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Hub-and-spoke free trade areas: theory and evidence from Israel

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HUB-AND-SPOKE FREE TRADE AREAS:

THEORY AND EVIDENCE FROM ISRAEL*

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Abstract

We study how the sequential formation of free trade areas affects trade flows between member countries. In a three–country, three–good model of comparative advantage if two countries have an FTA, and both sign a similar agreement with the third, trade between the two decreases. However, if only one of them signs an additional FTA, a hub- and-spoke pattern arises, and trade between the initial members increases. Israel's experience lends strong support to our model: trade between Israel and the EU, subject to an FTA since 1975, increased by an additional 29% after the introduction of the US-Israel FTA in 1985.

JEL Classification: F11, F13.
Keywords: Free trade areas, hub-and-spoke, Israel, trade flows.

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"The agreements with the European Union [and] the United States ... 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.

1 Introduction

Until the end of the 1990s Israel was the only country in the world to have comprehensive free trade agreements (FTAs) with both the United States and Europe. The Israeli business community perceived this unique position to be highly beneficial, since it allowed the country to act as a bridge between the US and the EU. In the absence of rules of origin, this point of view can be easily understood: Israel could import goods tariff-free from the United States, and re-export them, again tariff-free, to Europe (and vice versa). This would lead to *de facto* free trade between the three partners, but most trade would pass through Israel, making the country a trading hub. Importantly though, real world FTAs are subject to rules of origin, and as a result Israel was not in the position to simply re-export US goods tariff-free to the EU. The Israeli business community is unlikely to have overlooked the role played by rules of origin in an FTA. The question is then whether there is still a positive trade effect from being part of multiple separate free trade areas if rules of origin apply. More specifically, if two countries have an FTA between them, and one of them signs an FTA with a third partner, does this increase trade flows between the original two? This is an important question, which so far has not been systematically addressed by the literature, and which is likely to become even more relevant as the number of hub-and-spoke arrangements continues to grow (World Bank (2005)).

Recent work by Anderson and van Wincoop (2003) suggests that the Israeli business community might be wrong: trade between two countries depends on *relative*, rather than *absolute*, trade barriers. Given that Israel already had free trade with the European Union, liberalizing with the US made trade with the EU *relatively* less free, implying a reduction in trade flows between Israel and Europe. However, as earlier theoretical work by Kowalczyk and Wonnacott (1992) has already shown, the answer may be more complex: adding a new spoke could increase or decrease trade between the original partners, depending on whether the new FTA is a *substitute* or a *complement* to the existing one.

In this paper we build on the work by Kowalczyk and Wonnacott (1992) and propose a specific mechanism to suggest that, even if rules of origin apply, trade volumes between existing partners is likely to expand when one of them signs an FTA with a third country. In particular, we develop a three-country, three-good specific factors model, in which countries share identical preferences and produce all three goods, but because of asymmetric factor endowments each of them has a comparative advantage in a different product. Starting from a bilateral FTA between two countries, if both sign an FTA with the third, trade between the original two decreases. This is the Anderson and van Wincoop (2003) result. If, instead, only one of the two signs an FTA with the third, we get a hub-and-spoke arrangement, and trade between the original two increases. Although rules of origin preclude the hub from re-exporting imports from the original spoke to the new spoke, an indirect form of re-exporting is possible: the hub could increase its imports from the original spoke beyond what its own excess demand requires in order to export part of its home production to the new spoke.

We complement our theoretical findings with empirical evidence on the existence of hub-and-spoke effects. To carry out our analysis, we need to focus on countries that have signed multiple agreements with different partners at different times. Isolating the impact of a hub-and-spoke arrangement requires two additional conditions to hold. First, to credibly identify the effect of an FTA from background noise, the time lags between the different agreements signed by a country need to be sufficiently long. For example, although some of the agreements of the last ten years have given rise to hub-and-spoke arrangements (World Bank (2005)), the explosion in the number of FTAs starting at the end of the 1990s makes it virtually impossible to isolate the effect of any of those recent individual agreements. Second, to get a hub-and-spoke situation, existing trading partners should not simultaneously sign agreements with the same third country. For example, when both the US and Canada, who already had free trade between each other, signed an FTA with Mexico, giving rise to NAFTA, this did not lead to a hub-and-spoke situation.

For these reasons, the Israeli experience is unique: between 1975 and 1993 the country signed three major trade agreements, with on average a decade elapsing between each one of them. After establishing an FTA with the European Union in 1975, Israel signed a second agreement with the United States in 1985. In the terminology of our paper, this turned Israel into a hub, with the EU and the US being the spokes. It took nearly one more decade, until 1993, for Israel to sign a third FTA, providing a long enough time lag to identify the effect of the Israel-US agreement on Israel-EU trade.

To estimate how the position of Israel as a hub affected its trade with the EU, we start by considering aggregate trade flows and use a differences-in-differences approach within a gravity equation framework. Consistent with our theoretical model, we find that the Israel-US trade agreement increased trade between Israel and the EU by 29%. There is also strong support for the predictions of our model at the sectoral level. For example, for sectors in which the EU has comparative advantage, we find that net imports from the EU and net exports to the US both increase. Quantitatively the hub-and-spoke effects are large: it changes the sectoral composition of Israeli trade with the EU and the US by approximately 14%.

Given our use of the Israeli experience as an illustrative example, it is important to point out that a hub need neither be a large country, nor does it have to represent a substantial fraction of the trade volume of its partners. Indeed, agreements signed by a small hub will obviously have a small effect on the trade flows of its large trade partners, but they will have a substantial effect on the small country's own patterns of trade. For this reason, our empirical analysis focuses on Israeli trade volumes, and not on the effect on EU-US trade: any such effect is likely to be negligible.

We are not the first to explore the theoretical intricacies of hub-and-spoke arrangements.[1] Besides the important contribution of Kowalczyk and Wonnacott (1992) already mentioned, Kowalczyk (2000) develops a general model to study the welfare effects of membership in a preferential trading arrangement. Our analysis, instead, focuses on the effect of hub-and-spoke arrangements on trade volumes. 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. 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. Once again, they do not discuss the effects on trade volumes. Baldwin (2008) on the other hand, highlights the political economy risks connected to the presence of hub-and-spoke arrangements.

Recent work has analyzed the endogenous formation of regional agreements (Cadot, de Melo and Olarreaga (1999) and Cadot, de Melo and Olarreaga (2001)), and the optimal setting of tariffs (Ornelas (2005)). Given that our focus is on assessing the hub-and-spoke effects on trade volumes, rather than on welfare, 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.

Although there is a large empirical literature that has used the gravity equation to assess the effects of preferential trading arrangements on bilateral trade (e.g. Frankel (1997), Anderson and van Wincoop (2003), Ghosh and Yamarik (2004) and Baier and Bergstrand (2007)), so far it has not investigated the importance of hub-and-spoke situations. Our paper is one the first to empirically explore how hub-and-spoke free trade areas affect trade flows.[2]

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 presents the theoretical results of the paper, comparing trade volumes under different trading arrangements. In Section 4 we carry out our empirical analysis. Section 5 concludes the paper.

2 The model

In this section we develop a three-country, three-good model to study the trade volume effects of different FTA configurations (bilateral FTA, multilateral FTA and hub-and-spoke). The source of trade in our model are differences in factor endowments. When going from a bilateral FTA to a hub-and-spoke arrangement, indirect arbitrage can lead to an increase in trade between existing trade partners, giving rise to trade agreements being *complementary* (see Kowalczyk and Wonnacott (1992)). Since our empirical analysis focuses on Israel and its relations with the EU and the US, the model is kept general enough to allow for size asymmetries.

2.1 Model setup

Consider a perfectly competitive economy with three countries, indexed by superscripts $j =$ N (North), S (South) and M (Middle) and three goods, indexed by subscripts $i = 1, 2, 3$. Each country is populated by a mass γ^j of homogeneous agents, each supplying one unit of labor. In addition to labor, which is free to move across sectors, each country is endowed with three sector specific inputs:

$$\begin{aligned} \{K_1^N, K_2^N, K_3^N\} &= \gamma^N(1+\alpha, 1, 1) \\ \{K_1^S, K_2^S, K_3^S\} &= \gamma^S(1, 1+\alpha, 1) \\ \{K_1^M, K_2^M, K_3^M\} &= \gamma^M(1, 1, 1+\alpha) \end{aligned} \tag{1}$$

Good i is produced according to a Cobb-Douglas technology, combining labor and the sector specific input K_i:

$$Q_i^j = \gamma^j L_i^{j\beta} K_i^{j(1-\beta)} \tag{2}$$

where Q_i^j is the total production of good i in country j, and $0 \leq \beta < 1$. Technologies are identical across countries and neither labor nor the sector specific factors can move between countries. Consumers share the same preferences given by:

$$u(c_1, c_2, c_3) = c_1 c_2 c_3 \tag{3}$$

The differences in the endowments of the specific factors underlie the pattern of comparative advantage. North and South are 'competing importers' from the point of view of the Middle, whereas their exports are 'complements' to each other.

Trade barriers take Samuelson's 'iceberg' form.[3] In particular, a tariff τ^{jk} implies that $1 + \tau^{jk}$ units of a good have to be shipped from country j to country k for 1 unit to arrive. Let q_i^j be the price received by a producer in country j for each unit i he sells, 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 differ 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.

