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ABSTRACT

Hub-and-Spoke Free Trade Areas*

This paper analyzes how the sequential formation of free trade areas affects the volume of trade between member countries. In a three--country, three--good model, if two countries have a free trade area, and both sign a similar agreement with the third, trade between the two decreases, and welfare rises in both. However, if only one of them signs an FTA with the third, a hub-and-spoke pattern arises. If the two spokes have a comparative advantage in different goods, trade between the two countries in the initial FTA increases, with welfare rising in the hub and falling in the spoke. We provide evidence consistent with the theoretical model when studying the experience of Israel.

JEL Classification: F11 and F13
Keywords: free trade areas, hub-and-spoke, israel and trade volumes

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HUB-AND-SPOKE FREE TRADE AREAS*

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October 2006

Abstract: This paper analyzes how the sequential formation of free trade areas affects the volume of trade between member countries. In a three–country, three–good model, if two countries have a free trade area, and both sign a similar agreement with the third, trade between the two decreases, and welfare rises in both. However, if only one of them signs an FTA with the third, a hub-and-spoke pattern arises. If the two spokes have a comparative advantage in different goods, trade between the two countries in the initial FTA increases, with welfare rising in the hub and falling in the spoke. We provide evidence consistent with the theoretical model when studying the experience of Israel.

JEL Classification: F11, F13.

1 Introduction

The last decades have witnessed an explosion in the number of preferential trade agreements around the globe. According to the World Trade Organization, 230 are in force today, many more are planned and they overwhelmingly take the form of free trade areas. More than half of these agreements have been signed after 1994, and today trade between preferential partners makes up nearly 40 percent of total global trade. On average, each trading entity belongs to six preferential agreements, while this number rises to thirteen for developed northern countries

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(World Bank 2005). This complex network of free trade agreements has been colorfully compared to a 'spaghetti bowl' by Bhagwati (2002), and while its existence has been extensively documented in the literature, its implications for trade volumes are not yet fully understood.

The image of a spaghetti bowl vividly illustrates how one cannot look at a country pair in isolation when trying to understand the effects of a free trade area (FTA). One should consider not only whether there is an FTA between a country pair; the wider network of trade agreements should also be taken into account. This same point has been emphasized by Anderson and Wincoop (2003) who highlighted that it is *relative*, rather than absolute, trade barriers that matter. To see this, suppose that two countries, with no trade restrictions between them, expand free trade to a third country. In the framework of Anderson and Wincoop (2003), this leads to a drop in trade between the country pair. In spite of continuing to have free trade, in *relative* terms trade between the original partners has become less free, because trade barriers with the third country have been reduced.

In this paper we argue that introducing free trade with a third country need not reduce trade between a country pair if this leads to a hub-and-spoke arrangement. Although *relative* trade barriers go up between the original partners, trade may actually expand. To clarify the difference with the previous result, an example may help. As a starting point, assume that Cuba has established a free trade area with Jamaica. If both countries sign an FTA with Venezuela, trade between Cuba and Jamaica decreases. This is the result emphasized by Anderson and Wincoop (2003). If, instead, only Cuba signs an FTA with Venezuela, then Cuba becomes a hub. In a world without rules of origin, it is easy to see that trade is likely to increase. Cuba could import, say, coconuts from Venezuela, and re-export them to Jamaica. Although this would lead to *de facto* free trade between all three, to reach that outcome, all trade would have to pass through Cuba, dramatically increasing trade volumes. Of course in reality FTAs are bound by rules of origin. However, even then an indirect form of re-exporting can occur: rather than re-exporting Venezuelan coconuts to Jamaica, Cuba could export home grown coconuts to Jamaica, and substitute its domestic consumption by Venezuelan coconuts.

Though this example is based on a pure exchange economy, the central intuition carries over to a production economy. In that case, what would matter is the factor content of trade. In a hub-and-spoke situation, Cuba's imports from Venezuela would have the same factor content as its exports to Jamaica. In other words, Cuba would import "coconut-intensive" goods produced

in Venezuela, and export home produced "coconut intensive" goods to Jamaica. Under this generalization, rather than the imports and the exports being identical goods, it would be enough for the factor content of the imports and the exports to be the same.

A first contribution of this paper is to formalize the trade effects of hub-and-spoke arrangements. We consider a three-country three-good endowment economy in the spirit of Bond, Riezman, and Syropoulos (2004). To fix ideas, we call these countries North, Middle and South. Each country has a comparative advantage in a different good. We study three possible configurations: the bilateral FTA case (FTA between Middle and North, with MFN tariffs between the others), the hub-and-spoke case (FTA between Middle and North and between Middle and South, but MFN tariffs between North and South), and the multilateral free trade case (FTAs between all three).

Starting off with an FTA between North and Middle, we want to understand how expanding free trade to South affects the volume of trade between North and Middle. If only Middle signs an FTA with South, we have a hub-and-spoke arrangement. We find that trade between North and Middle increases. Welfare improves in both countries. If, instead, both countries sign an FTA with South, we have multilateral free trade. Compared to the bilateral FTA, we find that the volume of trade between North and Middle declines, with welfare rising in both countries.

This result shows that introducing free trade with a third country has different effects on trade volumes, depending on whether trade expands across the board, or whether, in contrast, it leads to a hub-and-spoke situation. If a pair of countries jointly introduce free trade with a third country, trade between the pair declines. However, if only one of them signs an FTA with the third country, we get a hub-and-spoke situation, and trade between the pair goes up.

A second contribution of the paper is to provide empirical evidence, consistent with these hub-and-spoke effects. The network of agreements signed by Israel in the last three decades makes for an appropriate testing ground. In 1975 Israel established an FTA with the European Union. In 1985 it signed a similar FTA with the United States. This gave rise to a hub-and-spoke configuration, with Israel being the hub, and the EU and the US being the spokes. Consistent with our theoretical framework, we find that this *increased* trade between Israel and the EU by nearly 30%, in spite of leading to greater relative trade barriers between the two. In 1993 Israel signed a third agreement, this time with EFTA. Since the EU already had free trade with EFTA, this led to multilateral free trade between Israel, the EU and EFTA. Consistent with the theory,

we find that this *decreased* trade between Israel and the EU.

We are not the first to explore the intricacies of hub-and-spoke arrangements.[1] Of particular interest is Kowalczyk and Wonnacott (1992), who analyze hub-and-spoke effects in the context of NAFTA. While this paper offers an excellent overview of the different possibilities, it falls short of providing a detailed theoretical model. Puga and Venables (1997) analyze how hub-and-spoke arrangements affect the location of industries in a Dixit-Stiglitz world. In contrast to our work, their focus is not on trade volumes, but on agglomeration in production. In particular, they show that a hub-and-spoke structure might hurt the spokes by making location in the hub more attractive. Saggi and Yildiz (2006) use instead a three-country oligopoly model to study how membership in multiple free trade arrangements might result in higher welfare for the hub, compared to free trade. However, they do not discuss the effects on trade volumes.

Recent work has analyzed the endogenous formation of regional agreements and the optimal setting of tariffs.[2] Given that our focus is mainly on assessing the hub-and-spoke effects on trade volumes, we do not explicitly model the tariff formation process. In other words, we take the external MFN tariff as given, and assume the formation of an FTA to imply the complete removal of any trade barriers amongst member countries. Furthermore, following Bond, Riezman, and Syropoulos (2004), we assume the formation of an FTA to be exogenous.[3]

Our work is complementary to the large empirical literature that, starting from the pioneering contribution of Tinbergen (1962), has used the gravity equation to assess the effects of preferential trading arrangements on bilateral trade volumes.[4] To the best of our knowledge the existing literature has so far failed to thoroughly investigate the importance of hub-and-spoke effects.[5] This is not surprising, because in standard gravity models the mechanism we describe does not arise. For the hub-and-spoke effect to be relevant, two conditions need to be satisfied. The spokes

[1] Early contributions can be traced back to Wonnacott (1975) and Wonnacott (1982).

[2] See, for instance, Ornelas (2005).

[3] It is worth pointing out that, in our modeling framework, if policy decisions are undertaken in each country by a social planner, the existence of prior agreements would not block the formation of a global free trade agreement. This is because the aggregate welfare of a country increases with the number of agreements it signs, regardless of any agreements signed between the other countries. In reality, of course, frictions and political economy considerations may well prevent the attainment of global free-trade. Therefore, examining trade configurations short of global free trade is not only reasonable, but given the observed patterned of trade agreements, of direct policy relevance as well.

[4] See, for instance, Frankel (1997), Baier and Bergstrand (2006) and Ghosh and Yamarik (2004).

