Missing data in the structural gravity: estimation bias due to the omission of internal trade

Marcel Vaillant[1] Manuel Flores[1] Pedro Moncarz[2]

[1]dECON-FCS-UdelaR [2]FCE-UNC, CICE-CIECS, CONICET

Workshop Instituto de Economía y Finanzas

Facultad de Ciencias Económicas

Universidad Nacional de Córdoba

11 de Septiembre de 2019

The so-call “gravity model of trade” found its theoretical foundation with the contributions of Eaton and Kortum (2002) and Anderson and van Wincoop (2003).

Since then, the term “Structural Gravity Model” is used to refer to the estimation of a theoretically consistent “gravity equation”.

The “gravity equation” is aimed at explaining the determinants of bilateral trade flows, either at the aggregate or sectoral level.

The structural gravity model responds to the following system:

$$X_{ijt} = \frac{Y_{it}}{\Omega_{it}} \frac{E_{jt}}{\Phi_{jt}} \phi_{ijt} \qquad (1)$$

$$\Omega_{it} = \sum_{j} \frac{E_{jt}}{\Phi_{jt}} \phi_{ijt} \qquad (2)$$

$$\Phi_{jt} = \sum_{i} \frac{Y_{it}}{\Omega_{it}} \phi_{ijt} \qquad (3)$$

X_{ijt}: exports from i to j at time t; Y_{it}: production of i at time t; E_{jt}: expenditure of j at time t; Ω_{it}: multilateral resistance of i at time t; Φ_{jt}: multilateral resistance of j at time t; ϕ_{ijt}: proximity (inverse of trade costs) from i and j at time t

A characteristic of the system (1)-(3) is that is a general equilibrium model:

$$Y_{it} = \sum_j X_{ijt}$$

$$E_{jt} = \sum_i X_{ijt}$$

X_{ijt} includes internal transactions ($i = j$)

The missing/zero trade issue:

a) X_{ijt} is zero (or too small to be captured by official statistics) for $i \neq j$

b) X_{ijt} is missing for $i=j$

For case a) we have some alternatives: Helpman, Melitz and Rubinstein (2008), Santos-Silva and Tenreyro (2009), and other non-linear models.

Case b) has attracted much less attention.

Empirical specification of the gravity equation (Fally, 2015 y CGZ, 2019):

$$X_{ijt} = \left(\frac{Y_{it} E_{jt}}{X_t^W} \right) \left(\frac{D_{ij} e^{\mathrm{b'w}_{ijt}}}{\Omega_{it} \Phi_{jt}} \right) + \varepsilon_{ijt}$$

$$(1) \qquad X_{ijt} = \exp\left(s_{it} + m_{jt} + \mu_{ij} + \mathrm{b'w}_{ijt} \right) + \varepsilon_{ijt}$$

$$(2) \qquad \hat{\Omega}_{it} = \frac{Y_{it} \Big/ \sqrt{X_t^W}}{e^{\hat{s}_{it}}}$$

$$(3) \qquad \hat{\Phi}_{jt} = \frac{E_{jt} \Big/ \sqrt{X_t^W}}{e^{\hat{m}_{jt}}}$$

$$(4) \qquad \hat{D}_{ij} = e^{\hat{\mu}_{ij}}$$

Empirical specification of the gravity equation (LWYZ, 2018):

(i) $$\sum_i \sum_j \sum_t \left[X_{ijt} - \left(\frac{Y_{it} E_{jt}}{X_t^W} \right) \left(\frac{D_{ij} e^{\hat{b}' w_{ijt}}}{\Omega_{it} \Phi_{jt}} \right) \right] w_{ijt} = 0$$

(ii) $$\Omega_{it} = \sum_j \frac{E_{jt} / X_t^W}{\Phi_{jt}} D_{ij} e^{\hat{b}' w_{ijt}}$$

