

Size, Position and Length in Value Chains in Latin America

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In this article, I develop a framework that divides global value chains into regional and extra-regional and studies the participation of Latin American countries in international fragmentation of production along 25 years of globalization. Measures of depth, position, and length are developed for each kind of value chain. Between 1990 and 2015 the engagement in activities related to international trade increased in every country in Latin America and the prevalent way of integration is in Extra-Regional Value Chains. While South America engages mostly in value chains as a source of value added transformed by others, Central America participates more as end of chains and Mexico switched its position to a net forward position in regional value chains. Finally, the article examines the relationship between participation and length of domestic segment of chains, finding that a deeper participation in Extra-regional Value Chains is associated with shortening of chains, but this relationship does not hold for Regional.

KEYWORDS

Global Value Chains, Regional integration, Input Output, Forward and Backward Linkages

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Introduction

- Fragmentation of world production
- 3 decades of regionalism
- Latin American countries integrate among themselves and with the world
- New databases to measure deepness of globalization

References of literature

- Wang et al (2017a) divides world production according to its share in domestic activities and trade activities, and the last in traditional and global value chain
- Wang et al (2017b) studies length of chains for each category
- World Bank and others (2017), WTO (2019)

Regional input output table

Destination →	Intermediate Regional			Intermediate Extraregional			Final regional use			Final Extra- regional use			Output
↓ <i>Source</i>	1	...	G	1'	...	H	1	...	G	1'	...	H	
1	Z^{11}	...	Z^{1t}	$Z^{11'}$	...	Z^{1k}	Y^{11}	...	Y^{1t}	$Y^{11'}$	...	Y^{1k}	X^1
s	Z^{s1}	...	Z^{st}	$Z^{s1'}$	...	Z^{sk}	Y^{s1}	...	Y^{st}	$Y^{s1'}$	...	Y^{sk}	X^s
G	Z^{t1}	...	Z^{tt}	$Z^{t1'}$	...	Z^{tk}	Y^{t1}	...	Y^{tt}	$Y^{t1'}$	...	Y^{tk}	X^t
1'	$Z^{1'1}$	...	$Z^{1't}$	$Z^{1'1'}$	...	$Z^{1'k}$	$Y^{1'1}$	...	$Y^{1't}$	$Y^{1'1'}$	...	$Y^{1'k}$	$X^{1'}$
f	Z^{f1}	...	Z^{ft}	$Z^{f1'}$	...	Z^{fk}	Y^{f1}	...	Y^{ft}	$Y^{f1'}$	...	Y^{fk}	X^f
H	Z^{k1}	...	Z^{kt}	$Z^{k1'}$	...	Z^{kk}	Y^{k1}	...	Y^{kt}	$Y^{k1'}$	...	Y^{kk}	X^k
V. Added	va^1	...	va^t	$va^{1'}$	...	va^k							
Output	X^{1T}	...	X^{tT}	$X^{1'T}$	...	X^{kT}							

Leontief Matrices

International Leontief matrix

$$A = Z\hat{X}^{-1}$$

$$A = \begin{bmatrix} A^{ss} & \dots & A^{st} & A^{sf} & \dots & A^{sk} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ A^{ts} & \dots & A^{tt} & A^{tf} & \dots & A^{tk} \\ A^{fs} & \dots & A^{ft} & A^{ff} & \dots & A^{fk} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ A^{ks} & \dots & A^{kt} & A^{kf} & \dots & A^{kk} \end{bmatrix}$$

$$X = AX + Y = AX + Y^D + Y^R + Y^F + Y^H \quad (1)$$

International Inverse Leontief matrix

$$B = (I - A)^{-1}$$

$$B = \begin{bmatrix} B^{ss} & \dots & B^{st} & B^{sf} & \dots & B^{sk} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ B^{ts} & \dots & B^{tt} & B^{tf} & \dots & B^{tk} \\ B^{fs} & \dots & B^{ft} & B^{ff} & \dots & B^{fk} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ B^{ks} & \dots & B^{kt} & B^{kf} & \dots & B^{kk} \end{bmatrix}$$

$$X = BY \quad (2)$$

Tracking the origin of value

From the column perspective, the output is the result of the combination of intermediate inputs plus the value added (Va). Leontief function of production:

$$X^T = u\hat{X} = uZ + Va = uA\hat{X} + V\hat{X} \quad (3)$$

Where, V is an $1 \times N(G + H)$ row vector of ratios of value added to product and u is an $1 \times N(G + H)$ vector of ones.

