PROPAGATION OF ECONOMIC SHOCKS IN HIERARCHICAL STRUCTURES AND NETWORKS. THE CASE OF THE EUROPEAN UNION

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SUMMARY

In this paper, we propose an analytical framework for understanding economic shocks from the perspective of systems theory and complexity. Unlike approaches that view shocks primarily as exogenous disturbances, this article argues that they should be understood as processes that emerge within the economic system through interactions among the triggering event, the system's structure, and transmission mechanisms. In this regard, the economic system is analysed as a structure of interdependencies that can take the form of hierarchical or network-type architectures. The analysis thus highlights that the way these interdependencies are organised influences the dynamics of shocks. In hierarchical structures, propagation tends to be more sequential and easier to localise. At the same time, in networks, the propagation of shocks occurs through multiple channels, making it more sensitive to feedback mechanisms, thresholds, and cumulative effects. The analytical framework developed is applied to the case of the European Union, interpreted as a system of interdependencies characterised by high levels of trade and financial integration but incomplete fiscal integration. The analysis shows that this configuration favours the rapid and differentiated propagation of shocks, accentuating asymmetries among Member States. The paper contributes to the literature on economic shocks by integrating a systemic perspective, highlighting the role of the system's architecture in their dynamics, and formulating implications for economic policy in interdependent systems.

Keywords: economic shocks, complex systems, network structure, shock propagation, hubs, European Union

INTRODUCTION

The analysis of economic shocks and their propagation is a central topic in the economic literature, as such shocks recur within economic systems and constitute a primary source of economic change. Depending on their nature, they may affect production, employment, trade, investment, or financial stability, generating effects that extend beyond the components initially affected.

An important aspect in understanding these processes is how economic shocks are transmitted within the economic system. In an economic system, there are multiple interdependencies among economic agents, institutions, sectors, and national economies, and shocks are transmitted through these relationships, which influence their effects. From this perspective, economic shocks can be understood as processes influenced not only by the characteristics of the triggering event but also by the structure of the system in which they occur. This aspect is of particular importance because economic systems may be organised in different ways, and the architecture of relationships among their components influences how information, resources, and the effects of disturbances circulate within them. In this context, hierarchical structures and network structures represent two fundamental forms of organisation, each associated with distinct mechanisms of coordination, interdependence, and transmission of economic effects. As a result, the same disturbance may generate different propagation trajectories and effects depending on the structure of the system in which it occurs.

In this paper, we develop a framework that enables analysis of the propagation of economic shocks in relation to the type of structure that characterises the system in which they emerge. Within this framework, we conduct a comparative study of hierarchical and network structures, which represent forms of organisation of the relationships established among the components of the economic system. This approach highlights how differences in system architecture influence propagation trajectories, feedback mechanisms, the degree of predictability, and the distribution of effects generated by economic shocks.

To empirically demonstrate the relevance of this perspective, the analysis is applied to the case of the European Union (EU), understood as a multilevel economic system characterised by a high degree of interdependence yet institutionally incomplete in terms of integration. From this perspective, the EU can be viewed as a set of interconnected national subsystems, coordinated through supranational institutional mechanisms. This configuration provides an appropriate framework for investigating how shocks propagate through hierarchical structures and complex networks, and how these mechanisms may amplify asymmetries among Member States.

All these aspects, along with this introduction and the conclusions section, are developed throughout five sections: the second section reviews the relevant literature on economic shocks, transmission mechanisms, and hierarchical and network-type economic structures; the third section introduces the conceptual delimitations employed in the analysis and clarifies the main concepts underpinning the proposed theoretical framework; the fourth section develops the analytical framework for the propagation of economic shocks and comparatively examines the transmission mechanisms specific to hierarchical and network structures; the fifth section applies the framework to the European Union, with particular emphasis on trade, financial, and institutional interdependencies and their implications for the propagation of economic shocks; finally, the last section summarizes the main conclusions and implications arising from the analysis.

LITERATURE REVIEW

ECONOMIC SHOCKS AND TRANSMISSION MECHANISMS

Traditionally, in economic literature, shocks are analysed as disturbances that affect key macroeconomic variables and cause the economic system to deviate from equilibrium. In this regard, much of the research focuses on identifying shocks and estimating their effects using macroeconomic and econometric models, such as VAR, SVAR, and DSGE (Blanchard & Quah, 1989; Cochrane, 1994; Smets & Wouters, 2007; Ramey, 2016). From this perspective, shocks are treated as exogenous factors stemming from technological changes, fiscal and/or monetary policies, shifts in aggregate demand, etc., and the emphasis is placed on their effects and on the mechanisms through which they are transmitted within the economy. Furthermore, some authors have shown that, in most approaches, the identification of shocks depends on the theoretical and methodological framework employed (Duarte & Hoover, 2012), whereas the nature of shocks and the role of economic systems in shaping their propagation are rarely examined. As regards the transmission of shocks, the literature identifies multiple transmission channels, including financial, monetary, and credit channels, which play a significant role in explaining how the effects of a disturbance propagate among the various components of the economic system (Mishkin, 1995; Bernanke & Gertler, 1995).

One aspect worth noting is that a specific strand of the literature focuses on asymmetric shocks in integrated economies and monetary unions. From this perspective, however, the focus of research is not on analysing the shocks *per se* but rather on how the economic system can counteract their effects. In this regard, many studies, primarily those concerning the Economic and Monetary Union (EMU) of the EU, clearly demonstrate that the same disturbance may generate different effects across Member States, due to differences in economic structure, institutional rigidities, exposure to shocks, and adjustment capacities (Theodoropoulos, 2005; Rosati, 2017). Furthermore, the literature emphasises the importance of absorption and adjustment mechanisms, such as labour mobility, economic policy coordination and risk-sharing mechanisms, in limiting the divergences caused by asymmetric shocks (Nchor, 2020).

Beyond these contributions, there is a body of literature relevant to our study that addresses shocks from the perspective of systems theory and complexity theory. In ecology, for example, many studies analyse disturbances from the perspective of how the events that trigger them influence the structure and functioning of ecosystems, emphasising that their effects depend not only on the characteristics of the disturbance but also on the properties of the affected system (Odum et al., 1979; Rykiel, 1985). Research on socio-ecological systems further develops this perspective by highlighting the role of feedback mechanisms, interdependencies, and adaptive processes in shaping the effects of disturbances (Filatova & Polhill, 2012). Similarly, the literature on complex systems shows that responses to disturbances are influenced by the system's internal organisation and by the interactions among its components (Grimm et al., 1992). These contributions suggest that the analysis of shocks can benefit from a perspective that pays greater attention to the system's structure and the mechanisms by which the effects of disturbances propagate.