[5] An exception is De Benedictis, De Santis, and Vicarelli (2005). However, they do not analyze how adding new spokes affects trade between the hub and existing spokes. Instead, they study how the effect of an FTA between two countries on their trade differs, depending on whether they are spokes or not.

must have a comparative advantage in different goods, and the hub must be endowed with some of the goods the spokes specialize in. If this is the case, the hub can satisfy its consumption of a certain good by importing it from one of the spokes, and thus exporting its own endowment of that same good to the other spoke. Although the hub imports and exports the same good, its imports are 'made in one of the spokes' and its exports are 'made in the hub'. In contrast, the monopolistic competition setup in gravity models has each variety being produced in only one country, and ignores issues of comparative advantage. Since all varieties are equally substitutable, the hub can no longer offer its goods to one of the spokes as a substitute for the exports of the other spoke. As a result, the possibility of the hub doing indirect arbitrage vanishes. This explains the absence in the standard gravity model of an increase in trade through the hub.

The rest of the paper is organized as follows. Section 2 introduces a simple three-country model of comparative advantage to explain the mechanism at hand. Section 3 contains the main results of the paper, comparing trade volumes and welfare levels under different trading arrangements. In section 4 we develop a methodology to empirically evaluate the presence of hub and spoke effects and apply it to the case of Israel. Section 5 concludes the paper.

2 The model

Consider a simple endowment economy with three countries: North (N), South (S) and Middle (M). Countries are indexed by superscripts $j = N, S, M$. Each country is populated by a unit mass of homogeneous agents. Three goods are exchanged in this economy, indexed by subscripts $i = 1, 2, 3$. The endowments of the three countries are

$$\begin{aligned} y^N &= (1+\alpha, 1, 1) \\ y^S &= (1, 1+\alpha, 1) \\ y^M &= (1, 1, 1+\alpha) \end{aligned} \tag{1}$$

Note that each country has a comparative advantage in a different good. In this sense, countries are 'complements' to each other.[6] This endowment economy can be thought of as the reduced form of a production economy with factors of production in fixed supply and sector-specific.

[6] The case of spokes being 'substitutes' will briefly be discussed in Section 3.2.

Preferences are identical across countries, and we assume them to be Cobb-Douglas of the form:

$$u(c_1, c_2, c_3) = c_1 c_2 c_3 \tag{2}$$

Trade barriers take Samuelson's 'iceberg' cost form. In particular, a tariff τ implies that $1+\tau$ units of a good have to be shipped for 1 unit to arrive.[7] Let q_i^j be the price received by a producer in country j for each unit i he produces, and p_i^j the price paid by a consumer in country j for each unit i he consumes. Because we will be considering free trade areas accompanied by rules of origin (ROOs), q_i^j may be different from p_i^j. For instance, if M has two separate FTAs with N and S, the price it pays for its imports of good 1 from N could very well be different from the price it receives for its exports of good 1 to S.

We can then rewrite the income of the representative consumer in the three countries as follows:

$$\begin{aligned} I^N &= q_1^N(1+\alpha) + q_2^N + q_3^N \\ I^S &= q_1^S + q_2^S(1+\alpha) + q_3^S \\ I^M &= q_1^M + q_2^M + q_3^M(1+\alpha) \end{aligned} \tag{3}$$

Consumption of good i in country j is:

$$c_i^j = \frac{I^j}{3p_i^j} \tag{4}$$

The starting point of our analysis is a *bilateral FTA* between two countries. Our goal is to analyze how trade liberalization with a third country affects trade between the original two. To do so, we distinguish between two cases. On the one hand, if both countries expand free trade to a third country, we have a *multilateral FTA*. On the other hand, if only one of the two countries liberalizes trade with the third country, we have a *hub-and-spoke arrangement*. As we will now see, these two cases will lead to diametrically opposed effects on trade between the original two.

2.1 The starting point: bilateral FTA

Under a *bilateral FTA* we assume that two countries, say N and M, have free trade between each other, while uniform MFN tariffs exist among all other countries. We take those MFN tariffs

[7] Although this assumption is made here only for tractability, it is well suited to describe an environment in which non-tariff barriers are becoming increasingly important as a trade policy instrument. In fact, non-tariff barriers, while introducing costly distortions to trade flows, only lead to very impartial rent capturing for the country that imposes them.

to be nonprohibitive.

We start by simplifying the price structure. In the absence of a hub, there cannot be a price difference between what producers receive and what consumers pay in a given country, so that $q_i^j = p_i^j$. Normalization and symmetry allow us to write $p_1^N = p_3^N = p_1^M = p_3^M = 1$. Since M and N import good 2 from S, it follows that $p_2^N = p_2^M = p_2^S(1+\tau)$. Prices in S are $p_1^S = p_3^S = 1+\tau$ and p_2^S. To simplify notation, we write $p_2^S = p_2$.

To solve out for the only unknown price level p_2, we use the trade balance between N and S:

$$(1+\tau)(c_1^S - 1) = p_2(1+\tau)(c_2^N - 1) \tag{5}$$

Combining this equation with the expressions for income (3) and consumption (4) allows to determine p_2:[8]

$$p_2 = \frac{3+\alpha+\tau}{3+\alpha+2\tau} \tag{6}$$

A first goal of our model is to compare trade flows across different trading arrangements. For the comparative statics exercises we carry out later in the paper, it is useful to compute trade between N and M as a share of their incomes. The value of trade between the two is $(c_3^N - 1)$. Using the expressions for income (3) and consumption (4) gives the shares

$$\left(\frac{x^{NM}}{I^N}\right)^{bilateral} = \left(\frac{x^{NM}}{I^M}\right)^{bilateral} = \frac{\alpha^2 + 3\alpha(1+\tau) + \tau(2+\tau)}{3((3+\alpha)^2 + (8+3\alpha)\tau + \tau^2)} \tag{7}$$

A second goal of our model is to compare welfare across trading arrangements. For the bilateral FTA case the welfare levels of the representative agents in the three countries are

$$\begin{aligned}
\left(u^N\right)^{bilateral} &= \frac{((2+\alpha)(3+\alpha+2\tau) + (1+\tau)(3+\alpha+\tau))^3}{27(1+\tau)(3+\alpha+\tau)(3+\alpha+2\tau)^2} \\
\left(u^M\right)^{bilateral} &= \frac{((2+\alpha)(3+\alpha+2\tau) + (1+\tau)(3+\alpha+\tau))^3}{27(1+\tau)(3+\alpha+\tau)(3+\alpha+2\tau)^2} \\
\left(u^S\right)^{bilateral} &= \frac{((3+\alpha)^2 + (11+3\alpha)\tau + 4\tau^2)^3}{27(1+\tau)^2(3+\alpha+\tau)(3+\alpha+2\tau)^2}
\end{aligned} \tag{8}$$

2.2 Expanding free trade symmetrically: multilateral FTA

If both member countries of the bilateral FTA, N and M, introduce free trade with the third country, S, we get a *multilateral FTA*. In our three-country setup, this is equivalent to global free

[8] This assumes a nonprohibitive tariff. It is straightforward to calculate the maximum τ at which the tariff would become prohibitive. Trade between N and S (and M and S) occurs as long as $p_2(1+\tau)$ is smaller than the price of good 2 in N (and M) in the absence of trade with S. The price of good 2 in the absence of trade with S is equal to $(2+\alpha)/2$. This implies that τ should be less than $\overline{\tau}^{FTA} = -1 + ((2+3\alpha+\alpha^2)/2)^{1/2}$.

trade. Because of total endowments being identical, and because of Cobb-Douglas preferences with equal weight on each good, all prices will be identical. After normalizing, we can say that $p_i^j = 1$ for $i = 1, 2, 3$ and $j = N, S, M$. The preferences imply that each country will consume one third of the total endowment of each good:

$$c_i^j = 1 + \alpha/3 \tag{9}$$

Each country thus exports $\alpha/3$ of the good in which it has a comparative advantage to each one of its trading partners. Trade between a pair of countries i and j as a share of their income is then:

$$\left(\frac{x^{ij}}{I^i}\right)^{multilateral} = \frac{\alpha/3}{3+\alpha} \tag{10}$$

Inserting the consumption levels (9) into the utility function gives the welfare levels of the representative agents in all three countries $j = N, M, S$

$$\left(u^j\right)^{multilateral} = \left(\frac{3+\alpha}{3}\right)^3 \tag{11}$$

2.3 Expanding free trade asymmetrically: hub-and-spoke

If instead of both countries introducing free trade with a third country, only one of them does so, we have a *hub-and-spoke* configuration, where the hub, say M, has separate FTAs with the spokes, N and S. Trade between the spokes continues to be limited by the presence of an MFN tariff τ.

The two FTAs are subject to rules of origin (ROOs). Simple arbitrage is therefore not allowed: M cannot import good 1 from N and re-export it to S. However, there exists the possibility of indirect arbitrage: M can import good 1 from N to satisfy its own consumption, and export its own endowment of good 1 to S. Although both goods are identical, the imports are "made in N" and the exports are "made in M". By symmetry, the same can happen with good 2.

The rules of origin are not always binding. ROOs are *non binding* if, at the price p_1^M, the demand for imports of good 1 in S is less than the endowment of good 1 in M. In that case, indirect arbitrage eliminates all price differences across countries. In terms of prices and consumption levels, the outcome replicates the multilateral FTA, which is why we say that the ROOs are non binding.

