The Research on the Formation Mechanism of Global FTAs Network

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Abstract– Free trade agreements have proliferated since the mid-1990s. This paper aims to analyze the evolutionary mechanism of global FTAs network based on the complex network science. Firstly, a network structure was set up through the relevant statistical data, followed by the analysis of its statistical properties. Secondly, with the econometric model, the properties of FTAs network, in addition to traditional geographic and economic determinants, are found to have an important impact on the formation of FTAs. Thirdly, models are revised to include institutional, cultural and historical determinants, which prove to be robust to various econometric specifications. Finally, the conclusion is presented.

1. Introduction

Since the mid-1990s, regional trade agreements have proliferated rapidly across the world. Not only have the FTAs been concluded with adjacent countries, but a large number of them have broken the regional boundaries, showing a network development trend.

Up to now, many literatures focus on the motivation for the FTAs formation from the perspective of welfare effect. Viner (1950), Kemp and Wan (1976), Baldwin (1997), Panagariya and Krishna (2002) analyze the potential trade creation, trade diversion and welfare distribution effect arising from the formation of FTAs or customs unions. Besides national welfare, political pressure also needs to be taken into consideration for the government to make economic decisions. Grossman and Helpman (1995), Levy (1997), Krishna (1998), Maggi and Rodriguez (2007), Sheng Bin (2007) emphasize the impact of interest groups on concluded FTAs as they lobby the government through the establishment of political and economic frameworks. In addition, Fernands and Portes (1998), Li (2003, 2008), Sun (2008) elaborate some non-traditional incentives such as maintenance of the coherence of economic policy, signal and obtaining of insurance, enhancement of the bargaining power, establishment of a coordinated mechanism, service for stable market access, the national security and diplomatic strategies.

The empirical literature on the formation mechanism of FTAs is first proposed by Baier and Bergstrand (2004). In their work, the economic and geographic determinants of FTAs are systematically analyzed, including location among countries, economic sizes and differences and capital-labor ratios. The impact of social, political and cultural elements on countries to conclude the FTAs is further studied by Marquez-Ramos et al. (2005). However, the interdependence of FTAs is neglected in the above literature. According to Egger and Larch (2008), the existing FTA is found to increase the likelihood of other non-member countries signing a new FTA, verifying the "domino effect" with spatial econometrics. Baldwin and Jaimovich (2010), Bergstrand et al. (2010) have also reached similar conclusions with other econometric models.

As FTAs have spread around the world since 1990s, and appeared to be an intertwined network phenomenon, Goyal and Joshi (2006), Furusawa and Konishi (2007), Daisika and Furusawa (2011) establish a network of evolutionary game framework and study the evolutionary path of global FTAs network in the multi-countries model.

However, the above studies of FTAs network analyze the evolution of FTAs network through simulation, not based on real FTAs data. The value added of this paper is to analyze each member's structural characteristics in global FTAs network and the impact on the formation and development of the agreements by constructing FTAs network on the basis of actual FTAs relativity.

The rest of this paper is organized as follows: Section two builds the evolution network of global FTA from 1995 to 2010 and calculates the differences at core and periphery level in the network among various countries based on the network statistical indicators. Section three analyzes the geographic, economic and network structure political, institutional and cultural factors in the global FTA network evolution process with panel logit model and further discusses the accuracy of predicting FTAs in the amended model. The final section is the conclusion.

2. Analyses of the structure characteristics of global FTA network

2.1 Construction of global FTAs network

The FTAs relations among countries are from the WTO database. Excluding non-sovereign countries and regions, the sample involves 190 countries. FTA matrices are constructed from 1995 to 2010. If the elements $fta_{ij}=1$, it means country i and country j have concluded a FTA in the past; While if $fta_{ij}=0$, the two countries don't reach an agreement.

2.2 Statistical indicators of FTAs network

There are several indicators to measure the network characteristics, including the average shortest path, clustering coefficient, degree distribution, etc. But this paper mainly focuses on "hub-spoke" feature of FTA network. Typically, four measures of FTAs network "centrality" are considered:[1]

(i) In-Degree, specified as C_{iRD}, it is given by $(\Sigma_j N_{ji})/(N-1)$, where $\Sigma_j N_{ji}$ represents the number of point i directly connected to the other points, N is the total number of points. In-Degree measures centrality of each node in the network, without considering other countries' control power. In FTAs network, In-Degree of the country i represents the ratio of the number of FTAs concluded by other countries with country i, divided by the maximum number of the potential partners.

(ii) Betweenness, specified as C_{iRB}, it is given by $(\Sigma_{j\neq i}\Sigma_{k\neq i} g_{ik}(i)/g_{jk})/(N-1)(N-2)$, where $g_{ik}(i)$ represents the number of shortest paths between i and k. g_{jk} is the number of the shortest path passing through i. Betweenness is a measure of one country's ability to control other participants. Within FTAs network, Betweenness is regarded as the possibility of the unsigned countries' connectedness with each other through country i.

