable firms to leverage collective R&D, boost scale investment, avoid duplication, and become more competitive in global defence markets. This would strengthen Europe's defence capacity, facilitate the development of critical technologies, and reduce the strain on individual national budgets.

Additionally, another policy improvement that would indirectly expand the role of European private contractors and strengthen their relationship with European governments is to increase publicly funded R&D spending on defence at the Union level. In 2022, EU Member States, along with the European Defence Fund (EDF), collectively invested around USD 12 billion in defence R&D¹⁸⁹, a figure dwarfed by the US, which spent almost USD 73 billion in federal defence R&D during the same period.¹⁹⁰ Emulating the US is important as public R&D spending on defence – which in the US accounts for over 40 percent of all federal R&D expenditures – has been found to stimulate business R&D spending in both the defence industry and the wider economy.¹⁹¹ Moreover, evidence also suggests that the positive effect of public R&D spending – in the defence industry in particular – on private R&D is important not only in itself, but also because it generates higher productivity and therefore economic growth.¹⁹² A significant rise in publicly funded R&D spending on defence at the EU level would attract greater private sector investment, help overcome national fragmentation, and ultimately boost the bloc's competitiveness.

One great obstacle for the EU, despite its own pronounced support for a better integrated defence industry, is that the individual Member States have ultimate say in security matters and over the years the more powerful, defence advanced members, have remained intransigent in their desires to keep their own industries firmly to hand.¹⁹³ In defence terms thus the EU label can be considered void: a French plane is a French plane, a German tank a German tank, and not 'EU' produce.

Simultaneously most of the EU big militaries have significantly declined in power, as described, and with it the EU's (defence) prestige. This is where the Big Bang emphasis on restoring the EU's authority is important. As it stands, procurement from the US has a positive impact on relations with a power who can "be depended upon" in terms of defence. Even if an EU company

¹⁸⁷ Draghi (2024, p. 164.) The future of European competitiveness: Part B | In-depth analysis and recommendations.

¹⁸⁸ Directorate-General for Defence Industry and Space (2024, p. 15.) A new European Defence Industrial Strategy: Achieving EU readiness through a responsive and resilient European Defence Industry. European Commission.

¹⁸⁹ European Defence Agency (2023) Defence Data 2022 / Key findings and analysis.

¹⁹⁰ National Science Board – Science & Engineering Indicators (2024, p.35.) Research and Development: U.S. Trends and International Comparisons.

¹⁹¹ Pallante, Russo, and Roventini (2023) Does public R&D funding crowd-in private R&D investment? Evidence from military R&D expenditures for US states.

¹⁹² Moretti, Steinwender, and Van Reenen (2019) The Intellectual Spoils of War? Defence R&D, Productivity and International Spillovers.

¹⁹³ Wilkinson (2020) The EU's Defence Technological and Industrial Base. European Parliament.

produced systems of a greater quality and operability than those of the US, the decline of EU (defence) prestige means that favouring the US is ever more important for its less powerful members. Hence a Finland or the Netherlands is incentivised to procure from the US, instead of France or Germany. A post-Big-Bang EU would have bolstered its defence-industrial capacity to the extent that it can take the initiative on its own defence.¹⁹⁴

The EU has responded as of late through the European Defence Industry Reinforcement Through Common Procurement Act¹, but the effects of EDIRPA will have to be closely observed in the coming years. In its overall efforts, the EU must aim to strike a balance between long term industry optimisation and the procurement needs of the short term.

Alongside the European defence market's own coordination, a much bigger budget on public defence R&D is probably the most important part of any policy to make the European defence sector more competitive and capable. As many countries now increase their spending on defence, they would want to draw commercial benefits from the expansion. Access to competitive and highly R&D intensive military equipment requires a different market and a more robust industry structure, one that is spread thin across many countries' own champions.

4. THE 8 PERCENT APPROACH: A BIG BANG IN EUROPEAN RESOURCE ALLOCATION

"[U]topian in its expectations, legalistic in its concept of methodology, moralistic in the demands it seemed to place on others, and self-righteous in the degree of high-mindedness and rectitude it imputed to ourselves."

George Kennan¹⁹⁵

Europe needs a Big Bang in its resource allocation for R&D and defence in order to build capacities that can shape outcomes within its own region and beyond. More money alone cannot propel the EU into faster and innovation-led economic growth. It also cannot provide strong enough capacities for peace in Europe or less erosion in global order, but it is a necessary condition for a Europe intent on contributing to its own region, its allies, and the world. No one can say with any degree of exactness what appropriate levels of spending should be – now or in the future – on R&D and the military: this is not an exact science. The good level of resource allocation will inevitably be a result of strategic imagination and political ambition rather than a measure-for-measure bottom-up account. On both scores, however, Europe is in an urgent need to build up capacities after decades of complacency. Now is a time for overcorrection.

What, then, are the levels of resources that are required for Europe to start to shape outcomes in innovation and defence? We are landing on a spending level now that equals 4 percent of GDP for R&D (public and private) and 4 percent for military expenditures. In total, these two areas would represent spending at 8 percent of GDP. This is where Europe should be now to be able

¹⁹⁴ Pfeiffer and Canon (2024) "Why Europe is Unprepared to Defend Itself", Bloomberg. Factually speaking, however, there is an issue of quality today – despite there being numerous EU produced defence systems across all defence categories, US' systems are still a step higher in terms of quality.

¹⁹⁵ George Kennan (1983, p.71.) Memoirs.

to shape outcomes. Obviously, this requires a very significant increase in government spending on the military and indirect fiscal measures that drive up business spending on R&D.

It is correct to say that Europe is making efforts to improve its capacity on both counts. It has acted to pool together greater funding, and there is growing awareness of the EU's gap to the global frontier of technology and the discrepancy between defence needs and current resource allocation for the military. However, the development is far too slow: it is moving at a snail's pace in R&D and the resource planning on military expenditures is not set against the target of Europe being capable to defend itself in a large conventional war anytime soon. The panic with its deteriorating security after Russia's all-out war on Ukraine in March 2022 has yet to materialise into resource allocation for actual capacity. The war has also prompted an even greater degree of egotism in overall security policy, with declining ambitions for Europe to contribute to global order in other theatres of conflict.

The modes we sketched in the Introduction can all be found in Europe. Obviously, a good part of Europe is paralysed – the Dante's Inferno scenario – in its approach to R&D and defence. It is barely capable of increasing nominal spending on R&D to keep the percentage allocation of GDP of the previous year. Confronted with overwhelming evidence that Europe's regulatory isolation from global technology markets is hurting European competitiveness, the EU and many governments have been unable to move. It is stuck. For some, the desired strategy is to double down on policies that hike energy costs and add to regulatory burdens – to prevent the creation of the necessary resources to be allocated to R&D and defence. Such is the Thelma & Louise method, with Europe metaphorically going over a cliff.

However, many countries are instead following the Bean Counter approach – praising themselves for improving, for instance, on military spending but doing so without a clear idea of shaping outcomes. In fact, European NATO members reaching, collectively, the 2-percent spending target on defence in 2024 seemed in some ways more like a hurried achievement to please the incoming second Trump administration than a resource allocation based on defined defence needs; Europe should increase defence spending out of its own volition, not because it is shamed or spooked into doing so. Similarly, many EU governments are increasing public spending on R&D without adding a strategy for what spending should go to; they should not only do so but also consider how to increase incentives for business R&D. It is the curse of the Bean Counter approach to think you are making progress because you spent incrementally more – more than in the previous year, yet hopelessly little.

In this chapter, we will look more closely at country strategies and performances. We will start with a profile of how countries are changing their resource allocations, and which approach and strategic pathway they seem to be following. These performances will then be compared to the Big Bang approach – an approach for which this chapter will provide resource estimates, both at the level of individual countries and at the EU level as a whole.

4.1. Profiling the Resource Paths of EU Countries

It makes obvious sense to employ a Bean Counter strategy. The standard approach to most resource allocation is based on gradual or incremental changes; such government policies assume that a smaller nominal or percentage change will compound into a larger aggregate change over time. It is correct to say that governments often cannot address problems in the short term. Improvements happen over time, whether it is about boosting underlying economic dynamism or allocating sufficient resources for core state obligations. However, incrementalism can easily turn into complacency and forgetfulness about the actual problem: difficult decisions become routinely deferred into the future because they are too difficult to deal with now. Such a mentality then devolves into a charade of governments striving to being seen to be prioritising something when, in reality, little effort is being made to address the problem. They shape narratives rather than outcomes.

More problematic, the gradualist approach is just not working when the problem is immediate and potentially very serious, just as in the case with weak military capacity. Many countries have gained first-hand experience in how a complacent attitude to defence spending is a foolish choice. If weakness provokes hostile countries into aggressive action, the budgetary consequences are enormous – not to mention the wider economic and social costs of war. A gradualist approach might work when a country starts from a solid base, but this is obviously not the case in Europe today.

Moreover, a gradualist approach assumes that comparable actors do not progress themselves. For instance, Europe may plan to incrementally increase its R&D spending to achieve a level that is comparable to the US in, say, 15 years. But in that time period, the US – and others – may also move in a gradualist fashion, if not at a faster clip. Once the current target has been hit, Europe would still be behind. In this way, competitiveness is a relative concept – it is about your own performance vis-à-vis other actors – and a catch-up process requires a different approach, a commitment to action.

The curse of the Bean Counter is that it does not shape outcomes while it lulls people into thinking it does. Take the case of defence. Rightly, many European countries have been alarmed about the state of their military capacities and adverse scenarios for wars in Europe after Russia's full-scale invasion of Ukraine in 2022. But Russia invaded Georgia already in 2008 and annexed Crimea in 2014, and the Russian leadership has not exactly been hiding its views on "the Russkiy Mir." Notably, European leaders recognised the threats in 2014 and decided to act, including NATO members deciding at the Wales summit that year to raise the target of defence spending to 2 percent of GDP and allocating a decided portion on arms procurement. Yet this approach did not solve the problem. Many countries are hitting the target of defence spending only in 2024 – ten years later – but in a completely different security environment. In fact, it turns out that 2 percent was not sufficient, partly because the adversaries have developed their capacity too. Obviously, Russia was not deterred by the increase in military spending in the eight years that followed its invasion of Crimea in 2014: it rather thought it could act with impunity because of Europe's military weakness. It could also

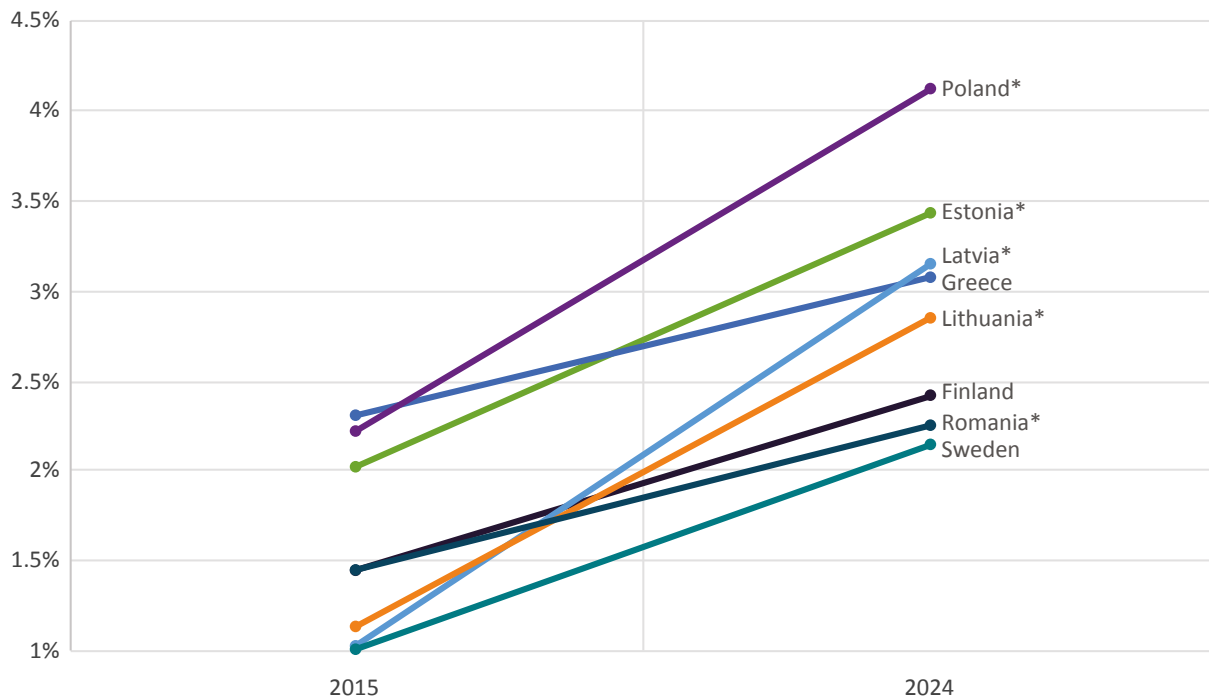
observe an obvious absence of resolve among Western leaders to deal with a revanchist Russia and its military campaigns.

