THE EFFECTS OF NAFTA ON CANADA, MEXICO AND THE UNITED STATES: A MUTIREGIONAL INPUT-OUTPUT ANALYSIS

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Introduction

The North American Free Trade Agreement (NAFTA) has been studied from various angles and for various purposes in its 24 years long history. Since last year NAFTA has been in a process of renegotiation under the pressure from the US current administration, arguing that the trade agreement has been *unfair* to the US economy and US labor force. But so far, there is no clear evidence that NAFTA has favored any country member against any other in any particular way.

Some important developments in Multi-Regional Input-Output Analysis (MRIO) and the building of the World Input-Output Database (WIOD) help to analyze in depth the type of trade agreements like NAFTA. Precisely in that direction is the report called *EU Exports to the World: Effects on employment and income* prepared in 2015 for the European Union by a group of distinguish members of the International Input-Output Association.

The objective of our study is to build and use a Multiregional Input-Output model for the North American region: Canada, Mexico and the US, to determine the effects of NAFTA for income, output and labor in each of the three economies, sharing the database and the procedures utilized in the EU report.

Methodology

Countries.

We consider in our analysis the data in the WIOD of 43 countries organized as follows:
NAFTA, (3) México, the US and Canada,
Europe (30) the 28 countries that belong to the European Union plus Swisszerland and Norway.
Asia (6) China, India, Japan, Indonesia, Korea and Taiwan.
Rest of the World the RoW of WIOD plus (4) Australia, Brazil, Russia and Turkey.

Data period, sectors and units of measurement

For our study we use the data *WIOD 2016*, that includes world i-o tables of 56 sectors, for 43 countries for each year from 2000 to 2014 at current prices in millions of US dollars.

The Model

We start from the following MRIO matrices and vectors:

$$\mathbf{Z} = \begin{bmatrix} \mathbf{Z}^{mx,mx} & \mathbf{Z}^{mx,usa} & \mathbf{Z}^{mx,cnd} & \mathbf{Z}^{mx,eu} & \mathbf{Z}^{mx,as} & \mathbf{Z}^{mx,rm} \\ \mathbf{Z}^{usa,mx} & \mathbf{Z}^{usa,usa} & \mathbf{Z}^{usa,cnd} & \mathbf{Z}^{usa,eu} & \mathbf{Z}^{usa,as} & \mathbf{Z}^{usa,rm} \\ \mathbf{Z}^{cnd,mx} & \mathbf{Z}^{cnd,usa} & \mathbf{Z}^{cnd,cnd} & \mathbf{Z}^{cnd,eu} & \mathbf{Z}^{cnd,as} & \mathbf{Z}^{cnd,rm} \\ \mathbf{Z}^{eu.mx} & \mathbf{Z}^{eu,usa} & \mathbf{Z}^{eu,cnd} & \mathbf{Z}^{eu,eu} & \mathbf{Z}^{eu,as} & \mathbf{Z}^{eu,rm} \\ \mathbf{Z}^{as,mx} & \mathbf{Z}^{as,usa} & \mathbf{Z}^{as,cnd} & \mathbf{Z}^{as,eu} & \mathbf{Z}^{as,as} & \mathbf{Z}^{as,rm} \\ \mathbf{Z}^{rm,mx} & \mathbf{Z}^{rm,usa} & \mathbf{Z}^{rm,cnd} & \mathbf{Z}^{rm,eu} & \mathbf{Z}^{rm,as} & \mathbf{Z}^{rm,rm} \end{bmatrix}$$

$$\mathbf{f} = \begin{bmatrix} \mathbf{f}^{mx,mx} & \mathbf{f}^{mx,usa} & \mathbf{f}^{mx,cnd} & \mathbf{f}^{mx,eu} & \mathbf{f}^{mx,as} & \mathbf{f}^{mx,rm} \\ \mathbf{f}^{usa,mx} & \mathbf{f}^{usa,usa} & \mathbf{f}^{usa,cnd} & \mathbf{f}^{usa,eu} & \mathbf{f}^{usa,as} & \mathbf{f}^{usa,rm} \\ \mathbf{f}^{cnd,mx} & \mathbf{f}^{cnd,usa} & \mathbf{f}^{cnd,cnd} & \mathbf{f}^{cnd,eu} & \mathbf{f}^{cnd,as} & \mathbf{f}^{cnd,rm} \\ \mathbf{f}^{eu.mx} & \mathbf{f}^{eu,usa} & \mathbf{f}^{eu,cnd} & \mathbf{f}^{eu,eu} & \mathbf{f}^{eu,as} & \mathbf{f}^{eu,rm} \\ \mathbf{f}^{as,mx} & \mathbf{f}^{as,usa} & \mathbf{f}^{as,cnd} & \mathbf{f}^{as,eu} & \mathbf{f}^{as,as} & \mathbf{f}^{as,rm} \\ \mathbf{f}^{rm,mx} & \mathbf{f}^{rm,usa} & \mathbf{f}^{rm,cnd} & \mathbf{f}^{rm,eu} & \mathbf{f}^{rm,as} & \mathbf{f}^{rm,rm} \end{bmatrix}$$

