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Effects of Hub-and-Spoke Free Trade Agreements on Trade: Panel Data Analysis

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Abstract

Overlapping free trade agreements (FTAs) have given rise to hub-and-spoke FTAs that may promote trade by giving an export advantage to the FTA hub country. We empirically investigate the effect of hub-and-spoke FTAs on trade using panel data consisting of 99 countries and covering the period 1960–1999. Our empirical analysis of the panel data yields three notable findings. First, FTAs have a significant and positive impact on trade. Second, hub-and-spoke FTAs increase trade above and beyond FTAs, and thus reinforce the trade-boosting effects of FTAs. Third, our results imply an annual growth rate of 4.9% in bilateral trade and hence a doubling of trade after 14½ years between FTA partners. Our results indicate that the hub-and-spoke nature of FTAs has a positive effect on trade, in addition to the direct, trade-liberalizing effect of FTAs. Therefore, in a world of overlapping FTAs, a more accurate empirical analysis of the relationship between FTAs and trade calls for taking into account the hub-and-spoke characteristic of FTAs.

I. Introduction

A large and well-established empirical literature uses the gravity equation and cross-sectional data to investigate the effect of free trade agreements (FTAs) on international trade flows. The overall balance of evidence from this literature is decidedly mixed, with some studies finding a more significant effect than others. The most serious econometric criticism of this literature is that almost all studies use *exogenous* right-hand-side dummy variables to capture the impact of FTAs on trade. If, as is likely, the FTA dummy variable is endogenous rather than exogenous, ordinary least squares (OLS) may yield biased and inconsistent coefficient estimates. Omitted variables are an important source of such endogeneity bias. For example, the presence of omitted variables that reduce the volume of trade between two countries but increase the likelihood of FTA between them will cause the FTA coefficient to be underestimated.

The few studies that adjust for the endogeneity of FTAs use instrumental variables on cross-sectional data. For example, Magee (2003) uses two stage least squares to estimate the effect of endogenous FTAs on trade but is unable to fine any reliable evidence—the estimated effect ranges from large and negative to large and positive. Baier and Bergstrand (2007) contend that cross-sectional regressions yield biased and inconsistent coefficient estimates due to the inclusion of time-invariant omitted variables that affect both FTA and trade. In other words, there are vast numbers of variables that are cross-sectionally correlated with both trade flows and the probability of having an FTA. Baier and Bergstrand address this fundamental shortcoming of cross-sectional techniques by using panel data instead of cross-section data, and estimate the effect of FTA on trade via fixed effect (FE) and first differenced (FD) regressions. Both FE and FD regressions eliminate time-invariant omitted variables and thus allow for consistent estimates of time-varying variables. Their main finding is a significant and positive effect of FTAs on trade.

In this paper, we empirically examine the impact of an increasingly prevalent feature of FTAs, namely, *overlapping of FTAs,* which give rise to hub-and-spoke FTAs on international trade. The primary contribution of our paper is to enrich and strengthen the empirical literature on the relationship between FTAs and trade by explicitly incorporating the hub-and-spoke nature of FTAs. We use the data and empirical framework of Rose (2004), and follow Baier and Bergstrand's approach to handling endogeneity. As of 31 December 2006, General Agreement on Tariffs and Trade/World Trade Organization (GATT/WTO) has been notified of 209 regional trade agreements (RTAs), of which

FTAs accounted for about 64%[1] Excluding the 44 service agreements and the 21 partial agreements, the proportion of FTAs rises further to 92%.[2] Many FTAs overlap one another and this allows some countries to become a hub in a network of FTAs. Relative to non-hub countries, an FTA hub country enjoys preferential access to more markets and hence an advantage in terms of export competitiveness. To the extent that such an advantage translates into more exports and hence trade, the hub-and-spoke feature of overlapping FTAs will have a positive effect on trade, above and beyond the direct, trade liberalizing effect of FTAs.[3]

The concept of hub-and-spoke trade systems is not new to the trade literature but empirical analysis has been limited to a few country-specific studies. Our contribution to the hub-and-spoke trade literature is that we apply the concept to hubs and spokes to FTAs, and perform a comprehensive empirical analysis of the effect of hub-and-spoke FTAs on international trade using panel data for 99 countries from 1960 to 1999.[4] Early works on hub-and-spoke trade systems include examinations of Canadian trade policy by Wonnacott (1975) and Wonnacott (1982). Kowalczyk and Wonnacott (1992) investigated the hub-and-spoke trade system in the context of North American Free Trade Agreement (NAFTA). Puga and Venables (1997) theoretically analyzed how overlapping FTAs affect the locational choice of industries under monopolistic competition. A forthcoming paper by Chong and Hur examined the welfare effects of hub-and-spoke FTAs for Japan, Singapore, and US using a computational general equilibrium model under perfect competition and monopolistic competition. What has been thoroughly lacking in the empirical literature on hub-and-spoke trade systems is a comprehensive analysis using data from a large number of countries. Our paper will help to fill this gap in the literature.

Our empirical analysis yields three main findings. First, FTAs have a significant and positive effect on trade. That is, FTAs do matter for trade. Second, the positive effect of a hub-and-spoke FTA on trade exceeds the positive effect of an FTA on trade. The greater trade effect of a hub-and-spoke FTA is due to the export competitiveness advantage enjoyed by the hub country. For example, the hub country belonging to two FTAs (A and B) can sell its exports at a lower price in B than spoke countries that only belong to A. Third, our estimation results imply that hub-and-spoke FTA doubles bilateral trade after

1 See www.wto.org for more details about RTAs.

2 Note that according to the counting method of the WTO, sometimes a new RTA is double-counted as one under GATT Article XXIV, the Enabling Clause or GATS (General Agreement on Trade in Services) Article V. For example, the FTA between Japan and Singapore reported as of 14 November 2002 is captured as a new RTA under GATS Article V as well. Another example is the FTA between India and Sri Lanka notified to WTO as of 22 June 2002 (date of entry into force as of 15 December 2001), which is categorized as a new RTA under the Enabling Clause.

3 A hub of overlapping FTAs is also attractive to foreign investors, who gain preferential access to multiple FTAs. While FTAs may thus promote foreign direct investment inflows, we do not examine those effects in this paper. Our paper looks at the trade effects of FTAs rather than the foreign direct investment effects of FTAs. Being an FTA hub also entails some costs. For example, a hub has to manage multiple sets of trade regulations such as those pertaining to RoO.

