Executive summary

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Russia's illegal invasion of Ukraine has brought war back to Europe. Failing to stop Russia's aggression would leave Europe at a critical disadvantage for decades, with a long-term threat to peace in the European Union. e EU can no longer rely on United States leadership in NATO and European countries therefore need to rapidly build-up their military capabilities.

European countries have increased the amounts spent on defence considerably in recent years but the underinvestment of previous decades means that gaps still exist. While the EU as a whole fvnnt 23cc 2%NATO aarv0 (v0 (T ud(el)1 (n0l(T)10 (d E) s0β9 Tdnn TJ0 -1.444 Td[pr)15 (o)-

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1 Introduction

War has returned to Europe. As there is no clear end in sight to the war in Ukraine, the question of armaments has become of central importance. Failing to deter Russia, or to support Ukraine adequately, would leave Europe at a major strategic disadvantage for decades to come. The challenge is multi-dimensional. Any strategy will need to take account of evolving Russian capacities, evolving political willingness and evolving defence industrial capacities.

Wol . (2024) showed that Russian military industrial capacities have increased signi cantly in the last two years. Production of key weapon systems now exceeds the levels of Russian material losses in Ukraine. The United States's top general in Europe has estimated that Russian military production outpaces that of the combined West (Cavoli, 2024). For example, he estimated that Russia now produces and refurbishes more than 1000 tanks per year, a number far larger than Western production. Wol . (2024) even found production numbers of up to 1500 tanks per year in Russia. Cavoli also estimated that Russia now has substantially more capacity than at the beginning of the war in 2022, despite the substantial Russian losses.

To achieve this massive production increase, Russia has systematically increased its spending on armaments. Russia now spends 30 percent of its budget on defence, rising to 40 percent if domestic security costs are factored in. Spending is now estimated to be above $120 billion per year. In purchasing power parity terms, this spending is substantially larger (see below). Some macroeconomic pressure is building on the Russian economy, with in ation and the real interest rate rising but, at the time of writing, it appears unlikely that Russia will not be able to continue to fund its war e orts.

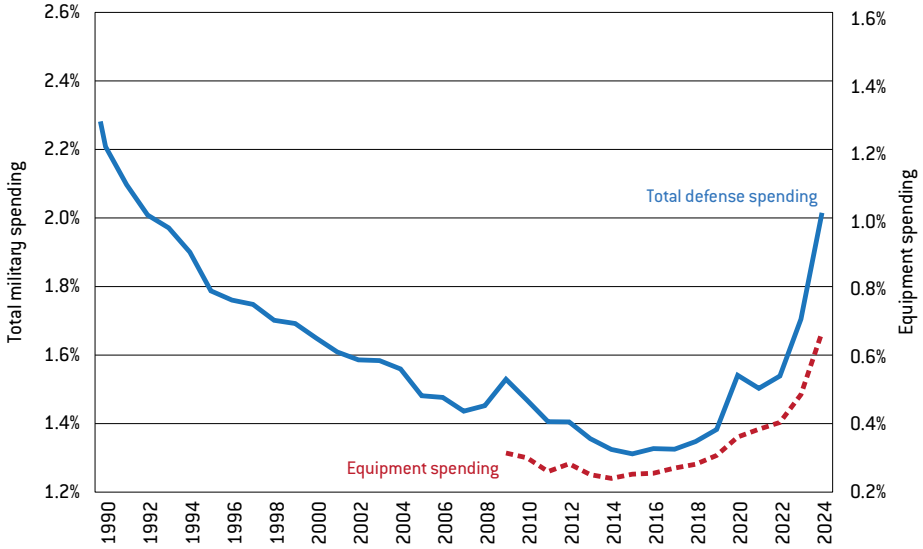
Importantly, even in a scenario of a settlement between Russia and Ukraine, assuming Russian industry continues to churn out materiel at current rates, the military build-up will accelerate massively as the loss of weapon systems on the battle eld declines. Wol . (2024) estimated that current production rates in Russia are high enough to build-up a full army the size of the German Bundeswehr in six to twelve months. In many ways, an arms race similar to or worse than that of the Cold War appears a possibility.

