Worldwide economic tsunami from the 2011 Japanese disaster

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Abstract

One year ahead from the natural disaster that affected Japan on March 2011 and the subsequent nuclear crisis, large uncertainty still exists in the quantification of its global economic consequences. Most of the studies account for the local physical damage excluding the cascading effects on world economies generated by disruption in the international supply-production chain. By combining a multiregional input-output model (MRIO) and the recently published World Input-Output Database (WIOD), this paper provides the first attempt of estimation of the global economic impacts generated by Japanese disaster. Starting from disruption in the supply-production chain of the "transport equipment" industry, the global economic impacts have been quantified and presented disaggregated by countries and sectors. Results show that the total reduction of output and GDP amounted to €270.5 billion and €94.3 billion, respectively and the most affected areas are Japan, United States and European Union.

Keywords: Natural disasters; Transport equipment industry, Supply-chain disruptions, Multi regional input-output, Japan

1. Introduction

The 9-degree Richter-scale earthquake that struck Japan on the 11^{th} of March of 2011, the tsunami that followed and the subsequent nuclear crisis largely affected the Japanese and the global economy. A report elaborated by the Japanese government estimated that the structural damage suffered by infrastructures, housings and firms ranges between €145 billion to €230 billion, corresponding to 3.6% and 5.6% of the Gross Domestic Product (GDP) in 2010 (Japan, Ministry of Economy, Trade and Industry, 2011). In addition, the electricity shortages and the structural damage that reduced the Japanese production capacities also affected the international production chain, extending the economic impacts largely beyond the national borders. According to data provided by the Japanese government, between February 2011 and May 2011 the Japanese exports decreased by €19.1 billion, generating important consequences in other countries, and particularly in sectors related to the automotive industry where Japan holds a strategic and leadership role. Damages suffered by Japanese factories and disruptions in the supply-production chain forced many companies to suspend production with consequent reduction of import-export activities and rapidly cascading effects on the global economy. The organization of industrial production on the basis of a just-in-time strategy and the high technological and specialized Japanese exports made impossible for other countries to supply international markets with products previously provided by Japan. Assembling a car requires more than 10,000 individual pieces, and every single one is needed to produce a finished product. As a consequence, the reduction in Japanese exports of transport equipments generated drops in the global production of vehicles. Immediately after the earthquake, for example, Toyota, Honda, Opel, Nissan and General Motors had frozen their production with losses of €54 million a day (Autonews website). Canis (2011) estimated that around 4.2 million vehicles were left to be produced, out of which 2 million would correspond to vehicles produced outside Japan. These supply shocks were rapidly transmitted not only to the whole transport equipments industry, which includes the manufacture of motor vehicles, parts, accessories, and other transport equipment (including ships, trains, aircrafts, motorcycles, etc) but also to other industries connected to these sectors such as the fabrication of basic metals, the fabricated metals and the production of rubbers and plastics. This domino effect was rapidly spread around worldwide. The increasing globalization of the international supply-production chain and the large inter-connectivity of world economies are the main reasons for the cascading effects which caused a high vulnerability of regional economies to any kind of disaster occurring anywhere in the world (Barker and Santos, 2010; Krausmann, 2004; Regmi, 2001; Yamano et al., 2007). In addition, the complex and the increasing connection that currently exists among countries and productions make difficult to quantify the total impacts generated by unexpected events. The lack of up-to-date international databases able to capture the trade relationships between countries and sectors, and the consequent limited use of multiregional models have made so far very difficult to carry out any kind of estimation of the cascading effects generated by Japanese natural disaster and resulting from disruptions in the international supply-production chain. Thus far, one year ahead from the Japanese earthquake, large uncertainties still exist in the quantification of its worldwide economic impacts. For this reason, most of the published estimations just accounted for the physical damage to infrastructures and/or for the direct losses of utilities and businesses. In an ever increasing inter-connected world, however, the quantification of the global economic impacts and the identification of the main transfer flows become of primary importance in order to reduce the magnitude of the socio-economic impact. In particular, the increasing frequency and magnitude of natural disasters and extreme events, generated by global warming and environmental stress, made risk management strategies and recoveries of primary importance both at national and international level (Monirul and Mirza, 2003). For these reasons, there is an urgent necessity of multi-regional models and databases able to include a fully-fledged description of international trade and supply-production chains.

