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Europe's defence industrial strategy and the EDTIB: a connectedness-based analysis of major European defence industries

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ABSTRACT

In the White Paper for European Defence – Readiness 2030, the European Defence Technological and Industrial Base (EDTIB) has a central role in the renewed impetus towards a European defence pillar triggered by the changes in the European geopolitical landscape. The EDTIB is a crucial pillar since it is required to produce and supply the weapons systems needed to augment EU states' military capabilities. Recognising its strategic importance, the Commission published the first-ever European Defence Industrial Strategy that seeks to increase intra-EU defence industrial cooperation and promote collaborative defence equipment development and procurement. The paper sets out to examine the degree of connectedness among major European defence industries applying a quantile connectedness approach to examine the degree and direction of connectedness among 15 major European defence companies. The estimations span the period from January 2018 to February 2024, which allows for a total of 1453 daily stock price observations per company. Results reported herein suggest the presence of a strong total connectedness among these major European defence industries. The findings reveal three broad groupings with respect to net total directional connectedness: a net-transmitting group, a net-receiving group of defence industries and finally a group that exhibits mixed connectedness.

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1. Introduction

The shockwaves of the 2022 Russian invasion of Ukraine and the ongoing armed conflict ever since, have shaken European security and have brought to the fore the need for greater coordination and enhanced integration in defence (inter alia: Costa and Barbé 2023, Fiott 2023a, Biscop 2024, Hartley 2024, Andersson and Britz 2025, Bartenstein *et al.* 2025). Among others, the deepening of European defence integration involves significant expenditures on military hardware and advanced weapons systems to augment existing defence capabilities, that are deemed to be inadequate to meet the challenges of the emerging new international security environment (Calcara *et al.* 2023). For example, the average annual growth in the defence budgets of the EU27 was 14.1% in 2023¹ (Tian

et al. 2023). The growth of this budgetary item was appreciably higher in EU members with geographic proximity to the war zone or to Russia (Christie *et al.* 2024). Poland's military spending grew in real terms by 74.6% in 2023, Estonia's by 28.7%, Denmark's by 39.3% and Finland's by 54%. Allowing for the inevitable within-budget dynamics when it comes to the allocation of such spending between different categories (Kofron and Stauber 2024), a significant part of this increase is due to the feverish (re)armament programmes many EU member states are implementing following the invasion of Ukraine by Russia, either to boost their military capabilities and/or to replenish their stocks of arms due to the extensive military assistance several of them have offered to Ukraine to meet the pressing needs the ongoing fighting with the invading forces generates.

Expected, a significant part of such spending on defence capital equipment inputs is directed towards the procurement of weapons systems, arms and munitions produced by the European Defence Technological and Industrial Base (EDTIB). Indeed, *a buy European* directive is strongly emphasised in the recently published White Paper for European Defence – Readiness 2030.² European defence manufactures that make-up the EDTIB, prominently figure among the largest arms producers globally³ and are in fact a central pillar of the EU's broader industrial and technological backbone (Kollias and Tzeremes 2022, Giacomello and Preka 2023, Mueller 2024). Examples include Airbus, MBDA, KNDS (trans-European), Thales, Dassault Aviation Group, Naval Group and Safran (France), Rheinmetall and ThyssenKrupp (Germany), Leonardo and Fincantieri (Italy), SAAB (Sweden), Navantia (Spain). As noted by Tzeremes (2024), the cumulative share of the EDTIB in global arms exports is the second largest following that of the US defence producers.

Recognising the strategic importance of the EDTIB for a common European defence pillar, the Commission has published the first-ever European Defence Industrial Strategy (EDIS).⁴ In a sense, EDIS represents the culmination of previous initiatives aiming to develop and actively support a common defence-industrial policy. Examples include the Permanent Structured Cooperation (PESCO), the European Defence Fund (EDF) and the European Defence Industrial Development Programme (EDIDP). As Fiott (2023b) points out, the EU has for several years pursued a gradual change in the way it supports and incentivises technological and industrial cooperation among European defence industries.

In the EDIS, the Commission outlines a strategic vision with a time horizon that spans to 2035 to strengthen the defence-industrial base of Europe. In broad terms, EDIS aims to reduce the existing fragmentation of the defence industries sector, increase intra-EU defence industrial cooperation and promote collaborative defence equipment development, production and procurement through the pooling of resources in both the production and acquisition of weapons systems. All these are issues that have been extensively addressed in the relevant literature (inter alia: Giumelli and Marx 2023, Vandercruysse *et al.* 2023, Anicetti 2024, Béraud-Sudreau and Schmitt 2024, Calcara and Simón 2024.). Indeed, in the EDIS Factsheet⁵ the Commission recognises that although the European defence industries are “a competitive global player capable of producing world-class advanced systems”, nonetheless their full potential is hampered by “years of underinvestment and fragmentation of defence demand along national lines”.

As stressed by Droff and Malizard (2023), in line with Augustine's laws, the development and production of technologically advanced weapons systems is becoming

increasingly complicated and very costly for a single country's defence industrial base to undertake and bear the financial burden. The joint development, production and procurement goals pursued by the Commission offer a potentially viable solution to this problem simultaneously facilitating the process of European integration. To this effect, in the EDIS documents, one of the targets set is that by 2030 EU members should procure at least 40% of their defence equipment in a collaborative manner and also 50% of members' equipment expenditure should be directed to purchases from the EDTIB with the goal that this share to increase to 60% by 2035.

Given these policy objectives, the present paper sets out to examine the degree and direction of connectedness among major European defence industries since the presence of such links is an important factor that will affect the successful implementation of the Commissions' ambitious aims. Specifically, in what follows, we apply the quantile connectedness approach of Chatziantoniou *et al.* (2021) to explore the spillover connectedness among 15 European major defence industries from January 2, 2018, to February 16, 2024. These major weapons systems producers constitute the backbone the Europe's defence-industrial base. To the best of our knowledge, the European defence industries' degree and direction of connectedness have not been examined hitherto in the extant relevant literature. The section that follows offers a brief review of the growing literature on how defence industries have been affected by the Russian invasion and the ongoing war in Ukraine, focusing on the EDTIB and its expected prominent role in the quest for strengthening European defence capabilities in view of the geopolitical turbulence unleashed by the second Trump Presidency⁶ (inter alia: Béraud-Sudreau and Schmitt 2024, Calcara and Simón 2024, Andersson and Britz 2025). The data used and the methodology applied to examine the issue at hand are presented in section three while the findings yielded from the quantile connectedness estimations are presented and discussed in section four. Section five concludes the paper.

2. Defence industries and the current geopolitical uncertainties

As previously noted, the new security landscape in the European continent that emerged following the invasion of Ukraine in 2022 caused an unprecedented in recent years increase in demand for arms and weapons systems. As Scarazzato *et al.* (2024) observe the invasion and ongoing war acted as an impetus for governments to announce and implement large-scale arms procurement plans that effectively require arms producers to switch from peacetime to wartime production to be able to respond to the surge in demand. In a similar vein, Calcara *et al.* (2023) point out that the EDTIB has to meet the challenge this surge in demand represents and also prepare for the long-term needs in weapons and technology generated by the broader geopolitical changes and the apparent shift towards a new strategic competition between major powers. Indicative of the new security era dawning in Europe is that Sweden and Finland, both with a long-standing historical tradition of neutrality, decided to join NATO (Arter 2023, Persson and Widmalm 2024). Moreover, the second Trump Presidency has accentuated and heightened uncertainty over long-term US commitment to Europe's security that originally emerged during his first presidential term and has shaken the European geopolitical landscape (Grant 2025). These new and unprecedented security challenges and concerns evoke a coordinated response by European countries (Desmaele 2022). The need for

such coordinated responses leads to military interdependence that acts as a driver for greater defence cooperation (Haroche 2020, Béraud-Sudreau and Pannier 2021).

The growing armament procurement programmes being implemented and planned by EU member states is reflected in the fact that the share of equipment expenditure in their defence budgets has already increased noticeably and the upward trend is expected to continue over the next years. For instance, equipment spending for EU countries that are also members of NATO increased from an average of 23.8% in 2021, a year before the Russian invasion, to 27% in 2022, to an estimated 27.6% in 2023 and is projected to reach around 32% in 2024.⁷ Among others, the Commission's EDIS, using appropriate tools and incentives, aims to support members' increases in defence spending and equipment procurement through the prioritisation of collaborative defence investments.⁸ The objective of this policy is on the one hand to augment members' military capabilities in view of the new regional and global threats and security challenges and augment the EU's security pillar and defence readiness.

Given the accelerating armaments globally, a strand of the literature has turned its attention to the defence industries examining how defence companies' market performance has been affected by the increased geopolitical tensions generated by the ongoing conflict in Ukraine and the rising geopolitical tensions globally. The results of Zhang *et al.* (2022) show strong co-movements between the daily returns and volatility of major defence and aerospace companies and the daily geopolitical risk index, suggesting the presence of a *flight-to-arms* phenomenon. As mentioned above, the eruption of the war in Ukraine induced the hasty implementation of unprecedented weapons procurement programmes that brought about a significant increase in the share of defence spending allocated to capital equipment purchases. For all NATO members, this share increased from an average of 23.7% in 2021, to 26.2% in 2022, to an estimated 27.5% in 2023 and is projected to reach 32.4% in 2024. The recorded increases in the share of equipment expenditure in NATO members' defence budgets verify the presence of the *flight-to-arms* phenomenon reported by Zhang *et al.* (2022). In a similar vein, Martins *et al.* (2025) report findings that indicate a positive and statistically significant stock price reaction in the case of the world's 100 largest listed defense firms following the beginning of the Russia–Ukraine armed conflict.