4 We use FTAs only up to 1999 due to the surge in the numbers of FTAs after 2000. Hence, including the FTAs formed after 2000 may yield an upward bias to our results. Baier and Bergstrand (2007) also used FTAs data up to 2000 only.

14½ years, which represents a 4.9% annual growth rate of trade. Our trade data indicates that actual bilateral trade among FTA countries grew annually by 5.1% on average. Therefore, our empirical analysis, which incorporates the hub-and-spoke nature of FTAs, is able to generate trade growth rates that are fairly close to actual trade growth rates.

The rest of this paper is organized as follows. Section II defines the hub country and spoke country of overlapping FTAs, and presents stylized evidence about FTA hubs and spokes in the real world. Section III discusses the data and methodology we use for our empirical analysis. The section also explores in greater detail the FE and FD models that we apply to panel data to address the endogeneity bias. Section IV examines the main results emerging from our empirical analysis. We look at and compare the results from the pooled OLS regressions, FE regressions, and FD regressions. Section V concludes with some final observations.

II. Definition and Evidence of FTA Hubs and Spokes

In this section, we define hub country and spoke country in a world of overlapping FTAs, and examine the extent to which hub-and-spoke FTAs are an empirical feature of real world trade. Measuring the trade effect of hub-and-spoke FTAs requires a precise definition of a hub and a spoke, which allows for their transformation into empirical variables. We also look at the evidence of hubs and spokes, as we define them, to identify which countries are real-world FTA hubs and get some sense of the prevalence of FTA hubs in the real world.

A. Definition of FTA Hub and Spoke

The following simple example is useful for giving the reader a more intuitive understanding of the hub-and-spoke concept. Suppose that Republic of Korea (henceforth Korea) has FTAs with the People's Republic of China (PRC) and Japan, but the PRC and Japan do not have an FTA with each other. In this case, Korea is clearly the hub country and the PRC and Japan are the spoke countries. Korea enjoys a price advantage in its exports to the PRC vis-à-vis Japan because its exports receive preferential treatment under the Korea–PRC FTA whereas Japanese exports do not. The preferential treatment takes the form of lower tariffs and non-tariff barriers that reduce the prices of Korean exports relative to those of Japanese exports. Likewise, preferential treatment under the Korea–Japan FTA will give Korean exports a price advantage relative to the PRC exports in the Japanese market. Therefore, in principle the FTA hub country in a hub-and-spoke FTA is able to export more and hence trade more in comparison with non-hubs. This export competitiveness advantage gives countries a compelling incentive to become FTA hubs and may help to explain the proliferation of FTAs in the real world. To the extent that the FTA hub country takes advantage of its favorable position, its actual export and trade volume will rise. Therefore, a hub-and-spoke FTA will increase trade above and beyond an FTA, which is an empirically testable proposition we test in this paper.

While the above intuitive example is conceptually helpful, a formal definition is required for incorporating hub and spoke into our empirical analysis. We formally define hub and spoke as follows:

> *Suppose that country i has bilateral FTAs with m countries (m is strictly greater than one) and country j is one of the m countries. Country j is defined as a spoke country if it has bilateral FTAs with m-2 or less countries among the m countries that have bilateral FTAs with country i. Country i is defined as a hub if it has at least two spokes.*

For example, suppose Korea has bilateral FTAs with the 10 member-states of the Association of Southeast Asian Nations (ASEAN). Korea is defined to be a FTA hub country if at least two ASEAN countries, say, Indonesia and the Philippines, have FTAs with eight or fewer ASEAN countries. In other words, according to our definition, an FTA hub country has at least two spoke markets. Let us assume that Indonesia and the Philippines do not have an FTA with each other. Further assume that Indonesia does not have an FTA with Malaysia, and that the Philippines does not have an FTA with Thailand. Korea has an export competitiveness advantage vis-à-vis Indonesia in Malaysia and the Philippines as well as advantage vis-à-vis the Philippines in Indonesia and Thailand. Therefore, according to our definition, Korea is an FTA hub country since it has two spoke markets in Indonesia and Philippines. Note that it is theoretically possible for country *i* and country *j* to be each other's hub and spoke at the same time if both countries belong to more than two FTAs.

B. Evidence of FTA Hubs and Spokes

Our primary data source for identifying FTAs and FTA hubs, as defined above, for the period 1958–2005 is the *Regional Trade Agreements Notified to the GATT/WTO and in Force by Date of Entry into Force*, available at the WTO website. The table provides detailed information about 186 RTAs during 1958–2005. We excluded agreements for trade in services since our analysis is more relevant for trade in goods, for which the advantages of FTAs for exporters are more concrete. We also excluded preferential agreements that are not completely in the form of free trade areas or customs unions as specified by GATT Article 24. Those omissions reduce our sample size to 132 agreements, which are listed in Appendix A.[5] Figure 1 below shows the number of new FTA hubs that have emerged each year during 1958–2005.

[5] There 34 agreements for trade in services and 18 preferential agreements. In addition, we excluded the Commonwealth of Independent States, which seems to be ineffective in the sense that many of its members have subsequently entered into bilateral agreements with each other despite the Commonwealth's existence. We do, however, include those bilateral agreements. We also exclude Romania's accession to the Central European Free Trade Agreement (CEFTA) in 1997 because it was the only member at that time.

Figure 1: Number of New FTA Hubs, 1958–2005

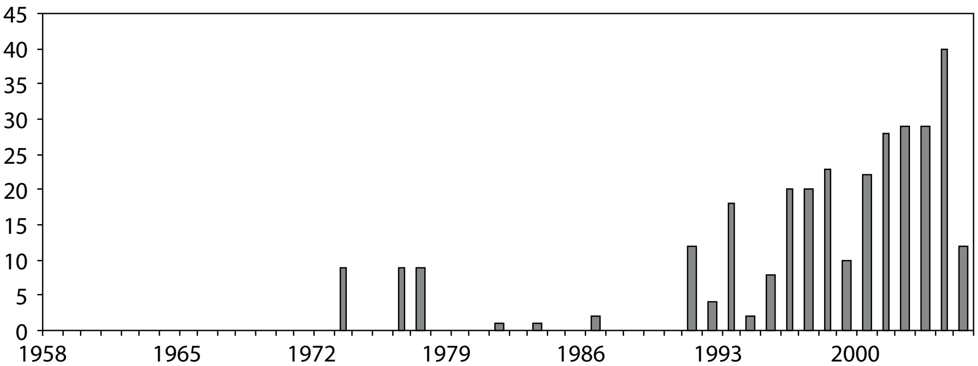

Table 1 below ranks 211 countries in terms of the frequency of becoming a new FTA hub (denoted by H^i_t for country i and time t) during 1958–2005.[6] Countries with the highest frequency of being FTA hubs (13 times) are the nine earliest members of the European Union (EU). Six countries that joined EU at later dates have the second highest frequency of becoming FTA hubs while European Free Trade Area (EFTA) countries have the third highest frequency. Eastern European countries such as Bulgaria, Romania, and Turkey have also recently joined many FTAs and have become FTA hubs. Mexico (5 times) and the US (4 times) have become FTA hubs in the Americas. Australia (3 times), Singapore (3 times), New Zealand (2 times), PRC (1 time), and Japan (1 time) are FTA hubs in the Asia and Pacific region. The overall evidence suggests that FTA hub countries are likely to be members of RTAs. In particular, EU members seem to be prominent FTA hubs.