The European Commission's Joint Research Centre - IPTS contributed to the FP7-funded project World Input-Output Database (WIOD) that provides the necessary information to estimate the local and the global impacts generated by unexpected events. In this paper, a Multi-Regional Input-Output model (MRIO) and the WIOD database are used to quantify the worldwide economic impacts generated by disruption in the international supply-production chain of "transport equipment" industry generated by Japanese disaster of March 2011. As far as we know, this is the first time that a MRIO model and a complete world input-output database are used to estimate the total economic effects generated by a catastrophic event. The paper is structured as follows: section 2 presents the inter-regional input-output model used to estimate the global economic impacts of the Japanese disaster and provides a short review of the studies that previously used similar methodologies. Section 3 reports data and data sources. Section 4 presents the results and section 5 the conclusions.

2. The Multi Regional Input-Output model

The model used in this paper to estimate the worldwide economics effects generated by Japanese disaster is based on the Input-Output (I-O) approach developed in the mid 20th century by the Nobel Prize Wassily Leontief. Constituted by a set of Supply, Use and I-O tables describing the flows of goods and services between economic sectors, the I-O approach is generally used to build economic models and to estimate the effects of economic changes. In addition, the information contained on the I-O tables of different regions/countries can be combined, using bilateral trade flows data, to develop Multi Regional Input-Output models (MRIO). A vast variety of I-O models have been used to analyze the inter-sectoral/intra-sectoral relationships and to estimate the economic impacts generated by unexpected events such as natural catastrophes (Okuyama et al., 1999, 2004; Okuyama, 2004; Yamano et al., 2007; Santos and Haime, 2004), energy constraints (Kerschner and Hubacek, 2009; Arbex and Perobelli, 2010) or financial crisis (Yuan et al., 2010). Moreover, a plurality of input-output risk-based models, as for example the inoperability input-output model (IIM) and its derivative (DIIM), have also been used to analyse the recovery of sectors and evaluate risk management strategies (Haimes and Jiang, 2001; Jiang and Haimes, 2004; Santos and Haimes, 2004; Lian and Haimes, 2006; Barker and Santos, 2010). However, the vast majority of these studies are mainly focused on a single country/regional perspective rather than including the intra-country/regional impacts produced by the existing links through international trade. One of the reasons for the lack of multi-regional analyses might have been the absence of publicly available and up-to-date multi-regional I-O databases. As mentioned before, the EU-funded project World Input Output Database (WIOD) largely contribute to fill this gap and opens up the door for the use of MRIO models with the purpose of estimating worldwide economic impacts of unexpected events such as the one occurred in Japan in 2011. In particular, the combined use of our MRIO model and the WIOD database allows investigating the multi-regional effects generated by regional shocks derived from changes in international trade, such as those derived form the Japanese disaster. The MRIO model used in this study is a mixed I-O model in which the exogenous shocks can be either final demand changes or changes in total outputs (see Miller and Blair, 2009 for a detailed description of this type of models). Mixed I-O models have often been applied in empirical studies to analyze the effects of constraints in the output of some sectors (Steinback, 2004). These models present, however, some intrinsic limitations related to its own formulations that can restrict its use for some analysis. On the one hand, the production technology of I-O models is based on the assumption of fixed coefficient. This means that a no substitution hypothesis is assumed between inputs of the production function. This can be a shortcoming for some analysis, but not in our paper. Since we use this model to analyze the effects of disruption in the supply-production chain of products that in the short term cannot be provided by other countries, a no substitution hypothesis is coherent to our case study. On the other hand, I-O models assume homogeneity across sectors. This means that all the production units in each sector produce the same output using identical technology. This is a limitation that affects our model, as it entails that the shock in the exports of transport components from Japan will transmit linearly across all the companies of the importing sector. In other words, we would be assuming that all the companies of the transport equipment sector in the importing country would be using the same quantity of Japanese components. However, as explained in the next section, we introduced a correction factor to relax this assumption.