Other factors also signalled European weakness. On the energy front, for instance, some European countries decided to grow their dependence on Russian gas after 2014 – and Europe has still not weaned itself off Russian energy supply.¹⁹⁶ The opportunity then to diversify sourcing and shift investment towards other energy sources was not used. For Germany, an attack on the Nord Stream pipelines was necessary for the country to rapidly move to a different supply of gas. Remarkably, as the missiles were hitting Kyiv and other Ukrainian cities, Germany decided to go ahead in 2023 with the closure of the last nuclear power plants, leading to higher energy costs. It is hard to think of a decision that better exemplifies the Thelma & Louise attitude to strategic choices.

However, it is the Bean Counter approach that has been the predominant guide for many European governments in the past ten years. There are a few states which operate on a gradually accelerating path, allocating substantially more resources in line with needs for innovation growth and military capacity building. However, the bulk of EU countries have grown slowly – in increments which profoundly lack aim and connection to the actual state of the economy and military capacity, growing hybrid warfare aggressions, and the fundamental military threats that can materialise in the next few years. Finally, there is a status quo group, countries with paltry growth in either R&D or military spending, or both, leading to falling real spending and to weaker capacity. In this landscape there is broad mismatch between the central aims decided collectively, in the EU or NATO, and actual resource allocation.

Figure 17 shows those EU countries with the most significant increase in defence expenditure between 2015 and 2024. Of these eight states (Estonia, Finland, Greece, Latvia, Lithuania, Poland, Romania, and Sweden), only three met the 2 percent NATO target in 2015 (Estonia, Greece, and Poland), and they all continued to grow their defence spending through to 2024. Latvia and Lithuania have also shot up in their trend since the invasion of Ukraine, owing to their proximity to the conflict. Finland and Sweden have also made notable increases – again owing to proximity to Russia, and their accession to NATO in 2023. Romania is an anomaly among this list in that it has fluctuated between increasing and decreasing rates of military spending and is expected to allocate 2.3 percent of GDP in 2024.

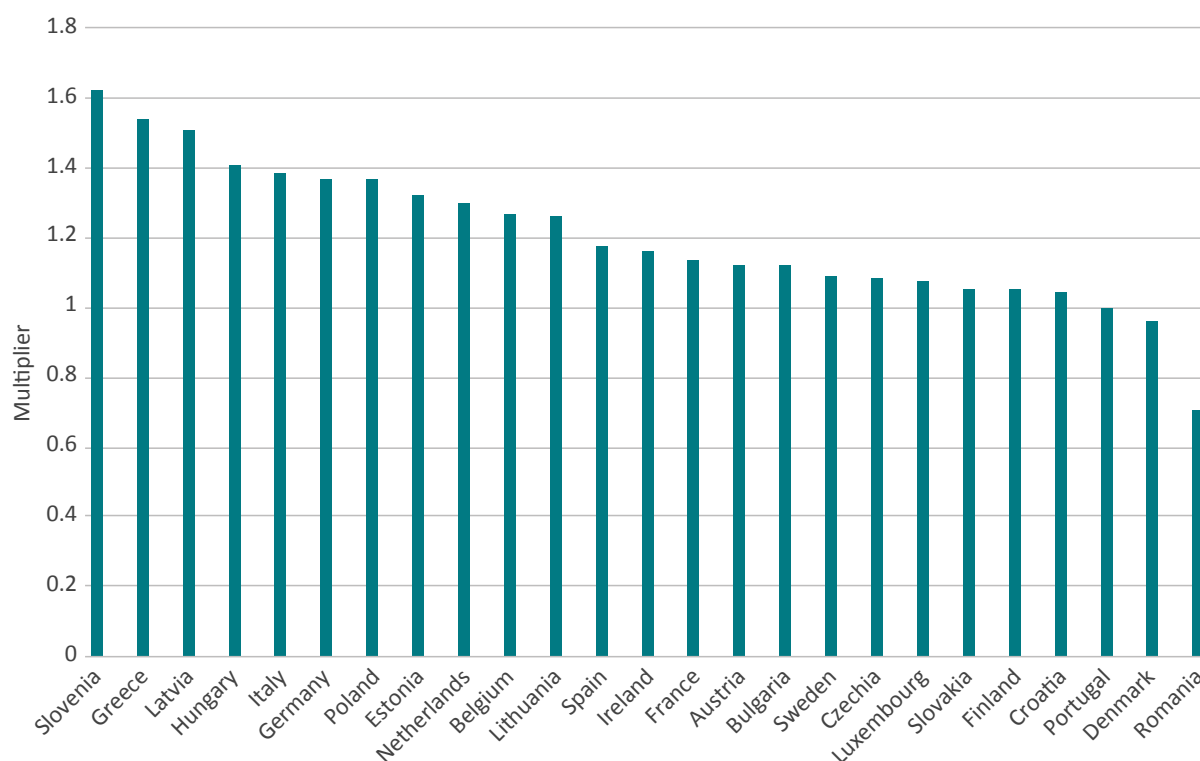
¹⁹⁶ Van Rijn (2024) The EU's continued dependency on Russian gas could jeopardize its foreign policy goals. Chatham House. According to this report, the EU sources much of its gas through Austria, and a new deal has been signed with Azerbaijan. Some member states have also signed independent deals with Turkey. All three of Austria, Azerbaijan, and Turkey in turn source most of their gas from Russia. Therefore, dependency on Russia remains.

FIGURE 17: EU-27 MEMBER STATES WITH THE FASTEST ACCELERATION OF DEFENCE EXPENDITURE AS A SHARE OF GDP, 2015 AND 2024

Source: ECIPE calculations based on NATO (2024) expenditure data.

Moving to R&D spending, it is apparent that most EU countries have not increased their nominal spending by a significant amount. Figure 18 is an index which tracks the growth of the R&D allocations in EU national budgets. The graph tracks what we call a "multiplier" – i.e. the number of times the nominal spending of a given year is greater than a previous year. In this case, the multiplier of 2022 R&D allocations compared with those from 2015. The use of GBARD (Gross Budget Allocation for R&D) in nominal terms here allows us to paint a better picture of R&D commitment in the EU. On this basis, the greatest improver has been Slovenia which had a 2022 allocation 1.6 times greater than in 2015, followed by Greece and Latvia at 1.5 times. Most countries lie between the 1.0-1.2 times range, which is hardly impressive, and at the bottom there are a handful of members (Portugal, Denmark, and Romania) who have recorded a decrease in total nominal GBARD since 2015.

FIGURE 18: EVOLUTION OF GROSS BUDGET ALLOCATION FOR R&D (GBARD) OF EU-27 MEMBER STATES IN NOMINAL FIGURES, 2015 AND 2022 (CONSTANT 2015 PRICES)



Source: ECIPE calculations based on OECD data; Notes: Nominal Terms, Constant 2015 Prices, PPP Converted. 2015 is taken as a base year (1 on the y-axis), Nominal Terms, Constant 2015 Prices, PPP Converted graph does not include Cyprus and Malta.

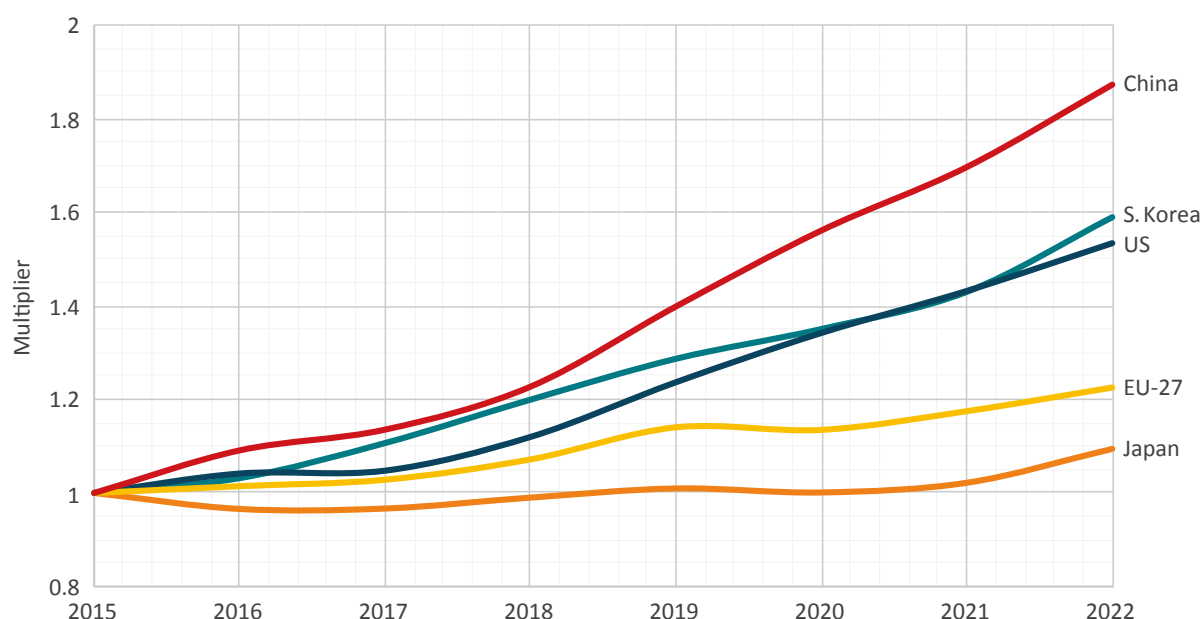
Slow progress has been made at the EU level overall, even if its institutions have made some efforts in expanding the share of EU funds allocated to R&D. Horizon Europe, the EU's R&D programme, has an EUR 86 billion allocation across the full multi-year budget between 2021 and 2027, and added to this is the European Innovation Council.¹⁹⁷ The proportion of the budget allocated for Research and Innovation has only increased by 0.4 percentage points, from 7.3 percent in the 2014-2020 budget to 7.7 percent in the 2021-2027 budget. In real terms however, the increase in R&D spending looks even more paltry. For reference, in 2022, the US saw a 5 percent increase in R&D spending in inflation-adjusted dollars from 2021¹⁹⁸; in the EU as a whole, R&D expenditure relative to GDP stood at 2.24 percent in 2022, compared to 2.27 percent in 2021, marking a slight decrease.¹⁹⁹

¹⁹⁷ European Commission (2021) MFF Breakdown.

¹⁹⁸ National Science Board – Science and Engineering Indicators 2024. (2024, p.7.) Research and Development: U.S. Trends and International Comparisons.

¹⁹⁹ Eurostat (2024) R&D expenditure.

FIGURE 19: EVOLUTION OF GROSS DOMESTIC EXPENDITURE ON R&D (GERD) FOR THE EU-27, US, JAPAN, SOUTH KOREA, AND CHINA, 2015 – 2022



Source: ECIPE calculations based on OECD data.

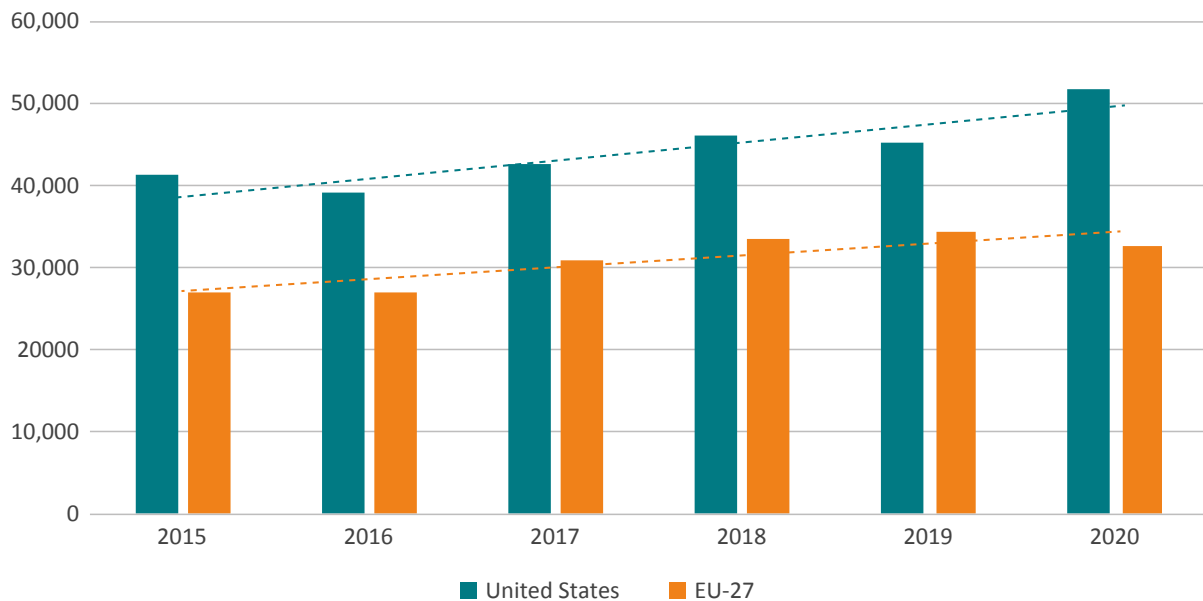
Incentives for firms to spend more on R&D are inadequate. The heavy lifting in getting Europe's R&D performance up will have to come from the private sector, and achieving such an outcome requires working with both the structural and intrinsic factors behind low BERD. Tax incentives for R&D spending and generally better FDI incentives are two approaches. Figure 20 compares the R&D incentives offered by the US and EU governments to the private sector. It records the total of direct R&D financing and tax credits offered by the two (nominal figures). Both have a roughly equal balance between direct BERD financing and tax credits²⁰⁰. The data only goes as far as 2020, at which point there was a significant gap between EU and US government R&D incentives offered. Brexit will have affected the EU trend, as the UK has a large R&D support regime – a reported USD 4 billion in 2021.