Switching the focus to the European defence industries, also using an event study methodology, Covachev and Fazakas (2025) find that European defence stocks exhibited appreciably better performance following the Russian invasion and the beginning of the ongoing war. As previously mentioned, because of the invasion, many European countries sharply increased their defence spending and defence equipment expenditure in particular. Expected, a significant portion of such spending is directed to procurement from European defence industries. Hence the improved market performance of these companies. The positive cumulative average abnormal returns reported by Covachev and Fazakas (2025) strongly point to market agents' expectations for increased turnover and profitability for European defence firms. Given EDTIB's pivotal role in the quest for a common European defence pillar as this is outlined and described in the Commission's EDIS documents,⁹ other studies have focused on a comparative analysis of the EDTIB's performance. Belin and Fawaz (2024) find that the profitability of European defence companies is lower compared to their US counterparts. Among other explanatory factors, this is attributable to the fragmentation of the European market and the relatively higher

dependence and concomitant exposure of the European defence industries on the civilian market. Similarly, the results of a comparative sales performance evaluation reported by Tzeremes (2024), also show that US defence industries have a dominant global presence and outrank many of the major European defence companies while the results reported by Balestra and Caruso (2025) indicate a strong correlation between the former's profitability and US electoral cycle.

As mentioned in the introduction, the present paper builds and expands on the existing European defence industries-focused studies. It does so by addressing empirically the degree and direction of connectedness among major EU defence manufacturers. Quantile connectedness analysis measures how different entities, in our case the major European defence firms included in our sample, influence each other in terms of shocks in their stock prices. Essentially, the research question examined herein is the degree to which the main European defence companies are interconnected and how these relations have changed during the period examined. Such connections between the stock prices of companies reflect the various backward and forward linkages that exist between upstream or downstream companies in a broader sector. In this case the constellation of firms that make up the European defence industrial base. Such linkages have long been present among the many companies that make up the European defence industrial base. For instance, the Eurofighter Typhoon is the product of a consortium of major defence European manufacturers – Leonardo, BAE Systems and Airbus – involving four countries: the UK, Germany, France, Italy and Spain. Similarly, the FREMM class frigates are a product designed by the Franco-Italian cooperation between Naval Group and Fincantieri. The current drive towards greater integration of the European defence market and more common defence projects builds on such pre-existing, well-established links between major European defence manufacturers. Thus, the issue of interconnectedness examined herein is also related to the current policy objectives and concomitant discourse concerning the EDTIB as these are detailed both in the EDIS as well as in the White Paper for European Defence – Readiness 2030 (inter alia: Giumelli and Marx 2023, Béraud-Sudreau and Schmitt 2024, Calcara and Simón 2024, Andersson and Britz 2025). These EDTIB-related policy objectives were summarised as follows by the President of the Commission when presenting to the European Parliament Plenary the Commission's new programme: "... We need a single market for defence. We need to strengthen the defence industrial base. ... And we need common European projects on defence".¹⁰ Identifying the presence of interdependence patterns through the analysis that follows offers useful insights for the policy pursued. In the next section, we briefly present the data, and the methodology used in the interconnectedness analysis.

3. Data and methodology

The data series used to delve into the issue at hand are drawn from DataStream¹¹ while the estimations adopt the quantile connectedness approach of Chatziantoniou *et al.* (2021). The estimations span the period from January 2, 2018, to February 16, 2024, allowing a total of 1453 daily stock price observations per company in the defense industry. The European defence industries¹² that make up our sample are: BAE Systems, Leonardo, Airbus, Thales, Dassault Aviation Group, Rolls Royce, Rheinmetall, Safran, Saab, Babcock International Group, ThyssenKrupp, Kongsberg Gruppen, Serco Group, QinetiQ and

Melrose Industries. The European defense industry exhibits both geographical diversity and sector breadth. The distribution of major companies is as follows: the UK (BAE Systems, Rolls Royce, Babcock International, Serco, QinetiQ, Melrose), France (Thales, Dassault Aviation, Safran), Germany (Rheinmetall, ThyssenKrupp), Italy (Leonardo), Sweden (Saab) and Norway (Kongsberg Gruppen). Meanwhile, Airbus stands out as a trans-European conglomerate with significant industrial footprints in France, Germany and Spain. These companies are primarily concentrated in the aerospace and defense sector, with various subsector specialisations, including aerospace (Airbus, Dassault Aviation, Saab), engine and propulsion systems (Safran, Rolls Royce), electronic and radar solutions (Thales, Leonardo), naval shipbuilding (Babcock, ThyssenKrupp), land systems (Rheinmetall, BAE Systems) and specialised defense services (Serco, QinetiQ) (Giacomello and Preka 2023, Tzeremes 2024). Just as in the case of their American counterparts, a few of them have emerged through a process of mergers and acquisitions and have many subsidiaries. For instance, Safran was founded through a merger between the aerospace engine manufacturer SNECMA and the electronics specialist SAGEM and later acquired Zodiac Aerospace. BAE Systems through the purchase and merger of British Aerospace and Marconi Electronic Systems. KNDS through a merger between Krauss-Maffei Wegmann and Nexter Systems. Leonardo (formerly Leonardo-Finmeccanica) through the integration of Agusta-Westland, Alenia Aermacchi, DRS Technologies, Selex ES and OTO Melara. As a group, these companies constitute the backbone of Europe's broader industrial and technological capacity and are prominent actors both in the European as well as the global arms market (Kollias and Tzeremes 2022, Mueller 2024). All are producers of state-of-the-art weapons systems serving in the inventory of the European national armed forces but also in many other armed forces globally given the export performance of the European defence producers.

Backward and forward industrial linkages are readily identifiable between the companies that make up the group examined herein. For example, Thales supplies the AESA¹³ radar fitted in Dassault's Rafale fighter airplane as well as other optronics for both Rafale and Eurofighter. The latter is produced by a consortium made up of Airbus, BAE Systems and Leonardo also present in our sample. Safran's counterparts and upstream industrial customers among others include Thales, Leonardo, Saab, Dassault Aviation and BAE Systems. Along with Rolls-Royce, Safran supplies engines to Airbus. The Type 31 frigates under construction by Babcock International will be equipped with the Thales TACTICOS combat management system and the NS110-4D AESA radar. ThyssenKrupp's F125 and MEKO-A200 Class frigates are fitted with Leonardo's OTO 127/64 LW naval gun.

The above are random examples of the many varied and multilevel industrial and commercial linkages that the group exhibits. They constitute the channels through which increases in upstream industries' output induce a change in the output of downstream industries. Such industrial links and dependencies are reflected in the companies' stocks. The connectedness methodology we employ herein allows us to examine the degree and as well as the direction of such connections and dependencies as this is reflected in the companies' traded stocks. Moreover, one could tentatively argue that the presence of an empirically traceable strong connectiveness suggests that the technological and industrial benefits of the Commission's instruments designed to support the European defence industry will spill over to a larger number of companies than the ones

directly engaged in the implementation of a defence design, development and production project. The European Patrol Corvette (EPC),¹⁴ a flagship PESCO project, is probably a representative example. The end product that will enter production will essentially be a ship hull – a common platform – that can be fitted with different weapon systems to accommodate different operational needs of the countries that will procure it. Potentially, such systems can be the products of different European companies that were not necessarily project partners during its implementation. Similarly, the EDIS goal to achieve that by 2030 at least 50% of members' equipment spending should be directed to procurement from the European defence industries (60% by 2035) will positively impact not only upstream industries but also a constellation of other manufactures and suppliers that are linked and connected to the major producers through the production and supply of a plethora of components and sub-systems that are integrated into the final weapon system.

The time series of the prices of the companies that make up our sample are transformed into log-returns. They are shown in [Figures 1 and 2](#). Given that the period of the data series used includes the outbreak of the pandemic, from a visual inspection of the figures a Covid-19 effect is readily identifiable in 2020 but also easily identifiable is the effect of the Russian invasion in February 2022 and the *flight-to-arms* reported by Zhang *et al.* (2022) as a response to the new security environment that dawned in Europe. Specifically, as can be observed in [Figure 1](#), the pandemic outbreak caused a sharp decline in the series as this has been the case for all indicators that quantify

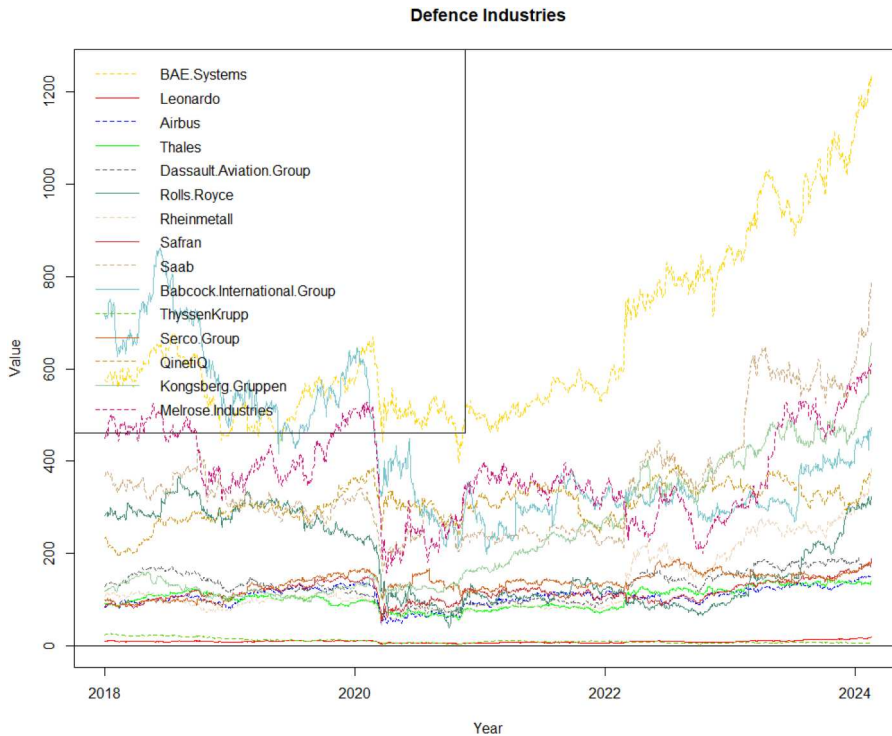


Figure 1. Time series of the sample.

