EXTENDED ABSTRACT

Title: GLOBAL SUPPLY CHAINS AND RISK DISRUPTION FROM A MRIO PERSPECTIVE

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Subject area: S15 – Análisis input-output y medio ambiente. Teoría y aplicaciones

1. Abstract:

Introduction

Since the beginning of globalization countries have been each time more connected. As a consequence, production have been organized around the so call global supply chains. Globalization has had positive effects on the different economies. However, natural disasters such as the earthquake and tsunami in Japan in 2011 or more recently, the COVID-19 pandemic has shown the risks associated to global supply chains in case of disruption and the need to go deeper into the metrics of countries and sectors regarding risk and exposure issue.
In this context, previous literature has focused on risks models and inoperability input-output models. With them, they estimate the impact of different possible shocks at multisectoral level. However, neither of them measures explicitly the risk of disruption of a supply chain. Thus, this work goes deeper in this issue working under a MRIO framework. The main aim is to propose different indicators of risks and draw the taxonomy of countries and sectors based on them. Besides, we analyze the impact that this taxonomy might have in economic development and environmental damage.

Methodology and data

In that context, we will apply different indicators to measure the level of risk from different perspectives. First, we will work with the interdependency matrix A* that uses the inoperability input-output models that can be built from the original input-output model.
Our starting point is the equilibrium equation in a MRIO model for the world economy, with *m* countries and *n* sectors in each country (Isard, 1951; Leontief, 1936, 1941; Miller & Blair, 2009)

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{y} \rightarrow \mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{y} = \mathbf{L}\mathbf{y} \qquad (1)$$

where **A** is the matrix of technical coefficients and each element a_{ij}^{rs} represents the volume of intermediate input *i* sourced from country *r* that is needed to produce a unit of output *j* in country *s*, **x** is the output vector and **y** is the vector of total final demand of countries, where each element y^r represents the worldwide final demand for products of the industry in country *r*. **L** is the Leontief inverse whose elements represents all the production generated in sector *i* and region *r* to fulfil the demands of inputs incorporated in all the steps of the production chain and ending in the final demand of sector *j* in region *s*.

From here we build the matrix of inoperability A* as in expression (2)

$$A^* = \hat{x}^{-1} A \hat{x} \qquad (2)$$

The elements of a particular row of an interdependency matrix tells us the additional inoperability added by each column (e.g., country-sector). Our view is that the average of each row can be interpreted as the average dependency of each chain.

Besides, business and management literature claim that in the last decade there was a tendency towards concentration of supply, increasing the vulnerability of the chains. Because of that the standard deviation of the Leontief inverse should also be considered as a proxy of previous idea.

We also calculate backward and forward linkages as measures of exposure to supply and demand. The backward is calculated as the sum of the sum columns of matrix A of technical coefficients and represents the share of foreign value added from foreign input providers. The forward is calculated as the sum rows of matrix B from Ghosh model and shows the share of exports of a given country on demand from foreign countries.

We finally calculate the position of countries/regions making use the measure of Antràs et al. (2012). It is the (weighted) average position of a region's output in the value chain in a specific year t, multiplying each term by their distance from final use plus one. Mathematically it is calculated as follows

$$POS_t^r = \frac{y_t^r}{x_t^r} + 2 * \frac{\sum_s a_t^{rs} y_t^s}{x_t^r} + 3 * \frac{\sum_s \sum_k a_t^{rk} a_t^{ks} y_t^s}{x_t^r} + 4 * \frac{\sum_s \sum_k \sum_t a_t^{rk} a_t^{kp} a_t^{ps} y_t^s}{x_t^r}$$
$$+ 5 * \frac{\sum_s \sum_k \sum_t \sum_d a_t^{rk} a_t^{kp} a_t^{pd} a_t^{ds} y_t^s}{x_t^r} \qquad (3)$$

