

European Resilience: Why European resilience requires autonomy outside and interdependence inside

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Executive summary. Europe's strategy for resilience [1,2] has to be realised in a world that remains highly interconnected: globalisation stood at a record-high 25% of its theoretical maximum in 2025 [3], and trade grew faster than the global economy [4]. This paper argues that connectivity and resilience are in tension, depending on the regime. In stable conditions, dense connections can diversify risk. In uncertain conditions, the same connections, where they carry concentrated dependence, transmit and amplify shocks non-linearly, in a way that is well described by the physics of systems close to a critical point. The evidence for the EU in 2025 shows a two-part structure: internal ties that are broad and dense (intra-EU goods exports of €4,025 billion against €2,584 billion to the rest of the world [5]), and external ties in energy and digital infrastructure that are concentrated in a few hubs (the three US hyperscalers hold about 70% of the European cloud market [6,7], and the US supplied 56.0% of EU LNG imports [8]). We conclude that Europe needs more autonomy as a whole and more interdependence within Europe, that companies should map and stress-test dependencies rather than connections, and that technology both accelerates the mechanism and enables preparation. The future cannot be predicted; it can be prepared for.

1. **Introduction:** A resilience strategy in an interconnected world

The 2025 Strategic Foresight Report, “Resilience 2.0”, frames resilience as a proactive capacity to thrive in turbulent times towards 2040 and beyond. It identifies four EU-specific challenges (competitiveness versus strategic autonomy, technology governance, demographic and environmental pressures, and democratic resilience) and eight areas for action, and it asks decision-makers to consider “unfamiliar or even hard-to-imagine scenarios” [1]. The Preparedness Union Strategy translates this outlook into 30 actions across five pillars, one of which is EU-level foresight and risk assessment [2].

This strategy is being pursued in a world that has not disconnected. The DHL Global Connectedness Report 2026 puts globalisation at 25% of its theoretical maximum in 2025, a record-high level, with goods trade at a record average distance of 5,010 km [3]. McKinsey Global Institute finds that trade grew faster than the global economy in 2025, and that connector economies absorbed rerouted flows: ASEAN's exports to the US rose by USD 80 billion and its imports from China by more than USD 100 billion [4]. Connections are being rewired rather than severed. Europe, the most globalised region [3], therefore has to build resilience inside a densely connected system.

This raises the question of the paper: does a resilient Europe need fewer connections, or a different kind? Section 2 describes the European economy and the structure of its ties. Section 3 draws the European economy as a graph, explains, economically and mathematically, why such a graph can be in a stable or an unstable regime, and uses the physics of critical points to describe the transition. Section 4 discusses how concentration turns into prices, how autonomy outside and control inside can raise resilience, and the role of technology; Section 5 draws consequences for the EU, for member states and for companies. Section 6 concludes.

2. What the European economy is made of, and how it is connected

Composition. EU GDP was €18.8 trillion in 2025. Germany (23.8%), France (15.8%) and Italy (12.0%) together account for 51.6% (own calculation) [9]. Services generated 73.7% of gross value added, industry 19.1%, construction 5.5% and agriculture 1.8% [10]. The firm structure is two-tiered [11]. In 2025, 33,998,170 SMEs made up 99.8% of businesses, employed 105.6 million people (63.7% of business-economy employment) and generated €5.847 trillion of value added (51.7%). Large enterprises employed 60.1 million people (36.3%) and generated €5.465 trillion (48.3%). A small number of large firms thus carry almost half of value added, while a very large number of small firms carry most of the jobs and have limited capacity to diversify alone.

Ties within the EU and with the rest of the world. Table 1 sets the ties within the EU against those with other countries and blocks. Two patterns emerge. First, the internal network is broad: intra-EU goods exports are 56% larger than exports to all non-EU countries combined, so that about 61% of member states' goods exports stay within the EU [5], spread over many partners. The internal network has its own hub, Germany [12], and financial ties are still incomplete: cross-border interbank lending reached 23% of euro-area interbank loans at end-2025, but equity integration and intra-euro-area direct investment are at historically low levels [13]. Second, external goods trade is large but spread across several partners (the US takes 21.0% of extra-EU exports, China supplies 22.3% of extra-EU imports [14]), whereas external ties in energy and cloud computing are concentrated in a few suppliers.