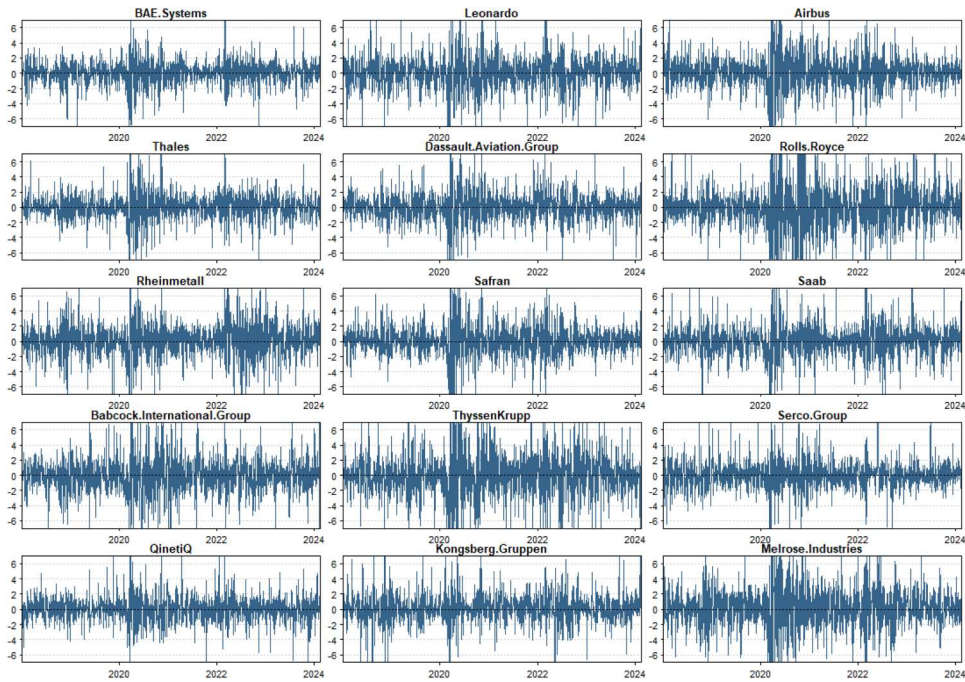


Figure 2. Log returns of the sample.

economic activity. The stringent public health measures implemented by almost all European countries had a severe impact on the economy and expectedly this is also present in the case of the defence companies that make up our sample. Following the return to normality, all series exhibit a steady upward trend that from 2022 can be attributable to the ongoing fervent (re)armament process caused by the Russian invasion of Ukraine (Zhang *et al.* 2022, Covachev and Fazakas 2025, Martins *et al.* 2025). In other words, this appreciation in the stock prices of the companies of our sample reflects markets agents' expectations for higher turnovers and profits for weapons and arms producers given the *flight-to-arms* triggered by the Russian invasion.

Moreover, given the multilevel linkages that connect these industries, new orders for a weapon system produced by one of them will positively affect the output and turnover of the company(ies) that produce components that are fitted in the weapon system procured. For instance, a new order for the Rafale fighter airplane produced by Dassault Aviation Group will lead to an increase in the output and turnover of Thales which supplies the AESA radar that Rafale is fitted with. Similarly, new orders for ThyssenKrupp's F125 class frigates will bring about an increase in the demand for Leonardo's Otobreda naval gun with which the frigate is armed. As pointed out above, these types of links are invariably reflected in the co-movements the companies' stocks exhibit.

We now turn to present briefly the methodology used in the estimations, the results of which are shown and discussed in the next section. Chatziantoniou *et al.* (2021), based on the quantile vector autoregression framework of Ando *et al.* (2022) and the models of Diebold and Yilmaz (2009, 2012), proposed an alternative estimation of the quantile connectedness model summarised below. Essentially, quantile connectedness is a statistical

method that measures how different entities, in our case the major European defense firms included in our sample, influence each other in terms of shocks to their stock prices. Industrial backward and forward linkages between the firms are the conduit for such connections between the stock prices of the companies involved. Backward and forward linkages refer to the potential increase in output induced in upstream or downstream industries in response to an increase in the industry's output. A new order for a weapon system produced by a defence manufacturer affects the valuation of its traded stocks that also feeds into the stock prices of its subcontractors that produce the components and subassemblies that will be fitted into the final system procured. Splitting the dataset into quantiles, we can analyse how much one firm's stock market movements are transmitted to or received from other firms with such industrial connections (Ando *et al.* 2022). For instance, the 5th percentile (0.05 quantile) describes the lowest 5% of observed values, while the 95th percentile (0.95 quantile) describes the highest 5%. In brief, the calculation of the generalised forecast error variance decomposition can be displayed as follows:

$$\theta_{ij}^v(\Delta) = \frac{\Sigma(\tau)_{ii}^{-1} \sum_{\delta=0}^{\Delta-1} (\lambda_i' \theta_{\delta}(\tau) \Sigma(\tau) \lambda_j)^2}{\sum_{\delta=0}^{\Delta-1} (\lambda_i' \theta_{\delta}(\tau) \Sigma(\tau) \theta_{\delta}(\tau)' \lambda_j)} \quad (1a)$$

$$\tilde{\theta}_{ij}^v(\Delta) = \frac{\theta_{ij}^v(\Delta)}{\sum_{j=1}^{\xi} \gamma_{ij}^v(\Delta)} \quad (1b)$$

The total connectedness to other covariates ($i \rightarrow j$) or *Net Transmitters*, that is defence industries whose stock returns strongly influence those of other firms, is estimated as:

$$C_{i \rightarrow j}^v(\Delta) = \sum_{j=1, i \neq j}^{\xi} \tilde{\theta}_{ji}^v(\Delta) \quad (2)$$

The total connectedness from other covariates ($j \rightarrow i$) or *Net Receivers*, that is defence industries whose returns are strongly influenced by those of other defence manufacturers, is estimated as:

$$C_{i \leftarrow j}^v(\Delta) = \sum_{j=1, i \neq j}^{\xi} \tilde{\theta}_{ji}^v(\Delta) \quad (3)$$

while the net total directional connectedness (N-TDC) of each variable is calculated as:

$$C_i^v(\Delta) = C_{i \rightarrow j}^v(\Delta) - C_{i \leftarrow j}^v(\Delta) \quad (4)$$

Lastly, the dynamic Total Connectedness Index (TCI) is a single indicator (scaled from 0% to 100%) that summarises the overall degree of interdependence in the defence industries, categorised as weak, moderate or strong connectedness. Although there is no general threshold for weak, moderate or strong TCI, invariably the degree of connectedness is categorised according to the Diebold and Yilmaz (2009, 2012) scale as follows: weak spillovers (below 30–40%), moderate spillovers (around 40–60%), strong connectedness (above 60–70%) and very strong connectedness (above 80–90%). TCI is estimated as follows:

$$TCI(\Delta) = \frac{\sum_{i,j=1, i \neq j}^{\xi} \tilde{\theta}_{ij}^v(\Delta)}{\xi - 1} \quad (5)$$

The quantile connectedness approach allows us not only to establish the degree of connectedness between the major European defence industries, an issue that constitutes the principal research question addressed herein, but additionally it allows us to identify the direction of this connectedness. Specifically, it allows us to group the companies of our sample in terms of the net total directional connectedness into three groups: a net-transmitting group, a net-receiving group of defence industries and finally a group that exhibits a mixed connectedness.

4. Findings and discussion

We start our empirical analysis with the standard pre-testing and summary statistics. These are shown in Table 1. As can be observed almost all the mean values of log returns covariates are positive, except for Babcock International Group and ThyssenKrupp, which have negative values. The highest volatility value is 0.118 for Kongsberg Gruppen, while the lowest volatility value is -0.112 for ThyssenKrupp. Rolls-Royce and ThyssenKrupp have the largest variance in volatility, at 12.661 and 11.512, respectively, indicating that these two variables represent the highest risk in the market. In contrast, BAE Systems (2.633) and QinetiQ (3.148) exhibit the lowest variance in volatility, indicating they represent the lowest risk asset in our sample. Regarding the skewness where the D'Agostino (1970) test is applied and the kurtosis test is that developed by Anscombe and Glynn (1983), the results indicate that our sample is asymmetric with a leptokurtic distribution. The null hypothesis of the Jarque and Bera (1980) normality test is rejected for the volatility series at the 1% significance level. It indicates a non-normal distribution. The outcomes of the unit root test (Stock *et al.* 1996) indicate that all volatility time series are stationary at the 1% significance level while the Fisher and Gallagher (2012) test for serial autocorrelation reveals the presence of autocorrelations. Lastly, the Kendall rank-rank-wise correlation demonstrates positive and statistically significant relationships among all the series, but the correlations are not high. The highest ratio is the one exhibited between Safran and Airbus at 54.7%.

In Tables 2–4 the empirical findings of connectedness estimations are presented. Specifically, Tables 2 and 4 exhibit the results of quantile tails at the 0.05th and 0.95th quantiles, respectively, whereas Table 3 displays the results of the middle quantile. Generally, these tables show the Total Connectedness Index (TCI) index of the sample as well as the connectedness FROM, TO and NET for each variable. The estimation outcomes of the quantile tails are very similar. The TCI value for the 0.05th quantile (Table 2) is 90.44%, and for the 0.95th quantile (Table 4), it is 89.93%, exhibiting a strong connection among the series.¹⁵ That points to strong industrial linkages between the companies of the sample that suggest significant spillovers and benefits that can accrue from the current strong policy spur towards strengthening the European defence industrial base, common European defence projects and eventually a single market for defence acquisitions by EU member states. Developing and producing technologically advanced weapons systems is increasingly complicated and very costly. Industrial cooperation for joint development, production and procurement offers a viable and effective alternative that also yields significant economies of scale since the final product is procured by many countries (Droff and Malizard 2023). Hence, among the EDIS targets is that by 2030 EU members states should procure at least 40% of their defence equipment in a collaborative

Table 1. Pre-tests and summary statistics.