Europe is thus in a sort of race with Russia. Four factors will be decisive: the available resources, the political determination to produce weapons and ammunition quickly and in su cient quantities, the costs and, nally, the necessary modernisation of weapons systems and military doctrine.

While Europe and the combined West in principle have the resources to outperform Russia because of their larger GDP, the mobilisation of scal resources and the commitment to do so on a longer-term basis still lag. European defence spending has increased substantially in the last few years but after years of under-investment it will take time for production capacities to be brought online and for stocks to increase again.

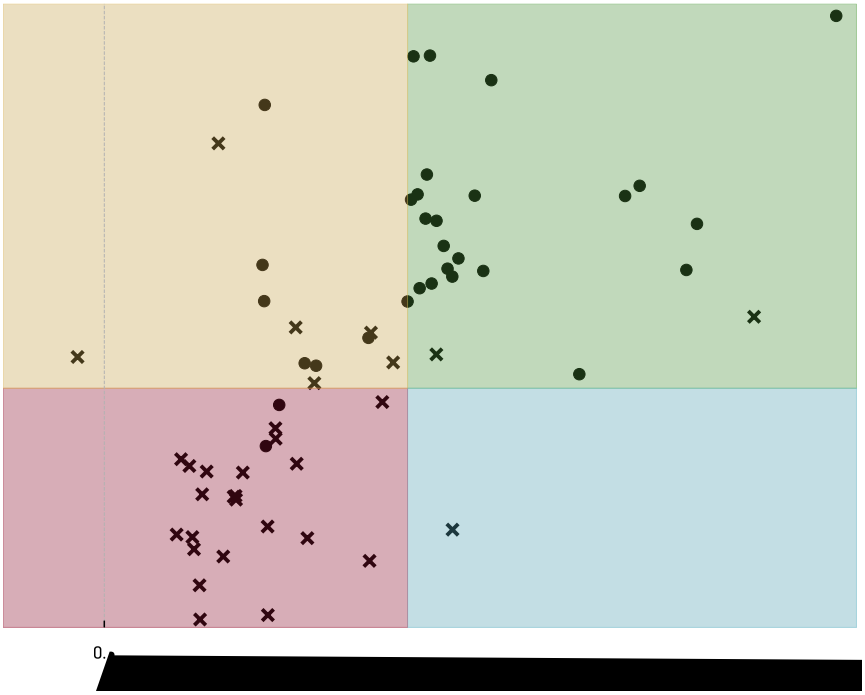
Figure 1 shows European Union defence spending (including personnel, operational and military equipment spending) and spending on military equipment. With falling defence spending, budgets for equipment spending became extremely small, with on average only 0.3 percent of GDP dedicated to it. For many years, Germany in particular invested only a very small proportion of its defence spending on military equipment. According to NATO gures, the share was only around 13 percent until 2019, compared to 25 percent in France. It was not until 2022 and 2023 that the share of investment in defence equipment increased signi cantly. However, Germany remains behind the United Kingdom and the US (Figure 2). In Poland, spending on equipment now even exceeds 50 percent of total defence spending. In 2024, eight NATO countries (seven EU countries and Canada) still do not reach the minimum overall defence spending target of two percent of GDP. is includes Italy and Spain, the third and fourth largest EU economies.

Figure 1: Defence spending in the EU (left scale) and spending on military equipment (right scale), % of GDP



Source: Wolff *et al* (2024). Note: 'Defence spending' refers to total EU27 defence expenditure from 1989-2023 and defence spending by EU NATO members in 2024. 'Equipment spending' refers to spending by EU NATO members. Czech Republic, Sweden and Finland are not included for 2009-2013 because of unavailability of data. EU members Austria, Cyprus, Ireland and Malta are not NATO members.