While data is limited to a few years only, R&D tax credits can be an effective incentive for innovative firms. In their current form, R&D tax credits require that companies run profits, which has sometimes skewed the allocation in favour of large firms. Yet the evidence suggests tax credits are effective and that the effects can emerge also in the short run.²⁰¹ There are also country examples showing they can boost R&D spending by SMEs.²⁰²

²⁰⁰ OECD MSTI.

²⁰¹ Bloom, Van Reenen, and Williams (2019) A Toolkit of Policies to Promote Innovation. Centre for Economic Performance, London School of Economics.

²⁰² Lokshin and Mohnen (2011) How effective are level-based R&D tax credits? Evidence from the Netherlands.

FIGURE 20: PRIVATE R&D INCENTIVES COMBINED (R&D FINANCING + TAX INCENTIVES), 2015–2020 (MILLIONS OF US DOLLARS)

Source: ECIPE calculations based on OECD Notes: Constant 2015 Prices, PPP Converted.

Based on the data and analyses presented so far, we can categorise the spending paths of different EU countries. Table 4 labels the spending approaches of EU member states in relation to gross R&D and defence expenditure, and it uses the categories that were set out in the Introduction of the paper: **Thelma & Louise** (metaphorically going over the cliff, not accepting that fundamental change is needed), **Dante's Inferno** (paralysis preventing desired resource changes to happen), **Bean Counter** (incremental improvements that do not shape outcomes), and, finally, **Big Bang** (rapid increases in resource allocation that help to solve problems).

In our analysis we have used a series of metrics to best categorise the various Member States, primarily by the increase – or lack thereof – in the percentage of GDP of gross R&D (GERD) and military expenditure. For R&D we have also considered the change in nominal budget allocations for R&D through the 'multipliers' – as observed in figure 18 – and year-on-year percentage changes. For defence, we also evaluate the change in spending across the two sub-periods within the last decade – the response recorded after Russia's annexation of Crimea in 2014 and NATO's subsequent targeting of 2 percent of GDP for defence but also after the invasion of Ukraine in 2022. Overall, with regard to defence, we take the attitude that investments made yesterday are more impactful than those made today. In other words, if a given EU state (Germany, for example) had opted to cover its strategic gaps in years prior, money spent today could be invested in bolstering absolute capabilities, rather than filling such gaps. Observing EU defence data, many states have boosted their defence spending in 2023 and 2024, while very few responded accordingly before 2022. Therefore, where appropriate, such trends have been considered in our evaluation. Finally, in both categories, qualitative factors have also been considered in making the final evaluation – e.g. Estonia and Slovenia for R&D, and Greece for defence.

TABLE 4: CATEGORISING THE SPENDING PATHS OF EU-27 COUNTRIES FOR R&D AND DEFENCE, 2015 AND 2024

Country	Summary of R&D Spending Track	Summary of Defence Spending Track
Austria	Bean Counter (Scenario 3)	Bean Counter (Scenario 3)
Belgium	Big Bang (Scenario 4)	Bean Counter (Scenario 3)
Bulgaria	Dante's Inferno (Scenario 2)	Big Bang (Scenario 4)
Croatia	Big Bang (Scenario 4)	Thelma & Louise (Scenario 1)
Cyprus	Bean Counter (Scenario 3)	Thelma & Louise (Scenario 1)
Czechia	Thelma & Louise (Scenario 1)	Bean Counter (Scenario 3)
Denmark	Thelma & Louise (Scenario 1)	Bean Counter (Scenario 3)
Estonia	Big Bang (Scenario 4)	Bean Counter (Scenario 3)
Finland	Thelma & Louise (Scenario 1)	Thelma & Louise (Scenario 1)
France	Thelma & Louise (Scenario 1)	Thelma & Louise (Scenario 1)
Germany	Dante's Inferno (Scenario 2)	Dante's Inferno (Scenario 2)
Greece	Bean Counter (Scenario 3)	Big Bang (Scenario 4)
Hungary	Bean Counter (Scenario 3)	Big Bang (Scenario 4)
Ireland	Bean Counter (Scenario 3)	Thelma & Louise (Scenario 1)
Italy	Thelma & Louise (Scenario 1)	Thelma & Louise (Scenario 1)
Latvia	Bean Counter (Scenario 3)	Big Bang (Scenario 4)
Lithuania	Thelma & Louise (Scenario 1)	Big Bang (Scenario 4)
Luxembourg	Thelma & Louise (Scenario 1)	Big Bang (Scenario 4)
Malta	Thelma & Louise (Scenario 1)	Bean Counter (Scenario 3)
Netherlands	Thelma & Louise (Scenario 1)	Thelma & Louise (Scenario 1)
Poland	Big Bang (Scenario 4)	Big Bang (Scenario 4)
Portugal	Dante's Inferno (Scenario 2)	Bean Counter (Scenario 3)
Romania	Dante's Inferno (Scenario 2)	Big Bang (Scenario 4)
Slovakia	Thelma & Louise (Scenario 1)	Thelma & Louise (Scenario 1)
Slovenia	Big Bang (Scenario 4)	Thelma & Louise (Scenario 1)
Spain	Bean Counter (Scenario 3)	Dante's Inferno (Scenario 2)
Sweden	Bean Counter (Scenario 3)	Bean Counter (Scenario 3)

Sources: ECIPE Calculations based on NATO, and SIPRI Data. Notes: See references for Austria, Cyprus, and Ireland's defence figures for 2024. Malta figure calculated from an estimated allocation of 0.5 percent of GDP

4.2. The Big Bang Approach

For Europe to start shaping outcomes, a Big Bang is needed in the resource allocation for R&D and military capacity. While the Bean Counter approach will gradually increase resources, small and incremental increases are just not enough to have a meaningful impact. Europe is seriously lagging behind the technology frontier now, and without real reforms to improve its performance, it will take a lot longer to catch up to leading economies. Similarly, the growing risks of war in Europe should entail raising military capacities now.

The Big Bang approach will require political leadership of a kind not currently visible in Europe. At the heart of Europe's Bean Counter attitude is, for want of a better term, the "impact assessment" method of politics – a model predicated on the desire to control an end result with the help of currently available facts and evidence. While this approach may include thorough analysis of potential impacts for each policy, it is also conceited in the sense that successful, outcome-shaping political leadership is often based on acting without desired degrees of knowledge. The impact-assessment method rather constrains policy and packages leadership into single and manageable units, depriving it of the necessary room for developing a strategic vision that acknowledges that the future can be radically uncertain.²⁰³

Impact assessments are deeply embedded in the EU's policymaking process, and in the best of worlds they provide a structured way to assess policy effects based on available data.²⁰⁴ While the intent is laudable – and the point here is not to bury them – they are emblematic of a style of politics in which leaders hide behind illusory appraisals. Such exercises do not just miss the big picture but intentionally deter leaders from seeing it. They allow for narratives framed around working to address a problem while not acting at all to shape an outcome. *Zeitenwende*, for instance, got billed as a radical break with past illusions and as a sign of German leaders finally "getting it." In hindsight, it seems more a strategy to delay necessary change and to shield leaders, while they approach military planning as an accountant would. In a mix of hubris and complacency, Europe's impact assessment style of politics projects an air of overconfidence, creating the illusion that it can control complex outcomes. Outcomes can, indeed, be shaped – but by providing resources and establishing the right general policy conditions.

The EU's approach to the space industry exemplifies this mindset – a sector that brings together both pillars of this paper: R&D and military capacity. In the early 1980s, the European Space Agency (ESA) launched Arianespace, the world's first commercial space launch service provider, sparking a major commercial satellite launch market. This bold initiative propelled Europe to dominance in the commercial space sector, commanding over 50 percent of the market within 15 years despite mounting global competition.²⁰⁵

For decades, Arianespace thrived due to a mix of market foresight and technical expertise. By the mid-2010s, however, a new wave of space innovation began to reshape the industry – and

²⁰³ John Kay and Mervyn King (2020). *Radical Uncertainty*.

²⁰⁴ European Commission (2024) *Impact assessments*.

²⁰⁵ Amos (2023) "Europe risks being 'a spectator in next space race'." BBC News.

this time with the effect of challenging Europe's leading role. Companies like Elon Musk's SpaceX transformed the market with the concept of reusable rockets, dramatically cutting launch costs by 90 percent and projecting even greater reductions in the near future.²⁰⁶

In 2013, an Arianespace executive dismissed the idea of reusable rockets as "a dream," one that people would eventually "wake up [from] on their own",²⁰⁷ grossly underestimating the potential of disruptive innovation and relying instead on established industry practices. ESA and Arianespace's failure to understand innovation and how technology could and would alter the market pushed Europe down the market hierarchy. These actors were trapped in the incremental mindset, unable to imagine the possibility of radical change. Now SpaceX manages nearly 70 percent of NASA's launches and represents 80 percent of space cargo launches. Today, even the EU depends on SpaceX for many of its satellite launches as Arianespace struggles with delays and, simply, to catch up.²⁰⁸ No impact assessment could have possibly anticipated this outcome.

To anticipate and prepare for the future, Europe now needs a "Big Bang" approach – a bold reset in which existing frameworks are replaced by strategic sensibility and an embrace of disruption. Rather than expending energy on exhaustive scenario forecasting and all the illusory documents it produces to give itself a semblance of leadership, Europe should act. More precisely, it should act with the goal of becoming a strong region in the fields that define global influence: innovation and defence. The best path forward is to build strength in those crucial fields, positioning Europe to be able to adapt to any event – even those we cannot foresee. Europe should become, to use a famous term, "antifragile": an entity that gets stronger every time the outside world throws a punch.²⁰⁹ By investing in its innovation and defence capabilities, Europe can move beyond trying to predict the future and instead be prepared to lead it.

The first step is to provide sufficient resources to overcorrect for past failures and underspending: a strategy to prepare Europe for a new reality. There is no exact formula for how big these resources should be. The right level of military spending can basically be summed up as follows: "more than your enemies and a bit more than is necessary to be able to hit back so hard in the event of an aggression that no one will ever hit you in the first place." No one can say what that sum would be. For instance, the United Kingdom raised its military spending between 1933 and 1938 from 2.2 to 6.9 percent of GDP²¹⁰; it still was not enough to shape an outcome on the European continent without a major US intervention. Provided the NATO alliance system holds up and can be made a lot more effective – with continued US provisions of the nuclear umbrella and strategic, logistical, and technological leadership – military spending does not need to hit almost 7 percent of GDP for necessary capacity and deterrence power. However, it is a useful figure to keep in mind when considering how much 4 percent is or is not.

²⁰⁶ Pethokoukis (2024) Moore's Law Meet Musk's Law: The Underappreciated Story of SpaceX and the Stunning Decline in Launch Costs. American Enterprise Institute.

²⁰⁷ Singapore Satellite Industry Forum 2013 – "Changing the Launch Game?" Discussion with Richard Bowles (Director of Arianespace).

²⁰⁸ Posaner (2024) "Europe's space chief confirms rocket rival to Musk's SpaceX won't launch this year." Politico.

²⁰⁹ Nassim Nicholas Taleb (2012) Antifragile: Things that Gain from Disorder.

²¹⁰ Keir Giles (2024, p.91.) Who Will Defend Europe? An Awakened Russia and a Sleeping Continent.

The expenditure rate we advise for a Big Bang approach is an approximate 4 percent of GDP in both R&D and military expenditures. In other words, this is where EU spending should be now in order to start shaping a better outcome for Europe. A 4 percent target based on the EU's GDP for 2024 would equate EUR 720 billion spent in each category. For R&D this would mean an extra EUR 315 billion, and for defence an extra EUR 380 billion, or a combined EUR 695 billion increase. To put it differently, there is a EUR 695 billion capacity hole in EU resource allocations.

For defence then, as part of a Big Bang, the EU (at EUR 720 billion) would bring itself much closer to the current levels of military spending in the US, which recorded roughly USD 876 billion or EUR 810 billion on defence in 2023 (although a further increase is expected on its part in 2024). The EU should also, in its defence initiative, further incorporate non-EU NATO members Norway and the UK. The UK is a significant contributor to the Ukraine effort and offers advanced (nuclear) naval capacity and has an established defence industry (and knowledge economy) – crucial for both parts of a Big Bang. It is a key node in the home defence network as part of NATO, and with its navy will be important for securing common interests in the Indo-Pacific. It is expected to spend roughly EUR 76 billion on defence in 2024. Norway is another important ally. It is already heavily integrated with Denmark, Finland, and Sweden, as part of 'NORDEFCO'²¹¹, and is expected to spend EUR 10 billion on defence in 2024. Taken together, European defence including Norway and the UK, would roughly equate EUR 806 billion – assuming a Big Bang in the EU alone. An expansion in British and Norwegian expenditure along the lines argued in the paper – 3.5 percent of GDP for the UK and 5 percent for Norway – would bring the Big Bang total to roughly EUR 870 billion. Such numbers, titanic though they may seem, will have the effect of uplifting the EU to a more geopolitically impactful role.

