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Interdependent Regional Trade Agreements and Production Networks: An Empirical Analysis*

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Abstract

Similar to determinants of natural trade partnerships such as geographical distance and factor endowments, production networks can be defined as a determinant of acquired trade partnerships. Deepening global production networks may generate positive welfare effects and lead to a proliferation in the formation of interdependent regional trade agreements (RTAs). This paper empirically investigates the linkage between production networks and the formation of interdependent RTAs by applying a qualitative choice model estimation methodology with panel data that cover bilateral country-pairs among 147 countries between 1995 and 2008. We find that country-pairs' existing RTAs with third countries increase the incentive for those country-pairs to form bilateral RTAs and enlarge existing RTAs. However, we cannot support existing findings about the competitive formation of new RTAs as being initiated by existing RTAs in other country-pairs worldwide. Furthermore, we argue that the interdependence of RTA formation has been more strongly driven by deepening production networks with third countries than by either lower trade costs (measured by distance) or larger market size (measured by GDP). We also find that production network-driven RTA interdependence is relevant only among the developed countries involved.

Keywords: *interdependence, production networks, regional trade agreements, qualitative choice model*

JEL Classifications: C25, F15

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I. INTRODUCTION

Regional trade agreements (RTAs) have been proliferating over the last two decades. As of October 2011, the WTO has been notified of 312 RTAs. Among them, 182 (58.3%) are free trade agreements (FTAs) and 23 (7.4%) are customs unions (CUs).[1] Since Viner (1950) addressed trade creation and the diversion effects of the CU, numerous studies have analyzed the trade and welfare effects of RTAs, from both theoretical and empirical bases.[2] The domino theory of regionalism introduced by Baldwin (1993) is a common explanation of why RTA formation has been proliferating. Countries excluded from an RTA can seek membership to existing RTAs and thus create this so-called domino effect; alternatively, they may be impelled to negotiate new RTAs among nonmembers, in order to counteract the intimidation of exclusion.[3]

Unlike the extensive body of theoretical literature devoted to countries' choices in forming RTAs, however, empirical investigations of RTA formation have been relatively few and are quite new. Most of the existing empirical studies have mainly focused on analyzing the quantitative trade effects of exogenously formed RTAs, rather than on directly investigating the determinants of RTA formation.[4] The studies of Baier and Bergstrand (2004) and Magee (2003) can be considered pioneering works that partially fill this research gap; each develops an econometric model that empirically analyzes endogenous determinants of RTA formation and predicts the likelihood of country-pairs forming RTAs. They mainly consider the participating countries' economic characteristics and highlight positive trade creation between members of a freer trade bloc as a main incentive to RTA formation.

However, empirical research on the interdependence of RTA—featuring a focus on the possible enlargement of existing RTAs and the competitive formation of new RTAs among nonmembers—has only recently gained currency.[5] Baldwin and Jaimovich (2010)

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[1] See the WTO website: http://rtais.wto.org/UI/publicsummarytable.aspx.

[2] For an informative survey of proliferating regionalism as found in both theoretical and empirical literature, see Lee, Park, and Shin (2008).

[3] Among the 312 RTAs of which the WTO has been notified, 11 (3.5%) are enlarged RTAs and 301 (96.5%) are new RTAs (see the WTO website: http://rtais.wto.org/UI/publicsummarytable.aspx).

[4] Unlike other empirical studies on the trade-creating effect of exogenously determined RTAs, Lee et al. (2008) find that countries excluded from an RTA can benefit more from the duplication of a separate RTA than from joining an existing RTA, owing to the strong "first-mover advantage" it generates, as Freund (2000) proposes.

[5] As in Baier, Bergstrand, and Mariutto (2011), RTA interdependence is defined as the effect

emphasize the trade-diversion effect as another benefit to members of an RTA, at the expense of third countries. The third-country effect on the probability of a country-pair having an RTA explains the formation of interdependent (or "contagious") RTAs. Baldwin and Jaimovich (2010) and Chen and Joshi (2010) each empirically test the third-country effect of enlarged RTAs by measuring the net welfare effect, and each find that the third-country effect plays an important role in those countries' decisions to establish new RTAs. Egger and Larch (2008) test the third-country effect that relates to enlarged RTAs and to new RTAs. They find that the enlargement of existing RTAs is more likely to occur, compared to the possible formation of new RTAs; they also find that interdependent linkages will be weakened by higher trade costs, measured in terms of bilateral distance, and strengthened by bilateral trade volume. Baier, Bergstrand, and Mariutto (2011) simultaneously estimate the two sources of RTA interdependence with a formal theoretical model and successfully decompose RTA interdependence into cases of RTA enlargement ("own-FTA") and the formation of new RTAs ("cross-FTA"). They find that, as sources of RTA interdependence, own-FTA effects are much stronger than cross-FTA effects.[6]

The existing empirical literature that tests the formation of interdependent RTAs, however, suffers from another important weakness in determining the cause of interdependence. What drives the interdependence of RTAs? To answer this question, Baier et al. (2011) test the third-country effects of market size, measured in terms of GDP, on the deepening interdependence of RTA; Egger and Larch (2008), meanwhile, estimate the positive probability of RTA formation as driven by cheaper trade costs and as measured in terms of bilateral distance. The current study proposes global production networks as another important driving force of RTA interdependence.

