TRADE INSIDE THE MERCOSUR: A SOCIAL NETWORK ANALYSIS

Ignacio Hierrezuelo

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ABSTRACT

The purpose of this article is to analize intra-regional trade in the Mercosur using as foundation the gravity model and adapting the Social Networks Analysis approach. After considering data from trade for 12 countries in 2018 I found conclusions which are consistent with is expected in gravity theory, Brazil and Argentina are major players in the region but other explanations should be given for the case of Venezuela. The paper is organized in 3 sections, first the ground theory, second the methodology and third the model and results.

Section 1

International Trade – Gravity Model

There are several models that can explain why countries trade, in this analysis I will focus on the Gravity Model. This model was born in 1962 with Tinbergen, he had a Phd in Physics and found that Newton´s law of gravitation idea could be applied to explain International trade. He explained bilateral commerce between countries focusing primarily on the countries GDP (this is the equivalent of mass in this case) and inversally proportional to th distance between them. The closer and bigger the partner country is, the higher the trade will be. Since its conception it has evolved from a gravity equation to a gravity model. This is not a theoretical model but an empirical one, this has a major implication, any empirical specification might suffer of omitted variables which generates inconvenients with the estimated coefficients. Gravity equations has been applied to several domains such as migration flows and Foreign Direct Investments flows, and also has been estimated to determine the impact of different economic integration processes.

In Tinbergen´s versión of the gravity equation, trade between two countries were determine by: the value of exports that country j can supply to country i measure in terms of GDP in US dollars, the importing market of country j measure by its GNP in US dollars, and the distance between the countries measure in 1000 nautical miles. So there were 3 explanatory variables and the model was expresed in the log-log form. Later on other authors add variables to this model such as a dummy variable that has value of 1 if the countries share a border or in other cases if the asset in question was treated with preferences in the imported country for instance with a tax reduction. Eventhough it has proved to have strong results emperically it was critize for not taking in consideration trade preferences. One of the key distinction of this model related to the rest is that it doesn´t consider demand or supply issues, or even prices, there weren´t any assumptions at all.

Mccallum (1995) uses a gravity equation which explains bilateral trade flows as a function of the output on both regions, their distance and the existence of a border. The importance of this paper is not due to the fact that it considers this elements but for identifying a major role on National borders on commerce. He found that after controlling

for country´s GDP and distance, the volumen of trade inside the country is way larger than the commerce across the border. He applied a regression with trade data from EEUU and Canada 1988 and found that trade inside Canadian provinces were 22 times higher than the trade between Canada-U.S. This result was considered 1 of the 6 puzzles of open macroeconomics, because economic theory couldn´t explain the size of this "home bias" difference.

Rose A (2000), this paper aims to explain the effects on international trade and Exchange rate volatilty of moneary unions, using as tool a gravity model. The empirical problem of estimating this, is that there is not much information about countries that enter and leave a currency unión to compare trade before and after. Instead of using traditional time series analysis, the author applied cross sectional variation. The model was an augmented gravity model because the autor add several variables to make the estimates more accurate. The conclusión was that countries involved in a monetary unión trade almost three times than countries that aren´t and also that it increases the rate volatility, overall the first effect higly domains.

In Anderson & van Wincoop (2003)[1] there was a reformulation of Tinbergen´s theory, in their words "*The key implication of the theoretical gravity equation is that trade between regions is determined by relative trade barriers. Trade between two regions depends on the bilateral barrier between them relative to average trade barriers that both regions face with all their trading partners*". They call this average trade barrier as the "multilateral resistance" and they argue that this concept is more broad than distance. The idea behind is that the higher the barriers to trade with one región, more incentives has a country to trade with a bilateral country.They took McCallum´s regression equation and add this term in order to validate his results. Their findings were that border barriers reduced trade bewteen those countries by a 44% so original estimates were biased. Eventhough country´s size is not mentioned in this statement, authors declare that the multilateral resistance behaves differently in smaller countries than in bigger ones because of the size of their inner markets.

Current literature has evolved trying to provide theoretical framework before estimating this equations, there were advances in modelling the demand function in Anderson (1979) or models related to Heckscher-Ohlin Deadorff (1998).

Section 2

Methodology – Social Network Analysis

All of the models comment so far share the same empirical methodology which is to apply regressions; the difference between models are the variables chosen to explain the bilateral trade. This kind of tool is pretty flexible so it allows many variations, but as it was mentioned there can be many biases that have an impact on results.