$$\mathbf{x} = \begin{bmatrix} \mathbf{x}^{mx} \\ \mathbf{x}^{usa} \\ \mathbf{x}^{cnd} \\ \mathbf{x}^{eu} \\ \mathbf{x}^{as} \\ \mathbf{x}^{rm} \end{bmatrix} \qquad \mathbf{v} = \begin{bmatrix} \mathbf{v}^{mx} \\ \mathbf{v}^{usa} \\ \mathbf{v}^{cnd} \\ \mathbf{v}^{eu} \\ \mathbf{v}^{as} \\ \mathbf{v}^{rm} \end{bmatrix} \qquad l = \begin{bmatrix} l^{mx} \\ l^{usa} \\ l^{cnd} \\ l^{eu} \\ l^{as} \\ l^{rm} \end{bmatrix}$$

where: **Z** is a multiregional matrix of inter-industrial flows; $\mathbf{Z}^{r,s}$ are submatrices showing the sales of intermediate inputs from country *r* to country *s*; superscripts, *mx* = Mexico, *cnd* = Canada, *us* = United States, *eu* = Europe ; *as* = Asia, and *rm* = Rest of the world.
f is a multiregional matrix of final demands where $\mathbf{f}^{r,s}$ are the vectors of final demand of country *s* from country *r*.
x is a column vector of multiregional Gross Outputs where $\mathbf{x}^r$ is the gross output of country *r*; **v** is a column vector of multiregional vectors of Value Added, where $\mathbf{v}^r$ is the vector of value added of country r; *l* is the column vector of multiregional labor, where l^r is the labor vector of country *r*.

Then we have the known identity equation:

$$\mathbf{Zi} + \mathbf{f} = \mathbf{x}$$

where: **Z**, **f** and **x** are the matrix and vectors above defined and **i** is the unitary vector or summation vector.

Thus, we can define a regional matrix for the North American Free Trade Agreement (NAFTA) zone, as:

$$\mathbf{Z}^{NAFTA} = \begin{bmatrix} \mathbf{Z}^{mx,mx} & \mathbf{Z}^{mx,usa} & \mathbf{Z}^{mx,cnd} \\ \mathbf{Z}^{usa,mx} & \mathbf{Z}^{usa,usa} & \mathbf{Z}^{usa,cnd} \\ \mathbf{Z}^{cnd,mx} & \mathbf{Z}^{cnd,usa} & \mathbf{Z}^{cnd,cnd} \end{bmatrix}$$

Which is a submatrix of the MRIO $\mathbf{Z}$ above defined.

Now we can define a NAFTA final demand matrix as:

$$\mathbf{f}^{NAFTA} = \begin{bmatrix} \mathbf{f}^{mx,mx} & \mathbf{f}^{mx,usa} & \mathbf{f}^{mx,cnd} & \mathbf{e}^{mx,eu} & \mathbf{e}^{mx,as} & \mathbf{e}^{mx,rm} \\ \mathbf{f}^{usa,mx} & \mathbf{f}^{usa,usa} & \mathbf{f}^{usa,cnd} & \mathbf{e}^{usa,eu} & \mathbf{e}^{usa,as} & \mathbf{e}^{usa,rm} \\ \mathbf{f}^{cnd,mx} & \mathbf{f}^{cnd,usa} & \mathbf{f}^{cnd,cnd} & \mathbf{e}^{cnd,eu} & \mathbf{e}^{cnd,as} & \mathbf{e}^{cnd,rm} \end{bmatrix}$$

Where $\mathbf{e}^{r,s}$ stands for total exports from country r to country s, it includes intermediate and final exports, that is, $\mathbf{e}^{rs} = \mathbf{f}^{rs} + \mathbf{Z}^{rs}\mathbf{i}$