Production networks have proliferated in recent years and are largely regional in nature. The manufacturing trade in parts and components through vertical supply chains in multiple countries has grown faster than total trade, especially in the East Asia region.[7] As shown in Tables 1 and 2 in Athukorala (2010), world network trade in parts and components increased by 471.4%, from US$511 billion in 1992–93 to US$2,409 billion in 2006–07, compared to a 274.9% increase in total trade, from US$1,207 billion to US$4,525 billion,

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of other RTAs on the probability of a country-pair creating an RTA.

[6] They define the "own-FTA effect" as the impact on the net welfare gains of an FTA between the two countries involved, owing either to having already established other FTAs—and hence the "cross-FTA effect," as an impact on the net welfare gains of an FTA between the pair—or to other FTAs existing in the rest of the world (Row).

[7] See Kimura (2006), Athukorala (2010), and Athukorala and Menon (2010).

during the same period. In particular, total exports (imports) as a share of the total manufacturing trade within production networks in East Asia has grown by 8.5 percentage points (15.5 percentage points), from 51.8% (44.4%) in 1992–93 to 60.3% (59.9%) in 2006–07, compared to the world average of a 5.4 percentage point (5.0 percentage point) increase, from 45.5% (45.7%) to 50.9% (50.7%), respectively. The share of East Asia to the total worldwide network of exports increased by 8.1 percentage points, from 32.2 % in 1992–93 to 40.3% in 2006–07; spearheading this trend was China, whose share increased by 12.4 percentage points during that time, from 2.1% to 14.5%.

On one hand, RTAs should increase the depth of production networks,[8] as free trade blocs create much freer and more easily accessed channels for the movement of goods, services, and resources among the countries involved. Among studies that serve as evidence of the positive linkage between RTAs and production networks, Orefice and Rocha (2011) investigate 96 preferential trade agreements among the EU, USA, ASEAN, China, India, Japan, and MERCOSUR, and they find that deeper integration increases production-network trade among members by 35 percentage points. UNESCAP (2011) highlights a positive linkage between RTAs and international production networks in East Asia, citing, for example, the "hollowing out" of Japanese and South Korean businesses by developing Asian countries. Those countries' industrial and trade policies have successfully developed production networks within the East Asia region. However, case studies conducted by UNESCAP (2011) are somewhat suspicious of the role of trade liberalization in deepening production networks. Athukorala and Yamashita (2006) also find no significant evidence of the promotion effect of RTAs on regional product fragmentation; they come to this conclusion after empirically testing AFTA, the EU, NAFTA, MERCOSUR, ANDEAN, and ANZCERTA excluding the AFTA case.

On the other hand, deepening global production networks may significantly affect the welfare effect of RTAs, because network production is mainly initiated by lower trade costs and differences in factor endowments, both of which are key factors that determine positive welfare effects. It is natural for geographically close neighbors to form an RTA, as transportation costs are comparably inexpensive and pre-RTA trade volumes tend to be large.[9] If the geographical distance and dissimilarity in factor endowments between two countries determine a "natural trade partnership," the production networks between those

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[8] Several studies investigate the impact of RTAs on production networks. UNCTAD (2011) is an excellent survey on the issue in the Asia–Pacific region.

[9] For more on the "natural trade partnership" issue, see Lee et al. (2008).

countries will determine an "acquired trade partnership." In addition to the static welfare effect, fast-growing network trade will enhance economic interdependence among interconnected countries, and deepening interdependence will generate more RTA-related benefits over time.

Global production networks may increase the trade-creation effect and reduce the trade-diversion effect of RTAs, and aid in the proliferation of interdependent RTAs. However, to date, no research attempt has been made to test the direction of linkage from deepening production networks to RTA formation.[10] We attempt to fill this research gap by applying a qualitative choice–econometric regression model developed in Baier and Bergstrand (2004), Egger and Larch (2008), Chen and Joshi (2010), and Baier et al. (2011) to panel data covering bilateral country-pairs among 147 countries between 1995 and 2008. In other words, this study empirically analyzes whether a deepening of global production networks increases the likelihood that interdependent RTAs will form. More specifically, we first investigate whether there is a statistically significant interdependence between enlarged RTA formation and new RTA formation, without considering the spatial factors between two countries. General interdependence is compared through the use of three different specifications, while considering spatial factors such as (i) trade costs, measured in terms of bilateral distances, (ii) economic sizes, measured in terms of GDP, and (iii) production networks, measured in terms of intermediate-good trade volume. In addition, we compare the member-specific network effects of RTAs by classifying each record of the entire sample in terms of its level of economic development, that is, developed versus developing countries.

This paper is organized as follows. Section II describes the model specifications and data used herein. Section III summarizes the empirical findings, and Section IV concludes this research.