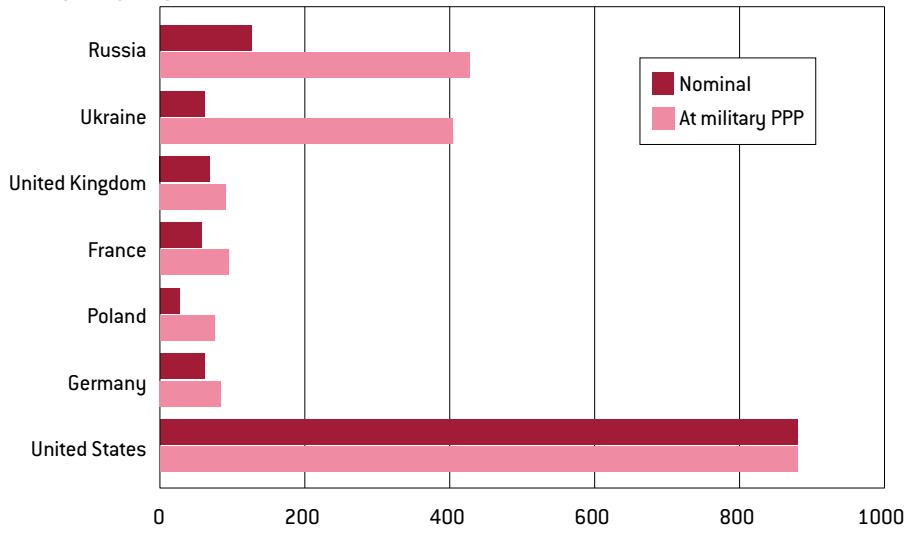
Figure 2: NATO members' defence and equipment spending, 2014 vs 2024, % of national GDP and of total defence expenditure, grouped by NATO commitments met



Source: Bruegel based on NATO. Note: figures for 2024 are NATO estimates. Members are grouped (coloured squares) by NATO commitments satisfied (eg 'Only equipment' means the country spends at least 20 percent of its defence expenditure on equipment, but less than 2 percent of its national GDP on defence).

Fiscal data thus shows that governments have been able to adjust defence budgets in response to the war and these increased budgets have also translated into larger budgets for equipment purchases. Wol

Figure 3: Military spending, 2023, $ billions, nominal and military purchasing power parity adjusted



Source: Bruegel based on Robertson (2021) and SIPRI.

Since Robertson's (2021) measure does not capture well the prices of military equipment, we have attempted to show price di erences for speci c military equipment. We have compiled the costs of battle tanks in di erent countries in euros at market exchange rates (Table 1). ere are substantial di erences between prices paid by China and Russia, and by the US and Germany. e Germany-US price di erence is also substantial. While the price for a US Abrams tank is higher than the price of German Leopard 2A6s sent to Ukraine, the modern versions of the latter, the Leopard 2A8, is estimated to cost closer to €30 million per unit. Even though US labour costs are higher, the US costs per tank are thus substantially lower – possibly an indication that low production numbers for the Leopard drive up prices. Still, even US production numbers are quite low, with an estimated monthly output of ve to ten[1]. Production of self-propelled howitzers follows similar patterns (Table 2).

Table 1: Estimated costs for third-generation main battle tanks in four countries

Country	Model	Cost (€)
China	Type 99A	2,309,896
Russia	T-90	4,157,812
Germany	Leopard 2A6	9,239,582
US	M1A2 Abrams	17,555,207
Germany	Leopard 2A8	29,000,000

Source: Bruegel based on Kiel Institute and media reports (contact the authors for details).