Table 1: Frequency of Becoming a New FTA Hub, 1958–2005

Ranking	Countries	$\Sigma_{t=1}^{2005} H^i_t$
1	Belgium, Denmark, France, Germany, Ireland, Italy, Luxemburg, Netherlands, United Kingdom	13
2	Greece, Portugal, Spain	11
3	Austria, Finland, Sweden, Switzerland	9
4	Iceland, Liechtenstein, Norway	8
5	Romania, Turkey	6
6	Bulgaria, Israel, Mexico	5
7	Armenia, Croatia, Georgia, Kyrgyz Republic, Macedonia, United States	4
8	Australia, Chile, Moldova, Russian Federation, Singapore	3
9	Albania, Bosnia and Herzegovina, Canada, El Salvador, Kazakhstan, New Zealand, Ukraine	2
10	People's Republic of China, Costa Rica, Cyprus, Czech Republic, Estonia, Hungary, Japan, Jordan, Latvia, Lithuania, Malta, Nicaragua, Palestine Authority, Poland, Slovak Republic, Slovenia, South Africa, Tunisia	1
11	Rest of the world (151)	0

[6] Some FTAs notified in 2006 onward are still under negotiation. Thus we limit our sample period to up to 2005 when all FTAs are currently in effect.

Since we have panel data of 211 countries over 48 years, our total number of observations is 10,128. Table 2 below shows that the unconditional probability of a randomly chosen country *i* being an FTA hub at randomly chosen time *t* is 3.04%. A country's conditional probability of being an FTA hub if it has never been an FTA hub before is only 0.63%. On the other hand, a country's conditional probability of being an FTA hub if it has been an FTA hub at least once before is much higher at 38.93%. This implies that countries that have been FTA hubs in the past are much more likely to become FTA hubs in the future.

Table 2: Conditional Probability of Being a New Hub

$P(H^i_t \mid \Sigma_j^{t-1958} H^i_{t-j})$	$H^i_t=0$	$H^i_t=1$	TOTAL
$\Sigma_{j=1}^{t-1958} H^i_{t-j}=0$	99.73% (9,431)	0.63% (60)	100% (9,491)
$\Sigma_{j=1}^{t-1958} H^i_{t-j}\geq 1$	61.07% (389)	38.93% (248)	100% (637)
Total	96.96% (9,820)	3.04% (308)	100% (10,128)

Note: $\Sigma_{j=1}^{t-1958} H^i_{t-j}=0$ means that a country has never been an FTA hub before. In this case, the probability of being an FTA hub is 0.63%. $\Sigma_{j=1}^{t-1958} H^i_{t-j}\geq 1$ means that a country has been an FTA hub at least once before. In this case, the probability of being an FTA hub is 38.93%. The unconditionally probability of being an FTA hub is 3.04%.

III. Data and Empirical Framework

Our primary data set is from Rose (2004), which uses the standard gravity model of trade to examine the impact of the WTO on international trade. The gravity model, a widely used workhorse of empirical analysis in international trade, explains the natural logarithm of bilateral trade with the logs of the distance between the two countries and their joint income. Most applications of the gravity model include a number of explanatory variables in addition to distance and joint income. Since our data are from Rose (2004), we use his basic empirical framework in the sense that we use the same explanatory variables. Rose asserts that his empirical strategy is to control for as many causes of trade as possible, which explains why the total number of variables in his data set is 43. As a result, we also control for a large number of trade determinants in addition to those of central interest to us, i.e., the FTA-related variables. Those variables are listed in Appendix C and include dummy variables for income levels (e.g., high-income); geographical location (e.g., East Asia); other geographical factors (e.g., landlocked); cultural/historical factors (e.g. common language) and status of WTO membership. The sample period of Rose's data set is 1960–1999.

We supplement Rose's data set with our data for FTAs and FTA hubs. As noted earlier, our primary source of data for these variables is the *Regional Trade Agreements Notified to the GATT/WTO and in Force by Date of Entry into Force*, available at the WTO website and reproduced in Appendix A. We construct an FTA variable and two FTA hub variables from all RTAs notified to the WTO between 1960 and 1999. Merging Rose's data set with our data set for FTAs and FTA hubs leaves us with a balanced panel data set consisting of 99 countries (see Appendix B) and running from 1960 to 1999.[7] As Baier and Bergstrand (2007) point out, FTAs are typically phased in over 5–10 years and thus will not become fully effective before this time period. Therefore, following Baier and Bergstrand, we exclude from our sample the post-2000 period that saw a surge of new FTAs.[8]

We now define the FTA variable and the two FTA hub variables. FTA^{ij}=1 for two countries *i* and *j* if they have an FTA with each other and FTA^{ij}=0 otherwise. If FTA^{ij}=1, HUB^{ij}=1 for country *i* if country *i* is an FTA hub with respect to country *j* and HUB^{ij}=0 otherwise. The volume of country *i*'s exports to country *j* will depend on whether the two countries have an FTA with each other, and, if so, whether country *i* is an FTA hub with respect to country *j*. In terms of our notation,

$$FTA^{ij}\begin{cases} 1 \Rightarrow\ HUB^{ij}\begin{cases} 1 & \rightarrow E_2^{ij} \\ 0 & \rightarrow E_1^{ij} \end{cases} \\ 0 \qquad\qquad\qquad \rightarrow E_0^{ij} \end{cases}$$

