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Sectoral Impacts of the Activity Standstill due to External Shocks such as COVID-19: An Approach Based on the Hypothetical Extraction Applied to the External Insertion of the Spanish Economy

Impactos sectoriales de la paralización de la actividad debido a impactos externos como el COVID-19: aproximación basada en la extracción hipotética aplicada a la inserción externa de la economía española

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Abstract

The COVID-19 pandemic has brought economic activity to a standstill unprecedented in recent history. The aim of this paper is to analyse the potential economic and sectoral impact resulting from suspension of certain activities. The analysis of production linkages and the hypothetical extraction method constitute the methods are applied, taking as a reference trade relation of Spain with the EU, USA and China in 2015. The results obtained based on the four possible scenarios proposed show a decline in GDP due to the paralysis of a set of sectors, revealing the existence of strong production linkages through Global Value Chains.

Keywords: production linkages; activity standstill; Global Value Chains; COVID-19; Spanish economy.

Resumen

La pandemia del COVID-19 ha provocado una paralización de la actividad económica sin precedentes en la historia reciente. El objetivo de este trabajo es analizar el impacto económico y sectorial potencial resultante de la suspensión de determinadas actividades. Los métodos empleados son el análisis de los encadenamientos productivos y el método de extracción hipotética, tomando como referencia las relaciones comerciales de España con la UE, EE. UU. y China en 2015. Los resultados obtenidos en base a cuatro posibles escenarios muestran un descenso del PIB debido a la parálisis de determinados sectores, revelando la existencia de importantes encadenamientos productivos a través de las Cadenas Globales de Valor.

Palabras clave: encadenamientos productivos; paralización de actividad; Cadenas Globales de Valor; COVID-19; economía española.

JEL classification/ clasificación JEL: F14; F17; C67.

1. Introduction

The COVID-19 crisis has led to a progressive standstill of the economic activity on a global scale, although not with the same intensity nor at the same time in all regions. This paralysis of production activity is taking place at a historical moment characterised by the intense process of economic globalisation that has been taking place over the last few decades. Moreover, it is a paralysis that affects both the demand side (confinement of the population and fall in consumption) and the supply side (closure of activities and supply disruptions), which makes its impact more complex and intense.

While the economic and social consequences of this kind of shocks are evident, there is a lack of knowledge and growing concern about the economic implications arising from decisions taken in these pandemic situations. In addition, there is a growing scientific interest in deepening our knowledge of a phenomenon that has so far been barely considered in the economic literature.

The aim of this paper is to analyse the potential economic and sectoral impact that results from the selective standstill of activities in a pandemic and global context such as the COVID-19, applied to the case of the Spanish economy and its external insertion. This analysis combines two methodological approaches, namely the production linkage approach and the hypothetical extraction approach, both based on input-output methodology. The data source used is the value-added trade *TiVA* database (OECD, version December 2018). Data has been collected for a set of 35 sectors for Spain, the European Union (excluding Spain from the set), the USA and China (these three territories represent most of Spanish trade relations).

The novelty of this paper is twofold. Firstly, it is one of the first attempts to assess the potential economic and sectoral impacts on the Spanish economy due to COVID-19 pandemic. Secondly, it uses *TiVA* database to identify the key, driving and driven sectors in order to isolate them from the system.

The paper consists of 4 sections, in addition to this introduction. Section 2 provides a brief review of recent literature on the extension of GVC and the relevance of international sectoral linkages, as well as a brief review of recent contributions on the impact of Covid-19 in the economic field. Section 3 presents the input-output methodology on production linkages and the hypothetical extraction method. Section 4 presents and discusses the main results. Finally, section 5 points out the main conclusions.

2. LITERATURE REVIEW

The globalisation process that has taken place over the last few decades differs from previous internalisation processes –where the place of production was already decoupled from the place of consumption– in various dimensions, such as the decrease of costs associated with the coordination of geographically dispersed activities, the rise of information and communication technologies and the decrease of transport costs (Feenstra, 1998; Gereffi, 1994, 1999; Gereffi et al., 2001; Timmer et al., 2014).

This has led to the rise of Global Value Chains (GVC), which are complex production networks characterized by the geographical dispersion of the different production stages of the same final product. The study of GVCs provides a better understanding of the characteristics of global industries, as well as on the performance of customers and suppliers networks that compose them (Gereffi & Fernandez-Stark, 2016).

According to the needs and capacities of the agents participating in global production networks, these are organized under different governance criteria. In this sense, depending on the relationship between the chain's leading multinationals and the associated companies, opportunities for economic development may arise, especially in the most relational and collaborative governance patterns –of mutual dependence and knowledge exchange between the companies integrated in the GVC–(Fransen & Knorringa, 2018; Gereffi, 2005; Gereffi & Lee, 2016; Humphrey & Schmitz, 2001).

The opportunities for economic improvement within the GVC are better known in the literature as upgrading processes, which consist in moving towards tasks that provide greater value added within the GVC in which a company participates. Industrial upgrading processes are closely related to innovative practices (Golini et al., 2018; Lee et al., 2018; Pietrobelli & Rabellotti, 2011; Pietrobelli & Staritz, 2018; Tian et al., 2019).