	BAE Systems				Airbus	Thales	Dassault Aviation Group	Rolls Royce	Rheinmetall	Safran
Mean	0.053	0.043	0.039	0.030	0.039	0.030	0.025	0.010	0.089	0.054
Variance	2.633	6.092	6.637	3.387	6.637	3.387	3.879	12.661	6.184	6.074
Skewness	-0.140**	-0.409***	-0.337***	0.080	-0.337***	0.080	-0.032	0.972***	0.568***	-0.642***
Kurtosis	4.742***	12.297***	15.588***	6.803***	15.588***	6.803***	4.634***	13.767***	10.386***	20.992***
JB	1365.041***	9189.023***	14728.438***	2801.774***	14728.438***	2801.774***	1299.470***	11694.998***	6603.499***	26758.561***
ERS	-16.076***	-15.239***	-9.065***	-11.715***	-9.065***	-11.715***	-14.266***	-13.471***	-7.959***	-15.785***
Q(20)	17.488**	15.084	52.181***	29.204***	52.181***	29.204***	13.357	42.515***	32.697***	62.120***
Q2(20)	416.828***	170.605***	998.319***	452.096***	998.319***	452.096***	338.831***	295.042***	180.820***	1522.771***
Kendall		Leonardo	Airbus	Thales	Airbus	Thales	Dassault Aviation Group	Rolls Royce	Rheinmetall	Safran
	BAE Systems	Leonardo	Airbus	Thales	Airbus	Thales	Dassault Aviation Group	Rolls Royce	Rheinmetall	Safran
BAE Systems	1.000***	0.326***	0.282***	0.386***	0.282***	0.386***	0.322***	0.264***	0.318***	0.280***
Leonardo	0.326***	1.000***	0.357***	0.382***	0.357***	0.382***	0.366***	0.295***	0.334***	0.342***
Airbus	0.282***	0.357***	1.000***	0.338***	1.000***	0.338***	0.381***	0.418***	0.290***	0.547***
Thales	0.386***	0.382***	0.338***	1.000***	0.338***	1.000***	0.450***	0.277***	0.334***	0.360***
Dassault Aviation Group	0.322***	0.366***	0.322***	0.450***	0.322***	0.450***	1.000***	0.296***	0.332***	0.390***
Rolls Royce	0.264***	0.295***	0.418***	0.277***	0.418***	0.277***	0.296***	1.000***	0.257***	0.421***
Rheinmetall	0.318***	0.334***	0.290***	0.334***	0.290***	0.334***	0.332***	0.257***	1.000***	0.291***
Safran	0.280***	0.342***	0.547***	0.360***	0.547***	0.360***	0.390***	0.421***	0.291***	1.000***
Saab	0.305***	0.327***	0.307***	0.347***	0.307***	0.347***	0.330***	0.258***	0.342***	0.305***
Babcock International Group	0.224***	0.226***	0.230***	0.221***	0.230***	0.221***	0.233***	0.246***	0.211***	0.245***
ThyssenKrupp	0.114***	0.221***	0.312***	0.155***	0.312***	0.155***	0.220***	0.294***	0.239***	0.277***
Serco Group	0.150***	0.133***	0.186***	0.159***	0.186***	0.159***	0.176***	0.134***	0.161***	0.183***
QinetiQ	0.267***	0.222***	0.246***	0.243***	0.246***	0.243***	0.241***	0.208***	0.207***	0.244***
Kongsberg Gruppen	0.196***	0.224***	0.191***	0.228***	0.191***	0.228***	0.227***	0.159***	0.227***	0.191***
Melrose Industries	0.216***	0.282***	0.399***	0.248***	0.399***	0.248***	0.286***	0.383***	0.309***	0.401***
	Saab	Babcock International Group	ThyssenKrupp	Serco Group	ThyssenKrupp	Serco Group	QinetiQ	Kongsberg Gruppen	Melrose Industries	
Mean	0.053	-0.029	-0.112	0.041	-0.112	0.041	0.032	0.118	0.021	
Variance	4.967	6.726	11.512	3.995	11.512	3.995	3.148	4.103	9.173	
Skewness	-0.112*	0.404***	-0.019	0.499***	-0.019	0.499***	0.072	-0.406***	-0.061	
Kurtosis	8.263***	13.469***	7.164***	12.039***	7.164***	12.039***	6.681***	11.984***	7.066***	
JB	4134.043***	11015.499***	3105.160***	8828.844***	3105.160***	8828.844***	2701.778***	8728.785***	3021.911***	
ERS	-13.479***	-10.352***	-5.402***	-8.745***	-5.402***	-8.745***	-13.053***	-16.773***	-12.059***	
Q(20)	17.743**	16.773*	15.159	11.174	15.159	11.174	12.781	12.253	29.247***	
Q2(20)	71.340***	15.851*	142.695***	27.411***	142.695***	27.411***	55.428***	16.846*	573.829***	

(Continued)

Table 1. Continued.

kendall	Saab	Babcock International Group	ThyssenKrupp	Serco Group	QinetiQ	Kongsberg Gruppen	Melrose Industries
BAE Systems	0.305***	0.224***	0.114***	0.150***	0.267***	0.196***	0.216***
Leonardo	0.327***	0.226***	0.221***	0.133***	0.222***	0.224***	0.282***
Airbus	0.307***	0.230***	0.312***	0.186***	0.246***	0.191***	0.399***
Thales	0.347***	0.221***	0.155***	0.159***	0.243***	0.228***	0.248***
Dassault Aviation Group	0.330***	0.233***	0.220***	0.176***	0.241***	0.227***	0.286***
Rolls Royce	0.258***	0.246***	0.294***	0.134***	0.208***	0.159***	0.383***
Rheinmetall	0.342***	0.211***	0.239***	0.161***	0.207***	0.227***	0.309***
Safran	0.305***	0.245***	0.277***	0.183***	0.244***	0.191***	0.401***
Saab	1.000***	0.213***	0.203***	0.162***	0.210***	0.240***	0.269***
Babcock International Group	0.213***	1.000***	0.226***	0.203***	0.248***	0.152***	0.268***
ThyssenKrupp	0.203***	0.226***	1.000***	0.169***	0.141***	0.149***	0.329***
Serco Group	0.162***	0.203***	0.169***	1.000***	0.182***	0.123***	0.237***
QinetiQ	0.210***	0.248***	0.141***	0.182***	1.000***	0.173***	0.208***
Kongsberg Gruppen	0.240***	0.152***	0.149***	0.123***	0.173***	1.000***	0.187***
Melrose Industries	0.269***	0.268***	0.329***	0.237***	0.208***	0.187***	1.000***

Notes: ***, ** and * display significance at 1%, 5% and 10%, respectively.

Table 2. Lowest (0.05) quantile connectedness findings.

Q = 0.05	BAE Systems		Leonardo	Airbus	Thales	Dassault Aviation Group	Rolls Royce	Rheinmetall	Safran
BAE Systems	9.42		6.37	6.66	7.48	6.52	6.10	6.93	6.75
Leonardo	6.72		8.97	6.82	7.39	6.27	6.27	6.89	7.01
Airbus	6.37		6.09	9.33	7.16	6.47	6.78	6.35	7.99
Thales	7.12		6.45	6.86	9.69	6.87	6.24	6.87	7.09
Dassault Aviation Group	6.67		6.42	6.87	7.59	8.80	6.13	6.85	7.23
Rolls Royce	6.41		6.06	7.38	7.10	6.31	9.39	6.36	7.39
Rheinmetall	7.02		6.43	6.60	7.47	6.67	5.89	9.04	6.99
Safran	6.36		6.20	7.83	7.20	6.48	6.68	6.53	9.58
Saab	6.72		6.23	6.67	7.41	6.48	6.00	6.90	6.77
Babcock International Group	6.73		5.97	6.67	7.03	6.36	6.40	6.45	6.94
ThyssenKrupp	6.20		6.31	7.06	6.53	6.36	6.45	6.64	7.11
Serco Group	6.60		5.88	6.75	6.86	6.21	5.96	6.42	6.85
QinetiQ	6.93		6.14	6.75	7.15	6.41	6.21	6.48	6.85
Kongsberg Gruppen	6.65		6.28	6.53	7.12	6.49	5.94	6.69	6.87
Melrose Industries	6.17		6.17	7.41	6.98	6.28	6.65	6.53	7.53
TO	92.66		87.01	96.86	100.47	90.45	87.73	92.90	99.36
NET	2.08		-4.02	6.20	10.16	-0.75	-2.89	1.94	8.94
	Saab		Babcock International Group	ThyssenKrupp	Serco Group	QinetiQ	Kongsberg Gruppen	Melrose Industries	FROM
BAE Systems	6.32		6.66	6.78	5.71	6.23	5.87	6.18	90.58
Leonardo	6.40		6.14	7.04	5.46	5.90	5.83	6.54	91.03
Airbus	6.18		6.18	7.15	5.69	5.71	5.48	7.05	90.67
Thales	6.53		6.35	6.51	5.50	5.83	5.78	6.31	90.31
Dassault Aviation Group	6.42		6.28	6.92	5.66	5.91	5.87	6.36	91.20
Rolls Royce	6.23		6.46	7.14	5.48	5.72	5.71	6.85	90.61
Rheinmetall	6.63		6.37	7.00	5.62	5.89	5.90	6.48	90.96
Safran	6.06		6.19	7.12	5.58	5.68	5.56	7.02	90.42
Saab	9.44		6.38	7.14	5.80	5.87	6.06	6.14	90.56
Babcock International Group	6.19		10.00	6.95	5.82	6.22	5.74	6.52	90.00
ThyssenKrupp	6.18		6.25	10.90	5.97	5.61	5.68	6.75	89.10
Serco Group	6.27		6.57	7.25	10.00	5.88	5.97	6.51	90.00
QinetiQ	6.23		6.69	6.80	5.90	9.43	5.83	6.20	90.57
Kongsberg Gruppen	6.29		6.27	7.11	5.71	5.85	9.94	6.27	90.06
Melrose Industries	6.14		6.40	7.26	5.84	5.64	5.60	9.40	90.60
TO	88.06		89.19	98.18	79.74	81.97	80.89	91.18	1356.66
NET	-2.49		-0.81	9.08	-10.26	-8.60	-9.17	0.58	TCI = 90.44%