Posmultiplying by \hat{X}^{-1} the expression is:

$$u = uA + V$$

That gives rise to the decomposition formula for production.

$$uI - uA = u(I - A) = V \rightarrow u = V(I - A)^{-1} = VB \rightarrow u = u\hat{V}B \quad (4)$$

Matrix of value added included in final demand

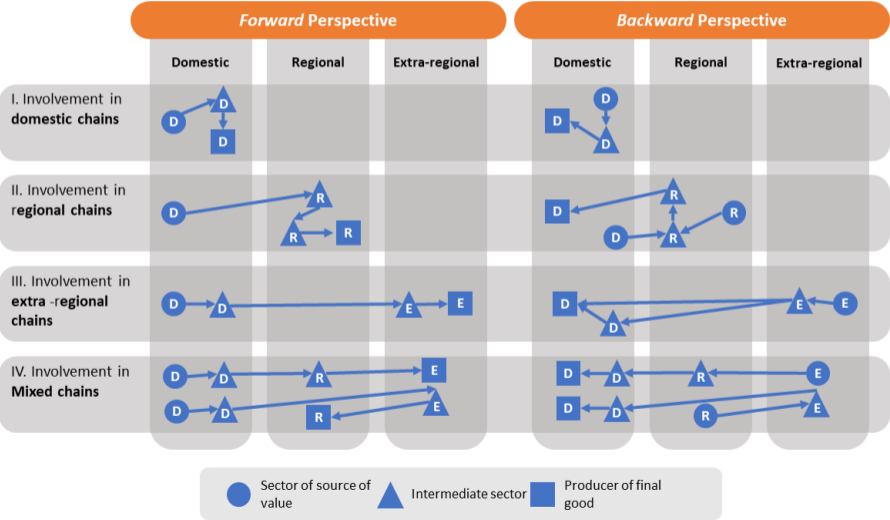
The link between value added in the sector i of country s and the final demand of sector j in country r is represented by the $N(G + H) \times N(G + H)$ matrix $\hat{V}B\hat{Y}$.

$$\hat{V}B\hat{Y} = \begin{bmatrix} v_1^1 b_{11}^{11} y_1^1 & v_1^1 b_{12}^{11} y_2^1 & \dots & v_1^1 b_{1j}^{1r} y_j^r \\ v_2^1 b_{21}^{11} y_1^1 & v_2^1 b_{22}^{11} y_2^1 & \dots & v_2^1 b_{2j}^{2r} y_j^r \\ \vdots & \vdots & \ddots & \vdots \\ v_i^s b_{i1}^{s1} y_1^1 & v_i^s b_{i2}^{s1} y_2^1 & \dots & v_i^s b_{ij}^{sr} y_j^r \end{bmatrix}$$

The generic term $v_i^s b_{ij}^{sr} y_j^r$ represents the total direct and indirect value added sourced in sector i of country s (v_i^s) included in final goods production of sector j in country r (y_j^r).

$$\begin{aligned} \hat{V}B\hat{Y}u^T &= \hat{V}BY = Va \\ u\hat{V}B\hat{Y} &= VB\hat{Y} = Y^T \end{aligned}$$

Slicing value added in chains



Domestic, regional and extra-regional transactions

$$A^{reg} = \begin{bmatrix} A^{ss} & \dots & A^{st} & 0 & \dots & 0 \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ A^{ts} & \dots & A^{tt} & 0 & \dots & 0 \\ 0 & \dots & 0 & 0 & \dots & 0 \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ 0 & \dots & 0 & 0 & \dots & 0 \end{bmatrix};$$

$$A^{-reg} = A - A^{reg} = \begin{bmatrix} 0 & \dots & 0 & A^{sf} & \dots & A^{sk} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ 0 & \dots & 0 & A^{tf} & \dots & A^{tk} \\ A^{fs} & \dots & A^{ft} & A^{ff} & \dots & A^{fk} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ A^{ks} & \dots & A^{kt} & A^{kf} & \dots & A^{kk} \end{bmatrix}$$