Although there are many opportunities for economic progress, participating in GVC is not exempt from risk: the high international competitiveness faced by companies, the need to make significant investments in order to participate in them, as well as labour and environmental problems arising from integration in the GVC –especially in developing countries– are just some of the issues that can be addressed. Several studies have analysed the risks derived from participating in GVCs, generally known as downgrading, which point out issues mainly related to the closure of some companies or the worsening of labour conditions as a vehicle for reducing costs and improving competitiveness through price reduction (Bernhardt, 2013; Chena & Noguera, 2020; Gereffi & Luo, 2014; Godfrey, 2015; Pegler, 2015; Selva & Medina, 2018).

However, regardless of how each individual GVC is managed and the benefits or risks involved, joining a GVC always entails significant interdependence with the other economies participating in the same network –and more particularly with the related.

This dependence may occur, in terms of production chains analysis, forward –dependence on sales– and/or backward –dependence on suppliers. Several studies have analysed industrial development policies based on the support to key industries identified in terms of internal and external production linkages. Also, they point out the importance of having a strong industrial system as a key element to be able to take advantage of the opportunities arising from the integration in the GVCs (Baldwin & Venables, 2015; López González et al., 2019).

The COVID-19 crisis has highlighted a new risk associated with the participation and extension of GVCs. The asymmetric paralysis of the economic activity in different sectors and in different countries has generated problems with the supply of certain products. These problems have been either due to the paralysis of the international transport of goods –preventing the procurement of inputs or the transport of finished products– or due to the paralysis of some of the intermediate industries of the global industrial network –hindering the completion of the productive cycle. As a result of this, many studies have recently emerged trying to outline the economic impact of the pandemic (Albert & Tercero-Lucas, 2020; Binder, 2020; Gong et al., 2020; McKibbin & Fernando, 2020; Nicola et al., 2020).

Crises associated with pandemics or adverse situations such as COVID-19 can lead to significant economic problems due to the internal paralysis of a country's economic activity. However, with the growing industrial interdependence of recent decades, the occasional standstill of a sector abroad can generate other internal economic problems (e.g., shortage of parts and components) due to foreign or external production linkages. In fact, it has been found that the existence of significant or critical external backward linkages can lead to a shortage of the necessary inputs for domestic companies to operate (Goldenberg, 2020; Kohler, 2020). Moreover, in the case of critical forward linkages, sectors with a strong presence in foreign markets could suffer a strong impact by losing an important amount of sales.

Within this framework, the work carried out by Dietzenbacher (2002, pp. 134-135) for a group of European countries found out that, especially in the case of forward linkages, some sectors are specialized in the internal market while others are specialized –and therefore dependent– on the external market. With regard to backward linkages, they point out that in general all sectors show some dependence on external inputs.

The study carried out by Boundi Chraki (2017) finds a high level of dependence in both purchases and sales among the member economies of the North American Free Trade Agreement (NAFTA), with Canada and Mexico being especially dependent on the US economy. The strong interdependence of this area suggests that the countries with important trade relations maintain high levels of productive interdependence between them (Rodil, 2017). Also, the work carried out by Boffa (2018) for a set of 66 countries finds important productive chains for some Asian countries with intense trade relations among them, emphasizing the central role played by China. Undoubtedly, in areas

with a higher degree of economic integration, such as the European Union, greater levels of intersectoral dependence will be found.

Regarding the problems arising from the COVID-19 crisis, the hypothetical extraction method emerges as a suitable analytical tool for inferring the economic consequences of a standstill of activity. This method was developed and improved by several authors (Cella, 1984; Clements, 1990; Strassert, 1968, among others) and consists essentially of measuring the economic impact in terms of total output or GDP resulting from the standstill (extraction) of a sector in an economy through input-output methodology.

Recently, Dietzenbacher et al. (2019) have proposed an extension of the hypothetical extraction method on an international scale, using multi-regional input-output tables (MRIO), although similar exercises have been carried out previously (Dietzenbacher et al., 1993; Zhao et al., 2016). In the above-mentioned proposal, the authors modelled the method of global extraction, pointing out an important difference with respect to the classic hypothetical extraction, which is focused on the national case. This methodological extension points out that global GDP does not change when a sector in a specific country is paralysed, assuming that the global final demand remains constant after the standstill of that sector.

Although the proposed method is useful for analysing the consequences of adverse situations or pandemics such as COVID-19, the assumption of fixed final demand is not appropriate in this context. The reason for this is that the COVID-19 pandemic has not only brought certain economic activities to a standstill but has also changed consumption patterns. In many countries, measures have been adopted to confine the population, thus paralysing not only production activity but also certain consumption categories. In this sense, in contrast to Dietzenbacher et al. (2019), it cannot be assumed that the overall GDP does not vary, since no sector in another country would be willing (or capable) to meet the production of the foreign sector that is ceasing activity, as final demand is paralyzed at the same time.

3. Methodology and data

3.1. Production linkages analysis

The open input-output (IO) system introduced by Leontief (1951) allows the analysis of the interactions of an economy, taking into consideration the origin and destination of the goods and services produced as well as the intermediate sells. In this framework, it is possible to analyse the linkages between industries, from the demand side (backward linkages) and from the supply side (forward linkages). The national IO model can be extended to include information on multiple economies (multi-regional IO or MRIO) in order to capture international sectoral interdependence.