Labor mobility across sectors implies a single equilibrium wage level in each country j:

$$w^j = q_1^j \gamma^j \beta L_1^{j(\beta-1)} K_1^{j(1-\beta)} = q_2^j \gamma^j \beta L_2^{j(\beta-1)} K_2^{j(1-\beta)} = q_3^j \gamma^j \beta L_3^{j(\beta-1)} K_3^{j(1-\beta)} \tag{4}$$

and labor market clearing requires that

$$L_1^j + L_2^j + L_3^j = \gamma^j. \tag{5}$$

Aggregate income can be written as follows:

$$I^j = q_1^j Q_1^j + q_1^j Q_2^j + q_3^j Q_3^j \tag{6}$$

Utility maximization implies that total consumption of good i in country j is:

$$C_i^j = \frac{I^j}{3p_i^j} \tag{7}$$

2.2 The starting point: bilateral FTA

We start by considering the effect of a *bilateral FTA* between two countries, say N and M. Under such an agreement, N and M have free trade between each other, while a uniform MFN tariff $\tau > 1$ is applied on trade between all other countries. We take MFN tariffs to be non–prohibitive, and further assume that model's parameters are such that each country exports exactly one good to all other countries.

In the absence of a hub, in each country there cannot be a difference between the price received by producers and that paid by consumers. As a result

$$q_i^j = p_i^j \tag{8}$$

for all i, j. Free trade between N and M implies that $p_i^M = p_i^N$. We normalize $p_1^N = p_1^M = 1$. 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 then $p_1^S = 1+\tau$, p_2^S and $p_3^S = p_3^M(1+\tau)$. To simplify notation, we write $p_2^S = p_2$ and $p_3^M = p_3$. Summarizing, this gives us

$$\begin{aligned}
p_1^N &= p_1^M = 1 \\
p_2^S &= p_2 \\
p_3^N &= p_3^M = p_3 \\
p_2^N &= p_2^M = (1+\tau)p_2 \\
p_1^S &= 1+\tau \\
p_3^S &= (1+\tau)p_3
\end{aligned} \tag{9}$$

Trade needs to be balanced, so that for each country the value of exports should equal the value of imports.[4] For N, S and M we therefore have:

$$(1+\tau)(C_1^S - Q_1^S) + (C_1^M - Q_1^M) = p_3(C_3^N - Q_3^N) + p_2(1+\tau)(C_2^N - Q_2^N) \quad (10)$$

$$p_2(1+\tau)(C_2^N - Q_2^N + C_2^M - Q_2^M) = (1+\tau)(C_1^S - Q_1^S) + p_3(1+\tau)(C_3^S - Q_3^S) \quad (11)$$

$$p_3(C_3^N - Q_3^N) + p_3(1+\tau)(C_3^S - Q_3^S) = (C_1^M - Q_1^M) + p_2(1+\tau)(C_2^M - Q_2^M) \quad (12)$$

We are now ready to define a bilateral FTA equilibrium, with free trade between N and M and nonprohibitive tariffs between the other country pairs.

Definition 1 *A bilateral FTA equilibrium, with free trade between N and M and a uniform nonprohibitive tariff between the other country pairs, is a vector of elements* (C_i^{j*}, Q_i^{j*}, L_i^{j*}, p_i^{j*}, q_i^{j*})*, where* $i = \{1,2,3\}$, $j = \{N,S,M\}$, $\tau^{NM} = \tau^{MN} = 1$, *and* $\tau^{NS} = \tau^{SN} = \tau^{MS} = \tau^{SM} = \tau > 1$, *that satisfies conditions (2), (4), (5), (6), (7), (8), (9), (10), (11) and (12).*

In what follows equilibrium variables referring to the bilateral FTA will be denoted by a '*'.

To compare trade flows across different regimes, it is useful to compute the value of trade between N and M as a share of the income in M. Denote by x^{jk} the value of exports of country j to country k. After some algebraic manipulation it can be shown that

$$\left(\frac{x^{NM*}}{I^{M*}}\right) = \frac{C_1^{M*} - Q_1^{M*}}{I^{M*}} = \frac{1}{3} - \frac{1}{1 + (1+\alpha)p_3^{*\frac{1}{1-\beta}} + (p_2^*(1+\tau))^{\frac{1}{1-\beta}}} \quad (13)$$

In the case of symmetric countries ($\gamma^N = \gamma^S = \gamma^M$), bilateral trade is balanced, and equation (13) can be interpreted as the average of imports and exports as a share of GDP.

2.3 Expanding free trade symmetrically: multilateral FTA

If both member countries of the bilateral FTA introduce free trade with the third country, S, we get a *multilateral FTA*. In our three-country setting, this is equivalent to global free trade. To define a multilateral FTA, it suffices to set $\tau^{jk} = 1$ for all j,k in Definition 1. Therefore, we have

Definition 2 *A multilateral FTA equilibrium, with free trade between N, M and S, is a vector of elements* (C_i^{j**}, Q_i^{j**}, L_i^{j**}, p_i^{j**}, q_i^{j**})*, where* $\tau^{jk} = 1$, $i = \{1,2,3\}$, $j,k = \{N,S,M\}$, *that satisfies conditions (2), (4), (5), (6), (7), (8), (9), (10), (11) and (12).*

In what follows equilibrium variables referring to the multilateral FTA will be denoted by a '**'.

By analogy with (13), we can determine exports from N to M as a share of the income in M:

$$\left(\frac{x^{NM**}}{I^{M**}}\right) = \frac{C_1^{M**} - Q_1^{M**}}{I^{M**}} = \frac{1}{3} - \frac{1}{1 + (1+\alpha){p_3^{**}}^{\frac{1}{1-\beta}} + {p_2^{**}}^{\frac{1}{1-\beta}}} \tag{14}$$

This expression will be useful when comparing the importance of trade across different configurations.

2.4 Expanding free trade asymmetrically: hub-and-spoke

If only one member of the the bilateral FTA introduces free trade with the third country, S, we obtain a *hub-and-spoke FTA* 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 $\tau > 1$.

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, indirect arbitrage can arise: M can import good 1 from N to satisfy its own consumption, and export its own production of good 1 to S. Even though the two goods are identical, the imports are "made in N" and the exports are "made in M". By analogy, the same can happen with good 2. We turn next to analyze the effects of binding and nonbinding rules of origin.

Binding rules of origin with nonprohibitive tariffs

The ROOs are *binding* if at the multilateral FTA prices the demand for imports of good 1 in S exceeds the production of good 1 in M. As a result, the price of good 1 in S will be greater than in M: $p_1^S = q_1^M > p_1^M$. An analogous condition applies to demand for imports of good 2 in S. Since prices of identical goods are different across countries, consumption (and welfare) will not replicate the multilateral FTA outcome.

As in the bilateral FTA case, we assume MFN tariffs to be non–prohibitive, so that there will be positive trade between N and S. Because of the two FTAs and normalization, $p_1^N = p_1^M = p_1 = 1$ and $p_2^S = p_2^M = p_2$. If ROOs are binding and tariffs nonprohibitive, we have $p_2^N = q_2^M = (1+\tau)p_2$ and $p_1^S = q_1^M = 1 + \tau$. Since M freely exports good 3 to N and S,

$p_3^M = p_3^S = p_3^N$. Summarizing,

$$\begin{aligned}
p_1^N &= p_1^M = 1 \\
p_2^S &= p_2^M = p_2 \\
p_2^N &= q_2^M = (1+\tau)p_2 \\
p_1^S &= q_1^M = 1+\tau \\
p_3^N &= p_3^S = p_3^M = p_3
\end{aligned} \tag{15}$$

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

$$q_i^j = p_i^j \quad \text{if} \quad (i,j) \neq \{(1,M),(2,M)\} \tag{16}$$

Once again, trade needs to be balanced: for each country the value of exports equals the value of imports. Hence, for countries N, S and M, we have:

$$(1+\tau)(C_1^S - Q_1^M - Q_1^S) + C_1^M = p_3(C_3^N - Q_3^N) + p_2(1+\tau)(C_2^N - Q_2^N) \tag{17}$$

$$p_2(1+\tau)(C_2^N - Q_2^M - Q_2^N) + p_2 C_2^M = p_3(C_3^S - Q_3^S) + (1+\tau)(C_1^S - Q_1^S) \tag{18}$$

$$p_3(C_3^N - Q_3^N + C_3^S - Q_3^S) + (1+\tau)Q_1^M + (1+\tau)Q_2^M = C_1^M + p_2 C_2^M \tag{19}$$

We can now define a hub-and-spoke equilibrium, with binding ROOs and nonprohibitive tariffs between the spokes as follows

Definition 3 *A hub-and-spoke FTA equilibrium, with M being the hub, where ROOs are binding and tariffs nonprohibitive, is a vector of elements (C_i^{j***}, Q_i^{j***}, L_i^{j***}, p_i^{j***}, q_i^{j***}), where $i = \{1,2,3\}$, $j = \{N,S,M\}$, $\tau^{NS} = \tau^{SN} = \tau > 1$, and $\tau^{NM} = \tau^{MN} = \tau^{MS} = \tau^{SM} = 1$, that satisfies conditions (2), (4), (5), (6), (7), (15), (16), (17), (18) and (19).*

Equilibrium variables referring to the hub-and-spoke configuration with binding ROO will be denoted by '***'.