E^{ij}, or exports from country *i* to country *j*, can be expressed as

$$E^{ij} = FTA^{ij}\left[HUB^{ij}E_2^{ij} + (1-HUB^{ij})E_1^{ij}\right] + \left[1-FTA^{ij}\right]E_0^{ij} \qquad (1)$$

where $E^{ij}{}_0$, $E^{ij}{}_1$ and $E^{ij}{}_2$ are functions of X^i, or a vector of control variables for country *i*.

$$E_2^{ij} = \alpha_2^i + \beta^i X^i + \varepsilon_2^i \,;\, E_1^{ij} = \alpha_1^i + \beta^i X^i + \varepsilon_1^i \,;\, E_0^{ij} = \alpha_0^i + \beta^i X^i + \varepsilon_0^i \qquad (2)$$

The volume of bilateral trade between country *i* and country *j* is the sum of E^{ij} and E^{ji}, which, making use of equations (1) and (2) above, can be expressed as

7 Rose's data set has bilateral trade for some countries with only one observation. These observations are dropped in FD regressions but not for OLS or FE regressions. We create a balanced panel so we can have comparable results for different regressions. A balanced panel with a long time series also allows us to better address the problem of serial correlation.

8 Including the post-2000 FTAs, which are likely to be less than fully effective due to the gradual nature of FTA-based trade liberalization, will impart an upward bias to the estimated effect of FTA on trade, especially in light of the rapid growth of FTAs in the post-2000 period.

$$\begin{aligned}&E^{ij}+E^{ji}\\&=\alpha_0+\beta^iX^i+\beta^jX^j+\mu_0FTA^{ij}+\mu_1FTAHUB^{ij}+\mu_2FTAHUB^{ji}\\&+FTA^{ij}(\varepsilon_1^i+\varepsilon_1^j-\varepsilon_0^i-\varepsilon_0^j)+FTAHUB^{ij}(\varepsilon_2^i-\varepsilon_1^i)+FTAHUB^{ji}(\varepsilon_2^j-\varepsilon_1^j)+\varepsilon_0^i+\varepsilon_0^j\end{aligned} \quad (3)$$

where

$FTAHUB^{ij}=FTA^{ij}\times HUB^{ij}$ and $FTAHUB^{ji}=FTA^{ij}\times HUB^{ji}$ (note $FTA^{ij}=FTA^{ji}$); $\alpha_0=\alpha^i_0+\alpha^j_0$; $\mu_0=\alpha^i_1+\alpha^j_1-\alpha^i_0-\alpha^j_0$; $\mu_1=\alpha^i_2-\alpha^i_1$ and $\mu_2=\alpha^j_2-\alpha^j_1$.

We are interested in estimating the value of μ_0, μ_1 and μ_2. A positive estimated value of μ_0 implies that an FTA has a positive effect on bilateral trade between country *i* and country *j*. If $\mu_0>0$, this implies that $(\alpha^i_1+\alpha j_1) > (\alpha^i_0+\alpha^j_0)$. That is, the sum of country *i*'s exports to country *j* and country *j*'s exports to country *i* are greater if they have an FTA with each other than if they do not. By definition, the sum of exports is bilateral trade, so this is equivalent to saying that bilateral trade is larger with an FTA than without an FTA.

A positive estimated value of μ_1 or μ_2 or both implies that the overlapping of FTAs has a further positive effect on the trade of FTA hub countries. However, we must distinguish between two possible scenarios. First, only one of the two estimates is positive, i.e., ($\mu_1>0$, $\mu_2=0$) or ($\mu_1=0$, $\mu_2>0$). This implies that $\alpha^i_2>\alpha^i_1$ or $\alpha^j_2>a^j_1$ and only one of the two FTA partners is a hub country. Second, both estimates are positive so that $\mu_1>0$ and $\mu_2>0$. This implies that $\alpha^i_2>\alpha^i_1$ and $\alpha^j_2>\alpha^j_1$, and both FTA partners are hub countries. As pointed out earlier, it is theoretically possible for two countries to be each other's hub and spoke at the same time if both belong to more than two FTAs. In either case, regardless of whether one or both of the FTA partners is a hub, bilateral trade is larger than if neither is a hub. That is, trade between two FTA partners is larger if they are in a hub-and-spoke relationship than if they are not.

Our empirically testable specification of the gravity model is

$$\ln T^{ij}_t=\alpha_0+\beta X^{ij}+\mu_0FTA^{ij}_t+\mu_1FTAHUB^{ij}_t+\mu_2FTAHUB^{ji}_t+\varepsilon^{ij}_t \quad (4)$$

T^{ij}_t is the total trade volume—the sum of E^{ij} and E^{ji}—between country *i* and country *j* at time *t*. The vector X^{ij} refers to the 43 explanatory variables for country i and j in Rose's data set. Those variables are listed in Appendix C and include five time-variant variables. One of the variables is a dummy binary variable that takes on the value of 1 if both countries are members of the same RTA, e.g., EU, and 0 otherwise. This is important because we want to separate out the FTA hub effect from the RTA membership effect.[9] We follow Baier and Bergstrand (2007) in including up to six lags of FTA^{ij}_t in the estimation of equation (4).[10] The lags capture an institutional feature of FTAs, i.e.,

[9] It was earlier pointed out in Section IIB that members of RTAs, especially the EU, are prominent FTA hubs.

[10] We also obtained the regression results that include up to 10 lags of FTA. However, the lags of FTA after 6 years are

they are typically phased in over a period of 5–10 years; as well as the nature of FTAs' economic effects, i.e., terms of trade changes associated with FTAs tend to have lagged effects on trade volumes. We also generalize the specification of equation (4) by including time dummy variables.

The first-differenced form of equation (4) can be expressed as:

$$\Delta \ln T_t^{ij} = \beta \Delta X_t^{ij} + \mu_0 \Delta FTA_t^{ij} + \mu_1 \Delta FTAHUB_t^{ij} + \mu_2 \Delta FTAHUB_t^{ji} + \Delta \varepsilon_t^{ij} \quad (5)$$

Notice that the term X_t^{ij} in (5) includes only the five time-variant explanatory variables from Rose's data set while the term X^{ij} in (4) includes all 43 explanatory variables from the same data set. Incidentally, the fixed effects model accounts for time-invariant variables so that its estimation also requires only the five time-variant variables.