The data for the analysis described below has been collected from the 2018 edition of TiVA (Trade in Value Added) database from the OECD. In particular, the information available on the indicator "Origin of value added in final demand" has been used as inter-industry transactions matrix (T)which, in this particular indicator, provides information on the origin of value added (by country and sector) to both domestic and external final demand. Interindustry relations between Spain, the United States, China and the European Union (EU27, by excluding Spain from the set) have been collected for a set of 35 sectors for the year 2015. The selection of these countries makes it possible to simplify the analysis with a minimum information loss, since the three areas account for around 70% of Spain's foreign trade relations. The total output of each country and sector has been obtained directly from the same database.

Using matrix notation, for a set of S sectors and n countries, the basic IO relations in the multi-regional model are as follows:

$$X=Ti+Fi$$
$$A=T\hat{X}^{-1}; \quad X=AX+Fi \tag{1}$$

Where $X_{(sn)\times 1}$, $T_{(sn)\times(sn)}$ y $F_{(sn)\times n}$ are the matrices of total output, intermediate transactions and final demand, respectively. $A_{(sn)\times(sn)}$ is the technical production coefficient matrix (direct input coefficients), a ratio indicating the proportion acquired by each purchasing sector, j, to each supplier sector, r, including diagonal cases where j=r. Also, i represents a unit matrix of the right size to perform the precise operations (snx1 to operate with T and nx1 to operate with F). $\hat{X}_{(sn)\times(sn)}$ is a square matrix in whose diagonal are the values of total output matrix X, where all other values are zero (any variable with a circumflex accent must be understood in the same way).

Rearranging results in the following:

$$Fi=(I-A)X$$
$$X=(I-A)^{-1}Fi=LFi \tag{2}$$

Where $L_{(sn)\times(sn)}$ is Leontief's inverse matrix, which reports on the production required by each sector to satisfy a unit of final demand. As an alternative to the demand-side model presented by Leontief, Ghosh (1958) proposed a supply-side model that relates total production to primary inputs. In practical terms, while in the demand model each column of matrix T is divided by matrix X, in the supply-side model, each row of the intermediate transaction matrix is divided by X. With $B_{(sn)\times(sn)}$ being the direct output coefficients matrix and $G_{(sn)\times(sn)}$ the inverse Ghosh matrix, they are obtained as follows:

$$B=\hat{X}^{-1}T; \quad T=\hat{X}^{-1}B$$
$$G=(I-B)^{-1}; \quad X=G'P \tag{3}$$

Where $P_{(1)\times(sn)}$ is the primary inputs vector[1]. Conceptually, Leontief's demand-side model assumes that input coefficients are fixed, while in Ghosh's model output coefficients are assumed to be fixed.

In general, Leontief's demand model is considered more appropriate for analysing backward production linkages, which measure changes in the intermediate demand of a sector when it undergoes a change in its production level. On the other hand, Ghosh supply-side model is considered the most appropriate for the analysis of forward linkages, which measure the changes in the intermediate supply of a sector when faced with changes in its output level[2].

Before proceeding to the mathematical description of the linkages, it should be clarified that in a multiregional model it is possible to differentiate linkages at three levels: strictly internal, strictly external and both, internal and external linkages of an economy jointly.

Henceforth, a two-country (C and d) model is assumed. In such a model, L and G matrices can be represented as a sub-matrix construction:

$$L=\begin{bmatrix} L^{cc} & L^{cd} \\ L^{dc} & L^{dd} \end{bmatrix}; \quad G=\begin{bmatrix} G^{cc} & G^{cd} \\ G^{dc} & G^{dd} \end{bmatrix} \tag{4}$$

In a multi-regional model, the first superscript represents the country of origin and the second the country of destination (where indicated, the first subscript represents the origin sector and the second the destination sector). For country C, strictly internal linkages derive from L^{cc} and G^{cc} while strictly external linkages derive from L^{cd} and G^{cd}.

A simple calculation of backward total linkages[3], bl_t, is the column sum of Leontief's inverse. Similarly, to obtain the total forward linkages, fl_t, the elements of the Ghosh inverse are added in rows. In a two-country model, total backward and forward linkages of country c are defined as:

$$\begin{aligned} bl_t(c)&=bl_t(cc)+bl_t(cd)=i'L^{cc}+i'L^{dc} \\ fl_t(c)&=f_t(cc)+fl_t(cd)=G^{cc}i+G^{dc}i \end{aligned} \tag{5}$$

[1] According to the equivalences of the input-output models, the total output (*X*) obtained from final demand is equivalent to that obtained from primary inputs, yet in the definition of the Ghosh model, which focuses on the supply side, primary inputs are used by definition in obtaining *X*.

[2] Despite the utility of the Ghosh model to measure forward linkages, there is some controversy about its use for a more extended IO analysis due to its possible inconsistency, model stability issues, and its interpretation, among other problems (De Mesnard, 2009; Guerra & Sancho, 2011).

[3] Direct linkages are derived from the technical coefficient matrices, *A* and *B*, while total linkages are obtained from Leontief (*L*) and Ghosh (*G*) inverse matrices. The estimation of total linkages is considered more appropriate as they reflect together the direct and indirect inter-sectoral relationships of an economy.

The elements $i'L^{cc}$ and $G^{cc}i$ capture the total internal backward and forward linkages, respectively. On the other hand, $i'L^{dc}$ and $G^{dc}i$ capture the total external backward and forward linkages.

