Mining resources in global value chains

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Date received: February 18, 2019. Date accepted: June 10, 2019

Abstract

This article identifies at an industrial-national level which global value chains make intensive use of mining, demonstrating additionally which companies are leading this phenomenon and what countries have elevated their position to greater added value. Calculations were performed using input-out analysis methods, complemented by network theory algorithms, and were based on international input-output tables produced by the OECD which provide information for 33 economic sectors in 63 countries for the period from 1995 to 2011. The evidence shows escalating cases towards more sophisticated links in global value chains (GVC) in the extractive sectors of Brunei, Indonesia and Malaysia.

Keywords: mining; global value chains; industrialization; input-output tables; social network theory; world consumption.

1. INTRODUCTION

Since the end of the last century, world trade has reached a new stage in the process of international division of labor, due to the formation of global value chains (GVCs) (Baldwin and Lopez-Gonzales, 2013). As a result, a scenario is made possible where there are new opportunities for industrialization in developing countries. Nonetheless, there are still a good number of countries whose export baskets are concentrated on raw materials which have little added value. Thus, it is important to identify in which GVCs mining resources have dominant or strategic weight; which countries are the principal providers of minerals; which companies are the leaders in the most important links in the chain; and to evaluate the cases in which a country has been able to make the jump to a more sophisticated link in a chain.

Thanks to databases such as the Inter-Country Input-Output Tables provided by the Organization for Economic Cooperation and Development (OECD, 2016), structural changes in international trade can be evaluated on the level of industry-country, identifying the degree of fragmentation of a specific chain's production, degrees of interdependence between sectors and where the greatest value added is concentrated—as proposed by Baldwin and Lopez-Gonzales (2013), Los *et al.* (2015), Timmer *et al.* (2014), among others.

In the case of the present research, an analysis of the role of natural resources in GVCs is performed at the level of the productive sector. Tools are used that are derived from input-output analyses and which are complemented by algorithms from network theory, drawing inspiration from the publications of García *et al*. (2008), Chai *et al.* (2011) and Noguera-Méndez *et al*. (2016).

This paper is organized as follows: the concept of linkage as used in the economic theory framework and the CGV approach is presented first. Following this, calculation tools typical of traditional input-product analyses and network theory are described, continuing on to results regarding the countries that have been able to reach positions of greater added value along the chain. Next, a description is given of the companies that lead these GVCs, and finally, conclusions are presented.

2. PRODUCTIVE LINKAGES AND INDUSTRIALIZATION

The division of labor and corresponding linkages between specialized tasks are two processes that, when they occur simultaneously, have favorable effects on productivity. In studies of industrialization, these processes have been considered implicit or explicit characteristics. Kuznets (1974) argues that since the beginning of the Industrial Revolution, the formation of a sector that offers capital goods has been an indispensable condition for the growth of other consumer goods and intermediate goods manufacturing in Europe.

Between these sectors, linkages arose quite naturally and are now an implicit part of their industrial strength, given that product innovations in the machine and tool industries are currently closely tied to the manufacturing processes in which they will be employed. This has the result of directly affecting their productivity, and in many cases, infecting processes in other related sectors (CECIMO, 2011).

Hirschman (1964), using input-output tables, finds that forward and backward industrial linkages create a strong sectoral interdependence in developed economies, and thus distinguish themselves from developing economies. Other authors, such as Leontief (1966), Rasmussen (1956), Chenery and Watanabe (1958), join Hirschman in offering various multipliers to evaluate productive chains, among which the Leontief coefficient—which will be used in this work—stands out.

Given industrialization processes around the world, in the second part of the 20th century, linkages take center stage in the international arena. Rodrik (2011) argues that economic growth in several developing countries is a result of the ability to integrate into the world economy through trade and investment. This idea is furthered by Hausmann *et al.* (2007), who develop a set of indicators based on the idea that one determinant of an economy's growth is the way in which it is globally linked through its exports. Thus, the export basket becomes a measure of the degree of industrialization in a country, and a sustained change in its composition implies having achieved an internal structural transformation (Hausmann and Klinger, 2006), driven by links with external markets.

The aforementioned authors add the concepts of diversification and complexity of production to discussions of the division of labor and linkages—which are now international—given that such features are important in countries with recent industrial development, specifically in several Asian economies. Hidalgo and Hausmann (2009) point out that countries with greater productive capacities are more diversified, since they can produce a greater variety of goods. The type of goods that a country exports is a good predictor of its per capita income.

The diversification approach is important as it contrasts with specialization in exports of primary goods, which is seen in several countries endowed with abundant natural resources and is the case for several economies in Latin America, the Middle East and Africa. The benefits resulting from this type of specialization are supported by the theory of comparative advantages from classical economics, and were accompanied by the liberal proposal of the eighties known as the Washington Consensus (Rodrik, 2011). This was applied in Latin America in the 1990s, with the goal of achieving basic macroeconomic equilibriums, namely fiscal, external and monetary.

Despite having enjoyed the sought-after macroeconomic equilibriums, the resulting small amount of diversification—accompanied additionally by an industrial delay—creates economies whose growth depends on excesses from external price booms of a few raw materials. The situation has been addressed, from another perspective, by the so-called "Dutch disease" of Corden and Neary (1982), and by the "curse of natural resources" of Sachs and Warner (2001). According to these authors, it is precisely the abundance of a resource that inhibits the growth of other sectors and even reduces their productivity, strengthening the bias of a concentrated export basket.

Finally, given the linkages that currently characterize transnational production, an appropriate approach for their study is that of GVCs, which are defined as the set of economic units carried out by the activities necessary in creating a product or service, from its conception until its sale to the end user. According to Gereffi and Lee (2016), this approach is meant to provide an understanding of how added value is created and captured within various types of industries. With this, it offers a more detailed level of evaluation when compared to the economic growth theories of the end of the last century, in which the use of macroeconomic tools, or those at the sectoral level, predominates (Dussel, 2018).

The focus here is a study of specific companies and industrial groups at the organizational level. It is centered on two features of current industrial organization: governance and scaling. Governance examines how the leading company organizes its supply chain on a global scale, while scaling identifies the strategies used by companies or countries to improve their positions regarding activities with greater added value in a chain (Gereffi and Lee, 2016).