In order to summarize the model used in this paper, an explanatory case, is presented for 2 regions with 2 sectors producing 2 goods that can be sold as intermediate inputs or as final products. Since both regions are open to external trade their domestic production can be consumed inside the region and/or abroad. The relations between the production and the consumption activities in the two regions can be expressed as depicted in table 1, where the element z_{ij}^{rs} of matrix $\mathbf{Z^{rs}}$ indicates the intermediate use by sector *j* of region *s* of goods produced by sector *i* of region *r*; the element y_i^{rs} of the vector $\mathbf{y^{rs}}$ denotes the final demand by region *s* of goods produced by sector *i* of region *r*; and the element x_i^r of vector $\mathbf{x^r}$ is the total output of sector *i* in region *r*.

Table1: Multi-Regional Input-Output table for 2 regions.

region		1	2	1	2	
	sector	1 2	1 2			
1	1 2	$\mathbf{Z}^{11}$	$\mathbf{Z}^{12}$	$\mathbf{y}^{11}$	$\mathbf{y}^{12}$	$\mathbf{x}^{1}$
2	1 2	$\mathbf{Z}^{21}$	$\mathbf{Z}^{22}$	$\mathbf{y}^{21}$	$\mathbf{y}^{22}$	$\mathbf{x}^{2}$

Table 1 can be expressed as a system of equations that in matrix form reads:

$$\begin{bmatrix} \mathbf{x}^1 \\ \mathbf{x}^2 \end{bmatrix} = \begin{bmatrix} \mathbf{Z}^{11} & \mathbf{Z}^{12} \\ \mathbf{Z}^{21} & \mathbf{Z}^{22} \end{bmatrix} \begin{bmatrix} \mathbf{e} \\ \mathbf{e} \end{bmatrix} + \begin{bmatrix} \mathbf{y}^{11} + \mathbf{y}^{12} \\ \mathbf{y}^{21} + \mathbf{y}^{22} \end{bmatrix} \qquad [1]$$

where $\mathbf{e}$ is a column vector of ones for summation.

The input coefficients are obtained from $\mathbf{A}^{\mathbf{rs}} = \mathbf{Z}^{\mathbf{rs}} \hat{\mathbf{x}}^{\mathbf{s}\,\mathbf{-1}}$, where a_{ij}^{rs} of matrix $\mathbf{A}^{\mathbf{rs}}$ indicates the quantity of output from sector *i* of region *r* used by sector *j* of region *s* to produce one unit of output. Now we rewrite equation [1] as follows:

$$\begin{bmatrix} \mathbf{x}^1 \\ \mathbf{x}^2 \end{bmatrix} = \begin{bmatrix} \mathbf{A}^{11} & \mathbf{A}^{12} \\ \mathbf{A}^{21} & \mathbf{A}^{22} \end{bmatrix} \begin{bmatrix} \mathbf{x}^1 \\ \mathbf{x}^2 \end{bmatrix} + \begin{bmatrix} \mathbf{y}^{11} + \mathbf{y}^{12} \\ \mathbf{y}^{21} + \mathbf{y}^{22} \end{bmatrix} \qquad [2]$$