As noted earlier, the biggest econometric criticism of the empirical literature on the relationship between FTAs and trade is that FTA variables are assumed to be exogenous rather than endogenous. To formally test for the exogeneity of FTAs, we perform the heteroskedasticity-robust C-test for exogeneity developed by Baum, Schaffer, and Stillman (2003). Table 3 below reports the results, which show that for pooled OLS regressions, the C-test rejects the null hypotheses that $FTA^{ij}{}_t$ and $FTAHUB^{ij}{}_t$ are exogenous at the 1% significance level.[11] In contrast, for the FE and FD regressions, the C-tests cannot reject the null hypotheses that all three FTA-related variables ($FTA^{ij}{}_t$, $FTAHUB^{ij}{}_t$ and $FTAHUB^{ji}{}_t$) are exogenous even at the 10% significance level. Our C-test results thus confirm Baier and Bergstrand's contention that the problem of endogeneity can be addressed by using panel data and FE/FD regressions.

Both FE and FD regressions assume that the errors in the regressions are serially uncorrelated. If the errors are serially correlated, the FE and FD estimators may be inefficient and inconsistent. There is a risk of serial correlation since bilateral trade levels in earlier years may affect current bilateral trade levels. We use the test for serial correlation outlined by Wooldridge (2002). Table 3 reports the results of the test, which involves running heteroskedasticity-robust OLS, FE and FD regressions on the residuals, and the lagged residuals. The results indicate serial correlation in the pooled OLS and FE regressions but not in the FD regressions.[12] We correct for serial correlation in pooled OLS and FE regressions by using the Prais-Winsten (1954) transformation.

We also test for strict exogeneity since its violation may also result in inefficient and inconsistent FE and FD estimators. For this purpose, we use a test put forth by

not significant. The results for regressions that include up to 10 lags are available upon request from the authors.

[11] In conducting the C-test of exogeneity, we have to assume excluded instruments correlated to FTA or FTAHUB but orthogonal to the error terms. However, as Baier and Bergstrand mention, it is difficult to find such instruments. For the C tests of exogeneity, we use as instruments the lagged log values of per capita trade and lagged log values of the sum of per capita real GDP.

[12] The notes in Table 3 provide a more in-depth discussion of the test and results.

Wooldridge (2002). For FE model, the test involves running a FE regression on the dependent variable, the regressors and the lead (t+1) values of the subset of regressors. For the FD model, the test involves running a regression on the FD dependent variable, FD regressors and a subset of regressors in levels. Based on the results, which are reported in Table 3, we can reject the null of strict exogeneity for the FE model but cannot do so for the FD model.[13] Therefore, the FD model, which does not suffer from serial correlation and does not violate strict exogeneity, is the most robust among the three models. Nevertheless, the estimates are broadly similar for the pooled OLS, FE, and FD regressions. This implies that endogeneity in pooled OLS regressions and violation of strict exogeneity in FE regressions does not seriously bias the results.

Table 3: Specification Tests

Variable	OLS Estimates		FE Estimates		FD Estimates	
	Statistic	P-Value	Statistic	P-Value	Statistic	P-Value
			C-Test for Endogeneity			
FTA^{ij}_t	8.521	0.004	1.135	0.287	1.836	0.175
$FTAHUB^{ij}_t$	0.671	0.412	1.352	0.245	0.052	0.820
$FTAHUB^{ji}_t$	16.231	0.0001	0.928	0.335	2.224	0.136
			Test for Serial Correlation			
ρ	0.898 (0.002)	0.000	0.743 (0.003)	0.000	−0.243 (0.004)	0.000
			Test for Strict Exogeneity			
γ	–	–	0.271 (0.032)	0.000	−0.003 (0.008)	0.687

OLS = ordinary least squares, FE = fixed effect, FD = fixed difference, FTA = free trade area.

Note: As developed by Baum, Schaffer, and Stillman (2003), the C-statistic is a test statistic for testing endogeneity of FTA^{ji}_t, $FTAHUB^{ij}_t$, and $FTAHUB^{ji}_t$. The test has a null that a regressor is exogenous and an alternative that it is endogenous. The C-statistic has a chi-square distribution and is robust to heteroskedasticity. Woodridge (2002) outlines a test for serial correlation for OLS, FE estimates, and FD estimates. The test involves running heteroskedasticity-robust OLS, FE, and FD regressions on the residuals and the lagged residuals. Where ρ is the coefficient of the lagged residuals, the null hypothesis is $\rho = 0$ for no serial correlation under OLS and alternative hypothesis of serial correlation is $\rho \neq 0$ in OLS regression. For FE regression, the null hypothesis of no serial correlation is $\rho = -1/(T-1)$ and the alternative hypothesis of serial correlation is $\rho > 0$. For FD regressions, the null hypothesis of no serial real correlation is $\rho = -0.5$ and the alternative hypothesis of serial correlation is $\rho > 0$. Wooldridge also specifies a regression-based tests for strict exogeneity in FE and FD models. For the FE model, the test involves running a fixed effect regression on the dependent variable, the regressors, and the lead of the subset of regressors (t+1). We consider only the FTA^{ij}_{t+1} for the test. With γ as the coefficient of FTA^{ij}_{t+1}, the null of strict exogeneity is $\gamma = 0$ against the alternative of violation of strict exogeneity of $\gamma \neq 0$. For the FD model, the test involves running a regression on the FD dependent variable, FD regressors, and a subset of regressors in levels. We consider only FTA^{ij}_t. With γ as the coefficient of FTA^{ij}_t, the null of strict exogeneity is $\gamma = 0$ against the alternative of violation of strict exogeneity of $\gamma \neq 0$. Values in parenthesis are robust standard errors.

[13] Please refer to the notes for Table 3 for a more in-depth discussion of the test and results.

IV. Empirical Results

Table 4 reports our results for the pooled OLS, FE, and FD regressions. The pooled OLS and FE regressions have been corrected for serial correlation by the Prais-Winsten transformation. We do not report the results for the 43 control variables in Rose (2004) but they are available from authors upon request. In general, our results for those variables are quite close to Rose's results, and most of the coefficient estimates have the expected signs and are significant. For example, the effect of sharing a common border on bilateral trade was positive and highly significant as was the effect of both trading partners being Asian countries. Membership in RTAs also had a positive, highly significant effect on trade.[14] On the other hand, the effect of distance between the trading partners was negative and highly significant, as was the effect of both partners being least developed countries. The fact that our results for the 43 control variables are largely consistent with economic intuition gives us some confidence that our empirical analysis will be able to isolate and identify the effects of FTAs and their hub-and-spoke nature on trade flows.

