EXTENDED ABSTRACT

Title: Building Global Supply Chain Resilience from a Practical Perspective: a Transport-Chain Resilience Indicator and its Applications

Authors and e-mail of all:

María Feo Valero
Instituto de Economía Internacional
Departamento de Estructura Económica
Universidad de Valencia
maria.feo@uv.es

Julián Martínez Moya
Departamento de Análisis Económico
Universidad de Valencia
julian.martinez-moya@uv.es

Vicente Pallardó López
Instituto de Economía Internacional
Departamento de Estructura Económica
Universidad de Valencia
Vicente.Pallardo@uv.es

Francisco Requena Silvente
Departamento de Estructura Económica
Universidad de Valencia
francisco.requena@uv.es

Ana Botella Andreu
Departamento de Dirección de Empresas
Universidad de Valencia
ana.botella@uv.es

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The term Global Value Chain (GVC) refers to an international production model based on organizational systems that interconnect companies through a network of agreements (Gereffi, 1994; Giroud and Mirza, 2015). This network does not have a legal identity in itself but is usually led by a Multinational company that does control key assets, intermediate products and associated knowledge to a different extent. What makes GVC different to previous international production systems is the strong relational nature between the actors (Kano, 2020).

The prevalence of GVC as the main system for organizing international production is lately being questioned. This is due to the recent weak performance of the system under severe stress of the last couple of years, including (but not only) the COVID Pandemic which has caused serious disruptions and or the total interruption of the delivery of products and firm's activity.

This scenario brings a shift in business (and policy) focus from "looking for efficiency" to "building resilience" (Antràs, 2020; Javorcik, 2020). In particular, at the operative level, the focus is turning increasingly to Supply chains. This is because Supply Chains are the channels through which the actors in GVC maintain their links making the whole production system work. Managing the Supply Chain improves competitiveness as reduces uncertainty in the network (Al-Mudimigh, Zairi, Moneim and Ahmed, 2004). Therefore, it is believed that improving supply chain resilience will make GVC stronger, making global economy more resilient to shocks (UNCTAD, 2021).

In recent decades, the number of studies contributing on the resilience of supply chains has rapidly grown due to the major changes occurring in the fragmentation of global production process and GVC. Supply chain resilience can be defined as the system adaptive capability to prepare for unexpected events, respond to disruptions and eventually return to stabilization after a shock by maintaining continuity of operations (Ponamarov and Holcomb, 2009). However, since supply chain resilience has been studied by many researchers, divergences in the definition of the concept exist depending on the scope and the phases analysed, differentiating among anticipation, resistance, and recover & response (Petit et al., 2010; Kamalahmadi and Parast, 2016; Ribeiro and Barbosa-Paroa, 2018). While some researchers focused on the reactive capabilities for reacting or recovery after a disruption (Rice and Coniato, 2003; Juttner and Maklan, 2011), others put more emphasis on the proactive capabilities to be prepared to anticipate any potential disturbance in the supply chain (Closs and

McGarrell, 2004; Ponomarov and Holcomb, 2009; Barlow, 2012; Saenz and Revilla, 2014).

Until now most of the literature has focused their efforts on the identification of the main antecedents and drivers that determine the resilience of the supply chains. Given the increasing interconnectedness and dependency among suppliers, manufacturers and other firms involved in the supply chains (Kamalahmadi and Parast, 2016), several factors are likely to influence their resilience. In this regard, the literature has identified collaboration, agility, visibility, management culture, flexibility and information sharing as the most important characteristics and drivers for achieving SCR (Ponis and Koronis, 2012; Blome et al., 2013; Bode and Macdonald, 2017; Dubey et al., 2018).

After the pandemic, the study of transportation and logistics has rapidly emerged as a relevant topic related to supply chain resilience (CoDEA, TRE). Regarding the flexibility and visibility, empirical evidence pointed that transport and logistics services are a relevant factor to enhance the resilience of a supply chain (Gligor and Holcomb, 2012; Mandal et al., 2016; Mandal et al., 2017). Integrated logistics capabilities were found to positively influence supply chain collaboration and supply chain visibility (Mandal et al., 2016). Some has incorporated some variable related to flexible transportation (Azebedo et al., 2013) or the logistics performance of service providers (Wagner and Bode, 2006). However, to the best of our knowledge, there is a lack of research focused on the role of transportation to enhance and achieve supply chain resilience. Especially, evaluating the current level of service and the choices made by companies, evaluating the resilience of the real supply chains. Moreover, there is also a lack of empirical papers that develop indicators to measure the current resilience level, allowing to anticipate early signals of potential vulnerabilities (Ribeiro and Barbosa-Povoa, 2018; Pettit et al., 2019; Hosseini et al., 2019). Despite the focus of the companies on such tools (Blackhurst et al., 2011), it is surprising how few academic studies there are on this relevant issue (Wang and Ip, 2009; Soni et al., 2014; Azevedo et al., 2016).