II. INTERDEPENDENCE OF RTAs: A QUALITATIVE CHOICE MODEL ANALYSIS

[10] The study of Orefice and Rocha (2011) is related to an empirical study of the two-way positive relationship between production networks, measured in terms of the import values of parts and components, and deeper integration, measured in terms of a set of indices; however, they do not directly investigate the bilateral relationship between product networks and the formation of RTAs.

1. Model Specifications

We employ the qualitative choice model of RTA formation—as do each of Baier and Bergstrand (2004), Egger and Larch (2008), Chen and Joshi (2010), and Baier et al. (2011)—to estimate the likelihood of country-pairs forming an RTA; we also consider the third-country effects of interdependent RTAs. As in Baier et al. (2011), we classify interdependence in terms of RTA enlargement and the formation of new RTAs. The model is based on the concept that the formation of an RTA between two countries is a discrete decision that is mainly based on the welfare effects of trade creation and trade diversion. The economic characteristics of the country-pair—including economic size, trade costs, similarity, and external linkages—are the main factors that determine the welfare effects of the RTA formation and thus influence the decision to form an RTA.

The baseline empirical specification is as follows:

$$\mathbf{Pr}(\boldsymbol{RTA_{ijt}} = 1) = \Phi(\boldsymbol{X'_{ij,t-1}\beta} + \gamma_1 \cdot \boldsymbol{MRTA_{i,t-1}} + \gamma_2 \cdot \boldsymbol{MRTA_{j,t-1}} + \gamma_3 \cdot \boldsymbol{RowRTA_{kl,t-1}} + \varepsilon_{ijt})$$

where RTA_{ijt} is the binary variable that takes the value of 1 if two countries have an RTA and 0 otherwise, with the response probability (Pr) for RTA. $\Phi(\cdot)$ is the cumulative probability function and $X'_{ij,t-1}$ is a vector of control variables representing the country-pair's economic characteristics. To preclude endogeneity bias, all explanatory variables are lagged by one period.

A. Country-pair Economic Characteristics

We introduce the country-pair's economic characteristics as follows; the expected signs are in parentheses.

- *Dist* (-) presents the natural log of the bilateral distance between country-pair *i* and *j*.
- *MDist* (+) is the natural log of remoteness of the country-pair from the rest of the world (Row).
- *Cont* (+) is a binary variable that takes the value 1 if two countries are on the same continent, and 0 otherwise.

- *MCont* (-) refers to the remoteness measured on the basis of the binary variable, *Cont*.
- *SumGDP* (+) is the country-pair's market size, measured as the natural log of the sum of *i*'s and *j*'s real GDP.
- *DiffGDP* (-) presents the dissimilarity of economic size, which is measured as the absolute value of the difference in the log of each country's real GDP.
- *DKL* (+) refers to the difference between two countries' relative factor endowments, measured as the absolute difference in real per-capita GDP.
- *SqDKL* (-) is the square of *DKL*.
- *Network* (+) presents the production networks between the two countries *i* and *j*, measured as the share of trade in intermediate goods over total trade.

To measure the remoteness of the country-pair, we adopt the multilateral resistance index for each country-pair as per Baier et al. (2011), as follows:

$$MDist_{ij} = \ln (1/N) \cdot (\Sigma^{N}_{k=1} Dt_{ik} + \Sigma^{N}_{k=1} Dt_{jk}),$$

where *Dt* is the bilateral distance between countries *i* (*j*) and *k*. Similarly, for country *i*'s multilateral resistance index for the binary variable *Cont*, we define

$$MCont_{i} = (1/N) \cdot (\Sigma^{N}_{k=1} Cont_{ik} + \Sigma^{N}_{k=1} Cont_{jk}).$$

B. Third-country Characteristics

For the third-country effects of an interdependent RTA while considering spatial weight—as in Egger and Larch (2008)—we define the multilateral index of country *i*'s (*j*'s) RTAs with every other country—excluding *j* and *i*, respectively—as follows:

$$MRTA_{i,t-1} = \Sigma_{k \neq j} W^{z}_{ik,t-1} \cdot RTA_{ik,t-1}$$

$$MRTA_{j,t-1} = \Sigma_{k \neq i} W^{z}_{jk,t-1} \cdot RTA_{jk,t-1}$$

$$RowRTA_{kl,t-1} = \Sigma_{k \neq i,j} \Sigma_{l \neq i,j} W^{z}_{kl,t-1} \cdot RTA_{kl,t-1}$$

For the domino effect of enlarged RTA membership ("own-RTA effect," in Baier et al. [2011]), $MRTA_{i,t-1}$ ($MRTA_{j,t-1}$) is defined as the unweighted or weighted sum of country *i*'s (*j*'s) RTAs with all other countries excluding *j* (*i*); this is a binary variable that takes the value of 1 if *i* (*j*, respectively) and *k* have an RTA in year $t-1$, and 0 otherwise. For the likelihood of forming a new RTA ("cross-RTA effect," in Baier et al. [2011]), $RowRTA_{kl,t-1}$ is defined as the unweighted or weighted sum of *Row*'s RTAs between k ($\neq i, j$) and l ($\neq i, j$); this is a binary variable that takes the value of 1 if *k* and *l* have an RTA in year $t-1$, and 0 otherwise.