HIERARCHICAL AND NETWORK STRUCTURES IN ECONOMIC SYSTEMS

The literature on systems theory suggests that the functioning of a system generally depends not only on the characteristics of its components but also on how the relationships within it are organised. In this context, hierarchical structures and networks represent fundamental forms of organisation in complex systems. With regard to hierarchical structures, Simon (1962) argues that many natural and social systems are organised into successive levels, with relationships distributed across layers of coordination and control. Similarly, von Bertalanffy (1968) emphasises that a system's properties do not depend exclusively on its components, but also on how the relationships among them are organised. Based on this, a number of studies in economics and organisational theory conceptualise firms, institutions, and governance mechanisms as hierarchical structures characterised by relatively stable relationships coordinated across different levels of the system. Williamson (1975), for example, views hierarchies as organisational mechanisms through which complex economic activities can be coordinated. More recently, Aoki (2001) highlights that organisational structures play an important role in information processing and the coordination of economic decisions.

Besides hierarchical structures, networks and the analysis of their role in the functioning of economic systems have become a significant body of specialised literature. From this perspective, economic systems are understood as sets of nodes with multiple connections, through which information, resources, goods, or financial flows circulate. Barabási and Albert (1999) demonstrate that the distribution of connections in many real-world economic networks is highly uneven, resulting in nodes with a disproportionately large number of links, known as hubs. Similarly, Barabási (2016) has highlighted that the positions of nodes and

the configuration of connections significantly influence the flow of information and resources within the economic system.

It is worth noting that, when applied to economics, these general ideas have formed the basis of specialised literature on production networks, financial networks, systemic risk, and related topics. Acemoglu et al. (2012) show that the structure of production networks influences the transmission of shocks from the local to the aggregate level, while Battiston et al. (2012) highlight the role of financial interdependencies in amplifying systemic risk. Likewise, Elliott et al. (2014) demonstrate that the position occupied by different components within a network can significantly influence the magnitude of contagion effects.

Although the literature offers numerous contributions regarding the functioning of hierarchical structures and economic networks, as well as their role in the transmission of information, resources, and disturbances, explicit comparisons between hierarchical and network-type structures as distinct channels for the propagation of economic shocks remain relatively limited. This observation is particularly relevant because the architecture of relationships among components may influence both the trajectories and the distribution of the effects generated by economic shocks.

RESEARCH GAP AND CONTRIBUTIONS

The existing literature, as discussed above, has helped explain economic shocks, transmission mechanisms, and the role of interdependencies in the propagation of their effects. Research in this field has contributed to the development of analytical tools for identifying shocks and assessing their effects (Blanchard & Quah, 1989; Smets & Wouters, 2007; Ramey, 2016), while studies on asymmetric shocks have highlighted how structural differences among economies influence the distribution of their effects. Likewise, research on hierarchical structures and networks has demonstrated how the organization of relationships among components shapes the circulation of information, resources and disturbances in complex systems (Simon, 1962; von Bertalanffy, 1968; Barabási & Albert, 1999). However, these approaches present a number of limitations:

- most of the literature treats shocks as exogenous disturbances, and attention is focused on the effects produced on the economic system rather than on the shock itself. As a result, the relationship between shock characteristics and the structure of the system through which it propagates is examined only to a limited extent.
- although the literature on asymmetric shocks shows that effects vary across economies, the explanations are general, being associated primarily with the characteristics of the affected economies and less with how the structure of relationships among components influences the distribution of effects.
- the literature on the internal organisation of economic systems focuses largely on specific transmission channels or specific network configurations. There are few analyses that compare hierarchical and network structures as distinct environments for the propagation of economic shocks and explore the differences between them.

Consistent with the limitations identified above, this paper aims to contribute to the literature on economic shocks by analysing the role of system structure in their propagation. While much of the existing research focuses on the nature of shocks, their transmission channels, or their effects, the present analysis shifts attention to the architecture of relationships among the components of the economic system and its role in the propagation of shocks. From this perspective, the study introduces a framework that allows for a comparison of how economic shocks propagate in two fundamental forms of system organisation, hierarchical structures and network-type structures.

CONCEPTUAL DISTINCTIONS

To clarify the analytical framework employed in the following sections, it is useful to introduce some conceptual distinctions that reflect how an economic system is organized and the nature of the relationships that may exist among its components. These conceptual distinctions are formulated in accordance with the perspective developed by Dinga (2015) and are as follows:

- *economic aggregate* vs. *economic system*. What they have in common is that both are assemblies of elements (economic agents, firms, institutions or, in the case of macrosystems, even the economic systems). The distinction between them, however, lies in the presence or absence of connections between these elements. An aggregate, for example, represents a simple collection of elements assembled together without any connections among them. By contrast, a system is a collection of elements connected to one another and functioning to achieve a common goal.
- *economic system* vs. *economic network*. A system, as defined above, allows for both hierarchical and non-hierarchical relationships among its constituent elements. A network is a set of elements connected exclusively through non-hierarchical, horizontal relationships. From this perspective, a network is a specific type of system characterised by a decentralised structure. In a network, the constituent elements are referred to as *nodes*.

- *economic network* vs. *economic hub*. In a network, connections among elements may be unevenly distributed, meaning that some nodes accumulate more links than others, thereby becoming more important within the network structure. These nodes, with a higher number of connections, are referred to as *hubs*.

From these distinctions, two broad types of architectures that may characterise an economic system can be identified:

a) *hierarchical structures*. Their main characteristic is the distribution of the elements that compose the economic system across different levels, resulting in "vertical" relationships. Thus, certain categories of elements may occupy higher levels (for example, the state with its institutions and related regulations), while others are subordinated (such as firms, households). From this perspective, hierarchical systems appear as centralised structures, with command and control centres and, thus, the possibility of direct intervention at lower levels. The connections they describe are generally standardised, and flows tend to follow relatively predictable trajectories.

b) *network-type structures*. As noted above, networks predominantly integrate "horizontal" relationships. Consequently, they operate in a decentralised manner, without hierarchies among the system's constituent elements. This does not imply the absence of coordination or control; rather, these functions emerge from the interactions among the elements that compose the network and are distributed across them. It should be noted that within an economic system, networks may operate autonomously as self-contained structures or may be connected to other structures, whether network-based or hierarchical.

The structures presented are not mutually exclusive, meaning that both hierarchical configurations and networks may coexist within the same system. Moreover, certain elements may belong simultaneously to both structures, being part of a hierarchical arrangement and a network. Nevertheless, in an economic system, there is an ordering relationship, as follows:

$$S \supseteq N \supseteq H$$

where, S = the economic system; N = the economic network; H = the set of hubs associated with a given economic network.

ORGANISATION OF THE ECONOMIC SYSTEM AND THE PROPAGATION OF SHOCKS: HIERARCHICAL STRUCTURES AND NETWORKS

Traditionally, economic shocks are analysed through the changes they induce in economic variables, typically attributed to factors exogenous to the economic system, while their effects are studied in terms of the deviations, they generate from a given reference state (Duarte & Hoover, 2012; Hoover, 2015). A consequence of this approach is that the analysis makes a clear distinction between the shock and the affected economic system, without attributing any role to the system's structure in the distribution of effects. This limits how economic shocks can be analysed, as their effects on economic systems cannot be fully explained without considering how these systems are internally organised.