2.3 Description of the statistical properties of FTAs network

The greater the values of In-degree and Betweenness are, the more central the country will be in the network. From the descriptive statistics in Table 1, we find that the differences between the maximum and minimum values and the variances of In-Degree and Betweenness increase as years go by, which indicates that some countries are at the center of global FTAs network with other countries on the periphery, and that this trend gradually expands over time.

Table1 Descriptive statistics for interconnectedness indicators of FTAs network

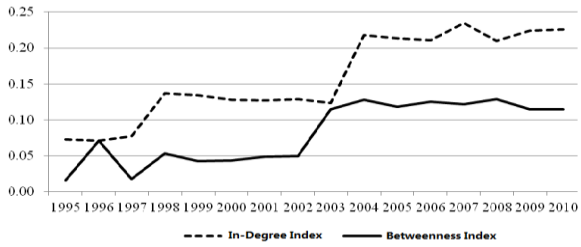
Year	In-Degree			
	Mean	Variance	Max	Min
1995	0.0381	0.0442	0.1105	0
2000	0.0563	0.0524	0.1842	0
2005	0.0912	0.0813	0.3053	0
2010	0.1341	0.1147	0.3526	0
Year	Betweenness			
	Mean	Variance	Max	Min
1995	0.0002	0.0011	0.0080	0
2000	0.0007	0.0024	0.0226	0
2005	0.0027	0.0083	0.0633	0
2010	0.0040	0.0084	0.0634	0

[1]Before 2000, countries in the FTAs network did not sign any free trade agreement; thereby FTAs network didn't contain the connectivity for each country, so Closeness and eigenvector centrality are not effective indicators to measure the connectedness of FTAs network.

The centralization index is an important indicator to depict the overall centrality of FTAs network diagram.

Figure 1 shows the changes of In-Degree and Betweenness index. It can be found that the two indicators are between 0 and 1, demonstrating the characteristics of "hub-spoke" network.

Figure 1 the trend of global FTA network centrality indicators between 1995 and 2010



2.4 Advantages of the hub points within global FTAs network

Within global FTAs network, countries at the center of the network enjoy some special advantages. Firstly, the core countries can export their products to all the periphery countries duty-free according to FTA, while the periphery, constrained by rules of origin, can't enter another country's goods market likewise; Secondly, in order to avoid tariff barriers, part of the investment will be transferred from the periphery to core countries; Finally, once a country becomes the hub node, the "domino effect" will make it a target, with which other countries would conclude FTA as a priority, which therefore further strengthens its core role within global FTAs network.

3. An Empirical Analysis of the causes of FTAs

3.1 Econometric Model

The dependent variable FTA is a binary variable, so this paper analyzes the formation mechanism of FTAs with the panel logit choice model, which is constructed as follows: $Pr(FTA_{ij}=1)=P(y_{ij}^*>0)= G(\beta_0+X_{ij}\beta)$

$Pr(FTA_{ij}=1)$ represents the probability of the conclusion of bilateral FTA agreements, ranging between 0 and 1. When $Pr(FTA_{ij}=1) \geq 0.5$, it means that $y^*>0$, indicating two countries signed a FTA, the value of FTA is 1.; When $Pr(FTA_{ij}=1) \leq 0.5$, it means that $y^* \leq 0$, indicating that two countries have not signed a FTA, FTA is 0. $G(\cdot)$ obeys the logistic distribution. X_{ij} represents the factors influencing the conclusion of bilateral FTAs, and β is the corresponding parameter values.

3.2 Explanatory variables

3.2.1 Factors of FTAs network feature

Due to the limitations of Closeness and Eigenvector centrality in the FTA network applications, this paper selects In-degree and Betweenness as the representative indicators of the FTA network structure.

Hypotheses 1: The larger the value of member i's In-degree (C_{iRD}) is, the higher the country's core position in the FTA networks is, the greater the likelihood of attracting other countries to sign the FTA is.

Hypotheses 2: The larger the value of member i's Betweenness (C_{iRB}) is the greater the ability of this member to control among the FTA network is, i.e. more likely to attract others to sign the FTA.

3.2.2 Geographical and economical determinants of FTAs

Due to space limitations, definition and expression of geographic and economic determinants of FTAs refer to Baier and Bergstrand (2004).

3.2.3 Institutional, language, historical and cultural determinants of FTAs

As to FTA's institutional, language, historical and cultural determinants, Baier and Bergstrand (2004) as well as other documents used them to test the robustness of the model, this paper also uses a similar approach. To test the robustness of the model this paper choose three indicators: whether the FTA members join WTO (WTO_i or WTO_j), whether they share a common language ($Comlang_{ij}$) and whether colonial contacts exist ($Colony_{ij}$).