By analogy with (13), exports from N to M as a share of income in M are readily determined. Remember that under a hub-and-spoke arrangement with binding ROO, M imports all its consumption of good 1 from N, so that $x^{NM} = C_1^M = I^M/3$. Therefore,

$$\left(\frac{x^{NM***}}{I^{M***}}\right) = \frac{1}{3} \tag{20}$$

Nonbinding rules of origin

ROOs are *nonbinding* if at the multilateral FTA price p_1^{M**}, the demand for imports of good 1 in S is less than the production of good 1 in M. An analogous condition applies to the demand for imports of good 2 in N. If ROOs are nonbinding, indirect arbitrage eliminates all price differences across countries. In terms of prices and consumption levels, the outcome replicates the multilateral FTA. Although this implies that consumption and utility are the same as in the multilateral FTA case, trade flows are not. In contrast to the multilateral FTA, under a nonbinding hub-and-spoke arrangement indirect arbitrage makes all trade between the spokes go through the hub. As a result, there is *excess* trade, compared to what would happen with free trade among all countries. In particular, exports from M to N not only include good 3 (in which M has comparative advantage), but also good 2 (in which S has comparative advantage, but in which M plays the role of arbitrageur). In contrast, under a multilateral arrangement M would not export good 2; instead, N would buy good 2 directly from S. Intuitively, ROOs will be nonbinding if either comparative advantage is not too strong, or if the hub is big enough relative to the spokes.

3 Trade volumes across different trading arrangements

We now study how trade between a country pair changes as free trade expands to a third country. Since prices depend on the different trading configurations, for comparative statics purposes we focus on trade as a share of GDP. As is standard in the literature, by trade we mean the average of imports and exports. We start by studying the case of symmetric countries because it yields analytical results that illustrate the mechanism at work. Given that our empirical analysis focuses on the trade agreements of Israel with the EU and the US, we then numerically explore the implications of size asymmetries between the hub and the spokes.

3.1 Symmetric Countries

When countries are symmetric ($\gamma^N = \gamma^S = \gamma^M$), bilateral trade will be balanced under the three configurations of interest. We can then establish

Proposition 1 *Consider three configurations with non–prohibitive tariffs: a bilateral FTA between N and M; a multilateral FTA between N, M and S; and a hub-and-spoke arrangement with binding ROOs, with M being the hub. If $\gamma^N = \gamma^S = \gamma^M$, and $\tau > 0$, then*

1. *symmetric trade liberalization — going from a bilateral FTA to a multilateral FTA — reduces trade between N and M as a share of GDP in M;*

2. *asymmetric trade liberalization — going from a bilateral FTA to a hub-and-spoke arrangement — increases trade between N and M as a share of GDP in M.*

Proof. See Appendix A. ■

The first result of Proposition 1 says that going from a bilateral FTA to global free trade reduces trade between the original pair as a share of GDP. This is reminiscent of the Anderson and van Wincoop (2003) finding: by liberalizing trade with a third country, trade barriers between N and M increase compared to the average trade barriers of the two countries with all their other trading partners. This leads to a decline in trade between them. The second result suggests instead that going from a bilateral FTA to a hub-and-spoke arrangement increases trade as a share of GDP between the original two, as the hub can play the role of an indirect arbitrageur given that the two spokes have a comparative advantage in different goods.[5]

Our analysis thus suggests that expanding free trade to a third country has an ambiguous effect on bilateral trade volumes. When both N and M allow free trade with S, trade between N and M *decreases* as a share of GDP in M. However, if only M introduces free trade with S, trade between N and M *increases* as a share of GDP of M. As a result, the usage of the notion of *relative* trade barriers to study trade flows cannot be generalized: when *relative* trade barriers between two countries increase, trade between them may either increase or decrease, depending on the trade configuration with third countries. The excess trade associated with the hub-and-spoke setting arises because the exports of a spoke can be substituted by goods obtained from the hub. By satisfying its own consumption using imports from one of the spokes, the hub frees up its production of that good to export it to the other spoke.

Although the hub-and-spoke effect seems to depend on the hub being able to produce perfect substitutes for the goods in which the spokes have a comparative advantage, it is not necessary for the good "made in the hub" to be identical to the good "made in one of the spokes". In a more complex Krugman (1981) style model, with comparative advantage at the sectoral level, and monopolistic competition at the sub-sectoral level, the hub-and-spoke effect would survive. As long as varieties within the same sector are closer substitutes than varieties across different sectors, the same mechanism would be at work.

Note that the hub-and-spoke effect only arises if spokes have a comparative advantage in different goods. If different spokes were 'substitutes' and export the same goods, the excess trade would disappear, as already argued by Kowalczyk and Wonnacott (1992). In such a 'competing exporters' framework, there would be no reason for trade between the spokes, and the hub would no longer carry out indirect arbitrage.

3.2 Size asymmetries between hub-and-spokes

As we already argued, one particularly clean example of a hub-and-spoke arrangement arose when Israel signed a free trade agreement with the United States in 1985, turning the country into a hub between the US and the EU. Since our empirical analysis will focus on this example, it is important to analyze whether our theory generalizes to a setting in which the hub and the spokes are of different sizes.

The presence of size asymmetries complicates the analysis substantially, as trade no longer needs to be pairwise balanced. As a result, trade openness, measured by the average of exports and imports as a share of GDP, no longer corresponds to expressions (13), (14) and (20). We therefore explore the properties of the different trading configurations numerically. In what follows we provide a summary of the numerical results, and refer the interested reader to Appendix B for a more detailed discussion.

To maintain the analysis as general as possible, we focus on a broad parameter space. The crucial parameter values are the relative size differences and the strength of comparative advantage. We allow the hub to be between 100 times larger and 100 times smaller than the spokes. That is, normalizing γ_M to 1, we let γ_N (and γ_S) vary from 0.01 to 100. The strength of comparative advantage is captured by α. For example, an α of 1 implies that the relative endowment of specific factor i in the country that has comparative advantage in good i is 100%

larger than in the other countries. In our numerical experiments we let α vary between 0 and 3.5. The other parameters of our model, β and τ, play a limited role and do not substantially affect our results.

We confirm point 1 of Proposition 1, i.e., going from a bilateral FTA to global free trade reduces trade between the original members of the bilateral agreement. This is consistent with the well known result from the gravity literature. Of more interest is what happens when we move from a bilateral FTA to a hub-and-spoke arrangement. We broadly confirm the existence of a hub-and-spoke effect, except if both comparative advantage is very strong *and* the relative size of the spokes is very large. In particular, in our benchmark experiment, represented in Figure 1, the switch from a bilateral FTA to a hub-and-spoke arrangement increases trade between the original partners for any γ_N (and γ_S) between 0.01 and 100, as long as $\alpha < 2.4$. In other words, even if the spokes are, say, 100 times larger than the hub, we still get a hub-and-spoke effect, as long as a country's relative endowment in the specific factor corresponding to the sector in which it has comparative advantage is less than 240% greater than in the other countries.

[INSERT FIGURE 1 APPROXIMATELY HERE]

Although the hub-and-spoke effect occurs for a broad set of parameters, it is instructive to understand why it disappears when comparative advantage is strong *and* the spokes are much larger than the hub. The switch from a bilateral FTA to a hub-and-spoke arrangement has two effects. On the one hand, from the point of view of the hub, the relative trade barriers with its original trading partner increase, reducing the incentive to trade. On the other hand, the possibility of indirect arbitrage makes the hub more interested in trading with its original partner. If the relative price of the goods involved in this indirect arbitrage is low, this latter (positive) effect will be weak, so that the former (negative) effect may dominate. This is more likely to happen when the hub is very small relative to the spokes. In that case, the good in which the hub has a comparative advantage is relatively scarce. This decreases the relative price of the goods the spokes specialize in, so that the value of the additional trade induced through indirect arbitrage is relatively low. As a result, the hub-and-spoke effect may get overturned. This is especially true when comparative advantage is strong, because in this case the relative scarcity of the good the hub specializes in is exacerbated, thus further lowering the relative prices of the exports of the spokes.

Notice finally that although in some cases the hub-and-spoke effect may disappear, Corollary 1 always holds. Even for those parameter values that lead to a drop in trade under the hub-and-spoke arrangement, compared to the bilateral FTA, that drop will always be *less* than under the multilateral FTA.

4 Evidence from Israel

We are now ready to empirically assess the predictions of our model. The main objective is to evaluate whether the move from a bilateral FTA to a hub-and-spoke configuration *increases* trade between the original members of the bilateral agreement. This prediction is then contrasted to the effect of moving from a bilateral FTA to a multilateral FTA. In that case we would expect trade between the original members of the bilateral agreement to *decrease*.

To empirically evaluate these predictions, we need to focus on countries that have signed multiple free trade agreements with different partners at different times. To be able to disentangle the effects of each individual agreement, there should be a considerable time lag between them. The Israeli experience in this regard is unique. Between 1975 and 1993 it signed three major free trade agreements, with on average a decade elapsing between each one of them. In addition, one of the Israeli agreements gave rise to a hub-and-spoke arrangement. For this reason Israel represents an almost ideal ground to evaluate the predictions of our theory. The main thrust of our analysis is carried out looking at aggregate trade flows, but in section 4.6 we also explore the empirical implications of our model at the sectoral level.