(iii) $$\Phi_{jt} = \sum_i \frac{Y_{it} / X_t^W}{\Omega_{it}} D_{ij} e^{\hat{b}' w_{ijt}}$$

(iv) $$D_{ij} = \frac{\sum_t X_{ijt}}{\left(\frac{Y_{it} E_{jt}}{X_t^W} \right) \left(\frac{D_{ij} e^{\hat{b}' w_{ijt}}}{\Omega_{it} \Phi_{jt}} \right)}$$

Let us assume $b'w_{ijt} = \beta \, PTA_{ijt}$, then what are the costs of excluding X_{ii} in terms of:

$$\hat{\beta},\ \hat{\Omega}_{it} \text{ and } \hat{\Phi}_{jt}$$

- Trade diversion
- Trade creation
- Preference for openness
- Idiosyncratic factors (e.g. size)

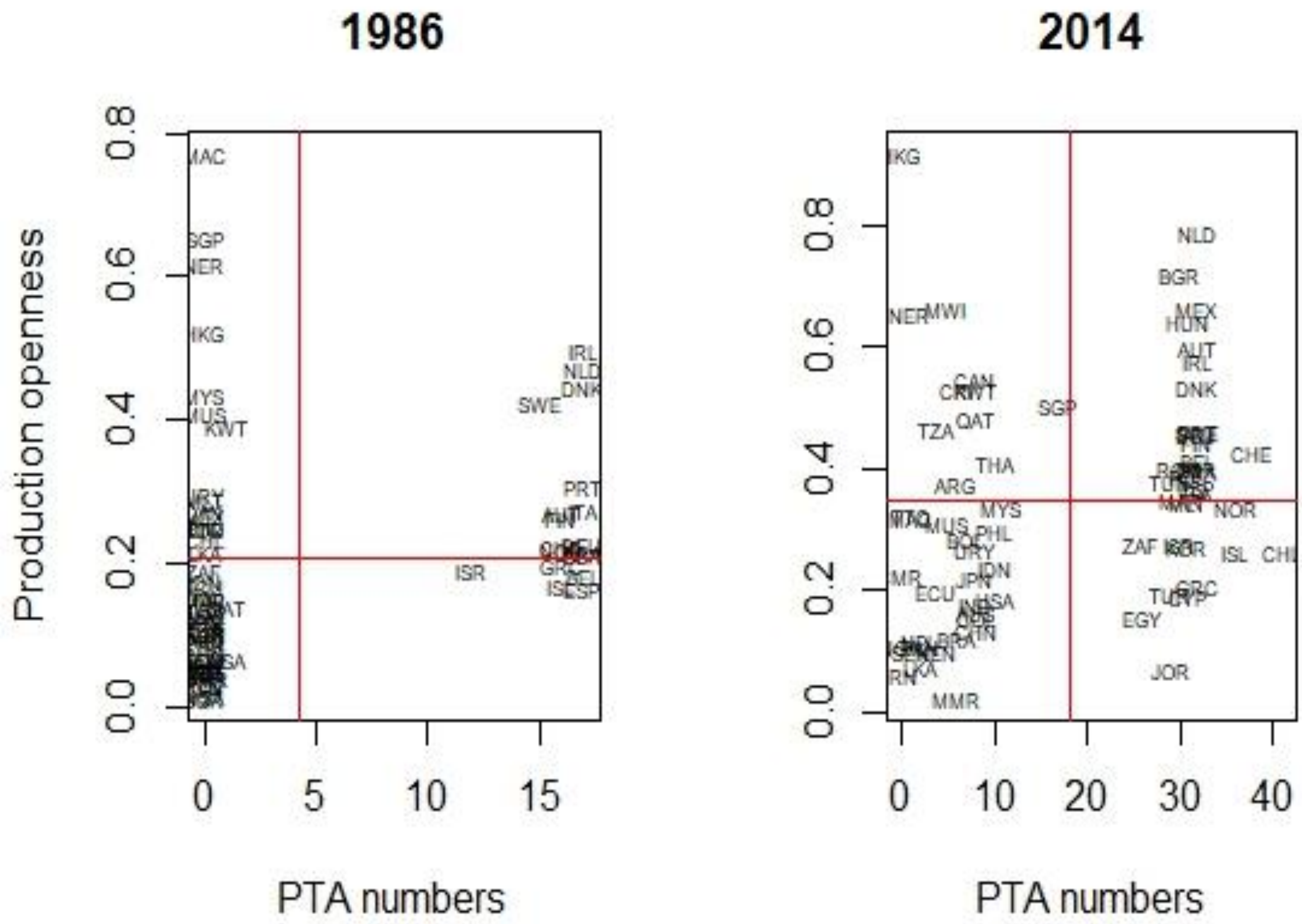
$$X_{ijt} = exp\left(s_{it} + m_{jt} + \mu_{ij} + \beta PTA_{ijt}\right) + e_{ijt}$$