Domestic, regional and extra-regional transactions

$$A^d = \begin{bmatrix} A^{ss} & \dots & 0 & 0 & \dots & 0 \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ 0 & \dots & A^{tt} & 0 & \dots & 0 \\ 0 & \dots & 0 & 0 & \dots & 0 \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ 0 & \dots & 0 & 0 & \dots & 0 \end{bmatrix}; A^{reg-d} = A^{reg} - A^d$$

$$A^{ext} = \begin{bmatrix} 0 & \dots & 0 & 0 & \dots & 0 \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ 0 & \dots & 0 & 0 & \dots & 0 \\ 0 & \dots & 0 & A^{ff} & \dots & A^{fk} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ 0 & \dots & 0 & A^{kf} & \dots & A^{kk} \end{bmatrix}; A^{-ext} = A - A^{ext}$$

Domestic, regional and extra-regional transactions

It should be defined also the Leontief Inverses matrices of these partitions of A.

$$L = (I - A^d)^{-1}; B^{reg} = (I - A^{reg})^{-1}; B^{ext} = (I - A^{ext})^{-1}$$

Borin and Mancini (2019) uses an equivalency between Leontief inverse matrix and some partition of it.

$$B = B^{reg} + B^{reg} A^{-reg} B \quad (5)$$

Also:

$$B^{reg} = L + LA^{reg-d} B^{reg} \quad (6)$$

$$B = B^{ext} + B^{ext} A^{-ext} B \quad (7)$$

The forward perspective of value chains: Following the use of domestic value added

Applying (5) in $\hat{V}B\hat{Y}$:

$$\hat{V}B\hat{Y} = \hat{V}B^{reg}\hat{Y} + \hat{V}B^{reg}A^{-reg}B\hat{Y}$$

Substituting B^{reg} using (6):

$$\hat{V}B\hat{Y} = \hat{V}L\hat{Y} + \hat{V}LA^{reg-d}B^{reg}\hat{Y} + \hat{V}LA^{-reg}B\hat{Y} + \hat{V}LA^{reg-d}B^{reg}A^{-reg}B\hat{Y}$$

Also, B in the third term can be decomposed using (7).

$$\begin{aligned}\hat{V}B\hat{Y} = & \hat{V}L\hat{Y} + \hat{V}LA^{reg-d}B^{reg}\hat{Y} + \hat{V}LA^{-reg}B^{ext}\hat{Y} + \\ & \hat{V}LA^{-reg}B^{ext}A^{-ext}B\hat{Y} + \hat{V}LA^{reg-d}B^{reg}A^{-reg}B\hat{Y}\end{aligned}\tag{8}$$

Domestic value added included in final goods without border crossing of intermediates can be divided according to the destination, using: $Y = Y^D + Y^R + Y^F + Y^H$.

Forward-looking segregation of value added

Term	Name	Concept
$\hat{V}LY^D$	Pure domestic value added	Domestic VA included directly in domestic consumed final goods
$\hat{V}LY^R$	Traditional exports to the region	DVA included directly in final goods exported to the region
$\hat{V}LY^F$	Traditional exports to extra-region	DVA included directly in final goods exported to extra-region
$\hat{V}LA^{reg-d} B^{reg} Y$	Regional value chains	DVA incl. in final goods in the region without stages in extra-region
$\hat{V}LA^{-reg} B^{ext} Y$	Extra regional value chains	DVA exported to extra-region for production without stages in the region
$\hat{V}LA^{-reg} B^{ext} A^{-ext} BY$	Mixed Value Chains	DVA in production of goods where both kind of countries participate
$\hat{V}LA^{reg-d} B^{reg} A^{-reg} BY$	Mixed Value Chains	<i>(Idem)</i>

Backward-looking segregation of final demand

The equivalent backward-perspective segregation is:

$$u\hat{V}B\hat{Y} = VB\hat{Y} = Y^T = VL\hat{Y}^D + VL\hat{Y}^R + VL\hat{Y}^F + VB^{reg}A^{reg-d}L\hat{Y} + VB^{ext}A^{-reg}L\hat{Y} + VBA^{-ext}B^{ext}A^{-reg}L\hat{Y} + VBA^{-reg}B^{reg}A^{reg-d}L\hat{Y} \quad (9)$$

Again, there are seven terms: $VL\hat{Y}^D, VL\hat{Y}^R, VL\hat{Y}^F$ accounts for DVA included in final good production, $VB^{reg}A^{reg-d}L\hat{Y}$ is RVC: regional value included in final demand, $VB^{ext}A^{-reg}L\hat{Y}$ is EVC, extra -regional value included in final demand and the last two are MVC.