Reordering expression [2], it yields:

$$\begin{bmatrix} \mathbf{I} - \mathbf{A}^{11} & -\mathbf{A}^{12} \\ -\mathbf{A}^{21} & \mathbf{I} - \mathbf{A}^{22} \end{bmatrix} \begin{bmatrix} \mathbf{x}^1 \\ \mathbf{x}^2 \end{bmatrix} = \begin{bmatrix} \mathbf{y}^{11} + \mathbf{y}^{12} \\ \mathbf{y}^{21} + \mathbf{y}^{22} \end{bmatrix} \qquad [3]$$

and considering, as in standard I-O analysis, the total output (denoted by "*x*") as endogenous and final demand (denoted by "*y*") as exogenous, equation [3] can be expressed in a fully fledged format as:

$$\underbrace{\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}}_{\mathbf{I}} \begin{bmatrix} x_1^1 \\ x_2^1 \\ x_1^2 \\ x_2^2 \end{bmatrix} = \underbrace{\begin{bmatrix} \left(1-a_{11}^{11}\right) & -a_{12}^{11} & -a_{11}^{12} & -a_{12}^{12} \\ -a_{21}^{11} & \left(1-a_{22}^{11}\right) & -a_{21}^{12} & -a_{22}^{12} \\ -a_{11}^{21} & -a_{12}^{21} & \left(1-a_{11}^{22}\right) & -a_{12}^{22} \\ -a_{21}^{21} & -a_{22}^{21} & -a_{21}^{22} & -\left(1-a_{22}^{22}\right) \end{bmatrix}^{-1}}_{\mathbf{(I - A)^{-1}}} \begin{bmatrix} y_1^{11} + y_1^{12} \\ y_2^{11} + y_2^{12} \\ y_1^{21} + y_1^{22} \\ y_2^{21} + y_2^{22} \end{bmatrix} \qquad [3a]$$

Now, let us assume that we wanted to analyse a constraint in the total output of sector 2 in region 2[1]. In such a case, sector 2's total output would become endogenous while sector 2's final demand would be exogenous. The assumptions on the remaining outputs and final demands of the other sector remain unchanged. Next, re-arranging equation [3a] so that to leave exogenous variables on the right-hand side and endogenous variables on the left-hand side, we obtain:

$$\underbrace{\begin{bmatrix} \left(1-a_{11}^{11}\right) & -a_{12}^{11} & -a_{11}^{12} & 0 \\ -a_{21}^{11} & \left(1-a_{22}^{11}\right) & -a_{21}^{12} & 0 \\ -a_{11}^{21} & -a_{12}^{21} & \left(1-a_{11}^{22}\right) & 0 \\ -a_{21}^{21} & -a_{22}^{21} & -a_{21}^{22} & -1 \end{bmatrix}}_{\mathbf{M}} \begin{bmatrix} x_1^1 \\ x_2^1 \\ x_1^2 \\ y_2^{21} + y_2^{22} \end{bmatrix} = \underbrace{\begin{bmatrix} 1 & 0 & 0 & a_{12}^{12} \\ 0 & 1 & 0 & a_{22}^{12} \\ 0 & 0 & 1 & a_{12}^{22} \\ 0 & 0 & 0 & -\left(1-a_{22}^{22}\right) \end{bmatrix}}_{\mathbf{N}} \begin{bmatrix} y_1^{11} + y_1^{12} \\ y_2^{11} + y_2^{12} \\ y_1^{21} + y_1^{22} \\ x_2^2 \end{bmatrix} \qquad [4]$$

Finally, by operating on equation [4] we get the following expression:

$$\begin{bmatrix} \mathbf{x_{no}} \\ \mathbf{y_{co}} \end{bmatrix} = \mathbf{M}^{-1}\mathbf{N} \begin{bmatrix} \mathbf{y_{no}} \\ \mathbf{x_{co}} \end{bmatrix} \qquad [5]$$

[1] Note that we could constrain the output of as many sectors as we want, but for clarification we have limited the constrained sector to one.