For our purposes, the most relevant coefficient estimates are those of the FTA variable and the two FTA hub variables, so we will focus upon those variables in our discussion of the results of the three regressions in Table 4. For the pooled OLS regressions, we include all of Rose's 43 explanatory variables but we only include the five time-variant variables for the FE and FD regressions. The pooled OLS results show that FTA^{ij} has a significant and positive impact on bilateral trade after 2 years. That is, countries that have an FTA with each other trade more with each other than countries having no FTA with each other. The coefficient estimate of $FTAHUB^{ji}$ is 0.076 and has a p-value of 6.0% while the coefficient estimate of $FTAHUB^{ij}$ is insignificant. The pooled OLS results thus lend some support to a positive effect of hub-and-spoke FTAs on trade but, as noted earlier, those results suffer from the endogeneity of the three FTA-related variables.

The results of the FE regressions, which do not suffer from endogenous FTA-related variables, indicate that FTA^{ij} has a significant and positive impact on bilateral trade. The average treatment effect of FTA, which refers to the notion that bilateral trade will differ based on whether or not the two countries share an FTA, is 0.083 after 5 years. The coefficient estimate of $FTAHUB^{ji}$ is 0.108 and has a p-value of 3.2% while the coefficient estimate of $FTAHUB^{ij}$ is insignificant. The total average treatment effect, or the sum of the FTA effect and the hub-and-spoke FTA effect, is 0.191. The FE results thus lend strong support to a positive effect of hub-and-spoke FTAs on trade but, as noted earlier, the FE model is a first order autoregressive process that may violate the assumption of strict exogeneity. Tests for strict exogeneity confirm that the assumption is violated, which implies that the FE estimators may be inefficient and inconsistent.

[14] As noted earlier, RTA members, especially EU members, figure prominently among FTA hubs. As such, we want to separate out RTA membership effects from FTA hub effects.

Table 4: Estimation Results for Heteroskedasticity-Robust OLS, Fixed Effect, and First-Differenced Models (dependent variable: ln(Itrade)$^{ij}{}_t$)

	OLS Estimation using the Prais-Winsten Transformation			FE Estimation using Prais-Winsten Transformation			FD Estimation		
Regressor	Coefficient	Robust standard error	P-value	Coefficient	Robust standard error	P-value	Coefficient	Robust standard error	P-value
$FTA^{ij}{}_t$	−0.021	0.046	0.644	-0.050	0.065	0.441	0.009	0.042	0.821
$FTA^{ij}{}_{t-1}$	0.012	0.019	0.517	0.013	0.032	0.680	0.000	0.018	0.986
$FTA^{ij}{}_{t-2}$	0.048***	0.017	0.004	0.047	0.033	0.158	0.040**	0.016	0.011
$FTA^{ij}{}_{t-3}$	−0.088***	0.023	0.000	−0.020	0.034	0.557	−0.002	0.017	0.895
$FTA^{ij}{}_{t-4}$	0.051***	0.015	0.001	0.029	0.035	0.395	0.041***	0.014	0.004
$FTA^{ij}{}_{t-5}$	0.074***	0.024	0.002	0.083**	0.040	0.039	0.070***	0.024	0.003
$FTA^{ij}{}_{t-6}$	0.066***	0.019	0.001	0.066	0.039	0.096	0.056***	0.018	0.002
$FTAHUB^{ij}{}_t$	−0.002	0.045	0.959	0.033	0.067	0.621	−0.004	0.041	0.921
$FTAHUB^{ji}{}_t$	0.076*	0.041	0.060	0.108**	0.050	0.032	0.075*	0.040	0.061
Sum	0.497***	0.012	0.000	0.243**	0.011	0.000	0.171***	0.014	0.000
$\ln(rgdp)^j{}_{it}$									
Additional regressors	43			4			4		
Time dummies	Yes			Yes			Yes		
No. of obs.	56576			56576			54912		
F-statistic	–			85.93		0.000	47.16		0.000
ATE				0.168			0.215		

***, **, and * indicate 1%, 5%, and 10% levels of significance, respectively.

OLS = ordinary least squares, FE = fixed effect, FD = fixed difference, FTA = free trade area, ATE = average treatment effect.

Note: $\ln(trade)^{ij}{}_t$ is the ln of country i and j's total trade with each other; $FTA^{ij}{}_t$ is dummy variable that is 1 if country i and country j have a free trade agreement (FTA) and 0 otherwise; $FTAHUB^{ij}{}_t$ ($FTAHUB^{ji}{}_t$) a dummy variable that is 1 if country i (j) becomes a hub when it enters into an FTA with country j (i) and 0 otherwise; sum ln(rgdp) is the sum of the log real GDP of country i and country j. ρ is the coefficient of the lagged residuals to test for serial correction. It is calculated by running regressions on the residuals with the lag of the residuals. The residuals for the fixed effects and first differenced models are derived from regressions of time-demeaned and FD variables, respectively. The additional regressors are described in Rose (2004) and Appendix C. The results of the additional regressors are mostly significant with the correct signs. These results are not reported because of space limitation but are available from the authors upon request. The Prais-Winsten (1954) transformation adjusts for serial correlation. ATE is the average treatment effect with at least 5% level of significance.

We earlier saw that the FD regressions do not suffer from endogeneity, serial correlation, and violations of strict exogeneity. As such, the FD estimators are efficient and consistent, and the FD results are therefore likely to be the more robust and reliable than the pooled OLS or FE results. The FD results indicate that the average treatment effect of FTAs at the 5% significance level, or the sum of FTA^{ij} coefficients significant at the 5% significance level is 0.207. This represents an annual growth rate of bilateral trade of about 3.5%.[15] The coefficient estimate of $FTAHUB^{ji}$ is 0.075 and has a p-value of 6.1% while the coefficient estimate of $FTAHUB^{ij}$ is insignificant. This suggests that a hub-and-

[15] The ATE of $e^{0.207}$ implies that the trade will be increasing by 123% over the 6 years. So the annual growth rate of trade is r=3.5%, which is calculated from $(1+r)^6=1.23$.

spoke FTA has a moderately significant positive impact on trade. If we incorporate the hub-and-spoke nature of FTAs, the average treatment effect of FTAs rises further to 0.282. This represents an annual growth rate of trade of about 4.9% and a doubling of trade volume after 14½ years.