Methods of governance involve a broad spectrum of strategies, such as: that of the market, based on the recurrent acquisition of simple supplies from the same supplier without further explicit coordination; the modular strategy, where the supplier produces supplies with explicit characteristics for the leading company, assuming the risks of the necessary investments; the relational strategy, where due to the complexity of the good being supplied, a mutual dependence is created between the two companies; the captive strategy, in which small suppliers are controlled and monitored by the leading company for the supply of an input; and the hierarchical strategy, which refers to the installation of a branch, under proprietary control, that provides the required input (Gereffi *et al.*, 2005). As for scaling, Gereffi and Lee (2016) classify it according to the scope of the improvement. That is, if a change has been achieved in the product, in the production process or if it has been possible to jump to a higher link in the chain.

Based on the GVC approach, Baldwin and Lopez-Gonzales (2013) develop measurements of trade in added value, to identify how its creation has changed across links in the chain. These authors, on the one hand, and Timmer *et al.* (2014), on the other, confirm that developed economies (say, G7 countries) have become mostly service providers, transferring manufacturing links to other countries (for example, China, Mexico and Poland) and promoting along with it their industrialization. Likewise, Blyde (2014) argues for the possibility of rapid industrialization in the case of countries that facilitate linkage of national sectors in a GVC. In other words, to the extent that particular cases of scaling within an economy accumulate, the result is a change in the structure of production that will be reflected by the composition of the export basket and other industrial development indicators.

3. DATA AND METHODS

Input-output analysis tools

The measurement of linkages is associated with the input-output tables (IOTs) developed by Leontief. In this text, the analyzed data come from international IOTs for the years 1995 and 2011, published by the OECD (2016), and which contain transactions between 33 economic sectors of 63 countries, for which the ISO3.1 nomenclature is used[1] . The evaluation is done on two levels: on one hand, the trade of inputs between sectors is analyzed and, on the other, the added value contained in them is examined.

Regarding trade in inputs, the intermediate demand table was used to calculate Leontief coefficients for goods with a high mineral and petroleum content, and to measure—according to Hirschman (1964)—the degree of linkages generated throughout the production process. Then, when performing the evaluation by country, the dragging capacity of these sectors on the national or foreign economy is calculated, and along with this, the degree of internal connection between the economies that supply raw materials. The calculation of coefficients for a sector *j* is done with equation (1), where *I* is the identity matrix and *A* is the matrix of technical coefficients (weight of an input *i* in the gross value produced by sector *j*). The sum of the resulting coefficients measures the carrying capacity of sector *j*.

$$B_j = \sum_{i=1}^{n} [(I-A)^{-1}]_{i,j} \tag{1}$$

In addition, the results of these calculations will be accompanied by indicators of the centrality of network theory (explained below) as they yield more real indices.

Regarding the evaluation of added value, the proposal by Los *et al.* (2015) is used to obtain the added value that is generated in each industry-country. With this, the analysis focuses on the degree of contribution by a country's mining sector to the total added value in a productive chain, and its displacements are shown for the period between 1995 and 2011. This calculation is done with equation (2).

$$g = \hat{v}(I-A)^{-1} Fe \tag{2}$$

Here, $\hat{v}$ is a diagonalized vector of value-added coefficients for each unit of gross value produced; $(I - A)^{-1}$ is the known inverse of Leontief; and, *Fe* is a column vector that contains the final demand for the industry-country to be evaluated only.

Network theory tools

Just as IOTs are made up of a set of industrial sectors and their monetary links, in the theory of social networks, a network is formed by a set of nodes and their respective connections. Although the technical coefficient and the Leontief coefficient measure the direct and indirect effects of the growth of an industry on the others, the method assumes with its calculation method that it is possible for a country to have infinite successive impacts—which is not true. Thus, the multiplier measures the potential effect, though not the actual one, of growth in a sector's final demand (Schuschny, 2005). In contrast, the range (Degree) and proximity (Closeness) indicators offered by network theory allow us to more accurately specify the extent of growth of one sector over the others.

The concept of range measures the number of direct links that node p_k has with the rest of nodes p_i that form a network of size n, calculated according to equation (3). Thus, the greater the range of an industry, the more effectively it can transmit its growth to those which are directly connected to it, while this impact weakens as indirect links are reached. The links represented by *a* can be purchases made by sector p_k from p_i (In Degree) or their sales (Out Degree), in monetary values (Borgatti and Everett, 2006). By dividing the links of each node with the total possible links in the network (*n - 1*), a standardized measure of the range is obtained, an indicator which used in the present work.

$$C_D(p_k) = \frac{\sum_{i=1}^{n} a(p_i, p_k)}{n-1} \tag{3}$$

The concept of proximity measures *d* number of jumps required by node p_k to reach all nodes p_i in a network, according to equation (4). In our context, this would indicate how instantaneous (a lower number of jumps) or how slow (a higher number of jumps) the effect of the growth of an industry on its related sectors would be. This link can occur through its purchases (In Closeness), or through its sales (Out Closeness), and is normalized by dividing it by the maximum direct connections in a network (Freeman, 1979). Given that in a more connected network the number of jumps is smaller, the reverse of this count is used; thus, the higher the index, there is a higher degree of closeness between the nodes.

$$C_C(p_k) = \left[\frac{\sum_{i=1}^{n} d(p_i, p_k)}{n-1} \right]^{-1} = \frac{n-1}{\sum_{i=1}^{n} d(p_i, p_k)} \tag{4}$$

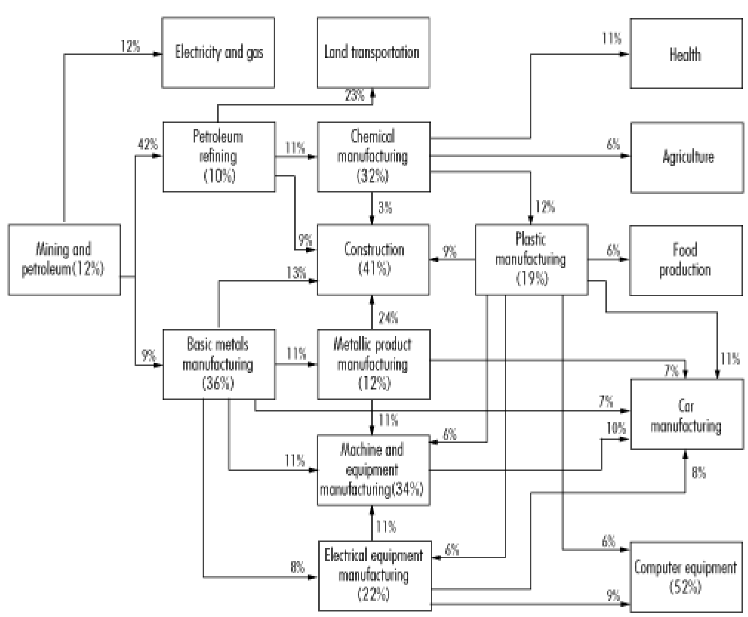
These and other tools from network theory are used by García *et al.* (2008), Chai *et al.* (2011) and Noguera-Méndez *et al.* (2016) as a way to calculate a sector's centrality and the degree of modularity that groups of nodes form, thus revealing strategic roles for some economic sectors that do not arise from a traditional input-output analysis. To calculate these indices, in the present paper Ucinet and Gephi software were used as a way to make visible the strongest links in the mineral trading network.