In contrast, ROOs are *binding* if at the price p_1^M, the demand for imports of good 1 in S is more than the endowment of good 1 in M. In that case, indirect arbitrage is not enough to eliminate price differences; the price M pays for good 1 will be lower than the price it receives for good 1. In what follows, we study these two cases in more detail.

Non binding rules of origin

If the ROOs are non binding, prices in the hub-and-spoke arrangement replicate those in the multilateral FTA. To see this, we start by showing that there can never be a difference between the price at which country i sells good j and the price at which i buys good j. Assume the export price of good 1 in M were to be greater than the local price of good 1 in M, i.e., $q_1^M > p_1^M$. If ROOs are non binding, part of the endowment of good 1 in M is not exported to S. Therefore, if $q_1^M > p_1^M$, there is an arbitrage opportunity: it is possible to buy good 1 at price p_1^M in M, and sell it at price q_1^M in S. In equilibrium, we must therefore have $q_1^M = p_1^M$. This insight can be generalized to $q_i^j = p_i^j$ for all i and all j.

It is now easy to see that prices will be equal across countries. Arbitrage ensures that the price of good 1 is the same in M and in S, i.e., $p_1^S = p_1^M$. Moreover, because of free trade between M and N, the price of good 1 should also be the same in M and in N, so that $p_1^N = p_1^M = p_1^S$. A similar argument ensures that $p_2^N = p_2^S = p_2^M$. Finally, because M exports good 3 to both N and S, and because of the two FTAs, it follows that $p_3^N = p_3^S = p_3^M$. Since the price of each good is equal across the three countries, these prices replicate the outcome under the multilateral FTA.

Although this implies that consumption and utility are the same as in the multilateral FTA case, trade flows are not. Indeed, this equilibrium is sustained through indirect arbitrage. As a result, there is *excess* trade, compared to what would happen were there to be free trade across all countries. Whereas the trade volume between N and M would be $\frac{1}{3}\alpha$ under a multilateral FTA, under the hub-and-spoke arrangement it is double:

$$x^{NM} = \frac{2}{3}\alpha \tag{12}$$

This *excess* trade occurs because M does not only export $\frac{1}{3}\alpha$ of good 3 (in which it has comparative advantage) to N, but also $\frac{1}{3}\alpha$ of good 2 (in which S has comparative advantage, but in which M plays the role of an arbitrageur). In a multilateral FTA, the exports of good 2 by M to N would disappear; instead, N would buy good 2 directly from S.

The condition that makes ROOs non binding remains to be determined. As argued before, ROOs do not bind if at a price p_1^M, $c_1^S - 1 \leq 1$. Substituting p_1^M by 1 and c_1^S by (9) gives us the following condition:

$$\alpha \leq 3$$

In other words, if comparative advantage is not too strong, the hub-and-spoke arrangement is equivalent to a multilateral FTA in terms of consumption and welfare. It does so by having the hub trade excessively with the spokes. However, if comparative advantage is sufficiently strong, indirect arbitrage will not suffice to eliminate price differences across countries. We turn to this case in the next subsection.

Binding rules of origin with nonprohibitive tariffs

When the ROOs are *binding*, the demand for imports of good 1 in S exceeds the endowment of good 1 in M. As a result, the price of good 1 in S will be greater than in M: $p_1^S = q_1^M > p_1^M$. By symmetry, the price of good 2 in N will be greater than in M: $p_2^N = q_2^M > p_2^M$. Since prices of identical goods are different across countries, consumption (and welfare) will not replicate the multilateral FTA outcome.

We start by simplifying prices. As in the bilateral FTA case, we assume MFN tariffs are nonprohibitive, so that there will be positive trade between N and S. We normalize $p_1^N = p_2^S = 1$. Because ROOs are binding, and tariffs are nonprohibitive, $p_2^N = q_2^M = 1 + \tau$. By symmetry, $p_1^S = q_1^M = 1 + \tau$. Because of the two FTAs, $p_1^M = p_2^M = 1$. Since M freely exports good 3 to N and S, we have $p_3^M = p_3^S = p_3^N$. We can thus reduce the number of different prices to three:

$$\begin{aligned} p_1^N = p_2^S = p_1^M = p_2^M &= 1 \\ p_2^N = p_1^S &= 1 + \tau \\ p_3^N = p_3^S = p_3^M &= p_3 \end{aligned} \tag{13}$$

Prices received by producers are typically the same as those paid by consumers, except for $q_1^M = p_1^S > p_1^M$ and $q_2^M = p_2^N > p_2^M$.

To determine the only unknown price p_3 in (13), we use the trade balance condition between N and M.[9] Under binding rules of origin, M imports all of its consumption of good 1, c_1^M, from

[9]Because of the symmetric setup, trade between each country pair must be balanced.

N. In return, it exports to N all its endowment of good 2, in addition to $c_3^N - 1$ units of good 3. The trade balance between N and M is then:

$$c_1^M = (1+\tau) + p_3(c_3^N - 1) \tag{14}$$

Substituting the consumption levels into (14) allows us to solve out for p_3:[10]

$$p_3 = \frac{3+\alpha+2\tau}{3+\alpha} \tag{15}$$

For the purpose of comparative statics, we compute trade between the hub M and the spoke N as a share of their incomes:

$$\begin{aligned} \left(\frac{x^{NM}}{I^N}\right)^{hub-and-spoke} &= \frac{(3+\alpha)^2 + 4(2+\alpha)\tau}{3((3+\alpha^2) + (5+\alpha)\tau)} \\ \left(\frac{x^{NM}}{I^M}\right)^{hub-and-spoke} &= \frac{1}{3} \end{aligned} \tag{16}$$

The level of welfare enjoyed in each country is obtained by substituting the consumption levels into the utility function (2):

$$\begin{aligned} \left(u^N\right)^{hub-and-spoke} &= \frac{((3+\alpha)^2 + (5+\alpha)\tau)^3}{27(3+\alpha)^2(3+\alpha+2\tau)(1+\tau)} \\ \left(u^S\right)^{hub-and-spoke} &= \frac{((3+\alpha)^2 + (5+\alpha)\tau)^3}{27(3+\alpha)^2(3+\alpha+2\tau)(1+\tau)} \\ \left(u^M\right)^{hub-and-spoke} &= \frac{((3+\alpha)^2 + 4(2+\alpha)\tau)^3}{27(3+\alpha)^2(3+\alpha+2\tau)} \end{aligned} \tag{17}$$

3 Trade and welfare across regimes

We are interested in understanding how the volume of trade between a country pair changes as free trade expands to a third country. As a starting point we assume the existence of a free trade area between N and M. We then look at how trade between N and M changes, as one or both countries liberalizes trade with S. In the first case, we have a hub-and-spoke arrangement; in the second case, we have a multilateral FTA. Since prices depend on the different trading configurations, for comparative statics purposes, we focus on trade as a share of GDP.

[10] We can now determine when τ is prohibitive. The idea is simple: the price at which N sells good 1 to S, $1+\tau$, should not be greater than the price at which M sells good 1 to S when trade is prohibited between N and S. The latter is equal to $\frac{4+5\alpha+\alpha^2}{13+5\alpha}$. Using this information, it immediately follows that τ is prohibitive if it is greater than $\overline{\tau}^{HS} = \frac{\alpha^2-9}{13+5\alpha}$.

3.1 Multilateral vs bilateral FTA

To compare the trade shares under a multilateral and a bilateral FTA between N and M, we divide (10) by (7):

$$\left(\frac{x^{NM}}{I^N}\right)^{multilateral} / \left(\frac{x^{NM}}{I^N}\right)^{bilateral} = \frac{\alpha((3+\alpha)^2 + (8+3\alpha)\tau + \tau^2)}{(3+\alpha)(\alpha^2 + 3\alpha(1+\tau) + \tau(2+\tau))} \tag{18}$$

The expression for M is identical. After some tedious algebra, which is omitted for brevity, one can show that the numerator is greater than the denominator. This is enough to establish the following

PROPOSITION 1 *Suppose there is a bilateral FTA between N and M, and a nonprohibitive MFN tariff between N and S and between M and S. If both N and M introduce free trade with S, trade between N and M as a share of income in N and M decreases.*

This result is intuitive. Under the bilateral FTA arrangement, trade is unrestricted between N and M, but not between either country and S. Moving to global free trade gives both N and M an additional trading partner, thus reducing the volume of trade between them. This is reminiscent of the Anderson and van Wincoop (2003) result. By liberalizing trade with a third country, trade between N and M becomes *relatively* less free. This explains the drop in trade between them.