Measuring length and position in value chains

Literature defines measures **Output Upstreamness**, from output to final demand, as the average number of times that the value is counted until it is included in a final good, and **Input Downstreamness** as the average number of times that the value added has been counted until it is included in the output (Antras et al (2012); Antras and Chor (2013), Miller and Termushoev (2017)).

Wang et al. (2017b) uses this concepts and, defining a chain from value added to final goods production, defines the average length of a chain as the ratio between two matrices.

$$PL = \frac{\hat{V}(1.I + 2.A + 3.A^2 + 4.A^3 + 5.A^4 + \dots)\hat{Y}}{\hat{V}(I + A + A^2 + A^3 + A^4 + \dots)\hat{Y}} = \frac{\hat{V}BB\hat{Y}}{\hat{V}B\hat{Y}} \quad (10)$$

The numerator uses the equivalence:

$$1.I + 2.A + 3.A^2 + 4.A^3 + 5.A^4 + \dots = BB$$

And the denominator uses:

$$B = (I - A)^{-1} = (I + A + A^2 + A^3 + A^4 + \dots)$$

Forward and backward length of chains

As for measures on participation, there is also a forward and a backward perspective of length of chains.

1. Forward perspective (Sector-Country as source of value):

$$PL_v = \frac{\hat{V}BB\hat{Y}_u^T}{\hat{V}B\hat{Y}_u^T} = \frac{\hat{V}BBY}{\hat{V}BY}$$

2. Backward perspective (Sector-Country as final user of value):

$$PL_y = \frac{u\hat{V}BB\hat{Y}}{u\hat{V}B\hat{Y}_u^T} = \frac{VBB\hat{Y}}{VB\hat{Y}}$$

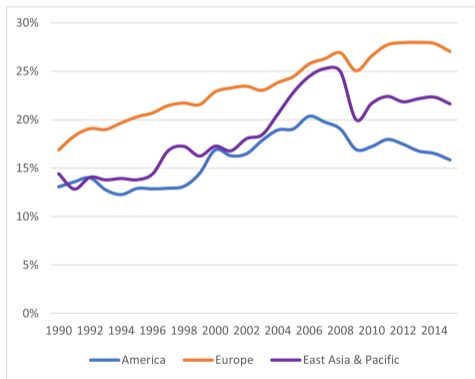
Slicing Length of Value chains (Forward)

Denominator	Numerator	Concept
$\hat{V}BY$	$\hat{V}BBY$	Total forward length of chains
$\hat{V}LY^D; \hat{V}LY^R; \hat{V}LY^F$	$\hat{V}LLY^D; \hat{V}LLY^R; \hat{V}LLY^F$	Length domestic chains (D, R, F)
$\hat{V}LA^{reg-d} B^{reg} Y$	$\hat{V}LLA^{reg-d} B^{reg} Y_+$	Domestic length of RVC
	$\hat{V}LA^{reg-d} B^{reg} B^{reg} Y$	Regional length of RVC
$\hat{V}LA^{-reg} B^{ext} Y$	$\hat{V}LLA^{-reg} B^{ext} Y_+$	Domestic length of EVC
	$\hat{V}LA^{-reg} B^{ext} B^{ext} Y$	Extra regional length of EVC
$\hat{V}LA^{-reg} B^{ext} A^{-ext} BY$	$\hat{V}LLA^{-reg} B^{ext} A^{-ext} BY_+$	Domest.length mix chains (1)
	$\hat{V}LA^{-reg} B^{ext} B^{ext} A^{-ext} BY_+$	Extra reg.length mix chains (1)
	$\hat{V}LA^{-reg} B^{ext} A^{-ext} BBY$	Global length of mix chains (1)
$\hat{V}LA^{reg-d} B^{reg} A^{-reg} BY$	$\hat{V}LLA^{reg-d} B^{reg} A^{-reg} BY_+$	Domest.length mix chains (2)
	$\hat{V}LA^{reg-d} B^{reg} B^{reg} A^{-reg} BY_+$	Extra reg.length mix chains (2)
	$\hat{V}LA^{reg-d} B^{reg} A^{-reg} BBY$	Global length of mix chains (2)