4. CENTRAL NODES AND VALUE GENERATION IN NATURAL RESOURCE CHAINS

Nodes and linkages in natural resource value chains

To produce an overview of the aspects of production in which mining resources participate globally, technical IOT coefficients for the year 2011 were calculated, grouping the data by industrial sector. Figure 1 shows that the main consumers of minerals and petroleum are the petroleum refining industry (42%), electricity and gas production (12%) and manufacture of basic metals (9%). Based on this information, the same figure shows the percentage of the gross value at which it is sold forward, forming worldwide production segments that make intensive use of minerals. These production chains end in various services, such as health care, or in manufacturing of products like automobiles and computer equipment. Therefore, these sectors and their intermediaries are the main target of this analysis.

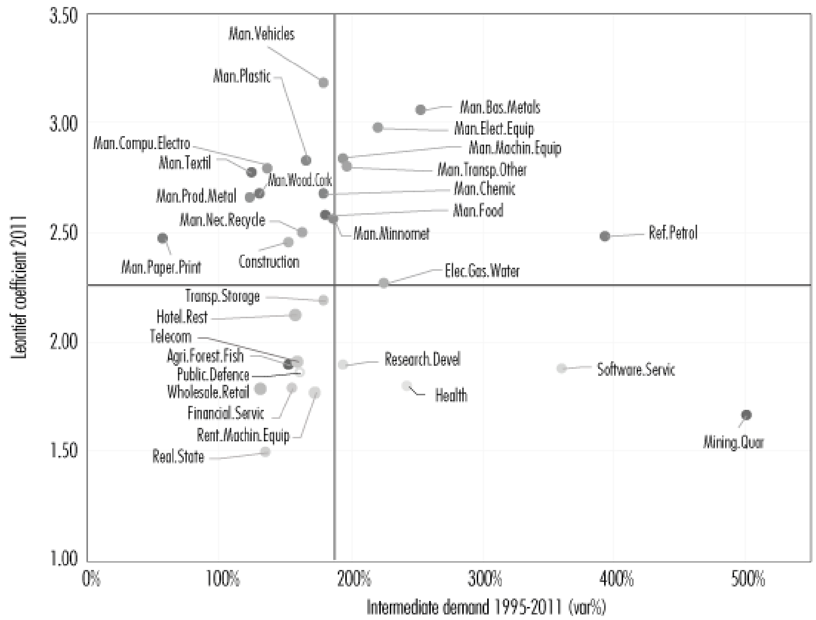
Figure 1. International production segments with intensive use of minerals and petroleum, 2011



Note: the numbers show the percentage of input sales in one sector or another.
In parenthesis, sales to the same sector are provided.
Data source: OECD (2016). Calculations and preparation by the author.

When comparing the IOTs for the year 1995 with those of 2011, there is a change in relative positions in global production which favors industries that make intensive use of minerals. The growth in monetary value produced by the mining sector, petroleum refineries and the manufacture of basic metals, stands out from the rest (see horizontal axis of figure 2).

Figure 2. Intermediate demand 1995-2011 (% variation) and Leontief coefficient by sector, 2011

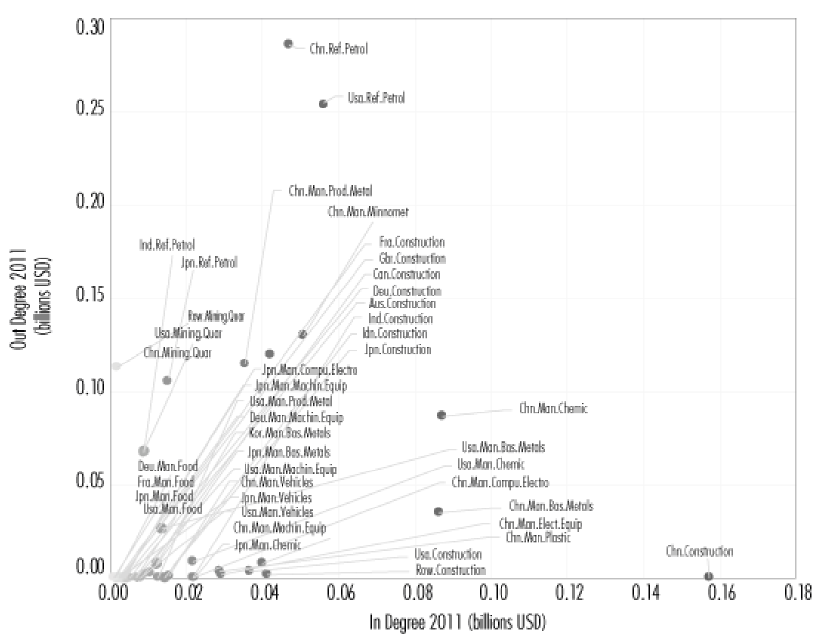


Note: the vertical and horizontal lines represent the averages of the respective variables.
Source: OECD (2016). Calculations and preparation by the author.

One way to identify which industry could have driven such growth is through the Leontief coefficient, calculated with equation (1), since the resulting figure measures the theoretical drag capacity of a sector. Figure 2 (vertical axis) also shows, according to this indicator, that it is automobile manufacturing that has generated the greatest direct and indirect impacts on other industries throughout the world. This is explained by its need to absorb a variety of inputs from various sectors, thus revealing its role as one of the engines of growth in the global economy. It is followed by the basic metal manufacturing sector, and then the electrical equipment, machinery and equipment industries, which are sectors that supply it.

Having identified that the fastest growing industries in the global economy are in turn consumers of minerals and petroleum, it can be seen below which countries correspond to these sectors. Based on the 50 countries-sectors with the highest intermediate demand, Figure 3 shows them sorted according to their direct purchases (In Degree) and their direct sales (Out Degree), excluding self-consumption.