where $\mathbf{x}_{\mathbf{no}}$ represents the endogenous total output of the non-constrained sectors 1 and 2 in region 1, and the endogenous total output of sector 1 in region 2, $\mathbf{y}_{\mathbf{co}}$ stands for the endogenous total final demand of regions 1 and 2 of the constrained sector 2's output in region 2, $\mathbf{x}_{\mathbf{co}}$ indicates the exogenous total main product output of the constrained sector (sector 2) in region 2, and $\mathbf{y}_{\mathbf{no}}$ depicts the exogenous final demand of regions 1 and 2 of the sector 1 and 2's output in region 1 as well as that of the sector 1's output in region 2. Equation [5] determines the level of final demand of the (supply constrained) sector 2's output in region 2 and the output of sectors 1 and 2 in region 1 and of sector 1 in region 2, on the basis of the (supply constrained) sector 2's output in region 2 and the total final demand for all sectors' output in region 1 together with the final demand of sector 1's output in region 2. This equation can be generalized for *m* sectors and *n* countries. Moreover, the number of supply constrained sectors can also be expanded. In our case study we will apply this model to 35 sectors and 41 regions, and the number of sectors with an output constrained will be 41, namely: the transport equipment industry for each region/country.

3. Data and methodology

The data used to build the MRIO model has been obtained from the symmetric world I-O table of the year 2008 of the WIOD database. This database comprises a set of harmonized supply and use tables and symmetric I-O tables that include data on international trade and satellite accounts related to environmental and socio-economic indicators. It comprises information from 1995 to 2009 for 35 industries, 60 products and 41 countries (27 EU countries, 13 non-EU countries and the Rest of the World as an aggregated region). The constraints applied in the total output of the transport equipment industry of each country are presented in Table 2. These changes in the output result in a new sectoral output that is imposed in the equation [5] of the model as a constraint in the respective region's total output of the transport equipment sector.

Table 2. Change in the output of "Transport Equipment" sector by region

Australia	-5,78%	Estonia	-	Japan	-20,66%	Russia	-0,23%
Austria	-	Finland	-	Latvia	-	Slovakia	-
Belgium	-0,60%	France	-0,97%	Lithuania	-	Slovenia	-
Brazil	-1,97%	Germany	-2.99%	Luxembourg	-	South Korea	-0,06%
Bulgaria	-	Greece	-	Malaysia	-	Spain	-0,80%
Canada	-10,87%	Hungary	-1,15%	Mexico	-1,76%	Sweden	-
China	-2,04%	India	-1,26%	Netherlands	-	Taiwan	-
Cyprus	-	Indonesia	-8,52%	Poland	-	Turkey	-2,51%
Czech Republic	-	Ireland	-	Portugal	-	UK	-6,39%
Denmark	-0,10%	Italy	-	Romania	-	USA	-9,09%
Rest of World	-						

Source: Robinet, 2011

These output reduction of Table 2 have been obtained from Robinet (2011), who quantified the reduction in the number of Light Vehicles (LV) produced for 129 facilities between March and May 2011. Starting from this data, we have aggregated the drop in the production by country and we have calculated the change that this figure represents with respect the total production of the year 2010 from the International Organization of Motor Vehicle Manufacturers (OICA, 2012). Finally, for each country, we have extrapolated the change in the production of LV to the whole transport equipment sector.