Dimension (2025 unless stated)	Within the EU	With the rest of the world
Goods trade	Intra-EU exports €4,025 bn, 56% above exports leaving the EU (€2,584 bn); intra-EU trade exceeds extra-EU trade for all member states except Ireland, Slovenia and Cyprus [5]. Germany is a top-four export destination for 25 member states; for 26 of 27 member states the top four partners take over 50% of intra-EU exports [12].	The US takes 21.0% of extra-EU exports (€554.9 bn); China supplies 22.3% of extra-EU imports (€559.4 bn); the UK takes 13.1% of extra-EU exports [14]. Several sizeable partners, none dominant.
Energy	Electricity generated inside the EU: 2,813 TWh, i.e. 2.8 trillion kWh [16]. Natural gas produced inside the EU: 1,331,049 TJ [17].	Natural gas imports:11,357,732 TJ, 8.5 times domestic production.. Energy imports of €336.7 bn: the US supplied 56.0% of LNG, Norway 52.1% of gaseous natural gas, Russia 13.9% of LNG and 10.4% of gaseous natural gas [8]. The US is expected to supply close to two-thirds of LNG in 2026 [18].
Digital	European cloud providers hold about 15% of the European cloud market; the largest, SAP and Deutsche Telekom, hold 2% each (first half of 2025) [6,7].	Amazon, Microsoft and Google together hold about 70% of the European cloud market (first half of 2025) [6,7].
Finance	Cross-border lending was 23% of euro-area interbank loans at end-2025 and non-domestic euro-area banks held 29% of deposits in 2025; equity integration and intra-euro-area direct investment are at historically low levels [13].	A significant part of euro-area equity investment flows outside the EU [13].

Table 1. Interconnections within the EU versus with the rest of the world. All figures refer to 2025 unless stated. Electricity and natural gas are different energy carriers and are not added.

Internal ties are therefore many-to-many, while the most critical external ties are few-to-one. What such a structure implies for resilience depends on how the network behaves under stress, which is the subject of the next section.

3. The core argument: The European economy as a graph with more than one regime

The EU as a graph. Figure 1 represents the European economy as a causal graph built from the variables of Section 2. The outcome nodes are the GDP of the three largest economies and of the other 24 member states, with their 2025 shares. GDP is driven by three transmission channels: input costs for energy and digital services, consumer demand (services generate 73.7% of value added), and trade flows, both within the EU (intra-EU goods exports of €4,025 billion) and with the rest of the world (€2,584 billion). Outside the EU boundary sit the external drivers: oil and gas prices, which act on input costs and on consumer demand; cloud and digital services, which act on input costs; and US demand and Chinese supply, which act on trade flows. Arrow thickness indicates concentration: the thick arrows come from a few suppliers (the US and Norway in gas, three US hyperscalers in cloud), the thin ones from diversified goods-trade partners. The graph has the two-part structure identified in Section 2: inside, a dense many-to-many system of channels and outcomes; outside, thin ties to many partners in goods trade but thick ties to a few hubs in cloud computing and energy. Feedbacks from GDP to demand and trade are omitted. Whether such a structure makes Europe robust or fragile is not a property of the drawing alone. It depends on how much of a disturbance passes along each arrow, and that depends on the regime.