We can now compare welfare under the bilateral FTA and under global free trade. Relative utility for both N and M is

$$\frac{(u^N)^{multilateral}}{(u^N)^{bilateral}} = \frac{(u^M)^{multilateral}}{(u^M)^{bilateral}} = \frac{(3+\alpha)^3(1+\tau)(3+\alpha+\tau)(3+\alpha+2\tau)^2}{((1+\tau)(3+\alpha+\tau) + (2+\alpha)(3+\alpha+2\tau))^3} \tag{19}$$

If $\tau = 0$, (19) is equal to 1. Differentiating (19) with respect to τ, and evaluating the expression at $\tau = 0$ gives

$$\frac{\alpha(6+5\alpha+\alpha^2)}{(3+\alpha)^3} > 0$$

This implies that with a small enough tariff, welfare is higher under global free trade than under bilateral free trade. This result is summarized in the following

PROPOSITION 2 *Suppose there is a bilateral FTA between N and M, and a sufficiently small nonprohibitive MFN tariff between N and S and between M and S. If both N and M liberalize trade with S, welfare increases in both N and M.*

3.2 Hub-and-spoke vs bilateral FTA

Instead of introducing a multilateral FTA, we now consider the consequences of creating a hub-and-spoke arrangement with M being the hub and N and S the spokes. We take ROOs to be binding, and tariffs to be nonprohibitive. In the case of N, we have:

$$\left(\frac{x^{NM}}{I^N}\right)^{hub-and-spoke} / \left(\frac{x^{NM}}{I^N}\right)^{bilateral} = \frac{(3+\alpha)^2 + 4(2+\alpha)\tau)((3+\alpha)^2 + (8+3\alpha)\tau + \tau^2)}{((3+\alpha)^2 + (5+\alpha)\tau)(\alpha^2 + 3\alpha(1+\tau) + \tau(2+\tau))} \tag{20}$$

After some tedious algebra,[11] one can show that the numerator in (20) is greater than the denominator. Thus, trade between N and M as a share of income in N increases when we move from a bilateral FTA to a hub-and-spoke arrangement. Likewise, trade between N and M as a share of income in M also increases. This is obvious from the following expression:

$$\left(\frac{x^{NM}}{I^M}\right)^{hub-and-spoke} / \left(\frac{x^{NM}}{I^M}\right)^{bilateral} = 1 + \frac{3(3+\alpha+2\tau)}{\alpha^2 + 3\alpha(1+\tau) + \tau(2+\tau)} \tag{21}$$

It is easy to show that the same result goes through if the ROOs are not binding. This allows us to state the following proposition:

PROPOSITION 3 *Suppose there is free trade between N and M, and a nonprohibitive MFN tariff between N and S and between M and S. If then M signs a free trade agreement with S, converting M into a hub, the volume of trade between N and M as a share of income of N and M increases.*

As argued before, the hub-and-spoke arrangement leads to *excess* trade between M (the hub) and N (the spoke). Since M can play the role of indirect arbitrageur, trade between the two increases, compared to a situation where there is only a bilateral FTA. In spite of *relative* trade barriers going up, there is now *more* trade between N and M.

Expanding free trade to a third country has thus an ambiguous effect on bilateral trade. When both N and M allow free trade with S, trade between N and M *decreases*. This is the message of Proposition 1. However, if only M introduces free trade with S, trade between N and M *increases*. This is the message of Proposition 3.

This excess trade arises because the exports of a spoke can be substituted by goods obtained from the hub. By satisfying its own consumption of a certain good by imports from one of the

[11] The analytical derivation is available from the authors.

spokes, the hub frees up its endowment of that same good to export it to the other spoke. Going back to our initial example, the hub imports coconuts "made in one of the spokes", and exports coconuts "made in the hub" to the other spoke.

One could argue that our result depends on both types of coconuts being perfect substitutes. This is not the case though. In a more complex Krugman (1981) style model, with comparative advantage at the sectoral level and monopolistic competition at the subsectoral level, the result would still hold. Since varieties within the same sector are closer substitutes than varieties across different sectors, the same mechanism would be at work. There is another reason why imports and exports need not be perfect substitutes. Once we move from an exchange economy to a production economy, it suffices for the factor content of the imports and the exports to be the same. In that case, Cuba would import "coconut-intensive" goods produced in Venezuela, and export home produced "coconut intensive" goods to Jamaica.

Note that the hub-and-spoke effect we describe depends on spokes having a comparative advantage in different goods. If different spokes were to be 'substitutes' and export the same goods, the excess trade would disappear. In that case there would be no room for indirect arbitrage by the hub, and the standard effect reemerges. Expanding trade to a third country raises *relative* trade barriers between the original country pair, leading to less trade between them. This drop in trade occurs because the hub-and-spoke arrangement amounts to a *de facto* multilateral FTA. Indeed, the hub-and-spoke configuration replicates a multilateral FTA, because liberalization between all three does not lead to any trade between the spokes.

In the standard gravity equation models *à la* Anderson and van Wincoop (2003) no excess trade arises either. Liberalizing trade with third countries unequivocally leads to a drop in trade between the original two. Most of those models use a one-sector framework with monopolistic competition.[12] Each variety is produced by only one country, and the elasticity of substitution between all varieties is the same. The hub no longer disposes of *relatively* close substitutes of the varieties of the spokes, because all varieties are *equally* substitutable. As a result, the possibility of doing indirect arbitrage vanishes.

[12] An exception to this is Evenett and Keller (2002), who show how the gravity equation applies in a Heckscher-Ohlin setting. However, as they point out, this only holds if each good is made by only one country.

In terms of welfare, we can easily compare utility levels between the bilateral FTA and the hub-and-spoke arrangement:

$$\begin{aligned}\frac{(u^N)^{hub-and-spoke}}{(u^N)^{bilateral}} &= \frac{(3+\alpha+\tau)(3+\alpha+2\tau)((3+\alpha)^2+(5+\alpha)\tau)^3}{(3+\alpha)^2((3+\alpha)^2+(8+3\alpha)\tau+\tau^2)^3} \\ \frac{(u^M)^{hub-and-spoke}}{(u^M)^{bilateral}} &= \frac{(1+\tau)(3+\alpha+\tau)(3+\alpha+2\tau)((3+\alpha)^2+4(2+\alpha)\tau)^3}{(3+\alpha)^2((1+\tau)(3+\alpha+\tau)+(2+\alpha)(3+\alpha+2\tau))^3} \end{aligned} \tag{22}$$

Expanding the numerators and the denominators of the above fractions allows us to conclude the following:

PROPOSITION 4 *Suppose there is free trade between N and M, and a nonprohibitive MFN tariff between N and S and between M and S. Rules of origin bind. If M signs a free trade agreement with S, converting M into a hub, welfare decreases in the spoke (N) and increases in the hub (M).*

This proposition says that the formation of a hub-and-spoke arrangement benefits the hub and hurts the spoke. This is not surprising. As the third country starts buying the hub's exports, the terms of trade of the hub improves, while those of the spoke worsen.

3.3 Hub-and-spoke vs multilateral FTA

Moving from a hub-and-spoke arrangement to a multilateral FTA lowers exports between N and M as a share of their respective incomes. This is an immediate consequence of combining Proposition 1 and Proposition 3. We therefore have:

PROPOSITION 5 *Suppose there is a hub-and-spoke arrangement, with free trade between M (hub) and N and S (spokes), and a nonprohibitive MFN tariff between N and S. If free trade is introduced between all three countries, the volume of trade between N and M as a share of income decreases.*

Note that trade decreases for two reasons. On the one hand, expanding free trade leads to a *relative* increase in trade barriers between N and M. On the other hand, the *excess* trade happening through the hub disappears.

When comparing welfare, the effect on N (the spoke) is obvious from Propositions 2 and 4: moving from a hub-and-spoke arrangement to a multilateral FTA, welfare in N increases. For M (the hub), utility under the hub-and-spoke relative to the multilateral FTA is:

$$\frac{(u^M)^{hub-and-spoke}}{(u^M)^{multilateral}} = \frac{((3+\alpha)^2+4(2+\alpha)\tau)^3}{(3+\alpha)^5(3+\alpha+2\tau)} \tag{23}$$

Expanding numerator and denominator, it is straightforward to show that utility in M decreases when going from hub-and-spoke to multilateral free trade. We therefore have the following result:

PROPOSITION 6 *Suppose there is a hub-and-spoke arrangement, with M being the hub and N and S the spokes. Assume also that a small enough nonprohibitive MFN tariff is applied to trade between N and S and that rules of origin bind. If free trade is introduced between all three countries, welfare increases in the spokes (N and S) and decreases in the hub (M).*

This proposition says that the introduction of multilateral free trade makes the hub lose its privileged position, whereas the spoke now benefits from improved terms of trade, thanks to expanded trade with the third country.

4 EVIDENCE FROM ISRAEL

> *"The agreements with the European Union, the United States and the EFTA countries places Israel in the unique position of being a Free Trade Area partner with the world's main economic regions. Thus, Israel is able to bridge countries that do not have mutual agreements..."* Baker Tilly Oren - Horowitz & Co., *Doing Business in Israel*, 1995.

We are now ready to empirically assess the implications of our model. Our theory makes two specific predictions. First, if both members of the original FTA expand free trade to a third country, trade between the original pair should *decline*. Second, if only one of them signs a free trade agreement with a third country, we get a hub-and-spoke arrangement, and trade between the original pair should *increase*.