Figure 3. Entrance and exit range for sectors with high mineral consumption, 2011



Source: OECD (2016). Calculations and preparation by the author.

On one hand, those industries with the greatest direct purchase include those such as construction, chemical manufacturing, basic metals and petroleum refining. These mostly originate in China, but also in the United States of America, Korea, India and Japan. Some manufacturing—such as vehicles and food—show a fairly small output range, because their sales are made more as a final good than as an intermediate good, thus forming the last links of the GVCs. This is not as true for chemical, basic metal and petroleum refining manufacturing, which play the double role of acquiring minerals as input (high input range) and making it available to the rest of the industry in the form of processed raw material (high output range), positioning themselves as intermediate links in the production segments.

Given the direct influence of car manufacturing and construction on petroleum refining and the manufacture of basic metals—especially in China, Japan, the United States of America, Korea and India— it is clear that this is the case due to the consolidation of a global mineral supply network. A large part of that network appears on the map in figure 4, where the lines represent the purchases of these five countries from their main suppliers. In China, the United States of America and India, their own mineral sectors are the main supplier; however, since these are insufficient, they must also resort to importation.

Figure 4. Suppliers of minerals for petroleum refining and manufacturing
of base metals in China, USA, Japan, Korea and India, 2011

Note: the country:rate label indicates the sale of minerals in millions USD.
The country.sector:rate indicates the buying of minerals by sector in millions USD.
The ROW location (countries grouped in the Rest of the World category) is not real.
Data source: OECD (2016). Calculations and preparation by the author.
Software used: Gephi 0.9.2 (Bastian et al., 2009).

In the case of Korea and Japan, the supply of minerals and petroleum comes mostly from outside their territory. Thus, the largest suppliers are: Saudi Arabia, Canada, Australia, Mexico and Russia; to this are added countries in South America that include Brazil, Colombia, Chile, Peru, among others; in Southeast Asia, Indonesia, Malaysia and Brunei are suppliers, in addition to South Africa; in Europe, beyond Norway and the United Kingdom, the role of other countries is reduced. It should be mentioned that a group of important countries that supply minerals and petroleum from the Middle East and other regions of the planet are grouped in the Rest of the World (ROW) category.

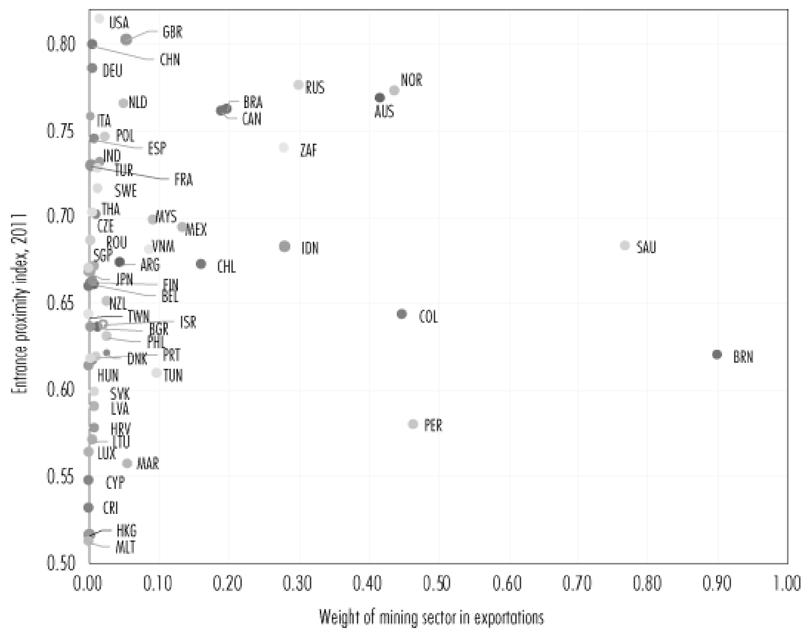
The high global consumption of minerals should have had an effect on certain macroeconomic variables for the supplying countries, depending on the weight of raw materials in each one's export basket. Thus, the horizontal axis in figure 5 shows Brunei, Saudi Arabia, Peru, Colombia, Norway and Australia as the countries whose mining exports exceed 40% of total exports; in Russia, South Africa and India, this is around 30%; and Mexico, Chile, Brazil and Canada, are between 10 and 20%.

The impact of global mineral consumption on these supplying countries has been diverse. For example, Net Currency Reserves, which feed on favorable balances in net exports, show an average annual growth of between 40 and 50% in Russia, Saudi Arabia and South Africa; in Mexico of 24%; in Brunei, Peru, Australia, India, Brazil and Canada between 10 and 20%; and in Colombia, Norway and Chile a growth somewhat below 10% per year, between 1995 and 2011 (The World Bank, 2018).

On the other hand, it is expected as well that the increase in mining exports has had a broad effect on sectors linked to extraction by way of its trade network. As mentioned above, this effect can be evaluated with the help of the Leontief coefficient and with the proximity index of equation (4) of the previous section. However, while the first indicator is strongly influenced by the value of the first purchase, for the second, the resulting figure is more affected by the number of direct and indirect links with other sectors.

Thus, figure 5 displays on the vertical axis the entrance proximity index for the supplying countries. Two groups can be identified: one includes countries where minerals have significant weight in their exports, but that have a low proximity index, which would indicate that the external demand received would not have a very widespread impact through their purchases from their trading network. Such is the case for Brunei, Saudi Arabia, Peru, Colombia, Indonesia and Chile, among others. In the second group, there are countries with a high percentage of mineral exports and high levels of integration within their trade networks, such as Norway, Australia, Russia, South Africa, Brazil and Canada. Meanwhile, Malaysia and Mexico are on the border between these two groups.

Figure 5. Weight of mining sector on exportations and proximity index for the same sector in principal supplier countries, 2011



Source: OECD (2016). Calculations and preparation by the author.

Moreover, if the proximity index is separated into its national and foreign components, the local effect of purchases from the export sector being evaluated is also smaller for the first group of countries mentioned.

Changes in value generation in the natural resources chain

Although the effect of the growth of mineral exports on certain macroeconomic variables is immediate, it could be expected that this will also stimulate scaling to links with greater added value for the sectors favored by the expansion of global demand. A signal of such change can be obtained by monitoring value added in the intermediate demand matrix, calculated according to equation (2), and attending to which sector has had greater growth in the resulting number. This would be in the extraction of primary goods, or in the sector that adds value through processing, with the understanding that processing is a more complex activity than extraction.