To analyze the interdependence of RTAs, we specify three different spatial weighting matrices (z), as follows:

$$\boldsymbol{W^{Network}_{ik,t-1} = [Int_{ik,t-1}/IM_{ik,t-1}] + [Int_{ki,t-1}/IM_{ki,t-1}]}$$

$$\boldsymbol{W^{GDP}_{ik,t-1} = [GDP_{k,t-1}/GDP_{world,t-1}]}$$

$$\boldsymbol{W^{Distance}_{ik} = e^{(-Dt_{ik}/500)}}$$

where *Int/IM*, *GDP*, and *Dt* are the share of bilateral trade between country *i* and third country k ($\neq j$) in intermediate goods, as a proxy variable for production networks; third country *k*'s GDP share of the world GDP, as a proxy for market size; and bilateral distance between country *i* and third country k ($\neq j$), as a proxy for trade costs,[11] respectively. We hypothesize that the deepening of production networks, larger market size, and cheaper trade costs increase the interdependence of RTA formation.

2. Data

The panel data on RTAs come from Baier et al. (2011), which provides all bilateral trade country-pairs from among 195 countries, for 46 years (1960–2005). We extend the time period into 2008, using the WTO Regional Trade Agreements Database. We then reconstruct our annual dataset covering 147 bilateral country-pairs for the 1995–2008 period because of limited availability of UN Comtrade data for network trade. Since annual variations are limited, we treat every three years as a single time period. We use Maddison (2011) for data on countries' GDP and per-capita GDP values. Data on distance and continents are taken

[11] We adopt the inverse-distance-based weighting scheme of Egger and Larch (2008).

from Centre d' Études Prospectives et d'Informations Internationales (CEPII). Finally, we use the share of trade in intermediate goods over total trade as a proxy for production networks. Data on bilateral imports at the three-digit Broad Economic Categories (BEC) level are obtained from the UN Comtrade database. The original BEC codes classify the fuels trade (31, 321, 322) as involving intermediate goods, but we do not include this trade. Thus, "intermediate goods" include BEC 42 (parts and accessories of capital goods except transport equipment), BEC 53 (parts and accessories of transport equipment), BEC 2 (Industrial supplies not elsewhere specified), BEC 111 (primary foods and beverages mainly for industry), and BEC 121 (processed food and beverages mainly for industry).[12]

3. Summary Statistics

The qualitative choice model analysis in this study uses annual data consisting of 21,179 country-pairs in total. The dataset features a panel structure that covers 147 countries from 1995 to 2008. Summary statistics for the data used in the estimations are presented in Table 1. Of 21,179 observations, 2,574 country-pairs (12.2 percent) belong to the membership of existing RTAs in a given year; 18,605 country-pairs (87.8 percent) are not members of any existing RTA.

In Table 1, we present some notable findings. First, the logarithmic mean of the geographical distance (*Dist*) between members of existing RTAs (RTA = 1) is shorter than those of the whole sample or those between countries excluded from existing RTAs (RTA = 0). This finding is supported by the higher mean of geographical location sharing (*Cont*) in existing RTAs. Second, there is no significant difference in economic size (*SumGDP* and *DiffGDP*), remoteness from Row (*MDist* and *MCont*), or production networks (*Network*), in terms of the membership of existing RTAs. However, the formation of existing RTAs—between both two developed countries (*NN_Network*) and a developed country and a developing country (*NS_Network*)—has been strongly driven by bilateral production networks, except in the case of RTAs between two developing countries (*SS_Network*). Third, countries within the country-pairs that have existing RTAs have much smaller variations in factor endowment, as measured by the logarithmic mean of real per-capita GDP and its

[12] Wherever there are missing data for trade in final goods, we use the International Monetary Fund's Direction of Trade (DOT) statistics. Because the BEC classification in the UN Comtrade database does not report data for 1996 and 1997, we exclude these two years from our analysis.

square value (*DKL* and *SqDKL*). Fourth, the third-country effects of RTA interdependence weighted by production networks—that is, the enlargement of existing RTAs ($W^{Network} \cdot RTA_i$ and $W^{Network} \cdot RTA_j$ for "own-FTA effect") and the formation of new RTAs ($W^{Network} \cdot RowRTA$ for "cross-FTA effect")—is positive, but as we compare the mean value of membership in existing RTAs, we find that the positive effect of new RTA formation is not sufficiently significant.

[Table 1 here]

While the aforementioned observations are informative, they are subject to some limitations. For example, when each variable is interpreted, the other variables are not appropriately controlled. A more systematic approach is outlined in the next section.