Both estimations of required spending build on the notion that the only way to correct for past mistakes is to overcorrect in the short term. Over time the level of military spending can be moderated: once necessary defence capacity has been rebuilt and sufficient deterrence power has been established, spending as share of GDP can go down. The opposite scenario applies for R&D spending: the 4 percent level now needs to be increased over time and a target for 2040 is 5 percent of GDP. Naturally, the Big Bang must be orchestrated differently in the two spending areas and there is a bigger challenge in R&D than in defence. First, as the previously analysis has already identified, Europe's core problem is under-performance in business R&D, and the shortfall can be attributed to two main categories of factors: intrinsic and structural. The structural part is important but will take time to change – not least because so many policy incentives in Europe now remain focused on middle technologies. In other words, a real boost of private sector R&D is predicated on a strategic shift away from the middle-tech focus towards more R&D intensive sectors.

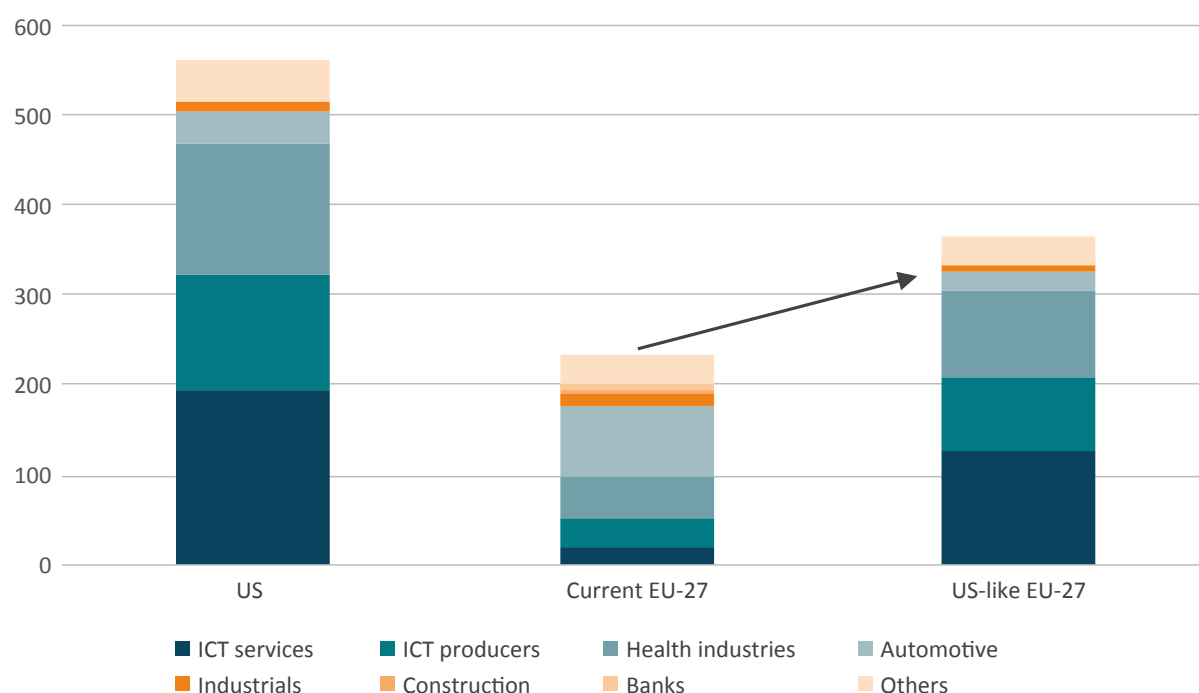
One way to illustrate the structural effect is shown in Figure 21. It compares business R&D spending from the leading R&D intensive companies across various industrial sectors in three iterations: 1) the actual R&D spending in the US and 2) the EU, and 3) a hypothetical

²¹¹ "Nordic Defence Cooperation."

scenario where the EU adopts a “US-like” spending distribution. This hypothetical model explores what EU R&D spending would look like if the EU’s industrial structure were like its US equivalent.

One notable difference in such a hypothetical scenario is the substantial increase in total business R&D spending. To match the US in proportion to GDP, EU business R&D expenditures would need to rise by at least 50 percent. This gap is likely to be even larger, given that the EU R&D Scoreboard captures only the top global R&D spenders, not the full scope of business R&D activity. More importantly, adopting a US-like spending pattern would require a significant reallocation towards high tech, cross-cutting sectors such as ICT services, ICT production, and pharmaceuticals/biotech. Under this scenario, R&D spending in these sectors would more than triple, increasing from under USD 100 billion to over USD 300 billion.

FIGURE 21: BUSINESS R&D SPENDING DISTRIBUTION BY INDUSTRIAL SECTOR FOR THE US, THE EU-27 AND A “US-LIKE” EU-27, 2022 (BILLIONS OF CURRENT US DOLLARS)



Source: ECIPE calculations based on the 2023 EU Industrial R&D Investment Scoreboard.

Now, the argument here is not that the EU should imitate the US. It is simply an example of how the structural effect of business R&D allocation works, and why it matters. It also points to the fact that this effect alone can have an impact on the gross allocation of R&D. Between 2012 and 2022, the total US R&D expenditure increased from 2.67 to 3.59 percent of GDP – an almost one percentage point rise within a decade, equivalent to an additional USD 308 billion annually, even after adjusting for inflation.²¹² Studies also reveal that more than 80 percent of the surge in US firms’ R&D spending was driven by three deep technology sectors: pharmaceuticals

²¹² OECD MSTI (2022) Gross Domestic Expenditure on R&D (GERD) – Percentage of GDP and Constant prices, US dollars, PPP converted, Millions, 2015.

and biotechnology, software and computer services, and technology hardware equipment – all sectors that are of great importance for modern military technology and warfare.²¹³

Moreover, under the propulsive force of an array of new legislation from the US government – the Inflation Reduction Act, the CHIPS and Science Act, the Bipartisan Infrastructure Law and the American Rescue Plan Act²¹⁴ – through a combination of federal incentives and tax credits, the US is expected to incentivise even more private funding towards R&D spending in the years to come in cutting-edge sectors like clean energy as well as computer and electronic manufacturing. These and other measures are likely to exacerbate the gap in business R&D spending between the EU and the US.

Public R&D spending cannot compensate for low-levels of business R&D spending – at least not comprehensively. Hence, our argument is not that governments should raise public R&D spending to 4 percent of GDP. The big policy changes that can affect an increase in total R&D spending, mirroring the 4 percent target, will have come through new and far stronger tax incentives for R&D and for investment in key high technologies. All EU countries can improve tax incentives for business R&D and, generally, use business taxes and regulation in order to attract more inward FDI in sectors that will leverage the structural effect.

The reality, however, is that it will take time for business R&D to scale up to necessary levels, and that greater responsibility will have to be taken by governments. Therefore, more public resources will need to be allocated to R&D. There are some obvious areas for such spending: public defence R&D in Europe is remarkably low, for instance, and there are several strategic R&D investments needed at top EU universities for them to remain competitive, in basic sciences and in large specialisms like space and satellites research, biotechnology, AI, quantum technology, nuclear power, clean tech, materials. Creating the fiscal conditions for such (and other) strategic expansions will require a substantial resource increase – an increase we estimate to be on par with 1 percentage point of GDP now. It would provide “shock therapy” for a sector that has fallen behind global leaders.

It is equally obvious that all countries cannot carry the same burden for expanding public R&D. Nor can changes to the structural composition of business R&D spending be assumed to happen equally across the EU. Capacities, conditions, and industry structures are very different between EU countries, and what is a realistic target for top R&D spenders like Belgium and Sweden is not realistic for bottom R&D spenders. It is the top R&D spenders and those with a stronger high-tech sector industry that have the best conditions for rapid expansion: they have the human capital, the institutions, the businesses, and the infrastructure to accommodate a large spending increase.

Figure 22 illustrates what gross R&D spending could look like if we break down the Big Bang scenario on EU countries. For this figure we have divided the EU’s membership into three groups based on their economic and absorptive capacities. The metrics for these groupings are

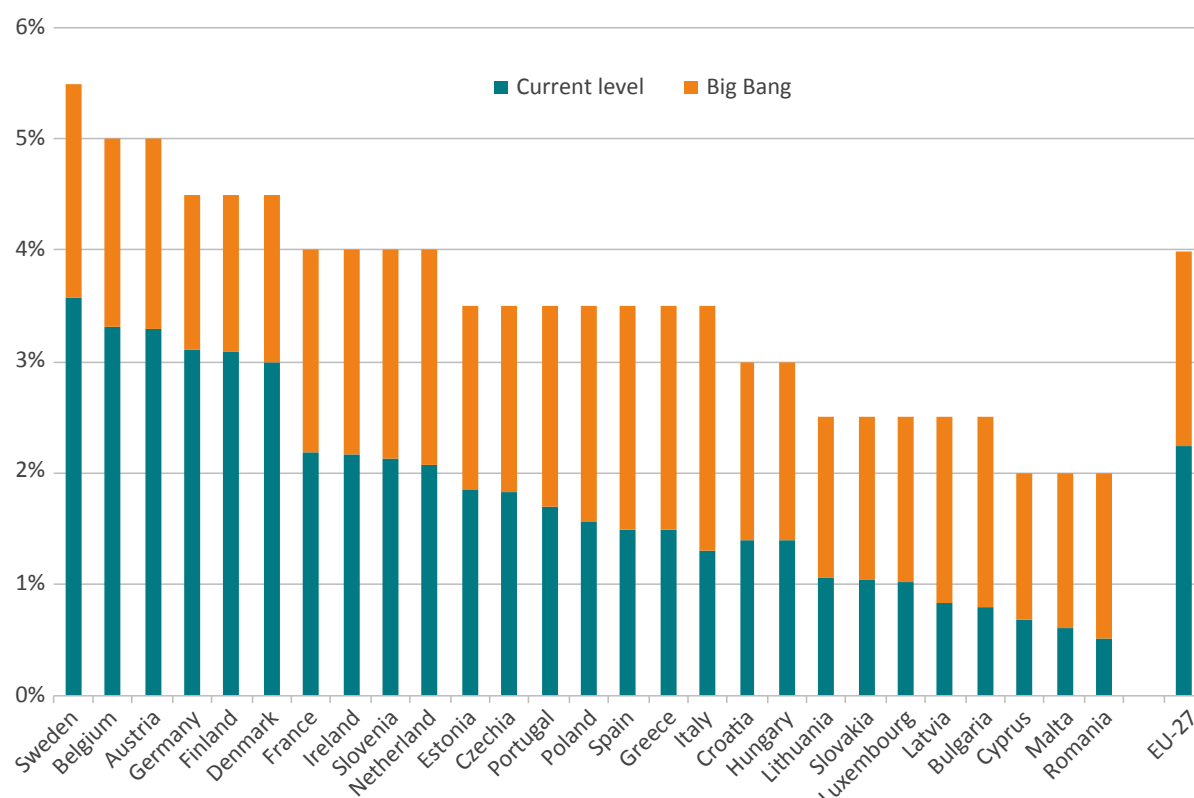
²¹³ Long (2024) A Closer Look at US Private Sector R&D Spending in a Global Context. Information Technology and Innovation Foundation.

²¹⁴ Arcuri (2023) “Innovation Lightbulb: A Trend in U.S. Research and Development Expenditure.” CSIS.

GDP, Industry Value Added, and spending on three categories related to absorptive capacity (Information and Communication; Professional-Scientific-and-Technical activities; and Public Administration, Defence, Education, Human Health and Social Work activities), all generated from OECD data.

Qualitative information on each country was also considered in order to demonstrate absolute potential.²¹⁵ Countries that are under-performing in R&D relative to their potential, such as Italy (1.32 percent, the lowest of Group 1), were kept in the highest possible group. While those “over-performing” such as Slovenia (the benchmark of Group 2, at 2.12 percent), were kept lower down. The new GERD of the EU thus amounted to 4 percent, placing it second behind South Korea and well above the US and China.

