Measuring value circulation in regional chains: assessing two alternative methods in South America

Midiendo la circulación del valor en cadenas regionales: aplicación de dos alternativas al caso de América del Sur

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Abstract

Since Hummels, Ishii and Ye (2001) seminal work there have been lots of proposals for measuring participation in global value chains with input-output tables. Conjointly to the development of measures, several projects created Inter-Country Input-output tables. To the extent that integrating data of different origins requires strong assumptions and confidence in sources, some projects keep more detailed inter country input-output tables at a regional level. In this paper I adapt two of the most complete methods conceived for global Input-output tables to the case of regional tables, and I use them to analyze the intraregional value chain trade of South America. Besides characterizing the trade in this region, this paper identifies and asses the differences between adaptations of Borin and Mancini (2019) source-based decomposition of gross exports and the Wang, Wei and Zhu (2018) method.

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Resumen

A partir del artículo de Hummels, Ishii y Ye (2001) se han propuesto varias medidas para medir la participación de los países en cadenas globales de valor. Conjuntamente con el desarrollo de medidas, diversos proyectos crearon Matrices Insumo Producto Multipaís para representar mejor el comercio mundial. Dado que integrar información de muchos países requiere de supuestos fuertes y confianza en las fuentes, algunos proyectos mantienen información detallada en matrices insumos producto regionales. En este artículo se adaptan dos de los métodos más completos concebidos para matrices globales al caso de matrices regionales y se aplican para describir el comercio intrarregional en cadenas en América del Sur. Además de esta caracterización, el artículo mide las diferencias entre la metodología source-based de Borin y Mancini (2019) y el método de Wang, Wei y Zhu (2018).

Palabras clave: comercio en valor agregado – cadenas globales de valor – integración regional – insumo producto.

1.- Introduction

One of the salient facts of current era of globalization is the interlink between sectors across countries and the international circulation of value-added. This connection of countries across intermediates goods give rise to new theoretical lectures of the fundaments of trade (Eaton and Kortum, 2002), a re-evaluation of gains of trade (Caliendo and Parro, 2015) and led to modification in global governance of multilateral trade (Baldwin, 2012).

Traditional data on gross trade flows fails in describe some of salient features of globalization (Yi, 2003) and national input-output tables also brings a partial view of international sharing of production (Hummels, Ishii, and Yi, 2001). In recent years there have been several projects of integration of world input-output tables (Tsigas, Wang, and Gehlhar, 2012, Johnson and Noguera, 2012, Timmer et al., 2015, Lenzen et al., 2013) and also the measures of integration on global value chains have been improved. Using these data, literature developed a full set of measures to characterize size, evolution, position, length, or depth of global value chains (GVC). Inter country input-output tables link sectors of different countries and enable a complete evaluation of relationships between final demand, intermediate domestic and foreign demand and value-added.

As a natural extension of input-output analysis, measures of value-added in trade identify the forward and backward linkages of international trade. Hummels, Ishii, and Yi (2001) set the most used definition of backward linkages, capturing the relationship between exports and the origin of value. They label it Vertical Share (VS). They also defined, without proposing a measure, the forward linkages of exports as the value-added of a country included in exports of other countries. Also, Johnson and Noguera (2012) defined the "value-added in exports" as the value-added sourced in a country and consumed in another.

Koopman, Wang and Wei (2014) set a methodology that decomposes gross exports of countries in domestic value-added, foreign content and double counted terms, integrating the previous measures of participation in global value chains (Hummels, Ishii, and Yi, 2001; Johnson and Noguera, 2012; Daudin, Rifflart, and Schweisguth, 2011) in a single scheme. Despite being a benchmark and a reference in the literature, Koopman, Wang and Wei (2014) decomposition do not enables further appliances in less-than overall levels. Wang, Wei and Zhu (2018) -henceforth WWZ- develop an accounting exercise that arrives to same Koopman, Wang and Wei (2014) categories but make possible bilateral, sector and bilateral- sector lectures. All the traditional and most widely used measures can be analyzed within WWZ framework. Los, Timmer, and de Vries (2016), Los and Timmer (2020), Miroudot and Ye (2018) and Johnson (2018), based in the "hypothetical extraction method", also split gross exports in domestic value-added, foreign value-added and double counting content. Also, Borin and Mancini (2015; 2019) develops a more general framework for decompositions of gross exports that identifies domestic or foreign value-added and double counting according to the required level of analysis (overall, bilateral, sectoral) and the purpose of the inquiry. Following Nagengast and Stehrer (2016) they show that some flows can be defined as value-added or as double-content depending on the perspective followed.

All these contributions are conceived for data that aims to represent input-output relationships of the entire world. Nevertheless, Regional Input-output Tables have a long tradition and recent international projects restored their importance (IDE JETRO, 2010; European Commission, 2018; CEPAL, 2016). There can be many reasons for building regional instead of world multi country input-output tables, e.g., this can be the way to include small countries negligible at global level, some more detailed data can be preferred but is not available at global level or the industry classification of global projects may not be useful for some purposes. In fact, despite being labeled as Global, most international sharing arrangements started as regional outsourcing and later they spread out their influence (Johnson and Noguera, 2017).

The use of regional input-output tables arises to some modification in metrics and interpretation. First, final demand is reinterpreted and regional and extra-regional will be considered apart. Second, imported intermediate inputs are split in regional and extra-regional, leading to another source of value. While regional inputs enter to model as in reference literature, extra-regional imports receive a different treatment. This adaptation only holds here if it is assumed that there is no regional or domestic value-added in extra-regional sourced inputs, or the value is negligible. Clearly, this assumption only is reasonable if the region is small or remote enough, like in the case of South America in relationship with the world. Global estimations of domestic value-added in imported inputs for Brazil validates this operational assumption (Koopman, Wang, and Wei, 2014; Los and Timmer, 2020).

Adapting global metrics to regional input-output tables, in this paper I develop a Source-Based decomposition of regional exports based in Borin and Mancini (2019) and I apply it to characterize the kind and degree of regional integration of South American countries using the regional Input-output tables launched by the Economic Commission for Latin America and the Caribbean (CEPAL, 2016)[1]. I develop also and alternative decomposition of regional exports based in Wang, Wei, and Zhu (2018) in order to illustrate more clearly the differences in both methods. All references mentioned here are based on different account segregation of terms that combine value-added, international and domestic linkages, and final demand. As long as Borin and Mancini (2019) and Wang, Wei, and Zhu (2018) are the more parsimonious and complete references in each strand of literature, I use both in order to discuss and asses the differences between methods. Borin and Mancini (2019) can be considered a representant of a strand of literature compatible with hypothetical extraction method and Wang, Wei, and Zhu (2018) can be considered the best effort to apply Koopman, Wang, and Wei (2014) in a bilateral basis.

The method developed here builds a bridge between both methodologies and it allows a lecture in different levels according with the alternatives methodological approaches (Wang et al., 2017b vis a vis Borin and Mancini, 2019).

This paper includes this introduction and three sections more. Section II introduces the methodological aspects of discussion and builds the accounting segregation used and the differences among methods. Then, section III shows the results of the application for regional trade of South American Countries, and section IV draws some conclusions.

1 Banacloche et al. (2020) also uses CEPAL (2016) input-output table to characterize South American integration with an adaptation of Koopman, Wang and Wei (2014) to regional input-output tables. As the framework used only applies for total exports, their analysis is done at this level.

II. Tracing value in bilateral exports with regional input-output tables

i.- General notation and definitions

Table 1 shows a regional input-output table with G regional countries $\{s,r,t \in G\}$ and the rest of world composed by H extra regional (also labeled as "foreign" in this article) countries $\{h \notin G, h \in H\}$.

Table 1. Regional input-output table

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Destination / Source		Intermediate use				Final regional use			Foreign use			Output
		1	2	…	G	1	…	G	1'	…	H	
Intermediate Inputs from region	**1**	Z^{11}	Z^{12}	$\cdots$	Z^{1G}	Y^{11}	$\cdots$	Y^{1G}	$Y^{11'}$	$\cdots$	Y^{1H}	X^1
	2	Z^{21}	Z^{22}	$\cdots$	Z^{2G}	Y^{21}	$\cdots$	Y^{2G}	$Y^{21'}$	$\cdots$	Y^{2H}	X^2
	⋮	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$	
	G	Z^{G1}	Z^{G2}	$\cdots$	Z^{GG}	Y^{G1}	$\cdots$	Y^{GG}	$Y^{G1'}$	$\cdots$	Y^{GH}	X^G
Intermediate foreign Inputs	**1'**	$Z^{1'1}$	$Z^{1'2}$	$\cdots$	$Z^{1'G}$							
	2'	$Z^{2'1}$	$Z^{2'2}$	$\cdots$	$Z^{2'G}$							
	⋮	$\vdots$	$\vdots$	$\ddots$	$\vdots$							
	H	Z^{H1}	Z^{H2}	$\cdots$	Z^{HG}							
Value-added		Va^1	Va^2	$\cdots$	Va^G							
Total Output		$(X^1)^T$	$(X^2)^T$	$\cdots$	$(X^G)^T$							

Source: Own Elaboration

Z^{sr} $\{s,r \in G\}$ is an NxN matrix of intermediate inputs produced in country s and used in country r, $\hat{Z}^{hr}$ $\{r \in G, h \notin G, h \in H\}$ is an NxN matrix of intermediate inputs imported by r from country h, Y^{sr} is an Nx1 vector of final goods produced in country s and consumed in country r, Y^{sh} is an vector of intermediate and final goods produced in country s and exported to country h, X^s is an Nx1 vector of output of country s and Va^s is a 1xN vector of direct value-added in country s. T is the transpose operator. In a general notation, final demand Y and production X can be expressed as NGx1 vectors, Z is a NGxNG matrix, $\hat{Z}$ is a NHxNG matrix and Va is a 1xNG vector.