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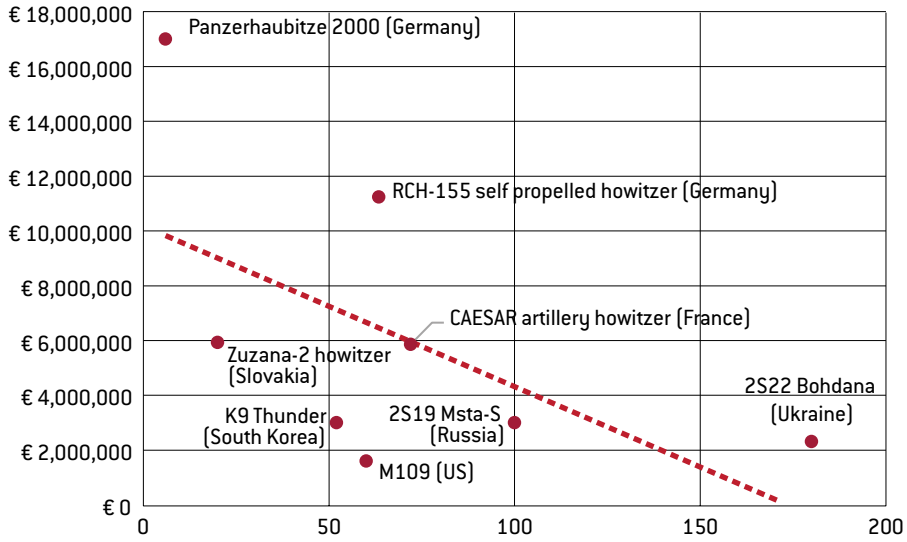
Table 2: Estimated costs for 155mm self-propelled howitzers, selected countries

Country	Model	Manufacturer	Cost (€)
Slovakia	Zuzana-2 howitzer	Konstrukta	5,932,705
France	CAESAR artillery howitzer	Nexter	5,863,133
Germany	RCH-155 self-propelled howitzer	KNDS	11,087,499
Germany	Panzerhaubitze 2000	KNDS and Rheinmetall	17,000,000
China	PLZ-05	Norinco	2,309,896
US	M109[2]	BAE Systems	1,602,871
Russia	2S19 Msta-S	Uraltransmash	1,478,333
South Korea	K9 under	Hanwha Land Systems	3,000,000
Ukraine	2S22 Bohdana	Kramatorsk Plant	2,309,896

Source: Bruegel based on Kiel Institute and media reports (contact the authors for details).

Figure 4: Self-propelled howitzer cost per unit and production annual capacity



Source: Bruegel based on information released by companies and specialised press in terms of purchase agreements and delivery dates.
Note: Production capacity per year should be considered a lower bound estimate.

While these numbers are not hard evidence of the bene ts of scale economies, the production numbers per type of tank/artillery system tend to be lower in Europe than in the US, Russia or South Korea (Figure 4). Moreover, reported prices per unit tend to be relatively high in Germany in particular, while for those manufacturers with higher production numbers per year, unit prices are lower. e European Commission (2022) estimated that the lack of cooperation results in high costs, estimated to be between €25 billion and €100 billion each year.

2 . e US M109 e a e, c ea e ba e a a e e ed e e. S d e e a e e f ba e, ce d be e e S K ea K9 de a d R a 2S19 M a-S.

3 Conceptualising European defence industrial policy

3.1 An overview of the EU's conceptual approach to defence industrial policy

e EU institutions deserve some credit for highlighting the urgency of addressing the shortcomings in European military equipment production and proposing some initial ideas for improvements. e European defence industrial strategy (EDIS), proposed by the European Commission on 5 March 2024[3], indeed aims to achieve "*E* *E* ".

According to the EDIS proposal, the European defence technological and industrial base (EDTIB) – the EU defence industry broadly de ned including SMEs working in the sector – had a turnover of about €70 billion and exported more than €28 billion worth in 2021, employing about 500,000 people. e EDIS plan aims to reduce fragmentation in the European defence industry and reduce weapons imports. Goals include increasing the

Designing a defence industrial policy at EU level is complicated even more by the institutional separation between industrial policies and security and defence policies. EU decision-makers are responsible for many aspects of industrial policy rulemaking (state aid, competition, cohesion), often with a signi cant and leading role for the European Commission. However, security and defence policy is largely a national competence (Leonard , 2019) and the most relevant cooperation framework is and remains NATO.