4.1 Israel's trade policy

Israel's trade policy in the immediate aftermath of statehood, and until at least 1962, was highly protectionist, and involved the extensive use of import quotas, which covered most final consumer goods (Michaely (1975)). The main goal of these policies, like in many other developing countries at the time, was to promote industrialization through import substitution (Kahane (1992)). In the mid sixties serious shortages in importable goods and the growing influence of a group of Chicago trained economists set in motion a gradual liberalization of trade. The process started with the tariffication of quantitative restrictions, which was then followed by a gradual reduction of actual tariff rates. In spite of that, the effective tariff rate on manufactured imports was still 22% in 1977 (Bar-Nathan and Baruh (1990)). Therefore, when Israel started signing preferential trading arrangements in the mid-1970s, there was still substantial room for further trade liberalization. The first FTA it signed was with the European Union in 1975. A decade later, in 1985, it signed a similar FTA with the United States.[6] 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.

[INSERT FIGURE 2 APPROXIMATELY HERE]

To illustrate the relevance of the Israeli example for our theory, Figure 2 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 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. This agreement coincided with the signing of the Uruguay round which can be viewed as a move towards global free trade. Taken together, we would expect those agreements to reduce trade between Israel and its existing preferential trading partners.[7]

4.2 Data

The data we use for the aggregate analysis comes from Rose (2004), and the sample covers the period between 1950 and 1997. Since we focus on Israel, we limit our attention to country pairs that involve Israel. Accounting for missing data, this gives us 47 years of observations and a maximum of 138 country pairs.The actual number of country pairs varies throughout this period though, as new countries have come into existence, with the maximum theoretical number of observations being 5,068. After accounting for "zero" trade observations, we were left with 3,755 observations.

[INSERT TABLE 1 APPROXIMATELY HERE]

Table 1 summarizes key features of Israel's trade activity. We consider five time periods: 1950-1974 precedes any of Israel's free trade agreements; 1975-1984 goes from the EU-Israel agreement to just before the US-Israel agreement; 1985-1992 starts with the US-Israel FTA and ends prior to the EFTA-Israel agreement; 1993-1994 covers the period from the Israel-EFTA agreement until the incorporation of some EFTA countries into the EU; and 1995-1997 covers the remainder of the sample. We also distinguish between six sets of trading partners. Apart from the US and the rest of the world, we consider four groups of countries in Europe: EU-9, the nine European countries that signed the Israel-EU agreement; Greece,Spain, and Portugal, that joined the EU in 1981 and 1986, and thus became party to the EU-Israel FTA; Austria-Finland-Sweden, members of EFTA that joined the EU in 1995; and finally Norway, Iceland and Switzerland, that were party to the Israel-EFTA agreement from 1993 onwards.

The first panel of Table 1 reports average annual trade. 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 region during the various time periods we consider. 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.[8] The third panel of Table 1 illustrates the evolution of this measure.

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 agreements. Note that in what follows, we investigate the effect of the Israeli trade agreements on Israeli trade. Our theory predicts that these agreements will also have an effect on trade between the other parties to these agreements, in this case the US and the EU, and the EU and EFTA. However, given the tiny size of Israel's economy relative to the EU, the US and the EFTA members, any such effect would be minuscule and not detectable in our short panel series.

4.3 Econometric methodology

Our econometric model adopts a differences-in-differences treatment effects approach in identifying the impact of trade agreements. Our dependent variable is the log of bilateral trade, while our explanatory variables include 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 effects of the different Israeli trade agreements on trade between the countries that are members of a preferential trade agreement. Assume, for instance, that 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) characteristics, the coefficients of agreement dummies would yield biased estimates of the true effects of these agreements if country pair dummies were not included.[9] A remaining concern is time-varying endogeneity. However, as we will discuss later, likely forms of this endogeneity would – if anything – strengthen our results.

Exclusively focusing on country pairs that involve Israel removes possible confounding effects. 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 differences in variability in country flows across partners and years and the resulting possibility of serial correlation in the error process, we adopt the recommendations of Bertrand, Duflo and Mullainathan (2004) to obtain 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 heteroscedasticity–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.[10] The two sets of standard errors are very similar, generally within ten percent of each other. In the tables, we report White's heteroscedasticity consistent within clusters standard errors and tests, but the sign and significance of the results obtained with the alternative methodology are comparable.

A potential concern with the methodology we have just outlined is that for approximately twenty–five percent of the trade flows in our sample, we observe zero values. In the benchmark specifications we exclude those observations, but this might lead to inconsistent estimates due to sample selection bias. To address this issue, in section 4.5 we explicitly introduce a selection equation in our model.

4.4 Main Results

Hub-and-spoke effects of FTAs

The agreement between Israel and the US in 1985 turned Israel into a hub, and the EU and the US into spokes. Our theory predicts this should have increased trade between Israel and the EU. To capture this effect, we allow the EU-Israel agreement to have a different impact on bilateral trade in the 1975-1984 period (during which Israel had no other agreements) and in the 1985-1992 period (during which Israel had a second agreement with the US). The hub-and-spoke effect implies that the effect on bilateral trade should be greater in the 1985-1992 period than in the 1975-1984 period. In addition to assessing these hub-and-spoke effects, we also analyze the effects of the EFTA-Israel agreement and the conclusion of the Uruguay round. Given that these agreements led to more global free trade, we would expect bilateral trade with the EU to have decreased. To evaluate this, we add a third time period, 1993-1997, and estimate the effect of Israel's agreements on trade flows for those years.

We therefore estimate the following model:

$$\begin{aligned}\log(Trade_{ijt}) &= \beta_{EU1} I_{t\in[75-84]} EU_{jt} + \beta_{EU2} I_{t\in[85-92]} EU_{jt} + \beta_{EU3} I_{t\in[93-97]} EU_{jt} \\ &+ \beta_{US2} I_{t\in[85-92]} US_j + \beta_{US3} I_{t\in[93-97]} US_j + \beta_{EFTA} I_{t\in[93-97]} EFTA_{jt} \\ &+ \alpha \log(GDP_{it} GDP_{jt}) + u_{ij} + v_t + e_{ijt}\end{aligned} \tag{21}$$

where 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, $I_{t\in[y1-y2]}$ are indicator variables that take the value of 1 if the year is between $y1$ and $y2$, 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. Note that the estimating equation has three separate terms for EU_{jt}, but only two for US_{jt} and one for $EFTA_{jt}$. That is because the EU-Israel FTA spans the three time periods, whereas the other agreements, US-Israel and EFTA-Israel, happened later.[11]

[INSERT TABLE 2 APPROXIMATELY HERE]

Table 2 (Model 1) reports the results of this regression. The hub-and-spoke effect is captured by the difference between the coefficients β_{EU2} and β_{EU1}. This measures the change in bilateral trade between Israel and the EU after the signing of the US-Israel agreement, relative to the change in trade between Israel and the rest of the world. As this turned Israel into a hub, our theory predicts bilateral trade with the EU should have increased. 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 ($e^{0.7762-0.5235} - 1 \approx 0.29$), and this is statistically significant at the 10 percent level.

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. According to our theory, we would expect this to 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 drop, which is statistically significant, amounts to a 28% decrease in trade. Likewise, US-Israel trade fell by a similar proportion.[12]

To test for the joint significance of all predictions made by our theoretical model, 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 these 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 2) 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

$$\begin{aligned} \log(Trade_{ijt}) \quad = \quad & \beta_{EU1} I_{t\in[75-79]} EU_{jt} + \beta_{EU2} I_{t\in[80-97]} EU_{jt} \\ & + \beta_{US2} I_{t\in[85-89]} US_j + \beta_{US3} I_{t\in[90-97]} US_j \\ & + \beta_{EFTA} I_{t\in[90-97]} EFTA_{jt} + \alpha \log(GDP_{it} GDP_{jt}) + u_{ij} + v_t + e_{ijt} \end{aligned} \tag{22}$$

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 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 3) we incorporate both delayed effects and hub-and-spoke effects by appropriately partitioning the time periods using the regression

$$\begin{aligned}\log(Trade_{ijt}) &= \beta_{EU1} I_{t\in[75-79]} EU_{jt} + \beta_{EU2} I_{t\in[80-84]} EU_{jt} + \beta_{EU3} I_{t\in[85-89]} EU_{jt} \\ &+\beta_{EU4} I_{t\in[90-92]} EU_{jt} + \beta_{EU5} I_{t\in[93-97]} EU_{jt} + \beta_{US3} I_{t\in[85-89]} US_j \\ &+\beta_{US4} I_{t\in[90-92]} US_j + \beta_{US5} I_{t\in[93-99]} US_j + \beta_{EFTA} I_{t\in[93-99]} EFTA_{jt} \\ &+\alpha \log(GDP_{it} GDP_{jt}) + u_{ij} + v_t + e_{ijt}\end{aligned} \quad (23)$$

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.[13] Moreover, the hub-and-spoke parameter estimates remain essentially unchanged from those in Model 1: 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.

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 three 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), the United States, and the six countries that were members of EFTA in 1993 (henceforth denoted as EFTA6).