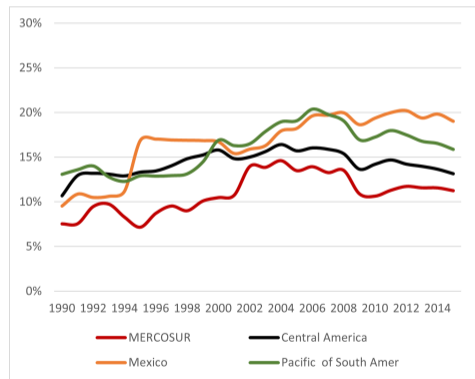
Data and Regions

- Database: EORA - UNCTAD
- Time Span: 1990-2015
- 26 sectors
- 189 countries
- Latin America, divided in 3 sub-regions
 - Mexico (NAFTA/USMCA)
 - Central America + Dom. Rep.
 - South America

Share of value related to international trade in total value



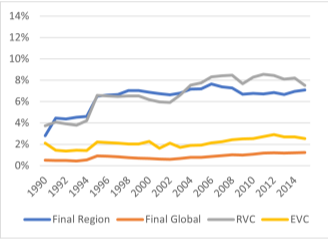
Global manufacturing hubs



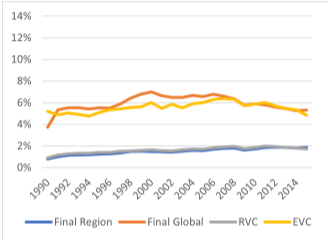
Latin America

Value related to international trade by activity

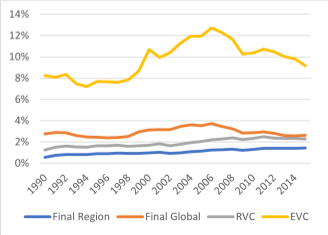
Mexico



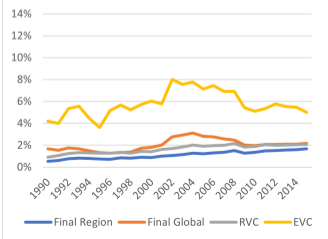
Central America + DR



South America Pacific

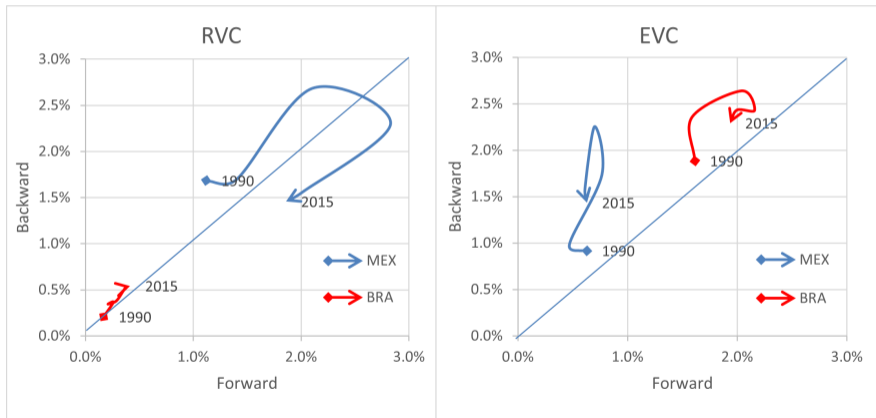


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Performance and position in Value Chains