In order to be able to classify the sectors of an economy according to their linkages, it is possible to normalize the indicators defined in (5). The average value of the set of backward and forward linkages is the unit, therefore those sectors with a normalized value above the average can be considered more relevant. When working with a multi-regional input-output model, standardized measures are first obtained independently for internal and external relations:

$$\overline{bl_t}(cc)=\frac{si'L^{cc}}{i'L^{cc}i}=\frac{sbl_t(cc)}{bl_t(cc)i};\quad \overline{fl_t}(cc)=\frac{sG^{cc}i}{i'G^{cc}i}=\frac{sfl_t(cc)}{i'fl_t(cc)}$$
$$\overline{bl_t}(dc)=\frac{si'L^{dc}}{i'L^{dc}i}=\frac{sbl_t(dc)}{bl_t(dc)i};\quad \overline{fl_t}(cd)=\frac{sG^{cd}i}{i'G^{cd}i}=\frac{sfl_t(cd)}{i'fl_t(cd)} \tag{6}$$

Whereas $\overline{bl_t}(cc)$ and $\overline{fl_t}(cc)$ capture the total standardised forward and backward linkages within country C, $\overline{bl_t}(dc)$ and $\overline{fl_t}(cd)$ capture country C total standardised external linkages. It is possible to obtain the total internal and external backward linkages of country c performing the following operation, in linear terms:

$$\overline{bl_t}(c)_j=\frac{\sum_{r=1}^{s} l_{rj}^{cc}+\sum_{r=1}^{s} l_{rj}^{dc}}{\left(\frac{1}{s}\right)\left(\sum_{r=1}^{s} l_{rj}^{cc}\sum_{j=1}^{s} l_{rj}^{cc}+\sum_{r=1}^{s} l_{rj}^{dc}\sum_{j=1}^{s} l_{rj}^{dc}\right)} \tag{7}$$

The standardized measure of total forward linkages internal and external of country c is obtained as follows:

$$\overline{fl_t}(c)_r=\frac{\sum_{j=1}^{s} l_{rj}^{cc}+\sum_{j=1}^{s} l_{rj}^{cd}}{\left(\frac{1}{s}\right)\left(\sum_{r=1}^{s} l_{rj}^{cc}\sum_{j=1}^{s} l_{rj}^{cc}+\sum_{r=1}^{s} l_{rj}^{cd}\sum_{j=1}^{s} l_{rj}^{cd}\right)} \tag{8}$$

In matrix terminology, expressions (7) y (8) can be expressed as follows:

$$\overline{bl_t}(c)_j=\frac{s\left(i'L^{cc}+i'L^{dc}\right)}{i'L^{cc}i+i'L^{dc}i};\quad \overline{fl_t}(c)_r=\frac{s\left(G^{cc}i+G^{cd}i\right)}{i'G^{cc}i+i'G^{cd}i} \tag{9}$$

3.2. HYPOTHETICAL EXTRACTION METHOD

Like the analysis of production linkages, the hypothetical extraction method aims to understand the importance of a sector in a country's economy. Conceptually, it consists in the analysis of how a country's production varies

if a sector is extracted from an economy. This method is appropriate for inferring the effects derived from the paralysis of the most relevant sectors of an economy, such as the one that has happened during the coronavirus crisis in various countries.

Technically, the method consists in removing (that is, to replace with "zeros") the row and column corresponding to the sector to be analysed from the technical production coefficient matrix, A, and from the final demand matrix, F.

A* and F* represent the new matrices after removing the column and row corresponding to the paralysed sector in the technical coefficient matrix and in the final demand matrix. The new total output matrix, X* can be obtained through expression (2):

$$X^{*}=\left(I-A^{*}\right)^{-1}Fi^{*}=L^{*}Fi^{*} \tag{10}$$

With L* being the new Leontief inverse matrix. A way to measure economic loss, Q, es:

$$Q=i'X-i'X^{*};\qquad Q\%=100\times\frac{i'X-i'X^{*}}{i'X} \tag{11}$$

To know the variation in terms of GDP (ΔGDP), it is necessary to apply the value-added coefficients, V, to expression (11):

$$v=1-i'A$$

$$\Delta GDP=vX-vX^{*};\qquad \Delta GDP\%=100\times\frac{vX-vX^{*}}{vX} \tag{12}$$

Note that in the estimation of the new GDP the value-added coefficients remain constant. This is because this analysis assumes that companies do not have the capacity in the short and medium term to change their production structure in the face of the paralysis of certain activities at home or abroad (i.e. in the short term it is assumed that they cannot replace the tasks of the global value chain that have been paralysed by an external shock).

In a multi-regional input-output model, it must be considered that by subtracting sector j from country c, this sector will stop importing and exporting to other sectors in other countries, whose technical coefficients of production and final demand to the subtracted sector must also be eliminated (replaced by "zeros"). That is, following the examples above, in a two-country and two-sector model, let assume that sector k in country c is paralyzed. The paralysed sector will not make any purchases or sales to other sectors in the same country or abroad (the corresponding technical production coefficients are zero). Nor will it make any sales to domestic or foreign final consumers. Being f_j^{cc} the final demand of sector j within country

c, and f_i^{cd} the final demand of sector j from country c with destination country d, mathematically this is defined as follows:

$$a_{kj}^{*cc}=a_{kj}^{*cd}=a_{ik}^{*dc}=0, \quad \forall i,j$$
$$f_k^{*cc}=f_k^{*cd}=0 \tag{13}$$

4. Results and discussion

First, total production chains in Spain, both internal and external, are presented for the 35 sectors analysed in 2015 (see Table 1), calculated as indicated in the expressions (7), (8) and (9). Key sectors are those whose forward and backward participation rates are both higher than unity. On the other hand, driving sectors are those with a backward share greater than one and driven sectors are those with a forward share greater than one.