Table 1 shows mining extraction and the industries in charge of its processing in the primary exporting countries (with the exclusion of advanced economies), and the primary destination countries. In each case, column 1 indicates the percentage of the total added value generated by the sector and that is acquired by a specific country, while column 2 indicates the times that the growth of added value in that sector exceeds the average growth of those linked to mining and processing. For example, column 1 for mining in Brazil shows that 7.1% of its added value goes to China and 2.5% to the United States of America, and that—according to column 2—both countries have encouraged this growth, exceeding 2 and 3.2 times on average thanks to the demand of the first and second, respectively. That is, these two countries have only strengthened extractive activity in Brazil, since the rest of the sectors have grown by a smaller proportion. The effect of demand from Japan, Korea and India on Brazil has been the same.

Table 1. Added value and its growth in sectors linked to mining in supplier countries, 1995-2011

Country	*Sector*	*JPN*		*KOR*		*USA*		*CHN*		*IND*	
		(1)	*(2)*	*(1)*	*(2)*	*(1)*	*(2)*	*(1)*	*(2)*	*(1)*	*(2)*
BRA	MINING.QUAR	2.0	3.0	0.7	2.1	2.5	3.2	7.1	2.0	1.0	2.1
	REF.PETROL	0.2	0.4	0.1	0.8	0.6	0.4	0.7	0.8	0.1	0.6
	MAN.CHEMIC	0.1	0.5	0.1	0.5	0.5	0.7	0.5	0.9	0.1	0.6
	MAN.BAS.METALS	0.9	0.8	0.7	0.8	2.4	0.7	1.5	0.7	0.6	0.8
	MAN.PROD.METAL	0.2	0.9	0.1	1.1	0.8	0.7	0.7	1.0	0.1	1.0

Country	Sector	JPN		KOR		USA		CHN		IND	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
BRN	MINING.QUAR	22.4	2.7	5.1	1.7	0.6	2.9	4.5	2.3	3.7	3.1
	REF.PETROL	4.5	-0.7	1.0	-0.1	0.2	0.0	1.7	0.3	0.9	1.1
	MAN.CHEMIC	2.2	7.5	3.6	5.1	1.9	1.2	7.0	2.0	0.8	0.3
	MAN.BAS.METALS	2.1	-0.8	1.7	0.2	6.6	2.6	3.3	0.4	2.7	0.8
	MAN.PROD.METAL	1.2	-0.5	0.4	0.1	0.6	-0.1	1.5	0.4	0.7	0.6
CHL	MINING.QUAR	11.8	2.6	2.4	1.9	1.7	1.0	12.3	1.6	3.9	2.3
	REF.PETROL	1.2	1.1	0.4	1.1	0.7	0.9	2.5	0.7	0.4	1.1
	MAN.CHEMIC	0.8	-0.1	0.4	0.3	1.3	0.1	1.5	0.3	0.4	0.4
	MAN.BAS.METALS	1.6	1.2	2.9	1.4	4.3	1.7	15.1	2.1	0.6	0.4
	MAN.PROD.METAL	0.8	0.3	0.3	0.5	0.6	0.3	1.7	0.7	0.3	0.6
COL	MINING.QUAR	0.6	1.5	0.4	1.6	17.0	1.0	3.3	1.7	1.3	1.8
	REF.PETROL	0.1	2.0	0.1	1.5	2.3	2.0	0.3	1.3	0.2	2.2
	MAN.CHEMIC	0.1	0.3	0.1	0.5	0.7	0.3	0.2	0.4	0.1	0.4
	MAN.BAS.METALS	0.6	2.3	1.2	1.8	13.0	2.2	5.5	1.8	0.6	0.9
	MAN.PROD.METAL	0.0	0.2	0.0	0.5	1.2	0.6	0.2	0.6	0.1	0.6
IDN	MINING.QUAR	8.6	0.8	3.5	0.9	0.9	1.1	7.7	1.2	3.4	1.3
	REF.PETROL	1.5	0.7	0.5	0.8	0.2	0.3	0.9	0.8	0.3	0.5
	MAN.CHEMIC	0.8	0.8	0.4	0.8	0.6	1.2	2.1	1.0	0.6	0.4
	MAN.BAS.METALS	11.8	1.3	3.1	1.5	2.2	1.6	5.4	1.4	2.1	1.1
	MAN.PROD.METAL	0.4	0.6	0.1	0.8	0.2	0.1	0.2	0.5	0.4	1.7
MEX	MINING.QUAR	0.4	0.5	0.3	2.0	13.8	1.4	1.6	2.4	0.8	2.2
	REF.PETROL	0.1	-0.1	0.1	0.4	2.5	0.7	0.2	0.5	0.1	0.6
	MAN.CHEMIC	0.2	0.1	0.1	0.4	3.4	0.5	0.5	0.5	0.2	0.3
	MAN.BAS.METALS	0.8	1.5	0.9	1.2	15.8	1.3	1.6	0.8	0.7	0.9
	MAN.PROD.METAL	0.2	1.6	0.1	1.1	10.9	1.1	0.4	1.0	0.1	1.1
MYS	MINING.QUAR	13.4	1.0	2.5	0.9	0.7	0.7	5.3	0.9	2.9	0.7
	REF.PETROL	2.3	1.7	0.9	1.2	0.5	2.6	3.4	1.6	0.8	1.7
	MAN.CHEMIC	1.8	0.9	0.9	0.7	1.2	0.8	5.1	0.7	1.4	0.8
	MAN.BAS.METALS	3.4	0.7	2.8	0.8	2.1	0.7	12.0	1.2	6.9	0.7
	MAN.PROD.METAL	2.0	2.1	0.7	1.8	1.3	1.3	3.1	1.4	1.5	1.9
PER	MINING.QUAR	4.9	1.1	2.7	1.4	3.9	0.6	12.3	1.2	1.0	1.4
	REF.PETROL	0.9	2.5	0.3	1.6	3.1	1.3	1.4	1.5	0.2	1.3
	MAN.CHEMIC	0.3	0.9	0.1	1.1	0.5	0.8	0.8	0.8	0.1	0.8
	MAN.BAS.METALS	1.1	0.1	0.5	0.2	11.6	1.0	5.2	0.4	2.6	0.8
	MAN.PROD.METAL	0.1	0.3	0.1	0.2	0.3	0.4	0.2	0.4	0.0	0.6
SAU	MINING.QUAR	8.5	1.7	3.7	1.1	6.2	0.8	7.3	2.1	5.1	1.1
	REF.PETROL	2.6	0.2	2.1	0.4	0.6	0.4	1.9	0.3	2.1	0.8
	MAN.CHEMIC	0.7	0.8	0.7	0.9	1.1	0.8	7.4	1.2	2.0	0.5
	MAN.BAS.METALS	1.0	1.2	1.0	1.3	1.0	1.3	1.2	0.8	4.4	0.9
	MAN.PROD.METAL	0.0	0.2	0.0	0.3	0.0	0.1	0.1	0.0	0.1	0.6
ZAF	MINING.QUAR	3.1	2.3	1.3	1.8	1.7	1.9	11.8	2.1	5.7	1.4
	REF.PETROL	0.4	3.1	0.1	2.1	0.4	2.5	0.7	1.4	0.7	1.4
	MAN.CHEMIC	0.7	0.2	0.2	0.5	1.2	0.7	1.6	0.6	1.4	0.3
	MAN.BAS.METALS	5.8	0.3	2.0	0.6	3.6	0.2	5.5	0.7	15.5	1.5
	MAN.PROD.METAL	0.7	-0.4	0.3	0.3	0.8	0.1	1.7	0.5	1.4	0.6