When it comes to de ning strategic interests in security and defence, the EU is far from reaching a clear shared understanding. At EU level, there is some coordination and a so-called 'strategic compass' – an action plan to strengthen EU security and defence policy – has been approved[4]. Yet, the security interests of EU member states are, and remain, di erent. e main military threat of Russia, while it is growing, is still perceived as much less worrying in some parts of the EU than others. is lack of shared strategic interest will obviously a ect the work of the new defence commissioner and of the High Representative of the Union for Foreign A airs and Security Policy.

e EU treaties make clear that national governments largely retain the competence for industrial policies and market-design questions in the defence/security eld. For example, Article 346 (2) of the Treaty on the Functioning of the EU (TFEU) stipulates that " *M S* ."[5]

Nevertheless, in practice, the EU is already involved at many levels in defence markets and defence cooperation and has been able to overcome political and legal obstacles (Figure 6). e change of direction in US defence policy under President Trump's rst administration, followed by Russia's illegal invasion of Ukraine pushed the EU to think about its weaknesses and develop a European defence strategy. Legal aspects such as the prohibition on funding defence purchases from the EU budget have been constraints, but the reformed European Peace Facility (Box 1) and the EU's ability to nd a way to provide ongoing funding to Ukraine based on the proceeds from frozen Russian assets show that measures can be implemented, even if not all member states are fully supportive (Véron, 2024). Di erent programmes have

Box 1: An overview on EU defence initiatives and structures

e EU's European Defence Fund (EDF), a fund of €8 billion for 2021-2027, is an instrument governed and implemented directly by the European Commission. It nances defence research (€2.7 billion) and development (€5.3 billion).

e Permanent European Structured Cooperation (PESCO) groups EU countries on a voluntary basis to cooperate in developing defence capabilities. It currently covers 26 member states except Malta, which participate jointly on projects in di erent military domains (such as cyber, maritime and air defence).

On military production, the Act in Support of Ammunition Production (ASAP, Regulation (EU) 2023/1525) is intended to motivate EU companies to work together to supply Ukraine with weapons and avoid supply-chain bottlenecks. Under the act, funding of €514 million has been provided to scale up production capabilities covering explosives (23 percent), powder (48 percent), shells (18 percent), missiles (10 percent) and testing (less than one percent).

On the procurement side, the European Defence Industry Reinforcement through Common Procurement Act (EDIRPA, Regulation (EU) 2023/2418) established a joint procurement instrument for acquiring weapons to meet the most urgent needs of member states (eg help for Ukraine). It has a total budget of €310 million (lower than the €500 million proposed by the European Commission). Implementation of the programme has been subject to delays.

For provision of defence support (operations and assistance measures) to third countries, the existing European Peace Facility (EPF) provides reimbursement to countries that export defence equipment to Ukraine. Since the start of the war in Ukraine, the EPF has mobilised €6.1 billion to assist Ukraine, and the facility has been increased by other €5 billion. A committee of EU country representatives oversees the EPF.

Planning military capabilities remains a national responsibility. However, common EU needs and a long-term strategy are scoped out in the European Defence Agency's Capability Development Plan (CDP). is sets out 22 di erent priorities grouped across ve military domains (land, maritime, air, space and cyber) and wi5 (a)wonaE cs, funm (up)-2i(o s)-4oidt export

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E ”[7], as well as noting that the forthcoming proposals in the white Paper on the future of European defence should respond to “ ”; suggesting that she endorses the paradigm shift of boosting domestic industrial capacities by directing to it military procurement and output planning, in order to address the EU's under-investment and production gaps.

e basic idea is that increasing the demand for weapons developed and produced in the EU will strengthen EDTIB, leading to greater strategic autonomy. Such a move is even more important at a time when the US military industrial base is facing di culties in su ciently ramping up production. Jones (2024) argued that the war in Ukraine has shown the de cien-cies of the US defence industrial base and that the US would not be prepared for a con ict in Taiwan. Moreover, a preference for European suppliers will be even more needed if NATO come under strain under the second Trump administration. Finally, an argument for a Euro-pean preference is that the military industry can have some positive innovation e ects on the wider economy (Box 3).