	Without internal trade		With internal trade			
	(1)		(3)			
β	0.0541***		0.4138***			
	(0.020)		(0.036)			
δ_1						
δ_2						
Observations	37,376		37,928			
s_{it}, m_{jt}, **and** μ_{ij} **F.E.**	YES		YES			
Globalization dummies	NO		NO			

$$X_{ijt} = exp\left(s_{it} + m_{jt} + \mu_{ij} + \sum_t b_t I(i \neq j) + \beta PTA_{ijt}\right) + e_{ijt}$$

	Without internal trade		With internal trade			
	(1)		(3)	(4)		
β	0.0541***		0.4138***	0.1112***		
	(0.020)		(0.036)	(0.030)		
δ_1						
δ_2						
Observations	37,376		37,928	37,928		
s_{it}, m_{jt}, **and** μ_{ij} **F.E.**	YES		YES	YES		
Globalization dummies	NO		NO	YES		

Countries with more PTAs are more open



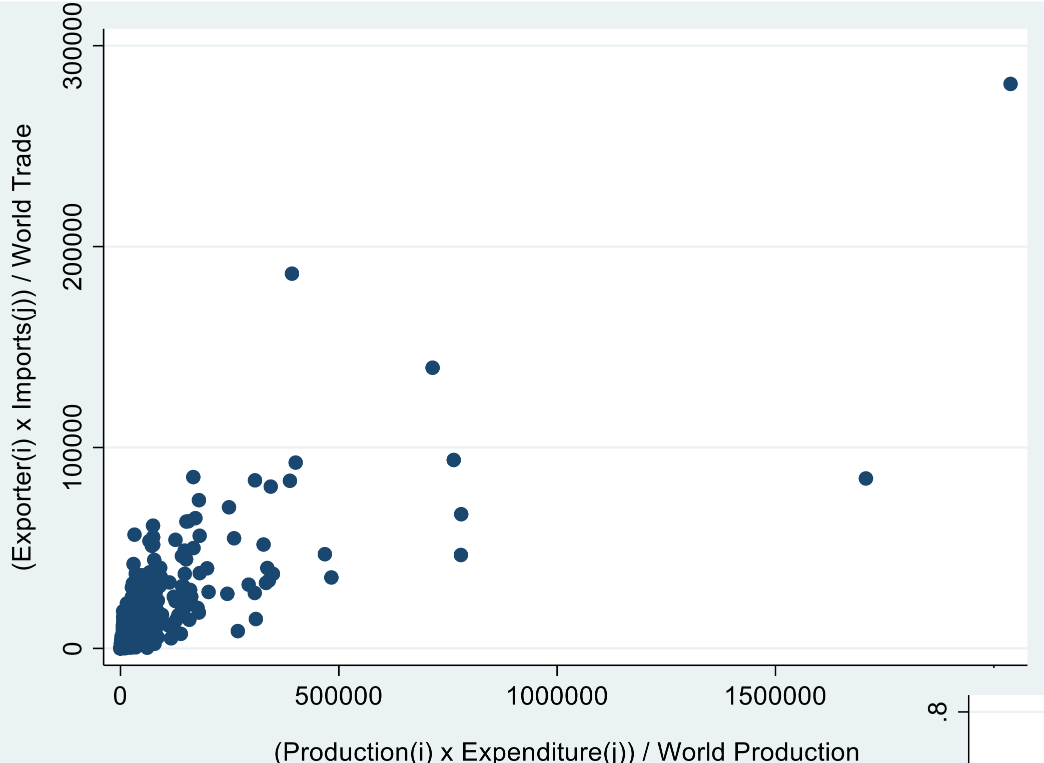
$$X_{ijt} = exp\left(s_{it} + m_{jt} + \mu_{ij} + \sum_t b_t I(i \neq j) + \beta PTA_{ijt} + \delta_1\left[PTA_{ijt} \times \left(NPTA_{it} \times NPTA_{jt}\right)\right]\right.$$