**Table 3.** Middle (0.5) quantile connectedness findings.

Q = 0.5	BAE Systems		Leonardo	Airbus	Thales	Dassault Aviation Group	Rolls Royce	Rheinmetall	Safran
BAE Systems	30.87		6.67	5.16	9.74	6.54	4.04	7.33	5.39
Leonardo	6.15		29.45	6.15	8.32	7.03	4.54	6.65	6.65
Airbus	3.74		5.34	24.80	6.16	6.38	7.96	4.53	14.10
Thales	8.08		7.59	6.76	26.21	6.75	4.57	6.78	7.11
Dassault Aviation Group	5.82		6.73	7.27	10.36	27.17	4.26	6.21	7.52
Rolls Royce	3.84		4.90	10.08	5.03	4.74	33.44	3.35	9.87
Rheinmetall	7.13		7.00	5.58	8.19	7.07	3.30	29.98	5.88
Safran	4.07		5.71	13.92	6.54	6.40	7.68	4.57	24.41
Saab	6.34		6.47	5.36	7.98	6.40	3.77	6.95	5.74
Babcock International Group	4.49		4.17	4.76	4.57	4.98	4.56	3.87	5.33
ThyssenKrupp	2.24		4.99	7.07	2.64	4.44	5.95	4.51	6.69
Serco Group	2.22		2.41	4.92	3.06	3.23	2.14	2.87	4.66
QinetiQ	6.54		5.47	4.43	5.91	5.27	3.17	4.00	4.36
Kongsberg Gruppen	4.21		5.29	3.62	5.72	5.03	2.08	5.06	3.76
Melrose Industries	3.22		4.64	10.00	3.85	4.59	6.88	4.65	9.77
TO	68.10		77.38	95.08	88.07	81.89	64.89	71.06	96.83
NET	-1.03		6.83	19.88	14.28	9.06	-1.68	1.04	21.24
	Saab	Babcock International Group	ThyssenKrupp	Serco Group	QinetiQ	Kongsberg Gruppen	Melrose Industries	FROM	
BAE Systems	6.04	3.64	2.03	1.25	4.73	2.84	3.75	69.13	
Leonardo	5.72	3.04	3.72	1.22	3.73	3.33	4.55	70.55	
Airbus	3.94	2.79	4.77	2.57	2.54	1.99	8.38	75.20	
Thales	6.46	2.92	1.96	1.48	3.60	3.09	3.65	73.79	
Dassault Aviation Group	5.47	3.40	3.27	1.74	3.37	2.79	4.65	72.83	
Rolls Royce	3.46	3.69	5.12	1.36	2.45	1.37	7.30	66.56	
Rheinmetall	6.50	3.05	3.68	1.61	2.74	3.16	5.12	70.02	
Safran	4.11	3.09	4.40	2.46	2.51	2.06	8.06	75.59	
Saab	32.43	3.18	3.18	1.84	2.66	3.05	4.65	67.57	
Babcock International Group	4.00	42.07	4.07	2.19	3.99	1.79	5.18	57.93	
ThyssenKrupp	3.67	3.94	40.51	3.04	1.90	1.35	7.06	59.49	
Serco Group	2.88	2.94	3.76	54.73	3.16	1.72	5.29	45.27	
QinetiQ	3.48	4.17	2.15	2.51	42.68	2.81	3.04	57.32	
Kongsberg Gruppen	4.50	2.21	1.94	1.51	3.11	48.67	3.29	51.33	
Melrose Industries	3.91	3.87	5.58	3.37	2.20	1.91	31.56	68.44	
TO	64.14	45.91	49.62	28.14	42.70	33.25	73.96	981.02	
NET	-3.43	-12.02	-9.87	-17.13	-14.61	-18.08	5.53	TCl = 65.40%	

Table 4. Upper (0.95) quantile connectedness findings.

Q = 0.95		BAE Systems		Leonardo	Airbus	Thales	Dassault Aviation Group	Rolls Royce	Rheinmetall	Safran
BAE Systems	BAE Systems	10.04		6.69	6.32	7.46	6.88	6.11	7.20	6.73
	Leonardo	6.74		9.53	6.74	7.03	6.92	6.31	7.09	6.86
	Airbus	6.10		6.44	9.50	6.73	6.79	6.67	6.64	7.94
	Thales	7.07		6.73	6.74	9.73	7.26	6.10	7.21	6.96
	Dassault Aviation Group	6.54		6.59	6.85	7.45	9.88	6.17	6.98	6.99
	Rolls Royce	6.26		6.47	7.20	6.51	6.68	9.92	6.77	7.20
	Rheinmetall	6.93		6.62	6.61	7.11	6.84	6.15	10.07	6.88
	Safran	6.30		6.45	7.88	6.68	6.86	6.73	6.74	9.56
	Saab	6.63		6.44	6.65	7.08	6.78	6.29	7.15	6.80
	Babcock International Group	6.57		6.33	6.53	6.47	6.59	6.31	6.64	6.74
	ThyssenKrupp	6.12		6.52	6.74	6.20	6.54	6.72	6.78	6.88
	Serco Group	6.17		6.06	6.72	6.39	6.57	5.82	6.72	6.83
	QinetiQ	6.83		6.34	6.60	6.86	6.62	6.00	6.60	6.71
	Kongsberg Gruppen	6.73		6.40	6.47	6.89	6.68	5.89	6.97	6.60
	Melrose Industries	6.05		6.40	7.40	6.17	6.39	6.65	6.72	7.35
TO	91.02		90.49	95.43	95.03	94.38	87.91	96.21	97.48	
NET	1.07		0.02	4.93	4.76	4.26	-2.17	6.27	7.04	
	Saab	BabcockInternational Group	ThyssenKrupp	Serco Group	QinetiQ	Kongsberg Gruppen	Melrose Industries	FROM		
BAE Systems	BAE Systems	6.46	6.09	5.68	5.64	6.54	6.08	6.07	89.96	
	Leonardo	6.40	5.98	6.15	5.72	6.16	6.04	6.32	90.47	
	Airbus	6.07	6.00	6.24	6.03	6.08	5.71	7.07	90.50	
	Thales	6.57	5.95	5.64	5.69	6.27	6.02	6.08	90.27	
	Dassault Aviation Group	6.54	5.95	5.93	5.95	6.06	5.95	6.19	90.12	
	Rolls Royce	6.24	6.14	6.51	5.65	5.95	5.69	6.81	90.08	
	Rheinmetall	6.56	6.01	5.97	5.81	6.05	6.05	6.35	89.93	
	Safran	6.18	5.93	6.11	5.91	6.01	5.67	6.99	90.44	
	Saab	9.98	5.93	6.07	5.89	5.97	6.05	6.29	90.02	
	Babcock International Group	6.22	10.51	6.22	6.14	6.39	5.86	6.49	89.49	
	ThyssenKrupp	6.31	6.24	10.23	6.28	5.96	5.69	6.80	89.77	
	Serco Group	6.10	6.44	6.36	11.05	6.22	5.97	6.58	88.95	
	QinetiQ	6.17	6.31	5.94	6.21	10.56	6.07	6.17	89.44	
	Kongsberg Gruppen	6.50	6.06	5.76	5.93	6.34	10.54	6.25	89.46	
	Melrose Industries	6.14	6.31	6.62	6.14	6.00	5.68	10.00	90.00	
TO	88.45	85.34	85.18	82.97	85.99	82.54	90.48	1348.89		
NET	-1.57	-4.15	-4.59	-5.98	-3.45	-6.92	0.48	TCl = 89.93%		

manner. Moreover, 50% of members' equipment expenditure should be directed to purchases from European defence producers aiming to reach 60% by 2035.

As can be seen, the highest contributor (TO) is Thales with 100.47% at the lowest quantile (Table 2) and Safran with 97.48% at the upper quantile (Table 4). The lowest contributor to the system, although the values are still high, is Serco Group with 79.74% at the lowest tail and Kongsberg Gruppen with 82.54% at the upper quantile. Serco Group also makes a small contribution (82.97%) at the 0.95th quantile. From the estimations, it appears that the highest receiver (FROM) is Dassault Aviation Group with a value of 91.20% (Table 2), although we can observe that all values are close to 90%. For the upper quantile (Table 4), the highest receivers are Airbus (90.50%), Leonardo (90.47%) and Safran (90.44%), with the values of the remaining series also close to 90%. Regarding the net volatility spillover indexes at the tail, it can be observed that half of the series exhibits a contributor role while the other half are receivers. On the one hand, at the lowest quantile (Table 2), BAE Systems, Airbus, Thales, Rheinmetall, Safran, ThyssenKrupp and Melrose Industries are the net transmitters. On the other hand, at the upper quantile (Table 4), BAE Systems, Leonardo, Airbus, Thales, Dassault Aviation Group, Rheinmetall, Safran and Melrose Industries are the net contributors. Finally, the pairwise volatility spillover among the variables is lowest at around 10% for both the 0.05th and 0.95th quantiles. The volatility value of the TCI at the middle quantile (Table 3) is 65.40%. Airbus and Safran are the highest volatility transmitters with values of 95.08% and 96.83%, respectively. Notably, these same variables are also the highest receivers of the system, with values of 75.20% and 75.59%, respectively. Additionally, the net volatility spillover shows that Leonardo, Airbus, Thales, Dassault Aviation Group, Rheinmetall, Safran and Melrose Industries are the net contributors. Similarly to the results for the tail quantiles, the pairwise volatility spillover among the variables is lowest at around 10%.

Figures 3 (0.05th quantile), 4 (0.5th quantile) and 5 (0.95th quantile) offer a visual depiction of the dynamic net pairwise volatility spillover indexes over time. If the blue area depicts positive values (above the black horizontal line which starts from zero), the variable is a net transmitter to another variable. Otherwise, if the blue area shows negative values (below the black horizontal line which starts from zero), the variable is a net receiver from another variable. The net pairwise volatility findings of tails are nearly equivalent with many fluctuations over time. The highest volatility fluctuations for both quantiles occur at the beginning of the COVID-19 pandemic period (starting in early 2020) and during the COVID-19 pandemic period (2021–2022). However, for the lowest quantile (0.05th), we can observe high volatility fluctuations at the beginning (2022) and during (2023–2024) that are attributable to the effects of the ongoing Russia–Ukraine war. This suggests that the outbreak of the COVID-19 pandemic played a crucial role in the low and high values of defence industries, changing the role from net transmitter to net receiver and vice versa. On the other hand, however, the outbreak of the Russia–Ukraine conflict appears to affect more the low values of defence industries. Looking at the middle quantile (Figure 4), we can note that the outbreaks of the COVID-19 pandemic and the Russia–Ukraine war do not have a significant influence, although there are some fluctuation ranges for a few of the companies in the sample examined (Figure 5).