In this paper I will apply Social Network Analysis which is a different kind of approach to ths subject but I believe that some interesting conclusions could be obtained. This type of analysis has been applied to many topics nowadays and even to trade, so first I will proceed to give some basic definitions and comment an article.

[1] Anderson J. E. and van Wincoop E. (2003). "Gravity with Gravitas: A Solution for the border puzzle"

According to Durland et al (2005)[2] "SNA is the study of relationships within the context of social situations. It contains the set of measures and analysis tools that are used to describe and understand relational data". The main idea behind this analysis is that you focus on interactions between agents, what kind of interactions or agents it doesn´t matter. Interactions are called LINKS and agents are called NODES and they are display in a network represented as a graph. The objetive is to represent a phenomenon by analysing this two components, understanding the parts of the whole makes possible an holistic view of the system and its dynamics. This analysis could be static with a snapshot of the information for a particular time or it could be dynamic. The most important questions that it could answered are, how are nodes related to each other, which node has a relevant position in this network, how is the flow inside this network and how it evolves.It has had different applications such as epidemiology, criminal activities detection, innovations diffusion, marketing campaigns viralization, multiplayer sports analysis and so on.

Links between nodes could be either symmetric (Undirected) or assymetric (Directed), the nature of the relationship stablish the type. For instance friendship is a symmetric relation whereas a buyer-consumer relation is asymmetric because the connection has a particular direction. Another property is that this Link could be weighted for some measure in order to stablish stronger or weaker relations. The density of the network is the proportion of total links againts the total of possible links that could exist given the number of nodes.

The degree of a node is the number of links to other nodes that a particular node has, on a network is possible to measure the degree of every node and to obtain a distribution degree of the network. This element is very important because it affects the dynamics of the network in the difussion process, it is possible to find uniform levels of degree of nodes or nodes with high concentrations of links and others with a few.

"Community Detection" is reffered to finding certain structure of groups of nodes in the network, there are several methods to look for this and their results not always agree.

Usually when researchers analyze the structure of a network at a given time one of the objetives is to find the most relevant nodes, which of them concéntrate the "Power". There are different measures of "Power" which study the level of Centrality of each node, depending on the subject and question a certain measure is more appropiate than another.

- Degree Centrality: Ranks nodes considerig the counts of links that each node has from higher to lower. If the links are directed if makes the distinction between the Centrality Indegree and Outdegree
- Closeness Centrality: Ranks nodes considering how is easy for one node to reach all others, considering the shortest path to reach each of them in the graph. The node that can reach the rest with the smallest path in sum has the highest centrality.
- Betweenes Centrality: Ranks nodes considering its intermediary position, so the position of the node in the network is what is important. So it analyze how many times a certain node is envolved in the shortest path of all of the rest of the nodes.

[2] Durland et al (2005). "An Introduction to social network analysis".

In Sangmoon and Eui-Hang (2002)[3] the authors applied this methodology to empirically determine if the world has indeed globalized or if it is regionalized. Using information on international commodity trade betwenn 1959 and 1996 they found that the number of connections in countries has increased been this evidence that globalization has occured. Another important result is that trade inside regions is higher than inter-regions, so ultimately they found conclusions that support both globalization and regionalization. Related to dependence theory of development they found evidence that instead of a centralization of trade in particular nodes a descentralization of commerce has been identified, the degree distribution of nodes is less concentrated due to the irruption of Asia and South America, although both processes has been different.

Section 3

Model - Results

In March 1991 The Asuncion Treaty set the corner stones for the creation of the Southern Common Market (Mercosur). Initially 4 countries signed the Treaty: Brazil, Paraguay, Uruguay and Argentina and after that Venezuela has been incorporated and Bolivia is in the middle of the process. The are also countries which have the Associate State status which are Chile, Ecuator, Peru, Colombia, Guyana and Suriname.

The purpose of this article is to analyze trade among all of this countries from a Social Network Analysis perspective considering the gravity model. So far the models explain use regressions with several explainatory variables, particularly GDP and Distance, the objective is to apply SNA to see if the results expected to this theory could be obtained with this methodolgy.