	Without internal trade		With internal trade			
	(1)	(2)	(3)	(4)	(5)	(6)
β	0.0541***	0.1566***	0.4138***	0.1112***	0.2616***	0.1257***
	(0.020)	(0.023)	(0.036)	(0.030)	(0.041)	(0.032)
δ_1		-0.0003***			0.0007***	0.0001*
		(0.000)			(0.000)	(0.000)
δ_2		0.0002**			0.0015***	0.0003***
		(0.000)			(0.000)	(0.000)
Observations	37,376	37,376	37,928	37,928	37,928	37,928
s_{it}, m_{jt}, **and** μ_{ij} **F.E.**	YES	YES	YES	YES	YES	YES
Globalization dummies	NO	NO	NO	YES	NO	YES

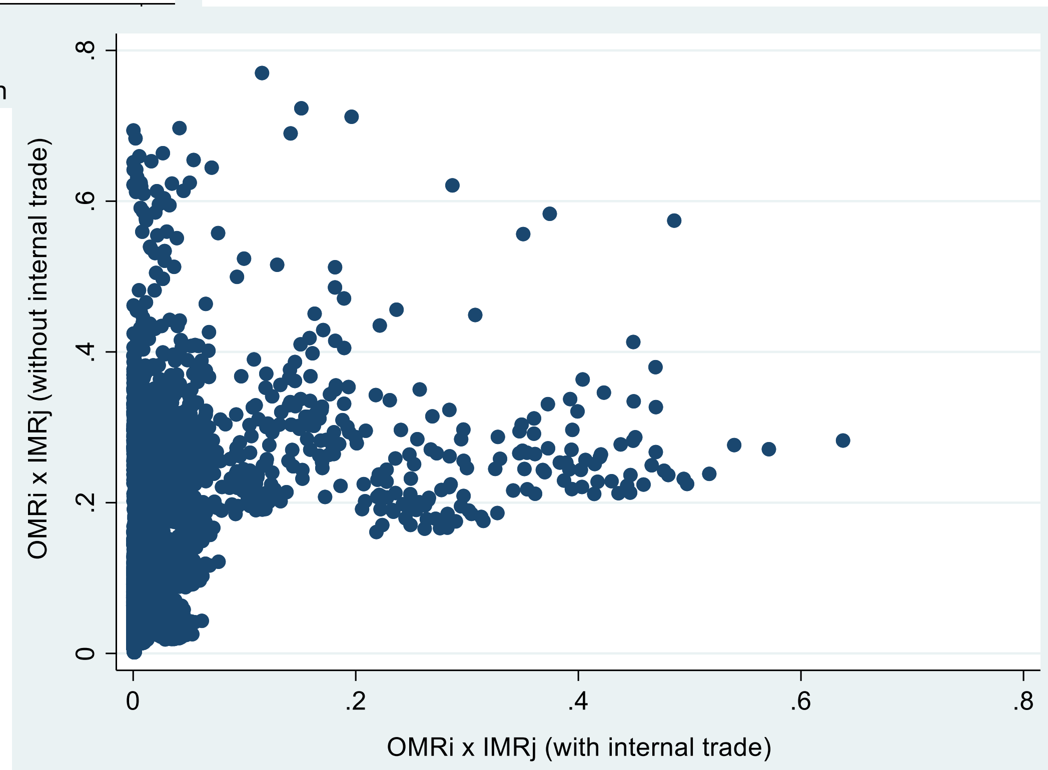
- Bias in multilateral resistances and trade proximities