In the context presented by the COVID-19 shock –or other similar crises–, characterised by the standstill of economic activity and final consumption, it can be stated that the driving sectors are also dependent on purchases (they depend on other sectors to be able to perform their production activity) and the driven sectors are dependent on sales (they depend on other industries as suppliers of them). Therefore, key industries are dependent on both purchases and sales at the same time.

As shown in Table 1, considering both internal and external linkages in Spain, service activities (such as accommodation, real estate, health, leisure and education) stand out as key sectors. Also, construction, electronic equipment production and textile production outstand with strong backward linkages.

Table 2 shows Spain's forward and backward production chains, with a distinction between strictly internal chains and the external ones of Spain with the USA, China and the European Union (excluding Spain). The results shown in Table 2 have been obtained according to expressions (5) and (6).

The results in Table 2 show that Spain is especially dependent on purchases from foreign industrial sectors, especially electronic equipment, textiles and machinery. At the same time, Spanish services are the sectors most dependent on sales, such as activities related to accommodation, financial activities, real estate or education. The forward linkages of the Spanish mining sector are also noteworthy.

The results obtained from the hypothetical global extraction are presented below. To estimate the impact in terms of GDP of a standstill in production activity, a selection of seven sectors was first made based on a triple criterion. Firstly, the relevance of their production linkages has been considered according to the results of the previous tables. Secondly, the weight of these sectors in the Spanish economy has been considered. Thirdly, those sectors that are most likely to be effectively paralysed have been selected based on recent experience with COVID-19.

Based on these criteria, the following seven sectors have been selected for the hypothetical extraction process: textiles, recreational activities, wholesale and retail trade, motor vehicles production, tourism, transport and storage, and education (see Annex 2 for correspondence with the sectors in the database).

TABLE 1. NORMALIZED INDEX OF SPAIN'S TOTAL FORWARD AND BACKWARD INTERNAL AND EXTERNAL LINKAGES (2015)

	Spain backward linkages (internal and external)	Spain forward linkages (internal and external)
Agriculture, forestry and fishing	0.707	0.948
Mining and extraction of energy producing products	0.610	0.812
Mining and quarrying of non-energy producing products	0.538	0.790
Mining support service activities	0.591	0.914
Food products, beverages and tobacco	0.821	0.672
Textiles, wearing apparel, leather and related products	*1.020**	0.757
Wood and products of wood and cork	0.588	0.767
Paper products and printing	0.615	0.789
Coke and refined petroleum products	0.646	0.615
Chemicals and pharmaceutical products	0.752	0.721
Rubber and plastic products	0.586	0.757
Other non-metallic mineral products	0.565	0.778
Basic metals	0.535	0.655
Fabricated metal products	0.657	0.775
Computer, electronic and optical products	*1.537**	0.821
Electrical equipment	0.749	0.710
Machinery and equipment, nec	0.967	0.772
Motor vehicles, trailers and semi-trailers	0.810	0.693
Other transport equipment	0.908	0.786
Other manufacturing; repair and installation of machinery and equipment	0.932	0.901
Electricity, gas, water supply, sewerage, waste and remediation services	0.715	0.832
Construction	*1.229**	0.902
Wholesale and retail trade; repair of motor vehicles	0.879	*1.021**
Transportation and storage	0.802	0.874
Accommodation and food services	*1.280**	*1.169**
Publishing, audiovisual and broadcasting activities	0.936	0.895
Telecommunications	0.930	0.998
IT and other information services	0.984	*1.000008**
Financial and insurance activities	0.770	*1.116**
Real estate activities	*1.985**	*2.221**
Other business sector services	0.727	*1.045**
Public admin. and defence; compulsory social security	*2.240**	*1.778**
Education	*3.586**	*3.199**
Human health and social work	*1.358**	*1.308**
Arts, entertainment, recreation and other service activities	*1.446**	*1.210**

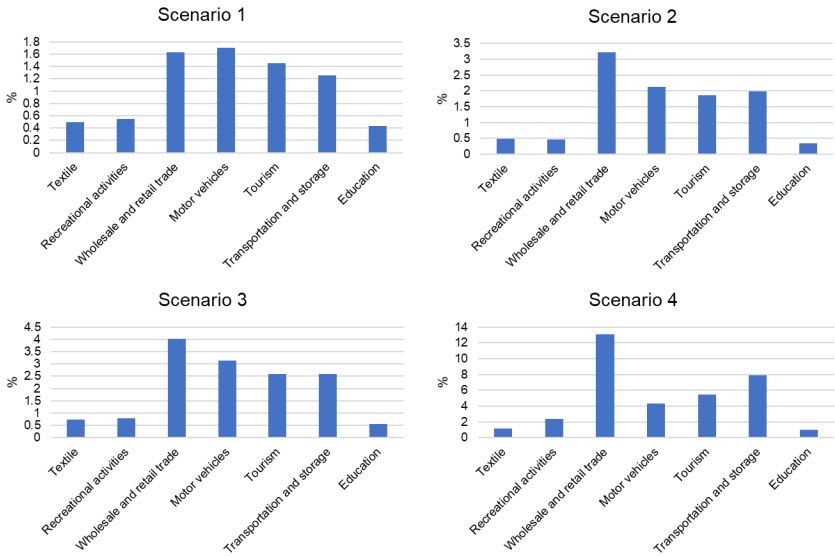
Source: Own elaboration from TiVA (Trade in Value Added, OCDE, 2018).