Adopting the view that the economy functions as a system helps overcome these limitations. From this perspective, an economic shock is no longer identified exclusively with either the event that triggers it or the effects it produces, but is understood as a process resulting from the interaction between that event (to the extent that it is relevant to the economic system), the system's structure, and its transmission mechanisms. An event is relevant to the economic system insofar as it can generate impulses that propagate through the system's network of relationships and significantly alter its state.

FORMAL REPRESENTATION OF ECONOMIC SHOCK PROPAGATION

To formally represent the propagation of economic shocks, we will consider a systemic framework consisting of a triggering event, the structure of the economic system, and the transmission mechanisms activated by that event. The economic shock thus emerges from their interaction. The variables employed in the economic shock propagation model are presented in Table 1.

Table 1.
Definitions of Variables

Symbol	Definition
E	Triggering event
S	Structure of the economic system
T	Transmission structure
ε	Initial stimulus generated by the event
ΔY	Changes in relevant economic variables
A	Matrix of interactions among transmission channels

Source: developed by the author.

Within this framework, the observed effects of an economic shock can be expressed as follows:

$$\Delta Y = f(E, S, T)$$

where E represents the triggering event, S the structure of the economic system, and T the set of activated transmission channels. This representation highlights that the impact of an economic shock is not determined solely by the initial event but also by how it interacts with the system's structure and the mechanisms through which its effects are propagated.

The structure of the economic system (S) plays a central role in this process, as it influences both the channels through which the effects are transmitted (T), and the way in which they interact during propagation. From this perspective, the structure of the system not only provides the context in which the economic shock manifests but also shapes the magnitude, distribution, and dynamics of the resulting effects.

Two important consequences follow from this relationship:

- the same event may generate different effects in systems characterised by different structural configurations;
- two systems may respond differently to the same disturbance, depending on where it is introduced into the structure of interdependencies.

In this context, transmission channels play a specific role in the propagation of economic shocks. They constitute the functional pathways through which the impulse generated by the triggering event is introduced into the system and produces changes in relevant economic variables. Transmission channels partially overlap with existing economic flows, but also include additional mechanisms, such as price adjustments, institutional reactions, changes in expectations, or changes in the behaviour of economic agents.

To meet the needs imposed by the proposed model, depending on their nature, the channels through which economic shocks are transmitted can be grouped into the following categories:

- real channels (trade, value chains, energy, the labour market);
- financial channels (banks, capital markets, credit);
- institutional channels (economic policies, regulations, constraints);
- expectations and confidence channels (anticipations, perceptions, confidence).

The set of channels identified above, considered as a transmission structure, can be represented as follows:

$$T = \{t_1, t_2, t_3, t_4\}$$

where t_1 = trade channels; t_2 = financial channels; t_3 = institutional channels; t_4 = expectations channels.

An important aspect to note is that, within an economic system, these transmission channels do not operate in isolation but are continuously interconnected. Thus, the activation of one of these channels can alter the functioning of the others, generating cumulative propagation processes. To highlight these interdependencies, the transmission structure can be represented by an interaction matrix:

$$A = [a_{ij}]$$

where ε each element a_{ij} expresses the intensity of the influence exerted by channel i on channel j.

Based on this structure, the propagation of the shock can be expressed as follows:

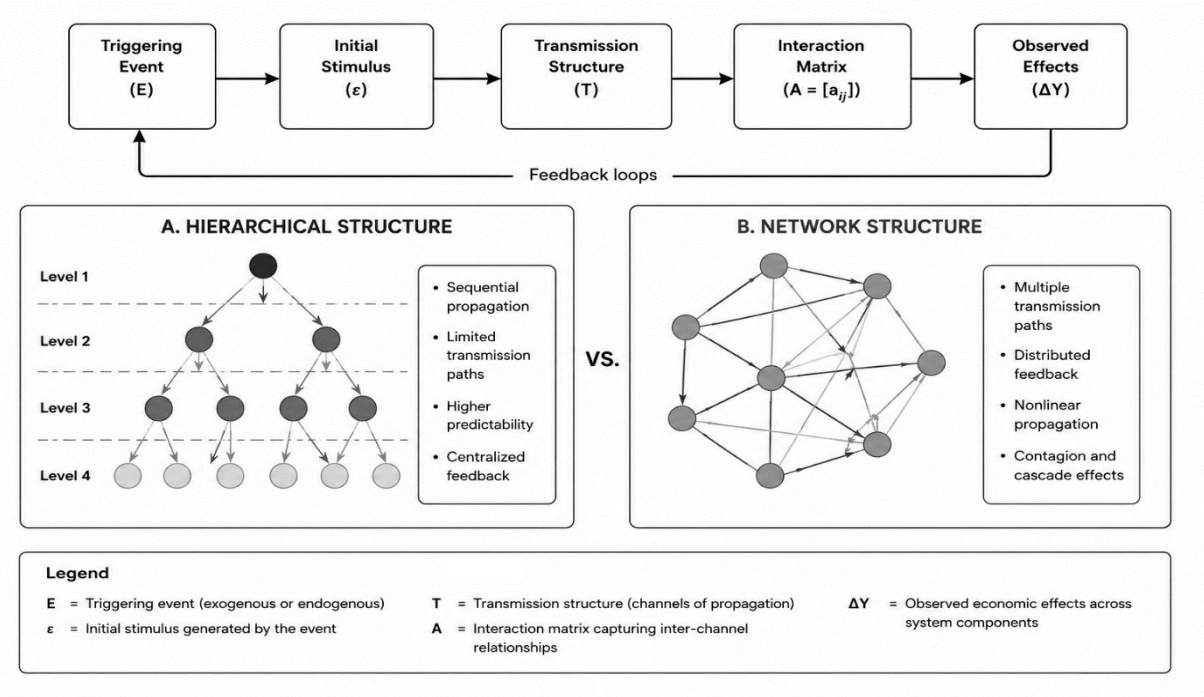
$$\Delta Y = A\varepsilon$$

where ε represents the initial impulse generated by the triggering event E.

In this framework, the propagation of the economic shock depends on the properties of the matrix A which captures the density of interdependencies and the intensity of the relationships between the transmission channels. Thus, the same event can generate different effects depending on the structural configuration of the economic system.

We summarise the relationships among the main elements of the proposed model and their roles in the propagation of economic shocks in Figure 1 below.

Figure 1.
Conceptual Framework of Economic Shock Propagation in Hierarchical and Network Structures



Source: developed by the author.

Figure 1 illustrates that the observed effects of an economic shock do not result directly from the triggering event itself, but rather from the interaction between the initial impulse generated by that event, the transmission channels it activates, and the relationships among them. From this perspective, the propagation of shocks appears to be a systemic process, influenced by the configuration of interdependencies and the feedback mechanisms developed within the economic system.