III. INTERDEPENDENCE OF RTAs: EMPIRICAL RESULTS

1. Estimation Results for the Probability of RTA Formation

A. General Results

We empirically investigate the relationship between the likelihood of forming an RTA and the economic characteristics of the countries within a country-pair, using a probit-model estimation with existing RTA data in a given year. Columns (1), (2), and (3) in Table 2 present the probit results for the probability of RTA formation. As we interpret the estimated coefficients in column (1) without considering the third-country effect of interdependence, all the country-pairs' economic characteristics behave in the way the model predicts, and most of the estimated coefficients are statistically significant (i.e., excluding continental partnership and multilateral resistance variables). To summarize, the probability of forming an RTA between country-pair *i* and *j* increases if (i) bilateral distance between them decreases, (ii) the country-pair's market size increases, (iii) dissimilarity in economic size between them reduces, (iv) difference in factor endowment between them decreases, and (v) production networks between them deepen.

[Table 2 here]

Columns (2) and (3) report the probability of RTA formation while considering third-country effects, spatially weighted by production networks. The spatial interdependence term strengthens the explanatory power of the model, as seen in higher pseudo-R square values, than that of column (1). Similar to the estimation that does not consider the third-country effect in column (1), as an exception of production networks between the pairs of countries, all the country-pair economic characteristics behave in the way predicted by the model, and all the estimated coefficients are statistically significant. On one hand, we find that *i*'s and *j*'s existing RTAs with third countries increase the incentive for the country-pair to form a bilateral RTA and enlarge the existing RTA (domino effect or "own-FTA effect"), which supports the results of Baier et al. (2011) and Egger and Larch (2008). We also find that an increase in *i*'s (*j*'s) membership with third countries by one standard deviation induces an increase in RTA membership probability by 1.1 (1.0) percentage points, according to the marginal effects figured in column (3).

On the other hand, however, we cannot support existing finding about the competitive formation of new RTAs ("cross-FTA effect"), as initiated by existing RTAs in other country-pairs in the Row. The estimated coefficients are significantly close to 0.

B. Member-specific Results

We break down the bilateral production networks by country-pairs' levels of economic development, and we report the estimation results in Table 3. The estimated coefficients of member-specific bilateral production networks indicate a significantly positive effect on RTA formation, between developed countries (*NN_Network*) and between a developed country and a developing country (*NS_Network*). However, the deepening production networks between developing countries (*SS_Network*) significantly reduce the likelihood of RTA formation.

[Table 3 here]

C. Weight-specific Results

We rerun the model with four different measures of interdependence: unweighted, production-networks-weighted, GDP-weighted, and distance-weighted third-country effect. Table 4 reports the estimated results thereof. We find that all four model specifications indicate a significantly positive third-country effect for enlarged RTA formation (domino effect or "own-FTA effect"), but significantly insignificant for the formation of competitive RTA formation ("cross-FTA effect") in the unweighted and the production-networks-weighted cases. However, the third-country effect on the formation of competitive RTAs is significantly positive for the spatial weight of GDP and insignificant for the distance-weighted case. In addition, the Pseudo-R square of the production-networks-weighted model specification is much higher than that of other alternative weight schemes.

[Table 4 here]

2. Sensitivity Analysis

In order to check the robustness of estimation results, we rerun the model with an alternative dataset of RTAs and alternative econometric methodologies. First, we rerun the model by using newly formed RTA data in a given year as the dependent variable, instead of data for existing RTAs in a given year. The new RTA variable takes a value of 1 if country *i* and *j* form an RTA in a given year t, and 0 otherwise. The binary variable of RTA formed in year t (RTA=1 at t) will be dropped from the data set since year t+1. As we compare the estimation results in Table 5 with those in Table 4, it becomes clear that the estimates are qualitatively similar to each other, thus supporting the robustness of estimation results.

[Table 5 here]

Second, there may exist omitted and unobserved cross-sectional heterogeneity. A standard solution for the problem of omitted and unobserved cross-sectional heterogeneity is the use of country-pair fixed-effects estimators. However, this is not simple when the dependent variable is a binary variable. As Neyman and Scott (1948) point out, fixed-effects probit estimation can be severely biased, due to the incidental parameters problem. To check for omitted-variable bias, Baier et al. (2011) employ the fixed-effects logit model; however, the fixed-effects logit model drops all observations that exhibit no variation in the dependent variable over time. In fact, 20,159 observations have been dropped in our dataset, with only 1,020 observations remaining as we apply the fixed-effects logit model. Instead, we adopt the random-effects (RE) and population-averaged (PA) probit model. The PA model focuses on the average response for observations that share the same covariates across all country-pairs, whereas the RE model focuses on subject-specific probabilities. The absolute values of the estimates from RE models are generally larger than those from PA models (see Tables 6 and 7). The estimates in Tables 6 and 7 are qualitatively similar to those in Tables 2 and 3, respectively, thus supporting the robustness of our estimation results.