The hypothetical extraction was carried out for the following four possible scenarios:

- Scenario 1: An external shock paralyses the selected sectors abroad, so that they do not supply neither the domestic nor the foreign market. However, the reference country (Spain) continues to export.
- Scenario 2: An external shock paralyses the exports of the reference country (Spain) for the selected sectors, so that they cannot supply foreign markets with inputs or final consumption goods.
- Scenario 3: The above assumptions are combined, so that the selected sectors are paralysed abroad and the reference country (Spain) is unable to supply foreign markets.
- Scenario 4: An external shock paralyses the selected sectors in the country of reference (Spain), so it is not possible to supply either the domestic market or foreign markets. The rest of the world is not affected.
- For each of the proposed scenarios, the variation in GDP is estimated both for a sector-by-sector standstill and for a simultaneous standstill of the selected sectors. The results for the individual standstill are presented in Figure 1.

It can be seen that in all the four scenarios proposed, Spain's GDP decreases in the face of the paralysis of the selected sectors. Also, as the constraints in each scenario increase, the impact on GDP is greater.

Figure 1. Estimate of the GDP decrease for each of the proposedscenarios. Percentage, 2015



Source: Own elaboration from TiVA (Trade in Value Added, OCDE, 2018).

Table 2. Normalized index of Spain's total forward and backward internal and external linkages by country, 2015

	Backward linkages Spain (normalized)				Forward linkages Spain (normalized)			
	Spain	U.S.	China	EU27*	Spain	U.S.	China	EU27**
Agriculture, forestry and fishing	0.754	0.346	0.156	0.453	0.883	0.764	*1.027**	*1.544**
Mining and extraction of energy producing products	0.632	*1.019**	0.080	0.435	0.777	*1.029**	0.907	*1.048**
Mining and quarrying of non-energy producing products	0.612	0.052	0.017	0.039	0.738	*1.027**	*4.008**	0.934
Mining support service activities	0.616	*1.314**	0.076	0.327	0.617	*4.138**	*2.203**	*2.630**
Food products, beverages and tobacco	0.841	0.629	0.308	0.785	0.718	0.276	0.372	0.397
Textiles, wearing apparel, leather and related products	0.782	0.900	*7.260**	*1.825**	0.722	0.736	0.826	*1.058**
Wood and products of wood and cork	0.647	0.121	0.173	0.204	0.788	0.556	0.743	0.632
Paper products and printing	0.659	0.285	0.113	0.380	0.788	0.707	0.846	0.811
Coke and refined petroleum products	0.677	0.722	0.166	0.445	0.659	0.610	0.295	0.267
Chemicals and pharmaceutical products	0.689	*2.113**	0.433	*1.172**	0.700	*1.02**	*1.174**	0.799
Rubber and plastic products	0.634	0.177	0.187	0.294	0.728	0.881	0.984	0.961
Other non-metallic mineral products	0.631	0.090	0.106	0.124	0.784	0.804	0.599	0.737
Basic metals	0.607	0.032	0.045	0.041	0.669	0.580	0.735	0.544
Fabricated metal products	0.691	0.294	0.363	0.470	0.770	0.919	0.864	0.771
Computer, electronic and optical products	0.758	*6.141**	*12.57**	*5.510**	0.754	*1.343**	*1.638**	*1.210**
Electrical equipment	0.688	0.593	*1.916**	*1.094**	0.699	0.772	0.947	0.768
Machinery and equipment, *nec.*	0.780	*1.265**	*2.078**	*2.491**	0.752	*1.021**	*1.542**	0.825