However, there are three important counterarguments against a Europe- rst strategy. First, a European preference in arms purchases might lead to slower than necessary arrival of some critical weapon systems. Second, European preference could also lead to the purchase of weapon systems that are inferior to the best available on the world market, especially if there is no additional growth of the industry. ird, European preference could result in paying higher prices for weapon systems that could be produced more cheaply elsewhere.

At the political level, an important counterargument against a European preference in arms purchases is the possible political reaction in the US. For decades, the US has provided a security guarantee via NATO but it has also bene ted from major European purchases of US weapons. Should the European side decide to rapidly reduce purchases of US weapons, the US Congress would certainly notice.

4 The European defence sector

4.1 Comparing market values of European defence companies

To increase military production, Europe will need its defence companies to scale up and new rms to emerge. In this section, we show that European defence companies are smaller than the top companies in the US, Russia and China. Only one European company, BAE Systems, ranked among the world's top 10 defence companies in 2022 (Table 3). e situation for the

Table 3: Global top 10 and European top 10 defence companies by turnover, 2022

Global rank	Company	Country	Armaments revenues, $ billions	Total revenues, $ billions	Armaments revenue as % of total revenues
1	Lockheed Martin Corp.	United States	59390	65984	90%
2	Raytheon Technologies	United States	39570	67074	59%
3	Northrop Grumman Corp.	United States	32300	36602	88%
4	Boeing	United States	29300	66608	44%
5	General Dynamics Corp.	United States	28320	39407	72%
6	BAE Systems	UK	26900	27712	97%
7	NORINCO	China	22060	82537	27%
8	AVIC	China	20620	82499	25%
9	CASC	China	19560	44458	44%
10	Rostec	Russia	16810	30295	55%
13	Leonardo	Italy	12470	15025	83%
14	Airbus	Trans-European	12090	61805	20%
17	ales	France	9420	18479	51%
23	Dassault Aviation Group	France	5070	7288	70%
25	Rolls-Royce	UK	4930	15647	32%
28	Rheinmetall	Germany	4550	6742	67%
29	Naval Group	France	4530	4578	99%
32	MBDA	Trans-European	4380	4428	99%
34	Safran	France	4200	20021	21%

Source: Bruegel based on SIPRI. Note: Blue rows indicate the European top 10 firms.

Since the Russian invasion of Ukraine, the market values of European defence companies

tanks and other systems for both countries between 2040 and 2045[9]. The French and German national authorities participate directly with Germany in the leading role. KNDS is another example of tank production, also based on Franco-German collaboration.

The European defence industry needs modernisation in preparation for wars of attrition, as in Ukraine. In addition to meeting industry's short-term needs, long-term investment is required. European defence is technologically behind on some military equipment, such as aircraft or helicopters (Draghi, 2024) and investment in defence R&D is essential to close this gap. Box 3 gives an overview of European defence R&D investments and a short review of the positive spillovers linked to this type of investment.

Box 3: Industrial policy and long-term needs, European defence to foster innovation

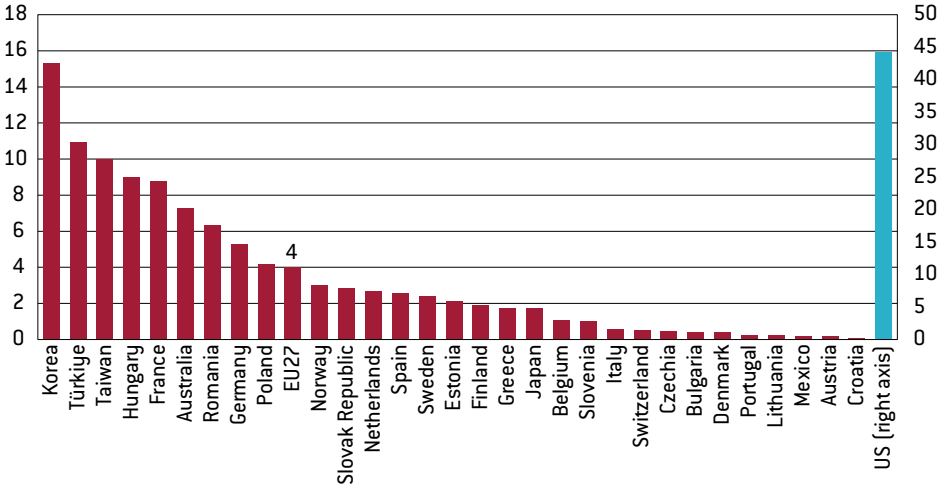
National defence takes up a substantial part of public R&D budgets in many countries (Figure 8). However, the shares in many European countries are lower than in the US. Draghi (2024) estimated the US-EU gap in total R&D investment in defence at almost €120 billion in 2023.