Overall, our empirical analysis based on pooled OLS, FE and FD regressions yields two main findings. First, FTAs have a positive and significant impact on bilateral trade between FTA members in all three regressions. Our results thus confirm the presence of average treatment effects for FTAs; i.e., whether two countries have an FTA or not matters for the volume of bilateral trade. Furthermore, the positive and significant effect seems to materialize not immediately but with a time lag. Second, the hub and spoke nature of FTAs appears to reinforce and augment the significantly positive effect of FTAs on trade. It is noteworthy that the estimated size of the hub-and-spoke effect is quite similar across the three regressions: 0.075 for FD, 0.108 for FE, and 0.076 for pooled OLS. This gives us some confidence about the robustness of our estimated hub-and-spoke effect. Interestingly and significantly, if we take into account both the direct effect of FTAs and the additional hub-and-spoke effect, the growth rate of trade implied by our FD results is 4.9%, which is quite close to the actual growth rate of 5.1% between FTA members computed from our data.

V. Concluding Observations

Although the concept of hub-and-spoke trade systems is not new to the trade literature, what has been lacking in the literature is a systematic empirical analysis of their effects. We hope that our paper helps to address this significant shortcoming in the literature. More specifically, we apply the concept of hubs and spokes to FTAs and use a panel data set comprising 99 countries and covering 40 years (1960–1999) to empirically examine the effect of FTA hubs and spokes on trade. Our point of departure is an increasingly prominent stylized fact of international trade in the real world, namely the overlapping of FTAs, which give rise to hub-and-spoke FTAs. Intuitively, an FTA hub belonging to two FTAs—A and B—enjoy a competitive advantage in exporting its goods vis-à-vis FTA spokes, which belong to only one of the two FTAs. The hub has a price advantage vis-à-vis A-only countries in the B market and price advantage vis-à-vis B-only countries in the A market. To the extent that this advantage results in higher exports and hence trade, we can expect the hub-and-spoke feature of overlapping FTAs to increase trade above and beyond the direct, trade-liberalizing effect of FTAs.

Indeed one of our two main empirical findings is that the hub-and-spoke nature of FTAs in a world of overlapping FTAs does indeed have a positive and significant effect on bilateral trade among FTA members. More precisely, our results imply an average annual growth rate of trade of 4.9% between FTA members and hence a doubling of bilateral trade after 14½ years. This growth rate of 4.9% implied by our regression results is remarkably close to the actual growth rate of 5.1% we computed from our data, which lends credibility to the robustness of our results. The positive and significant effect of hub-and-spoke FTAs reinforces our other main empirical finding, namely a positive and significant effect of FTAs on trade. Our finding of a positive relationship between FTAs and trade reconfirms the results of Baier and Bergstrand (2007), which do not account for hub-and-spoke effects. Their results imply a 7% annual growth rate of bilateral trade between FTA members and a doubling of trade after 10 years. However, the actual growth rate of trade we computed from their data was only 4.3%, significantly below the growth rate implied by their regression results.

At a broader level, both our paper and Baier and Bergstrand represent efforts to improve and refine the empirical analysis of the relationship between FTAs and trade. In fact, we use the methodology developed by Baier and Bergstrand to address the econometric issue of endogenous FTA-related variables. In this paper, we propose to further improve the measurement of FTA's trade effects by accounting for a characteristic of FTAs hitherto neglected by the empirical literature. More specifically, we argue that in a world of overlapping FTAs, a more accurate estimation of the effect of FTAs on trade requires taking into account the hub-and-spoke nature of FTAs. Furthermore, the proliferation of FTAs is likely to further increase the empirical relevance of hub-and-spoke FTAs in the future. Our empirical evidence provides some support for our argument that the empirical analysis of FTAs would benefit from explicitly recognizing those effects.

Given the large and growing role of FTAs in international trade, it is of utmost importance to measure their impact as accurately as possible. This suggests there is plenty of scope for useful future research. For one, the empirical literature fails to incorporate rules of origin (RoO). These rules are an essential part of FTAs and define the conditions under which the importing country will view a product as originating in an FTA partner. RoO entail costs, e.g., a Mexican firm's costs of certifying the Mexican origins of its exports to the US under NAFTA, which introduce a protectionist bias. Inactive FTAs is another potential issue for future research. For example, an FTA may exist in name only if firms forego the FTA-based preferential treatment and act as if they were from outside the FTA area. Including inactive FTAs in the empirical analysis distorts the estimation of an FTA's trade effects. However, operationalizing RoO and inactive FTAs for empirical purposes will be far from straightforward.

Appendix A

List of Regional Trade Agreements Notified to WTO, 1958–2005 (132 Agreements)

1958: European Community
1960: European Free Trade Association
1961: Central American Common Market
1970: EFTA accession of Iceland
1971: EC–Overseas Countries and Territories
1973: EC–Switzerland and Liechtenstein; EC accession of Denmark, Ireland and United Kingdom; EC–Iceland; EC–Norway; Caribbean Community and Common Market
1976: EC–Algeria
1977: Agreement on Trade and Commercial Relations between the Government of Australia and the Government of Papua New Guinea; EC–Syria
1981: EC accession of Greece
1983: Closer Trade Relations Trade Agreement
1985: United States–Israel
1986: EC Accession of Portugal and Spain
1991: EC–Andorra: Southern Common Market
1992: EFTA–Turkey
1993: EFTA–Israel; Armenia–Russian Federation; Kyrgyz Republic–Russian Federation; EC–Romania; EFTA–Romania; Faroe Islands–Norway; Faroe Islands–Iceland; EFTA–Bulgaria; EC–Bulgaria
1994: North American Free Trade Agreement; Georgia–Russian Federation
1995: Romania–Moldova; EC accession of Austria, Finland and Sweden; Faroe Islands–Switzerland; Kyrgyz Republic–Armenia; Kyrgyz Republic–Kazakhstan; Armenia–Moldova
1996: EC–Turkey; Georgia–Ukraine; Armenia–Turkmenistan; Georgia–Azerbaijan; Kyrgyz Republic–Moldova; Armenia–Ukraine
1997: EC–Faroe Islands; Canada–Israel; Turkey–Israel; EC–Palestinian Authority; Canada–Chile; Eurasian Economic Community; Croatia–Former Yugoslav Republic of Macedonia
1998: Kyrgyz Republic–Ukraine; Romania–Turkey; EC–Tunisia; Kyrgyz Republic–Uzbekistan; Mexico–Nicaragua; Georgia–Armenia
1999: Bulgaria–Turkey; Central European Free Trade Agreement accession of Bulgaria; EFTA–Palestinian Authority; Georgia–Kazakhstan; Chile–Mexico; EFTA–Morocco
2000: Georgia–Turkmenistan; EC–South Africa; Bulgaria–FYROM; EC–Morocco; EC–Israel; Israel–Mexico; EC–Mexico; Southern African Development Community; Turkey–FYROM
2001: Croatia–Bosnia and Herzegovina; New Zealand–Singapore; EFTA–FYROM; EC–FYROM; Romania–Israel; EFTA–Mexico; India–Sri Lanka; United States–Jordan; Armenia–Kazakhstan
2002: Bulgaria–Israel; EFTA–Jordan; EFTA–Croatia; Chile–Costa Rica; EC–Croatia; EC–Jordan; Chile–El Salvador; Albania–FYROM; FYROM–Bosnia and Herzegovina; Canada–Costa Rica; Japan–Singapore