4. Results

As a consequence of the catastrophic events that struck Japan on March of 2011, the supply-chain of the "transport equipment" industry suffered disruptions all over the world. On the one hand, many Japanese companies were forced to stop their production processes, which had effects on the supplying industries of other countries. Subsequently, Japanese exports of transport equipments decreased by €10.6 billion between February 2011 and May 2011 causing important disruptions all over the world. According to our estimations, the world output of "transport equipment" industry decreased by €140.7 billion (-4.51%). In terms of GDP the reduction was €36.8 billion. However, these figures do not take into account for the impacts in other industries that directly or indirectly supply inputs to the transport equipment production and, consequently, were also affected by disruption in the "transport equipment" industry. We estimated that those indirect effects would have contributed to reduce the total global production by an additional €129.8 billion and the GDP generation by €57.5 billion. As a result, if we consider both the direct and the indirect effects, the disruption on the supply-chain of the "transport equipment" industry would have reduced the output of the world economy by €270.5 billion (-0.3%) and the GDP by €94.3 billion (-0.2%). Table 3 shows the change in the GDP broken down into sectors. The "transport equipment" industry absorbed most of the reduction in the total GDP (39%) generation, followed by "renting machinery and equipment services and other business activities" (8.45%), manufacture of "basic metals and fabricated metals" (7.89%), "wholesale trade" (7.32%) and extraction of "mining and quarrying" (4.8%). Unsurprisingly, "transport equipments" was also the sector with the largest reduction in its GDP (-4.82%) followed by "manufacture of basic metals and fabricated metals" (-0.66%), "rubber and plastics" (-0.63%) and "electrical and optical equipment" (-0.31%). All the remaining economic sectors suffered smaller GDP reductions.

Table 3. Change in Gross Domestic Product by sector

Sector	Change GDP (billion €)	Change GDP (%)	% over total change
Transport Equipment	-36.78	-4.82%	39.03%
Renting of M&Eq and Other Business Activities	-7.96	-0.18%	8.45%
Basic Metals and Fabricated Metal	-7.43	-0.66%	7.89%
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	-6.90	-0.24%	7.32%
Mining and Quarrying	-4.52	-0.20%	4.80%
Financial Intermediation	-3.42	-0.12%	3.63%
Electrical and Optical Equipment	-3.16	-0.31%	3.35%
Inland Transport	-2.14	-0.17%	2.27%
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	-2.02	-0.09%	2.14%
Rubber and Plastics	-1.99	-0.63%	2.11%

Machinery, Nec	-1.80	-0.26%	1.91%
Chemicals and Chemical Products	-1.77	-0.23%	1.88%
Electricity, Gas and Water Supply	-1.74	-0.18%	1.85%
Real Estate Activities	-1.69	-0.04%	1.79%
Other Community, Social and Personal Services	-1.46	-0.09%	1.55%
Post and Telecommunications	-1.01	-0.10%	1.07%
Hotels and Restaurants	-0.90	-0.08%	0.96%
Pulp, Paper, Paper , Printing and Publishing	-0.87	-0.16%	0.93%
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	-0.83	-0.15%	0.88%
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	-0.77	-0.15%	0.81%
Other Non-Metallic Mineral	-0.73	-0.21%	0.78%
Coke, Refined Petroleum and Nuclear Fuel	-0.71	-0.18%	0.76%
Agriculture, Hunting, Forestry and Fishing	-0.59	-0.03%	0.63%
Construction	-0.50	-0.02%	0.53%
Water Transport	-0.43	-0.25%	0.45%
Food, Beverages and Tobacco	-0.37	-0.03%	0.39%
Textiles and Textile Products	-0.34	-0.10%	0.37%
Public Admin and Defence; Compulsory Social Security	-0.33	-0.01%	0.36%
Wood and Products of Wood and Cork	-0.26	-0.16%	0.28%
Manufacturing, Nec; Recycling	-0.25	-0.10%	0.26%
Education	-0.16	-0.01%	0.17%
Air Transport	-0.15	-0.10%	0.16%
Health and Social Work	-0.14	-0.01%	0.15%
Leather, Leather and Footwear	-0.09	-0.14%	0.09%
Private Households with Employed Persons	-0.01	-0.01%	0.01%
	-94.25	-0.20%	100.00%