To allow a more comprehensive picture of the defence industries under scrutiny, we proceeded with estimating the dynamic total connectedness index (TCI) and the net total directional connectedness (N-TDC) for each variable. Specifically, the dynamic TCI

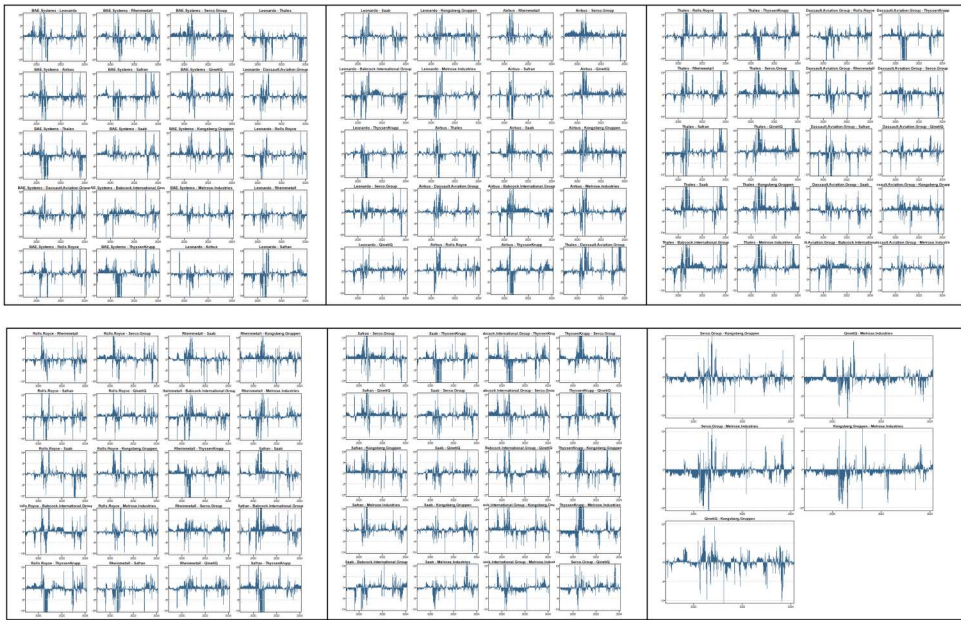


Figure 3. Dynamic net pairwise connectedness at the 0.05th quantile.

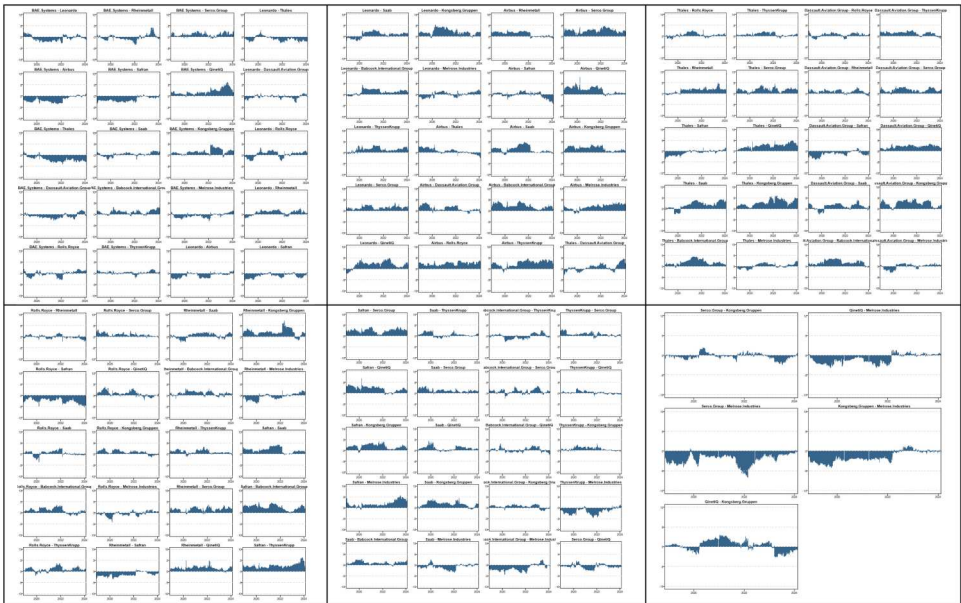


Figure 4. Dynamic net pairwise connectedness at the 0.5th quantile.

is presented in [Figure 6](#). The time period examined is depicted on the horizontal axis, while the left vertical axis shows the quantile distribution from the lowest quantile (0.05th) to the upper quantiles (0.95th) and on the right vertical axis is the rate of TCI. The higher the dynamic TCI, the darker the tone of the colour bar on the right axis.

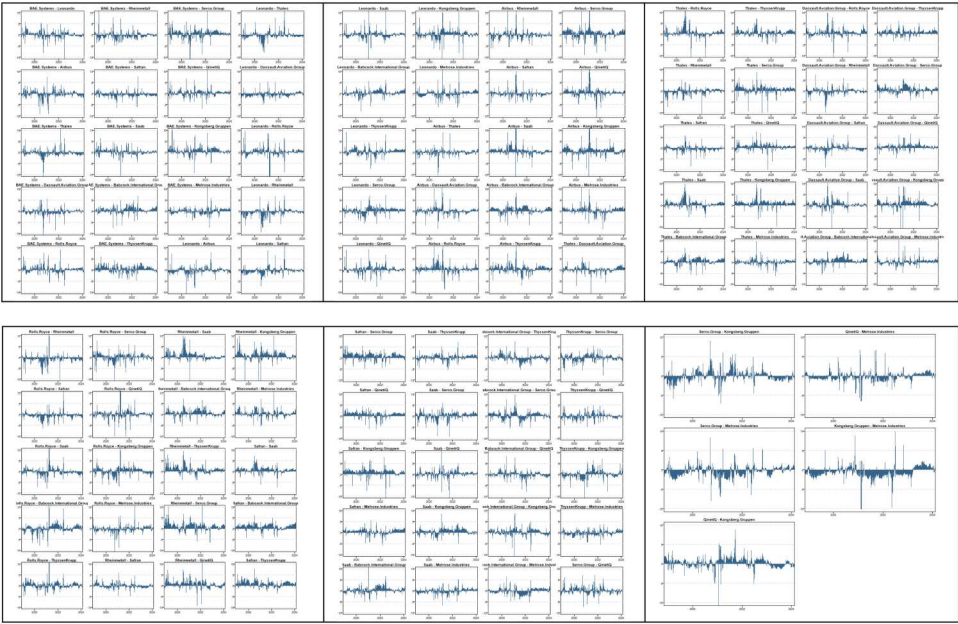


Figure 5. Dynamic net pairwise connectedness at the 0.95th quantile.

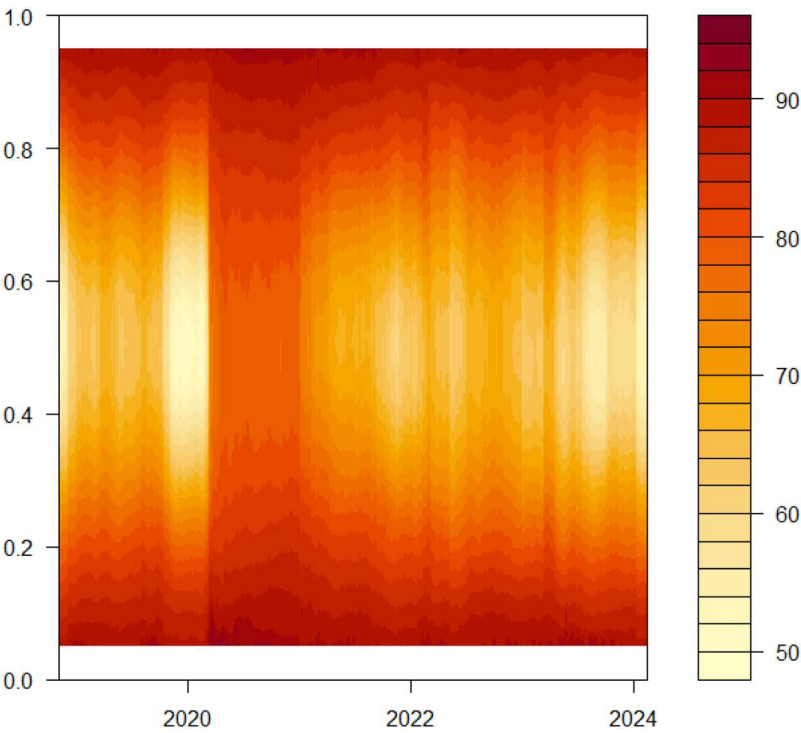


Figure 6. Dynamic TCI.

Hence, we can observe that at the lower and upper quantiles, the connectedness is stronger than in the middle quantiles, except from early 2020 onwards. This is clearly associated with the outbreak of the COVID-19 pandemic. For this latter period, connectedness is present in the middle quantiles, albeit not as strong as it is in the tail quantiles.

The N-TDC of each defence industry is plotted in [Figures 7–9](#). Again, the horizontal axis represents the time period, the left vertical axis shows the quantile distribution from the lowest quantile (0.05th) to the upper quantiles (0.95th) and the right vertical axis indicates the N-TDC. The darker the tone of the red colour, the more the industry is considered an influencer to the system (the values of TDC are positive). Conversely, the darker the tone of the blue colour, the more the industry is considered a receiver of the system (the values of TDC are negative). If the shade is lighter, then the values of N-TDC are close to zero, indicating that this specific defense company plays a neutral role. We have separated the defense companies into three different groups based on these specific findings. The first group includes the net-contributing industries ([Figure 7](#)), which are Airbus, Thales, Dassault Aviation Group and Safran. The second group contains the net-receiving