2003: EFTA–Singapore; EC–Chile; CEFTA accession of Croatia; EC–Lebanon; Panama–El Salvador; Croatia–Albania; Turkey–Bosnia and Herzegovina; Turkey–Croatia; Singapore–Australia; Albania–Bulgaria; Albania–UNMIK (Kosovo); Romania–Bosnia and Herzegovina

2004: Romania–FYROM; Albania–Romania; PRC–Macao, China; PRC–Hong Kong, China; United States–Singapore; United State–Chile; Republic of Korea–Chile; Moldova–Bosnia and Herzegovina; European Union Enlargement; Bulgaria–Serbia and Montenegro; EC–Egypt; Croatia–Serbia and Montenegro; Romania–Serbia and Montenegro; Moldova–Serbia and Montenegro; Albania–Serbia and Montenegro; Moldova–Croatia; Albania–Moldova; Bulgaria–Bosnia and Herzegovina; Moldova–FYROM; Moldova–Bulgaria; Albania–Bosnia and Herzegovina; EFTA–Chile

2005: Thailand–Australia; US–Australia; Japan–Mexico; Turkey–PLO; EFTA–Tunisia; Thailand–New Zealand; Turkey–Tunisia

CACM = Central American Common Market, CARICOM = Caribbean Community and Common Market, CEFTA = Central European Free Trade Agreement, CER = Closer Trade Relations Trade Agreement, EAEC = Eurasian Economic Community, EC = European Community, EFTA = European Free Trade Association, FYROM = Former Yugoslav Republic of Macedonia, MERCOSUR = EC–Andorra: Southern Common Market, NAFTA = North American Free Trade Agreement, OCTs = EC–Overseas Countries and Territories, PATCRA = Agreement on Trade and Commercial Relations between the Government of Australia and the Government of Papua New Guinea, SADC = Southern African Development Community.

Appendix B

List of Economies (N=99)

Algeria
Angola
Argentina
Australia
Austria
Barbados
Belize
Benin
Bolivia
Brazil
Burkina Faso
Cameroon
Canada
Cape Verde
Central African Rep.
Chad
Chile
People's Republic of China, Colombia
Congo, Rep.
Costa Rica
Cote D'Ivoire (Ivory Coast)
Cyprus
Denmark
Dominican Rep.
Ecuador
Egypt
El Salvador
Ethiopia
Fiji
Finland
France
Gabon
Gambia
Germany
Ghana
Greece
Guatemala
Guinea
Guinea-Bissau
Guyana
Haiti
Honduras
Hong Kong, China
Hungary
Iceland
India
Indonesia
Iran
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Kenya
Republic of Korea
Madagascar
Mali
Mauritania
Mauritius
Mexico
Morocco
Mozambique
Netherlands
New Zealand
Nicaragua
Niger
Nigeria
Norway
Pakistan
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Portugal
Romania
Saudi Arabia
Senegal
Sierra Leone
South Africa
Spain
Sri Lanka
Suriname
Sweden
Switzerland
Syria
Tanzania
Thailand
Togo
Trinidad and Tobago
Tunisia
Turkey
Uganda
United Kingdom
United States
Uruguay
Venezuela

Appendix C

Additional Regressors in Table 4

Sum of the log of real GDP of country i and j*
Common language
Both countries in GATT/WTO
Both founding GATT members
Caribbean dummy (i)
Caribbean dummy (j)
Dummy for common colonizer post-1945
Dummy for pairs currently in colonial relationship*
Dummy for pairs ever in colonial relationship
Dummy for same nation/perennial colonies
East Asian dummy (i)
East Asian dummy(j)
GATT/WTO accession (i)
GATT/WTO accession (j)
General System of Preferences dummy*
High income dummy (i)
High income dummy (j)
Islands
Land border dummy
Landlocked
Latin-Caribbean dummy (i)
Latin-Caribbean dummy (j)
Least developed dummy (i)
Least developed dummy (j)
Log of distance
Low income dummy (i)
Low income dummy (j)
Maximum years in GATT/WTO
Middle East and North African dummy (i)
Middle East and North African dummy (j)
Middle income dummy (i)
Middle income dummy (j)
Minimum years in GATT/WTO
Neither country in GATT/WTO
One country in GATT/WTO
One founding GATT member
RTA dummy of 1 for joint membership in any of the following—EC/EU, USIS, NAFTA, CARICOM, PATCRA, ANZD, CACM, MERCOSUR, ASEAN, SPARTECA—and 0 otherwise*
South Asian dummy (i)
South Asian dummy (j)
Strict Currency Union*
Sub-Saharan Africa dummy (i)
Sub-Saharan Africa dummy (j)
Years inside GATT/WTO (i)
Years inside GATT/WTO (j)

*Indicates time-variant variables.

GATT/WTO = General Agreement on Tariffs and Trade/World Trade Organization, EC/EU = European Community/European Union, USIS = US–Israel Free Trade Agreement, NAFTA = North American Free Trade Agreement, CARICOM = Caribbean Community and Common Market, PATCRA = Agreement on Trade and Commercial Relations between the Government of Australia and the Government of Papua New Guinea, ANZD = Australia–New Zealand Free Trade Agreement, CACM = Central American Common Market , MERCOSUR = EC–Andorra: Southern Common Market, ASEAN = Association of Southeast Asian Nations, SPARTECA = South Pacific Regional Trade and Economic Cooperation Agreement.

Source: The dataset is from Andrew Rose's website (see faculty.haas.berkeley.edu/arose).

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About the Paper

Joseph D. Alba, Jung Hur, and Donghyun Park investigate the effect of hub-and-spoke free trade agreements (FTAs) on trade using panel data. They find that hub-and-spoke FTAs increase trade above and beyond FTAs. More specifically, this type of FTA causes trade to double after 14-and-a-half years.

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