The international Leontief matrix $A=ZX^{-1}$ enables the usual notation in input-output analysis. The international Leontief inverse matrix is defined as: $B=(I-A)^{-1}$.

Each A^{sr} is an NxN matrix containing the ratios of utilization of origin s in the production of country *r*. The main block diagonal (s=r) corresponds to domestic intermediate transactions, whereas when s≠r is the case of international trade of intermediates.

Each sub matrix B^{sr} is the total output necessary in each n sector of country s to fulfill one additional unit of final demand in each *n* sector of *r*. Analogously, we can define the local Leontief inverse matrix as a measure for total domestic output necessary in each *n* sector to fulfill one additional unit of final demand without considering international sourcing of intermediates: $L=(I-A^{D})^{-1}$.

From the perspective of user, gross output X can be split according to destination.

$$X = AX + Y^{D} + Y^{R} + Y^{F} \qquad (1)$$

Where *A* accounts only for intrarregional intermediate inputs. Y^{D} accounts for domestic final demand, Y^{R} accounts for intrarregional final demand and Y^{F} includes both intermediate and final demand from countries out of matrix. Note that intermediate exports to extra-zone will be treated as final demand. For simplification, all foreign countries are treated as one: $Y^{sF}=\sum^{H}_{h} Y^{sh}$.

From the perspective of the sources of value in production, output is produced according to a function of production that includes domestic and regional inputs included in Z, foreign inputs included in $\hat{Z}$ and value-added:

$$X^T = u\hat{X} = uZ + w\tilde{Z} + \tilde{V} = A\hat{X} + wA^X\hat{X} + \tilde{V} = uA\hat{X} + F\hat{X} + V\hat{X} \quad (2)$$

Where u and w are 1xNG and 1xNH vectors of ones, $F=wA^X$ is a 1xNG vector containing the sum of extra-regional inputs included in one unit of production and A^X is an NHxNG matrix containing ratios of use of foreign intermediates as a share of production $A^X=\hat{Z}X^{-1}$. $\hat{Z}$ is the NHxNG matrix of foreign use of intermediates. Post-multiplying by X^{-1} we get the partition of sources of value:

$$u = uA + F + V = F(I-A)^{-1} + V(I-A)^{-1} = FB + VB = u\hat{F}B + u\hat{V}B \quad (3)$$

There is a key assumption that must be made to adapt world-level definitions to an incomplete set of information: Exports to extra zone must be treated as being only in final goods. Although this does not seem very realistic, the only important issue is to assure that there is no regional value-added returned to the region embedded in intermediates. Therefore, all exports to extra zone are consumed abroad so there is no regional or domestic value-added in foreign inputs. While in some big and open trading blocs it seems unreasonable, in another remoter, small sized and closed ones the assumption does not seems so unrealistic. In their application of Koopman, Wang and Wei (2014) in South America, Banacloche, Cadarso, and Monsalve (2020) also consider this limitation.

The second innovation is the fact that there is foreign supply of inputs. Then, the production in a country s will involve domestic value-added, value-added generated in a regional partner *(V^r, V^t)* and foreign content included in foreign inputs *(F)*. Note that as long as there is not a complete foreign input-output table, it cannot distinguish between foreign value-added and foreign double-content.

Therefore, I will refer to that as foreign content (including both genuine value-added and double content) instead of foreign value-added[2].

Borin and Mancini (2019) show that it would be useful to define a matrix of intermediates that excludes the international trade of intermediates sourced in s ($A^{st}=0\ \forall t\neq s$):

$$A_{\not{s}} = \begin{bmatrix} A^{11} & A^{12} & \dots & A^{1s} & \dots & A^{1G} \\ A^{21} & A^{22} & \dots & A^{2s} & \dots & A^{2G} \\ \dots & \dots & \ddots & \dots & \dots & \vdots \\ 0 & 0 & 0 & A^{ss} & \cdots & 0 \\ \dots & \dots & \dots & \dots & \ddots & \vdots \\ A^{G1} & A^{G2} & \dots & A^{Gs} & \square\ \dots & A^{GG} \end{bmatrix}.$$

The inverse of this matrix is:
$B_{\not{s}} = (I - A_{\not{s}})^{-1}$

Borin and Mancini (2019) shows that International Leontief Inverse Matrix B can be expressed as the addition of two matrices, being the first $B_{\not{s}}$ and the complement the interaction of complete and incomplete matrix ($B=B_{\not{s}}+B_{\not{s}}A_{\not{s}}B$). For country *s* as user, this relationship can be expressed separately for country *s* sourcing itself and the rest (t):

$$B^{ss} = L^{ss} + L^{ss} \sum_{u\neq s}^{G} A^{su} B^{us} \qquad (4)$$

$$B^{ts} = B_{\not{s}}^{ts} + B_{\not{s}}^{ts} \sum_{t\neq s}^{G} A^{su} B^{us} \qquad (5)$$

2 Banacloche et al. (2020) name this input as imported content, in order to show that it could also have domestic or regional content.

It can be showed that $L^{ss} = B_{s}^{ss}$, that is, (4) is a particular case of (5) when *s=t*. While (4) is of general use in literature (Koopman, Wang, and Wei, 2014; Wang et al., 2017b; Wang, Wei, and Zhu, 2018), Equation (5) is key in the hypothetical extraction strand of literature (Miroudot and Ye, 2018; Los, Timmer, and de Vries, 2016; Los and Timmer, 2020).

Equation (4) split total effects of demand of *s* in production of s in pure domestic and international induced effects. The second term of (4) accounts for the effects originated in *s* and affecting *s* not directly through domestic linkages but indirectly trough linkages that *s* has with other countries that in turn depends on *s*. Equation (5) splits relationship between production and demand in s and t in a similar way: B_{s}^{ts} accounts for effects of demand in s on production in t without considering the requirements of inputs sourced in *s* that sectors in t could have. B_{s}^{ts} assures that the effect of demand in s in production in t does not contain value-added in *s* induced by international trade. The complement is the effect of demand in *s* that *t* faces that includes some stages of production in *s*.

ii. A new source-based decomposition of bilateral exports using Regional Input-output Tables

Borin and Mancini (2019) define the Directly Absorbed Value-added in Trade as:

$$DAVAX^{sr} = V^{s}L^{ss}Y^{sr} + V^{s}L^{ss}A^{sr}L^{rr}Y^{rr} \qquad (6)$$

This is the measure of the trade from s to r that only crosses one border. It correspond to value-added sourced in exporting country s and directly sent to r, both for direct consumption ($DAVAX\_fin^{sr} = V^{s} L^{ss} Y^{sr}$) or as intermediate but transformed and directly consumed in destination ($DAVAX\_int^{sr}=V^{s} L^{ss} A^{sr} L^{rr} Y^{rr}$).

$DAVAX^{sr}$ is at the core of the GVC participation ratio used in the 2020 World Development Report (World Bank 2019) at a country level. In fact, this index is defined as the difference between gross exports and DAVAX. So, $GVCX^{s}=uE^{s*}- DAVAX^{S*}$. As long as some authors include $DAVAX\_int^{sr}$ as a measure of "simple" participation in GVC (Wang et al., 2017b), the point is still matter of controversy. Nevertheless, this discussion does not affect our benchmark.

Following Borin and Mancini (2019), we will divide overall participation in regional value chains in backward and forward. Forward participation is the value-added sourced in *s* that is not consumed directly in *r*, so is included in its exports. Backward participation is the domestic, regional and foreign value-added and double counted flows included in the imported inputs that *s* uses in their exports to *r*. As Borin and Mancini (2019) note, this concept is exactly the same as (Hummels, Ishii, and Yi 2001) pioneering definition of Vertical Share and differs from Koopman, Wang, and Wei (2014) and Wang, Wei, and Zhu (2018).

Then, gross exports will be divided according to four terms. The two first are defined in (7), the third are forward linkages and the fourth are backward linkages:

$$E^{sr} = DAVAX\_fin^{sr} + DAVAX\_int^{sr} + RVC\_fwd^{sr} + RVC\_bwd^{sr} \quad (7)$$

Borin and Mancini (2019) shows that domestic value-added in exports is the sum of the three first terms and defines the global value chains trade as the sum of the last two. For descriptive purposes, it is useful to divide both Forward and Backward terms.

RVC_fwd^{sr} is divided according to where value-added is finally consumed. A convenient division is the importer country (DVA_p^{sr}), another regional partner (DVA_reg^{sr}), the country of origin (RDV^{sr}) and, for data with incomplete input out tables, extra-zone markets (DVA_for^{sr}):

$$RVC\_fwd^{sr} = DVA\_p^{sr} + DVA\_reg^{sr} + RDV^{sr} + DVA\_for^{sr} \quad (8)$$

DVA_p^{sr} represents the value-added sourced in *s* and directly exported by it, transformed in *r*, reexported to another regional country (labeled t) and finally consumed in *r*. Note that it includes some kind of back-and-forth trade from *r* to *t*.

DVA_reg^{sr} represents the value-added sourced in *s*, transformed in *r* and finally consumed in a third country. Al least two regional countries participate in production. Note that this flow is forward linkages in the relationship between *s* and r but is backward linkages in the relationship between *r* and *t*.