The gross output, value added and labor vectors:

$$\mathbf{x}^{NAFTA} = \begin{bmatrix} \mathbf{x}^{mx} \\ \mathbf{x}^{usa} \\ \mathbf{x}^{cnd} \end{bmatrix} \qquad \mathbf{v}^{NAFTA} = \begin{bmatrix} \mathbf{v}^{mx} \\ \mathbf{v}^{usa} \\ \mathbf{v}^{cnd} \end{bmatrix} \qquad \mathbf{l}^{NAFTA} = \begin{bmatrix} \mathbf{l}^{mx} \\ \mathbf{l}^{usa} \\ \mathbf{l}^{cnd} \end{bmatrix}$$

Thus, the technical coefficient matrix for the NAFTA region is:

$$\mathbf{A}^{NAFTA} = \mathbf{Z}^{NAFTA} \hat{\mathbf{x}}^{NAFTA^{-1}} \tag{1}$$

The Leontief's inverse is:

$$\mathbf{L}^{NAFTA} = (\mathbf{I} - \mathbf{A}^{NAFTA})^{-1} \tag{2}$$

The gross output equation is

$$\mathbf{x}^{NAFTA} = \mathbf{L}^{NAFTA^{-1}} \mathbf{f}^{NAFTA} \tag{3}$$

To calculate NAFTA gross outputs generated by exports to other regions, we have the equation:

$$\mathbf{x}^{NAFTA} = \mathbf{L}^{NAFTA^{-1}} \mathbf{e}^{NAFTA} \tag{4}$$

The equation for value added coefficients:

$$\mathbf{va}^{NAFTA} = \hat{\mathbf{x}}^{NAFTA^{-1}} \mathbf{v}^{NAFTA} \tag{5}$$

Value added generated by exports from the NAFTA region to other regions is given by the equation:

$$\mathbf{va}_{exNAFTA}^{NAFTA} = \mathbf{va}^{NAFTA\prime} \ \mathbf{L}^{NAFTA^{-1}} \mathbf{e}^{NAFTA} \tag{6}$$

Where: $\mathbf{va}^{i\prime} \mathbf{L}^{rs^{-1}} \mathbf{e}^{sk}$ is the value added generated in country i of the NAFTA region due to the exports of intermediate inputs of that country to country s of that region, and the exports of that country to non-NAFTA member country k.

Now we can define the matrix of import coefficients of inputs, from non-NAFTA region countries to the NAFTA region as:

$$\mathbf{A}^{noNAFTA,NAFTA} = \mathbf{Z}^{noNAFTA,NAFTA} \ \hat{\mathbf{x}}^{NAFTA^{-1}} \tag{7}$$

where: $\mathbf{Z}^{noNAFTA,NAFTA}$ is the matrix of imported inputs from outside NAFTA to the NAFTA region countries.

$$\mathbf{Z}^{noNAFTA,NAFTA} = \{\mathbf{z}^{rs}\} \ \forall \ r \ \neq mx \ , usa, cnd, \ s \ \neq eu, asi, rm.$$

The value of imports from outside NAFTA required for NAFTA countries to export outside NAFTA is given by the expression:

$$\mathbf{A}^{noNAFTA,NAFTA} \ \mathbf{L}^{NAFTA^{-1}} \mathbf{e}^{NAFTA} \tag{8}$$

Finally, the following equation gives us the value added generated outside NAFTA by the exports of NAFTA to other regions:

$$\mathbf{va}_{exNAFTA}^{noNAFTA} = \mathbf{va}^{noNAFTA\prime} \ \mathbf{A}^{noNAFTA,NAFTA} \ \mathbf{L}^{NAFTA^{-1}} \mathbf{e}^{NAFTA} \ \mathbf{L}^{NAFTA^{-1}} \mathbf{e}^{NAFTA} \tag{9}$$

For labor, we get first the equation for labor coefficients

$$lc^{NAFTA} = \hat{\mathbf{x}}^{NAFTA^{-1}} l^{NAFTA} \tag{10}$$

Then we have:

$$lc_{exNAFTA}^{NAFTA} = lc^{NAFTA\prime} \ \mathbf{L}^{NAFTA^{-1}} \mathbf{e}^{NAFTA} \tag{11}$$

where: $lc^{i\prime} \mathbf{L}^{rs^{-1}} \mathbf{e}^{sk}$ is the amount of labor generated in country i of the NAFTA region due to the exports of intermediate inputs of that country to country s of that region, and the exports of that country to non-NAFTA member country k.