Table 2 (Model 4) parallels equation (21) 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 Model 4, the break points are the same as those of equation (21).[14] The pattern of coefficients is similar to that of Model 1: 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 effect is statistically significant, and so is the joint test of all trade flow changes predicted by our model; in fact, even more significant than in the results reported in Model 1.

The remaining two regressions parallel those of Model 2 and 3. Although we do not report the results for brevity, the parameter estimates show that lagged agreement effects are not statistically significant, neither when they are considered 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.

4.5 Adjusting for Selection

The analysis so far has omitted observations with zero trade flows. This leads to a loss of information, but more importantly it could possibly lead to inconsistent estimates due to sample selection bias. To address this issue, we estimate the following two–equation specification:

$$\log(Trade_{ijt}) = \beta_{\mathbf{jt}}\mathbf{X_{ijt}} + \varepsilon_{ijt} \qquad \textit{Main equation} \qquad (24)$$

$$PosTrade_{ijt} = 1 \quad \text{if} \quad \mathbf{b_{jt}}\mathbf{Z_{ijt}} + \epsilon_{ijt} \geq 0 \qquad \textit{Selection equation} \qquad (25)$$

where $\mathbf{b_{jt}}$ and $\beta_{\mathbf{jt}}$ are parameter vectors (possibly varying over time and across trade partners), $\mathbf{Z_{ijt}}$ and $\mathbf{X_{ijt}}$ are vectors of controls (with potentially common elements), ϵ_{ijt} and ε_{ijt} are normally distributed error terms with variance 1 and σ^2 respectively, and $Corr(\epsilon_{ijt}, \varepsilon_{ijt}) = \rho$. Equation (24) is the main specification, whereas equation (25) models the possible presence of sample selection. In particular, note that $\log(Trade_{ijt})$ is observed only if $PosTrade_{ijt} = 1$. Of course, if $\rho = 0$, selection is not a concern, and equation (24) can be estimated consistently on its own. These "stand alone" estimates are those reported in Table 2.

To identify the possible effect of selection, without resorting to a functional form restriction in the selection equation, we need to include in equation (25) at least one additional control that is not included in equation (24) and that, conditional on $\mathbf{X_{ijt}}$, affects the probability of observing positive trade flows, without directly impacting trade volumes. To this end, for each of Israel's actual or *potential* trade partners we have computed the number of *other* countries with which the trade partner had positive trade flows in year t, $Partners_{jt}$. A high value of $Partners_{jt}$ suggests that country j has a high propensity to trade, and thus we expect this country to be more likely to exhibit positive trade flows with Israel as well.[15] In carrying out our analysis, we have implemented a parsimonious specification of the selection equation, in which – besides $\log(Partners_{jt})$ – we have included a full set of year dummies to capture the fact that the propensity to trade is likely to change substantially over time. Equations (24) and (25) are jointly estimated using maximum likelihood,[16] but we have also estimated these models using a two–step Heckman selection procedure, obtaining very similar results.

[INSERT TABLE 3 APPROXIMATELY HERE]

Table 3 reports our findings. We cannot reject the null hypothesis of no sample selection bias, as the estimate for ρ is positive and statistically significant. Still, our main results do not appear to be materially affected (see models 1 through 4 in Tables 2 and 3). Similarly, the p-values of the three tests we perform (Hub-and-Spoke effects, Hub-and-Spoke + Multilateral effects, Lagged Agreement effects) are also not impacted. Notice furthermore that the coefficient of $\log(Partners_{jt})$ is positive and strongly significant in the selection equation, suggesting that this variable affects the probability of observing positive trade flows. These results are robust to a series of alternative specifications for the selection equation, that are available from the authors upon request.

4.6 Sectoral Analysis

So far we have assessed the implications of our model for aggregate trade flows. In this section we explore whether the main hub-and-spoke mechanism we have identified can also be observed when looking at sector-level flows. The sector-level predictions of our model regarding the effect of the Israel-US agreement can be restated as follows. Since this FTA turned Israel into a hub, we expect Israel's net imports from the EU to increase in sectors in which the EU has a comparative advantage, and we expect Israel's net exports to the US to increase in those same sectors. Consistent with our theory, this would lead to trade from the EU to the US through Israel in sectors in which the EU has comparative advantage. Similarly, we expect Israel's net imports from the US and net exports to the EU to increase in those sectors in which the US has a comparative advantage. In this case as well, Israel would act as a hub between the US and the EU. For our analysis we use the well known dataset described in Feenstra, Lipsey, Deng, Ma and Mo (2005), which reports bilateral trade flows at the four–digit SITC (Rev.2) level, covering almost all trading entities in the world over the period 1962-2000.

A key question is how to define a country's comparative advantage, and to answer it several factors need to be taken into account. First, in our three–country setting we might well have some sectors in which both spokes have a comparative advantage vis à vis Israel. Since our theory suggests that in this case no hub-and-spoke effect should be observed, we say that a spoke has a comparative advantage in a sector only if the other spoke does not. Second, comparative advantage evolves over time. Since we focus on the effect of the Israel-US FTA, we empirically identify the sectors in which a country enjoys a comparative advantage by looking at trade flows in the seven years preceding the agreement. Third, we focus on net exports when defining comparative advantage. Fourth, the existence of trade imbalances may bias the definition of comparative advantage in favor of the surplus countries, and to correct for this bias, we need to normalize trade flows.

Based on this discussion, we start by defining those sectors in which the EU or the US has a comparative advantage relative to Israel. Let XP_{jkt} denote the exports of Israel to trade partner j in sector k and year t, and let MP_{jkt} denote the imports by Israel from that partner in sector k and year t. We say that the US has a comparative advantage in sector k if

$$\frac{\sum_{t\in(1978-1984)} MP_{US,k,t}}{\sum_k \sum_{t\in(1978-1984)} MP_{US,k,t}} > \frac{\sum_{t\in(1978-1984)} XP_{US,k,t}}{\sum_k \sum_{t\in(1978-1984)} XP_{US,k,t}} \tag{26}$$

and

$$\frac{\sum_{t\in(1978-1984)} MP_{EU,k,t}}{\sum_k \sum_{t\in(1978-1984)} MP_{EU,t}} < \frac{\sum_{t\in(1978-1984)} XP_{EU,k,t}}{\sum_k \sum_{t\in(1978-1984)} XP_{EU,t}} \tag{27}$$

jointly hold.

The first condition suggests that for the US to have comparative advantage in sector k, net imports by Israel from the US in that sector must be positive after correcting for aggregate trade flows to take into account potential trade imbalances. The second condition requires that for the US to have a comparative advantage vis à vis Israel in sector k, normalized net imports from the EU in that sector should be negative. This additional restriction helps us identify sectors in which the US has comparative advantage relative to both Israel and the EU. By analogy, the EU[17] is defined to have a comparative advantage in sector k if the sign of inequalities (26) and (27) are reversed. Based on these definitions, we construct two indicator variables, $AdvUS_k$ and $AdvEU_k$, taking a value of one respectively if the US and the EU have a comparative advantage in sector k. Our analysis looks at the trade effect in the seven years following the creation of the hub-and-spoke arrangement, corresponding to the period 1985-

1991. Taken together, we are implicitly assuming that comparative advantage has not changed substantially during the 14 years spanning 1978-1991.

We can now define the appropriate dependent variable for our analysis. Recall that our goal is to determine how the hub-and-spoke arrangement affects trade flows in different sectors between different regions. For example, we want to see whether – after the establishment of the US–Israel FTA in 1985 – net exports from Israel to the US increase in sectors in which the EU has a comparative advantage. To this end, we aggregate trade by region and sector as follows. We model three regions, indexed by $j' = US, EU, ROW$, i.e. the US, the EU and the rest of the world. We also distinguish four groups of sectors, $\kappa = US, EU, ISR, OTH$, based on which country or region enjoys a comparative advantage. The first group corresponds to all sectors in which the US has comparative advantage. The second and the third group consist of sectors in which, respectively, the EU and Israel have a comparative advantage,[18] whereas the last group consists of all other sectors. An observation in our data is therefore indexed by a region, a sector group, a direction of trade and a year. For the same reason as in the definition of comparative advantage, our dependent variable needs to be corrected for the possibility of trade imbalances. We therefore normalize sector trade between two countries by the aggregate trade between them. Given that this normalization distinguishes between imports and exports, our dependent variable also takes into account the direction of trade:

$$\text{Partner Ratio}_{j',\kappa,t,d} = \frac{TradeFlow_{j',\kappa,t,d}}{\sum_{\kappa} TradeFlow_{j',\kappa,t,d}} \tag{28}$$

where $d = XP, MP$ indicates whether the observation refers to exports or imports, so that $TradeFlow_{j',\kappa,t,d}$ corresponds to the value of directional trade flows between Israel and country group j' in sector group κ and year t.