RDV^{sr} is value-added exported from s to r but finally consumed in *s*. This term, defined as Reflecting Trade by Daudin, Rifflart, and Schweisguth (2011) and Koopman, Wang, and Wei (2014), does not belong to “Value-added in Exports” concept defined firstly by Johnson and Noguera (2012), because it is not consumed abroad.

DVA_for^{sr} is value-added sourced in *s*, transformed in *r* and exported to extra-zone by r or another regional country. As long as we assume that foreign inputs do not contain regional value, this flow is consumed in extra-zone. This flow is regional trade induced by foreign demand and reflects the fact that, even if we are analyzing regional trade, foreign demand should be considered in the framework (Banacloche, Cadarso, and Monsalve 2020). This term arises as a consequence of working with regional instead of global complete input-output tables.

Backward linkages have a different nature than forward and thus the split follows a distinct interpretation. Nevertheless, the aggrupation according to source of value follows the same logic. Backward linkages are divided in Domestic sourced Double Counted term, bilateral value-added, regional value-added, regional double counted and foreign content.

$$RVC\_bwd^{sr} = DDC^{sr} + BVA^{sr} + RVA^{sr} + RDC^{sr} + FC^{sr} \quad (9)$$

Domestic double-content *(DDC^{sr})* is value-added sourced by s but in previous stages of production, that is, it enters in this flow included in imported inputs that s makes from regional countries (remember that there is no regional value-added in extra zone inputs).

BVA^{sr} and RVA^{sr} are partner and other regional value-added included in *s* exports. The source-based method assures that this value-added do not contains any stage in *s*. RDC^{sr} is regional (including partner) double counted flow. It arises from the fact that some foreign value-added could already have been counted in other intermediates exports from *s* to a regional partner and then finally included in exports from s to *r*.

Another source of value in gross regional exports is foreign input used in production *(FC^{sr})*. It could be included directly by *s* or indirectly by a partner through regional intermediates used by *s* (see *DFC* and *RFC* in table below). From the perspective of the identification of backward linkages there is not much relevancy in distinguishing both kinds of flows, except if estimation of foreign content is done at overall regional exports. In that case just direct term should be counted and indirect is redundant, given that it is already included in another flow. Table 2 includes the definition of each term.

Table 2. A source- based Bilateral decomposition of gross exports from s to r with regional input- output tables

Term	Subterm	Formula
$DAVAX_{fin}$	---	$(V^s L^{ss})^T \# Y^{sr}$
$DAVAX_{int}$	---	$(V^s L^{ss})^T \# (A^{sr} L^{rr} Y^{rr})$
RVC_fwd	DVA_p (1)	$(V^s L^{ss})^T \# (A^{sr}(B^{rr} - L^{rr})Y^{rr})$
	DVA_p (2)	$(V^s L^{ss})^T \# \left(A^{sr} \sum_{t \neq s,r}^{G} B^{rt} Y^{tr}\right)$
	DVA_reg (1)	$(V^s L^{ss})^T \# \left(A^{sr} \sum_{t \neq s,r}^{G} B^{rt} Y^{tt}\right)$
	DVA_reg (2)	$(V^s L^{ss})^T \# \left(A^{sr} \sum_{t}^{G} B^{rt} \sum_{u \neq s,r,t}^{G} Y^{tu}\right)$
	DVA_for	$(V^s L^{ss})^T \# \left(A^{sr} \sum_{t}^{G} B^{rt} \sum_{t} \sum_{h}^{H} Y^{th}\right)$
	RDV	$(V^s L^{ss})^T \# \left(A^{sr} \sum_{t}^{G} B^{rt} Y^{ts}\right)$
RVC_bwd	DDC	$\left(V^s L^{ss} \sum_{t \neq s}^{G} A^{st} B^{ts}\right)^T \# E^{sr}$
	BVA	$(V^r B_s^{rs})^T \# E^{sr}$
	RVA	$\left(\sum_{t \neq s,r}^{G} V^t B_s^{ts}\right)^T \# E^{sr}$
	RDC	$\left(\sum_{t \neq s}^{G} V^t B_s^{ts} \sum_{u \neq s}^{G} A^{su} B^{us}\right)^T \# E^{sr}$
	DFC	$(F^s L^{ss})^T \# E^{sr}$
	RFC	$\left[\left(F^s L^{ss} \sum_{t \neq s}^{G} A^{st} B^{ts}\right)^T + \left(\sum_{t \neq s}^{G} F^t B^{ts}\right)\right] \# E^{sr}$

Source: Own Elaboration

Despite being a reference in the literature, Koopman, Wang, and Wei (2014) gained several critics in last years. Johnson (2018) highlights that there is inconsistency in Koopman, Wang and Wei (2014) because intermediate goods are contained both in exports and in production used to fulfill exports. He argues that if they are measured in exports, they should be extracted from input requirement matrix for production. By doing so (working with a matrix that extracts A^sr from A) one can track from exports to output and then from output to value-added. Despite being done for Koopman, Wang and Wei (2014) decomposition, this comment applies also for WWZ. Borin and Mancini (2019) classify all decompositions according to the treatment of this issue: they find that Johnson (2018), Los, Timmer, and de Vries (2016), Los and Timmer (2020), Miroudot and Ye (2018) and themselves account for a correct treatment of possible endogeneity of intermediate in exports and that Koopman, Wang, and Wei (2014), WWZ and Nagengast and Stehrer (2016) override this problem.

Los and Timmer (2020) argues that WWZ decomposition is mathematically valid but arbitrary because it lacks an economic model behind the choosing of accounting segregation. More important, they criticize the fact that the sum of value-added in exports of WWZ bilateral decomposition over all countries is equal to overall value-added in exports. This value-added is included in doubled counting term, but it should be included in bilateral relationship. Interestingly, Los and Timmer (2020) argue that the difference between the sum of bilateral value-added in exports (according to their method exposed there and also in Los, Timmer and de Vries (2016)) and overall value-added in exports is a measure of the importance of loops and so a measure of WWZ bias. From selection of biggest countries and using WIOD for 2014, they find that Germany has the largest double counting of VAX (1,8%) and Australia and Brazil the lowest (0,1%).

A more complete analysis of Koopman, Wang, and Wei (2014) (and by extension of WWZ) method is done by Borin and Mancini (2015; 2019). First, as Los and Timmer (2020) and WWZ, they state that there is no such thing as a unique method to account for value-added in disaggregated trade flows, so each empirical question has to address the proper measure. The concept of value-added and foreign content must be precisely defined in each exercise. They argue that the boundaries must be defined at the proper level, being the whole country, a bilateral relationship or even a bilateral sectoral one. The specific sectoral bilateral relationship is the relevant perimeter, and only the items that enter multiple times in this trade flow should be considered as double counted. Note that Koopman, Wang and Wei (2014) and WWZ have a broader concept of double counted, especially in the foreign content split in foreign value and double counted. They consider as double counted all the trade that crosses foreign borders many times, even if it is not the border of the country of reference. Miroudot and Ye (2018) develops a framework based in hypothetical extraction method consistent with Los, Timmer, and de Vries (2016) an apply it to WIOD 2014, finding systematic difference –in both directions- with Koopman, Wang and Wei (2014) method.

The second critic is that in Koopman, Wang and Wei (2014) there is an arbitrary and inconsistent selection of when a cross border is value-added and when is double counted. Given that in the value-added sourced in s and included in final demand in r there could be several countries participating as intermediate producers, it should be clear the border of reference used to define both value-added and double counted (Nagengast and Stehrer, 2016). Two extreme cases are presented in the literature: the source- based and the sink- based approaches. In the source- based approach the value-added is recorded as closely as possible to the moment when it is produced. Every cross border beyond the first is double counted. As an example, using (4) the value-added of s in final exports to *r*, $V^s B^{ss} y^{sr}$, can be split in $V^s L^{ss} y^{sr} + V^s L^{ss} \sum^{G}_{t \neq s} A^{st} B^{ts} y^{sr}$, where the first term is source-based value-added and the second is source-based double counting. In the sink-based approach the value-added is recorded as closely as possible to the moment where it is ultimately absorbed in the production of final goods. Following the same example, the value-added of *s* in final exports to r is totally value-added $V^s B^{ss} y^{sr} + 0$, because there is no further transformation after leaving *s* country by last time. Borin and Mancini (2019) points that Koopman, Wang and Wei (2014) and WWZ split domestic content of exports with a mixed approach, treating final exports with sink- based and intermediate exports with source- based approach. Table 3 shows an example of both methods for Domestic Content of Exports *(*$V^s B^{ss} E^{sr} = V^s B^{ss} y^{sr} + V^s B^{ss} A^{sr} X^r$*)*.

Table 3. Sink and source-based method of decomposition of gross exports: an example

Type of good	Term	Source- based		Sink- based	
		Value-added	Double Counted	Value-added	Double Counted
Final	$V^s B^{ss} y^{sr}$	$V^s L^{ss} y^{sr}$	$V^s L^{ss} \sum_{t \neq s}^{G} A^{st} B^{ts} y^{sr}$	$V^s B^{ss} y^{sr}$	0
Inter-mediate	$V^s B^{ss} A^{sr} X^r$	$V^s L^{ss} A^{sr} X^r$	$V^s L^{ss} \sum_{t \neq s}^{G} A^{st} B^{ts} A^{sr} X$	$V^s B^{ss} A^{sr} L^{rr} X_r^{(\to sY}$	$V^s B^{ss} A^{sr} L^{rr} B^s_{rs} E$

Source: Own elaboration based on Borin and Mancini, 2019)

Source: Own elaboration based on Borin and Mancini, 2019)

Where: $X_j^{(\rightarrow sY*)} = y^{rr} + \sum_{r \neq t}^{G} y^{rt} + \sum_{r \neq t}^{G} A^{rt} \left(\sum_{u \neq s}^{G} \sum_{v}^{G} B_{tu}^{s} y^{uv} + B_{ts}^{s} y^{ss} \right)$ captures all production of r that is not used in exports of *s*.