What to expect from the model?

The model allowed us to get a detailed information about the impact NAFTA has had in each of the three country members in three basic variables Gross Output, Value Added and Labor during the period from 2000 to 2014.

However, the ideal situation would be to have got information with the same level of disaggregation for years before 1994 –when NAFTA started– so as to compare the most recent data with the previous situation for each country without NAFTA.

One of our hypothesis is that NAFTA was a one shot event, that is, it impacted the economy, maybe very strongly, but in the short run. That, could not be proved in this model.

However, the model can help us to answer the initial question of which was the country that has been the most benefited by NAFTA, under the assumption that free trade is a win-win game, according to orthodox neoclassical thinking.

So, we applied all the equations in the model and tried to organize the results in a summarized format, easy to interpret and capable of leading us to answer the basic question posed.

Some important results

Despite its reputation as a highly open economy, the US value added depends much more in its domestic activities than it does in its export activities. In Table 1, the data for 2014 indicates that 90.8 per cent of the US value added is generated by the US final demand, net of exports, while only 1.6 and 7.6 are generated by exports to NAFTA and the Rest of the World, respectively. Canada's value added is generated 75 per cent by its own final demand and the rest 25 per cent by its exports, 13.6 per cent by exports to NAFTA. Mexico's value added is generated 81 per cent by domestic activities and the rest by exports. And also 13.6 per cent by exports to NAFTA (see Table 1).

According to our model's estimations the amount of value added generated by exports to NAFTA in 2014 was greater in the US (275 billion dollars) than in Canada (227 billion) or in Mexico (167 billion) as shown in Table 1.

Table 1					
VALUE ADDED GENERATED BY FINAL DEMAND					
Millions of US Dollars					
	2000	**2014**	**% share**	**2014-2000**	**% Var.**
UNITED STATES					
Value Added Total	10,284,778.0	17,348,070.0	100.0	7,063,292.0	68.7
Final Demand	9,523,408.1	15,757,643.6	90.8	6,234,235.5	65.5
Exports to NAFTA	141,803.1	275,487.2	1.6	133,684.0	94.3
Exports to RoW	619,566.7	1,314,939.2	7.6	695,372.5	112.2
CANADA					
Value Added Total	698,250.3	1,675,520.8	100.0	977,270.5	140.0
Final Demand	492,186.0	1,260,946.9	75.3	768,760.9	156.2
Exports to NAFTA	140,656.7	227,410.1	13.6	86,753.4	61.7
Exports to RoW	65,407.6	187,163.8	11.2	121,756.1	186.1
MEXICO					
Value Added Total	614,135.9	1,227,752.1	100.0	613,616.2	99.9
Final Demand	506,005.9	990,888.9	80.7	484,883.1	95.8
Exports to NAFTA	84,180.0	166,787.1	13.6	82,607.1	98.1
Exports to RoW	23,949.9	70,076.0	5.7	46,126.1	192.6
Source: Elaborated with model's calculations					

During this 14-year period of analysis, the value added figures show only minor changes which may be due to inflation, since we are using current prices values all along. But the structure remains more or less the same.

The other important issue is of course labor. Table 2 shows that in the US 93 per cent of jobs are generated by domestic activities and 7 per cent by exports; only 1.2 per cent by exports to NAFTA. In Canada domestic activities generated 79 per cent of total labor, 10.5 per cent by exports to NAFTA and the difference by exports to other countries. In the case of Mexico, the importance of domestic activities in generating employment is 85 per cent, the exports to the US generate 11 per cent and the rest are exports to other countries.

Table 2

EMPLOYMENT GENERATED BY FINAL DEMAND

Number of workers

	2000	2014	% share	2014-2000	% Var.
UNITED STATES					
Total Employment	150,433,351	155,770,460	100.0	5,337,109	3.5
Final Demand	140,960,969	144,565,800	92.8	3,604,831	2.6
Exports to Canada	1,027,421	1,258,537	0.8	231,116	22.5
Exports to Mexico	742,982	623,874	0.4	-119,108	-16.0
Exports to RoW	7,701,979	9,322,250	6.0	1,620,271	21.0
CANADA					
Total Employment	15,143,131	18,449,875	100.0	3,306,744	21.8
Canada Final Demand	11,117,595	14,525,645	78.7	3,408,049	30.7
Exports to USA	2,604,467	1,936,649	10.5	-667,819	-25.6
Exports to Mexico	57,036	77,355	0.4	20,320	35.6
Exports to RoW	1,364,032	1,910,226	10.4	546,194	40.0
MEXICO					
Total Employment	31,748,215	38,996,763	100.0	7,248,548	22.8
Mexico Final Demand	27,230,832	32,843,898	84.2	5,613,065	20.6
Exports to USA	3,594,505	4,401,314	11.3	806,809	22.4
Exports to Canada	151,141	285,040	0.7	133,899	88.6
Exports to RoW	771,737	1,466,511	3.8	694,774	90.0
Source: Elaborated with model's calculations					