[Table 6 here]

[Table 7 here]

3. Prediction

To investigate how well the predictions made by this study's empirical model align with the actual data, we measure the fitted probabilities of country-pairs' RTA formation in a given year by controlling for the effect of existing RTA relationships. As in Baier and Bergstrand (2004), we use a cut-off probability of 0.5 to determine whether or not an RTA had been predicted. As in Table 8, the model successfully predicts the formation of existing RTAs by 49% with unweighted third country effect, 48% with spatial-weighted by production networks, 38% with GDP-weighted, and 43% with distance-weighted.[13] Based on this finding, we may argue that the interdependence of RTA formation has been more strongly driven by deepening production networks with third countries than by trade cost or market size.

[Table 8 here]

IV. CONCLUDING REMARKS

Similar to determinants of natural trade partnerships—such as geographical distance and factor endowments—production networks can be defined as a determinant of acquired

[13] Close to the predicted power of 53%, as estimated by Egger and Larch (2008).

trade partnerships. Deepening global production networks may generate positive welfare effects and thus lead to a proliferation in the formation of interdependent RTAs. By applying a qualitative choice model estimation to determine the likelihood of interdependent RTA formation, we empirically investigate the linkage between production networks and RTA formation.

We find that the probability of forming an RTA between a country-pair comprising i and j increases if (i) the bilateral distance between them decreases, (ii) the country-pair's market size increases, (iii) the dissimilarity of economic size between them reduces, (iv) the difference in factor endowment between them decreases, and (v) the production networks between them deepen.

Regarding the interdependence of RTA formation that is driven by deepening production networks, we find that a country-pair's existing RTAs with third countries increase the incentive for that country-pair to form a bilateral RTA and enlarge the existing RTA. However, we cannot support existing findings about the competitive formation of new RTAs, and that they are initiated by existing RTAs in other country-pairs in the Row. Moreover, in interpreting the model's explanatory power and accuracy of prediction, we argue that the interdependence of RTA formation has been more strongly driven by deepening production networks with third countries than by trade cost (measured in terms of distance) or market size (measured in terms of GDP). We also find that RTA interdependence driven by production networks applies only to the developed countries involved.

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Table 1. Summary Statistics

	Total (obs. = 21,179)		RTA = 1 (obs. = 2,574)		RTA = 0 (obs. = 18,605)	
	Mean	Std. D.	Mean	Std. D.	Mean	Std. D.
Dist	8.57	0.84	7.46	0.91	8.73	0.71
Mdist	17.83	0.31	17.68	0.34	17.85	0.29
Cont	0.03	0.17	0.15	0.36	0.01	0.12
MCont	0.04	0.03	0.04	0.02	0.04	0.03
SumGDP	12.42	1.43	12.38	1.42	12.43	1.43
DiffGDP	11.81	1.88	11.54	1.92	11.85	1.87
DKL	1.38	0.98	0.80	0.60	1.46	1.00
SqDKL	2.88	3.49	1.01	1.35	3.14	3.62
Network	0.32	0.25	0.32	0.18	0.32	0.26
NN_Network	0.01	0.06	0.04	0.12	0.00	0.04
NS_Network	0.11	0.20	0.13	0.19	0.11	0.20
SS_Network	0.20	0.26	0.15	0.21	0.21	0.27
$W^{Network} \cdot RTA_i$	2.30	3.13	4.12	3.60	2.04	2.97
$W^{Network} \cdot RTA_j$	2.69	3.44	4.65	3.93	2.41	3.28
$W^{Network} \cdot RowRTA$	32,481	6,167	32,894	6,396	32,424	6,133

Table 2. Probit Results: Probability of RTA Formation

	(1)	(2)	(3)	
			Coefficient	Marginal effect
Dist (-)	-0.926 (0.023)***	-0.963 (0.025)***	-0.976 (0.025)***	-0.080 (0.004)***
Mdist (+)	0.015 (0.055)	0.942 (0.063)***	0.968 (0.064)***	0.079 (0.006)***
Cont (+)	0.038 (0.074)	0.139 (0.081)*	0.147 (0.082)*	0.014 (0.009)
MCont (-)	-4.877 (0.637)	-1.806 (0.740)**	-1.691 (0.745)**	-0.138 (0.061)**
SumGDP (+)	0.363 (0.021)***	0.160 (0.023)***	0.142 (0.023)***	0.012 (0.002)***
DiffGDP (-)	-0.167 (0.015)***	-0.101 (0.015)***	-0.094 (0.016)***	-0.008 (0.001)***
DKL (+)	0.202 (0.062)***	0.231 (0.064)***	0.236 (0.064)***	0.019 (0.005)***
SqDKL (-)	-0.210 (0.024)***	-0.224 (0.025)***	-0.224 (0.025)***	-0.018 (0.002)***
Network (+)	0.278 (0.059)***	-0.192 (0.068)***	-0.031 (0.071)	-0.003 (0.006)
$W^{Network} \cdot RTA_i(+)$		0.132 (0,004)***	0.136 (0.005)***	0.011 (0.001)***
$W^{Network} \cdot RTA_j(+)$		0.125 (0.004)***	0.127 (0.004)***	0.010 (0.001)***
$W^{Network} \cdot RowRTA(+)$		-0.000 (0.000)***	-0.000 (0.000)***	-0.000 (0.000)***
Pseudo-R square	0.35	0.43	0.43	
Year fixed	No	No	Yes	
No. obs.	21,179	21,179	21,179	

Notes:
(i) Expected signs are in parentheses.
(ii) Standard errors are reported in the parentheses, and *, **, and *** denote significance at the 10%, 5%, and, 1% levels, respectively.