THE PROPAGATION OF SHOCKS IN HIERARCHICAL STRUCTURES

In hierarchical structures, the system's components are arranged across multiple levels, and relationships are predominantly organised vertically, which allows economic shocks to propagate accordingly. This type of organisation means that the impulse (ε) generated by a triggering event must pass through a relatively limited number of nodes or decision levels. Furthermore, the transmission of shocks is subject to mechanisms of validation, filtering, or transformation specific to each level of the hierarchy, thereby giving the propagation process a sequential character (Simon, 1962).

In this context, compared with decentralised structures, the shock's propagation trajectories are more clearly defined, and the number of possible transmission pathways is relatively limited. All of this gives the process greater predictability, since the relationships among components are generally stable and well known.

From the perspective of the model presented in Section 4.1, the hierarchical organisation of the system influences both the transmission structure T and the interactions among transmission channels represented by the matrix A. Because flows tend to follow predetermined paths and are mediated through a relatively small number of decision-making levels, interactions between channels are more limited than in network-type structures. Thus, shock propagation occurs through a smaller number of possible pathways, and the effects tend to be easier to anticipate and monitor.

Given our assumption that the economy functions as a complex system, the propagation of shocks tends to follow a nonlinear path. However, this nonlinearity is limited by the relatively ordered nature of the relationships among components, which reduces the number of simultaneous interactions and the possibility of emergent effects. At the same time, feedback mechanisms tend to be more clearly defined and institutionally embedded, being integrated into the system's decision-making structure, which helps monitor the propagation and correct deviations as they arise. In principle, the system therefore possesses a greater capacity to control and direct its response to disturbances.

Under these conditions, although triggering events may occur randomly, the dynamics of propagation tend to be more predictable, and policy or regulatory

interventions can act relatively directly on the relevant transmission channels, thereby limiting potential adverse effects. Nevertheless, this configuration entails a specific vulnerability: when central nodes or decision points are affected, shocks may propagate throughout the entire system because these elements concentrate key transmission mechanisms. As a result, the impact of the shock is generally more concentrated and easier to localise, but it can be significantly amplified if these nodes are affected.

In summary, within hierarchical structures, the propagation of economic shocks tends to be sequential, more concentrated, and easier to localise. The intensity of the resulting effects is determined not only by the characteristics of the triggering event, but also by its position within the system's architecture and by the role occupied by the affected components in the transmission mechanism.

THE PROPAGATION OF SHOCKS IN NETWORK STRUCTURES

Unlike hierarchical structures, networks are characterised by a multitude of connections that serve as alternative pathways for the transmission of shocks. In this context, the impulse generated by the triggering event (ε) does not follow a single, predetermined path, but is distributed simultaneously through multiple channels, with its effects influenced by the configuration of interdependencies among the system's components, which function as nodes (Barabási, 2016).

Within this type of structure, there are no clearly defined relationships of subordination and no single centres of coordination. Consequently, the effects of a disturbance may be propagated through different paths, recombine, and interact with one another, making the dynamics of propagation more difficult to anticipate than in hierarchical structures (Watts, 2002).

From the perspective of the model presented in Section 4.1, network structures are characterised by a more complex transmission structure T and a denser interaction matrix A, reflecting numerous connections and alternative propagation pathways. Under these conditions, the effects of a disturbance can be transmitted simultaneously through multiple channels and to multiple components of the system. As a result, propagation becomes less predictable and more dependent on the configuration of the interdependencies existing within the network.

If we accept the assumption that the economy functions as a complex system, the propagation of shocks in network structures is characterised by pronounced nonlinearity. Depending on the configuration of interdependencies, the same disturbance may generate very different effects, ranging from the non-complete absorption of the initial impulse (ε) to large-scale propagation throughout the entire system. The intensity of these effects depends not only on the characteristics of the triggering event but also on how the components of the interaction system evolve over time. In this context, the system's thresholds and critical points play a particularly important role. Up to a certain level, the impulses generated by a disturbance can be absorbed without major consequences. However, once critical thresholds are exceeded, qualitative changes in system dynamics may occur, giving rise to extensive propagation processes (Bak, 1996).

Feedback mechanisms also play a central role in the dynamics of shocks. Unlike hierarchical structures, where feedback is explicitly integrated into the decision-making architecture, feedback in networks is distributed and emergent, arising from interactions among system components. The activation of one transmission channel may alter the functioning of others, generating cumulative processes that can either amplify or attenuate the initial effects of a disturbance (Forrester, 1961; Meadows, 2008).

A particularly important role in this process is played by hubs, that is, nodes that concentrate a large number of connections within the network (Barabási & Albert, 1999). Due to their position within the structure, they can amplify, attenuate, or redirect the effects of economic shocks. Depending on the location of the disturbance and the position occupied by hubs within the network, the same impulse (ε) may generate effects that remain locally contained or may trigger large-scale cascading propagation processes (Watts, 2002).

The complexity of propagation is further amplified by the interconnection of different types of economic networks. Trade, financial, institutional, and expectations networks do not operate in isolation but are interconnected, forming multilayer structures (Kivelä et al., 2014). Under these conditions, the impulses (ε) associated with an economic shock may be transferred from one level of the system to another, simultaneously activating multiple transmission mechanisms and generating effects that extend beyond the initial sphere of the disturbance.

Thus, in network structures, economic shocks cannot be associated with a single transmission channel. Rather, they emerge from the interaction of multiple networks and propagation mechanisms. The dynamics of their effects are shaped by the density of interdependencies, the distribution of connections, and the position occupied by the various components within the system. As a result, the propagation of shocks tends to be less predictable, more sensitive to feedback mechanisms, and more prone to cumulative effects and systemic contagion processes.

THE EUROPEAN UNION AS A SYSTEM OF INTERDEPENDENCIES: IMPLICATIONS FOR THE PROPAGATION OF SHOCKS

In this section, we will apply the theoretical framework developed in the preceding sections to the case of the EU to examine how its specific structure influences the propagation of economic shocks. From an organisational perspective, the EU can be understood as a hybrid system that integrates both elements of a hierarchical structure, which involve decision-making and coordination processes implemented through supranational institutions and mechanisms (Baldwin & Wyplosz, 2022), as well as characteristics typical of network structures, arising from the relationships among Member States that generate trade, financial, and institutional interdependencies.

From this perspective, the EU may be characterized as a system combining: a) a high degree of interdependence; b) incomplete institutional integration (Baldwin & Wyplosz, 2022; De Grauwe, 2020). In terms of the framework developed earlier, these characteristics influence both the transmission structure T and the interactions among the transmission channels described by the matrix A, determining specific mechanisms for the propagation of economic shocks. Thus, the effects of shocks are shaped both by the density of network relationships between member states and by the institutional mechanisms through which these are coordinated and managed at the European level.