3.3 Empirical results and Robustness test of the Econometric model

Econometric results of the analysis can be seen from Table 3, it shows that the network factors have a significant positive influence upon the formation of the FTA between countries. Among them, the degree of centrality coefficient and Betweenness centrality are significantly positive, which mean that if a country makes more use of its advantages to conclude FTA with other countries; the resultant core position of the country in the whole network will attract more countries to sign FTAs, leading to a self-reinforcing effect.

Econometric results of the model about geographic and economic factors effectively verify Baier and Bergstrand (2004) five hypotheses out of six: that the closer the distance between the FTA member countries is, the greater the distance between the weighted average of each other with the other countries is; the larger the sum of the GDP between the two countries, the smaller the differences in the factor endowments between the two countries and the other countries in the world; the greater the signing of the FTA trade creation effect, the smaller the trade diversion effect, the greater the possibility of concluding an FTA. Differences in relative factor endowments formation of an FTA between the two countries maintain an inverted U-shaped relationship, i.e. at the initial stages; the comparative advantages of the two countries to conclude FTA occupy a leading role. The larger the differences in endowments of countries, the more advantages the comparative advantages have, the higher the net revenue got from the agreements, the greater the possibility of signing the FTAs. However, with the specialization and economies of scale, the probability of both parties to conclude the FTA becomes lower.

To test the robustness of the model, this paper sequentially adds whether the two sides have WTO member status, common official language, a colonial linkage, representing language, history and culture respectively. The results from Table 3 show the three variables are highly significant: the status of a country's WTO member will make it easier to conclude FTAs because of its relatively lower tariffs and non-tariff barriers, more liberal trade policies as well as the WTO dispute settlement mechanism. The dominant country will influence colonial countries socially and politically, helping to conclude FTA with each other. However, the common official language factor is significantly negative: if the FTA member countries share a common official language, they are less likely to conclude an FTA, inconsistent with the expected results. However, the introduction of the, language, historical and cultural factors do not change significantly each explanatory variable coefficients in Table 3, and in line with the expected sign, and thus, the structural factors, geographic and economic factors in the model network are very strong.

Table 3 Panel logit model estimation results

Independent variable	Model 1	Model 2	Model 3	Model 4
Network				
C_{iRD}	33.03*	36.69*	35.13*	34.18*
C_{jRD}	35.65*	37.18*	37.41*	34.06*
C_{iRB}	47.56*	21.11*	22.47*	19.00*
C_{iRB}	62.24*	49.70*	35.45*	34.89*
Geographic				
D_{ij}		-9.05*	-8.69*	-8.89*
$Remote_{ij}$		1.04*	0.93*	0.82*
Economic				
GDP_{ij}		0.83*	0.82*	0.73*
$GDPSIM_{ij}$		-0.11		
$DROWKL_{ij}$		-3.25*	-3.47*	-3.31*
$DPCGDP_{ij}$		0.80*	0.77*	1.15*
$DPCGDP_{ij}^2$		-0.50*	-0.48*	-0.51*
Robust test				
WTO_i				3.42*
WTO_j				9.58*
$Comlang_{ij}$				-1.28*
$Colony_{ij}$				1.74*
year dummy	no	yes	yes	yes
Observation	186048	175891	175891	175891

3.4 The accuracy of model predictions

An important indicator to judge the merits of a discrete choice model is the model prediction accuracy. Among the actual signed FTAs, the number of bilateral FTAs is 14,200, while the number of not signing is 161,691. Our logit model correctly predicts that the actual number of signing the FTAs is 7155 and 160,283 did not sign FTAs, with the accuracy rate being 50.4% and 99.1% respectively. If the rate is calculated in accordance with precise indicators, this paper's forecasting accuracy rate will be up to 83.6%.

Finally, to measure whether the FTA networks structure has any contribution to accurately predicting the formation of FTA, we also calculate the accuracy under the model that excludes the FTA networks and compare the results with those in the former model. The results show that without the FTA network factors, the model predicts only 5662, out of the actual signed FTAs, 10% lower than the accuracy of the model including the FTA network structure. In other words, the prediction accuracy will be improved significantly, if the FTA network structure is taken into consideration.

4. Conclusion

In this paper, the most important innovation is that, by building a global FTAs network framework, found the network structural factors (degree centrality and betweenness centrality) have a significant impact on the FTAs formation. In the global FTAs network, there is a self-reinforcing mechanism, and the core countries will further strengthen its power in the FTAs network. In addition, the paper systematically analyzes the determinants of FTAs formation by using panel discrete choice model and further validates the five hypotheses Baier and Bergstrand (2004) proposed, especially the proposition about "inverted U-shaped" relationship between the FTAs formation and the difference from factor endowment of different countries.

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