To empirically evaluate these predictions, we need to focus on countries that have signed multiple free trade agreements with different partners at different times. Crucially, to be able to disentangle the effects of each individual agreement, there should be a considerable time lag among them, as the agreements are often implemented over long time periods and as a consequence their effects need not be instantaneous. Although several countries are members to multiple free trade areas — remember the 'spaghetti bowl' — the large majority of existing FTAs have been signed in the last decade, making it very difficult to isolate their individual effects. The Israeli experience is in this regard unique. Between 1975 and 1993 it signed three major free trade agreements, with on average a decade elapsing between each one of them. For this reason Israel represents an

almost ideal ground to evaluate the predictions of our theory.

4.1 Israel's trade policy

Three events have characterized Israeli trade policy in the last thirty years. In 1975 Israel signed an FTA with the European Union. A decade later, in 1985, it signed a similar FTA with the United States. Yet another decade later, in 1993, an FTA between Israel and EFTA entered into force. Almost simultaneously the Uruguay round of multilateral trade negotiations was concluded in 1994. In addition to the FTAs with the EU, the US and EFTA, Israel entered into a potpourri of agreements in the late 1990s with Turkey, Canada, and Slovakia (in 1997), the Czech Republic, Hungary and Slovenia (in 1998) and Poland (in 1999). As it is difficult to disentangle the trade effects of each one of the recently established free trade areas, we will limit our analysis to the time period ending in 1997.

According to the 1975 FTA treaty between Israel and the EU all goods with the exception of agricultural products were to be traded duty free. Although the implementation was not completed until 1989, the EU abolished its tariffs and quotas on all industrial products by July 1977 (World Trade Organization 1999). The 1975 agreement has been replaced in 1995 by a treaty of association between Israel and the EU. This further extended free trade to cover a list of agricultural products.

The 1985 agreement between Israel and the United States was implemented over a ten year period, coming into full operation by January 1st 1995. Duties on goods like airplane and motor parts, electrical products, processed raw diamonds, soybeans and corn were eliminated immediately upon conclusion of the agreement. Duties on products specified in list A (including paper, cigarettes, heavy mechanical equipment, computer parts, leather and shoes, cars and certain textile items) were phased out by January 1st 1989. Between 1990 and 1995 residual restrictions were eliminated on textiles and clothing, chemicals and certain high tech products. Duties on highly sensitive items, such as figs and cold-storage equipment, were also eliminated by January 1st 1995.

The FTA between Israel and EFTA was signed in 1993 and took effect in the same year. It called for reciprocal free trade in most industrial goods (in particular, the goods in chapters 25 to 97 of the Harmonized System), and some agricultural products. Israel also signed additional

bilateral agreements with some EFTA countries, aimed at further promoting trade liberalization in agriculture.[13]

Immediately following the 1993 EFTA agreement, the Uruguay round of multilateral negotiations was concluded in 1994. As a result, Israel committed to: (i) bind 53% of all tariff lines, including all agricultural lines;[14] (ii) replace most quantitative restrictions on agricultural goods with tariff-rate quotas, even if some of these continue to be extremely high;[15] (iii) reduce domestic support to agriculture by 12% between 1995 and 2005 and cut agricultural export subsidies by similar amounts. These somewhat limited commitments to multilateral trade liberalization are due to the developing country status enjoyed by Israel in several areas.

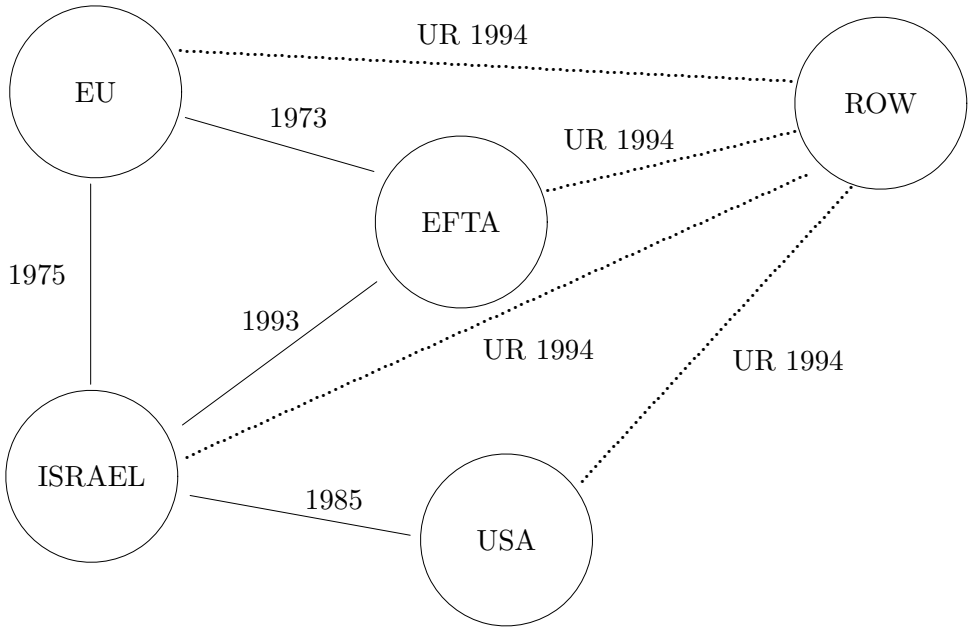

Figure 1: *Israel's Free Trade Areas*

To illustrate the relevance of the Israeli example for our theory, Figure 1 provides a graphical representation of the different agreements Israel signed. As can be seen, the FTA with the US turned Israel into a hub, and the European Union and the US into spokes. According to our

[13]For further details on Israel's current trade policy see World Trade Organization (1999) and World Trade Organization (2005).

[14]Currently, tariff bounds vary between 0 and 560% for agricultural goods and between 0 and 272% for manufactured goods

[15]For example, the duty bounds for imports of bovine animal products are equal to 190%.

model, this should have led to an increase in trade between Israel and the European Union. In contrast, the FTA with EFTA amounted to the establishment of multilateral free trade between Israel, EFTA and the EU. Our model predicts in this case a decrease in trade between Israel and the European Union. As for the Uruguay round, it can be viewed as a move towards global free trade. As a result, we would expect trade between Israel and its existing preferential trading partners to decline.

4.2 Data

The data we use come from Rose (2004), and the sample covers the period between 1950 and 1997. Since our analysis focuses on Israel, we limit our attention to country pairs that involve Israel. This gives us 47 years of observations and 138 country pairs. After accounting for missing values, we are left with 3,755 observations.[16]

Table 1 summarizes key features of Israel's trade activity. In this table we distinguish five periods: Period 1 (1950-1974) predates any of Israel's free trade agreements; Period 2 (1975-1984) starts with the year of the EU-Israel agreement and concludes before the US-Israeli agreement; Period 3 (1985-1992) starts with the US-Israel agreement and ends prior to the EFTA-Israel agreement; Period 4 (1993-1994) starts with the EFTA-Israel agreement and finishes prior to the departure of Austria, Sweden and Finland from EFTA and their accession to the EU; and Period 5 (1995-1997) are the remaining years of our sample. We also distinguish six different sets of trade partners: EU-9, the nine member countries of the EU at the time of the formation of the EU-Israel agreement; Greece-Spain-Portugal, the three Mediterranean countries that joined the EU in 1981 and 1986, and thus became party to the EU-Israel free trade agreement; Austria-Finland-Sweden, the three countries that left EFTA to join the EU in 1995, and thus terminated one trade relationship with Israel to become party to another; Norway-Iceland-Switzerland, the three countries that were party to the Israel-EFTA agreement from 1993 onwards; the United States; and the rest of the world, with whom trade was further liberalized upon the conclusion of the Uruguay round in 1994.

The first panel of Table 1 shows the average annual trade with each country group in each

[16] Aggregate, rather than sectoral, data is used because detailed country-pair sectoral data do not cover the entire period of interest. Moreover, identifying the factor content of sectoral flows would add an additional layer of complication (and possible source of modeling error) to the econometric analysis.