With internal trade: $$X_{ijt} = \frac{Y_{it} E_{jt}}{Y_t^w} \frac{\breve{\phi}_{ij} \exp(\mathrm{b'w}_{ijt})}{\Omega_{it} \Phi_{jt}}$$

Without internal trade: $$X_{ijt} = \frac{X_{it} M_{jt}}{X_t^w} \frac{\breve{\phi}_{ij} \exp(\mathrm{b'w}_{ijt})}{\Omega_{it} \Phi_{jt}}$$

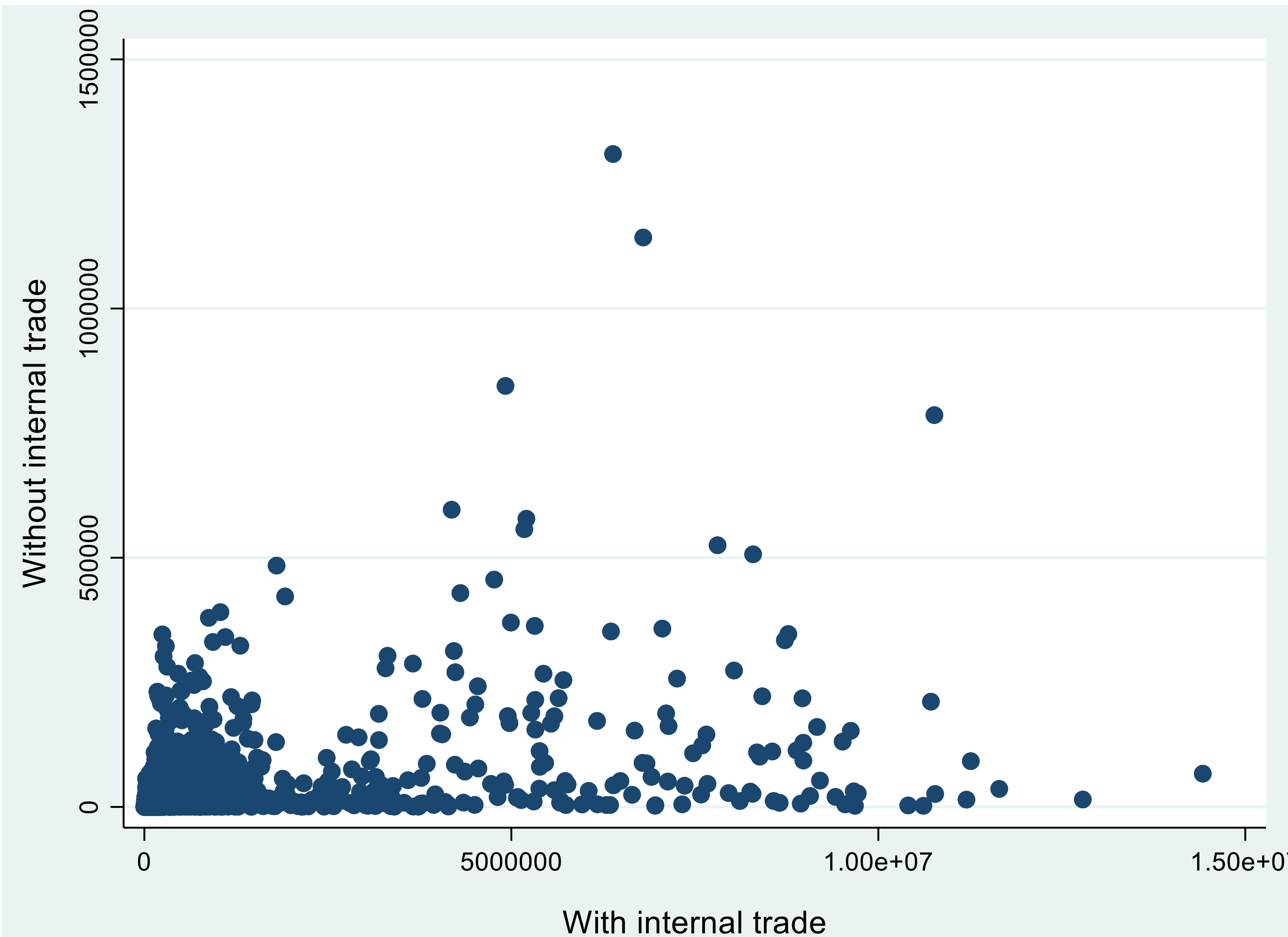


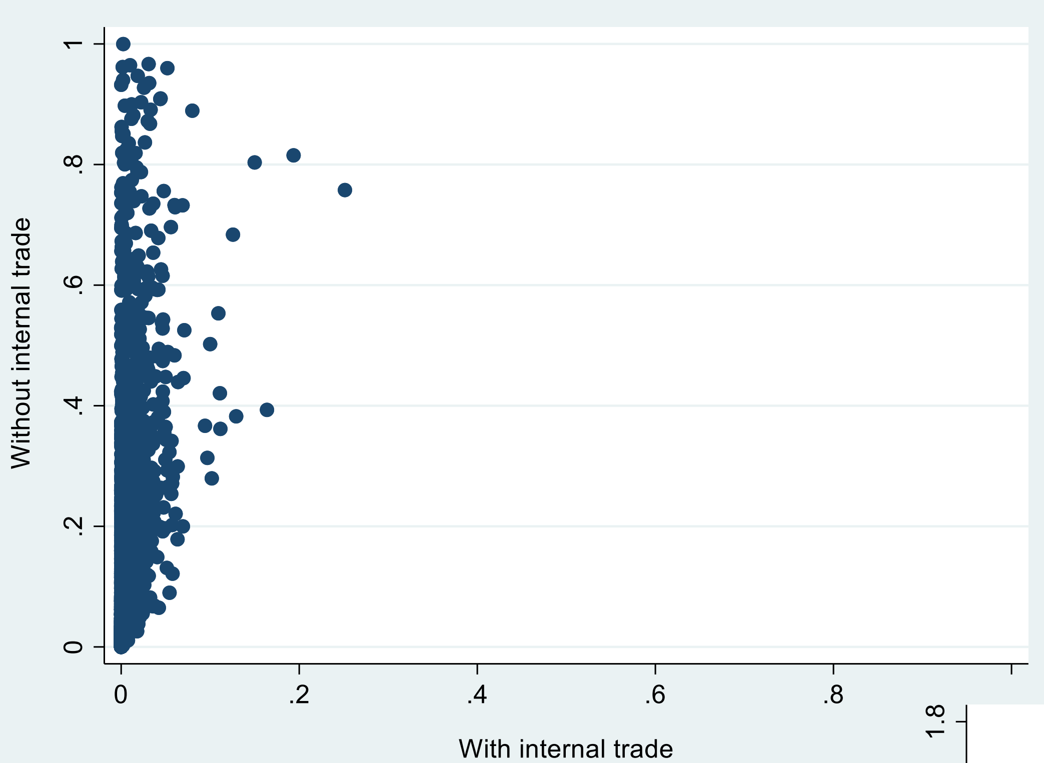
(Exporter(i) x Imports(j)) / World Trade
300000
200000
100000
0
0
500000
1000000
1500000
(Production(i) x Expenditure(j)) / World Production