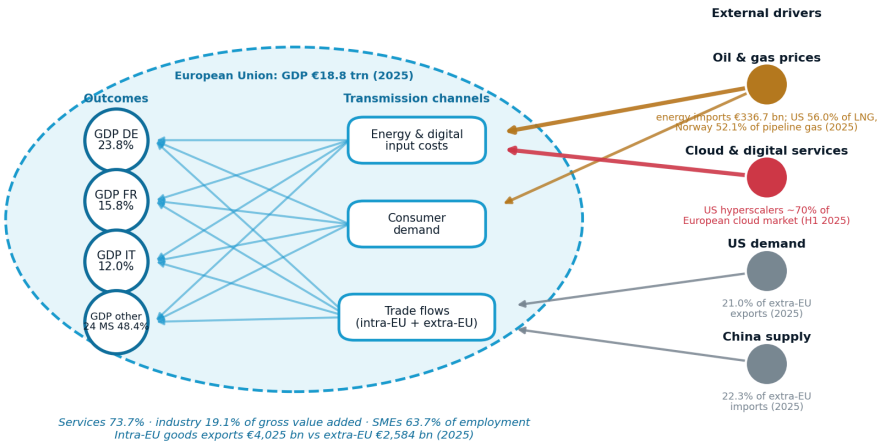


Figure 1. The EU as a causal graph. Outcomes: GDP shares of the three largest EU economies and the other 24 member states (MS) [9]. Channels: input costs, consumer demand and trade flows, with intra-EU and extra-EU goods exports [5] and sector and SME shares [10,11]. External drivers with dependence shares [6,7,8,14]. Arrows are stylised causal links, not estimated effects; arrow thickness indicates the concentration of the source.

Why such a graph can display several regimes: the economic rationale. A shock hitting one node reaches its neighbours only to the extent that they cannot replace what they lose. Replacement relies on buffers: inventories, spare capacity, alternative suppliers, credit lines and time. In calm conditions these buffers are plentiful relative to the disturbance, a lost link is re-routed, and the shock stays local. In a crisis three things change together. The alternatives are hit by the same shock or face competing demand from other affected firms; buffers are drawn down, so that they are not available for the next shock; and expectations shift, so that precautionary hoarding and pre-emptive orders remove even the spare capacity that would have been available. The loss of substitutability then feeds the stress that caused it. A network with an unchanged structure can therefore sit in a low-stress regime, in which connections diversify and absorb, or in a high-stress regime, in which the same connections

transmit, and it can move from the first to the second abruptly. The two regimes are not two graphs; they are two states of one graph.

In such a conceptual abstraction of the world, it's worth considering the mathematics at play to gain an understanding of the dynamics of such a system, to assess how things evolve under stress and hence enable prescriptive analytics and hedging advice. The following paragraph is written for the mathematically minded reader. However, the argument of the paper can be followed regardless.

The mathematics of the two regimes. Consider a vector ε of shocks and a dependence matrix A, whose entry A_{ij} is the share of activity in j that relies on inputs from i, as in input–output models [19]. The total response x is the sum in Eq. (1): the shock acts directly (k = 0), then through direct suppliers (k = 1), through suppliers' suppliers (k = 2), and so on. This is a perturbation expansion in the strength of coupling. It converges only if the spectral radius ρ(A), the largest eigenvalue of A, is below 1, and then sums to the amplification M(ρ) of Eq. (2), where R_K is the error made by stopping after K terms.

$$\mathbf{x} = \sum_{k=0}^{\infty} A^k \varepsilon = (I - A)^{-1} \varepsilon, \quad \rho(A) < 1 \qquad (1)$$

$$M(\rho) \simeq \frac{1}{1-\rho}, \quad R_K = \frac{\rho^{K+1}}{1-\rho} \qquad (2)$$

The economic rationale enters through the coupling itself. Write $A_{ij}(\theta) = a_{ij}[1 - s_{ij}(\theta)]$ (Eq. 3): a_{ij} is structural dependence, set by technology, contracts and infrastructure, and $s_{ij} \in [0, 1]$ is the share of that dependence that can be substituted in regime θ. With most alternatives available, $\rho_{eff} = \rho(A(\theta))$ is well below 1, the series of Eq. (1) converges after a few terms, and the correlation between two nodes r links apart decays as $\rho^r = \exp(-r/\xi)$ with correlation length $\xi = -1/\ln \rho$ of the order of one link (Eq. 7). Shocks stay local, an assessment of direct exposure is sufficient, and connectivity is beneficial: idiosyncratic shocks average out in the aggregate [19] and, in financial networks, connectivity absorbs shocks up to a threshold [20]. In this regime interconnectedness does not jeopardise resilience; it adds to it.