STRUCTURAL CHARACTERISTICS OF THE EUROPEAN UNION SYSTEM

Within the EU, several forms of integration define a specific structure of interdependencies. These forms of integration, which shape the EU as an economic system, are:

- *trade integration*. From a trade perspective, the EU is a deeply integrated area, with supply chains that extend beyond the national borders of Member States, generating mutual dependencies among economies. The literature on international trade and production networks highlights that such structures tend to amplify the transmission of shocks, as local disruptions in the economic system can spread rapidly along value chains (Antràs, 2020).
- *financial integration*. There is a significant degree of financial integration within the EU, but it is characterised by major asymmetries. Financial exposures are not evenly distributed among member states; rather, they are concentrated in certain centres, revealing nodes that are more centrally positioned within the network. Research on financial networks shows that instability can be amplified in such configurations, as disturbances affecting central nodes tend to spread more rapidly throughout the system (Acemoglu et al., 2012).
- *fiscal integration*. It is limited due to the absence of fully developed fiscal mechanisms at the central European level. This situation constrains the system's capacity to respond to shocks in a coordinated manner, creating an imbalance between the level of interdependencies that generate vulnerabilities and the instruments available for managing shocks. The literature on monetary unions emphasizes that this discrepancy can amplify the effects of asymmetric shocks in the absence of risk-sharing or shock-absorption mechanisms at the central level (Thirion, 2017; De Grauwe, 2020).

Taken together, these three dimensions describe the configuration of the EU's structure of interdependencies and the manner in which this structure shapes the propagation of shocks across member states. It should be noted, however, that trade integration and financial integration primarily reflect the density of network-type relationships among Member States, while fiscal integration expresses the hierarchical dimension, namely the extent to which the EU possesses common institutions and mechanisms capable of stabilizing the economy against shocks at the supranational level.

To illustrate these characteristics empirically, Table 2 presents a set of indicators of trade, financial, and fiscal integration in the EU over the period 2002–2024. These indicators demonstrate strong trade and financial interdependencies alongside a relatively limited common fiscal capacity.

Table 2.

Structural Dimensions of Economic Integration in the EU (2002-2024)

Dimension	Indicator	2002	2008	2013	2019	2024
Trade integration	Intra-EU exports share (%)	50.2	51.1	46.5	44.8	44.5
Financial integration	Transactions with euro-area counterparties (%)	n.a.	47.6	34.4	43.5	37.1
Fiscal integration	EU budget (% EU GDP)	~1.0	~1.0	~1.0	~1.1	~1.1

Source: developed by the author, based on Eurostat and ECB data

Note: The EU budget has remained close to 1% of EU GDP throughout the period, indicating a comparatively low degree of fiscal integration relative to trade and financial integration.

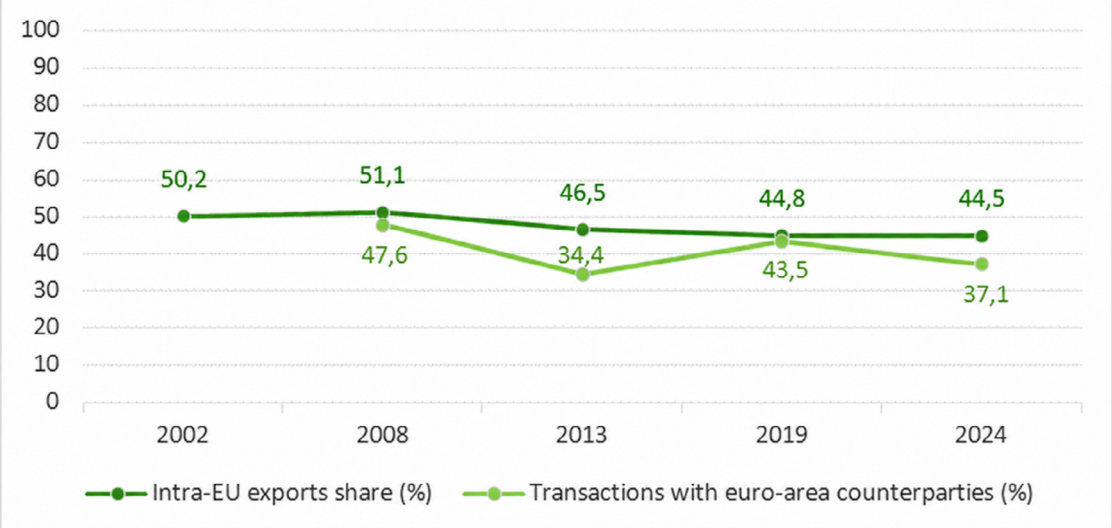
The data in Table 2 indicate that trade integration remained at a high level throughout the period analysed. Intra-EU exports accounted for approximately 45–50% of member states' total exports. This finding suggests relatively dense relationships among EU economies, indicating that, from the perspective of the transmission of economic shocks, changes in one part of the economic system could be rapidly transmitted to other components through trade flows and supply chains.

Similarly, the financial integration indicator recorded high values, reflecting significant linkages among financial actors across member states. Although the share of transactions involving euro-area counterparties located in other countries fluctuated over time, values exceeding 34% indicate that the EU financial system remained substantially interconnected. In this context, conditions were created for difficulties arising in a particular segment of the system to spread through mutual exposures, thereby facilitating financial contagion (Allen & Gale, 2000).

The evolution of trade integration is clearer in Figure 2, which shows the share of intra-EU exports in total exports between 2002 and 2024.

Figure 2.

Evolution of Intra-EU Export Integration



Source: developed by the author based on Eurostat and ECB data.

In contrast to the two dimensions, the data reported in Table 2 confirm relatively limited fiscal integration, with the EU budget remaining at a low level throughout the period, close to 1% of aggregate GDP. This suggests that the development of common stabilization instruments has not kept pace with the process of economic integration, creating a structural vulnerability from the perspective of economic shocks (De Grauwe, 2020). Thus, the system's capacity to respond in a coordinated manner to shocks has remained relatively limited compared to the extent of existing interdependencies.

Consistent with the analytical framework proposed in Section 4.1, high levels of trade and financial integration have increased the density of the EU's transmission structure *T*. As the number and intensity of economic

connections expanded, the matrix of interactions *A* within the system became denser, facilitating the propagation of disturbances across national economies. At the same time, limited fiscal integration reduced the system's capacity to mitigate the effects propagated through these channels.

From this perspective, the EU may be characterised during the period under analysis as a system with highly developed mechanisms for transmitting economic shocks but with limited common stabilisation mechanisms. This configuration explains why, within the EU, economic shocks spread rapidly across Member States and why their effects persisted or were unevenly distributed.

IMPLICATIONS FOR PROPAGATION MECHANISMS

At the outset, it is important to distinguish propagation mechanisms from transmission channels, which represent the pathways through which a shock's effects are transmitted to the economic system (whether trade-, financial-, institutional-, or expectations-based). Propagation mechanisms should be understood as processes resulting from the interaction between these channels and the structure of the economic system. From this perspective, the propagation of shocks is an emergent process, resulting from the interaction between transmission channels and the structure of interdependencies that characterize the system in which it occurs (Mitchell, 2009; Meadows, 2008).