Table 1. Descriptive Statistics

Period	EU-9	Greece-Spain-Portugal	Austria-Finland-Sweden	Norway-Iceland-Switzerland	United States	Rest of the World
Average Bilateral Trade (millions of real $)						
1950-1974	7.49	0.28	0.68	0.74	4.54	3.01
1975-1984	22.11	1.16	1.67	3.96	16.22	11.76
1985-1992	28.37	1.89	1.69	4.77	23.46	15.37
1993-1994	36.29	2.91	2.35	5.30	31.41	24.90
1995-1997	49.02	4.57	2.86	5.46	38.95	33.04
Average Bilateral Trade (% of Israeli trade with all countries in the corresponding group)						
1950-1974	44.7%	1.7%	4.1%	4.4%	27.1%	18.0%
1975-1984	38.9%	2.0%	2.9%	7.0%	28.5%	20.7%
1985-1992	37.5%	2.5%	2.2%	6.3%	31.1%	20.3%
1993-1994	35.2%	2.8%	2.3%	5.1%	30.5%	24.1%
1995-1997	36.6%	3.4%	2.1%	4.1%	29.1%	24.7%
Average Trade Intensity (scale free)						
1950-1974	1.86	1.60	1.76	1.66	2.12	1.40
1975-1984	2.03	1.83	1.88	1.74	2.28	1.41
1985-1992	2.05	1.86	1.87	1.78	2.32	1.39
1993-1994	2.09	1.92	1.91	1.75	2.35	1.48
1995-1997	2.11	1.96	1.94	1.77	2.38	1.52
Number of Observations						
1950-1974	168	70	72	72	24	1,191
1975-1984	70	30	30	30	10	752
1985-1992	56	24	24	24	8	579
1993-1994	14	6	6	6	2	163
1995-1997	23	9	9	9	3	271

Notes: Trade and Trade Intensity are unweighted averages across the countries and years that correspond to each cell. The scale-free measure of Trade Intensity for a given country pair is equal to the ratio of bilateral trade divided by the square root of the product of country GDPs. Dark shaded cells correspond to the existence of bilateral trade agreements between Israel and the corresponding countries. Lightly shaded cells indicate existence of agreement during only part of that period (Greece joined the EU and hence became party to a trade agreement with Israel starting in 1981, Spain and Portugal joined the EU and thus also became party to a agreement with Israel in 1986).

period. The volume of trade has been growing rapidly with all partners, and that with the EU-9 appears to be the single largest. Trade with the US is the second most important in terms of volume, followed by that with the rest of the world. The second panel of Table 1 reports the share of Israeli trade with each of the regions during each of the time periods we consider. These shares not only better reflect the importance of Israeli trade with these regions because they account for overall increase in Israeli trade volume.

Maybe of greater importance than the volume of trade (or the group's percentage share of Israeli trade) is the trade intensity of Israel with its different partners. We define the trade intensity between countries i and j in year t as $Trade_{ijt}/((GDP_{it}GDP_{jt})^{0.5}$ where $Trade_{ijt}$ is the volume of trade and GDP_{it} is Gross Domestic Product of country i in year t (and similarly for country j). Note that this measure is scale-free.[17] The third panel of Table 1 reports the evolution of the trade intensity, reporting the average value of trade intensity for countries within each group for each of the time periods. As can be seen, the trade intensity with the EU-9 increased in the period 1975-1984, following the Israel-EU FTA, and rose further in the early 1990s. The trade intensity with Greece-Spain-Portugal followed a similar (though a bit more gradual) pattern, likely because these countries joined the EU in two different years. As for the trade intensity with Austria-Finland-Sweden and Norway-Iceland-Switzerland, it also increased over time, but by a lesser amount than in the first two groups. Moreover, the Israel-EFTA agreement seemed to have had little or no effect on the trade intensity with those countries. The trade intensity with the US increased the slowest over our sample period, though the US-Israel agreement seemed to have provided a small boost. Finally, the trade intensity with the rest of the world was roughly constant until 1993, at which point it increased sharply following the conclusion of the Uruguay round.

To determine whether these descriptive statistics are consistent with our theoretical framework, formal econometric analysis is necessary. It is essential to control for overall changes in the propensity to trade, and to estimate (rather than impose) the elasticity between output and trade. Moreover, statistical analysis will allow us to disentangle trade effects that are due to the subsequent addition of spokes and those that are due to delays or lags in the trade effects of earlier

[17] Other recent research defines trade intensity by the ratio $Trade_{ijt}/((GDP_{it}GDP_{jt})$ for the purpose of generating a dependent variable that incorporates the gravity restriction of unitary elasticity of trade volume with respect to a trading partner's GDP (see, for instance, Baier and Bergstrand (2006)). This measure is not scale-free, and thus not appropriate as a summary descriptive measure of trade intensity.

agreements.

4.3 Econometric methodology

Our econometric model adopts a differences-in-differences treatment effects approach in identifying the effect of trade agreements. Our dependent variable is log of bilateral trade, while as independent variables we incorporate country pair fixed effects, year fixed effects, a number of treatment variables (trade agreement dummies), and the log of the product of the trade partners' GDPs. The inclusion of both year and pair fixed effects allows us to identify the effect of the different Israeli trade agreements on trade between the countries that are members of a preferential trade agreement. Say we want to measure the effect of the Israel-EU agreement of 1975 on trade between Israel and the EU. In that case, we would estimate how trade between Israel and the EU member states changed before and after 1975, *relative* to how trade between Israel and all other countries changed before and after 1975. When doing so, we control for changes in the GDPs of the two countries.

The use of year and country pair fixed effects allows us to address a number of concerns. Year fixed effects account for any possible changes over time in Israeli trade with the rest of the world. Country pair fixed effects control for any permanent features of Israel's trade partners that may affect trade between them: physical distance, transportation, culture, immigration links, and others. Furthermore, country pair dummies also address a possible endogeneity concern. If free trade agreements are systematically related with unobserved country (or country pair)[18] characteristics, the coefficients of agreement dummies would yield biased estimates of the true effects of these agreements if country pair dummies were not included.[19,20] A remaining concern is time-varying endogeneity. However, we discuss later why this is not likely to be an issue, and in fact is inconsistent with our results.

Exclusively focusing on country pairs that involve Israel removes possible confounding effects.

[18] Given that we focus exclusively on country pairs that involve Israel, country pair dummies are the same as country dummies.

[19] See Baier and Bergstrand (2006) and Baltagi, Egger, and Pfaffermayr (2003) for a further discussion.

[20] Notice that in what follows we estimate agreement effects for particular country pairs, and thus make no claim on the effect of any future trade agreements of Israel. Thus, our analysis is not subject to the critique that current agreements may provide upward biased predictions for the effects of future agreements because Israel selected its early agreements amongst the most promising set of candidates.

Year dummies now reflect only the secular change in Israeli trade, rather than the average secular change between any country pair. Likewise, the GDP elasticities measure the impact of GDP changes on Israeli trade, rather than a global average. Moreover, using only country pairs that include Israel does away with any possible effects from not correctly accounting for all trade agreements between third countries. Given the large number of observations per year that involve Israel, any associated loss of efficiency from omitting non-Israeli flows would be minimal, and would likely be overwhelmed from biases arising from the above factors.

Given the likely differences in variability in country flows across partners and years and the resulting likely serial correlation in the error process, we adopt the recommendations of Bertrand, Duflo, and Mullainathan (2004) for obtaining appropriate standard errors. In particular, we compute standard errors with the two approaches that have been shown by Bertrand et al. (2004) to perform best for treatment effects panel data: (i) using White's heteroskedasticity consistent covariance matrix, adjusted for taking arbitrary within panel correlation into consideration, and (ii) using a covariance matrix based on block bootstrap in which entire histories of countries are sampled with replacement.[21] The two sets of standard errors are very similar, within ten percent of each other, with those based on the block bootstrap generally being the larger of the two. The only exception are the parameter estimates for the United States agreements, which are 50 to 80 percent higher under the bootstrap.[22] In the tables, we report the more conservative bootstrap standard errors and tests.

4.4 Results

Effects of FTAs on member countries

[21] We have also supplemented these with AR(1)-GLS estimation in some of the analysis, which is a third but less well performing approach discussed in Bertrand, Duflo, and Mullainathan (2004). Statistical significance of the hub-and-spoke effects is somewhat reduced compared to the levels reported here, and ranges, depending on specification, from approximately the 5 to the 10 percent level.

[22] We have used 20,000 replications to compute the block bootstrap covariance matrix. Standard errors for individual countries are computed from the subset of replications in which that individual country is included in the bootstrap sample. Covariances between two country dummy variables (and by extension test statistics involving multiple parameters) are computed from the subset of replications in which both countries are included in the bootstrap sample. To ensure that our estimates are precise, we computed two additional sets of block bootstrap standard errors and chi-squared statistics using different random number seeds. Standard errors are generally within ± 0.001 of each other and chi-squared statistics within 2% of each other across the three sets of replications. Chi-squared test significance does not depend on the choice of bootstrap covariance variance.

We start by analyzing the direct effect of FTAs on trade flows between Israel and the member countries. In other words, we estimate the average percentage increase in trade flows due to each of Israel's three trade agreements (EU, US and EFTA) relative to pre-agreement levels. We control for changes in the trade flows with non-agreement countries and changes in economic activity. In particular, we estimate the model

$$\begin{aligned} \log(Trade_{ijt}) &= \beta_{EU} FTA_{ijt} EU_{jt} + \beta_{US} FTA_{ijt} US_j + \beta_{EFTA} FTA_{ijt} EFTA_{jt} \\ &\quad + \alpha \log(GDP_i GDP_j) + u_{ij} + v_t + e_{ijt} \end{aligned} \tag{24}$$

where FTA_{ijt} is an indicator variable that takes the value of 1 if there is a free trade agreement in effect between Israel (country i) and country j in year t, EU_{jt} takes the value of 1 if country j is a member of the EU in year t, US_j is an indicator variable for the United States, $EFTA_{jt}$ takes the value of 1 if country j is a member of EFTA in year t, u_{ij} are country pair fixed effects, v_t are year fixed effects, and e_{ijt} is a random variable that captures transient factors that affect trade.