Notes: (1) Percentage of value added generated by exporting sector, according to destination, 2011; (2) Times that the growth in value added of the sector surpassed the average in industries linked to mining, 1995-2011.

Source: prepared by the author.

The table demonstrates visible cases of scaling in the chemical industry in Brunei, the manufacture of basic metals in Indonesia and the petroleum refining and metal product manufacturing in Malaysia. Although the table does not show it, the forward mining chain reaches other sectors in these countries, such as the pharmaceutical and food industries in Brunei, as well as the manufacture of ceramics, glass and cement and transportation equipment in Indonesia, and machinery and equipment, transportation equipment and the food industry in Malaysia.

To understand scaling in these Asian countries, it is necessary to recognize the use of two applied industrial policy tools: long-term development plans, and the use of councils to promote investment. Development plans rest on a pragmatic foundation, because they combine the active economic role of the State with private capital. They are divided into five-year periods, promote national and foreign investment oriented towards external markets, and see diversification as a path to sustainable growth. In Brunei, the current plan is the so-called Wawasan Brunei 2035 (Brunei Embassy Washington DC, 2018), launched in 2007 and which is the continuation of the previous plan, which was launched in 1985. Meanwhile in Indonesia, the primary plan is called the National Long-Term Development Plan 2005-2025, accompanied by a medium plan and a master plan for accelerating economic development (Ministry of National Development Planning, 2018). In Malaysia, the Third Industrial Master Plan 2006-2020, which is part of so-called Vision 2020, was launched in 1991 (MITI, 2018).

Investment promotion councils are government entities that serve as a link between various ministries and the private sector or civil society. In Brunei and Indonesia, such councils report directly to the sultan and the presidency, respectively; in Malaysia they respond to the Ministry of International Trade and Industry. The councils have the function of facilitating investment through the dissemination of opportunities and assistance services, among others, as well as generating proposals and monitoring of policies that promote investment, in accordance with the goals established in the respective development plans. Use of these tools has resulted in improvements in infrastructure, the formation of human capital and the establishment of industrial clusters, all of which—together with the establishment of special economic zones—has succeeded in forming a local industry linked to the GVC in Southeast Asian countries (López, 2014; Ramírez, 2017).

For the rest of the countries-sectors in table 1, scaling is not demonstrated conclusively. Petroleum refining is an extended industry in countries which export this resource, however, the table shows that the cases in which the demand for refining exceeds that which receives extractive activity occurs in a timely manner, Peru and South Africa being those with the most occurrences. The same applies to the basic metals industry which accompanies mineral extraction and, according to the table, in Colombia and Chile receives some stimulus from the consumer countries.

This is consistent with Rodil’s (2017) results, who finds that the share of value generated in Brazil, Chile and Colombia by the export of goods produced in other countries has grown significantly since 1995, indicating a strengthening of participation by these countries in the early stages of GVCs. At the same time, for Mexico—according to Pérez (2017)—though its basic metals exports have increased, their imported content grew much more, thus reducing the relative weight of local added value. Thus, the industrializing effect of such scaling is very limited.

On the other hand, the same table shows that, among the five purchasing countries being analyzed, the figures indicate that China and India are the countries whose demand has served to further strengthen the extractive nature of the supplying countries.

5. GOVERNANCE OF NATURAL RESOURCES IN GVCs

At this point in the analysis it is necessary to bring in the role of transnational companies which govern production segments that make intensive use of minerals, given that the options for scaling up local national or foreign productive units along the chain and, therefore, the possible industrializing impact on the rest of the economy, are conditioned by the strategies of the leading companies.

Although the GVC approach is developed to analyze what happened with the transnationalization of production in the last decades of the twentieth century, in the case of usage of mining resources this internationalization occurs much earlier. Addressing this point, table 2 shows the group of transnationals linked to the extraction and processing of minerals which have the greatest presence across the world. This information was obtained in each case from the respective web portal and, given the large number of companies, some common patterns regarding their governance strategies are highlighted below.

According to the origins of the companies, they can be classified into two groups: those of Anglo-Saxon origin and those of Asian origin. Petroleum companies of Anglo-Saxon origin were founded in the second half of the 19th century and it is known that their transnationalization occurred towards the beginning of the 20th century. All of the companies shown in table 2 have built vertical production chains that begin with the extraction of petroleum/gas, undergo refining/liquefaction and reach at least the chemical industry, or even the generation of energy. The backward linkages and governance applied by its extractive subsidiaries depend on the conditions of the host country at the time of its arrival and subsequent development.