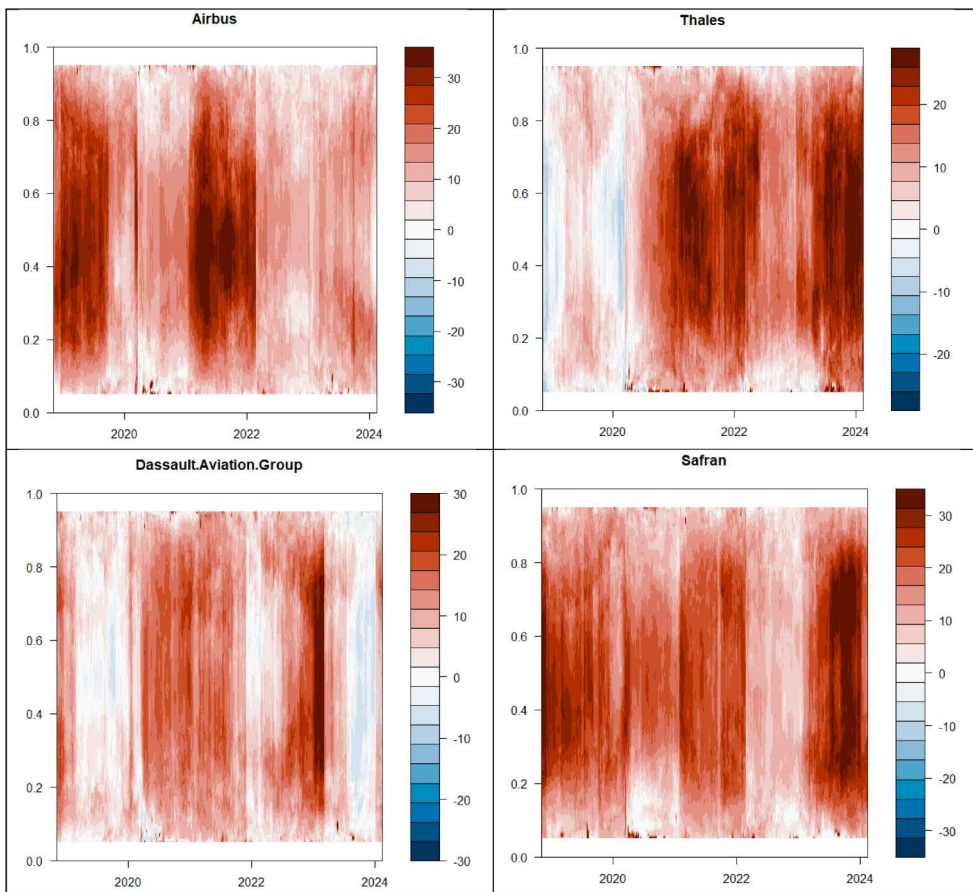


Figure 7. N-TDC of net-transmitting defence industries.

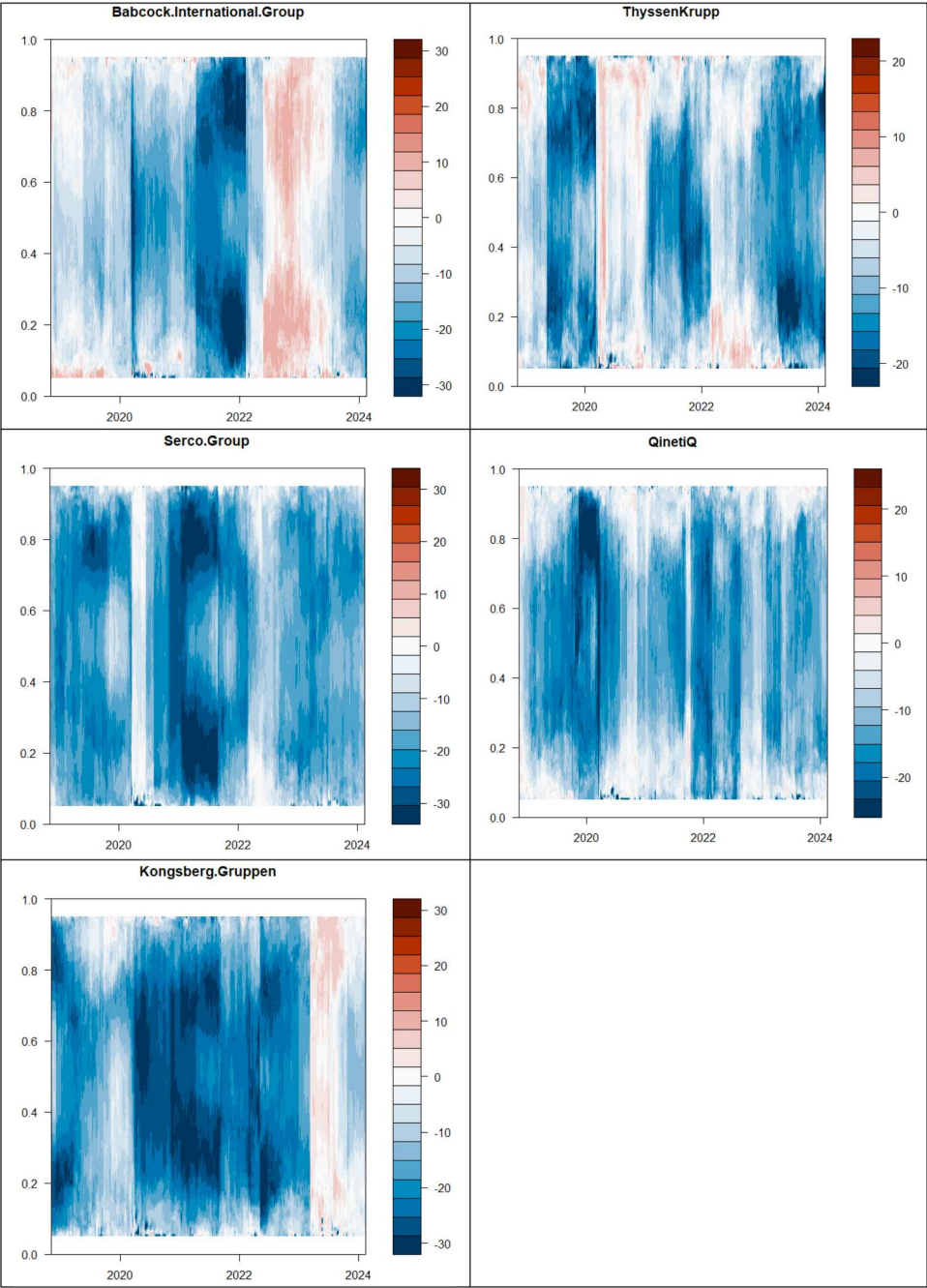


Figure 8. N-TDC of net-receiving defence industries.

industries (Figure 8), which are Babcock International Group, ThyssenKrupp, Serco Group, QinetiQ and Kongsberg Gruppen. The last group consists of mixed industries (Figure 9), which can assume either a net-contributing or net-receiving role depending on the time-frame one focuses on.

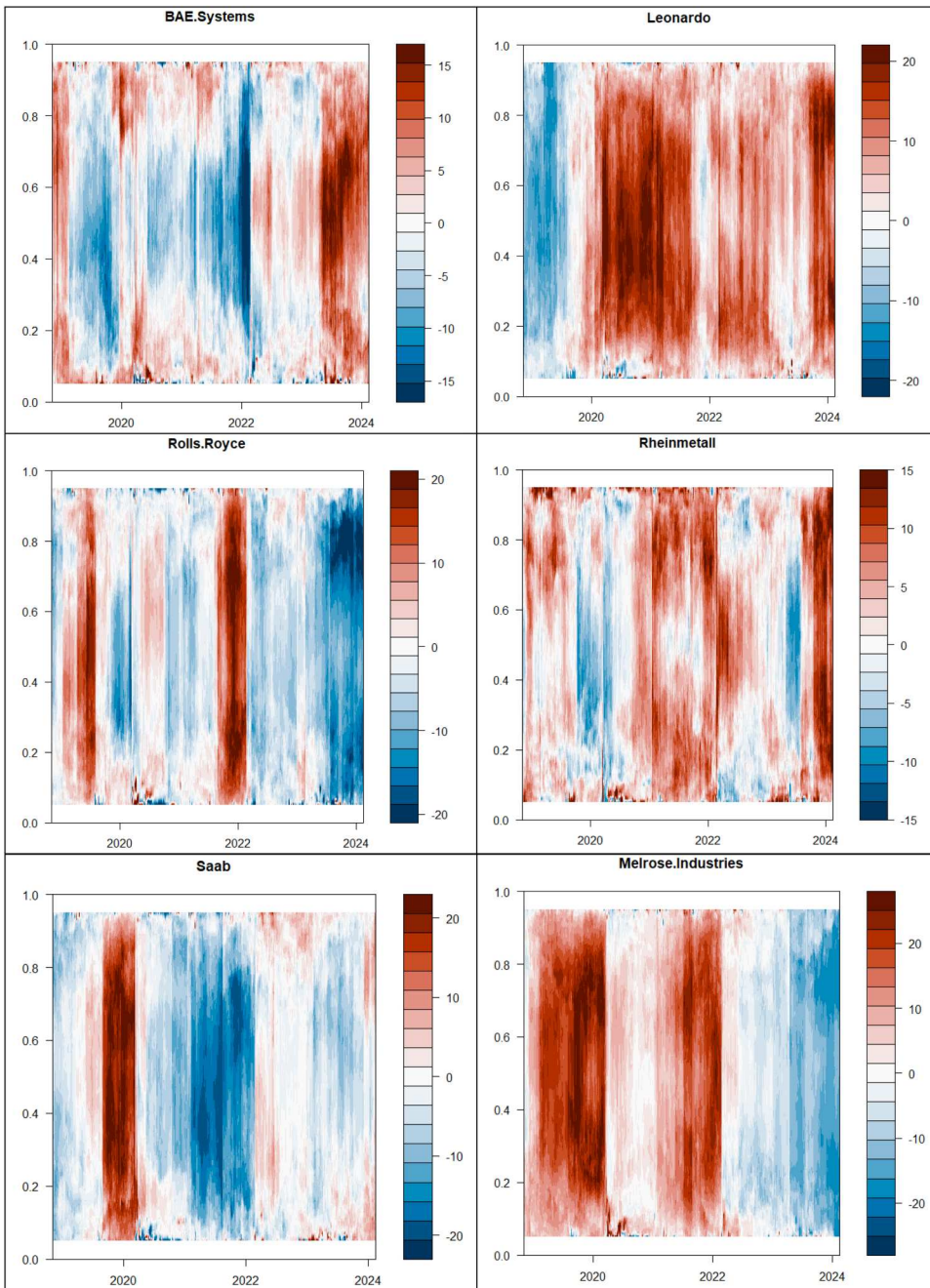


Figure 9. N-TDC of mixed defence industries.