In the case of the EU, the combination of high trade integration, significant financial integration, and limited fiscal integration results in a specific configuration, reflected in the particular way in which the transmission structure *T* and the matrix of interactions *A* are defined and which directly shapes the mechanisms of economic shock propagation. This structure of the EU has several implications for the propagation of economic shocks, as follows:

- *rapidity of propagation*. The high level of trade integration and the existence of extensive supply chains enable economic disturbances to be transmitted rapidly among Member States. The high number of trade links means that the effects of a shock are not limited to the components initially and directly affected, but tend to spread simultaneously to multiple components of the system. In terms of the proposed model, trade integration contributes to an increase in the density of the transmission structure *T*, thereby increasing the likelihood of rapid propagation of the effects.
- *the multiplicity* of propagation mechanisms. There are multiple dimensions of integration (trade and financial integration) and, thus, multiple levels of interdependence, that means that economic shocks can be transmitted through multiple mechanisms simultaneously (Acemoglu et al., 2012). Such mechanisms include flows of goods and services, mutual financial exposures, portfolio adjustments, credit tightening, and changes in risk perception. Regarding the matrix of interactions *A* this implies alternative channels for the propagation of shocks, thereby facilitating contagion processes and systemic effects (Allen & Gale, 2000).
- *limited capacity* for mitigation. As we have shown, while the EU is highly integrated in trade and finance, the capacity for fiscal stabilisation at the European level remains relatively limited. Thus, there are powerful mechanisms for transmitting shocks within the economic system, but the tools for absorbing and mitigating them are relatively limited. Within the proposed framework, this situation can be interpreted as a limitation on the system's ability to reduce the intensity of the effects propagated through the structure. Thus, propagation depends not only on the existence of transmission channels but also on the institutional capacity to interrupt or moderate the transmission processes.

All these characteristics create conditions for both amplification effects and differentiated impacts of economic shocks within the EU. Given the multiple transmission channels, effects generated in one channel may influence the functioning of the others, and the resulting system-wide reactions may generate feedback mechanisms. At the same time, the limited capacity for mitigation means these effects are not uniformly absorbed across the system. As a result, the impact of shocks tends to be distributed unevenly among EU member states, depending on their position within the network of interdependencies and their capacity for national adjustment. Thus, the propagation mechanisms described above create conditions for the emergence of asymmetric effects, which are analysed in the following section.

ASYMMETRIES AND DIFFERENTIATION OF IMPACT

Within the EU structure discussed, the economies of the member states occupy different positions in the network of interdependencies, which causes the effects of propagated economic shocks to be distributed unevenly throughout the economic system. In the framework presented in Section 4.1, these differences in network position can be understood as variations in the components of the transmission structure *T* and the interaction matrix *A*. In this context, the impulse associated with a single event may generate different effects across the economies of

Member States, depending on the configuration of the relationships it encounters along its path, resulting in an uneven distribution of shock effects (Acemoglu et al., 2012). This asymmetry in the effects of economic shocks can be explained by the following distinct mechanisms:

- *differences in centrality*. Some of the member states' economies exert greater influence than others on the overall structure of the EU's economic system. Those that are more integrated into trade and finance thus function as hubs in the EU's economic network and serve as key points through which economic shocks propagate to the rest of the system (Barabási & Albert, 1999; Acemoglu et al., 2012). From this perspective, shocks affecting economies that occupy central positions within the network are more likely to generate system-wide effects, whereas shocks affecting more peripheral economies tend to have a more limited distribution of impacts (Acemoglu et al., 2012).

To highlight differences in centrality within the EU's economic system, Table 3 presents the share of selected Member States[1] in the EU's GDP and in intra-EU exports. These indicators provide an overview of the position occupied by national economies within the European network of interdependencies.

Table 3.

Economic Hubs within the EU in 2024

Country	Share of EU GDP (%)	Share of intra-EU exports (%)
Germany	24.02	20.81
France	16.20	7.93
Italy	12.22	7.85
Spain	8.85	6.09
Romania	1.96	1.65

Source: developed by the author based on Eurostat data.

The data reported in Table 3 reveal inequality among EU member states in the distribution of overall economic activity and intra-EU trade. Among them, Germany is one of the main hubs, accounting for 24% of the EU's GDP and approximately 21% of total intra-EU exports, followed by France and Italy, which have lower but still significant shares of these two indicators. Owing to their positions within the European economic network, these economies play a significantly greater role in the propagation of economic shocks than less developed economies such as Romania.

Within the proposed framework, these differences translate into variations in the position occupied by national economies within the EU's transmission structure *T*. Those economies with a greater number of active connections are located closer to the centre of the network and therefore possess a greater capacity to contribute to the propagation of shocks and the generation of systemic effects, whereas others occupy more peripheral positions.

- *differentiation* of exposure to shocks. While more developed and highly connected economies play a more significant role in the propagation of economic shocks, the less developed and more peripheral economies are more exposed to receiving these shocks. This is largely due to their greater dependence on economic flows originating from other EU economies—many of which occupy central positions—as well as their more limited capacity for adjustment at the national level. In these situations, peripheral economies are affected indirectly through secondary propagation mechanisms, even though they are not the original source of the disturbance (Acemoglu et al., 2012; Allen & Gale, 2000).
- *the interaction between economic structure and the institutional framework*. Given the limited degree of fiscal integration and the absence of fully developed mutual stabilisation mechanisms, the differences resulting from structural divergences cannot be fully compensated. This means that, once they occur, the effects of economic shocks persist longer in some economies than in others, and their trajectories differ (De Grauwe, 2020).

The interaction of these mechanisms amplifies the effects of economic shocks in some parts of the system and mitigates them in others, resulting in an asymmetry in the distribution of economic effects. In this context, the analysis of EU-specific economic shocks must take into account not only the transmission mechanisms but also the distribution of effects within the system.

[1] The Member States listed in Table 3 were selected based on their importance within the EU's economic system and their relevance to our study.

ILLUSTRATING THE PROPAGATION MECHANISMS OF ECONOMIC SHOCKS THROUGH RECENT EPISODES

The propagation mechanisms discussed above can be more clearly illustrated by analysing recent episodes that have affected the EU. For this purpose, we consider the cases of the 2008–2009 Global Financial Crisis and the COVID-19 pandemic shock. Beyond their impact on the EU economy, these episodes are particularly relevant because each possessed its own distinct characteristics and therefore constitutes a specific case for analysis. What is of interest here is how the same structure of interdependencies influenced the propagation of different types of shocks.

To this end, Table 4 presents the annual real GDP growth rates in selected EU Member States during the Global Financial Crisis (2009) and the COVID-19 pandemic (2020). These data provide an overview of the magnitude of the economic effects during the two episodes and highlight the differentiated nature of their effects across the European system.

Table 4.