Table 2. Transnational leaders in natural resource chains

Company	Sectors	Countries*	Supplies to sector
Royal Dutch Shell, United Kingdom, 1833	Mining, Refining, Chemistry, Energy	Brunei, Malaysia	Commercialization (combustibles and lubricants), Chemistry, Plastics
BHP Billiton, Australia, 1851	Mining, Basic metals	Brazil, Chile, Colombia, Peru	Basic metals, Chemistry, Energy
Exxon Mobil, United States of America, 1859	Mining, Gas refining, Chemistry	Brazil, Colombia, Indonesia, Malaysia, South Africa	Commercialization (combustibles and lubricants), Plastics, Transportation equipment
Rio Tinto, United Kingdom, 1873	Mining, Basic metals	Brazil, Chile, Indonesia	Commercialization, Basic metals, Transportation equipment
Mitsubishi Corporation, Japan, 1873	Mining, Basic metals, Chemistry, Machinery and Equipment, Transportation equipment, Infrastructure, Energy, Finance, Processed foods, Commercialization	Saudi Arabia, Brazil, Brunei, Chile, Indonesia, Malaysia, Mexico	Commercialization, Basic metals, Chemistry, Machinery and Equipment, Infrastructure, Energy
Chevron Corp, United States of America, 1876	Mining, Gas refining, Chemistry	Saudi Arabia, Brazil, Colombia, Indonesia, Mexico	Commercialization (combustibles and lubricants), Chemistry, Plastics
BP, United Kingdom, 1908	Mining, Refining, Chemistry, Energy, Engineering services, Commercialization	Brazil, Indonesia, Malaysia	Commercialization (combustibles and lubricants), Chemistry, Plastics, Transportation equipment
Total S.A., France, 1924	Mining, Gas refining, Chemistry	Saudi Arabia, Brazil, Brunei, Indonesia, Mexico, South Africa	Commercialization (combustibles and lubricants), Transportation equipment
Glencore, Switzerland, 1974 (Xtrata, 1926)	Mining, Basic metals, Agriculture, Commercialization	Argentina, Chile, Peru	Basic metals, Chemistry, Commercialization, Processed foods
Grupo Repsol, Spain, 1927	Mining, Refining, Chemistry, Energy	Colombia, Indonesia, Mexico, Peru	Commercialization (combustibles and lubricants), Chemistry, Plastics, Transportation equipment, Energy
Petroleum and Natural Gas Corporation Limited, India, 1947	Mining, Petroleum refining	Brazil, Colombia	Commercialization (combustibles and lubricants), Chemistry
China Minmetals Corporation, 1950 (MMG Limited, 2009)	Mining, Basic metals, Engineering services, Construction, Finance, Commercialization	Peru	Commercialization, Mining, Basic metals, Construction
Reliance Industries Limited, India, 1957	Mining, Petroleum refining, Chemistry, Textiles	Malaysia	Commercialization, Chemistry, Plastics, Textiles, Transportation equipment
SK Innovation, South Korea, 1962	Mining, Refining, Chemistry, Machinery and Equipment, Transportation	Peru	Commercialization (combustibles and lubricants), Chemistry, Plastics, Transportation equipment
Posco, South Korea, 1967	Mining, Basic metals, Chemistry, Energy	Brazil, Indonesia, Malaysia, Mexico	Commercialization, Basic metals, Chemistry, Machinery and Equipment, Transportation equipment, Construction, Energy
Nippon Steel and Sumitomo Metal, Japan, 1970	Basic metals, Chemistry	Saudi Arabia, Brazil, Indonesia, Malaysia, Mexico, South Africa	Basic metals, Chemistry, Machinery and Equipment, Transportation equipment, Construction
China National Petroleum Corporation, 1988 (PetroChina Company Limited, 1999)	Mining, Gas refining, Chemistry, Machinery and Equipment, Engineering services, Construction, Finance, Commercialization	Brazil, Indonesia, Peru	Commercialization (combustibles and lubricants), Chemistry, Machinery and Equipment, Engineering services, Construction

Note: *only those referred to in table 1 are mentioned.

Source: prepared by the author.

Economies with little industrial development become enclaves, such that linkages to local production are very limited, with a predominantly hierarchical governance style, since they install branches that limit themselves to guarantee the supply of fuel abroad. In this way, the local economy is detached from the global value chain, as is still the case in several places in Latin America. However, the same transnationals adopt relational governance strategies vis-à-vis governments with clearly defined industrial policies, such as in Asian economies today, to the point of forming alliances with local state-owned enterprises. This is true for companies such as Shell in Brunei, which 50% share the property of petroleum extraction; Exxon and Pertamina in the extraction in Indonesia; and BP and Petronas in the petrochemical industry in Malaysia.

Regarding forward linkages, it is common that refining activity accompanies extraction in the host country; however, beyond that, they supply inputs to industries outside the country of extraction—such as chemistry, plastics and automotive sectors located in various regions around the world. These form part of the final goods GVC, in which they no longer have leadership, which is instead in the hands of the companies which offer the final good. However, they do directly or indirectly control the fuel chain that reaches the final consumer through service stations. In this sector, given the predominant business model, governance is captive, as the leading company subscribes vertical agreements with owners of the gas stations that will be responsible for distributing the good, with exclusivity and price control requirements.

As for mining companies of Anglo-Saxon origin, they resemble petroleum companies to the extent that extraction and some refining processes are carried out in the host country, with hierarchical governance, and with very limited backward linkages in the case of Latin America. Because of the type of good they offer (metal products), they do not become leaders of final goods value chains, although they do form part of the production segments that end up in the construction, machinery and equipment, computer equipment, and automotive industry equipment sectors.

Companies of Asian origin, with the exception of Mitsubishi, are formed after World War II, within the context of the formation of new countries and forms of government in Asia. According to the prevailing nationalist sentiment, these companies are state-owned enterprises or private companies that are subject to government growth strategies (López, 2014). Thus, Minmetals and the National Petroleum Corporation are Chinese state enterprises, while Posco and SK are multi-sector and family-controlled Korean conglomerates, and Mitsubishi and Sumimoto are Japanese conglomerates that, unlike the Korean ones, include a financial area.

Almost at the same time of their creation, these companies begin their transnationalization processes in search of minerals and petroleum, in order to make possible the planned economic growth. In the 2000s, this will be enhanced by their respective governments, thanks to the signing of *ad hoc* commercial agreements (Wilson, 2014). They establish hierarchical governance with branches in countries with abundant mining resources, and also relational, when they should form alliances with state companies, local private ones, or even existing transnationals.

Unlike Anglo-Saxon transnationals, whether petroleum or mining, these are vertically integrated companies, forming production chains that range from extraction, refining and the chemical industry, to construction, machinery and equipment manufacturing, transport equipment manufacturing, power generation and commercialization. They may even include side businesses such as engineering and financial services. That is, they are leaders in complete value chains, which end in final goods and services. Given the state or family origin of these corporations, according to Carney (2005), the management of the chain is based on control of the property of the companies that compose it; in contrast, Western networks are made up of companies that are linked based on contracts.