The results, which are reported in Table 2 (Model 1), show that both the EU and the US trade agreements led to a considerable increase in bilateral trade flows with Israel. Compared to the period before 1975, trade with the EU went up 81% after the signing of the Israel-EU agreement ($e^{0.5953} - 1 \approx 0.81$). In the case of the US, the effect of the 1985 FTA was even bigger: trade went up by 96% ($e^{0.6719} - 1 \approx 0.96$). In contrast, the Israel-EFTA trade agreement of 1993 appears to have had a negative (though not statistically significant at the 5% level) effect on trade. The reason for this is likely to have been the overall trade liberalization with the rest of world due to the successful conclusion of the Uruguay round in 1994. As is well known (see Hoekman and Kostecki 2001) the effect of the Uruguay round was to lead developing countries to increase the average share of tariffs line bound by WTO rules from 22% to 72%, while transition economies increased the share of bound items from 73% to 98% and developed countries from 78% to 99%. As a result, the trade liberalization effect of the Uruguay round on trade between Israel and the rest of the world is likely to have been greater than the effect of the Israel-EFTA agreement on trade between Israel and the EFTA countries. This is consistent with the figures in Table 1. The trade intensity between Israel and the rest of the world grew strongly after 1993, not only in absolute terms, but also relative to its trade with other countries. It is this relative growth which can explain the negative coefficient on trade with EFTA.

Table 2. Effect of Israeli Trade Agreements on Bilateral Trade Flows.

Trade Agr. and Other Parameters:		Model 1		Model 2		Model 3		Model 4	
Trade Partner	Time Period	Parameter	Standard Error	Parameter	Standard Error	Parameter	Standard Error	Parameter	Standard Error
European Union	1975-1979	0.5953	0.1968	0.5235	0.1558	0.5770	0.1451	0.5779	0.1445
	1980-1984							0.4736	0.1885
	1985-1989			0.7762	0.2340	0.5987	0.2137	0.7165	0.2286
	1990-1992							0.8712	0.2615
	1993-1997			0.4519	0.2473			0.4518	0.2474
United States	1985-1989	0.6719	0.3448	0.7851	0.3985	0.7379	0.3745	0.7526	0.3819
	1990-1992					0.6316	0.3322	0.8385	0.4327
	1993-1997			0.5079	0.2813			0.5076	0.2812
EFTA	1993-1997	-0.3566	0.3989	-0.3830	0.4034	-0.3565	0.3998	-0.3831	0.4033
log(GDPi GDPj)		0.9698	0.3119	0.9696	0.3121	0.9698	0.3121	0.9680	0.3122
R-squared		0.8459		0.8460		0.8459		0.8460	
Observations		3,755		3,755		3,755		3,755	
Chi-squared statistics and p-values:									
Year Fixed Effects		139.03	0.0000	141.93	0.0000	136.99	0.0000	140.35	0.0000
Pair Fixed Effects		181.05	0.0070	180.29	0.0077	180.89	0.0071	180.23	0.0078
Hub-and-Spoke Effects				7.82	0.0499			10.72	0.0133
Lagged Agreement Effects						1.23	0.5404	2.06	0.5594

Notes: Parameter estimates for 47 year and 138 country-pair indicator variables are omitted and joint test of significance are reported for all four models. Standard errors are based on block bootstrap (20000 replications resampling entire country pair histories). Standard errors based on White's heteroskedasticity consistent covariance matrix adjusted for temporal correlation within country pairs are nearly identical and typically differ in the third significant digit.See text for further discussion on standard errors.

Hub-and-spoke effects of FTAs

In Table 2 (Model 2) we assess the existence of hub-and-spoke effects of the US-Israel FTA, and further analyze the effects of the EFTA-Israel agreement and the conclusion of the Uruguay round. In particular, we allow for the EU-Israel trade agreement to have a different impact on bilateral trade in the 1975-1984 period (during which Israel had no other agreements), in the 1985-1992 period (during which Israel had a second trade agreement with the US), and in the 1993-1997 period (during which Israel added an agreement with EFTA and liberalized trade with the rest of world). Similarly, for the US-Israel agreement we distinguish between 1985-1992 and 1993-1997. The estimated model is

$$\begin{aligned} \log(Trade_{ijt}) &= FTA_{ijt}EU_{jt}[\beta_{EU1}I_{t\in[75-84]} + \beta_{EU2}I_{t\in[85-92]} + \beta_{EU3}I_{t\in[93-97]}] \\ &+FTA_{ijt}US_{j}[\beta_{US2}I_{t\in[85-92]} + \beta_{US3}I_{t\in[93-97]}] + \beta_{EFTA}FTA_{ijt}EFTA_{jt} \\ &+\alpha\log(GDP_iGDP_j) + u_{ij} + v_t + e_{ijt} \end{aligned} \tag{25}$$

where $I_{t\in[y1-y2]}$ are indicator variables that take the value of 1 if the year is between $y1$ and $y2$.

The agreement between Israel and the US in 1985 turned Israel into a hub, and the EU and the US into spokes. According to Proposition 3, we would expect this to have increased trade between Israel and the EU. Our estimates support this view. The coefficient on EU-Israel trade increased from 0.5235 for the period 1975-1984 to 0.7762 for the period 1985-1992. This implies an increase in EU-Israel trade by 29% between these two periods ($e^{0.7762-0.5235}-1 \approx 0.29$).

The subsequent further liberalization between Israel and EFTA in 1993 amounted to a move towards more 'global' free trade between Israel and the EU. Indeed, since the EU already had an agreement with EFTA, dating back to 1973, the FTA between Israel and EFTA led to multilateral free trade between the three of them. Consistent with Proposition 5, this should imply a decrease in trade between Israel and the EU. Note that we expect the conclusion of the Uruguay round in 1994 to have had similar effects. By liberalizing trade with the rest of the world, it can likewise be interpreted as a move towards more 'global' free trade. As suggested by Proposition 1, this should reduce trade between existing members of FTAs, such as between Israel and the EU or between Israel and the US. These predictions are borne out by our regressions. The coefficient on EU-Israel trade fell from 0.7762 for the period 1985-1992 to 0.4519 for the period 1993-1997. This amounts to a 28% drop in trade. US-Israel trade also fell after 1993, by a similar proportion.

To test for the joint significance of the hub-and-spoke effects, we test for the constancy of parameters across periods for each of the trade agreements (i.e., whether $\beta_{EU1} = \beta_{EU2} = \beta_{EU3}$ and $\beta_{US2} = \beta_{US3}$). We find that the hub-and-spoke effects are statistically significant at the 5 percent level.

Delayed effects of FTAs

One may be concerned that the increase in EU-Israel trade following the US-Israel agreement is driven by the delayed effect of the EU-Israel agreement, and not by hub-and-spoke effects. In Table 2 (Model 3) we test for this possibility by removing the hub-and-spoke effects, and replacing them by delayed free trade agreement effects. In particular, we allow the effect of a trade agreement to be different in the first 5 years after its formation and in the subsequent years. This yields the specification

$$\begin{aligned} \log(Trade_{ijt}) &= FTA_{ijt}EU_{jt}[\beta_{EU1}I_{t\in[75-79]} + \beta_{EU2}I_{t\in[80-97]}] \\ &\quad + FTA_{ijt}US_j[\beta_{US2}I_{t\in[85-89]} + \beta_{US3}I_{t\in[90-97]}] + \beta_{EFTA}FTA_{ijt}EFTA_{jt} \\ &\quad + \alpha\log(GDP_iGDP_j) + u_{ij} + v_t + e_{ijt} \end{aligned} \tag{26}$$

The estimates show that delayed effects are not important, and of the "wrong" sign in the case of the US-Israel agreement. In any event, they are not jointly statistically significant on the basis of a chi-squared test of $\beta_{EU1} = \beta_{EU2}$ and $\beta_{US2} = \beta_{US3}$. This conclusion is not affected if we distinguish between the first 3 and the subsequent years of a trade agreement.

Hub-and-spoke and delayed effects of FTAs

In Table 2 (Model 4) we incorporate both delayed effects and hub-and-spoke effects by appropriately partitioning the time periods using the regression

$$\begin{aligned} \log(Trade_{ijt}) &= FTA_{ijt}EU_{jt}[\beta_{EU1}I_{t\in[75-79]} + \beta_{EU2}I_{t\in[80-84]} + \beta_{EU3}I_{t\in[85-89]} \\ &\qquad + \beta_{EU4}I_{t\in[90-92]} + \beta_{EU5}I_{t\in[93-97]}] \\ &\quad + FTA_{ijt}US_j[\beta_{US3}I_{t\in[85-89]} + \beta_{US4}I_{t\in[90-92]} + \beta_{US5}I_{t\in[93-99]}] \\ &\quad + \beta_{EFTA}FTA_{ijt}EFTA_{jt} + \alpha\log(GDP_iGDP_j) + u_{ij} + v_t + e_{ijt} \end{aligned} \tag{27}$$

The delayed effects are not significant, but the hub-and-spoke effects remain so. In fact, their

statistical significance is at the 1.33% level.[23] Moreover, the hub-and-spoke parameter estimates remain essentially unchanged from those in Model 2: the effect of the formation of the US-Israel trade agreement on EU-Israel trade is similar in the two models, and so are the effects of the EFTA-Israel FTA and the conclusion of the Uruguay round on Israel-EU and Israel-US trade.