WWZ methodology follows as closely as possible the Koopman, Wang and Wei (2014) method and philosophy. The unique difference is that WWZ allocate the entire pure double counted as vertical share measure, instead of excluding the domestic part of double counting as Koopman, Wang and Wei (2014) do. By following so closely that reference, WWZ main decomposition do not have a clear-cut interpretation, as it pointed in the references cited above. In the revised version of the original paper, the authors include as Appendix D an alternative decomposition that departs somewhat from Koopman, Wang and Wei (2014) and is more consistent (though not completely) with a source- based criteria, at least in the splitting of domestic content.

Despite having some comparison between several methods[3], there is not a direct algebraic nor quantitative assessment between WWZ and Borin and Mancini (henceforth B&M) source-based decomposition. Figures 1 and 2 depict the logic of both decomposition and the aggrupation of terms in broad categories. While Borin and Mancini (2019) goes directly to tracking previous flows of value in sourcing country, WWZ are primary interested in tackling possible use of value redundantly in destination. Table B1 in Appendix B compares algebraically both methodologies, grouping term by term.

3 See Appendix C of Borin and Mancini (2015) for a comparison between their source-based method and Koopman, Wang and Wei and Section 5.1 of Borin and Mancini (2019) for an perspective- based classification of alternative methods.

Figure 1. A Source-Based decomposition of Bilateral Exports with regional input-output tables.

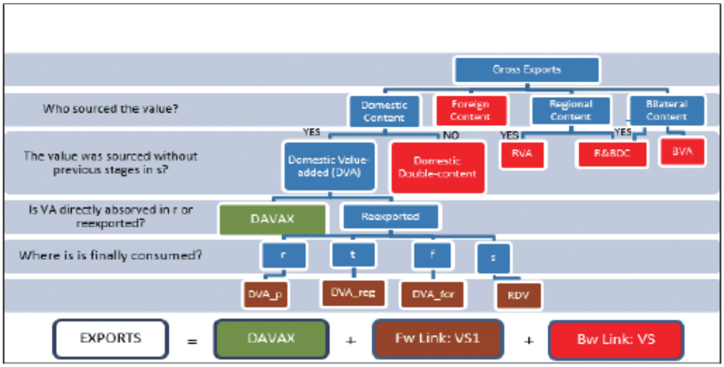


Figure 2. A Wang, Wei and Zhu (2018) based decomposition of Bilateral Exports with regional input-output tables.

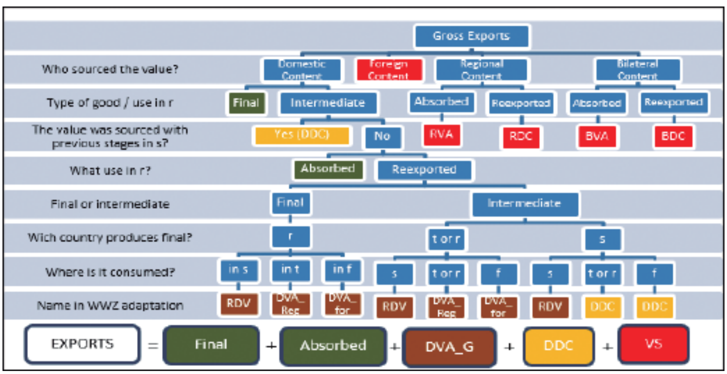


Table B1 in Appendix shows that the relevant differences among two methods rely on the value-added included in final goods, in the terms accounting for Domestic Doble Counting and in the measures in Bilateral and Regional Value-added (BVA, RVA) and Regional Double Counted (RDC).

The difference between the first term according to B&M source-based decomposition ($DAVAX_{fin}$) and Value-added included in final good accord to WWZ is:

$$Dif1\colon\ (V^s B^{ss})^T \# Y^{sr} - DAVAX_{fin} = \left(V^s L^{ss} \sum_{t \neq s}^{G} A^{st} B^{ts} \right)^T \# (Y^{sr})$$

This value is part of *DDC* in the decomposition followed in this paper and can be named: "Indirect domestic value-added included in exports of final goods". This value corresponds to domestic value-added included in foreign intermediates used by domestic country in final good exports. So WWZ only counts as double just the share that is used in intermediates. But some intermediates are directly consumed at destination an so they should receive the same treatment as if they were final goods. This is the inconsistency that some authors point at WWZ decomposition, as pointed above. *Dif*1 is Domestic Value-added in WWZ but not in B&M source-based approach. Note that if we apply B&M sink-based approach the difference with WWZ arise in the treatment of intermediates instead of final. While "indirect domestic value-added in exports of final goods" will be both counted as value-added, WWZ will label as double counted a part of intermediates that should also be treated as value-added. That is why Borin and Mancini (2019) asserts that WWZ uses a "mixed" (either source nor sink) approach for Domestic Content.

The second difference arises in the treatment of Forward Linkages. While B&M considers also the Direct Domestic value-added in intermediate goods re-imported by source country and further reexported, WWZ excludes this flow from DVA and treats it as a portion of Double Counting.

$$Dif2{:}\ DVA_{reg\_2}^{B\&M} + DVA_{for\_2}^{B\&M} - (DVA_{reg_2}^{WWZ} + DVA_{for_2}^{WWZ}) = (V^s L^{ss})^T \\ \# \left(A^{sr} B^{rs} \sum_{t \neq s}^{G} Y^{st} + A^{sr} B^{rs} \sum_{h}^{H} Y^{sh}\right)$$

As a consequence, both methodologies measure Domestic Value-added in Other Countries Exports in a different way and so propose alternative measures of Hummels, Ishii, and Yi (2001) concept of Forward Vertical Specialization (VS1). B&M label this flow as Forward Linkages and WWZ as DVA_G.

The third main difference among techniques is the split of bilateral and regional value-added and double-content terms. In both methods the sum of regional, bilateral, and double counted terms gives the same value:

$$\left(\sum_{t \neq s}^{G} V^t B^{ts}\right)^T \# (E^{sr})$$

Nevertheless, there are differences in the definition of each term. Table 4 shows the differences. For simplicity, BVA and RVA are consolidated[4].

Table 4. Bilateral and Regional Content decomposition. Bilateral, Regional and Double Counted Value according to B&M and WWZ

BVA , RVA and RDC	B&M	WWZ
$\left(\sum_{t \neq s,r}^{G} V^t B_s^{ts}\right)^T \# (Y^{sr} + A^{sr} L^{rr} Y^{rr})$	BVA and RVA	BVA and RVA
$\left(\sum_{t \neq s,r}^{G} V^t B_s^{ts}\right)^T \# (A^{sr} L^{rr} E^{r*})$	BVA and RVA	RDC
$\left(\sum_{t \neq s}^{G} V^t B_s^{ts} \sum_{u \neq s}^{G} A^{su} B^{us}\right) \# (Y^{sr} + A^{sr} L^{rr} Y^{rr})$	RDC	BVA and RVA
$\left(\sum_{t \neq s}^{G} V^t B_s^{ts} \sum_{u \neq s}^{G} A^{su} B^{us}\right) \# (A^{sr} L^{rr} E^{r*})$	RDC	RDC

Source: Own Elaboration

4 Using $\sum_{t \neq r,s}^{G} V^t B^{ts} + V^r B^{rs} = \sum_{t \neq s}^{G} V^t B^{ts}$

The first term captures the foreign value that does not contain any stage of production in s before being effectively used in s in his exports to r and that is directly consumed there. Last term includes foreign value that already had had a stage of production in s before being reimported again by s and used in their exports to r but are in turn reexported by r. This term, almost negligible, is considered double counted in both methods. The second and third term contain the differences among methods. B&M consider as double counted only the foreign value that is effectively used more than once by s, and they do not care about the use that r does of this value. WWZ consider as double counted the foreign value that country s includes in its exports and that country r will in turn include in its own exports. In conclusion, B&M try to identify a loop in production in s and WWZ try to assess the multiple crossing of intermediates in a more general way. Section III.iii shows that WWZ method give rise to a bigger share of double counting in foreign content. Also, in their method double counting is more prevalent in countries that exports to another exporters. In turn, in B&M method double counting is a producer issue.

III. Tracing regional value chains in the bilateral trade in South America

i. General results: following the value-added and foreign content

Our decomposition of regional trade on a bilateral basis depicted in Table 2 is applied to the versions 2005 and 2011 of the ECLAC input-output tables. Details of this matrix can be founded in CEPAL (2016)[5]. Appendix C lists the 40 sectors.

5 The matrix can be downloaded in: https://www.cepal.org/sites/default/files/events/files/matrizlatina2011_compressed_0.xlsx

Table 5 show the aggregated results for each country as exporter. In 2011, 82% of total regional exports are value-added directly included in the sourcing country (*VAX* in Johnson and Noguera (2012) definition), while 18% is Backward integration in global value chains *(BwLE)*. This ratio ranks from 12% for Venezuela to 25% for Chile and Bolivia. Half of the value-added directly.included by exporter is included in intermediates than are consumed directly in country of destination ($DAVAX_{int}$). This -in the terminology of (Wang et al. 2017b)- Single Regional Value Chain is pervasive in Bolivian and Venezuelan regional exports, which rely heavily in mineral products.