In a similar way, table 4 shows the results of the disruption in the supply chain by region/country. All the regions analyzed suffered negative effects in their GDP. In particular, Japan absorbed half of the total impacts, with a reduction of the GDP that approximate €47.2 billion (-1.23%). European Union was also largely affected by disruption in the supply-production chain. The aggregated reduction in the total GDP reached €8.4 billion (8.96% of the total losses). Within EU, United Kingdom (€3.7 billion), Germany (€1.3 billion) and France (€1.2 billion) were the Member States with the largest GDP losses. However, excluding Japan, the United States was the country with the largest reduction in the GDP (€12.5 billion). It is also worth pointing out the reduction in the GDP of China (€7 billion) and Canada (€5.6 billion). In relative terms, apart from Japan, Indonesia experienced the largest drop in the GDP (-0.52%) followed by Canada (-0.50%), Australia (-0.20%), China (-0.19%), Mexico (-0.14%), Taiwan (-0.12%) and United States (-0.11%).

Table 4. Change in Gross Domestic Product by region

	Change GDP (billion €)	Change GDP (%)	% over total change
Japan	-47.20	-1.23%	50.08%
United States	-12.52	-0.11%	13.28%
EU27	-8.44	-0.06%	8.96%
United Kingdom	-3.70	-0.19%	3.92%
Germany	-1.31	-0.05%	1.38%
France	-1.20	-0.06%	1.28%
Spain	-0.50	-0.04%	0.53%
Italy	-0.41	-0.02%	0.43%
Sweden	-0.15	-0.04%	0.16%
Austria	-0.11	-0.04%	0.12%
Poland	-0.08	-0.02%	0.08%
China	-7.00	-0.19%	7.42%
Canada	-5.64	-0.50%	5.98%
Rest of World	-4.98	-0.08%	5.28%
Indonesia	-2.07	-0.52%	2.20%
Australia	-1.52	-0.20%	1.62%
Brazil	-1.32	-0.12%	1.40%
Mexico	-1.20	-0.14%	1.27%
India	-0.59	-0.06%	0.63%
Russia	-0.55	-0.05%	0.58%
South Korea	-0.51	-0.07%	0.54%
Taiwan	-0.36	-0.12%	0.38%
Turkey	-0.35	-0.07%	0.37%
Total	-94.25	-0.20%	100.00%

5. Conclusions

This study presents the first attempt to quantify the worldwide economic impacts generated by Japanese disaster of March 2011. The use of a multiregional input-output model together with the World Input-Output Database (WIOD) allowed estimating the worldwide cascading effects generated by disruption in the supply-production chain of the "transport equipment" industry. Results show that the direct impact on the worldwide output and GDP reduction of the "transport equipments" industry was €140.7 billion and €36.8 billion respectively. However, when the indirect effects generated in the other economic sectors by disruption in the "transport equipment" industry are accounted, the total reduction of output and GDP rises to €270.5 billion and €94.3 billion, respectively. These results make neatly evident the importance of the cascading effects generated by the disruptions in the international supply chain of this sector. Japan absorbed almost half of the total impact, with a reduction in the GDP of €47.2 billion (-1.23%). The European Union suffered losses by €8.4 billion, being United Kingdom (€3.7 billion), Germany (€1.3 billion) and France (€1.2 billion) the most affected Member States. Apart form Japan, the United States was the country with the largest GDP reduction (€12.5 billion). The impacts in China (€7 billion) and Canada (€5.6 billion) were also relevant. The results of this study highlight the importance of taking into account the cascading economic effects generated by disruptions on the international supply-production chain. However, the large and complex relationships that exist between economic sectors and regions across the world are generally not taken into account when analyzing the economic impacts of unexpected events. The scarce use of worldwide multiregional models and the lack of databases have been the main constraints for assessing the inter-regional effects of disasters. The innovative approach presented in this paper is based on the use of a mixed multiregional input-output model and a world input-output database, allowing for the first time, to quantify the worldwide economic effects generated by a disruption in the international supply-chain of a sector due to an unexpected event. The results of this type of analysis could be useful for decision making in many different areas such as risk management strategies and recoveries, logistics and production organization strategies.

Disclaimer

The views expressed here are those of the authors and do not necessarily reflect the views and policies of the European Commission

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