With Data from 2018 obtained from the World Bank site[4] we found these countries GDPs

Country	GDP in MM Dollars 2018	Count of Neighbour Countries[5]
Brazil	$ 1.868.626	10
Argentina	$ 519.872	5
Venezuela	$ 482.359	3
Colombia	$ 331.047	4
Chile	$ 298.231	3
Peru	$ 222.045	5
Ecuador	$ 108.398	2
Uruguay	$ 59.597	2
Paraguay	$ 40.497	3
Bolivia	$ 40.288	4
Guyana	$ 3.879	3
Suriname	$ 3.591	2

[3] Sangmoon K and Eui-Hang S. (2002). "A Longitudinal Analysis of Globalization and Regionalization in International Trade: A Social Network Approach".

[4] https://wits.worldbank.org
https://data.worldbank.org/indicator/NY.GDP.MKTP.CD

[5] Only countries listed in the table where considered for this calculation

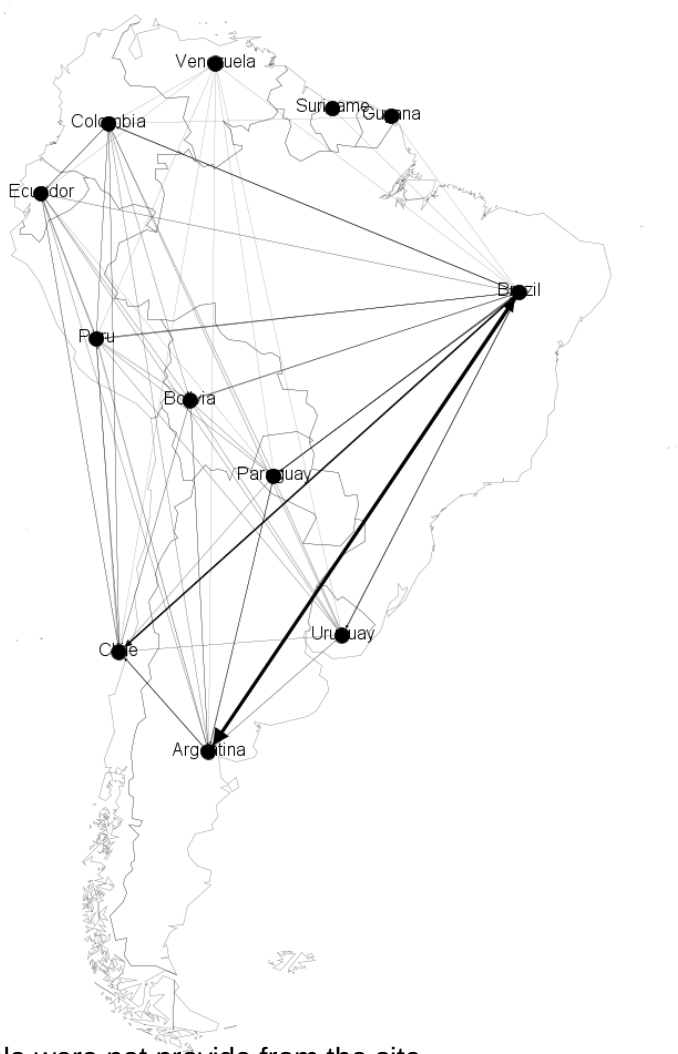
Considering Exports data from 2018 for this countries I proposed a model where the countries are the nodes and the links are going to be determine by the size of exports, first considering them in absolute value and then by taking the proportion of value over the total of exports of that country to remove the effect of the size of the country.

From a gravity point of view Brazil should be by far the country with the highest Indegree Centrality it has borders with everyone except for Chile and Ecuador and has more than three times the GDP of Argentina. Next in line Argentina and Venezuela are strong candidates in the ranking and beneath those Colombia Chile and Peru. Also it should be interesting to see if the community detection algorithms finds a group between the Participants of the Mercosur.

1. **First Escenario**: 12 Countries, There is a Link between countries if only if the Export Value is higher than 10 million dollars, otherwise the relation is not considered[6].

Trade in the Mercosur 2018 in MM of Dollars[7]

Country	Weighted indegree
Brazil	23,69
Argentina	20,47
Chile	14,11
Peru	8,42
Colombia	6,26
Paraguay	5,04
Ecuador	4,69
Uruguay	4,59
Bolivia	4,17
Venezuela	1,42
Guyana	0,05
Suriname	0,03



[6] Data of Exports from Venezuela were not provide from the site

[7] The darker the colour of the line indicates a stronger relation (due to the size of the export, the arrow indicates the direction).