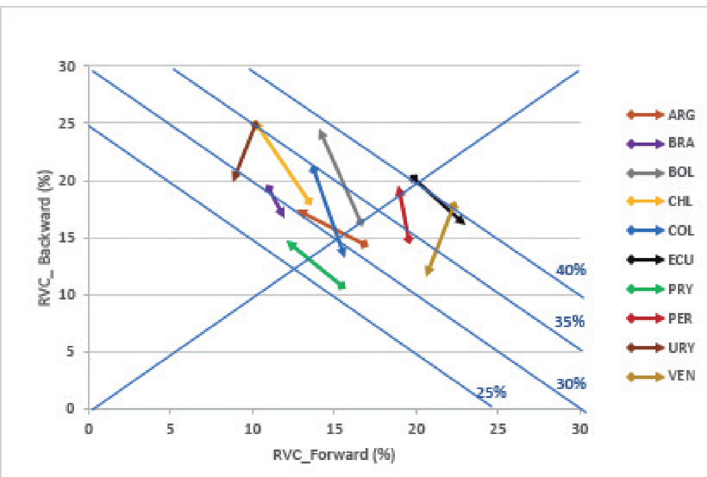
Domestic Value-added in Final goods ($DAVAX_{fin}$) is important for Brazil and Paraguay regional exports. In both countries a third of total regional exports rely in this concept. 13% of total regional exports is value-added originated in the exporting country not directly consumed in importing country but reexported anywhere (*FwLE)*. Table C2 in Appendix show the same estimation for 2005. In the period, $DAVAX_{fin}$ globally declined by 5 percentage points and $DAVAX_{int}$ raised, while Forward linkages declined by 1 percentage points and Backward remained nearly unchanged. Decline in $DAVAX_{fin}$ was especially important in Chile, Bolivia, Colombia and Uruguay. While in Bolivia and Chile they were partially compensated by rise in Backward and $DAVAX_{int}$, in Colombia and Uruguay Backward also declined and the compensation is due to $DAVAX_{int}$.

Table 5. Accounting segregation of South America intra zone trade. In million dollars and percentages. 2011

	Regional exports	Share of Value-added in Exports (in %)			Share of Foreign and double counted
		$DAVAX_{fin}$	$DAVAX_{int}$	$FwLE$	$BwLE$
Argentina	35,966	26	43	13	17
Brazil	53,742	35	36	12	17
Bolivia	7,394	5	57	14	25
Chile	16,898	27	37	10	25
Colombia	12,907	19	52	16	13
Ecuador	7,514	19	42	23	16
Paraguay	4,238	34	39	12	15
Peru	9,616	25	36	19	20
Uruguay	5,620	21	50	9	20
Venezuela	6,290	1	67	21	11
TOTAL	**160,185**	**27**	**42**	**13**	**18**

Source: Own elaboration

Figure 3. RVC participation by type. Evolution 2005-2011. In % of gross exports to region.

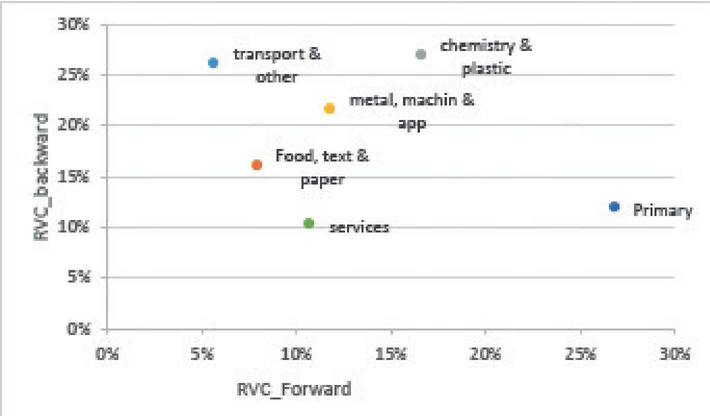


Source: Own Elaboration

Figure 3 summarizes the participation of regional value chains in regional trade by exporting country and shows the change in time. The starting dot of the arrow is 2005 and the end is 2011. Countries above the 45 degrees line have more backward participation and countries below are more forward. All countries have a RVC total share that ranks between 25% and 40%. Figure shows that Ecuador, Perú, Bolivia and Venezuela are the countries where RVC terms are higher but, except in Bolivia, in these countries regional trade is less relevant. Chile and Uruguay are the more backward biased countries and Paraguay is the country with less participation in the period. Argentina and Brazil, the biggest participants in regional trade tend to have a similar backward biased participation. Given that they trade manufacturing goods in the region, it should be expected more backward share, but results shows that these closed economies tend to incorporate little foreign content in exports.

It could be argued that the low level of values capturing RVC trade is due to aggregation effect, where primary and agriculture- based industry products prevail in trade. Nevertheless, Figure 4 shows that results for industry are not conclusively different from aggregated ones. Therefore, GVC trade in South America is scarce even in manufacturing products. In chemistry and plastic sectors, total Forward and Backward linkages account for 44% of exports, and in Transport Equipment industry they account for 32% of exports.

Figure 4. GVC participation in regional South American trade, by exporting sector. Year 2011. In million dollars.

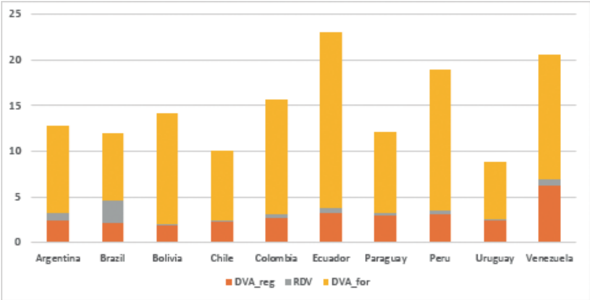


Source: Own elaboration

For the global value chain analysis, it is useful to focus on the nature of Forward and Backward Linkages of exports and imports. Table 2 showed the decomposition of both flows. While Forward linkages can be divided according to the final consumption of the value, for backward linkages it is relevant the source of value. In this paper, both flows are divided according to the exporter, the importer, third regional countries, and extra-zone. Also, for Backward Linkages genuine value-added must be divided from double counted.

Figure 5 shows that Extra-regional demand is the main important source of forward linkages in region. 10 out of 13 percentage points of total forward linkages are induced by extra-zona demand, showing the importance on global trade for South American internal trade. In Ecuador, 19% of regional exports are induced by foreign demand of regional partners. The second term in importance is third country demand, except for Brazil where its own demand accounts for 2,4% of its regional exports.

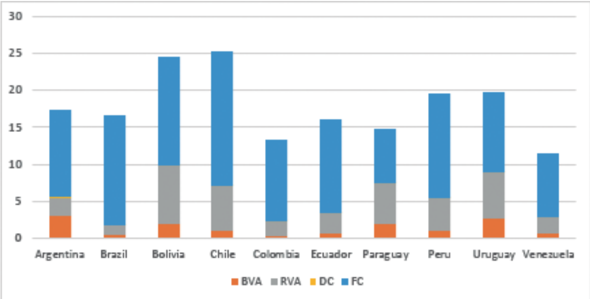
Figure 5. Forward Linkages divided according to final consumption as shares of total regional exports by Country



Note: DVA_reg: Value consumed in the region (includes DVA_p); RDV: value consumed in exporting country; DVA_for: Value exported to extra-zone. See Table 2 for a formal definition. Source: Own elaboration

Figure 6 shows a similar picture in the case of Backward Linkages: 14% of total Backward Linkages are included in inputs sourced in extra-regional countries.

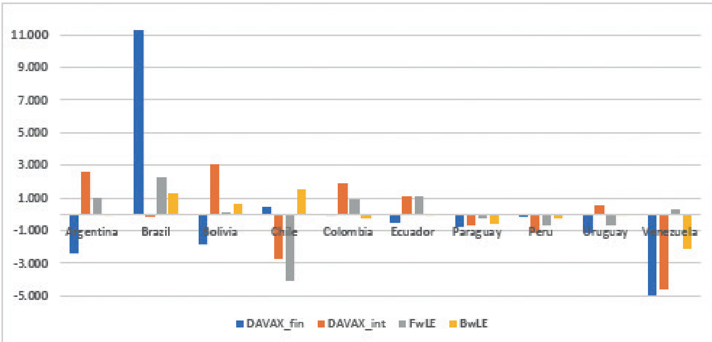
Figure 6 Backward Linkages divided according to sourcing of value as shares of total regional exports by Country



Note: BVA: Value-added originated in importing country; RVA Value-added originated in a third country of the region; DC: Double counted terms (domestic and region); RDFC Foreign Content. See Table 2 for a formal definition. Source: Own elaboration

A useful property of the bilateral decomposition method is that it enables a comparison between the position of the country as exporter and its position as importer, giving rise to a GVC meaningful interpretation of balance of trade. Figure 7 decomposes the regional trade balance (export minus imports) according to the kind of trade considered. Argentina is a net importer and consumer of regional value-added directly embedded in final goods, mostly by their relationship with Brazil, which accounts for a huge surplus in value-added in final goods in the region. Venezuela, Bolivia and Uruguay (these two in relative terms) are important destinations of value-added exports in final goods. The picture is very different when trade of intermediates directly consumed in destination is considered ($DAVAX_{int}$). This is the unique flow where Brazil does not hold surplus, basically due to imports of gas from Bolivia. Argentina and Colombia are also net exporters of valued added in intermediates directly consumed by importer and Chile and Venezuela are net importers. A comparison with 2005 (Appendix) shows that Argentina worsened the trade deficit in the period, switching from a balanced position in value-added in final goods to a deficit and reducing the surplus position in intermediates. While Brazil was the sole net exporter of foreign value-added in 2005, six years later it shares this position with Chile.