Our research aims to close this gap by developing an indicator that permits evaluating the resilience of the transport chain at different levels (region or sector) which makes it useful for the full range of actors interested in improving the supply chain resilience. Furthermore, our indicator identifies tools for improvement under the scope of the company, policy makers and those elements affecting the transport chain that are given.

Finally, our indicator is designed to be available to the community as is composed of openly accessible data and information.

More specifically, we develop a composite indicator to measure supply chain resilience using the proactive approach. Given the complex and dynamic nature of global supply chain operations, it is required constant vigilance to evaluate and identify the sources of resilience and the potential weaknesses and vulnerabilities to which companies are exposed (Pettit et al., 2019). In this regard, Blackhurst et al., (2011) identified that, due to the importance of resilience for policy-makers and companies, 85% of the companies under study highlighted the need for leading indicators that support them monitor their supply chains to make strategic decisions. Therefore, it is crucial the development of new analytical tools that turn the data generated by supply chain operations into quantitative metrics that provide useful information to decision-makers (Bhagwat and Sharma, 2007; Blackhurst et a., 2011; Ribeiro and Barbosa-Pavoa, 2018; Pettit et al., 2019).

Our indicator, called Strategic Vulnerability Index (SVI), takes companies' supply chain strategies as given to establish, based on the different indicators it incorporates, a measure of the resilience associated with their current transport chains. These indicators are grouped into 3 dimensions established according to whether or not the company can directly affect said elements and thereby modulate and mitigate its level of exposure to risks linked to the transport chain. Thus, the so-called *company dimension* groups together those elements whose configuration can affect the resilience of the transport chain to a greater or lesser degree and on which the company has direct decision-making capacity. This dimension consists of 3 indicators that measure the degree of control that the importer has over the transport chain (approximated based on the incoterms used), the degree of concentration of the modal split with respect to the modes of transport available (intermodality) and the degree of concentration of supplies in specific months of the year (seasonality).

The second dimension, *market dimension*, also groups together components that can condition the resilience of transport but whose configuration is beyond the control of companies since they are variables whose levels derive directly from the decision to source from one country or another (which we must remember in our approach is considered exogenous). This dimension is made up of the variable distance (the greater the distance, the greater the transit time of the transport chain, the lower the probability of having direct service, and the greater probability of suffering delays), the quality of

the logistics infrastructures in the supplying countries (Logistic Performance Index of the World Bank in its global dimension weighted by the country's share with respect to the total imported) and the maritime connectivity offered (Liner Shipping Bilateral Index of UNCTAD).

Finally, a third macroeconomic dimension is incorporated that allows complementing the two previous components with indicators on the macroeconomic stability of the countries from which you supply. The relevance of macro factors (those related to both macroeconomics and institutions) must be considered when analysing the vulnerability of current (or potential) value chains. The stability of the economic, legal, and institutional framework of the key countries for a particular chain may be of critical importance for keeping (or changing) the way a firm gets its imported products/components/commodities. Even if Russia´s invasion of Ukraine has sadly and strongly shown that relevance of factors aliens to the logistics and transport components for the international trade, it was already obvious that strong movements (within a particular economy along time) or very different levels (among countries) regarding elements as exchange rates, levels of corruption, capital human availability or labour productivity seriously affect firms´ international supplies. For this reason, we introduce a macro component in our SVI. That component itself is a composite index, consisting of four different pillars approaching the countries' economic stability (inflation and exchange rate volatility), productive efficiency (total factor productivity, labour productivity), institutional quality (corruption, governmental efficiency, and economic freedom) and resources and costs (labour costs, physical and human capital).

To illustrate the potential of this indicator an application to the case of Spain is made that allows to drawn conclusions on the positioning of the different Spanish Autonomous Communities both in relation to the global index and in relation to the indicators that make it up.

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