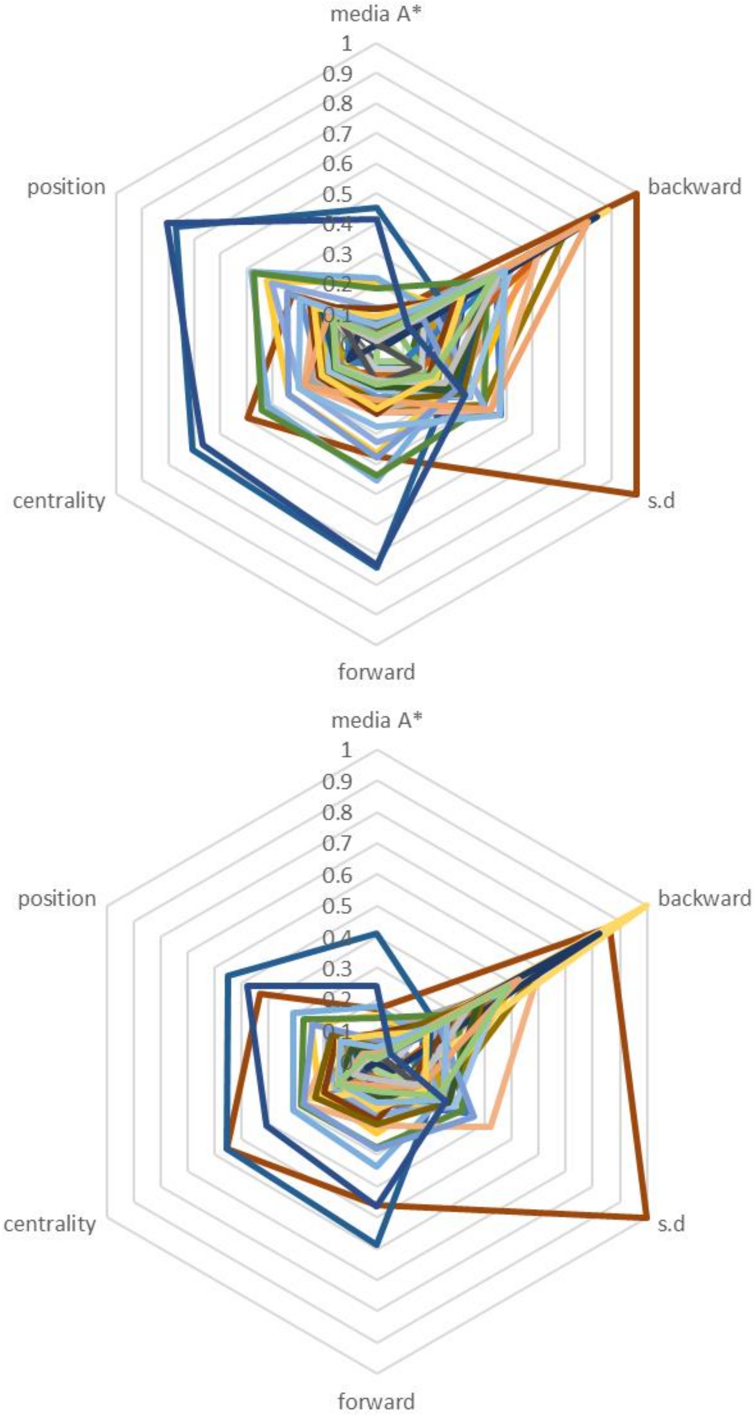
The interpretation of this measure is that larger values of position are associated with higher levels of upstreamness of region. That is to say, the higher the value of position, the higher the level of upstreamness and the region is situated in the first steps of the global value chain, being an exporter of intermediate inputs and an importer of final goods. On the contrary, the lower the value of position measure, the higher the level of downstreamness of region, being an importer of intermediate inputs and an exporter of final goods. Previous literature show that the more upstream a country is, the higher is the risk of disruption.

Empirically, we will use WIOD and EUREGIO database. WIOD database covers the period 2000-2014 and it is constituted by 44 countries (included RoW). EUREGIO database is a regional database which covers 249 European regions with a disaggregation of 14 economic sectors for the period 2000-2010. Making use of these two databases, the objective is to analyze the evolution of risk in global value chains at the national and regional levels.

Preliminary results

Applying the risk measures explained above, we have obtained a series of preliminary results. Figure 1 shows the results obtained for the WIOD database.

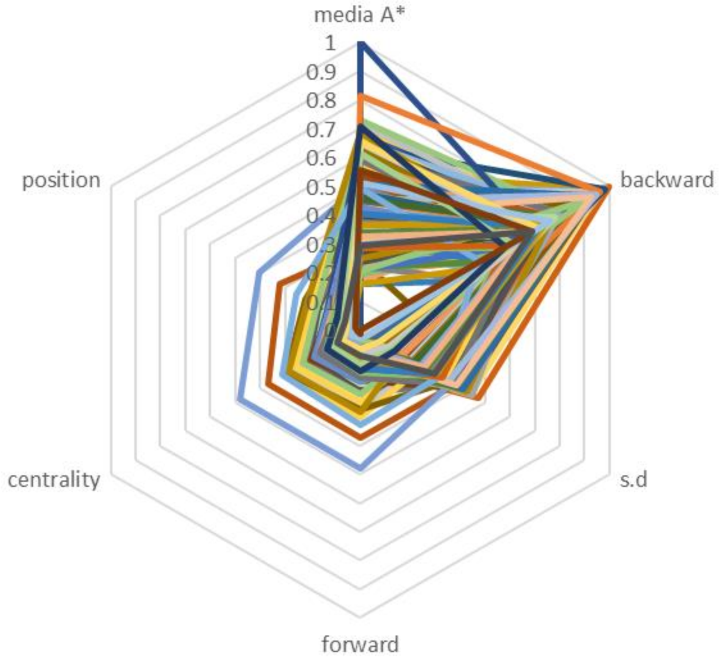
FIGURE 1.
Risk results for WIOD database, 2000 and 2014, respectively