$$A_{ij}(\theta) = a_{ij}\,[1 - s_{ij}(\theta)], \qquad \rho_{\text{eff}}(\theta) = \rho(A(\theta)) \qquad (3)$$

Multiple regimes appear when substitutability depends on the level of stress u itself. Let $\rho_{eff}(u) = \rho_a[1 - s(u)]$, where ρ_a is the coupling if no substitution were possible and s falls as stress rises. The stress level that the system settles at is then the solution of Eq. (4), equivalently the shock that produces a given stress is ε(u) in Eq. (5). Figure 2b plots this for illustrative values ($\rho_a = 0.9$; s falling from 0.8 to 0 as u passes 1). For a small shock (ε below about 0.19) only a low-stress solution exists; for a large shock (above about 0.51) only a high-stress solution exists; in between, both solutions exist, and which one the system occupies depends on its history (hysteresis). At the turning points of the curve the response du/dε diverges: the loop gain, that is ρ_{eff} plus the effect of stress on ρ_{eff}, reaches 1. This is the mathematical form of the regime switch: a small change in shock or in buffers moves the system between branches, and the analysis based on Eq. (1) from the low-stress branch understates the outcome on the other branch. The curve is a stylised computation from the stated equations, not an estimate from data.

$$u = \frac{\varepsilon}{1 - \rho_{\text{eff}}(u)}, \quad \rho_{\text{eff}}(u) = \rho_a\,[1 - s(u)] \qquad (4)$$

$$\varepsilon(u) = u\,[1 - \rho_{\text{eff}}(u)] \qquad (5)$$

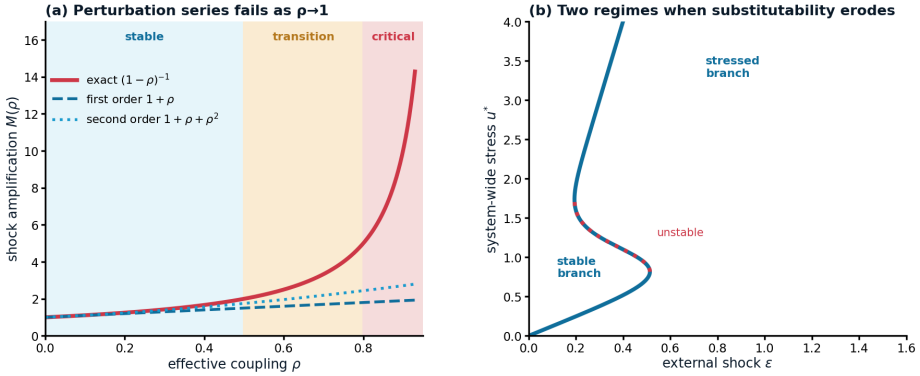


Figure 2. (a) Amplification M(ρ) from Eq. (2) with first- and second-order truncations; shaded regions are indicative. (b) Stress u as a function of shock ε from Eq. (5), with $\rho_a = 0.9$ and s(u) = 0.8/(1 + exp((u − 1)/0.18)); the dotted section is unstable. Both panels are computed from the stated equations and are illustrative.*

What-if scenarios that could trigger a regime switch. The mechanism can be illustrated with three hypothetical cases. These are stylised thought experiments, not forecasts and not estimates. (i) Cloud capacity. Amazon, Microsoft and Google hold about 70% of the European cloud market, European providers about 15% and the largest of them 2% each [6,7]. If one provider's capacity were restricted, its customers would move to the others, which is easy when few are affected and s is high. If the restriction applied to US providers as a group, the alternatives would be subject to the same shock, all affected firms would seek the same scarce capacity and skills at once, and migration would take longer than the disruption. The AWS outage of October 2025, which lasted more than 15 hours [21], shows how quickly a single hub can affect many firms. (ii) Gas and LNG. The EU's import dependency rate for natural gas was 87.6% in 2025 [17], the US supplied 56.0% of LNG imports in 2025 [8], and its share is expected to reach close to two-thirds in 2026 [18]. A loss of one supplier can be covered from storage or other cargoes. A simultaneous loss across several suppliers turns every European buyer into a bidder for the same cargoes, storage is drawn