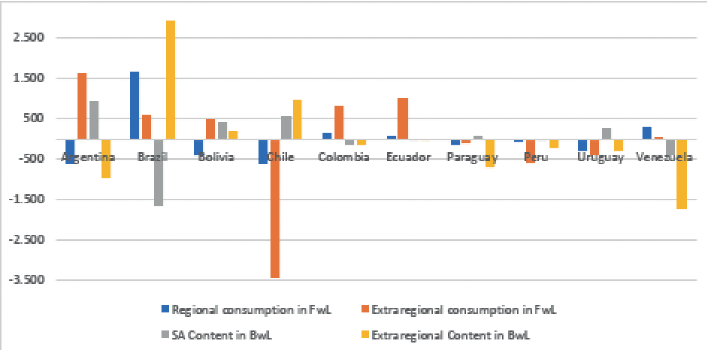
Figure 7. Net regional trade balance according to CGV categories. Year 2011. in million dollars.



Source: Own elaboration

The trade balance perspective is useful also for analyzing the net participation of countries in Regional Value Chains. Figure 8 should be interpreted carefully. In the forward linkages, a positive net value means that a country participates more as a source of value than as a platform (first importer, second exporter), that is, the value-added of a country is used in exports of another regional partner. A negative value in net forward linkage means that this country is positioned as platform of regional value. In the backward linkages, countries with net positive flow are platforms for regional or foreign value and countries with net negative flow are receivers of this value.

Figure 8- Net participation of countries in Backward and Forward Linkages according to region of sourcing and destination



Source: Own elaboration

The net negative value of Chile in extra-regional consumption in Forward Linkages is outstanding. Chile outperform in this flow due to it linkages with Asian and North American markets. In its foreign exports Chile carries value-added from Argentina, Brazil and Ecuador. Brazil is the main source of regional value-added that circulates in South America. In the Backward Linkages view, Chile and Brazil are main responsible for circulation of foreign inputs in South American trade, and Venezuela and Argentina are the main net importer and consumer of it. Because of both Forward and Backward perspectives, Chile arises as the main platform of value-added circulation between South America and the rest of the World, and Argentina as the main source of value.

ii. Bilateral and sector perspective: pinpointing RVC trade in South America

Table 5 showed that despite of being largely composed by direct absorbed value-added trade (DAVAX), there is some amount of trade related to international value chains. Backward and Forward Linkages trade accounts for 31% of regional exports.

Table 6 shows the top 20 bilateral sector flows in terms of Forward Linkages (FwLE). They are the core of forward linkages integration in GVC in South America. As noted before, most of this trade is due to foreign demand that enhances regional trade. Top 20 flows account for 38% of total FwLE. The average ratio of FwLE on exports of this group is 29%, doubling total average (14%). Energy sector dominates this kind of flow. Petroleum, mining (even non- energy mining) and electricity and gas are among the top. The participation of Chile as an importer of regional inputs and using them in their own exports is remarkable. The role of foreign demand in Chilean exports of Mining to Brazil is also remarkable.

There are also heavy forward linkages in Ecuador exporting Mining to Peru and Bolivia doing the same to Brazil and Argentina. Given the little economic size of Bolivia, this flow is very relevant. Outside motor vehicles and petroleum, there is only one manufacturing sector in the top ten: one fifth of Brazilian exports of basic chemical products to Argentina is value-added that is again included in Argentinean exports (mostly in the agriculture exports to extra zone).

Table 6. – Forward participation in global value chains. Top bilateral sectors: million dollars and shares (of total trade and of bilateral sector flow).

Exporter	Importer (reexporter)	Sector	Value	share in total FwLE trade $\frac{FwLE^{s,r,n}}{\sum_s \sum_r \sum_n FwLE^{s,r,n}}$	Share of FwLE in exports $\frac{FwLE^{s,r,n}}{E^{s,r,n}}$
BRA	CHL	Mining (energy)	1,139	5.3	34
ECU	PER	Mining (energy)	872	4.0	46
BRA	ARG	Motor vehicles	837	3.9	9
COL	CHL	Mining (energy)	669	3.1	37
PER	CHL	Mining (non energy)	608	2.8	64
ECU	CHL	Mining (energy)	443	2.0	35
BOL	BRA	Mining (energy)	399	1.8	15
CHL	BRA	Mining (non energy)	344	1.6	35
ARG	BRA	Agriculture	308	1.4	13
CHL	BRA	Non - ferrous metals	284	1.3	15
ARG	CHL	Mining (energy)	280	1.3	33
ARG	BRA	Bussines services	280	1.3	14
ARG	BRA	refined petroleum	260	1.2	13
VEN	BOL	refined petroleum	259	1.2	48
BRA	ARG	Iron and steel	241	1.1	23
BRA	ARG	Basic chemical products	228	1.1	21
BOL	ARG	Mining (energy)	206	1.0	12
VEN	ECU	refined petroleum	189	0.9	26
PER	COL	Non - ferrous metals	186	0.9	47
COL	PER	Mining (energy)	175	0.8	49

Source: Own Elaboration

Table 7 shows the top 20 bilateral sector flows in terms of backward linkages (BwLE). Although they explain more than top forward (41% vs 38%), both sides bilateral flows in automotive sector of Argentina and Brazil account for 13,4%. This trade is ruled by a bilateral treaty and is highly monitored by both administrations, so high deviations from balanced trade are precluded. Table 7 shows that Argentinean exports rely more on foreign content than Brazilian (43% vs 19%), but 19 percentage point out of 43 are regional value-added, mostly from Brazil. Bolivian exports of mining product to neighboring Brazil and Argentina contains 29% of foreign content. As it appears in both lists and its shares of both forward (21%) and backward (31%) complex regional value chains are higher than average, Brazilian exports to Argentina of Basic Chemical products appear to be the most integrated in RVC bilateral sector in the region. In the period between 2005 and 2011 the backward linkages share remained unchanged at 31% but forward linkages reduced four percentage points, in favor of single regional value chains. Also, this bilateral sector reduced by a half its importance in total regional trade in the period.

Table 7. – Backward participation in global value chains. Top bilateral sectors: million dollars and shares (of total trade and of bilateral sector flow).

Exporter	Importer	Sector	Value	share in total BwLE trade $\frac{BwLE^{s,r,n}}{\sum_s \sum_r \sum_n BwLE^{s,r,n}}$	Share of BwLE in exports $\frac{BwLE^{s,r,n}}{E^{s,r,n}}$
ARG	BRA	Motor vehicles	1,956	6.9	43
BRA	ARG	Motor vehicles	1,869	6.5	19
BOL	BRA	Mining (energy)	768	2.7	29
BOL	ARG	Mining (energy)	486	1.7	29
CHL	BRA	Non-ferrous metals	364	1.3	20
BRA	CHL	Mining (energy)	333	1.2	10
BRA	ARG	Basic chemical products	325	1.1	31
ARG	BRA	Refined petroleum	321	1.1	16
BRA	ARG	Other chemical products	299	1.0	26
BRA	ARG	Machinery and equip.	270	0.9	20
ARG	BRA	Basic chemical products	264	0.9	36
BRA	ARG	Iron and steel	229	0.8	22
CHL	BRA	Basic chemical products	201	0.7	38
ARG	BRA	Agriculture	199	0.7	8
BRA	ARG	Electrical machinery and apparatus, nec	176	0.6	22
BRA	ARG	Rubber and plastic prods.	167	0.6	22
BRA	URY	Refined petroleum	160	0.6	29
BRA	ARG	Refined petroleum	154	0.5	29
BRA	ARG	Radio, television and communication	150	0.5	42
CHL	PER	Transportation	149	0.5	45

Source: Own Elaboration

iii. A comparison between two methods of gross exports accounting decomposition

As mentioned in section II, table B1 in Appendix includes a comparison between two methods of decomposition of gross exports. Most notable differences are the treatment of "Indirect Value-added sourced in s exported to r", treatment of "Direct Domestic Value-added reimported in s and further reexported" and in identification of regional value-added and double counting in backward linkages. While WWZ method follows Koopman, Wang and Wei (2014) as close as possible, the authors in Appendix D of their paper develops an alternative decomposition that uses DAVAX definition both for final and intermediates, and identifies as GVC trade the "indirect value-added" consumed in r. While the alternative formulation of WWZ solves the first difference among methods, the second and third remains.

Table 8 shows the split of Gross exports according to WWZ and their differences with the Source Based approach followed here. There are two causes besides the low differences among methods: most of value is added in sourcing country without international sharing of production and as long as working without a complete matrix inhibit splitting Foreign Content in value-added and double counted, the magnitudes of differences of this significant flow cannot be sized in this paper. The exam of the very difference among the estimation of both domestic and regional double counting illustrates the idea that if both methods apply in a more integrated region and a complete input-output table the divergence will be bigger. Both columns and rows containing Domestic and Regional and Bilateral Double Counting (DDC and B&RDC) shed light into the differences between alternative approaches.