OMRi x IMRj (without internal trade)
.8
.6
.4
.2
0
0
.2
.4
.6
.8
OMRi x IMRj (with internal trade)

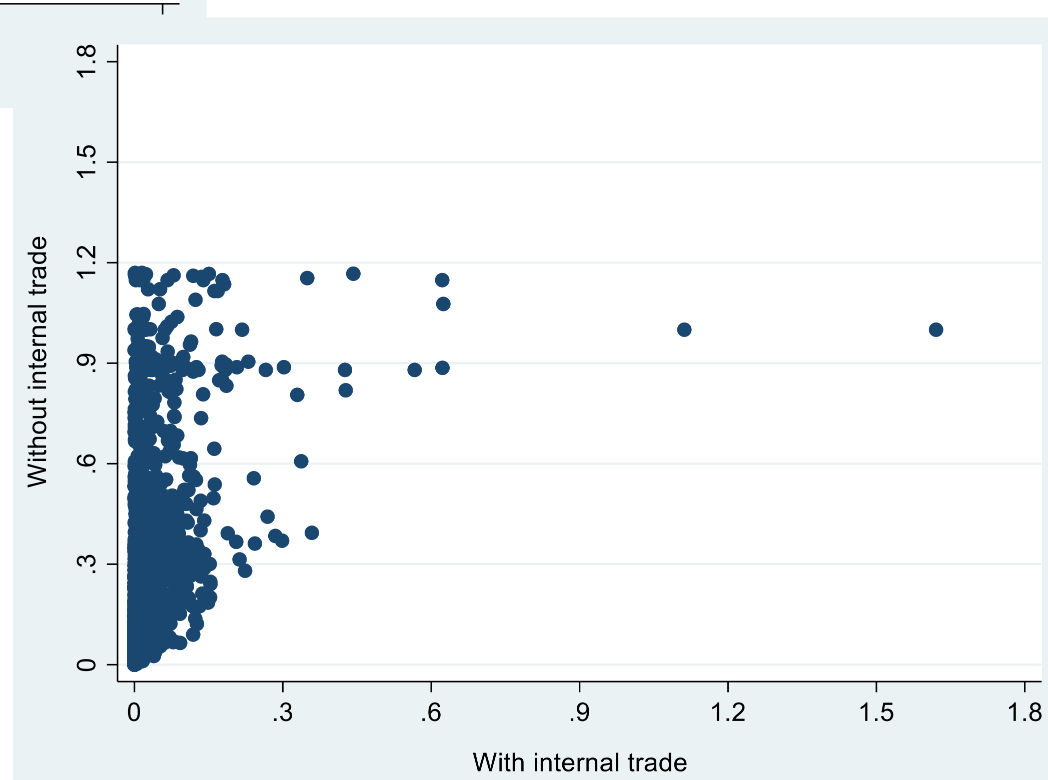
$$\left(\frac{X_{it}}{\Omega_{it}}\right)\left(\frac{M_{jt}}{\Phi_{jt}}\right)\frac{1}{X_t^w} \quad \text{versus} \quad \left(\frac{Y_{it}}{\Omega_{it}}\right)\left(\frac{E_{jt}}{\Phi_{jt}}\right)\frac{1}{Y_t^w}$$





← Permanent proximity $\left(\breve{\phi}_{ij}\right)$

$\left(\breve{\phi}_{ij} e^{\mathrm{b'w}_{ijt}}\right)$ Overall proximity ←



- Some comparative static exercises

$$\frac{X_{ijt}^{1}}{X_{ijt}^{0}} = \exp\left(\mathrm{b}'\left(w_{ijt}^{1} - w_{ijt}^{0}\right)\right)\left(\frac{\Omega_{it}^{0}\Phi_{jt}^{0}}{\Omega_{it}^{1}\Phi_{jt}^{1}}\right)$$

Superscripts 0 and 1 refer to pre- and post-change scenarios

- Some comparative static exercises

For the pre-change scenario we use the predicted values obtained after the model is estimated.