down and hoarding raises prices further, which reduces s again. (iii) Funding. If one bank loses interbank funding, others can replace it; if many banks do at once, each hoards liquidity, and the lenders that could substitute are the ones in distress [20]. In each case the substitute is not independent of the shock, and stress triggers reactions that consume buffers, which is the loop of Eq. (4).

A further mechanism follows directly from Eq. (3). When the shock strikes many firms at once, s(u) falls not only because a given supplier or hub is impaired, but because the substitute itself becomes rival: cloud capacity, LNG cargoes and specialised skills are all pools of finite size, and a queue of firms drawing on the same pool simultaneously depletes it faster than the shock alone would. Migrating workloads, rerouting cargoes or hiring the relevant engineers all compete for the same scarce capacity, so the effective substitutability available to any one firm falls with the number of firms seeking it, not just with the size of the shock. The price of that capacity, wages, spot cargo prices, contractor rates, rises as a result, and that rise is itself part of the loop: it rations the scarce resource toward whoever can pay most, discourages the marginal firm from substituting at all, and so lowers s(u) further and raises $\rho_{eff}(u)$ in turn. A shock that a single firm could have absorbed by substituting away can therefore tip the whole system from the low-stress branch to the high-stress branch of Eq. (5) once enough firms try to substitute at the same time, even though no single firm's demand for the scarce resource changed.

The physics of the transition. Statistical physics has studied what happens when a system approaches such a critical point, and its lessons apply to the economic graph. First, the reach of a shock, ξ, diverges (Fig. 3a), as do the response M and the variance of the aggregate, $\mathrm{Var}(x) \approx \sigma^2 M^2$ (Eqs. 6 and 7): fluctuations and sensitivity to perturbations grow together, a fluctuation–dissipation type of relation. The observable signature of an economy approaching the critical regime is therefore an increase in the volatility of outcomes, and in the persistence of deviations, which is critical slowing down [22]. Second, the system loses its characteristic scale. This is scale invariance: fluctuations at all scales are correlated, and cascade sizes follow a power law instead of an exponentially truncated distribution. In the simplest branching model the avalanche-size exponent is 3/2 [23] (Fig. 3b), so that very large events are not exceptional but structural. Third, perturbation theory breaks down. The expansion of Eq. (1) converges ever more slowly as $\rho \to 1$ (Fig. 2a), the truncation error R_K no longer vanishes, and for $\rho \geq 1$ the series diverges: an assessment built on small deviations from today's state misses the dynamics. Fourth, near the critical point behaviour becomes universal, governed by the structure of the network rather than the detail of individual links [24,26], and structure matters greatly. The threshold for contagion is set by the largest eigenvalue of the network [27], and in scale-free networks with pronounced hubs it vanishes [28]: a few concentrated dependencies, such as those in Figure 1, can make the entire system near-critical. When networks are coupled to each other, the transition changes character from gradual to abrupt, and a small initial failure can propagate to collapse [29].

$$\mathrm{Var}(\mathbf{x}) \approx \sigma^2 \, M(\rho)^2 \quad (6) \qquad \xi = -\frac{1}{\ln \rho} \sim (1-\rho)^{-1}, \quad M \sim |1-\rho|^{-\gamma}, \quad P(s) \sim s^{-3/2} \; (\rho = 1) \quad (7)$$