FIGURE 22: GROSS DOMESTIC EXPENDITURE ON R&D (GERD) FOR EU-27 COUNTRIES IN A BIG BANG SCENARIO (PERCENTAGE OF GDP)



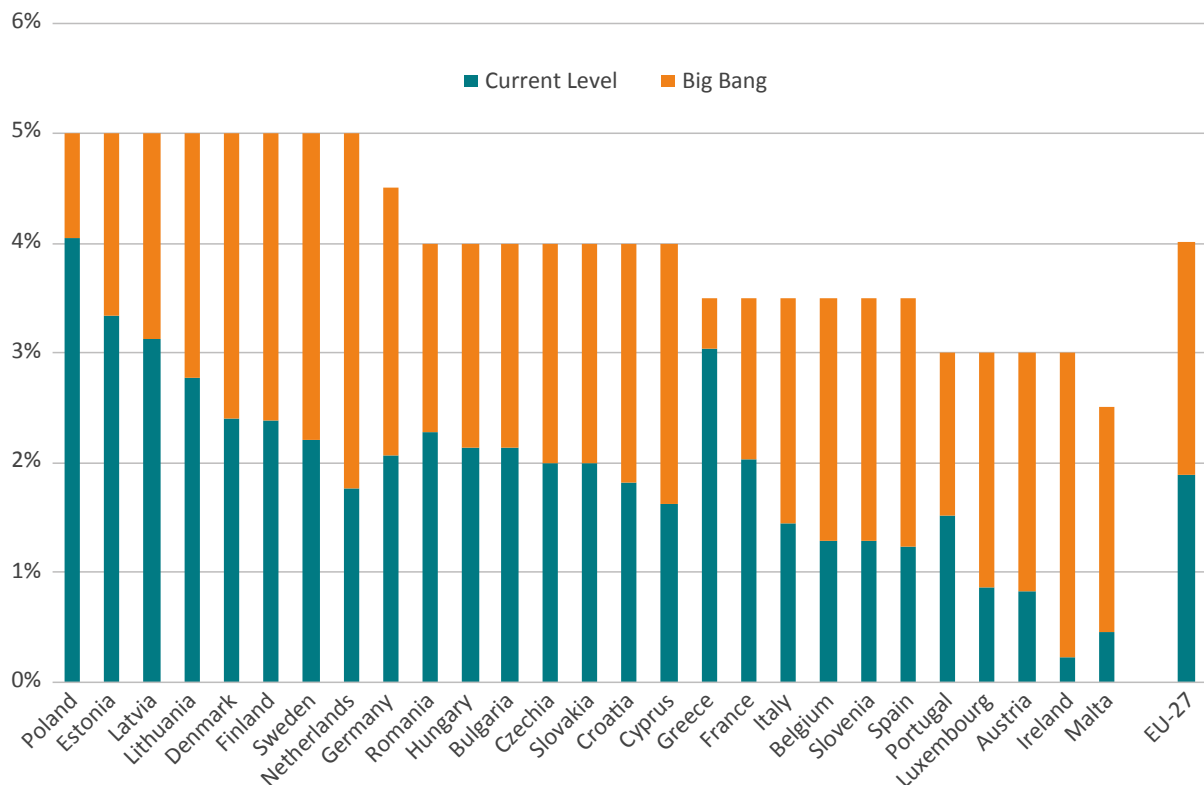
Source: ECIPE calculations based on NATO (2024) and WB: SIPRI (2013-2022) data, based on groupings of ‘similar’ economies (by GDP, Industry Value Added, and estimated “absorptive capacity”, using OECD data from 2022).

A similar approach guides the Big Bang approach to military spending, as can be observed in Figure 23, for which we have grouped EU members similarly as in Figure 22. First, countries with a high and rising military expenditures have the potential to reach expenditure levels from

²¹⁵ Key to the Big Bang philosophy, is that Member States act in accordance with their maximum potential, i.e., following the trend of Belgium in R&D and Poland in Defence, in the short term.

the top category. In the second group, countries in the Baltic Sea region and with proximity to Russia should raise their military expenditures disproportionately – which some countries, notably Poland and Estonia, are already doing. Poland is estimated to have military expenditures above 4.5 percent of GDP in 2025. Estonia is estimated to climb above 4 percent of GDP in the same year. Third, countries with substantial defence sectors will have to take a greater responsibility. They also stand to benefit economically from Europe's expansion of military expenditures.

FIGURE 23: DEFENCE SPENDING FOR EU-27 COUNTRIES IN A BIG BANG SCENARIO (PERCENTAGE OF GDP)



Source: ECIPE calculations based on SIPRI and NATO data. Notes: Groupings of EU states based on qualitative factors including proximity to conflict zones (Ukraine), and military-industrial capacity. Quantitative factors such as fiscal capacity and fiscal health are also considered. See Dorn, Potrafke, & Schlepper (2024)²¹⁶

Neither the R&D nor the military spending levels and their distribution across countries are based on exact science. These are judgements based on shortfalls in capacity and performance, and they suggest a more strategic orientation to European statecraft, one that is reasonable and necessary now given the need to overcorrect past mistakes. Obviously, the methodology is based on top-down reasoning – not bottom-up estimates on exactly how and where Europe under-performs, and what individual units and systems need. The bottom-up approach is impossible as a method for understanding where Europe should be at this point. It will only give us the pretence of an estimate, one that is free from a strategic impulse.

²¹⁶ Dorn, Potrafke, and Schlepper (2024) European defence spending in 2024 and beyond: How to provide security in an economically challenging environment.

Obviously, the allocations assigned for each country are not written in stone. We have assigned them based on what we observe as ambitious for each country. It is obvious that France and Italy spending 4 percent on defence would be more impactful than most others spending 5 or 6 percent, due to their large economies and advanced defence industries. Both countries have significant untapped capacity. True, their current fiscal constraints make it seem like an impossible task to move very quickly to these rates of spending.²¹⁷ On the other hand, their non-defence expansion in public expenditures over the last years have, as previously noted, been substantial. Equally, members like Sweden and the Netherlands have greater fiscal breathing room – with lower public deficits and debts – and have significant defence industries and can make much stronger contributions to the defence of the Baltic Sea region and geopolitical stability in the Indo-Pacific. Regardless, major military powers must show their mettle in the long term: if the EU's sense of command is to be restored, it will not happen without serious capacity growth from Germany, the UK, and France.

Let us sum up what the Big Bang equals in nominal spending. R&D spending as a share of GDP in the EU has remained unmoved at 2.25 percent in the past years.²¹⁸ Assuming this trend persists and utilising IMF estimates for 2024 nominal GDP, R&D spending for 2024 is projected to amount to approximately EUR 405 billion. Under our proposed target of 4 percent of GDP allocation, the R&D-focused Big Bang would require an additional **EUR 315 billion** (EUR 720 billion in a Big Bang total, minus EUR 405 billion in current spending).

In terms of military expenditure, according to nominal 2024 NATO estimates and to 2023 SIPRI ones for non-NATO members of the EU, defence spending by EU Member States will reach a collective EUR 340 billion in 2024.²¹⁹ To meet our proposed target of 4 percent of GDP allocation, the defence-focused Big Bang would necessitate an additional **EUR 380 billion** (EUR 720 billion in a Big Bang total, minus EUR 340 billion in current spending).

Combining these dimensions, the total additional expenditure required for Big Bang approach amounts to **EUR 695 billion**.

²¹⁷ While our paper is focused more on the 'why' a Big Bang in spending R&D, there are several studies on the 'how', such as Dorn et al. reported in the footnote above.

²¹⁸ Eurostat (2024) R&D expenditure.

²¹⁹ European Defence Agency (2024) 2024 Coordinated Annual Review on Defence (CARD) report.

5. CONCLUSION

"[It] behoves one to adapt Oneself to the Times if one wants to enjoy Continued Good Fortune"

*Niccolò Machiavelli*²²⁰

Yet again Europe faces a strategic moment in its history that requires transformative actions – this time to address its economic, technological, and military weaknesses. The challenges are multifaceted: waning global influence in technology and innovation and insufficient military capacity amidst rising threats are two of them. They both require a Big Bang in resource allocation – ideally in tandem with other policies that boost economic performance and deepen alliances. In this paper, we have set out the 8 percent approach: boosting total spending in the EU by EUR 695 billion in order to reach 4 percent spending targets for both R&D and defence. It is a policy of overcorrection, addressing the fact that Europe has underspent on both for several decades and, as a result, stunted its technology performance and defence capacity.

Both areas, R&D and defence, hang together. Europe's lagging position in global technology and innovation has deep geopolitical implications – including inadequate provision of frontier military technology. The EU, once a leader in industrial and technological advancements, is now trailing behind not only the US but also smaller high-tech nations such as Taiwan and South Korea. Rising technological powers like China outperform the EU on several metrics of technology and innovation. Investment in critical technologies such as telecoms, satellites, AI, quantum technology, and non-fossil energy remains inadequate, with European businesses contributing far less to R&D compared to their international counterparts. To change this Europe also needs to get closer to its friends, including smaller high-tech nations.

The EU's failure to meet its own R&D spending targets reflects deeper structural issues. While the Lisbon Strategy set a goal of allocating 3 percent of GDP to R&D, current spending remains stagnant at around 2.1 percent. Worse, this target is outdated given the R&D intensity of leading economies, which now exceed 3 percent and are climbing. For instance, South Korea allocates about 5 percent of GDP to R&D and leading states in the US (e.g. Massachusetts and New Mexico) have an R&D allocation that is more than twice the size of EU R&D leaders such as Belgium and Sweden. A substantial increase in R&D spending is necessary for Europe to avoid being sidelined in the new industrial revolution which is already proceeding apace.

Moreover, Europe's technological deficiencies extend to commercialisation. In fact, most of the under-performance in the EU is manifested in the business sector – with embarrassingly low levels of business R&D and obvious issues with accelerating structural economic change. Hence, problems cannot be solved by adding more public R&D: Europe rather needs to work with multiple policies that ease the condition for business R&D and experimentation, and that provide better opportunities for innovation growth. This is becoming urgent. High-growth industries, such as telecommunications and semiconductors, are moving operations outside Europe due to regulatory and market constraints – as well as simply because margins and profits are just so much better outside of the EU.

²²⁰ Niccolò Machiavelli (1983 [1531], p.430) *The Discourses*.

Europe's military deficiencies are even more worrying. Decades of inadequate resource allocation have left EU Member States ill-prepared for modern conflicts, with depleted ammunition stocks, outdated equipment, and insufficient production capabilities. While Russia's aggression in Ukraine has galvanised political support for defence, actual spending increases remain piecemeal and incremental – leading, in the best of worlds, to Europe having capacity to win a war in, say, a decade. Yet the threats are far more immediate and Europe's defence spending, often measured as a percentage of GDP, is far below the levels required to counter them effectively.

The lack of urgency in addressing these deficiencies is dangerous. Modern warfare increasingly relies on advanced technologies: think hypersonic missiles, drones, and integrated communications systems. Europe's inadequate 5G infrastructure, for instance, hinders both its military and economic capacities. Furthermore, reliance on the United States for security underlines the fragility of Europe's strategic position, at a time of shifts in US foreign policy. Even without them, Europe should become more self-reliant but the shifts underline the need.

The Big Bang approach advocates for a radical overcorrection to address decades of underspending in R&D and defence. Incremental increases in spending are no longer sufficient given the magnitude of the challenges. Instead, Europe must commit to a rapid and substantial reallocation of resources that equal:

- 1. R&D Spending at 4 percent of GDP:** High-performing EU Member States like Sweden, Germany, and Belgium should lead the charge, targeting R&D expenditures of 5 percent or more of their GDP. This would help close the technology gap with global leaders and stimulate innovation spillovers across the EU;
- 2. Defence Spending at 4 percent of GDP:** NATO's proposed increase in defence spending targets is a step in the right direction. However, Europe must go beyond symbolic commitments, ensuring that investments translate into tangible capabilities. Immediate priorities include modernising traditional weapon systems and developing next-generation technologies.

The Big Bang approach is not merely about increasing spending. It is also about strategic alignment. Europe must therefore:

- Define clear priorities, focusing on transversal and critical technologies with broad applications across civilian and military domains;
- Increase coordination between EU institutions and Member States to maximise the impact of expenditures;

- Allow for consolidation in the defence sector to promote economies of scale and better defence R&D performance;
- Deepen partnerships with both the US and allies in the Indo-Pacific region while promoting European competitiveness and Europe's ability to make stronger contributions to security and prosperity globally.

Niccolò Machiavelli in his less famous, yet more elaborate book 'The Discourses', states that it "behoves one to adapt to the times" if they are to enjoy continued good fortune. He also asserts that a given republic must now and again be recentred upon its founding principles and virtues, if it is to survive prosperously. While increased spending in the areas discussed in this paper may address the former, there is great political effort needed alongside this, if the EU is to achieve the latter.²²¹

²²¹ Niccolò Machiavelli (1983[1531], p.385-390) *The Discourses*. He explains how a given Kingdom, Republic, or even Religion requires constant renaissance if it is to survive long. In this sense, the EU may need to discover its original self once more. Such proceedings, as argued, may be "brought about either by some external event" (as experienced by the EU today) "or by its own intrinsic good sense." By composition, perhaps the EU could look toward both.

REFERENCES

AI-Kommissionen . Färdplan för Sverige. . Government Document, Stockholm: AI Kommissionen, 2024.

Alcaro, Riccardo, e Hylke Dijkstra. «Re-imagining EU Foreign and Security Policy in a Complex and Contested World.» *The International Spectator*, 2024: 1-18.

Allen, Gregory C., e Doug Berenson. Why Is the U.S. Defense Industrial Base So Isolated from the U.S. Economy? 20 August 2024. <https://www.csis.org/analysis/why-us-defense-industrial-base-so-isolated-us-economy> (consultato il giorno December 26, 2024).