Table 3. Member-Specific Probit Results: Probability of RTA Formation

	(1)	(2)	
		Coefficient	Marginal effect
Dist (-)	-0.963 (0.025)***	-0.978 (0.025)***	-0.079 (0.004)***
Mdist (+)	0.963 (0.063)***	0.998 (0.064)***	0.079 (0.006)***
Cont (+)	0.113 (0.080)	0.118 (0.082)	0.010 (0.008)
MCont (-)	-0.448 (0.732)	-0.078 (0.726)	-0.006 (0.058)
SumGDP (+)	0.115 (0.023)***	0.087 (0.024)***	0.007 (0.002)***
DiffGDP (-)	-0.091 (0.016)***	-0.081 (0.016)***	-0.006 (0.002)***
DKL (+)	0.269 (0.068)***	0.285 (0.068)***	0.023 (0.005)***
SqDKL (-)	-0.245 (0.026)***	-0.251 (0.026)***	-0.020 (0.002)***
NN_Network (+)	1.063 (0.189)***	1.467 (0.187)***	0.116 (0.016)***
NS_Network (+)	0.358 (0.089)***	0.648 (0.093)***	0.051 (0.007)***
SS_Network (+)	-0.354 (0.077)***	-0.201 (0.080)**	-0.016 (0.006)**
$W^{Network}\cdot RTA_i(+)$	0.119 (0.005)***	0.122 (0.005)***	0.011 (0.001)***
$W^{Network}\cdot RTA_j(+)$	0.113 (0.004)***	0.114 (0.005)***	0.009 (0.001)***
$W^{Network}\cdot RowRTA(+)$	-0.000 (0.000)***	-0.000 (0.000)***	-0.000 (0.000)***
Pseudo-R square	0.43	0.44	
Year fixed	No	Yes	
No. obs.	21,179	21,179	

Notes:
(i) Expected signs are in parentheses.
(ii) Standard errors are reported in the parentheses, and *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 4. Weight-Specific Probit Results: Probability of RTA Formation

Existing RTAs in a given year	Unweighted	Network weighted	GDP weighted	Distance weighted
Dist	-0.100 (0.026)***	-0.976 (0.025)***	-0.919 (0.023)***	-0.923 (0.023)***
Mdist	1.124 (0.066)***	0.968 (0.064)***	0.230 (0.057)***	0.524 (0.058)***
Cont	0.144 (0.083)*	0.147 (0.082)*	0.023 (0.074)	0.178 (0.077)***
MCont	-1.296 (0.752)*	-1.691 (0.745)**	-3.578 (0.664)***	-4.156 (0.694)***
SumGDP	0.135 (0.024)***	0.142 (0.023)***	0.218 (0.023)***	0.275 (0.022)***
DiffGDP	-0.090 (0.015)***	-0.094 (0.016)***	-0.161 (0.015)***	-0.135 (0.015)***
DKL	0.236 (0.065)***	0.236 (0.064)***	0.274 (0.062)***	0.216 (0.063)***
SqDKL	-0.233 (0.025)***	-0.224 (0.025)***	-0.252 (0.025)***	-0.219 (0.025)***
Network	0.100 (0.070)	-0.031 (0.071)	0.363 (0.060)***	0.234 (0.065)***
$MRTA_i$	0.050 (0.002)***			
$MRTA_j$	0.049 (0.002)***			
RowRTA	-0.000 (0.000)***			
$W^{Network} \cdot RTA_i$		0.136 (0.005)***		
$W^{Network} \cdot RTA_j$		0.127 (0.004)***		
$W^{Network} \cdot RowRTA$		-0.000 (0.00)***		
$W^{GDP} \cdot RTA_i$			1.227 (0.076)***	
$W^{GDP} \cdot RTA_j$			1.014 (0.064)***	
$W^{GDP} \cdot RowRTA$			0.002 (0.000)***	
$W^{Distance} \cdot RTA_i$				0.198 (0.009)***
$W^{Distance} \cdot RTA_j$				0.203 (0.010)***
$W^{Distance} \cdot RowRTA$				0.000 (0.003)
Pseudo-R square	0.47	0.43	0.37	0.39

Note:
Standard errors are reported in parentheses, and *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 5. Probit Results for the Probability of RTA Formation: Sensitivity Analysis