Starting from the four net-transmitting defense industries (Figure 7), the most influential industry throughout the examined period appears to be Safran, a major world producer of aircraft and helicopter engines for both military and commercial use. This role is stronger before the outbreak of the COVID-19 pandemic (2018-2020), during and at the

end of the pandemic (2021–2022) and during the Russia–Ukraine war (2023–2024). Especially during the Russia–Ukraine war, Safran shows net-transmitting behaviour across the entire quantile distribution. Thales also exhibits a strong net-contributing tendency during the COVID-19 period and the Russia–Ukraine conflict, while Airbus presents a similar net-transmitting role before and at the end of the COVID-19 period. Finally, the Dassault Aviation Group also influences the system during the COVID-19 period and at the beginning of the Russia–Ukraine conflict.

Turning to the net-receiving group (Figure 8), Serco Group is a net-receiving company for almost the entire period. Babcock International Group exhibits a strong net-receiving tendency during the COVID-19 period. Kongsberg Gruppen is also a net-receiving industry, except from 2023 onward, when it shows a neutral trend. For QinetiQ, this role is strongly induced at the outbreak of the pandemic, showing the same behaviour as ThyssenKrupp, which displays net-receiving tendencies in the middle, lower middle and upper middle quantiles during 2021 and across all quantiles in the post-2023 period.

Finally, in Figure 9 the mixed group, i.e. companies that exhibit both contributing or net-receiving role depending on the period, is presented. Leonardo shows net-transmitting activity post-2020, with this role being particularly strong during the pandemic and then towards the end of 2023 onwards. However, it exhibits net-receiving behaviour at the start of the examined period. Saab is a powerful net-contributor before the COVID-19 pandemic (end of 2019 and early 2020) but becomes a net-receiver, especially at the middle, lower middle and upper middle quantiles, during 2021 (COVID-19). Melrose Industries shows a strong net-influencer tendency at all quantiles before and at the end of the pandemic, but it becomes a net-receiver during the Russia–Ukraine conflict. Rolls Royce emerges as a contributor before and at the end of the pandemic, but it shows a net-receiver tendency at the beginning of the Russia–Ukraine conflict, which is further augmented during the war. Rheinmetall demonstrates a net-receiving behaviour at the middle quantiles only before the pandemic (end of 2019 and early 2020) and at the beginning of 2023, in contrast to its net-contributing behaviour, especially at the tails, during the COVID-19 period. This becomes more pronounced across all quantiles at the end of 2023 and onwards. Finally, BAE Systems is a net-receiver at the middle, lower middle and upper middle quantiles before and up to the end of the COVID-19 pandemic. A role traceable across almost all quantiles. Then, it displays a neutral role with slight signs of contributing at the middle quantiles but shows a clear net-transmitting tendency during the Russia–Ukraine conflict.

5. Concluding remarks

The Russian invasion of Ukraine is widely considered an important defining event for European security and in broader terms for the international political and economic system (inter alia: Fiott 2023a, Biscop 2024, Zielinski *et al.* 2024). Among many other strategic, geopolitical and economic effects, it triggered significant, unprecedented increases in European defence budgets. These were mostly driven by a sharp rise in armaments expenditures to boost European defence competences vis-à-vis a resurgent Russia and also in view of the USA's shifting strategic focus. A robust common European defence pillar necessitates significant capital equipment inputs to support the implementation

of a common security and defence policy or, for that matter, to pursue a European strategic autonomy whereby EU member-states are able in the medium term to reduce their current military and security dependency on the USA given the latter's shifting geostrategic focus towards the Pacific and China (inter alia: Fiott [2023a](#), Hoeffler *et al.* [2024](#), Ditrych and Laryš [2025](#)).

In the renewed quest for a common European defence, as this is encapsulated in the recently presented by the European Commission White Paper for European Defence – Readiness 2030,¹⁶ the European defence industrial base is a crucial pillar since it is required to produce and supply the weapons systems needed to augment EU member states' military capabilities. As stressed by Giacomello and Preka ([2023](#)), the EDTIB is not only vital to EU's security and defence but also a crucial part of Europe's industrial and technological backbone that can further EU members' collaboration and integration as well as act as a source of innovation and technological advancement. This is emphasised in the White Paper for European Defence – Readiness 2030 where it is noted that directing the rapidly increasing rearmament expenditures towards "made in Europe" arms and weapons systems will not only ensure European long-term security but also yield economic benefits for all EU countries.¹⁷ This crucial role of the EDTIB is also stressed in the Commission's EDIS aiming "*to strengthen the competitiveness and readiness of the EDTIB*"¹⁸ with a time-horizon of implementation spanning to 2035. It aims to reduce EDTIB's fragmentation, promote collaborative defence equipment development, production and procurement and increase intra-EU defence industrial and technological cooperation that will strengthen the effort to develop a credible and robust European defence pillar. As stressed in the relevant documents, a "strong EU defence industry is an essential pre-requisite to achieve defence readiness ... to protect the security of its citizens, the integrity of its territory and critical assets or infrastructures, and its core democratic values and processes".¹⁹

Our quantile connectedness analysis shows a strong network effect. Certain major defense companies (e.g. Safran, Airbus) serve as "transmitters," indicating that an uptick in their production or investment positively affects other firms in the sector. This suggests that supporting such "hub" companies can trigger significant spillovers throughout the sector. Thus, the funds envisaged in ReArm Europe Plan/Readiness 2030, for the procurement of weapons systems constitute "... important investments in European defence industrial capabilities" given that "we must buy more European. Because that means strengthening the European defence technological and industrial base. That means stimulating innovation. And that means creating an EU-wide market for defence equipment".²⁰ The strong connectedness findings reported above point to significant benefits for the sector's companies through the existing industrial backward and forward linkages that act as conduits for such spillovers. Nonetheless, although the EDTIB is highly interconnected, fragmentation remains a challenge, partly because countries protect their own "national champions." Hence, a more unified defense market as envisaged in the White Paper for European Defence – Readiness 2030 could enhance the EU's goal of strategic autonomy (Hoeffler *et al.* [2024](#), Andersson and Britz [2025](#)). Moreover, targeted support, such as co-financing schemes, technology-transfer incentives and supply-chain "matchmaking" platforms, could keep "receiver" firms competitive (Giacomello and Preka [2023](#), Vandercruysse *et al.* [2023](#)). In this way, it can be ensured that "receivers" remain integral to the broader defense landscape.

In summary, the preceding analysis using the quantile connectedness approach revealed the presence of a strong total connectedness among the major European defence industries and three broad groupings with respect to net total directional connectedness: a net-transmitting group, a net-receiving group of defence industries and finally a group that exhibits a mixed connectedness. Based on these findings, a tentative and cautious inference is that the EDIS's as well as the ReArm Europe Plan/Readiness 2030 aims seem to be grounded on a pragmatic assessment of the EDTIB's potential in the quest for a common European defence and security pillar. The strong connectedness identified by the preceding estimations suggests that in view of the multitude of instruments and incentives the Commission is implementing, there are significant industrial and technological benefits that can accrue for the constellation of industries that make up the defence industrial base of Europe.

Notes

1. Authors' estimations from SIPRI data.
2. As mentioned by the Commission President Ursula von der Leyen in her speech when presenting the White Paper: "... We must buy more European. Because that means strengthening the European defence technological and industrial base ..." https://ec.europa.eu/commission/presscorner/detail/en/ip_25_793.
3. According to SIPRI's database: <https://www.sipri.org/visualizations/2023/sipri-top-100-arms-producing-and-military-services-companies-world-2022>.
4. https://defence-industry-space.ec.europa.eu/eu-defence-industry/edis-our-common-defence-industrial-strategy_en. EDIS was first announced by Commission President von der Leyen during her 2023 State of the Union speech: https://ec.europa.eu/commission/presscorner/detail/en/speech_23_4426.
5. https://defence-industry-space.ec.europa.eu/document/333faee1-a851-44a6-965b-713247515d39_en.
6. See for instance: <https://ecfr.eu/publication/alone-in-a-trumpian-world-the-eu-and-global-public-opinion-after-the-us-elections>.
7. NATO data. Data are not available for EU members that are not also members of NATO, i.e. Austria, Cyprus, Ireland and Malta.
8. https://defence-industry-space.ec.europa.eu/document/download/643c4a00-0da9-4768-83cd-a5628f5c3063_en?filename=EDIS%20Joint%20Communication.pdf.
9. https://defence-industry-space.ec.europa.eu/eu-defence-industry/edis-our-common-defence-industrial-strategy_en.
10. https://enlargement.ec.europa.eu/news/speech-president-von-der-leyen-european-parliament-plenary-new-college-commissioners-and-its-2024-11-27_en.
11. <https://www.refinitiv.com/en/>.
12. We opted to include into the sample UK based defence manufacturers given their strong ties with continental defence industries. For all intents and purposes these industrial and technological ties have not been fundamentally affected by Brexit. For example, the original consortium developing the sixth-generation fighter aircraft Tempest was comprised by BAE Systems, Rolls-Royce, Leonardo and MBDA UK the British division of the pan-European missile producer MBDA. In 2022, with the addition of Mitsubishi Heavy Industries of Japan the Tempest project evolved to the Global Combat Air Programme, with BAE Systems (UK), Mitsubishi Heavy Industries (Japan) and Leonardo (Italy) being the project's industrial partners.
13. Active Electronically Scanned Array.
14. <https://www.pesco.europa.eu/project/european-patrol-corvette-epc/>.
15. As previously noted, there is no general threshold for weak, moderate or strong TCI. Nonetheless, in the relevant literature it is classified according to the Diebold and Yilmaz (2009,

- 2012) scale as follows: weak spillovers (below 30–40%), moderate spillovers (around 40–60%), strong connectedness (above 60–70%) and very strong connectedness (above 80–90%).
16. https://ec.europa.eu/commission/presscorner/detail/en/ip_25_793.
 17. https://commission.europa.eu/topics/defence/future-european-defence_en.
 18. https://defence-industry-space.ec.europa.eu/document/333faee1-a851-44a6-965b-713247515d39_en.
 19. https://defence-industry-space.ec.europa.eu/document/download/643c4a00-0da9-4768-83cd-a5628f5c3063_en?filename=EDIS%20Joint%20Communication.pdf.
 20. As stressed by the Commission's President Ursula von der Leyen when presenting the White Paper for European Defence – Readiness 2030: https://ec.europa.eu/commission/presscorner/detail/en/ip_25_793.

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