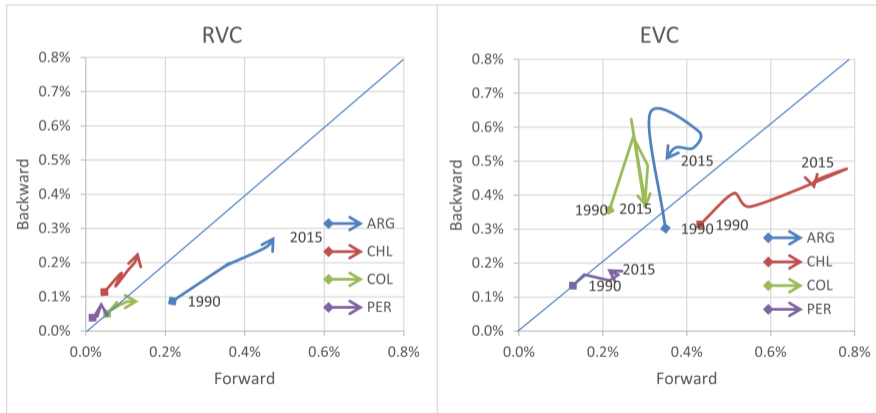
A- Big countries: Mexico and Brazil



Mexico changed its position in RVC: started as a user of regional value (an end of chains) but finished a net source. USMCA new rules of origin may reverse the change. Brazil is a net user and biased to Extra Regional Value Chains.

Performance and position in Value Chains

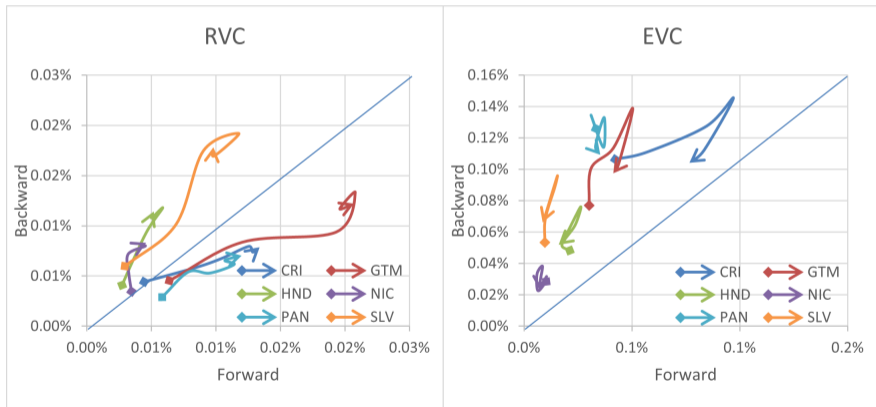
B- Medium size countries: Argentina, Chile, Colombia and Peru



Argentina is biased to RVC and performs as a net source of value. Chile and Peru highlights as source of value to EVC. Colombia engaging in VC is scarce

Performance and position in Value Chains

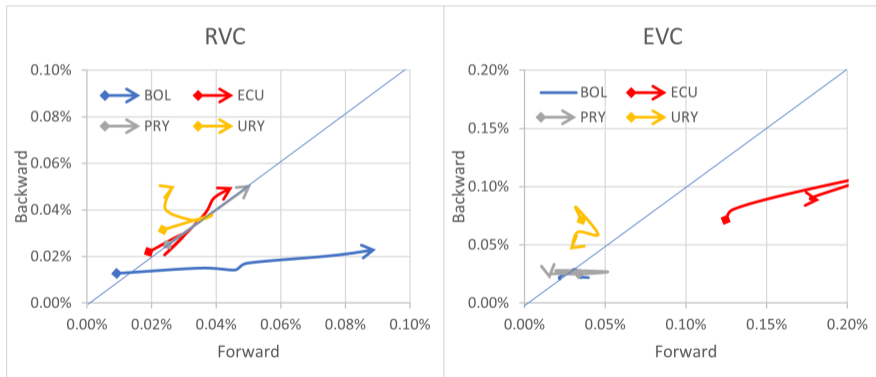
C- Central American Countries



Rise in EVC participation until the global crisis and a fall thenceforth. Strongly backward biased participation in EVC. RVC in Central America is less important but they have a rising tendency.