Amos, Jonathan. Europe risks being 'a spectator in next space race'. BBC News. 23 March 2023. <https://www.bbc.com/news/science-environment-65053729> (consultato il giorno December 29, 2024).

Arcesati, Rebecca, Francois Chimits, e Antonia Hmadi. Keeping Value Chains at Home: How China controls foreign access to technology and what it means for Europe. MERICS, Berlin: MERICS, 2024.

Arcuri, G. Innovation Lightbulb: A Trend in U.S. Research and Development Expenditure. CSIS. 16 June 2023. <https://www.csis.org/analysis/innovation-lightbulb-trend-us-research-and-development-expenditure>.

Aries, Hannah, Bastian Giegerich, e Tim Lawrenson. «The Guns of Europe: Defence Industrial Challenges in a Time of War.» 19 June 2023. <https://www.iiss.org/en/online-analysis/survival-online/2023/06/the-guns-of-europe-defence-industrial-challenges-in-a-time-of-war/>.

Aronsson, Albin. «The United Kingdom.» *Western Military Capability in Northern Europe 2023. Part I – National Capabilities*. A cura di Björn Ottosson e Krister Pallin. Stockholm: FOI, 25 March 2024.

ASEAN. «ASEAN-China Joint Statement on Synergising the Master Plan on ASEAN Connectivity (MPAC) 2025 and the Belt and Road Initiative (BRI).» ASEAN. November 2019. <https://asean.org/wp-content/uploads/2019/11/Final-ASEAN-China-Joint-Statement-Synergising-the-MPAC-2025-and-the-BRI.pdf>: (consultato il giorno December 2, 2024).

Atkinson, Robert D. Go to the Mattresses: It's Time to Reset U.S.-EU Tech and Trade Relations. Washington, D.C.: ITIF, 2024.

Australian Strategic Policy Institute. Critical Technology Tracker. 2024. <https://www.aspi.org.au/report/critical-technology-tracker> (consultato il giorno September 10, 2024).

Azoulay, P., E. Fuchs, A.P. Goldstein, e M. Kearney. «Funding Breakthrough Research: Promises and Challenges of the "ARPA Model".» *Innovation Policy and the Economy*, 2019: 69-96.

Ballester, B. *The Cost of Non-Europe in Common Security and Defence Policy*. External Government Report, European Parliamentary Research Service, European Parliament, Brussels: European Commission, 2013.

Barna, S., D. Feldman, Bienkowska, Reilly, T. E., B. Szewczyk, e M. Coget. *Mobilizing Greater Defence Capabilities in Europe: the EU's Defence Industrial Strategy*. *Global Policy Watch*, 2024.

Barnett, Jonathan. *Democracies' Advantage: Leveraging Innovation Coalitions to Meet the Autocratic Challenge*. CSIS. 20 June 2024. <https://www.csis.org/blogs/perspectives-innovation/democracies-advantage-leveraging-innovation-coalitions-meet> (consultato il giorno December 24, 2024).

BEA. *Experimental R&D Value Added Statistics for the U.S. and States Now Available*. 9 May 2024. <https://www.bea.gov/news/blog/2024-05-09/experimental-rd-value-added-statistics-us-and-states-now-available#:~:text=R%26D%20activity%20is%20highly%20concentrated,%2C%20Texas%2C%20and%20New%20York>.

Benson, E., C. Mouradian, e P. Alvarez-Aragones. *Evaluating Chip Overcapacity and Trans-Atlantic Trade toolkit*. Washington D.C.: CSIS, 2024.

Benson, Emily, e Gloria Sicilia. *Navigating Tides: The European Union's Expanding Role in the Indo-Pacific*. 2024. <https://www.csis.org/analysis/navigating-tides-european-unions-expanding-role-indo-pacific>.

Benson, Emily, Federico Steinberg, e Pau Alvarez-Aragones. *The European Union's Economic Security Strategy Update*. Washington: CSIS, 2024.

Bergmann, Max, e Christopher B Johnstone. *Europe's Security Role in the Indo-Pacific*. Washington: CSIS, 2024.

Bergmann, Max, e Federico Steinberg. *Europe's Fiscal Crossroads*. Washington: CSIS, 2024.

Blanco, Francisco A., Francisco J. Delgado, e Maria J. Presno. «R&D expenditure in the EU: convergence or divergence?» *ECONOMIC RESEARCH-EKONOMSKA ISTRAŽIVANJA*, 2020: 1685-1710.

Bloom, N., C. I. Jones, J. Van Reenen, e M. Webb. «Are Ideas Getting Harder to Find?» *American Economic Review* (American Economic Association) 110, n. 4 (2020): 1104-1144.

Bloom, Nicholas, John Van Reenen, e Heid Williams. *A Toolkit of Policies to Promote Innovation*. Discussion Paper - Think Tank Report, London School of Economics, London: Centre for Economic Performance, 2019.

Bomprezzi, Pietro, Ivan Kharitinov, e Christoph Trebesch. Ukraine Support Tracker – Methodological Update & New Results on Aid “Allocation”. Research Report, Kiel: Kiel Institute for the World Economy (IfW Kiel), 2024.

Bowles, R. «Changing the Launch Game.» Singapore Satellite Industry Forum 2013 – Changing the Launch Game. 2013.

Briani, V. The Cost of Non-Europe in the Defence Field. Think Tank Report, Centre for Studies on Federalism; Istituto Affari Internazionali, 2013.

Brown, Larisa. Armed forces could not stop an invasion, admits defence secretary. The Times. 24 October 2024. <https://www.thetimes.com/uk/defence/article/war-not-ready-john-healey-6norr2jg> (consultato il giorno December 26, 2024).

BRUNO, RANDOLPH LUCA, ELODIE DOUARIN, JULIA KOROSTELEVA, e SLAVO RADOSEVIC. «The Two Disjointed Faces of R&D and the Productivity Gap in Europe.» Journal of Common Market Studies, 2022: 580-603.

Bundesministerium der Verteidigung. Defence Policy Guidelines 2023. Government Document, Berlin: Bundesministerium der Verteidigung, 2023.

Bundesministerium für Finanzen. «Budget at a glance.» Bundesministerium für Finanzen (Austria). 2023. https://www.bmf.gv.at/dam/jcr:087f6623-cffc-4d89-b535-f64c4404602b/Budget_2024_at_a_glance.pdf.

Busbarat, Pongphisoot (Paul), et al. How Has China's Belt and Road Initiative Impacted Southeast Asian Countries? 5 December 2023. <https://carnegieendowment.org/posts/2023/12/how-has-chinas-belt-and-road-initiative-impacted-southeast-asian-countries?lang=en>: (consultato il giorno December 2, 2024).

Celli, Viviana, Augusto Cerqua, e Guido Pellegrini. « Does R&D Expenditure Boost Economic Growth in Lagging Regions.» Social Indicators Research , 2024: 249-268.

Chiappinelli, O., et al. «A green COVID-19 recovery of the EU basic materials sector: identifying potentials, barriers and policy solutions. » Climate Policy, 2021: 1328-1346.

Chinn, David, Nadine Griebmann, Hugues Lavandier, Rafael Ocejo, Tobias Otto, e Katherina Wagner. Innovation and efficiency: Increasing Europe's defense capabilities. London: McKinsey & Co., 2024.

Christou, Jean. Cyprus to Hike its Military Spending. Cyprus Mail. 17 November 2023. <https://cyprus-mail.com/2023/11/17/cyprus-to-hike-its-military-spending> (consultato il giorno 01 10, 2025).

Clarivate. Top 100 Global Innovators 2024. 2024. <https://clarivate.com/top-100-innovators/the-top-100/>.

Cohen, Wesley M., e Daniel A. Levinthal. «Absorptive Capacity: A New Perspective on Learning and Innovation.» *Administrative Science Quarterly* 35, n. 1 (1990): 128-152.

Congressional Research Service (CRS). «The Pacific Deterrence Initiative: A Budgetary Overview.» 9 January 2023. <https://crsreports.congress.gov/product/pdf/IF/IF12303>.

Coste, Oliver. *Europe, Tech and War*. Self-Published, 2022.

Demertzis, Maria, Marta Domínguez-Jiménez, e Lionel Guetta-Jeanrenaud. *Europe should not neglect its capital markets union*. Brussels: Bruegel, 2021.

Department of Defence (Ireland). Press Release - Record allocation of €1.35 billion in Defence funding in Budget 2025. Dublin, 1 October 2024.

Deutsch, Jillian. Ericsson CEO Says Weak Europe Market Forces Firm to Grow Abroad. *Bloomberg*. 18 November 2024. <https://www.bloomberg.com/news/articles/2024-11-18/ericsson-chief-looks-for-growth-in-us-as-europe-falls-behind> (consultato il giorno December 24, 2024).

Die Bundesregierung. *National Security Strategy: Robust, Resilient, Sustainable. Integrated Security for Germany*. Government Report, Berlin: Die Bundesregierung, 2023.

Dirox. *Competitiveness in the ICT Sector of South Korea*. 2023. <https://dirox.com/post/competitiveness-in-the-ict-sector-of-south-korea#:~:text=South%20Korea%20is%20one%20of,phones%2C%20computers%2C%20and%20software>. (consultato il giorno September 16, 2024).

Dorn, Florian, Niklas Potrafke, e Marcel Schlepper. «European defence spending in 2024 and beyond: How to provide security in an economically challenging environment.» *EconPol Policy Report*, n. 45 (2024).

Draghi, Mario. *The future of European competitiveness Part A | A competitiveness strategy for Europe*. External Government Report, Brussels: European Commission, 2024.

Draghi, Mario. *The future of European competitiveness Part B | In-depth analysis and recommendations*. External Government Report, Brussels: European Commission, 2024.

Dugo, Andrea. *South Korea Versus Japan: What Can the EU Learn From the Two Countries?* ECIPE. October 2024. <https://ecipe.org/blog/south-korea-japan-what-can-eu-learn/> (consultato il giorno December 25, 2024).

Dugo, Andrea, e Fredrik Erixon. *A Strategy for a Competitive Europe: Boosting R&D, Unleashing Investment and Reducing Regulatory Burdens*. Policy Brief, Brussels: ECIPE, 2024.

DW News. Germany's Military is Aging and Shrinking, Says Report. 12 March 2024. <https://www.dw.com/en/germanys-military-is-aging-and-shrinking-says-report/a-68504942> (consultato il giorno December 25, 2024).

EEAS. A Strategic Compass for Security and Defence. . Brussels: EEAS, 2022.

Engström, Alina. «Germany.» Western Military Capability in Northern Europe 2023: Part I – National Capabilities. A cura di Björn Ottosson e Krister Pallin. Stockholm: FOI, 25 March 2024.

Erixon, Fredrik, e Oscar Guinea. Reforming Standard Essential Patents: Trade, Specialisation, and International Jurisprudence. . Policy Brief, Brussels: ECIPE, 2023.

Erixon, Fredrik, e Oscar Guinea. Strategic Autonomy and the Competitiveness of Europe's Innovative Pharmaceutical Sector: A Wake-up Call. Policy Brief, Brussels: ECIPE, 2023.

Erixon, Fredrik, Oscar Guinea, e Oscar du Roy. If the EU was a State in the US: Comparing Economic Growth between the EU and US states. Policy Brief, Brussels: ECIPE, 2023.

Erixon, Fredrik, Oscar Guinea, e Oscar du Roy. Keeping Up with the US: Why Europe's Productivity is Falling Behind. Policy Brief, Brussels: ECIPE, 2024.

ETER. Internationalisation of Academic Staff in European Higher Education. European Tertiary Education Register, 2019.

EU-European Centre of Excellence for Civilian Crisis Management. «A Global Strategy for the European Union's Foreign and Security Policy.» June 2016. [https://www.coe-civ.eu/kh/a-global-strategy-for-the-european-unions-foreign-and-security-policy#:~:text=The%202016%20Global%20Strategy%20\(EUGS,the%202003%20European%20Security%20Strategy](https://www.coe-civ.eu/kh/a-global-strategy-for-the-european-unions-foreign-and-security-policy#:~:text=The%202016%20Global%20Strategy%20(EUGS,the%202003%20European%20Security%20Strategy).

EUR-Lex. «EUR-Lex.» 8 February 2007. <https://eur-lex.europa.eu/EN/legal-content/summary/placing-taxation-at-the-service-of-research-and-development.html>.

European Commission – Directorate-General for Defence Industry and Space. A new European Defence Industrial Strategy: Achieving EU readiness through a responsive and resilient European Defence Industry. Government Document - Join Communication, Brussels: European Commission, 2024.

European Commission. EU innovation performance continues to improve in spite of challenges. 2022. https://ec.europa.eu/commission/presscorner/detail/en/IP_22_5682 (consultato il giorno September 15, 2024).

- European Innovation Council. 2024. <https://op.europa.eu/en/publication-detail/-/publication/3874fc76-f87f-11ee-a251-01aa75ed71a1>.

European Commission. Impact Assessments. Government Report, Brussels: European Commission, 2024.