New RTAs in a given year	(1) Unweighted		(2) Network weighted	
	Coefficient	Marginal effect	Coefficient	Marginal effect
Dist	-0.485 (0.034)***	-0.125 (0.001)***	-0.458 (0.033)***	-0.013 (0.001)***
Mdist	0.548 (0.096)***	0.014 (0.003)***	0.427 (0.095)***	0.012 (0.002)***
Cont	0.184 (0.141)	0.006 (0.005)	0.190 (0.138)	0.007 (0.006)
MCont	-3.148 (1.264)**	-0.081 (0.033)**	-3,350 (1.246)***	-0.093 (0.035)***
SumGDP	0.052 (0.035)	0.001 (0.001)	0.059 (0.035)*	0.002 (0.001)*
DiffGDP	-0.044 (0.024)*	-0.001 (0.001)*	-0.046 (0.024)*	-0.001 (0.001)*
DKL	0.420 (0.100)***	0.011 (0.002)***	0.422 (0.099)**	0.012 (0.003)***
SqDKL	-0.234 (0.037)***	-0.006 (0.001)***	-0.230 (0.036)***	-0.006 (0.001)***
Network	0.150 (0.094)	0.004 (0.002)	0.132 (0.093)	0.004 (0.003)
$MRTA_i$	0.023 (0.003)***	0.001 (0.000)***		
$MRTA_j$	0.024 (0.002)***	0.001 (0.000)***		
RowRTA	-0.001 (0.000)***	-0.000 (0.000)***		
$W^{Network} \cdot RTA_i$			0.055 (0.008)***	0.002 (0.000)***
$W^{Network} \cdot RTA_j$			0.055 (0.007)***	0.002 (0.000)***
$W^{Network} \cdot RowRTA$			-0.000 (0.000)***	-0.000 (0.000)***
Pseudo-R square	0.14		0.12	
Year fixed	Yes		Yes	
No. obs.	18,895		18,895	

Notes:
(i) The new RTA assumes a value of 1 if country *i* and *j* form an RTA in a given year t, and 0 otherwise. The binary variable of RTA formed in t will be dropped from the data set since t+1.
(ii) Standard errors are reported in parentheses, and *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 6. Results for the Probability of RTA Formation, by Alternative Estimation Methodologies: Sensitivity Analysis

Existing RTAs in a given year	PA probit	RE probit
Dist	-0.950 (0.032)***	-7.545 (0.197)***
Mdist	0.507 (0.085)***	4.699 (0.407)***
Cont	0.230 (0.109)**	1.071 (0.467)**
MCont	-5.864 (1.042)***	-36.325 (4.966)***
SumGDP	0.271 (0.029)***	1.930 (0.164)***
DiffGDP	-0.094 (0.020)***	-0.859 (0.111)***
DKL	0.393 (0.089)***	2.462 (0.491)***
SqDKL	-0.304 (0.037)***	-1.982 (0.195)***
Network	-1.162 (0.0556)***	-1.023 (0.405)**
$W^{Network} \cdot RTA_i$	0.084 (0.005)***	0.680 (0.037)***
$W^{Network} \cdot RTA_j$	0.056 (0.005)***	0.566 (0.032)***
$W^{Network} \cdot RowRTA$	-0.000 (0.000)***	0.000 (0.000)
Year fixed	Yes	Yes
No. obs.	21,179	21,179

Note:
Standard errors are reported in parentheses, and *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 7. Member-Specific Results for the Probability of RTA Formation, by Alternative Estimation Techniques: Sensitivity Analysis

Existing RTAs in a given year	PA probit	RE probit
Dist	-0.947 (0.032)***	-8.264 (0.289)***
Mdist	0.526 (0.085)***	5.504 (0.474)***
Cont	0.228 (0.109)**	2.723 (0.718)**
MCont	-5.139 (1.054)***	-25.339 (5.499)***
SumGDP	0.247 (0.030)***	1.648 (0.181)***
DiffGDP	-0.088 (0.020)***	-0.804 (0.121)***
DKL	0.435 (0.092)***	2.848 (0.543)***
SqDKL	-0.324 (0.037)***	-2.301 (0.219)***
NN_Network	0.858 (0.242)***	12.145 (1.680)***
NS_Network	0.057 (0.100)	3.002 (0.681)***
SS_Network	-0.230 (0.061)***	-2.919 (0.495)***
$W^{Network} \cdot RTA_i$	0.080 (0.005)***	0.704 (0.043)***
$W^{Network} \cdot RTA_j$	0.051 *0.005)***	0.569 (0.042)***
$W^{Network} \cdot RowRTA$	-0.000 (0.000)***	-0.000 (0.000)
Year fixed	Yes	Yes
No. obs.	21,179	21,179

Note:
Standard errors are reported in parentheses, and *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 8. Predictions about RTA Formation

	Unweighted		Network weighted		GDP weighted		Distance weighted	
Actual / Prediction	RTA=1	RTA=0	RTA=1	RTA=0	RTA=1	RTA=0	RTA=1	RTA=0
RTA = 1	0.49	0.02	0.48	0.02	0.38	0.02	0.43	0.02
RTA = 0	0.51	0.98	0.52	0.98	0.62	0.98	0.57	0.98

Note:
The figures in each cell represent the percentage of observations for which $RTA_{ijt} = 1$ (i.e., form an RTA) or 0 (i.e., do not form an RTA) are predicted to have $RTA_{ijt} = 1$ or 0, with a probability >0.5.