Table 8 Gross Exports decomposition according to B&M source- based and Differences with WWZ. In million dollars. Year 2011

		WWZ								
		DVA (fin+int)	DVA_reg	DVA_for	RDV	DDC	B&RVA	RDC	FC	Total
B&M	DAVAX	110,012								110,012
	VAX_reg+p	34	4,016			32				4,082
	VAX_for			15,562		156				15,717
	RDV				1,824					1,824
	DDC	32				43				75
	B&RVA						6,503	341		6,844
	RDC						4	0.2		5
	FC								21,626	21,626
	Total	110,079	4,016	15,562	1,824	230	6,508	341	21,626	160,185

Source: Own Elaboration

IV. Conclusions

South American participation in global value chains is limited to sourcing of intermediate commodities from primary factors so the level of value-added in exports is high for every country of the region. Into the extent that the pattern of intra-regional trade is different than global, it could be useful to adapt and apply global measures to new regional available data.

Results do not show a radically different pattern when considering regional input-output tables and focus on regional trade. Regional sharing of production in South America is scarce. Most trade is in domestic value-added and is mainly consumed in importing country without further circulation. Regional Value Chains trade, measured as the sum of Forward and Backward linkages of regional exports, accounts for almost one third of total. Most of both kind of linkages are due to participation of foreign countries, even as sources of value (in Backward Linkages) or destination (in Forward Linkages).

Chile arises as the main platform for partners value indirect integration to global markets. That is, a big share of forward linkages consumed out of the region uses Chile as a second manufacturing country. Main partners in this flow are Argentina, Ecuador, and Peru and these links are mostly in mining sectors.

Apart from these flows related to mining, the bilateral relationship in manufacturing between Brazil and Argentina also is outstanding, especially in basic chemistry. Nevertheless, as long as the main manufacturing exporter of the region tend to use low share of regional or foreign inputs, backward linkages are less than expected in manufactures. Given the importance of Colombia in the North part of the continent, it should be expected more participation in flows.

The article showed that foreign markets are important even for regional integration and that it could be necessary to design smart systems of rules of origin and circulation in order to build strong regional platforms and benefit from economies of scale.

Low level of integration in intermediates shrank the quantitatively differences of using alternative decomposition methods for identifying chains and flows. Nevertheless, the article showed that if the level of manufacturing sharing increases, it could be needed accurate measures for a proper diagnostic.

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Appendix

A- Demonstration of bilateral decomposition of gross exports (Table 2)

Using Eq (3) in the case of sourcing country s yields:

$$(A1) \qquad {u_n}^T = (\textstyle\sum_t V^t B^{ts})^T + (\sum_t F^t B^{ts})^T$$

Where $u_n$is a 1xN vector. Using element wise multiplication (#), (A1) can be operated on every element of the vector of gross exports E^{sr}.

$$(A2) \qquad E^{sr} = (\textstyle\sum_t V^t B^{ts})^T \# E^{sr} + (\sum_t F^t B^{ts})^T \# E^{sr}$$

The first term is regional value-added included in gross exports. It can be divided according to the sourcing country in s, the bilateral partner r and the rest of regional countries t.

$$(A3) \quad E^{sr} = (V^s B^{ss})^T \# E^{sr} + (V^r B^{rs})^T \# E^{sr} + \left(\textstyle\sum_{t\neq r,s} V^t B^{ts}\right)^T \# E^{sr} + (\sum_t F^t B^{ts})^T \# E^{sr}$$

The fourth term of (A3) is Foreign Content in exports. It can be split in $\sum_t F^t B^{ts} = \sum_{t\neq s} F^t B^{ts} + F^s B^{ss}$ and $F^s B^{ss}$ can be further divided using Eq. (4) in $F^s L^{ss} + F^s L^{ss} \sum_{t\neq s}^{G} A^{st} B^{ts}$. Then:

$$(A4) \quad (\textstyle\sum_t F^t B^{ts})^T \# E^{sr} = F^s L^{ss} \# E^{sr} + (\sum_{t\neq s} F^t B^{ts} + F^s L^{ss} \sum_{t\neq s}^{G} A^{st} B^{ts}) \# E^{sr} = DFC + RFC$$

Using (5), the second term of (A3) is

$$(A5) \quad V^r B^{rs} \# E^{sr} = V^r B_s^{rs} \# E^{sr} + (V^r B_s^{rs} \textstyle\sum_{t\neq s}^{G} A^{st} B^{ts}) \# E^{sr}$$

And again using (5) in the third term of (A3) yields:

$$(A6) \left(\textstyle\sum_{t\neq r,s} V^t B^{ts}\right)^T \# E^{sr} = \left(\sum_{t\neq r,s} V^t B_s^{ts}\right)^T \# E^{sr} + \left(\sum_{t\neq r,s} V^t B_s^{ts} \sum_{t\neq s}^{G} A^{su} B^{us}\right)^T \# E^{sr}$$

The first term of (A5) is BVA, the first term of (A6) is RVA, the second term of (A5) and (A6) can be consolidated in one: $(\sum_{t\neq s} V^t B_s^{ts} \sum_{t\neq s}^{G} A^{su} B^{us})^T \# E^{sr}$.

Then, second and third term of (A3) are bilateral and regional value-added and regionally sourced double counted terms:

$$(A7) \quad (V^r B^{rs})^T \# E^{sr} + \left(\textstyle\sum_{t\neq r,s} V^t B^{ts}\right)^T \# E^{sr} = V^r B_s^{rs} \# E^{sr} + \left(\sum_{t\neq r,s} V^t B_s^{ts}\right)^T \# E^{sr} + (\sum_{t\neq s} V^t B_s^{ts} \sum_{t\neq s}^{G} A^{su} B^{us})^T \# E^{sr} = BVA + RVA + RDC$$

Equation (4) is used again in order to split first term of (A3), that is, domestic content included in exports, in direct valued added and indirect. According to a source-based definition, the second is double counted.

$$(A8) \qquad (V^s B^{ss})^T \# E^{sr} = (V^s L^{ss})^T \# E^{sr} + (V^s L^{ss} \textstyle\sum_{t\neq s}^{G} A^{st} B^{ts}) \# E^{sr}$$

The second term is DDC^{sr}. Note that part of DDC^{sr}, $(V^s L^{ss} \sum_{t\neq s}^{G} A^{st} B^{ts}) \# Y^{sr}$, is considered Double Counted trade in this scheme, but is part of value-added according to Koopman, Wang, and Wei (2014) and WWZ and also is value-added in the sink-based decomposition of gross exports (Borin and Mancini 2019). This flow corresponds to domestic value-added included in intermediates exported abroad, returned home and included in s exports to r. According to source-based criteria, this flow was considered value-added the first time it leaved s, and should be double counted afterwards.

The first term of (A8) can be further divided using a simple division of exports between final and intermediate goods, $E^{sr} = Y^{sr} + A^{sr}X^{r}$.

$$\text{(A9)} \quad (V^{s}L^{ss})^{T}\#E^{sr} = (V^{s}L^{ss})^{T}\#Y^{sr} + (V^{s}L^{ss})^{T}\#A^{sr}X^{r}$$

The first term is $DAVAX\_fin^{sr}$. The second term will be divided according to the place of final production and consumption. The division according to the place of final production in s, r and t, yields:

$$\text{(A10)} \quad X^{r} = \sum_{t} B^{rt}Y^{t*} = B^{rs}Y^{s*} + B^{rr}Y^{r*} + \sum_{t\neq s,r} B^{rt}Y^{t*}$$

Each term of (A10) is further divided according to location of demand (A11). The first term in each Equation represents demand from s, the second represents demand from r, the third represents demand from t and the fourth represent demand from extrazone. In the case of third countries (A11c), it is also necessary to identify an extra term capturing a fourth destination in regional trade, different from s, r and t.

$$\text{(A11a)} \quad B^{rs}Y^{s*} = B^{rs}\left(Y^{ss} + Y^{sr} + \sum_{t\neq s,r} Y^{st} + \sum_{h} Y^{sh}\right)$$

$$\text{(A11b)} \quad B^{rr}Y^{r*} = B^{rr}\left(Y^{rs} + Y^{rr} + \sum_{t\neq s,r} Y^{rt} + \sum_{h} Y^{rh}\right)$$

$$\text{(A11c)} \quad B^{rt}Y^{t*} = B^{rt}\left(Y^{ts} + Y^{tr} + Y^{tt} + \sum_{h} Y^{th} + \sum_{u\neq t,s,r} Y^{tu}\right)$$

Every term in (A11) is identified with an ordinal, e.g. (A11b2) stand for second term of equation b: $B^{rr}Y^{rr}$; (A11c4) stand for fourth term of equation c: $B^{rt}\sum_{h} Y^{th}$.

All terms of (A11) are included in the second term of (A9). Table A1 shows the relationship between these terms and definition of table 2.