European Commission. MFF 2021-2027. Brussels: EU, 2021.

- «MFF 2021-2027 breakdown.» 2021. https://commission.europa.eu/document/download/31a0d09a-2548-49b8-8d85-d6342ad76d29_en?filename=mff_2021-2027_breakdown_current_prices.pdf (consultato il giorno September 2, 2024).
- «The European Defence Fund, factsheet, 2018.» European Union. 13 June 2018. https://ec.europa.eu/commission/sites/beta-political/files/budget-may2018-eu-defence-fund_en_0.pdf (consultato il giorno January 9, 2025).
- What is the capital markets union? 2022. https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/capital-markets-union/what-capital-markets-union_en?prefLang=nl (consultato il giorno 09 17, 2024).

European Defence Agency. Coordinated Annual Review on Defence (CARD). Government Report, Brussels: European Defence Agency, 2024.

- Defence Data. 2024. <https://eda.europa.eu/publications-and-data/defence-data> (consultato il giorno December 26, 2024).
- Defence Data 2022 / Key findings and analysis. 2023. (consultato il giorno December 26, 2024).

European Investment Bank. EIF and NATO Innovation Fund join forces to unlock private capital for Europe's defence and security future. Press Release, Brussels: European Commission , 2024.

Foreman-Peck, James, e Peng Zhou. «R&D subsidies and productivity in eastern European countries.» Economic Systems, 2022.

Fowler, Annabelle, Kathleen Grieve, Andreas Maos, e Tim Wilsdon. «Quantifying public and private investment in European biopharmaceutical research and development.» Health Affairs Scholar, 2024: 2-6.

France 24. 'You got to pay!': Trump threatens to 'encourage' Russia to attack NATO allies behind on payments. 11 February 2024. <https://www.france24.com/en/americas/20240211-you-gotta-pay-trump-threatens-to-urge-russian-attack-of-nato-allies-behind-on-payments> (consultato il giorno December 29, 2024).

Fuest, C., D. Gros, P.-L. Mengel, G. Presidente, e J. Tirole. EU INNOVATION POLICY: HOW TO ESCAPE THE MIDDLE TECHNOLOGY TRAP. European Policy Analysis Group, Milan: Institute for European Policymaking, Bocconi University, 2024.

Furuya, Yukiko, Mohammad Ismail Nooraddini, Wenjing Wang, e Michele Waslin. A Portrait of Foreign-Born Teachers in the United States. Fairfax, Virginia, USA: George Mason University: Institute for Immigration Research, 2019.

Gahn, Santiago José. On the long-run relationship between R&D expenditures and GDP: some considerations for the case of Italy (1963-2013) . Milan: CRANEC: Centro di Ricerche in Analisi Economica e Sviluppo Economia Internazionale, 2022.

Gardner, Jonathan. We have no Plan B if Ukraine falls, says Estonia. 2024. <https://www.bbc.co.uk/news/articles/c722zxj0kyro> (consultato il giorno August 25, 2024).

Gebauer, Matthias, e Marina Kormbaki. Vier Milliarden für Eurofighter sind eine gute Investition. Die Welt. 19 April 2024.

Geiger, Waldemar. Bundeswehr draws lessons from the Ukraine war: impact in depth, protection of critical infrastructure and unmanned systems. 10 September 2024. <https://www.hartpunkt.de/bundeswehr-zieht-lehren-aus-dem-ukraine-krieg-wirkung-in-der-tiefe-schutz-kritischer-infrastruktur-und-unbemannte-systeme/>.

Gholz, Eugene, e Harvey M. Sapolsky. «The defense innovation machine: Why the U.S. will remain on the cutting edge.» Journal of Strategic Studies 44, n. 6 (2021): 854-872.

Giles, Keir. Who Will Defend Europe? An Awakened Russia and a Sleeping Continent. . London: Hurst Publishers, 2024.

Gould, Joe. Kathlene Hicks Warns of "Substantial Decline" in Defence-Industrial Base Competition, Defence News . 12 April 2022. <https://www.defensenews.com/pentagon/2022/04/12/kathleen-hicks-warns-of-substantial-decline-in-defense-industrial-base-competition/> (consultato il giorno December 29, 2024).

Griffith, Rachel, Stephen Redding, e John Van Reenen. «R&D and Absorptive Capacity: Theory and Empirical Evidence.» Scandinavian Journal of Economics 105, n. 1 (2023): 99-118.

Hancock, Alice, Andy Bounds, e Alec Russell. EU to Demand Technology Transfers from Chinese Companies. Financial Times. 19 November 2024. <https://www.ft.com/content/f4fd3ccb-ebc4-4aae-9832-25497df559c8> (consultato il giorno December 25, 2024).

Hawkings, Amy. Taiwan foreign minister warns of conflict with China in 2027. 2023. <https://www.theguardian.com/world/2023/apr/21/taiwan-foreign-minister-warns-of-conflict-with-china-in-2027> (consultato il giorno August 25, 2024).

Haythornthwaite, Rick. Agency and Agility: Incentivising People in a New Era . Government Report, London: UK Ministry of Defence, 2023.

Heidenkamp, H. The Private Sector's Role in Defence: Challenges and Opportunities for Government and Industry. In: The Future of Warfare in the Twenty First Century. Think Tank Report, Abu Dhabi: Emirates Centre for Strategic Studies and Research, 2024.

Hofmann, Frank. Germany's Bundeswehr: How ready is it to defend NATO? 2024. <https://www.dw.com/en/germanys-bundeswehr-how-ready-is-it-to-defend-nato/a-68734753>.

Hojnik, J., Prokop, V., & Stejskal, J. «R&D as bridge to sustainable development? Case of Czech Republic and Slovenia.» *Corporate Social Responsibility and Environmental Management*, 2022: 146-190.

Huffman, David, e John M. Quigley. «The role of the university in attracting high tech entrepreneurship: A Silicon Valley tale.» *The Annals of Regional Science*, n. 36 (2002): 403-419.

Huggler, Justin. 'German army used broomsticks instead of guns during training'. *The Telegraph*. 18 February 2015. <https://www.telegraph.co.uk/news/worldnews/europe/germany/11420627/German-army-used-broomsticks-instead-of-guns-during-training.html>.

Iris Wanzenböck, Martina Neuländtner, Thomas Scherngell. «Impacts of EU funded R&D networks on the generation of key enabling technologies.» *Papers in Regional Science*, Volume 99, Issue 1, 2020: 3-25.

Irving, Doug. *What Nato Countries and Other U.S. Allies Contribute to the Collective Defense*. Santa Monica: RAND , s.d.

Jonsson, Oscar. *Försvaret av Sverige*. Stockholm: Mondial Förlag, 2024.

Jr, Lynn White. *Medieval Technology and Social Change*. Oxford: Oxford University Press, 1964.

Juncos, Ana E., e Sophie Vanhoonacker. «The Ideational Power of Strategic Autonomy in EU Security and External Economic Policies.» *Journal of Common Market Studies*, 2024: 955-972.

Kennan, George. *Memoirs*. New York, NY: Pantheon, 1983.

Kramer, Franklin D. *The Sixth Domain: The Role of the Private Sector in Warfare*. Think Tank Report, Washington D.C.: Atlantic Council Scowcroft Centre for Strategy and Security, 2023.

Kučera, Jozef, e Milan Fiľa. «R&D EXPENDITURE, INNOVATION PERFORMANCE AND ECONOMIC DEVELOPMENT OF THE EU COUNTRIES.» *ENTREPRENEURSHIP AND SUSTAINABILITY ISSUES*, 2022.

LaPlante, W., e S. Pettyjohn. *Virtual Fireside Chat*. Transcript, Washington, D.C.: US Department of Defence, 2023.

Lau, Stuart. Von der Leyen vows to stop China from invading Taiwan. 2024. <https://www.politico.eu/article/ursula-von-der-leyen-vows-to-stop-china-from-invading-taiwan/> (consultato il giorno August 25, 2024).

Leonard, Mark. *Why Europe will Run the 21st Century*. New York, NY: Public Affairs, 2005.

Letta, E. Much more than a market. Speed, Security, Solidarity. Empowering the Single Market to deliver a sustainable future and prosperity for all EU Citizens. External Government Report, Consilium, Brussels: European Commission, 2024.

Liotard, Isabelle, e Valerie Revest. «Grand Challenges, Innovation Policy, and Contests Illustrative Cases in the United States and Europe.» *Journal of Innovation Economics & Management* , 2024: 187-214.

Lipton, Eric. Elon Musk Dominates Space. Rivals are Calling Foul, New York Times, May 28. The New York Times. 28 May 2024. <https://www.nytimes.com/2024/05/28/us/politics/elon-musk-space-launch-competition.html> (consultato il giorno December 25, 2024).

Lokshin, B., e P. Mohnen. «How effective are level-based R&D tax credits? Evidence from the Netherlands.» *Applied Economics* 44, n. 12 (2011): 1527-1538.

Long, T. A Closer Look at US Private Sector R&D Spending in a Global Context. Information Technology and Innovation Foundation. Think Tank Report, Information Technology and Innovation Foundation, 2024.

Machiavelli, Niccolò. The Discourses. Traduzione di Leslie J Walker. London: Penguin Books, 1983 [1531].

MacKenzie, Lucia. Russian defense spending overtakes Europe, study finds. Politico. 12 February 2025. <https://www.politico.eu/article/russian-defense-spending-overtakes-europe-study-finds/> (consultato il giorno February 14, 2025).

Malekos-Smith, Z.L. The Quantum Man and the Sea of Risks. Washington D.C.: CSIS, 2024.

Malenko, A., T. Balmforth, e M. Hunder. Russia fired new ballistic missile at Ukraine, Putin says. Reuters. Reuters. 22 November 2024. <https://www.reuters.com/world/europe/russia-launches-intercontinental-ballistic-missile-attack-ukraine-kyiv-says-2024-11-21/> (consultato il giorno December 23, 2024).

Mangasarian, Leon, e Jan Techau. Führungsmacht Deutschland: Strategie ohne Angst und Anmassung. DTV. Munich: dtv Verlagsgesellschaft mbH & Co. KG, 2017.

Maulny, Jean-Pierre. The Impact of the War in Ukraine on the European Defence MarkeT. Policy Paper, Paris: IRIS, 2023.

McKERNAN, JAMES BLACK, et al. Resourcing Defense Cooperation in Europe amidst Russia's war in Ukraine. Santa Monica: RAND, 2024.

McKinsey&Co. Can European Biotechs achieve greater scale in a fragmented landscape. McKinsey & Co., 2021.

Mead, Walter Russell. «The Return of Hamiltonian Statecraft: A Grand Strategy for a Turbulent World. .» *Foreign Affairs* 103, n. 5 (2024).

Melkozerova, V. NATO's Stoltenberg rebukes allies for tepid support of Ukraine. *Politico*. 29 April 2024. <https://www.politico.eu/article/jens-stoltenberg-says-ukraine-allies-do-not-deliver-their-promises-enables-russia-battlefield-gains/> (consultato il giorno December 29, 2024).

MERICS. *MERICS China Essentials*. Berlin: MERICS, 2024.

Miyagawa, T., e T. Ishikawa. *On the Decline of R&D Efficiency*. Discussion Paper, Tokyo: RIETI, 2019.

Moncada-Paternò-Castello, P., C. Ciupagea, K. Smith, A. Tübke, e M. Tubbs. «Does Europe perform too little corporate R&D? A comparison of EU and non-EU corporate R&D performance.» *Research Policy* 39, n. 4 (2010): 523-536.

Morcos, Pierre, e Colin Wall. *War on the Rocks*. 2022. <https://warontherocks.com/2022/01/are-european-navies-ready-for-high-intensity-warfare/> (consultato il giorno 8 25, 2024).

Moretti, E., C. Steinwender, e J. Van Reenen. *The Intellectual Spoils of War? Defense R&D, Productivity and International Spillovers*. Working Paper, Washington, D.C.: National Bureau of Economic Research, 2019.

National Audit Office. *Investigation into military support for Ukraine*. Government Report, London: National Audit Office, 2024.

National Science Board. *Research and Development: U.S. Trends and International Comparisons*. Government Report, Washington, D.C.: National Science Board, 2024.

NATO. «Defence Expenditure of NATO Countries (2014-2024).» 2024.

NGEU. *Next Generation EU*. 2024. https://next-generation-eu.europa.eu/index_en (consultato il giorno September 2, 2024).

Nindl, E., H. Confraria, e F. Rentocchini. *EU Industrial R&D Investment Scoreboard*. Policy Report, Brussels: European Commission, 2023.

North, Douglass C. *Structure and Change in Economic History*. WW Norton & Company, 1981.

Nöstlinger, Nette. "'I am pissed off!' German army official bemoans 'bare' forces as Russia invades Ukraine.". *Politico*. 24 February 2022. <https://www.politico.eu/article/i-am-pissed-off-chief-of-the-german-army-alfons-mais-states/> (consultato il giorno December 2, 2024).

O'Hanlon, Michael, e Lauri Tähminen. "Yes to Finland and Sweden in NATO". The Hill. 23 May 2022. <https://thehill.com/opinion/international/3495672-yes-to-finland-and-sweden-in-nato/> (consultato il giorno December 12, 2024).