Defence R&D spending is aimed at enhancing national security, but might also generate positive broader growth effects by boosting innovation. The literature on public subsidies for R&D and their effects on the rate of innovation, while not totally conclusive, suggests that there are some positive effects, especially when public funding focuses on basic R&D, which individual companies find difficult to fund because they cannot capture the overall benefits generated. Wolff and Reinthaler (2008) showed positive employment and innovation effects linked to public R&D subsidies given to firms, and Moretti [...] (2023) found significant increases in private R&D and productivity following on from public defence R&D investments. However, Barro and Redlick (2011) and Dimos and Pugh (2016) did not find evidence for these positive spillovers onto private R&D.

An important counterargument against government subsidies is that they only substitute for companies' own private funding. Given that the number of top researchers and engineers in companies is limited, the only effect is to replace one source of funding with another. In the defence sector specifically, however, defence research occasionally leads to breakthrough innovation, which alters growth paths by creating totally new general-purpose technologies. Mowery (2012) argued that some areas of Israeli defence-related R&D and procurement generated significant innovation for civilian and company use, for instance in the IT sector, and similarly for commercial aviation (Mowery, 2015).

9 La a Ka a a d Ca eb La , 'F a ce a d Ge a e e e - e a ba e a ', *Politico*, 22 Se e be 2023, https://www.politico.eu/article/france-germany-give-new-push-to-joint-next-generation-battle-tank/.

Figure 8: Public R&D spending on defence, % of total public R&D expenditure, major developed economies



Source: Bruegel based on OECD.

In sum, while European defence policy contributes to the main objective of maintaining national and collective security, it is also an industrial policy tool. Public investment in defence R&D can generate positive spillovers onto private R&D and ultimately productivity growth.

5 A European approach to increase military equipment output at reasonable costs

e US and the EU have both started major initiatives to increase military production. e US Department of Defense (DoD) in September 2024 reported on its initiatives to increase production in the context of the Ukraine Defense Contact Group[10]. e DoD documents substantial increases in ammunition production and weapon production, but also shows the very substantial problems in increasing capacities. Production numbers for key weapon systems remain below Russian equivalents, especially when taking into account Russian access to North Korean and Iranian production[11]. Russia continues to outpace Ukraine in terms of ammunition quantities (Wol , 2024). It is thus important to reconsider how to boost military production in the US and in Europe. Here we focus mostly on the EU.

Conceptually, there are two broad ways to think about how to organise and increase the production of military equipment in Europe.

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11 F e a e, US d c fa e e a c ea ed b a a , b e ceed b a fac f e a e d c f e ece a e c a . US d c f ab e a e e a d a e e 18,000 e , c e a e E ea d c e ed b Ge a 700,000 e ea . e be a e bec a ed e da e f e a 10,000 e b R a a e .

e rst approach would establish a 'war economy'. It has been suggested that Europe should adopt an EU defence production act similar to the US Defense Production Act, which gives the US president substantial powers to direct critical material and nancial ows to the production of defence goods[12]. Putting aside the di culties of creating such as scheme in a fragmented European polity and a fragmented defence market, we are sceptical about such command-type economic policy guidance[13]. Intervening in an economy and directing resources towards a speci c type of production is usually an expensive and rather ine cient way of achieving a policy goal. e EU may still play its part in providing smart incentives to increase the production and competitiveness of the European defence industry. However, a full war-economy approach appears politically infeasible in the absence of war on EU soil. A strong reliance on state intervention in defence companies, possibly driving the creation of pan-European companies with strong state involvement, could be part of the war-economy approach. It would risk becoming a rather slow and bureaucratic approach to defence production.