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Motor vehicles, trailers and semi-trailers	0.699	0.688	0.587	*2.004**	0.649	0.875	0.895	*1.016**
Other transport equipment	0.795	*3.411**	*1.077**	*1.464**	0.770	0.860	0.927	0.890
Other manufacturing; repair and installation of machinery and equipment	0.862	0.973	*1.972**	*1.360**	0.894	0.869	0.846	0.974
Electricity, gas, water supply, sewerage, waste and remediation services	0.784	0.234	0.147	0.280	0.872	0.545	0.578	0.572
Construction	*1.248**	0.898	0.814	*1.214**	*1.003**	0.219	0.212	0.233
Wholesale and retail trade; repair of motor vehicles	0.900	0.778	0.320	0.840	0.972	*1.235**	*1.388**	*1.365**
Transportation and storage	0.839	0.597	0.315	0.596	0.847	*1.004**	0.992	*1.060**
Accommodation and food services	*1.299**	*1.148**	0.351	*1.353**	*1.15**	*1.045**	0.745	*1.398**
Publishing, audiovisual and broadcasting activities	0.974	0.954	0.286	0.712	0.923	0.706	0.627	0.718
Telecommunications	0.963	0.891	0.285	0.773	0.998	0.798	0.774	*1.059**
IT and other information services	0.970	*1.083**	0.280	*1.276**	0.934	*1.871**	*1.134**	*1.354**
Financial and insurance activities	0.818	0.717	0.078	0.475	*1.095**	*1.472**	*1.077**	*1.219**
Real estate activities	*2.184**	0.726	0.235	0.715	*2.326**	*1.343**	*1.131**	*1.594**
Other business sector services	0.787	0.386	0.097	0.356	*1.001**	*1.44**	*1.080**	*1.329**
Public admin. and defence; compulsory social security	*2.404**	*1.114**	0.666	*1.239**	*1.949**	0.632	0.512	0.669
Education	*3.814**	*2.291**	0.551	*2.357**	*3.406**	*1.533**	*1.175**	*1.950**
Human health and social work	*1.453**	0.837	0.429	0.758	*1.393**	0.723	0.647	0.759
Arts, entertainment, recreation and other service activities	*1.508**	*1.183**	0.462	*1.137**	*1.267**	0.649	0.549	0.903

Source: Own elaboration from TiVA (Trade in Value Added, OCDE, 2018).

** EU27 is the name given to the European Union after removing Spain.

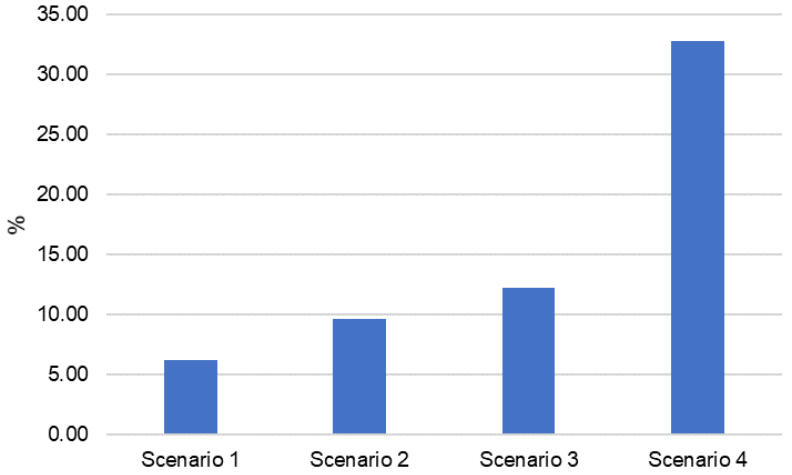
Some similarities can also be drawn between all the scenarios, where the sectors with the greatest impact on GDP are wholesale and retail trade, motor vehicle production, tourism and transportation and storage, with an impact on GDP that ranges from 1.2% to 4% between scenarios 1 to 3.

Scenario 4 shows the most pessimistic results as it is based on the standstill of production activity in Spain for the selected sectors. Here, the impact of the paralysis of wholesale and retail trade stands out, potentially leading to a 12% fall in GDP.

It should be noted that the analysis of the tourism sector is especially complex, since a large part of its economic implications are computed as domestic consumption once foreign tourists enter the country; that is, a significant part of the income derived from foreign tourism is computed as income in the final domestic demand distributed in various sectors. Therefore, for a detailed analysis on the impact of the standstill in tourism, this sector should be considered together with others, especially with the commercial and transport ones.

Figure 2 shows the estimated decline in GDP when considering a joint standstill of the selected sectors for each of the scenarios. In this case, the results of the simultaneous extraction do not correspond to the simple aggregation of the results obtained from the individualized extraction. It is worth noting the difference in the decline in GDP between scenarios 1, 2 and 3 and scenario 4, in which the impact on GDP of a shutdown of production activity in Spain for all selected sectors is greater than 30%. This difference is mainly due to the predominance of the domestic market over GDP (paralysed

FIGURE 2. ESTIMATE OF THE GDP DECREASE FOR A JOINT STANDSTILL OF THE SELECTED SECTORS. PERCENTAGE, 2015



Fuente: Own elaboration from TiVA (OCDE, 2018).

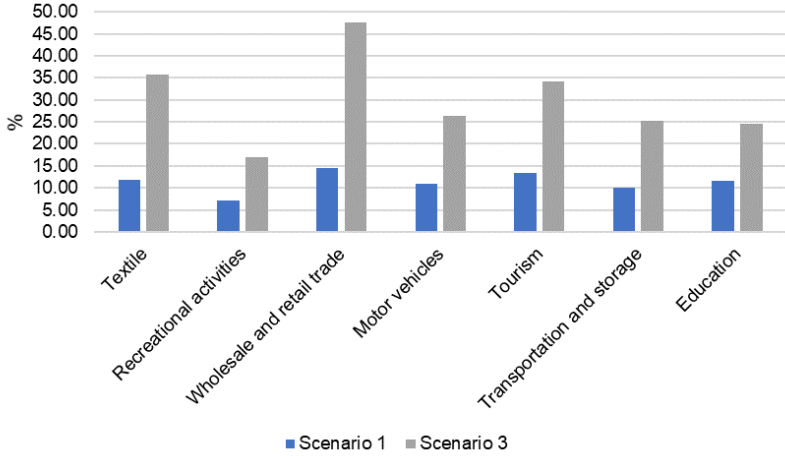
in scenario 4), despite Spain's important external relations with the selected key partners.