Our estimating equation relies on eight fixed effects to capture the impact of the hub-and-spoke arrangement on specific trade flows:

$$\begin{aligned}\text{Partner Ratio}_{j',\kappa,t,d} \;=\; & \lambda_{AdvUS-USx} + \lambda_{AdvUS-USm} + \lambda_{AdvEU-USx} + \lambda_{AdvEU-USm} \\ & + \lambda_{AdvUS-EUx} + \lambda_{AdvUS-EUm} + \lambda_{AdvEU-EUx} + \lambda_{AdvEU-EUm} \\ & + \Gamma 1_{j',d,t} + \Gamma 2_{j',d,t} + U_{\kappa,d} + v_{j',\kappa,t,d} \end{aligned} \tag{29}$$

where $\lambda_{AdvPartner1-Partner2x}$ is an indicator variable taking a value of one if for this observation *Partner1* has a comparative advantage, the observation corresponds to export from

Israel to *Partner2*, and the hub-and-spoke agreement is in effect. The indicator variable $\lambda_{AdvPartner1-Partner2m}$ is defined in a similar way, but corresponds to Israel importing (rather than exporting) from *Partner2*. The coefficients on these variables capture the hub-and-spoke effects on the relevant sectors and trade directions. To account for other extraneous systematic factors we include a set of additional fixed effects. First, we allow for different intercepts for partner–directions, taking also into account that these might be further affected by the presence of hub-and-spoke agreements. We therefore include $\Gamma1_{j',d}$, a vector of four fixed effects for country trade direction combinations prior to the hub-and-spoke agreement (those with *ROW* are omitted), and $\Gamma2_{j',d}$, a similar vector of four fixed effects for country trade direction combinations following the hub-and-spoke agreement (once again, those with *ROW* are omitted).[19] Second, we include $U_{\kappa,d}$, a vector of fixed effects for sector/direction combinations. The last term in the estimating equation, $v_{j',\kappa,t,d}$, is a zero–mean disturbance term.

[INSERT TABLE 4 APPROXIMATELY HERE]

The results of the estimation of equation (29) are reported in column (1) of Table 4. The theoretical model predicts that the formation of a hub-and-spoke agreement should lead to an increase in net exports from Israel to the US in sectors for which the EU has a comparative advantage. This suggests that $\lambda_{AdvEU-USx} - \lambda_{AdvEU-USm}$ should be positive. As can be seen in column (1), consistent with our theoretical predictions, the share of exports to the US of goods in which the EU has a comparative advantage increased by 11.70%, whereas the share of imports from the US in goods in which the EU has a comparative advantage decreased by 16.68% after the US–Israel agreement was signed.[20] Although both numbers separately support the predictions of our model, we are only interested in the difference between the two. For flows that are in expectation balanced, these coefficients – if interpreted structurally – imply that the share of net exports to the US in which the EU has a comparative advantage increased by 28.39%. Taking into account that trade is not balanced, we also computed the implied change in the value of net exports between Israel and the US for sectors in which the EU has a comparative advantage, and find an average annual figure of 558 million dollars for the period included in our analysis.

Our theory makes three additional predictions on the effects of the hub-and-spoke arrangement. First, there should be an increase in net imports by Israel from the EU in sectors in which the EU has a comparative advantage, thus implying that $\lambda_{AdvEU-EUx} - \lambda_{AdvEU-EUm}$ should be negative. Consistent with the theory, our estimates imply a decrease by 352 million dollars in net imports, a figure that is statistically significant at the 5% level. Second, we expect an increase in net exports by Israel to the EU for sectors in which the US has a comparative advantage, i.e. $\lambda_{AdvUS-EUx} - \lambda_{AdvUS-EUm}$ should be positive. Our corresponding estimate has the correct sign, but is not statistically significant. Third, our theory predicts an increase in net imports by Israel from the US in goods in which the US has comparative advantage, i.e. $\lambda_{AdvUS-USx} - \lambda_{AdvUS-USm}$ should be negative. Our estimated coefficient has a positive sign, but it is not statistically significant. Given that two out of our four coefficients have the correct sign and the other two are not statistically significant, we conclude that our results are broadly consistent with the implications of the model. On average, a structural interpretation of the parameters suggests that for countries with balanced trade, a hub-and-spoke arrangement similar to the one studied here changes the sectoral composition of trade between the hub and the spokes by 13.7%.[21]

We have assessed the robustness of our results in various ways. First, we have used an alternative normalization for trade flows, which corrects for Israel's exports with all countries, rather than just by overall trade with the partner. As a result, we run equation (29) using the following alternative dependent variable:

$$\text{Global Ratio}_{j',\kappa,t,d} = \frac{TradeFlow_{j',\kappa,t,d}}{\sum_{j'} TradeFlow_{j',\kappa,t,d}} \tag{30}$$

The results reported in column (2) of Table 4 suggest that the predictions of our model find even stronger support: all the implied trade changes have now the expected sign and are statistically significant. Second, we are concerned that our definition of comparative advantage might be driving some of our results. We have thus experimented with a "stricter" definition that assigns comparative advantage to a country only if the difference between imports and exports is a least 10%, and obtained similar results (see Table 4, columns (3) and (4)).

5 Conclusions

This paper has developed a simple model of comparative advantage to study how the expansion of free trade to a third party affects trade volumes of a country pair. Starting off with an FTA between two countries, we have considered two scenarios. In the first scenario, only one of the countries signs an FTA with the third party. This gives rise to a hub-and-spoke arrangement. Trade between the hub and the spoke increases. In the second scenario, both countries sign a free trade agreement with the third party. In this case we have a multilateral free trade area, and trade between the two original member countries decreases.

We have then brought our theory to the data, using Israel as a case study. Israel's experience fits our model well because it started signing FTAs in the early seventies, and its agreements are far enough apart in time to allow us to disentangle their individual effects. Our empirical analysis has found robust evidence suggesting that the Israel-US free trade agreement of 1985 turned the country into a hub. The hub-and-spoke effect we identify is not only statistically significant, it is also economically important: the Israel-US agreement of 1985 increased Israel-EU trade by an estimated 29%.

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A Proof of Proposition 1

Proof. To establish point 1, we need to show that the right hand side of expression (13) is greater than (14). Under symmetry, $p_1 = p_3 = 1$, so that we need to show that $p_2^*(1+\tau) > 1$. Assume the contrary. The material balances for good 2 and good 3 are

$$(Q_2^N + Q_2^M + Q_2^S) - (C_2^N + C_2^M + C_2^S) = \tau(C_2^N - Q_2^N + C_2^M - Q_2^M) \quad (31)$$

$$(Q_1^N + Q_1^M + Q_1^S) - (C_1^N + C_1^M + C_1^S) = \tau(C_1^S - Q_1^S + C_1^M - Q_1^M) \quad (32)$$

If $p_2(1+\tau) \leq 1$, then $p_2 < 1$. In that case $C_2^N \geq C_1^N$, $C_2^M \geq C_1^M$, $C_2^S > C_1^S$, $Q_2^M \leq Q_1^M$, $Q_2^N < Q_1^S$, and $Q_2^S < Q_1^N$, so that $(Q_2^N + Q_2^M + Q_2^S) - (C_2^N + C_2^M + C_2^S) < (Q_1^N + Q_1^M + Q_1^S) - (C_1^N + C_1^M + C_1^S)$. The left hand side of (31) is thus strictly smaller than the left hand side of (32). Symmetry in sizes implies bilateral trade balances must hold. Therefore, $(C_2^N - Q_2^N)p_2(1+\tau) = (C_1^S - Q_1^S)(1+\tau)$, so that $C_2^N - Q_2^N \geq C_1^S - Q_1^S$. We already know that $C_2^M \geq C_1^M$ and $Q_2^M \leq Q_1^M$, so that $C_2^M - Q_2^M > C_1^M - Q_1^M$. This, together with $C_2^N - Q_2^N \geq C_1^S - Q_1^S$, implies that the right hand side of (31) is bigger than or equal to the left hand side of (32). This contradicts the finding that the left hand side of (31) is strictly smaller than (32), so that it must be that $p_2^*(1+\tau) > 1$. This concludes the proof of point 1. For point 2 to be correct, (20) must be greater than (13). This result is immediate. ■

B Trade volumes with size differences between the hub and the spokes

In this subsection we explore the robustness of Proposition 1 when there are size differences between the hub and the spokes. To obtain results that are as general as possible, we focus on a broad parameter space, summarized in Table A1.

Table A1: Parameter values

γ_M	1
$\gamma_N = \gamma_S$	[0.01,100]
α	]0, 3.5]
β	(0, 0.1, 0.5, 0.9)
τ	(0.1, 0.25, 0.5)

As we will show later, the exact values of β and τ play a limited role with respect to our results, both qualitatively and quantitatively. Without much loss of generality, we will therefore focus our discussion on the case in which $\beta = 0$ and $\tau = 0.1$. This leaves us with two parameters, the relative size of the spokes, $\gamma_N(\gamma_S)$, and the strength of comparative advantage, α.

[INSERT FIGURE 3 APPROXIMATELY HERE]

Depending on the parameter values, rules of origin may be binding or not, and tariffs may be prohibitive or not.[22] Figure 3 focuses on the hub-and-spoke configuration, and illustrates three possible situations. Starting from the left, the first region corresponds to small values of α or $\gamma_N (= \gamma_S)$. In that case, the rules of origin are nonbinding, and prices in the three countries are identical to those under the multilateral FTA. As argued before, ROOs will not bind when either comparative advantage is weak or the spokes are not too large relative to the hub. For slightly higher values of α or $\gamma_N (= \gamma_S)$ rules of origin become binding. In this second region the price at which the hub exports its own production of 1 and 2 is higher than the price at which it buys those same goods from the spokes, but the price difference is too small for there to be any trade between the spokes. Therefore, although the rules of origin bind, there is no trade between the two spokes. Once α or $\gamma_N (= \gamma_S)$ become large enough, we get a third region, where rules of origin are still binding, but tariffs have become nonprohibitive. The difference between the buying and the selling price in the hub is now large enough for there to be trade between the two spokes.