e second approach would be to integrate segmented defence markets and increase competition in the market in the hope of driving down costs and increasing e ciency and timeliness of production. e greater competition brought about by market integration should, , , contribute to a higher level of industrial innovation. In normally structured markets, pursuing this approach would be relatively straightforward and uncontroversial – as a proven way to maximise e ciency. Defence products, however, are special in that the number of customers is limited to governments, and security priorities override economic e ciency priorities.

e most important factor in successfully implementing the second approach is thus trust among EU countries. e more integrated markets become, the more likely it will be that defence production specialises, with production sites for speci c products concentrating in certain countries. Specialisation improves e ciency but those countries that still have a broad defence industry might object on the basis that they would lose direct access to some

6 Conclusions

It has become urgent to move beyond the current piecemeal approach to European defence.

procurement o ces will issue di erent speci cations even for the same basic product. Beyond the reform of national procurement o ces, more joint EU procurement, for example through the EDA, could lead to greater market integration.

Moreover, despite being a global standard-setter, the EU plays no role in standards for weapons. As a consequence, weapons production is fragmented and more expensive than necessary and interoperability is low, complicating logistics and undermining combat e ectiveness. EU countries have provided to Ukraine 10 di erent howitzer types and currently manufacture ve di erent versions versus only one in the US (Draghi, 2024). While NATO has established standardisation agreements for artillery, they are thus clearly not enforced. Enforcement by the EU of NATO standardisation agreements in EU countries could thus further contribute to market integration.

Fragmented EU export rules could undermine market integration[15]. Current rules on arms-related exports, both within and outside the EU, would bene t from more solid legal underpinning in a directive or regulation with transposition dates and/or enforcement tools. is would ensure e ective standardisation and greater alignment of national policies. To account for the risks related to weaker ethical considerations while standardising export rules, post-shipment onsite inspections (Bromley . , 2022) enforced by an EU agency could guarantee a level playing eld across EU countries.

C: Towards 'intelligent European preference' for more innovation and strategic autonomy

e EU should avoid procuring only European, but there are strategic justi cations for more procurement from resident rms[16]. Such 'intelligent European preference' can increase industry capabilities and foster innovation while reinforcing strategic autonomy[17], but it needs to account for comparative advantages and disadvantages. For some products, cheap and scaled-up production remains of paramount importance (eg artillery shells for Ukraine). Procuring arms from third countries remains perfectly reasonable, especially if the security of supply is high and interoperability with European systems can be reasonably guaranteed.

Ukraine and its defence industrial base are of great importance to the EU defence strategy and could be transformative for the EU's military industrial capacity. For many products, Ukraine is the cheapest producer, and is also the most innovative and advanced (eg modern drone warfare). e UK should also be considered an integral partner for the European defence industrial base. Finally, as long as the EU remains dependent on the US security guarantee, it needs to carefully calibrate how the building its own defence industrial base will impact US political perceptions.

D: Supply chain security

e EU could play a role in securing defence supply chains by regularly monitoring and assessing risks of over-dependency. Since the start of the war in Ukraine, the European Commission has discovered signi cant vulnerabilities, for example in relation to the security of supply of explosives and propellants. It would be a natural role for the EU to issue alerts on limits in production capacities. e EU is aware of the importance of assessing security risks, such as those for dual-use technologies. e EU economic security strategy, for example, sets out critical technology areas and requests risk assessments from member states (European Commission, 2023, 2023a). ere exist, however, challenges in addressing these issues (Chimits . , 2024). Some of the competences required remain at the national level – for instance foreign policy responsibility – making a common and e ective response more di cult.

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16 See f e a e Ca ca a *et al* (2023) f a acade c d c .

17 See f e a e Ca e e a d Ka e (2023).

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