OECD. Main Science and Technology Indicators. 2024. <https://www.oecd.org/en/data/datasets/main-science-and-technology-indicators.html>.

Ortega-Argilés, R, M Piva, e M Vivarelli. «The transatlantic productivity gap: Is R&D the main culprit?» Canadian Journal of Economics/Revue canadienne d'économie 47, n. 4 (2014): 1342-1371.

P., Aghion. A Primer on Innovation and Growth. Policy Brief, Brussels: Bruegel, 2006.

P.Azoulay, E.Fuchs, A. Goldstein, e M.Kearney. «Funding Breakthrough Research: Promises and Challenges of the "ARPA Model".» Innovation Policy and the Economy, 2019: 69-96.

Pallante, G., E. Russo, e A. Roventini. «Does public R&D funding crowd-in private R&D investment? Evidence from military R&D expenditures for US states.» Research Policy 52, n. 8 (2023).

Parker, Jessica. Europe needs a decade to build up arms stocks, says defence firm boss. BBC. 13 February 2024. <https://www.bbc.co.uk/news/world-europe-68273449>.

Patalano, Alessio. Italy: The Globally Connected Mediterranean Power? 1 August 2024. <https://rusi.org/explore-our-research/publications/commentary/italy-globally-connected-mediterranean-power> (consultato il giorno December 2, 2024).

Pethokoukis, J. Moore's Law Meet Musk's Law: The Underappreciated Story of SpaceX and the Stunning Decline in Launch Costs. American Enterprise Institute. 26 March 2024. <https://www.aei.org/articles/moores-law-meet-musks-law-the-underappreciated-story-> (consultato il giorno December 29, 2024).

Pfeiffer, Tom, e Christopher Cannon. Why Europe is Unprepared to Defend Itself. 2024. <https://www.bloomberg.com/graphics/2024-nato-armed-forces/> (consultato il giorno 10 17, 2024).

PIID., US Department of Defence IDV Award Information. System for Award Management. Customised Report, Washington, D.C.: US Department of Defence , 2023.

Pomeranz, Kenneth. The Great Divergence: China, Europe, and the Making of the Modern World Economy. Princeton: Princeton University Press, 2000.

Posaner, J. Europe's space chief confirms rocket rival to Musk's SpaceX won't launch this year. Politico. 2024. <https://www.politico.eu/article/esa-confirms-ariane-6-rocket-launch-slips-to-2024/>.

Radicic, Dragana, Zoran Borovic, e Jelena Trivic. «Total factor productivity gap between the "New" and "Old" Europe: an industry-level perspective.» *Post-Communist Economies* 35, n. 7 (2023): 770-795.

Rainer, B.W. «Funding of research & innovation in the field of medical technologies and biomedical engineering over the different European framework programmes.» *Biomedical Engineering Letters* (2024) (*Biomedical Engineering Letters* (2024) 14:153–162), 2024: 153-162.

Rainsford, Sarah, e Paul Kirby. War a Real Threat and Europe not Ready, Warns Poland's Tusk. *BBC News*. 30 March 2024. <https://www.bbc.co.uk/news/world-europe-68692195> (consultato il giorno 12 24, 2024).

Rankin, Jennifer. Macron sparks anger by saying Europe should not be 'vassal' in US-China clash. 2023. <https://www.theguardian.com/world/2023/apr/10/emmanuel-macron-sparks-anger-europe-vassal-us-china-clash> (consultato il giorno August 25, 2024).

Räsänen, Markku, Henriikki Mäkynen, Mikko Möttönen, e Jan Goetz. «Path to European quantum unicorns.» *EPJ Quantum Technology*, 2021.

Rathbone, John Paul. Russian defence spending exceeds all of Europe combined, study finds. *Financial Times*. 12 February 2025. <https://www.ft.com/content/g3d44b5a-a087-4059-9891-f18c77efca4b> (consultato il giorno February 13, 2025).

Reuters. China's Xi says 'reunification' with Taiwan is inevitable. 2023. <https://www.reuters.com/world/asia-pacific/china-calls-taiwan-president-frontrunner-destroyer-peace-2023-12-31/> (consultato il giorno August 25, 2024).

- Germany only has 20,000 high explosive artillery shells left, report says. *Reuters*. 19 June 2023. <https://www.reuters.com/world/europe/germany-only-has-20000-high-explosive-artillery-shells-left-report-2023-06-19/>.
- Hungary's Orban says Russia stands to gain as 'irrational' West loses power. *Reuters*. 2024. <https://www.reuters.com/world/europe/hungarys-orban-says-russia-stands-gain-irrational-west-loses-power-2024-07-27/> (consultato il giorno 8 25, 2024).

Rhode, Benjamin. *Europe without America*. London: IISS, 2024.

Robertson, Noah. The Pentagon wants industry to transform again to meet demand. Can it? *Defense News*. 20 February 2024. <https://www.defensenews.com/industry/2024/02/20/the-pentagon-wants-industry-to-transform-again-to-meet-demand-can-it/> (consultato il giorno December 26, 2024).

Roland, A. *Delta of Power: The Military-Industrial Complex*. JHU Press, 2021.

Schilde, Kaija. «European Military Capabilities: Enablers and Constraints on EU Power?» *Journal of Common Market Studies* 55, n. 1 (2017): 37-53.

Schilde, Kaija. «Weaponsing Europe.» *Journal of Common Market Studies*, 2022.

Schneider-Petsinger, Marianne, Veerle Nouwens, Alice Billon-Galland, Andrew Cainey, e Gareth Price. *Transatlantic cooperation on the Indo-Pacific: European and US priorities, partners and platforms*. London: Chatham House - Royal Insitute of International Affairs, 2022.

Schumpeter, Joseph. *Capitalism, Socialism and Democracy*. . New York, NY: Harper & Brothers, 1942.

Selten, Friso, Cameron Neylon, Chun-Kai Huang, e Paul Groth. «A longitudinal analysis of university rankings .» *Quantitative Science Studies*, 2020: 1109-1135.

Serlet, Thibault. *How Universities lead to Successful SEZs*. *Financial Times* . 14 April 2022. <https://www.fdiintelligence.com/content/opinion/how-universities-lead-to-successful-sezs-80777> (consultato il giorno July 24, 2024).

Shah, Raj M, e Christopher Kirchhoff. *Unit X: How the Pentagon and Silicon Valley are Transforming the Future of War*. Scribner. . New York, NY: Scribner, 2024.

Sky News. *Urgent Review as D-Day Parachute Jump Scaled Back Due to Lack of RAF Aircraft*. 19 May 2024. <https://news.sky.com/story/urgent-review-as-d-day-parachute-jump-scaled-back-due-to-lack-of-raf-aircraft-13139179> (consultato il giorno December 26, 2024).

Sorbo, Maria del, Carina Faber, Marco Grazi, Francesco Matteucci, e Miriam Ruß. *Assessing changes in EU innovation policy programs: from SME instrument to EIC accelerator for start-up funding*. Milan: Vita e Pensiero, 2024.

Stewart, Phil, e Idrees Ali. «How the US is preparing for a Chinese invasion of Taiwan.» *Reuters*, 31 January 2024.

Swanström, Niklas, Fredrik Erixon, e Mrittika Guha Sarkar. *The US and EU, and the Emerging Supply Chain Network: Politics, Prospects and Allies*. Armin Lear Press, 2024.

Tähtinen, Lauri. *A Shared EU-US Economic Agenda for the World: Engagement as an Imperative*. Briefing Paper, Helsinki: FIIA, 2023.

- EU-Mercosur: So Much More Than A Dead Deal *CSIS Commentary*. 26 March 2024. <https://www.csis.org/analysis/eu-mercotur-so-much-more-dead-deal>. (consultato il giorno December 24, 2024).

Taleb, Nassim Nicholas. *Antifragile: Things that Gain from Disorder*. London: Random House, 2012.

Tallis, Benjamin. *The End of Zeitenwende*. *Reflections After Two Years of Action Group Zeitenwende*. DGAP. 30 August 2024. <https://dgap.org/en/research/publications/end-zeitenwende> (consultato il giorno December 25, 2024).

Terzi, Alessio, Monika Sherwood, e Aneil Singh. «European industrial policy for the green and digital revolution.» *Science and Public Policy*, 2023: 842-857.

The New Economy. How Estonia became Europe's Tech-Hotspot. 2019. <https://www.theneweconomy.com/technology/how-estonia-became-europes-tech-hotspot> (consultato il giorno September 15, 2024).

The White House. US Indo-Pacific Strategy. Washington D.C., U.S.: The White House, 2022.

Tomoshige, Hideki. *Innovation Lightbulb: Private Investment in Quantum Technology*. Washington: CSIS, 2024.

Trofimov, Yaroslav. Has World War III Already Begun? *Wall Street Journal*. 13 December 2024. <https://www.wsj.com/world/has-world-war-iii-already-begun-16fb94c9> (consultato il giorno December 24, 2024).

US Department of Defense. Opening Remarks by Secretary of Defense Lloyd J. Austin III at the 20th Ukraine Defense Contact Group. 19 March 2024. <https://www.defense.gov/News/Speeches/Speech/Article/3710899/opening-remarks-by-secretary-of-defense-lloyd-j-austin-iii-at-the-20th-ukraine/> (consultato il giorno December 12, 2024).

US Department of Defense. State of Competition within the Defence-Industrial Base. Government Document, Washington, D.C.: US Department of Defense, 2022.

Van Rij, Armida. The EU's continued dependency on Russian gas could jeopardize its foreign policy goals. 2024. <https://www.chathamhouse.org/2024/06/eus-continued-dependency-russian-gas-could-jeopardize-its-foreign-policy-goals> (consultato il giorno September 20, 2024).

Vasselier, Abigaël, e Francois Chimits. *Relations between the European Union and China: what to watch for in 2024*. Berlin, Germany: MERICS: Mercator Institute for China Studies, 2024.

Vinnova. Civilia innovationer ska stärka Sveriges försvarsförmåga. . 17 June 2024. <https://www.vinnova.se/nyheter/2024/06/civila-innovationer-ska-starka-sveriges-forsvarsformaga/> (consultato il giorno December 29, 2024).

Vogl, V., M. Åhman, e L. J. Nilsson. «The making of green steel in the EU: a policy evaluation for the early commercialization phase.» *Climate Policy*, 2020: 78-92.

Wang, Jenn-Hwan. «From Technological Catch-Up to Innovation-based Economic Growth: South Korea and Taiwan Compared.» *Journal of Development Studies* 43, n. 6 (2007): 1084-1104.

Wanzenböck, Iris, Martina Neuländtner, e Thomas Scherngell. «Impacts of EU funded R&D networks on the generation of key enabling technologies: Empirical evidence from a regional perspective.» *Papers in Regional Science* 99 (2019): 1-22.

Wardoyo, Prasto. Indonesian, Russian navies hold first joint drills in Java Sea. 4 November 2024. <https://www.reuters.com/world/indonesia-russia-navies-hold-first-joint-drills-java-sea-2024-11-04/>.

Wilkinson, Benedict. «The EU's Defence Technological and Industrial Base.» External Report, European Parliament Sub-Committee on Security and Defence, European Parliament, Brussels, 2020.

Wintour, Patrick. If China invaded Taiwan it would destroy world trade, says James Cleverly. 2023. <https://www.theguardian.com/world/2023/apr/25/if-china-invaded-taiwan-it-would-destroy-world-trade-says-james-cleverly> (consultato il giorno August 25, 2024).

Wolff, G. B. The European defence industrial strategy: important but raising many questions. Bruegel. 19 March 2024. <https://www.bruegel.org/analysis/european-defence-industrial-strategy-important-raising-many-questions> (consultato il giorno December 29, 2024).

Wolff, G.B. European Defence Industrial Strategy. Brussels: Bruegel, 2024.

- «Fit for war in decades: sluggish German rearmament versus surging Russian defence production.» Bruegel. 16 September 2024. Fit for war in decades: sluggish German rearmament versus surging Russian defence production.

Wolff, Guntram B., Alexandr Burilkov, Katelyn Bushnell, e Ivan Kharitonov. Fit for war in decades: sluggish German rearmament versus surging Russian defence production. Brussels: Bruegel, 2024.

World Population Review. Most Technologically Advanced Countries. 2024. <https://worldpopulationreview.com/country-rankings/most-technologically-advanced-countries> (consultato il giorno September 12, 2024).

Youssef, Nancy A., e Gordon Lubold. Pentagon Runs Low on Air-Defense Missiles as Demand Surges. Wall Street Journal. 29 October 2024. https://www.wsj.com/politics/national-security/pentagon-runs-low-on-air-defense-missiles-as-demand-surges-7fc9370c?mod=hp_lead_pos1 (consultato il giorno December 29, 2024).

Zuzana, S., R. Barca, e D. Flis. Why the EU Fails to Deliver on Arms Pledges to Ukraine. VSquare | Investigating Central Europe. 25 July 2024. <https://vsquare.org/eu-fails-arms-pledges-ukraine-absent-ammo/> (consultato il giorno December 29, 2024).