Performance and position in Value Chains

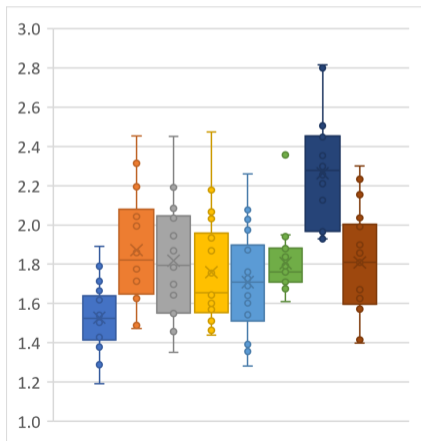
D- Small South American Countries



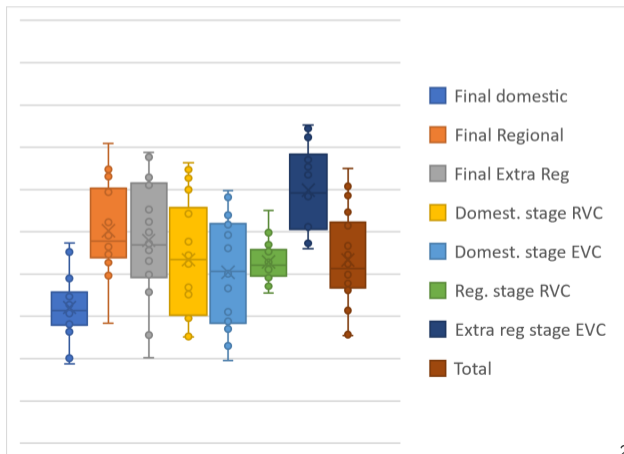
RVC is important (forward) for Paraguay and Bolivia. Ecuador is strongly forward in EVC and Uruguay is backward both in RVC and EVC. All these countries' participation in international value chains raised their importance in the period

Length of chains: domestic and international segment

2014-15

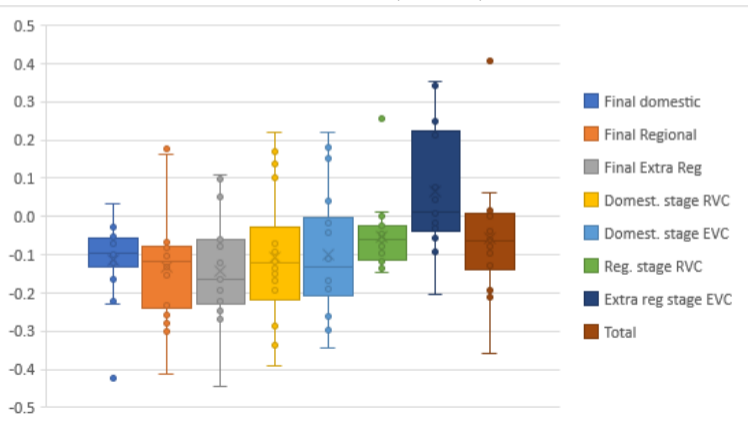


1992-1993



Length of chains: domestic and international segment

Differences 1992/3-2014/15

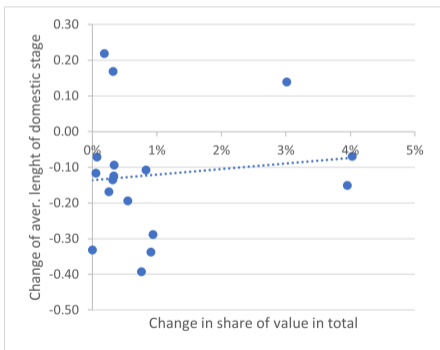


Latin America did not contribute to rise in fragmentation of production. Domestic stages shortened in every flow

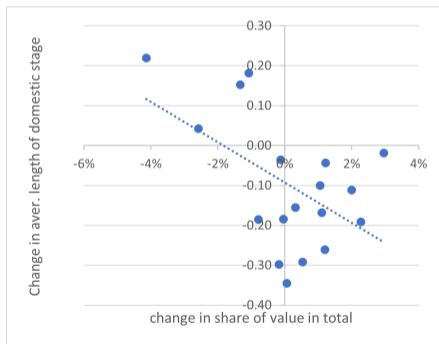
Participation and Length of chains

Change in average length and in share of value in total value: 1992-2015. LAC countries

RVC



EVC



Despite having negative correlation between participation and length in both kinds of chains, only rising participation in EVC led to higher specialization

Conclusions

- Both global and regional trade activities gained participation in LAC countries since 1990
- Nevertheless, no country in LAC reached the level of integration of European and East Asian Blocks
- Mexico, Bolivia and Argentina gained sizable participation in (biased forward) RVC
- Chile, Peru and Ecuador raised their participation in EVC, on a forward basis
- Brazil and Colombia show little involvement in RVC and backward position in both
- Central American countries are strongly biased towards backward participation
- Across LAC countries, higher involvement in GVC is associated with higher specialization, but increasing involvement only raise specialization in EVC (not in RVC)

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