In the case of labor generated by exports to NAFTA, Mexico is the leader with 4.6 million workers in these activities, Canada is second with 2 million and the US third with 1.9 million people. Here we can see important changes in this period from 2000 to 2014, the US generated less jobs in the exports to Mexico, 119 thousand, and Canada lost 668 thousand in its exports to the US.

In Table 3 it is shown in particular that there in more value added generated by exports from Mexico 155.3 billion dollars to the US, than by exports from the US 95.6 to Mexico. Also in Table 4 there is more labor generated by exports from Mexico to the US (4.4 million workers) than by exports from the US to Mexico (623.7 thousand workers). Canada figures are also higher than those of the US in both indicators, but not as much as Mexico.

Table 3				
VALUE ADDED GENERATED IN NAFTA TRADE				
Millions of Dollars				
	2000	**2014**	**% share**	**2000-2014**
From US to NAFTA	141,803.1	275,487.2	41.1	133,684.0
Exports to Canada	81,897.9	179,820.9		97,923.0
Exports to Mexico	59,905.3	95,666.3		35,761.0
From Can to NAFTA	140,656.7	227,410.1	34.0	86,753.4
Exports to USA	137,839.2	219,533.9		81,694.7
Exports to Mexico	2,817.5	7,876.2		5,058.7
From Mex to NAFTA	84,180.0	166,787.1	24.9	82,607.1
Exports to USA	80,418.1	155,276.8		74,858.8
Exports to Canada	3,762.0	11,510.3		7,748.3
Total NAFTA	366,639.9	669,684.4	100.0	303,044.5
Source: Elaborated with model's calculations				

Table 4				
EMPLOYMENT GENERATED BY NAFTA TRADE				
Number of workers				
	2000	**2014**	**% share**	**2000-2014**
From US to NAFTA	1,770,403	1,882,410	21.9	112,007
Exports to Canada	1,027,421	1,258,537		231,116
Exports to Mexico	742,982	623,874		-119,108
From Can to NAFTA	2,661,503	2,014,004	23.5	-647,499
Exports to USA	2,604,467	1,936,649		-667,819
Exports to Mexico	57,036	77,355		20,320
From Mex to NAFTA	3,745,646	4,686,354	54.6	940,708
Exports to USA	3,594,505	4,401,314		806,809
Exports to Canada	151,141	285,040		133,899
Total Emp NAFTA	8,177,552	8,582,768	100.0	405,216
Source: Elaborated with model's calculations				

Conclusions

1. For the US NAFTA is not really important as a source of value added generated by exports or employment generated by exports in its territory.

2. Despite its being the country that generates more value added in its exports to NAFTA, taken trade individually it generates less value added exporting to Canada than Canada exporting to the US, and also exports to Mexico generate less value added than Mexico exporting to the US.

3. In the case of labor Mexico clearly is generating more labor by exporting to the US and to Canada, than each of them exporting to Mexico.

It follows that the US administration is wrong complaining about NAFTA being unfair to the US, since it gets more value added from trading with NAFTA than the other two country members, Mexico and Canada. The problem seems to be that taken each country trade to the US in particular the value added generated is more in each of them than in the US with each. It looks strange but that's what the figures indicate. So it seems that the US government is looking at the figures in this particular way. And so the trading partner which was Mexico turned into its trading enemy.

In the case of labor, the situation is clear, Mexico is generating more labor by its exports activities than the US. But the US government forgets that exactly that was the whole idea: to generate labor in Mexico so as to prevent migration to the US. The thing is that migration has not stop anyway, because the Mexican economy is not working for various reasons, even before NAFTA.

President Trump is mixing up things trying to have his own NAFTA, that is, modified for what he thinks is his convenience and stop Mexican migration to the US at all cost. The answer is we don't need NAFTA we can use the World Trade Organization rules and play the game as anybody else in the world.