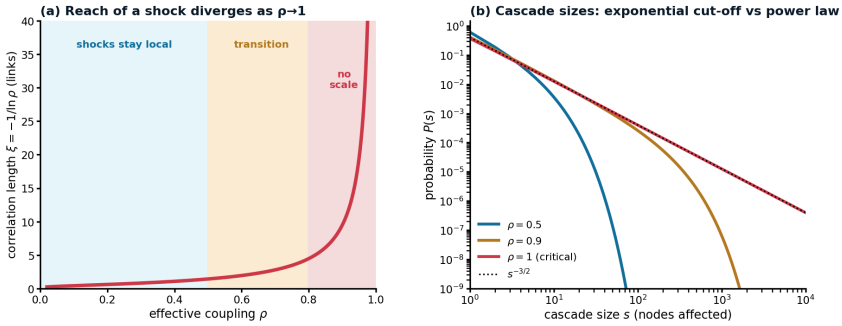


Figure 3. (a) Correlation length ξ = −1/ln ρ. (b) Cascade-size distribution of a branching process with Poisson offspring of mean ρ (Borel distribution): exponentially truncated for ρ < 1, a power law $s^{-3/2}$ at ρ = 1. Both panels are computed from the stated formulas and are illustrative.

4. Reading the graph: Prices, autonomy, control and technology

4.1 Concentration, dependence and prices

The graph shows that the number of links is not what matters. Interconnectedness counts links; dependence is a large a_{ij} combined with a low s_{ij}, concentrated in hubs. The graph also has a price dimension. In a stylised argument, a supplier can raise its price up to the cost its customer would incur by switching, so the premium a hub can extract rises with the dependence share a_{ij} and falls with the substitutability s_{ij}. Two conditions must hold together. The first is concentration: few suppliers hold most of the market, as in cloud, where three US providers hold about 70% [6,7], or in LNG, where one country supplied 56.0% of imports [8]. The second is insufficient competitiveness of the alternatives: the outside option is too weak to discipline the hub, as when European cloud providers hold about 15% of the market and the largest 2% [6,7], or when the EU's import dependency rate for natural gas is 87.6% [17]. When both hold, dependence is monetised as a higher price and not only as a risk of disruption. In an unstable regime the effect strengthens, because s falls on many links at once (Section 3): scarcity replaces competition as the price-setting mechanism, and the increase passes from suppliers to the whole economy. The Eurosystem's June 2026 scenarios show the scale: against a baseline of 3.0% inflation and 0.8% growth in 2026, the severe energy price scenario gives 4.0% and 0.5% [31]. Price increases are thus the visible form in which the network effects of Section 3 reach firms and households, and concentration combined with weak alternatives is the condition under which they become large.

4.2 Autonomy outside, interdependence inside: The role of control

Partition the dependence matrix of Figure 1 into an internal block E and an external block X. For non-negative matrices the spectral radius of the whole is at least that of each block [33] (Eq. 9), and, neglecting feedback, an external disturbance x_X reaches Europe as $x_E = (I - A_{EE})^{-1}A_{EX}x_X$ (Eq. 8): it enters through the external links A_{EX} and is then amplified by the internal network. To be resilient against the outside, Europe should therefore strive for more autonomy: shrink A_{EX} and raise s on the links that remain, by building European alternatives and diversifying suppliers. Autonomy is not autarky; the aim is that no external hub is both large and irreplaceable.

$$\mathbf{x}_E = (I - A_{EE})^{-1} A_{EX}\,\mathbf{x}_X \quad (8) \qquad \rho(A) \geq \max\{\rho(A_{EE}), \rho(A_{XX})\} \quad (9)$$

The same logic applies inside the EU. Internal density raises $\rho(A_{EE})$, and the internal network has its own hub: Germany is a top-four export destination for 25 member states [12]. Concentration, weak alternatives and high prices can therefore arise inside as well. The key difference is control. The behaviour of an external supplier cannot be governed by the EU, whereas the internal network operates under a common legal order, a single market and shared policy instruments [2]. The EU can thus shape a_{ij} (how concentrated the structure is), s_{ij} (how easily a link can be replaced) and competition (how contestable the markets are), at least to the extent Member States agree to this. That this control works as intended is the central assumption of the argument, not a proven result. We illustrate how network effects can be altered in 3 industries:

- **Transport and logistics (raises s through alternative routes; limits dependence on single gateways).** The TEN-T Regulation of 2024 requires the core network to be completed by 2030, the extended core network by 2040 and the comprehensive network by 2050, with one European rail traffic management system across the network and terminals able to take 740-metre trains [34]; a more interoperable network allows goods to be re-routed between modes and member states. The EU Ports Strategy of 4 March 2026, for ports that handle around 74% of external trade, provides for criteria and guidance on foreign ownership and control of strategic ports and on EU funding of third-country ports [35].
- **Financial integration (raises s among banks and investors under stable regimes).** The Market Integration and Supervision Package of 4 December 2025, part of the Savings and Investments Union, addresses barriers to integrated financial markets [36], which bears on the low equity integration in Table 1 [13].
- **Shared buffers in energy (raises s under stress).** The revised gas storage regulation, voted by the European Parliament in 2025, extends the scheme to 31 December 2027, sets an 83% filling target to be reached between 1 October and 1 December, allows deviations of up to 4 percentage points and aims to lower refilling costs [37].

The design principle is common to all: raise substitutability where concentration cannot be avoided, keep alternatives competitive so that dependence is not priced, and keep internal density where it can be governed.

4.3 The role of technology: Accelerator and instrument

Technology accelerates the mechanism described above. Digital services concentrated in few providers propagate failures instantly: the AWS outage of 20 October 2025 lasted more than 15 hours and generated more than 17 million user reports worldwide [21]. New dependencies emerge together with innovation: AI-related goods drove 42% of goods trade growth in the first three quarters of 2025 [3]. Technology also enables preparation. The 2026 AI Index describes a field “hitting breakthrough capabilities” [38]. These capabilities make it feasible to estimate dependency graphs from transaction, logistics and text data, to learn causal structure, to run large ensembles of scenarios and to monitor early-warning indicators; in the notation of this paper, to estimate $a(\theta)$, $s(\theta)$ and ρ_{eff} instead of assuming them. It is even more important, however, that these tools are used in the right hands. Estimating network parameters requires experts who know the dependencies of a sector: which contracts, routes and infrastructures can really be substituted, at what cost and how fast. Translating a scenario into an outcome requires an understanding of the financial consequences, from margins and working capital to hedging and financing. Turning both into a model that is calibrated, stress-tested and honest about its uncertainty requires skill in financial engineering. Without this combination, larger ensembles of scenarios give false precision: a model fitted to calm periods reproduces the calm regime, and a generated scenario is only as informative as the dependence structure it is run through. Technology scales expert judgment and does not replace it. An additional risk: the tools of preparation are themselves concentrated in the hubs discussed in Section 4.1, so that autonomy in technology is part of the resilience question, not separate from it. The Commission's Cloud and AI Development Act, which aims to at least triple EU data-centre capacity within 5–7 years and to set four levels of sovereignty assurance for cloud services, is an example of a measure that addresses this [39].

5. What this means

5.1 For the EU and its policies

The analysis points to four priorities for EU policy. First, resilience policy should target dependence, not connectivity: a_{ij} and s_{ij} on the links that matter, not the number of links. This requires a shared, regularly updated map of concentrated dependencies and scenario analysis that goes beyond small deviations from today's state, which is consistent with the foresight and risk-assessment pillar of the Preparedness Union [2] and with the call of the Strategic Foresight Report to consider “unfamiliar or even hard-to-imagine scenarios” [1]. Second, on the outside, the EU should reduce the share of critical inputs that depend on a single external hub and raise substitutability on the remaining links, through diversified sourcing and European alternatives, including the screening of foreign ownership of strategic infrastructure such as ports [35]. Third, on the inside, it should use its control to deepen the integration that creates real substitutes (Section 4.2). Fourth, it should keep alternatives competitive, since an uncompetitive substitute does not discipline the hub (Section 4.1).