Asymmetric Impact of Major Economic Shocks in the European Union

Country	GDP Growth 2009 (%)	GDP Growth 2020 (%)
Germany	-5.5	-4.1
France	-2.8	-7.4
Italy	-5.3	-8.9
Spain	-3.8	-10.9
Romania	-5.5	-3.6
EU27	-4.3	-5.6

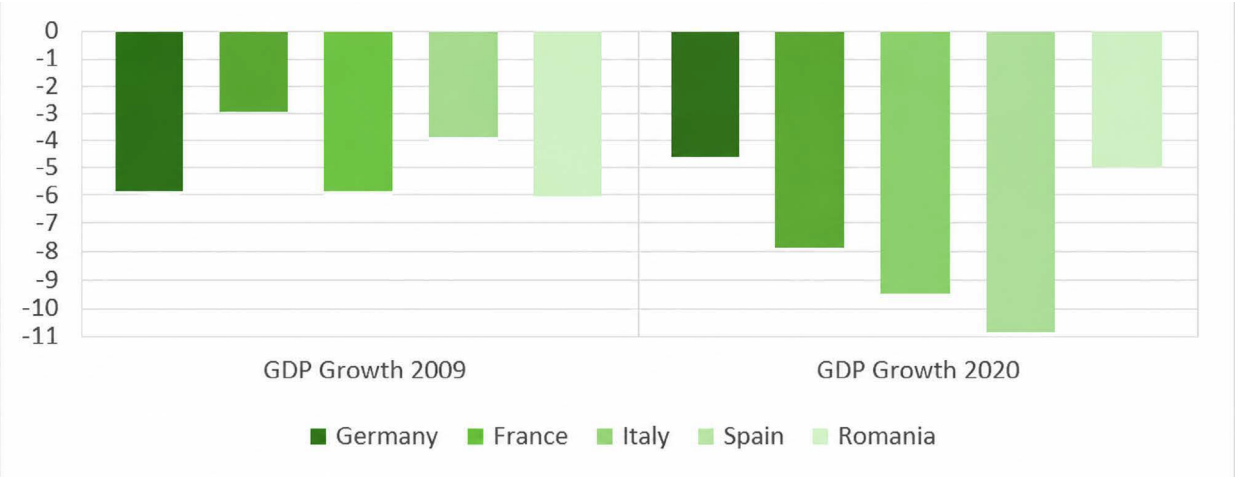
Source: developed by the author based on Eurostat data.

The figures reveal significant differences in the severity of economic contractions across countries. All economies were affected by both shocks, but the magnitude of the impact varied considerably. These differences support the argument developed throughout this paper that the effects of economic shocks are determined not only by the characteristics of the triggering event but also by the position of economies within the network of interdependencies, their exposure to transmission channels, and their capacity to absorb shocks.

Figure 3 provides a visual comparison of the economic impact of the 2008–2009 Global Financial Crisis and the COVID-19 shock across selected Member States.

Figure 3.

GDP growth during major shocks



Source: developed by the author based on Eurostat data.

Figure 3 confirms that the economic impact of the two shocks was unevenly distributed across Member States. While all economies were affected, the magnitude of the contractions varied substantially, suggesting that the effects of shocks depend not only on the triggering event but also on the structure of interdependencies and each economy's position within the European system.

THE GLOBAL FINANCIAL CRISIS (2008–2009)

The 2008–2009 Global Financial Crisis provides a relevant example of how an economic shock can propagate within a system characterised by high financial interdependencies, such as the EU. From the perspective of the framework proposed in this paper, the episode can be analysed in terms of the triggering event, the activated transmission channels, the resulting propagation mechanism, and the effects generated within the European system.

Under this framework, the *triggering event (E)* was the deterioration of the U.S. subprime mortgage market and the bankruptcy of major financial institutions, such as Lehman Brothers, in September 2008 (Brunnermeier, 2009). *The initial impulse (ε)* generated by this event consisted of deteriorating financing conditions, rising uncertainty, and reduced liquidity in international financial markets. These events occurred outside the EU, but their effects spread rapidly from the U.S., with the shock subsequently transmitted to the European economic system through activated financial channels and propagating to other components of the economy.

Within the EU, *the transmission mechanism (T)* consisted primarily of financial and trade interdependencies established among Member States. At the onset of the crisis, financial institutions in the EU were closely interconnected through interbank markets, cross-border exposures, and shared holdings of financial assets (Lane, 2013). These relationships served as the primary channels through which the shock's effects were transmitted to other components of the EU system. Consequently, difficulties arising in one part of the financial system rapidly affected other institutions and markets, highlighting the tendency of rapid propagation of shocks associated with highly interdependent structures.

It is worth noting that the shock's propagation was not limited to the financial sector. The reduction in liquidity and the tightening of credit conditions, for example, affected investment and consumption, leading to a decline in economic activity and trade. The effects that initially emerged in the financial sector were transmitted further through trade and production channels, thereby triggering multiple propagation mechanisms.

In this context, the matrix A can be interpreted as describing the relationships between the financial (F) and trade (C) channels activated during the propagation of the shock. Elements such as a_{FC} thus indicate how the deterioration in financial conditions affected the real economy, while elements such as a_{CF} describe the reverse reactions, the effects of the decline in economic activity on the financial sector. Through these interactions, the initial effects of the shock were amplified and propagated to an increasing number of components of the EU's economic system.

Another aspect highlighted by the 2008–2009 financial crisis is how the effects of the economic shock were amplified through feedback mechanisms activated at the EU system level. For example, the decline in economic activity affected firms' operations and borrowers' capacity to repay, placing additional pressure on the financial system. In turn, difficulties in the financial sector led to further credit tightening and an acceleration of the economic decline (Brunnermeier, 2009; Claessens et al., 2010). Through these processes, the effects generated in the financial component of the economic system triggered reactions that fuelled new disturbances in other components of the system, thereby amplifying the overall impact of the shock.

Beyond the above, as shown in Table 4, the effects of the crisis were not distributed evenly among Member States. Germany and Romania recorded more significant declines in GDP, with 5.5% in 2009, while economies such as Spain and France recorded smaller contractions (-3.8% and -2.8%), below the EU average (-4.3%). This uneven distribution of the shock's effects can be explained by differing exposures to the shock and unequal capacities to adjust. In other words, although the initial disruption was common to all Member States, the resulting economic impact varied from one economy to another.

THE COVID-19 PANDEMIC SHOCK

Unlike the 2008–2009 financial crisis, the COVID-19 pandemic was driven by an exogenous shock that simultaneously affected production processes, factor mobility, and economic exchange. From this perspective, the pandemic highlights how a non-financial shock can activate transmission channels and generate effects throughout the EU's economic system.

In accordance with the framework developed in this paper, the *triggering event (E)* in this case was the COVID-19 pandemic and the measures adopted to limit the virus's spread among the population. *The initial impulse (ε)* generated by this event manifested itself through the interruption of economic activities, reduced mobility of persons, disruptions to production processes, and disturbances in supply chains. These initial effects were introduced into the economic system through the activated transmission channels and subsequently spread to multiple components of the EU economy.

At the EU level, *the transmission structure (T)* consisted primarily of interdependencies in trade and production among Member States. Integrated supply chains and the intensity of trade meant that disturbances occurring

in one economy were rapidly transmitted to other economies. In this context, the interruption of activity in certain firms or sectors affected not only the economies in which they were located, but also other components of the EU system that depended on the same flows of goods, services, and production inputs (Antràs, 2020).