For the post-change scenario we need to recover the MRs:

$$\left.\begin{matrix}\hat{b}\\ \hat{\tilde{\phi}}_{ij}\\ w_{ijt}^{1}\end{matrix}\right\}\Rightarrow\begin{cases}\Omega_{it}^{1}=\sum_{j}\dfrac{E_{jt}/Y_{t}^{w}}{\Phi_{jt}^{1}}\,\hat{\tilde{\phi}}_{ij}\exp\left(\hat{\mathrm{b}}'\,\mathrm{w}_{ijt}^{1}\right)\\ \Phi_{it}^{1}=\sum_{i}\dfrac{Y_{it}/Y_{t}^{w}}{\Omega_{it}^{1}}\,\hat{\tilde{\phi}}_{ij}\exp\left(\hat{\mathrm{b}}'\,\mathrm{w}_{ijt}^{1}\right)\end{cases}\qquad\left.\begin{matrix}\hat{b}\\ \hat{\tilde{\phi}}_{ij}\\ w_{ijt}^{1}\end{matrix}\right\}\Rightarrow\begin{cases}\Omega_{it}^{1}=\sum_{j\neq i}\dfrac{M_{jt}/X_{t}^{w}}{\Phi_{jt}^{1}}\,\hat{\tilde{\phi}}_{ij}\exp\left(\hat{\mathrm{b}}'\,\mathrm{w}_{ijt}^{1}\right)\\ \Phi_{it}^{1}=\sum_{i\neq j}\dfrac{X_{it}/X_{t}^{w}}{\Omega_{it}^{1}}\,\hat{\tilde{\phi}}_{ij}\exp\left(\hat{\mathrm{b}}'\,\mathrm{w}_{ijt}^{1}\right)\end{cases}$$

- Some comparative static exercises

Three counterfactuals:

a) No-MERCOSUR

b) Agreement between EU and MERCOSUR

c) Agreement between EFTA and MERCOSUR

Simulated effects on International Trade

Agreement Mercosur and EU | **Agreement Mercosur and EFTA** | **Non-Mercosur**

(a) Gravity model with internal transactions

Agreement Mercosur and EU

Destiny	Origin		
	EU	MCS	RoW
EU	0.94	16.50	0.46
MCS	11.49	2.93	4.51
RoW	0.26	8.58	-0.06

Agreement Mercosur and EFTA

Destiny	Origin		
	EFTA	MCS	RoW
EFTA	1.49	9.24	0.54
MCS	8.28	-0.01	1.02
RoW	0.51	1.72	-0.01

Non-Mercosur

Destiny	Origin	
	MCS	RoW
MCS	-10.53	-0.53
RoW	-0.84	0.00

(b) Gravity model without internal transactions

Agreement Mercosur and EU

Destiny	Origin		
	EU	MCS	RoW
EU	-0.68	-6.01	1.68
MCS	-6.96	-8.48	5.35
RoW	1.52	5.12	-0.56

Agreement Mercosur and EFTA

Destiny	Origin		
	EFTA	MCS	RoW
EFTA	-2.68	4.75	-0.02
MCS	3.71	-1.49	0.17
RoW	-0.04	0.29	0.00

Non-Mercosur

Destiny	Origin	
	MCS	RoW
MCS	-8.12	1.39
RoW	2.13	-0.03

Summary

- The gravity model is theoretically well-founded.

- There have been important advances for the estimation of the model: large sets of fixed-effects and zero-trade values.

- Still, there is a gap in terms of the required statistics to do a proper estimation of the structural model: absence of reliable data on internal transactions.

- The omission of internal transactions in the estimation appears not to be inconsequential.

What next?

- Characterize the bias due to the omission of internal trade: analytically and with a Montecarlo exercise
- Develop an iterative procedure to “generate” internal trade