To study the behavior of trade volumes under a hub-and-spoke arrangement, we start, once again, by considering a bilateral FTA between N and M, and analyze how trade between this country pair changes when one M liberalizes trade with S. Figure 1 (in the main text) analyzes that case for $\beta = 0$ and $\tau = 0.1$. Here we show that changing the values of β or τ does not substantially affect the results. For instance, in Figure 4, we set $\beta = 0.5$ and keep $\tau = 0.1$. Once again, the hub-and-spoke effect is only overturned when α is above 2.4, and γ_N and γ_S is sufficiently large.[23]

[INSERT FIGURE 4 APPROXIMATELY HERE]

There is one small difference with Figure 1 though: the minimum level of γ_N and γ_S for which the hub-and-spoke effect disappears is slightly lower in Figure 4. This is related to the higher value of β. To gain some intuition for this result, notice that two opposing forces are at work. On the one hand, a higher β weakens comparative advantage. This strengthen the hub-and-spoke effect, much in the same way as a lower α. On the other hand, a higher β allows production to more easily adjust to changes in relative prices. This weakens the hub-and-spoke effect.[24] While a higher β strengthens this second (negative) force, a lower value of α does not. This explains why an increase in β, in contrast to a decrease in α, may make it more likely for the hub-and-spoke effect to be overturned.

These numerical exercises suggest that if comparative advantage is not too strong and spokes are not too large relative to the hub, then the hub-and-spoke effect continues to be present.[25] The following result summarizes our findings:

RESULT 1 *If comparative advantage is not too strong and the spokes are not too large relative to the hub, then going from a bilateral FTA between N and M to a hub-and-spoke arrangement, with M being the hub, increases trade between N and M as a share of GDP in M. If not, it decreases trade between N and M as a share of GDP in M.*

NOTES

[1]Early contributions can be traced back to Wonnacott (1975) and Wonnacott (1982). Hub-and-spoke arrangements have also been recently studied by Goyal and Joshi (2006) in the context of network analysis and by Chen and Riordan (2007) in the context of an oligopoly model with differentiated products.

[2]Other examples are De Benedictis, De Santis and Vicarelli (2005) and Alba, Hur and Park (2010). 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.

[3]Although analytically less tractable, assuming tariffs that generate fiscal revenues does not change our qualitative predictions. The results for this case are available upon request from the authors.

[4]Note that trade between any two countries need not be balanced, since the setup is not symmetric.

[5]Throughout our analysis, we have implicitly assumed that MFN tariffs are not affected by the creation of a free trade area. Empirical evidence (see Ornelas and Freund (2008) and Ornelas and Freund (2010)) suggests that for member countries, MFN tariffs tend to decline following the establishment of an FTA. Since this force would weaken the hub-and-spoke effect identified in our model, any empirical evidence in favor of the hub-and-spoke effect should be interpreted as a lower bound.

[6]Notice that even before the Israel-US free trade agreement was reached, a substantial portion of Israeli exports could enter duty free in the US. The opposite was not true, however, as Israeli producers were successful in taking advantage of the ISI provisions to limit foreign competition in their market.

[7]One might think that the EFTA-Israel agreement should have increased trade between Israel and the US, because Israel became a hub between EFTA and the US. However, there are two offsetting effect. First, before the EFTA-Israel agreement, the US could already indirectly trade duty free with EFTA through Israel and the EU. Second, the conclusion of the Uruguay round coincided in time with the EFTA-Israel agreement.

[8]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 (2007)). This measure is not scale-free, and thus not appropriate as a summary descriptive measure of trade intensity.

[9]See Baier and Bergstrand (2007) and Baltagi, Egger and Pfaffermayr (2003) for a further discussion. 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.

[10]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 et al. (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.

[11]Introducing three separate terms for EU_{jt}, US_{jt} and one $EFTA_{jt}$ does not change the subsequent empirical results.

[12]Note that the statistically insignificant negative coefficient on the EFTA variable should not come as a surprise, because it is affected by both the EFTA-Israel FTA and the Uruguay round. While we would expect the EFTA-Israel effect to be positive, we would expect the Uruguay round effect to be negative.

[13]The statistical significance of delayed effects is obtained from 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 effects identified in our model is obtained from the joint test of the following three parameter restrictions: $\beta_{EU2} = \beta_{EU3}$ and $\beta_{EU4} = \beta_{EU5}$ and $\beta_{US4} = \beta_{US5}$. The statistical significance of the hub-and-spoke (vs bilateral trade) effects is obtained from significance of the difference $\beta_{EU3} - \beta_{EU2}$.

[14]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.

[15]Note that $Partners_{jt}$ does not take into consideration trade volumes, and that the vector $\mathbf{X_{ijt}}$ includes standard gravity fixed effects and other terms. Thus, conditional on $\mathbf{X_{ijt}}$, $Partners_{jt}$ reflects primarily the absence of impediments for the presence of trade flows rather than being informative on the actual size of these flows.

[16]The standard errors of the main equation are computed on the basis of a robust covariance matrix that accounts for heteroskedasticity and clustering at the country pair level.

[17]In this section, European Union refers to the EU-10.

[18]Notice that, following the logic spelled out in equations (26) and (27), we say that Israel has a comparative advantage in a sector if and only if its (normalized) net exports are positive both with respect to the EU and the US.

[19]In the absence of any other regressors, Γ1 and Γ2 would be zero, since sectoral percentages add to 100% for each trade partner, year, and trade direction. However, these variables are not zero when the other regressors are included. As robustness checks, we experimented removing the first set or both sets and the results are comparable.

[20]The percentage changes are relative to the share of other sectors for which neither the EU nor the US have a comparative advantage.

[21]This figure has been calculated using the coefficients in the bottom half of column (1) of Table 4, i.e. (28.39+24.60+3.11-1.24)/4.

[22]To say that a given parameter combination leads to prohibitive tariff, there should be at least one country pair (i, j) such that both $x^{ij} = 0$ and $x^{ji} = 0$.

[23]The pictures for other values of β or other values of τ are similar.

[24]In particular, the hub-and-spoke arrangement increases the relative price of good 3 in N. The higher is β, the greater the increase in production of good 3 in N, and thus the bigger the drop in imports of good 3 by N. In addition, the hub-and-spoke arrangement lowers the relative price of good 1 and 2 in M. The larger is β, the greater the drop in production of both goods in M. This limits the capacity of M to act as a hub.

[25]As further robustness checks, we carried out our numerical analysis also using CES preferences (with values for the elasticity of substitution of 1/2 and 3) and for tariffs that generate income. In the case of the CES, an increase in the elasticity of substitution steepens and (for the most part) shifts out the separating frontier in Figures 1 and 4. The opposite is true if the different goods become more complements. Using revenue generating tariffs, instead of iceberg costs, has no observationally significant effect on this frontier.

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 (in 100 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	0.18%	0.05%	0.11%	0.12%	0.29%	0.04%
1975-1984	0.28%	0.08%	0.12%	0.27%	0.51%	0.03%
1985-1992	0.27%	0.08%	0.09%	0.25%	0.55%	0.03%
1993-1994	0.28%	0.10%	0.11%	0.23%	0.61%	0.03%
1995-1997	0.35%	0.13%	0.12%	0.22%	0.68%	0.04%
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. See text for the correspondence between periods and trade partners to trade agreements.