The propagation of the economic shock, in this case, was driven by the interaction between trade channels (C) and production channels (P). In *the interaction matrix (A)*, the relationships a_{PC} describe the effects of reduced production on trade flows, while the relationships a_{CP} express the impact of disrupted trade flows on production processes. Through these interactions, the effects generated in one segment of the supply chains were transmitted to other segments, contributing to the propagation of the disturbance throughout the EU economic system (Baldwin & Freeman, 2021).

As with the 2008–2009 Global Financial Crisis, the pandemic confirms that the effects of economic shocks can be amplified through feedback mechanisms within the economic system. The reduction in production and economic activity affected household incomes and aggregate demand in EU countries, which in turn further reduced firms' activity and economic exchanges. Thus, the initial disturbances induced by the COVID-19 pandemic in the economic system also triggered reactions in other components of the system, amplifying the impact of the shock.

The effects of the COVID-19 pandemic shock were also distributed unevenly across Member States. The data presented in Table 4 show that, in 2020, Spain recorded a GDP decline of 10.9%, Italy of 8.9%, France of 7.4%, Germany of 4.1%, and Romania of 3.6%. These results reflect varying degrees of exposure to the shock, shaped by each country's economic structure, the importance of sectors directly affected by mobility restrictions, and the adaptive capacity of national economies. Economies dependent on activities such as tourism, transportation, or mobility-related services were affected more than those with a different sectoral structure.

DISCUSSION AND POLICY IMPLICATIONS

The analysis presented in this paper highlights that the system-level effects of economic shocks are shaped not only by the characteristics of the triggering event or initial disturbance, but also by how the shocks interact with the system. The application of the proposed theoretical model to the EU has shown that the high degree of trade and financial interdependencies facilitates the rapid propagation of shock effects across national economies, while differences in countries' positions within the network and their unequal capacity to adjust contribute to the asymmetric distribution of these effects. This leads to several key findings, as follows:

- A first important finding concerns the role of economic centrality in the dynamics of shocks. As the data presented in Table 3 suggests, economic activity and intra-EU trade are unevenly distributed among Member States, with some economies occupying significantly more prominent positions within the European network of interdependencies. In such configurations, disturbances affecting central economies tend to generate broader effects across the entire system than those affecting peripheral economies. This observation confirms the importance of network structure in modelling propagation processes and suggests that the impact of a shock depends not only on its intensity but also on the position of the affected component within the system.
- A second finding of the analysis is the coexistence of multiple transmission channels in the propagation of economic shocks. The discussion presented in Sections 4.1 and 4.2, together with the two episodes examined, showed that the effects of a shock are not transmitted through a single mechanism, but rather through the simultaneous interaction of multiple channels. In the case of the Global Financial Crisis, the shock initially spread through financial channels but was subsequently transmitted to the real economy and international trade through specific channels. During the COVID-19 pandemic, the main mechanism was the interaction between production and trade channels. In both situations, the effects were amplified by interactions among different transmission channels and by feedback mechanisms within the system.
- A third finding emphasize the asymmetric nature of the effects of economic shocks. The evidence presented in Table 4 indicate that the same disturbance can generate different outcomes across Member States. Both during the Global Financial Crisis and the COVID-19 pandemic, the magnitude of economic contractions varied significantly across economies. These differences point to varying exposures to shocks, different economic structures, and differing positions within the network of interdependencies and in terms of adjustment capacities. From this perspective, the asymmetries are not merely consequences of the shocks, but rather the different ways in which they interact with the characteristics of the system's components.

The results discussed above yield a series of implications for economic policy within highly interconnected systems. These implications are:

- the effectiveness of interventions depends on the ability to identify components relevant to the economic system. In structures with unevenly distributed centralities, disturbances affecting central nodes can generate disproportionate effects for the entire system. From this perspective, preventive measures and stabilisation policies should pay particular attention to institutions,

sectors, and economies that occupy central positions within the network of interdependencies.

- the existence of multiple propagation mechanisms suggests the need for coordinated interventions. Policies targeting a single transmission channel may be limited in effectiveness, as effects can continue to propagate through other channels. Therefore, managing economic shocks requires an integrated approach that accounts for the trade, financial, and institutional dimensions of their propagation.
- the asymmetric distribution of effects necessitates relatively flexible adjustment mechanisms. Given that the same shock can produce different effects across the various components of the system, uniformly applied measures may lead to unequal outcomes. This highlights the importance of instruments that can respond differently depending on the characteristics and vulnerabilities of the various components.

In the case of the EU, these implications are reinforced by the fact that, as shown in Table 1, the high level of trade and financial integration is not matched by an equivalent degree of fiscal integration, which results in a high capacity for the propagation of shocks but lacks the instruments to absorb their effects. From this perspective, strengthening the resilience of the EU system requires not only improving the response to shocks after they occur but also incorporating the structural conditions that shape their propagation into the measures designed to address them. In this regard, three priorities are particularly important:

a strengthening monitoring and intervention capabilities in systemically important sectors;

b reducing excessive interdependencies that may amplify the effects;

c developing coordination and stabilisation mechanisms that are better aligned with the existing degree of economic integration within the EU.

It should be noted that addressing these areas does not necessarily entail centralising economic policies at the EU level, but rather achieving better alignment between the EU's institutional architecture and the structure of economic interdependencies that characterise it.

CONCLUSIONS

In this paper, we aimed to analyse the propagation of economic shocks from the perspective of the structure of the economic system in which they occur. Based on the premise that the effects of shocks depend not only on the characteristics of the triggering event but also on the architecture of relationships among the system's components, we developed an analytical framework that links the triggering event, the transmission mechanisms, and the structure of the economic system.

The analysis revealed that hierarchical structures and network-type structures generate different mechanisms for the propagation of economic shocks. In hierarchical structures, propagation tends to follow more clearly defined paths, characterised by a relatively higher degree of predictability and the possibility of intervention through existing coordination levels. In contrast, in network-type structures, the existence of multiple connections and distributed feedback mechanisms fosters more complex propagation processes that are less predictable and more sensitive to the configuration of interdependencies among components.

Applying the proposed framework to the EU has shown that the high degree of trade and financial integration contributes to the development of strong mechanisms for transmitting economic shocks, while limited fiscal integration reduces the system's capacity to absorb and mitigate their effects. The analysis also highlighted that the positions occupied by national economies within the European network of interdependencies, and their varying capacities for adjustment, contribute to the asymmetric distribution of shock effects across Member States.

The main contribution of this paper lies in developing a comparative framework for analysing the propagation of economic shocks in hierarchical and network-type structures and highlighting the role of the architecture of relationships between components in shaping their effects. From this perspective, the findings suggest that the analysis of economic shocks could benefit from greater attention to the system's structure and the mechanisms by which the effects of disturbances propagate among its components.

At the same time, the analysis remains predominantly theoretical and conceptual. Future research may expand the proposed framework by developing empirical indicators of economic interdependencies, component centrality, and propagation mechanisms, and by applying it to other types of economic systems and categories of shocks.

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