The results are some what consistent from what is expected, Brazil is the most important country in the región but closely follow by Argentina, then Chile Peru and Colombia. The bilateral trade between Argentina and Brazil is the highest of the region, the value of exports from Brazil to Argentina is almost 15 thousand millón dollars whereas argentinean exports are around 11.3 thousand million dollars. Interesting the case of Venezuela which is close to the bottom, this means that there are some variables that this model is not taking into account

Related to Community Detection using the Leiden Algorithm and not imposing any specific number of clusters I found this;

Country	Cluster Leiden
Suriname	2
Guyana	1
Venezuela	0
Brazil	0
Argentina	0
Chile	0
Peru	0
Colombia	0
Ecuador	0
Uruguay	0
Bolivia	0
Paraguay	0

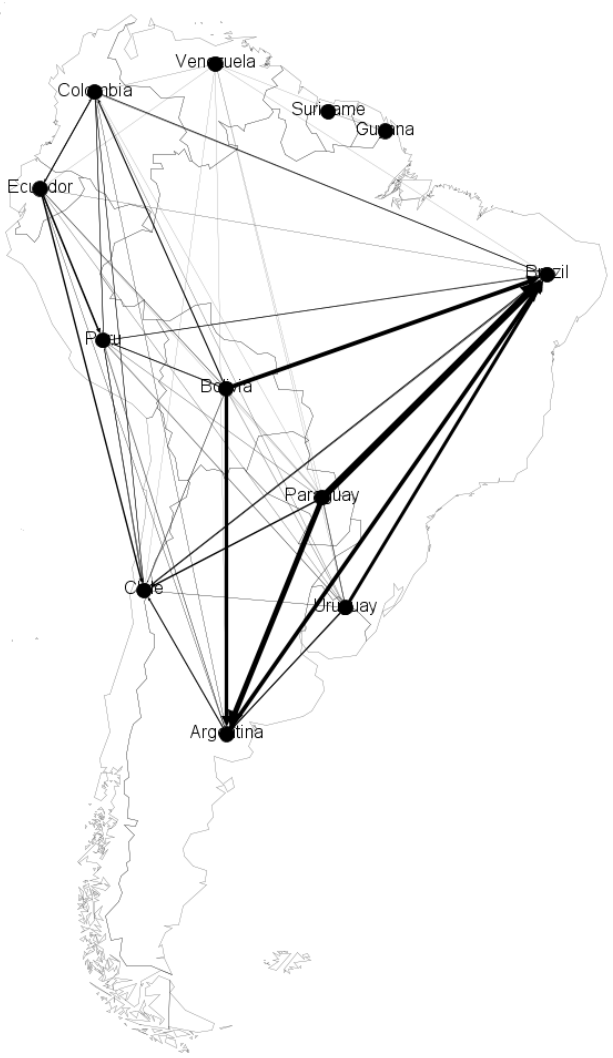
Meaning that besides the cases of Surinam and Guyana the algorithm does not distinguish between participants of the Mercosur or Associate States. I also applied the Girvan-Newman approach to find communities, in that case instead of 3 clusters it found 5 the difference in that case is that it created 2 more communities to separate Paraguay and Venezuela. Is interesting to see in this case that the Algorithm is separating Paraguay, a participant member of the Mercosur, which is in the middle of the Indegree nodes Rank.

Eventhough I have calculate them I do not believe that is necessary to show the results for other measures of Centrality, in this particular topic I believe that centrality degree is the suitable measure because what I am trying to study is the direct connection between countries through the analysis of direct exports.

2. **Second Escenario**: 12 Countries, There is a Link between countries if only if the total value of exports towards the country divided by the total value of exports of the country is greater than 0.1%, otherwise the relation is not considered.

Trade in the Mercosur 2018 as a proportion of total exports of the country

Country	Weighted indegree
Brazil	95,79
Argentina	55,17
Chile	29,27
Peru	22,48
Colombia	14,28
Ecuador	10,27
Paraguay	6,59
Bolivia	6,46
Uruguay	5,48
Venezuela	2,64
Suriname	0,64
Guyana	0,25



Measuring the weight of the relation in this way has change the order between a few countries but nothing else so results are pretty much the same regarding order. In this case the importance of Brazil is much higher showing an important difference with the second country, this findings are more consistent with gravity theory where we were expecting a larger value from that country and a relevant value from Argentina but far from it.