5.2 For member states

Member states differ in how they sit in the graph. For 26 of the 27, the top four partners take more than 50% of intra-EU exports, and Germany, with 23.8% of EU GDP [9], is a top-four export destination for 25 of them [12]: a disturbance in the hub reaches almost every member state, and resilience of the hub is therefore a matter for all. Only Ireland, Slovenia and Cyprus export more outside the EU than inside [5], so their exposure to external partners is structurally different. Three consequences follow. First, each member state should map its own exposure, by partner and by hub, and not rely on the EU average. Second, in a stressed regime member states should coordinate and not compete for the same scarce substitutes. If each one hoards gas, cargoes or capacity, the loop of Eq. (4) is reproduced at national level, which is one reason why the storage rules provide for coordinated targets with limited flexibility [37]. Third, much of what determines a_{ij} in practice, such as public procurement, national infrastructure and supervision, is exercised nationally (own reasoning), so consistent implementation of EU rules is a condition for substitutability across borders.

5.3 For European companies: The need to prepare

A company is not a single node of the graph. It is a subgraph: its own sites and units, its suppliers and customers, the cloud and energy providers it uses, and the financing on which it relies. Its resilience is governed by the effective coupling of that subgraph, $\rho(A_S)$, which cannot exceed that of the whole graph [33], and by the external hubs the subgraph touches. Subgraphs overlap: companies that use the same cloud provider, the same LNG-linked energy price or the same port share a hub, so that a failure of the hub hits all of their subgraphs at once, and their shocks are correlated. Subgraphs also nest: large firms carry 48.3% of value added and SMEs 63.7% of employment [11], so the sourcing decisions of large firms propagate to smaller suppliers that have little capacity to diversify. The central message for companies is that **preparation cannot wait for the crisis**. Substitutability is built in calm periods, because in a stressed regime the alternatives are scarce, contested and slow to activate, and the future cannot be predicted.

5.4 Hedgeo: Helping European companies prepare

Hedgeo will provide European scenario intelligence, built to support the preparation described in Section 5.3. It will first address logistics and shipping, industrial manufacturing and energy-intensive companies, sectors with the route exposure, supplier concentration and energy sensitivity identified in Sections 3 and 4. It works through two branches: consulting, for tailored analysis of risks and their interdependencies, and software, for the continuous and scalable version. Five key points describe how it helps.

- **It asks the "what if" in the company's own words.** A user states a risk question in natural language, and a language model turns it into a set of structured scenarios, expressed as values for macro variables such as oil prices, freight rates, the dollar and yield curves.
- **It represents the company as a causal graph.** The model is a directed acyclic graph over observed, hidden and action variables. Each unit of a company represents a subgraph. Active inference updates a belief about hidden drivers, and the platform reports the impact of a scenario on the company's key performance indicators against a baseline. The model is a readable document that can be inspected, not a black box.
- **It recommends action.** The platform proposes actionable advice through prescriptive analytics in the form of both financial hedging as well as business strategy per downside scenario with expected cost and benefit, which is the "buy substitutability in advance" of Section 5.3 made concrete and comparable.
- **It lets smaller firms benefit from sector knowledge without sharing their books.** Client's accounting stays within its own boundary.
- **It is hosted in Europe.** Hedgeo is focused on Europe, well aligned with Europe's mission to build more resilience.

6. Conclusion: The paradox of looking forward

The world is inherently volatile: half of the experts surveyed for the Global Risks Report 2026 expect a turbulent or stormy world over the next two years, and 57% over ten years [40]. In such a world organisations must look ahead, yet the causal structure they must understand is increasingly complex, because the coupling that determines how shocks propagate, changes with the regime itself. This is the paradox: the more one needs to look forward, the harder it becomes. Fortunately, 2026 is a year in which technology has continued to bloom, making it increasingly possible to capture complex causal relationships [38].

The argument of this paper is that connectivity is not the enemy of resilience, but concentrated dependence is and that the two become indistinguishable in unstable regimes. Europe therefore needs more autonomy as a whole, by shrinking its external dependence on a few hubs, while increasing interdependence within Europe where substitution can be governed. Nevertheless, predicting the future is not possible. Preparing for it is.

Appendix: References

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