This does not mean that the relevance of Spain's external relations should be neglected. In fact, the results indicate that if no inputs are obtained from the foreign selected sectors, Spanish GDP could be reduced by around 5% (scenario 1). If, in addition to not receiving inputs, if it were not possible to supply foreign markets, the impact on GDP would exceed 10% (scenario 3).

Finally, the results show the existence of strong intra-industrial linkages. At the national level, the most affected sectors correspond to the paralyzed industries abroad, although the entire economy bears losses to some extent due to changes in the overall production structure (see Figure 3).

In this sense, all the selected sectors exhibit strong intra-industry relations (although recreational activities to a lesser extent), and therefore the economic loss for the counterpart sectors to those affected is relatively greater than the economic loss for the whole economy.

Figure 3. GDP decrease in the selected Spanish sectors due to the standstill of the same industries abroad. Percentage, 2015



Fuente: Own elaboration from TiVA (OCDE, 2018).
Note: Scenario 2 is not included as its results are, in this case, similar to those of scenario 3.

5. Conclusions

The COVID-19 pandemic has led to a global economic standstill unprecedented in recent history with as yet unknown economic consequences. In a context of intense global production interdependence characterized by

Global Value Chains, it becomes relevant to be able to anticipate the economic effects that similar adverse situations may cause.

The analysis carried out in this paper, which focuses on the external insertion of Spain with the EU, the USA and China based on the study of global production linkages and the hypothetical extraction method (both based on input-output methodology) points to the existence of relevant external linkages that make the Spanish economy vulnerable to shocks that could paralyse production activity. As ins known, this activity standstill can be not only at home, but also abroad, and even in a scenario where the external shock did not lead to the standstill of domestic activity.

The results suggest that, in the short and medium term, an external shock such as a pandemic (e.g., COVID-19) would cause the disruption of inputs (in addition to consumer goods) necessary for production activity. Because of supply shortages, the national industry would not be able to adapt to the new environment. In this sense, firms will not be able, for example, to assume the tasks of their respective global chains that have been paralyzed abroad. Even in the best of the four scenarios considered (paralysis of activity abroad with the possibility that Spain will continue to export), a negative impact on the Spanish economy has been observed (between 6% and 33% depending on the scenario considered). At a sectoral level, intra-industry relations on a global scale stand out, showing that the national sectors most affected by an external standstill of certain activities are precisely their counterpart sectors.

Finally, it is not easy to predict the economic impact of pandemics such as COVID-19 due to their global, asymmetric and uncertain impact. In this regard, many research lines remain open, both in terms of impact and measures to reduce the economic problems arising from the pandemic as new knowledge on COVID-19 is acquired.

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ANNEXE 1

TABLE 3. LIST OF INDUSTRIES

TiVA (December 2018) classification	*ISIC Rev. 4 classification*	*Label*	*TiVA classification*	*ISIC Rev. 4 classification*	*Label*
D01T03	01 to 03	Agriculture, forestry and fishing	D30	30	Other transport equipment
D05T06	05 to 06	Mining and extraction of energy producing products	D31T33	31 to 33	Other manufacturing; repair and installation of machinery and equipment
D07T08	07 to 08	Mining and quarrying of non-energy producing products	D35T39	35 to 39	Electricity, gas, water supply, sewerage, waste and remediation services
D09	9	Mining support service activities	D41T43	41 to 43	Construction
D10T12	10 to 12	Food products, beverages and tobacco	D45T47	45 to 47	Wholesale and retail trade; repair of motor vehicles
D13T15	13 to 15	Textiles, wearing apparel, leather and related products	D49T53	49 to 53	Transportation and storage
D16	16	Wood and products of wood and cork	D55T56	55 to 56	Accommodation and food services
D17T18	17 to 18	Paper products and printing	D58T60	58 to 60	Publishing, audiovisual and broad-casting activities
D19	19	Coke and refined petroleum products	D61	61	Telecommunications
D20T21	20 to 21	Chemicals and pharmaceutical products	D62T63	62 to 63	IT and other information services
D22	22	Rubber and plastic products	D64T66	64 to 66	Financial and insurance activities
D23	23	Other non-metallic mineral products	D68	68	Real estate activities
D24	24	Basic metals	D69T82	69 to 82	Other business sector services
D25	25	Fabricated metal products	D84	84	Public admin. and defence; com-pulsory social security
D26	26	Computer, electronic and optical products	D85	85	Education
D27	27	Electrical equipment	D86T88	86 to 88	Human health and social work
D28	28	Machinery and equipment, nec	D90T96	90 to 96	Arts, entertainment, recreation and other service activities
D29	29	Motor vehicles, trailers and semi-trailers			

ANNEXE 2

TABLE 4. CORRESPONDENCE OF THE SELECTED SECTORS WITH TiVA DATABASE CLASSIFICATION

Textiles, wearing apparel, leather and related products	Textile
Arts, entertainment, recreation and other service activities	Recreational activities
Wholesale and retail trade; repair of motor vehicles	Wholesale and retail trade
Motor vehicles, trailers and semi-trailers	Motor vehicles
Accommodation and food services	Tourism
Transportation and storage	Transportation and storage
Education	Education