Related to community detections in this case the Leiden Algorithm could not distinguish communities whereas Girvan-Newman found 4 clusters with the same results than last time but forming a cluster between Guyana and Suriname instead of having them separated.

Conclusions:

At a macro level the Social Network Analysis approach to trade in the Mercosur gives conclusions that are consistent with Gravity Theory, measuring by Indegree Centrality Brazil is the key player in the region and it is follow by Argentina. Related to communities, both algorithms Leiden and Girvan-Newman could not differentiate among participants of the Mercosur and Associate States. Also the results are more consistent with the model when instead of measuring by absolute amounts, participation of total exports is considered. The case of Venezuela could not be explained by the gravity model, given the size of the market in the region could be considered as a proof that more variables has to be taking into account in order to give an explanation on international trade. It is important to remember that data for Venezuelean exports is not informed by the World Bank since 2014 so the coefficients found didn´t contained this information. This not have an impact in the Indegree centrality of Venezuela because in that case what it matters is if other countries are exporting to it All in all I believe that this methodology could be usefull to study gravity models particularly because as it was mentioned until there is a solid theoretical foundation for this models the use of regressions might suffer from omitted variable problems.

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DATA APPENDIX

Countries	Argentina	Bolivia	Brazil	Chile	Colombia	Ecuador	Guyana	Paraguay	Peru	Suriname	Uruguay	Venezuela
Argentina		$ 643.985,00	$ 11.291.357,00	$ 3.036.518,00	$ 650.002,00	$ 406.531,00	$ 8.785,00	$ 1.253.198,00	$ 1.169.516,00	$ 5.854,00	$ 1.227.044,00	$ 358.991,00
Bolivia	$ 1.451.271,00		$ 1.720.645,00	$ 122.661,00	$ 473.817,00	$ 155.475,00	$ -	$ 54.812,00	$ 373.997,00	$ -	$ 10.472,00	$ 4.535,00
Brazil	$ 14.951.516,00	$ 1.452.325,00		$ 6.389.093,00	$ 2.805.328,00	$ 904.850,00	$ 40.303,00	$ 2.945.451,00	$ 2.158.847,00	$ 34.686,00	$ 3.008.947,00	$ 576.941,00
Chile	$ 798.365,00	$ 1.158.164,00	$ 3.388.071,00		$ 722.124,00	$ 493.269,00	$ 3.179,00	$ 647.237,00	$ 1.732.156,00	$ 1.749,00	$ 116.063,00	$ 73.714,00
Colombia	$ 295.541,00	$ 142.951,00	$ 1.561.755,00	$ 1.190.344,00		$ 1.851.967,00	$ 11.641,00	$ 26.282,00	$ 1.165.001,00	$ 4.924,00	$ 54.045,00	$ 354.294,00
Ecuador	$ 241.681,00	$ 37.042,00	$ 106.935,00	$ 1.466.665,00	$ 832.530,00		$ 139,00	$ 8.257,00	$ 1.615.108,00	$ 67,00	$ 28.686,00	$ 35.722,00
Guyana	$ 21,00	$ -	$ 268,00	$ 12,00	$ 960,00	$ 471,00		$ -	$ 44,00	$ 9.585,00	$ 12,00	$ 3.099,00
Paraguay	$ 2.188.459,00	$ 54.514,00	$ 2.808.903,00	$ 624.621,00	$ 10.652,00	$ 44.545,00	$ -		$ 121.609,00	$ 5.460,00	$ 145.273,00	$ 18.637,00
Peru	$ 179.677,00	$ 665.576,00	$ 1.719.533,00	$ 1.226.572,00	$ 760.679,00	$ 858.473,00	$ 4.342,00	$ 14.737,00		$ 4.311,00	$ 48.428,00	$ 27.011,00
Suriname	$ -	$ -	$ 564,00	$ 8,00	$ 86,00	$ 8,00	$ 3.689,00	$ 40,00	$ 52,00		$ 2,00	$ 274,00
Uruguay	$ 409.255,00	$ 57.521,00	$ 1.133.259,00	$ 91.406,00	$ 22.612,00	$ 10.994,00	$ 3.406,00	$ 139.296,00	$ 124.794,00	$ 586,00		$ 21.272,00
Venezuela	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	