Notice that this pattern of results is inconsistent with any plausible correlation of time varying unobservable variables with the formation of the trade agreements (time constant unobservables are absorbed by the country-pair fixed effects). The concern with time-varying endogeneity is that a pair of countries sign an agreement when the trade propensity between them is likely to become stronger anyway. If that were the case, then the parameter estimates of Model 3 would exhibit negative delayed effects, in the sense that the effect of an FTA on bilateral trade would be strong initially, but weaken over time. This is certainly not the case. Moreover, time varying endogeneity would be a concern for our hub-and-spoke parameter estimates reported in Model 2 (and also 4) if Israel signs an agreement with a country when the trade propensity with countries subject to prior agreements becomes stronger; this is a truly unlikely proposition (and if it were true, it would render our theory untestable).

Changing membership of EU and EFTA

One possible confounding factor in the above analysis is that membership of the EU and EFTA changed over time. If the effects of a free trade agreement between Israel and other countries vary by country, then changes in the effect of a trade agreement between Israel and the EU (or EFTA) may be driven by changes in the composition of the members of the EU (or EFTA). To examine the empirical relevance of this issue, we re-estimate variants of the four models described above, keeping the composition of the EU and EFTA fixed. In particular, we distinguish between the nine members of the EU as of 1975 (henceforth denoted as EU9), the three Mediterranean countries that joined the EU in 1981 and 1986 (Greece, Spain, and Portugal, henceforth denoted as MEDIT), the United States, and the six countries that were members of EFTA in 1993 (henceforth denoted as EFTA6). The first regression, which parallels (24), estimates the average (over time) effect of

[23]The statistical significance of delayed effects is obtained from the chi-squared of the joint test of the following three parameter restrictions: $\beta_{EU1} = \beta_{EU2}$ and $\beta_{EU3} = \beta_{EU4}$ and $\beta_{US3} = \beta_{US4}$. The statistical significance of the hub-and-spoke effects is obtained from the chi-squared of the joint test of the following three parameter restrictions: $\beta_{EU2} = \beta_{EU3}$ and $\beta_{EU4} = \beta_{EU5}$ and $\beta_{US4} = \beta_{US5}$.

free trade agreements of Israel with each of these country groups, and is given by

$$\begin{aligned}\log(Trade_{ijt}) &= \beta_{EU9}FTA_{ijt}EU9_j + \beta_{MEDIT}FTA_{ijt}MEDIT_j + \beta_{US}FTA_{ijt}US_j \\ &\quad +\beta_{EFTA6}FTA_{ijt}EFTA6_j + \alpha\log(GDP_iGDP_j) + u_{ij} + v_t + e_{ijt}\end{aligned} \tag{28}$$

where $EU9_j$ is an indicator variable for the nine members of the EU as of 1975, $MEDIT_j$ is an indicator variable for Greece, Spain, and Portugal, $EFTA_j$ is an indicator variable for the six EFTA members as of 1993, and the other variables are as defined previously. Notice that the country group indicator variables are no longer indexed by t, as they are of constant composition over time. When comparing Model 1 in Table 3 to Model 1 in Table 2, the results are very similar. This suggests that our previous results are not due to changes in the composition of the EU and EFTA.

The second regression reported in Table 3 parallels equation (25) in that the effect of trade agreements are allowed to vary as new major agreements are signed between Israel and other parties. As can be seen in Table 3 Model 2, the break points are the same as those of equation (25).[24] The pattern of coefficients is similar to that of Table 2 Model 2: the effect of the FTA with EU9 is economically and statistically significant for the 1975-1984 period, increases with the formation of the Israel-US agreement (which coincides with the Israel agreement with Spain and Portugal), and decreases in 1993 with the formation of the Israel-EFTA agreement (which coincides with the conclusion of the Uruguay round). The effect of the trade agreement with the US is strong but declines after the formation of the 1993 agreements, while that with Spain, Greece, and Portugal is constant throughout the period. The hub-and-spoke effects are jointly statistically significant, even more so than in the results reported in Table 2.

The third and fourth regressions reported in Table 3 parallel those of Model 3 and 4 in Table 2 and examine the possibility that these results are driven by delayed effects of the different trade agreements. The parameter estimates and tests of these two regressions show lagged agreement effects are not statistically significant, neither when they are on their own nor when they are estimated jointly with the hub-and-spoke effects. In contrast, the hub-and-spoke effects remain statistically significant when estimated jointly with lagged effects.

[24] In other words, we do not treat the entry of Greece and of Spain and Portugal in 1981 and 1986, respectively, as distinct events. The reason is that the entry of Greece is very insignificant, and that of Spain and Portugal is only one year later than the far more important US-Israel agreement.

Table 3. Effect of Israeli Trade Agreements on Bilateral Trade Flows - Fixed Group Composition.

Trade Agr. and Other Parameters:		Model 1		Model 2		Model 3		Model 4	
Trade Partner	Time Period	Parameter	Standard Error	Parameter	Standard Error	Parameter	Standard Error	Parameter	Standard Error
EU-9	1975-1979	0.6347	0.1991	0.5487	0.1714	0.5976	0.1587	0.5975	0.1562
	1980-1984							0.5060	0.2058
	1985-1989			0.8257	0.2276	0.6452	0.2198	0.7723	0.2235
	1990-1992							0.9018	0.2568
	1993-1997			0.5037	0.2710			0.5036	0.2707
Greece, Spain, Portugal	1986-1990	0.6946	0.5111	0.7234	0.4956	0.6006	0.4922	0.6411	0.4884
	1991-1992					0.7851	0.5342	0.9196	0.5227
	1993-1997			0.7277	0.5475			0.7276	0.5475
United States	1985-1989	0.6702	0.3442	0.7864	0.3992	0.7401	0.3758	0.7537	0.3825
	1990-1992					0.6293	0.3316	0.8398	0.4334
	1993-1997			0.5078	0.2814			0.5075	0.2813
EFTA-6	1993-1997	-0.3051	0.3212	-0.3180	0.3266	-0.3010	0.3231	-0.3182	0.3265
log(GDPi GDPj)		0.9614	0.3141	0.9634	0.3145	0.9614	0.3143	0.9617	0.3145
R-squared		0.8460		0.8461		0.8460		0.8462	
Observations		3,755		3,755		3,755		3,755	
Chi-squared statistics and p-values:									
Year Fixed Effects		139.35	0.0000	141.74	0.0000	137.80	0.0000	140.37	0.0000
Pair Fixed Effects		180.84	0.0072	179.29	0.0089	180.88	0.0071	179.18	0.0090
Hub-and-Spoke Effects				12.55	0.0137			12.60	0.0134
Lagged Agreement Effects						5.23	0.1555	2.21	0.5305

Notes: Parameter estimates for 47 year and 138 country-pair indicator variables are omitted and joint test of significance are reported for all four models. Standard errors are based on block bootstrap (20000 replications resampling entire country pair histories). Standard errors based on White's heteroskedasticity consistent covariance matrix adjusted for temporal correlation within country pairs are nearly identical and typically differ in the third significant digit.See text for further discussion on standard errors. EFTA-6 includes Austria, Finland, Iceland, Norway, Sweden, and Switzerland. Greece joined the EU, and thus because party to a Free Trade Agreement with Israel on 1981; the effect of that agreement for the 1981-1985 is reflected in the chronologically earilest coefficient of the "Greece, Spain, Portugal" variable.

5 Conclusions

In this paper we have developed a simple framework to study the effects on trade volumes and welfare of membership in multiple free trade agreements when countries differ in their comparative advantage. We have considered two main scenarios, starting from an initial configuration in which two countries are member of a free trade arrangement, while trade with third parties is restricted by means of a non-prohibitive MFN tariff. In the first scenario, one country turns into a hub by becoming member of multiple free trade agreements, while the other becomes a spoke. In this case trade between the hub and the spoke increases, while welfare rises in the hub and falls in the spoke. In the second scenario, both countries sign a free agreement with a third party. In this case we have a multilateral free trade area, and trade between the two original member countries decreases, while welfare increases in both.

We have then brought our model to the data, using Israel as a case study. Israel's experience fits our model well because this country has been active in using bilateral agreements as a tool to expand its trade flows since the early seventies. Furthermore, Israel's decisions to enter its various agreements are far enough apart in time to allow us to disentangle their individual effects. Our empirical analysis finds robust evidence suggesting that the Israel-US free trade agreement of 1985 turned the country into a hub, as was hoped for by the Israeli business groups that favored this initiative.

The analysis carried out in the paper can be extended in several directions. On the theory side, the model could be generalized to include an arbitrary number of countries that differ in their comparative advantage. On the empirical side, when longer time series on trade flows become available, it should be interesting to look for hub-and-spoke effects using disaggregate industry-level data. Finally, as the 'spaghetti bowl' has become an increasingly relevant phenomenon in the last few years, in the near future more countries are likely to exhibit a pattern similar to Israel, and a more general study of the phenomenon will be feasible.

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