Table A1. Relationship between terms of (A11) inserted in (A9) and concepts

Terms	Formula	Concept
A11a1+ A11b1+ A11c1	$(V^{s}L^{ss})^{T}\#A^{sr}\sum_{t} B^{rt}Y^{ts}$	RDV^{sr}
A11a2+ A11a3+A11b3+A11c5	$(V^{s}L^{ss})^{T}\#A^{sr}\sum_{t\neq s,r} B^{rr}Y^{rt}+$ $(V^{s}L^{ss})^{T}\#A^{sr}\sum_{t\neq r} B^{rt}\sum_{u\neq t,s,r} Y^{tu}$	$DVA\_reg\_2^{sr}$
A11a4+A11b4+A11c4	$(V^{s}L^{ss})^{T}\#A^{sr}B^{rr}\sum_{h} Y^{rh}$ $+ (V^{s}L^{ss})^{T}\#A^{sr}\sum_{t\neq r} B^{rt}\sum_{h} Y^{th}$	DVA_for^{sr}

A11c2	$(V^sL^{ss})^T \# \left(A^{sr}\sum_{t\neq s,r}^{G} B^{rt}Y^{tr}\right)$	$DVA\_p\_2^{sr}$
A11c3	$(V^sL^{ss})^T \# \left(A^{sr}\sum_{t\neq s,r}^{G} B^{rt}Y^{tt}\right)$	$DVA\_reg\_1^{sr}$
A11b2	$(V^sL^{ss})^T \# (A^{sr}L^{rr}Y^{rr})$	$DAVAX\_int^{sr}$
	$(V^sL^{ss})^T \# (A^{sr}(B^{rr}-L^{rr})Y^{rr})$	$DVA\_p\_1^{sr}$

Then, Table A1 shows that second term of (A9) is equal to the sum of $DAVAX\_int$ and RVC_fwd. Then, inserting (A9) in (A8), and (A4), (A7) and (A8) in (A3) retrieves a completely source- based decomposition of bilateral gross exports according to GVC terms.

B- Comparison between a Decomposition of bilateral exports based in Borin and Mancini (2019) and a decomposition based in Wang, Wei y Zhu (2018) with regional inter country tables.

Table B1. Comparison between accounting segregation of bilateral exports with regional input-output tables according to Borin and Mancini method and Wang, Wei and Zhu method.

Subterm B&M	Based on B&M	Based on WWZ	Reference in WWZ
$DAVAX_{fin}$	$(V^sL^{ss})^T \# Y^{sr}$	$(V^sB^{ss})^T \# Y^{sr}$	1
$DAVAX_{int}$	$(V^sL^{ss})^T \# (A^{sr}L^{rr}Y^{rr})$	$(V^sL^{ss})^T \# (A^{sr}B^{rr}Y^{rr})$	2
DVA_p (1)	$(V^sL^{ss})^T \# (A^{sr}(B^{rr}-L^{rr})Y^{rr})$		
DVA_p (2)	$(V^sL^{ss})^T \# \left(A^{sr}\sum_{t\neq s,r}^{G} B^{rt}Y^{tr}\right)$	$(V^sL^{ss})^T \# \left(A^{sr}B^{rr}\sum_{t\neq s,r}^{G} Y^{rt}\right)$	4
DVA_reg (1)	$(V^sL^{ss})^T \# \left(A^{sr}\sum_{t\neq s,r}^{G} B^{rt}Y^{tt}\right)$	$(V^sL^{ss})^T \# \left(A^{sr}\sum_{t\neq r,s}^{G} B^{rt}Y^{tt}\right)$	3
DVA_reg (2)	$(V^sL^{ss})^T \# \left(A^{sr}\sum_{t\neq s}^{G} B^{rt}\sum_{u\neq s,r,t}^{G} Y^{tu}\right)$	$(V^sL^{ss})^T \# \left(A^{sr}\sum_{t\neq s,r}^{G} B^{rt}\sum_{u\neq s,t}^{G} Y^{tu}\right)$	5
	$(V^sL^{ss})^T \# \left(A^{sr}B^{rs}\sum_{t\neq s}^{G} Y^{st}\right)$	$(V^sL^{ss})^T \# \left(A^{sr}B^{rs}\sum_{t\neq s}^{G} Y^{st}\right)$	9
DVA_for	$(V^sL^{ss})^T \# \left(A^{sr}\sum_{t\neq s}^{G} B^{rt}\sum_{t}\sum_{h}^{H} Y^{th}\right)$	$(V^sL^{ss})^T \# \left(A^{sr}\sum_{t\neq s,r}^{G} B^{rt}\sum_{t}\sum_{h} Y^{th} + \left(A^{sr}B^{rr}\sum_{h} Y^{rh}\right)\right)$	---

	$(V^s L^{ss})^T \# \left(A^{sr} B^{rs} \sum_h^H Y^{sh}\right)$	$(V^s L^{ss})^T \# \left(A^{sr} B^{rs} \sum_h^H Y^{sh}\right)$	9
RDV	$(V^s L^{ss})^T \# \left(A^{sr} \sum_t^G B^{rt} Y^{ts}\right)$	$(V^s L^{ss})^T \# \left(A^{sr} \sum_t^G B^{rt} Y^{ts}\right)$	6,7 and 8
DDC (1)	$\left(V^s L^{ss} \sum_{t \neq s}^{G} A^{st} B^{ts}\right)^T \# E^{sr}$	$\left(V^s L^{ss} \sum_{t \neq s}^{G} A^{st} B^{ts}\right)^T \# (A^{sr} X^r)$	10
BVA	$(V^r B_{\underline{s}}^{rs})^T \# E^{sr}$	$(V^r B^{rs})^T \# Y^{sr}$	11
		$(V^r B^{rs})^T \# (A^{sr} L^{rr} Y^{rr})$	13
RVA	$\left(\sum_{t \neq s,r}^{G} V^t B_{\underline{s}}^{ts}\right)^T \# E^{sr}$	$\left(\sum_{t \neq s,r}^{G} V^t B^{ts}\right)^T \# Y^{sr}$	12
		$\left(\sum_{t \neq r,s}^{G} V^t B^{ts}\right)^T \# (A^{sr} L^{rr} Y^{rr})$	14
RDC	$\left(\sum_{t \neq s}^{G} V^t B_{\underline{s}}^{ts} \sum_{u \neq s}^{G} A^{su} B^{us}\right)^T \# E^{sr}$	$(V^r B^{rs})^T \# (A^{sr} L^{rr} E^{r*})$	15
		$\left(\sum_{t \neq r,s}^{G} V^t B^{ts}\right)^T \# (A^{sr} L^{rr} E^{r*})$	16
DFC	$(F^s L^{ss})^T \# E^{sr}$	$\left(\sum_t^G F^t B^{ts}\right)^T \# (Y^{sr} + A^{sr} X^r)$	----
RFC	$\left[\left(F^s L^{ss} \sum_{t \neq s}^{G} A^{st} B^{ts}\right)^T + \left(\sum_{t \neq s}^{G} F^t B^{ts}\right)\right] \# E^{sr}$		

Source: Own Elaboration

C. ECLAC Latin American Input-output Table

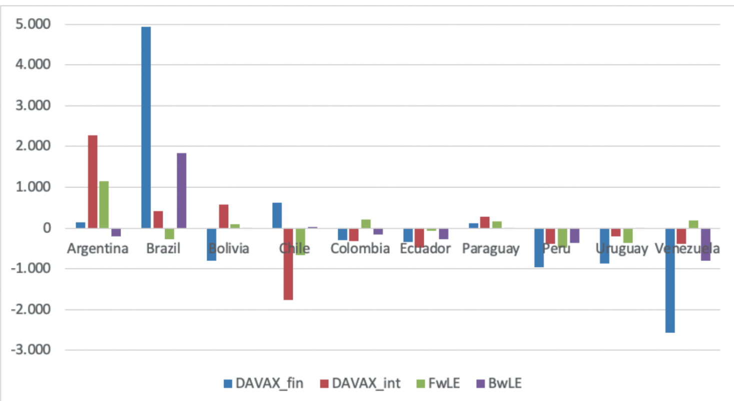
Sector	Description
01	Agriculture and forestry
02	Hunting and fishing
03	Mining and quarrying (energy)
04	Mining and quarrying (non-energy)
05	Meat and meat products
06	Wheat products and pasta
07	Sugar and confectionery
08	Other processed food
09	Beverage
10	Tobacco
11	Textiles
12	Apparel
13	Footwear
14	Wood and products of wood and cork
15	Pulp, paper, printing and publishing
16	Coke, refined petroleum and nuclear fuel
17	Basic chemical products
18	Other chemical products (excluding pharmaceuticals)
19	Pharmaceuticals
20	Rubber and plastics products
21	Other non-metallic mineral products
22	Iron and steel
23	Non-ferrous metals
24	Fabricated metal products, except machinery and equipment
25	Machinery and equipment nec (excluding electrical machinery)
26	Office, accounting and computing machinery
27	Electrical machinery and apparatus, nec
28	Radio, television and communication equipment nec
29	Medical, precision and optical instruments
30	Motor vehicles, trailers and semi-trailers
31	Aircraft and spacecraft
32	Other transport equipment
33	Manufacturing nec; recycling (include furniture)
34	Electricity and gas
35	Construction
36	Transportation
37	Post and telecommunication
38	Finance and insurance
39	Business services of all kinds
40	Other services

Table D1. Accounting segregation of South America intra zone trade. In million dollars and percentages. 2005

	Regional exports	Share of Value-added in Exports (in %)			Share of Foreign and double counted
		DAVAX_fin	DAVAX_int	FwLE	BwLE
Argentina	15,991	28	41	17	14
Brazil	19,525	39	31	11	19
Bolivia	2,176	15	52	17	16
Chile	8,201	41	27	13	18
Colombia	4,572	27	38	14	21
Ecuador	2,340	23	37	20	20
Paraguay	2,062	38	36	15	11
Peru	3,614	17	49	20	15
Uruguay	1,512	29	36	10	25
Venezuela	2,977	8	52	22	18
TOTAL	**62,971**	31	37	15	17

Source: Own elaboration

Figure D1. Net regional trade balance according to CGV categories. Year 2005. in million dollars.



Source: Own Elaboration