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

<table>
<tr><th colspan="2">Trade Agr. and Other Parameters:</th><th colspan="2">Model 1</th><th colspan="2">Model 2</th><th colspan="2">Model 3</th><th colspan="2">Model 4</th></tr>
<tr><th>Trade Partner</th><th>Time Period</th><th>Parameter</th><th>Standard Error</th><th>Parameter</th><th>Standard Error</th><th>Parameter</th><th>Standard Error</th><th>Parameter</th><th>Standard Error</th></tr>
<tr><td rowspan="5">European Union (EU-9 for Model 4)</td><td>1975-1979</td><td rowspan="2">0.5235</td><td rowspan="2">0.1524</td><td>0.5770</td><td>0.1424</td><td>0.5779</td><td>0.1420</td><td rowspan="2">0.5487</td><td rowspan="2">0.1641</td></tr>
<tr><td>1980-1984</td><td rowspan="4">0.5987</td><td rowspan="4">0.2086</td><td>0.4736</td><td>0.1855</td></tr>
<tr><td>1985-1989</td><td rowspan="2">0.7762</td><td rowspan="2">0.2289</td><td>0.7165</td><td>0.2238</td><td rowspan="2">0.8257</td><td rowspan="2">0.2194</td></tr>
<tr><td>1990-1992</td><td>0.8712</td><td>0.2572</td></tr>
<tr><td>1993-1997</td><td>0.4519</td><td>0.2437</td><td>0.4518</td><td>0.2439</td><td>0.5037</td><td>0.2567</td></tr>
<tr><td rowspan="3">Greece, Spain, Portugal</td><td>1986-1990</td><td></td><td></td><td></td><td></td><td></td><td></td><td rowspan="2">0.7234</td><td rowspan="2">0.4330</td></tr>
<tr><td>1991-1992</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>1993-1997</td><td></td><td></td><td></td><td></td><td></td><td></td><td>0.7277</td><td>0.5064</td></tr>
<tr><td rowspan="3">United States</td><td>1985-1989</td><td rowspan="2">0.7851</td><td rowspan="2">0.1595</td><td>0.7379</td><td>0.1502</td><td>0.7526</td><td>0.1535</td><td rowspan="2">0.7864</td><td rowspan="2">0.1599</td></tr>
<tr><td>1990-1992</td><td rowspan="2">0.6316</td><td rowspan="2">0.1713</td><td>0.8385</td><td>0.1964</td></tr>
<tr><td>1993-1997</td><td>0.5079</td><td>0.1779</td><td>0.5076</td><td>0.1780</td><td>0.5078</td><td>0.1783</td></tr>
<tr><td>EFTA (EFTA-6 for Model 4)</td><td>1993-1997</td><td>-0.3830</td><td>0.3825</td><td>-0.3565</td><td>0.3786</td><td>-0.3831</td><td>0.3826</td><td>-0.3180</td><td>0.3017</td></tr>
<tr><td>log(GDPi GDPj)</td><td></td><td>0.9696</td><td>0.3078</td><td>0.9698</td><td>0.3079</td><td>0.9680</td><td>0.3080</td><td>0.9634</td><td>0.3099</td></tr>
<tr><td>R-squared</td><td></td><td colspan="2">0.8460</td><td colspan="2">0.8459</td><td colspan="2">0.8460</td><td colspan="2">0.8461</td></tr>
<tr><td>Observations</td><td></td><td colspan="2">3,755</td><td colspan="2">3,755</td><td colspan="2">3,755</td><td colspan="2">3,755</td></tr>
<tr><td colspan="2">Trade Agr. Effect</td><td>F-statistic</td><td>p-value</td><td>F-statistic</td><td>p-value</td><td>F-statistic</td><td>p-value</td><td>F-statistic</td><td>p-value</td></tr>
<tr><td colspan="2">Hub-and-Spoke Effects</td><td>3.11</td><td>0.0801</td><td></td><td></td><td>3.48</td><td>0.0642</td><td>4.90</td><td>0.0285</td></tr>
<tr><td colspan="2">Hub-and-Spoke + Multilateral Effects</td><td>2.67</td><td>0.0499</td><td></td><td></td><td>3.67</td><td>0.0139</td><td>4.78</td><td>0.0012</td></tr>
<tr><td colspan="2">Lagged Agreement Effects</td><td></td><td></td><td>0.54</td><td>0.5840</td><td>1.31</td><td>0.2732</td><td></td><td></td></tr>
</table>

Notes: All models include 138 country-pair fixed effects and 47 year indicator variables, with p-value of 0.0000 in all regressions. Standard errors are based on White's heteroskedasticity consistent covariance matrix adjusted for temporal correlation within country pairs. EFTA-6 includes Austria, Finland, Iceland, Norway, Sweden, and Switzerland. Greece joined the EU, and thus became party to a Free Trade Agreement with Israel on 1981; the effect of that agreement for the 1981-1985 is reflected in the chronologically earliest coefficient of the "Greece, Spain, Portugal" variable.

Table 3. Effect of Israeli Trade Agreements on Bilateral Trade Flows: Selection Adjusted Estimates.

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
Main Equation:									
European Union (EU-9 for Model 4)	1975-1979	0.5069	0.1501	0.5534	0.1404	0.5548	0.1399	0.5298	0.1622
	1980-1984					0.4632	0.1830		
	1985-1989	0.7635	0.2269	0.5817	0.2067	0.7040	0.2217	0.8085	0.2178
	1990-1992					0.8584	0.2550		
	1993-1997	0.4251	0.2420			0.4250	0.2420	0.4725	0.2557
Greece, Spain, Portugal	1986-1990							0.7203	0.4286
	1991-1992								
	1993-1997							0.7072	0.5031
United States	1985-1989	0.7712	0.1582	0.7235	0.1491	0.7384	0.1523	0.7724	0.1585
	1990-1992			0.6105	0.1698	0.8251	0.1946		
	1993-1997	0.4808	0.1763			0.4806	0.1763	0.4806	0.1767
EFTA (EFTA-6 for Model 4)	1993-1997	-0.3904	0.3728	-0.3624	0.3690	-0.3905	0.3727	-0.3302	0.2949
log(GDPi GDPj)		0.9872	0.3024	0.9873	0.3025	0.9857	0.3024	0.9807	0.3043
Selection Equation									
log(OtherPartners)		1.7117	0.2064	1.7115	0.2064	1.7116	0.2064	1.7117	0.2064
rho		0.2242	0.0472	0.2233	0.0472	0.2241	0.0472	0.2239	0.0473
log likelihood		-7742.4090		-7744.1510		-7742.1730		-7740.7020	
Observations		5,068		5,068		5,068		5,068	
Trade Agr. Effect		Chi-2 statistic	p-value	Chi-2 statistic	p-value	Chi-2 statistic	p-value	Chi-2 statistic	p-value
Hub-and-Spoke Effects		3.25	0.0714			3.48	0.0619	5.04	0.0247
Hub-and-Spoke + Multilateral Effects		8.76	0.0327			11.85	0.0079	19.01	0.0008
Lagged Agreement Effects				1.25	0.5364	3.77	0.2871		

Notes: All models include 138 country-pair fixed effects (in main equation) and 47 year indicator variables (in both equations), with associated p-values of 0.0000. Standard errors are based on White's heteroskedasticity consistent covariance matrix adjusted for temporal correlation within country pairs. EFTA-6 includes Austria, Finland, Iceland, Norway, Sweden, and Switzerland. Greece joined the EU, and thus became party to a Free Trade Agreement with Israel on 1981; the effect of that agreement for the 1981-1985 is reflected in the chronologically earliest coefficient of the "Greece, Spain, Portugal" variable.

Table 4. Sectoral Effects of US-Israel FTA on US-Israel and EU-Israel Trade.

		(1) Partner Ratio		(2) Global Ratio		(3) Partner Ratio, 10% margin		(4) Global Ratio, 10% margin	
Country of Comp. Adv	Partner and Trade Direction	Parameter	Standard Error	Parameter	Standard Error	Parameter	Standard Error	Parameter	Standard Error
United States	Exports to US	-2.24%	2.72%	-15.29%	4.14%	-2.74%	2.70%	-15.25%	3.93%
United States	Imports from US	-3.48%	1.37%	0.21%	2.56%	-3.32%	1.37%	0.53%	2.50%
European Union	Exports to US	11.70%	3.83%	6.66%	4.37%	12.72%	3.84%	7.27%	4.28%
European Union	Imports from US	-16.68%	2.07%	-7.17%	2.45%	-15.34%	2.07%	-6.43%	2.41%
United States	Exports to EU	4.07%	2.11%	26.51%	4.03%	3.06%	2.07%	25.34%	3.74%
United States	Imports from EU	0.96%	1.40%	8.80%	2.86%	0.44%	1.40%	8.12%	2.87%
European Union	Exports to EU	-30.80%	3.28%	-22.44%	3.74%	-31.28%	3.27%	-23.18%	3.62%
European Union	Imports from EU	-6.20%	2.08%	1.00%	2.84%	-6.89%	2.09%	-0.12%	2.87%
Partner x Period F.E. F-stat and p-value		7.83	0.0000	2.92	0.0037	6.90	0.0000	2.86	0.0044
Sectoral F.E. F-stat and p-value		286.56	0.0000	0.67	0.6948	292.06	0.0000	0.68	0.6908
R-squared		0.8411		0.3222		0.8432		0.3333	
Unweighted Hub-and-Spoke Effects and standard errors									
United States	United States (net)	1.24%	3.04%	**-15.50%**	4.87%	0.58%	3.03%	**-15.78%**	4.66%
European Union	United States (net)	**28.39%**	4.36%	**13.83%**	5.01%	**28.06%**	4.36%	**13.71%**	4.92%
United States	European Union (net)	3.11%	2.53%	**17.72%**	4.94%	2.62%	2.50%	**17.22%**	4.71%
European Union	European Union (net)	**-24.60%**	3.88%	**-23.44%**	4.70%	**-24.39%**	3.88%	**-23.06%**	4.62%
Trade Value-weighted Hub-and-Spoke Effects (in thousand $) and standard errors									
United States	United States (net)	20,187	61,653	**-88,941**	26,030	6,828	61,295	**-92,668**	25,500
European Union	United States (net)	**558,243**	88,098	**420,090**	140,343	**553,553**	88,219	**412,058**	138,599
United States	European Union (net)	43,415	46,681	**117,011**	25,947	38,936	46,172	**116,763**	25,138
European Union	European Union (net)	**-352,352**	71,020	**-606,733**	137,632	**-344,189**	71,002	**-590,349**	136,873

Notes; The number of observations is equal to 336 for all regressions. All models include 8 sectoral fixed effects interacted with direction of trade, and partner fixed effects interacted with direction of trade and Hub&Spoke agreement. Standard errors are based on a heteroskedasticity consistent covariance matrix. European Union consists of the first 10 members. Hub-and-Spoke effects consistent with theoretical predictions and statistically significant at the 5 percent level are in bold. See text for details.