Backward or forward linkages with local production in the countries where they invest depend on how advanced the internationalization of their own production process is, as well as the capacities and opportunities offered by the host country. Given its years of existence, Mitsubishi is a case of very advanced internationalization; this is how in Chile it participates in the production of iron, in Mexico it produces plastics, in Brunei it produces liquefied natural gas, in Indonesia it manufactures cars, and it has a branch of financial and business consulting in Malaysia. On the other hand, the Korean company Posco, specialized in the production of steel, obtains raw materials mainly from Canada, New Caledonia and Russia, and also processes metals in steel plants in Brazil and Mexico. It also produces wire rod and steel sheets in Indonesia, Malaysia and Mexico.

Chinese petroleum and mining companies correspond to more recent internationalization cases. Petrochina extracts petroleum and gas in 30 countries, including Brazil, Indonesia and Peru. It is a subsidiary of China National Petroleum Corporation, conglomerated with companies in several links of the petroleum chain, from the installation of wells to the commercialization of retail fuel. MMG extracts minerals in Australia, DR Congo, Laos and Peru, but is a subsidiary of China Minmetals, a conglomerate to whom it supplies, and whose subsidiaries range from steel companies to companies in the real estate sector. Thus, the GVCs formed by both conglomerates absorb from the world the raw material necessary to make possible the accelerated process of industrialization and urbanization implemented in China in the 2000s.

6. CONCLUSIONS

While—according to the Leontief coefficient—automobile manufacturing is the activity with the greatest theoretical capacity to drag, the proximity index shows that it is construction which has the most direct and indirect links with the rest of the industries at a global level. It is the growth in both sectors, between 1995 and 2011, that has mobilized intermediate industries, such as petroleum refining, chemical manufacturing, basic metals and metal products, specifically in China, Korea, the United States of America, India and Japan, to absorb the mining resources of the planet.

Among the countries still being developed, the world's largest suppliers of mining resources, in order of sales value, are: Saudi Arabia, Indonesia, Brazil, Mexico, South Africa, Colombia, Malaysia, Peru, Chile and Brunei. However, according to the proximity index for the extractive sector of each one, those with a reduced scope for their backward linkages are: Colombia, Peru, Chile and Brunei; therefore, the contagious effect of their growth is restricted.

With regard to forward linkages, the value added assessment shows industrial scaling in the chemical industry of Brunei, basic metals manufacturing in Indonesia and petroleum refining and metal products manufacturing in Malaysia, as they have been able to progress to more sophisticated links in chains that use mining resources. In the case of Latin American economies, the results indicate that, with the exception of Mexico, they have strengthened their position in the initial stages of the GVCs. In the Mexican case, the industrializing effect of scaling in the metal transformation sectors is limited by the relative reduction of added value generated within the country.

The contribution of industrialization scaling becomes visible in Malaysia and Indonesia, when the share of value added in manufacturing to the GDP is calculated. This participation increased by 4% in both cases, from the beginning of the nineties until 2008; simultaneously, in Colombia and Chile it fell by 4 and 2%, respectively. For Brunei, Mexico and Peru, the reduction is milder (UNIDO, 2019). After the 2008 crisis, manufacturing lost weight in the GDP of all countries. Although the effect of industrialization on economic development is not automatic, since it depends on the redistributive policies of each country, the Human Development Index data shows an annual improvement of 1.14 and 0.91% for Indonesia and Malaysia, respectively, which is a higher percentage than the rest of the countries, except Colombia, which has 0.97%.

Among the transnationals evaluated—those that lead GVCs—are petroleum companies, in the strict sense of the definition, since they manage processes from the extraction of hydrocarbons to the sale of fuel to the final consumer in service stations. Also, the case of Mitsubishi is similar, given that it is in charge of companies that participate in mineral extraction and reach even to vehicle sales by way of concessionary establishments.

The cases of industrial scaling in which the transnationals evaluated here participate correspond to forward movements along the value chains, and not to backward movements. This is the case because, in general, mining companies make large purchases of machinery, equipment and supplies in global markets, thereby limiting their contribution to the local creation of industries in the corresponding sectors. Otherwise, it is more frequent for a hydrocarbon company to add to extraction the activity of petroleum refining or liquefaction of gas, or for a mining company to add metal refining. This should be taken into consideration in the development of industrial policies.

There are important differences between the multinationals being evaluated which are of Anglo-Saxon origin, as opposed to those of Asian origin. The latter form more integrated intersectoral networks, both vertically and horizontally. Mitsubishi and the Chinese conglomerates are the most branched cases, since they use ownership control to a greater extent along the links of the chain, to guarantee the flow of natural resources from their raw material state until the good or final service they offer, be it gasoline or housing. However, the industrializing effect of these companies in developing economies depends on the degree of internationalization of their own production chain. While Japanese and Korean transnationals are trying to internationalize more advanced stages of mineral and hydrocarbon processing, Chinese companies have tried to stock up on raw materials to make their own industrialization processes possible.

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[1] ARG=Argentina; AUS=Australia; AUT=Austria; BEL=Belgium; BGR=Bulgaria; BRA=Brazil; BRN=Brunei; CAN=Canada; CHE=Switzerland; CHL=Chile; CHN=China; COL=Colombia; CRI=Costa Rica; CYP=Cyprus; CZE=Czech Republic; DEU=Germany; DNK=Denmark; ESP=Spain; EST=Estonia; FIN=Finland; FRA=France; GBR=United Kingdom; GRC=Greece; HKG=Hong Kong; HRV=Croatia; HUN=Hungary; IDN=Indonesia; IND=India; IRL=Ireland; ISL=Iceland; ISR=Israel; ITA=Italy; JPN=Japan; KAZ=Kazakhstan; KHM=Cambodia; KOR=South Korea; LUX=Luxembourg; LVA=Lithuania; MAR=Morocco; MEX=Mexico; MLT=Malta; MYS=Malaysia; NLD=Netherlands; NOR=Norway; NZL=New Zealand; PER=Peru; PHL=Philippines; POL=Poland; PRT=Portugal; ROU=Romania; ROW=Rest of the World; RUS=Russia; SAU=Saudi Arabia; SGP=Singapore; SVK=Slovakia; SVN=Slovenia; SWE=Sweden; THA=Thailand; TUN=Tunisia; TUR=Turkey; TWN=Taiwan; USA=United States of America; VNM=Vietnam; ZAF=South Africa.