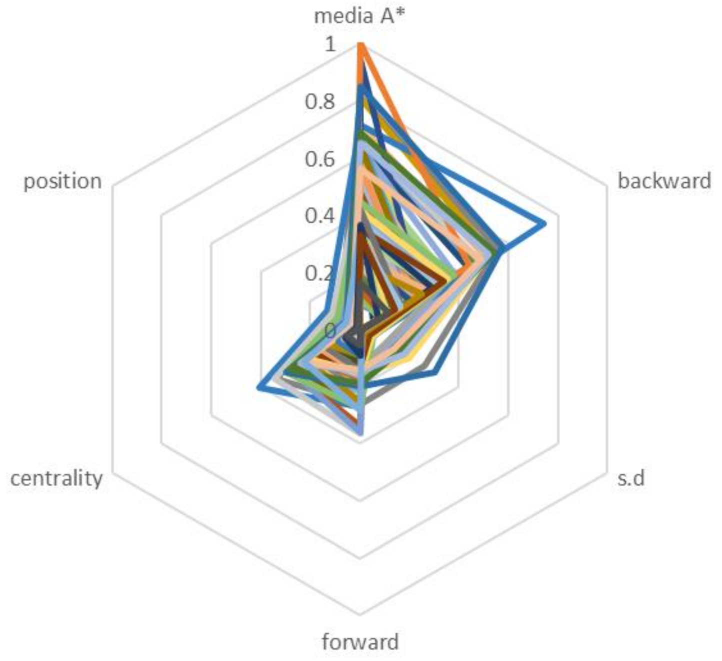


Source: Own elaboration

As we can observe in Figure 1, there are greater differences between countries in 2014 than in the first year of the database (2000). In the first year, and despite the fact that countries such as Germany or the USA (two blue lines) seem to present higher values of the "forward", "position" and "centrality" measures, the patterns followed by all the countries in the sample are similar with the exception of China (dark red line) that presents completely different patterns than the rest of the sample. However, in the second figure (corresponds to 2014), countries no longer show similar patterns of risk behavior. For example, China presents high values for the "backward" and the "standard deviation", which shows its great exposure to global production processes on the supply side, as well as a greater risk due to its high standard deviation (lower concentration, lower risk in GVCs).

FIGURE 2
Risk results for EUREGIO database, 2000 and 2010, respectively





Source: Own elaboration

Figure 2 shows the same procedure applied to the EUREGIO database for the first and last year of the sample (2000 and 2010, respectively). In this case, at the regional level, greater differences are observed at the beginning of the period (in the year 2000). Once again, the first graph shows how the European regions follow very similar patterns, which indicates an increase in the dependency between them. The lines that stand out in this case correspond to regions of Eastern countries (such as Slovakia and Lithuania) and to regions of some Central European countries (such as Luxembourg or France).

Final comments

The recent processes of globalization and internationalization of production processes have led many countries and regions of the world to present a greater productive dependence on each other. The fact of having greater interdependence entails certain risks in these processes, and therefore, in the generation of global value chains. As stated above, the main objective of this paper is to propose different indicators of GVCs risks and draw the taxonomy of countries, regions, and sectors based on them.

Therefore, after carrying out some very preliminary analyses, we can draw some initial conclusions. It seems that there are very similar patterns of risk in global value chains, both at the national level (measured with WIOD) and at the regional level (measured with EUREGIO). In the first case, we obtain that the countries present greater differences between them towards the end of the period studied, the opposite occurring at the regional level. In addition, some countries like China stand out for their low risk related to their high levels of dispersion and their weak linkages with the rest of the sample. On the other hand, Germany and the USA present a higher level of risk related to low dispersion (lower standard deviation) and a high backward and forward value (large linkages on the demand and supply sides, respectively).

In the next steps we will apply a principal component analysis to get one indicator of risk. Later, we will estimate the impact this indicator have on economic growth and environmental damage.

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Keywords: *risk disruptions, supply chains, input-output, principal component analysis*
JEL codes: F10, F60