Journal of Agribusiness 36, 2 (Fall 2018)

The Role of Foreign Direct Investment in the Elasticity of Substitution between Exports and Imports

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The Armington elasticity of substitution captures the trade-off interaction between imports and domestic sales. Recently, foreign direct investment (FDI) has become a significant source of international investment. This study incorporates the effect of horizontal FDI in this elasticity. Including FDI affects the modeling and value of the trade elasticity, providing new insights on the behavior of U.S. firms vis-a-vis the tradeoff between horizontal FDI and exports. This new Armington elasticity of substitution estimates provide a lower value than predecessors. This means that the impacts of a trade policy (such as tariffs) are expected to be lower due to FDI substitution.

***Key words**:* Armington Elasticity, Export Determinants, FDI, Foreign Direct Investment, Foreign Sales, International Sales, Trade Elasticity, Trade War

In the last two decades, globalization has motivated companies to operate in foreign countries. Firms may engage in international markets through exporting their goods and services. (Oberhofer and Pfaffermayr, 2012). In 2016, exports represented around 28% of the world gross domestic product (GDP), 20% of China GDP, and 13% of the U.S. GDP, making it an important component for most economies (The World Bank, 2018).

Nevertheless, firms also sell products by engaging in foreign direct investment (FDI) in which they invest in production facilities or buy an existing plant overseas (Laurin, 2012; Ekholn, Forslid, and Markusen, 2007). Among these ways to invest in other countries, horizontal FDI is based on having all the processes of production in one foreign plant to serve that specific country (Helpman, Melitz, and Yeaple, 2004). FDI is currently becoming one of the main sources of capital to finance industrial expansion. For the United States in 2012, foreign companies (U.S. affiliates) represented $12.2 billion in total assets (U.S. Bureau of Economic Analysis (BEA), 2013). Thus, the operations of multinational companies have become a concern for host and home economies. Many countries have adopted several policies to attract FDI due to the benefits for both parties.

Empirical trade studies based on economic modeling require analyses on how firms' investment behaviors change due to a movement of commodity prices. It is a common practice for these types of research projects to be built using Computing General

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Equilibrium (CGE) models (McDaniel and Balistreri, 2002). CGEs offer several advantages: they provide a perspective of both consumption and production, capturing the trade interaction; the accounting economic identities are kept in equilibrium; and they are consistent with welfare economic theory such as Pareto and Walras' Law, among others (Hertel, 2002).

In CGE models, such as the Global Trade Analysis Project (GTAP), price fluctuations are used to determine the effects of a trade policy on social welfare and trade (McDaniel and Balistreri, 2002). These price variations are captured in the elasticity of substitutions in consumption and production structures. Because trade and FDI are the two channels of interaction between other countries, Kreinin and Plummer (2008) evaluated this relationship in different regions—Mercado Común del Cono Sur (Southern Cone Common Market, or MERCOSUR), the North American Free Trade Agreement (NAFTA, which is evolving into the United States-Mexico-Canada Agreement (USMCA) at the printing of this journal); and the Association of Southeast Asian Nations (ASEAN)—finding that FDI and trade were substitutes.

Previous studies such as McDaniel, Gallaway and Rivera (2000), Hummels (1999), and Hertel (2002) have estimated the trade elasticity (i.e., known as Armington elasticity which evaluates relationship between imports and domestic products). These values then have been incorporated into CGE models such as GTAP. However, based on the facts previously mentioned, it is likely that FDI could have an effect in the sectorial Armington elasticities of substitution.

These parameters play a crucial role in the behavior of the CGE model's results. They connect variations in prices with changes in quantities that spill onto other values of the economy (Donnely et al., 2004). Thus, more precise elasticities would allow a better reflection of the economy when evaluating impacts of trade policies on the U.S. economy. Assessing trade policies is an important and timely issue considering recent changes in trade and investment patterns among important trade partners such as the United States and China. Recently these two countries have faced dramatic changes in trade policies such as increases in tariffs for several manufacturing and agricultural commodities (Li, He, and Lin, 2018).

In addition, a substantial body of literature has examined the effects of inward FDI (money earned by the host country) showing its different benefits and the indirect spillover effects on the host domestic firms. Nevertheless, only a relatively smaller body of work has focused of outward FDI on the home economy. Specifically, these previous studies have focused on the impact on domestic employment and capital investment, omitting the impact on trade and the economy (Tang and Altshuler, 2015).

Our study evaluates the effects of horizontal FDI in the Armington elasticity of substitution and the relationship of the elasticity of trade with respect to trade costs when horizontal FDI is included in the model. In doing so, this research intends to better understand the behavior of U.S. firms vis-a-vis the tradeoff between horizontal FDI and exports. As a result of this better understanding, we can address trade policies such as tariffs in a more comprehensive manner. Hence, we provide new, corrected estimates for the Armington elasticity of substitution used in general equilibrium models such as GTAP to include the effect of horizontal FDI which allows better simulations. We follow the theoretical framework by Helpman, Melitz, and Yeaple (2004) which is based on firm heterogeneity (i.e. it assumes that, depending on the level of productivity of the firm, this company can sell domestically, export, or engage in FDI).

Literature Background

The estimation of the Armington elasticity of substitution has been the subject of different studies. Stern et al. (1976) used a standard approach to obtain the aggregate industry elasticity for U.S. imports, classifying the sectors as moderately and extremely sensitive. Shiells and Reinert (1993) disaggregated U.S. imports in two groups: (1) NAFTA members and (2) the "rest of the world" for 128 sectors using several estimation procedures. They found that the estimates were robust across the procedures. On the other hand, Gallaway, McDaniel and Rivera (2003). analyzed the long-run aspect in the general equilibrium models to offer better Armington elasticities, finding that these estimates were up to five times larger than the short-run estimates and corroborating the analysis made by McDaniel and Balistreri (2002).

Hummels (1999) used a multi-sector monopolistic competition framework to explain the effect of barriers in trade volumes. He isolated the effect of trade (cost) in foreign sales (exports only) using fixed-effect models. He found the following relationship of foreign sales (X) with the transportation cost (τ): $-\frac{\partial lnX}{\partial ln\tau} = \sigma$. This relation suggests that the negative slope of the coefficient of trade cost is equivalent to the elasticity of substitution.

Chaney evaluated the intensive and extensive trade margins (2008). Specifically, he analyzed the relationship of aggregate export (trade) elasticity ζ with respect to fixed and variable trade costs. He assumed that firms follow a Pareto distribution of productivity with a shape parameter γ. Thus, he observed that the elasticity of substitution σ is not the driver of the effect on the elasticity of trade flows with respect to variable trade costs:

$\zeta = -\frac{\partial lnX}{\partial ln\tau} = (\sigma - 1) + (\gamma - (\sigma - 1)) = \gamma$. In fact, this study concluded that $-\frac{\partial lnX}{\partial ln\tau}$ gives the shape parameter γ as a result, and not the Armington elasticity σ.

On the other hand, the inclusion of FDI in economic models has been done in two main studies. The first one was made by Brainard (1997), in which he studied the trade-off between proximity to consumers and concentration in production using aggregate sectors and two types of activities: corporate (such as research and development) and production activities (fixed and variable trade costs). He found that the higher the expenditure on differentiated products in the foreign market, the greater the elasticity of substitution across varieties. The second study was developed by Helpman, Melitz, and Yeaple (2004), in which they introduced the firm-level heterogeneity assuming the least productive firm would be forced to exit because its productivity would not permit it to have positive profits (Helpman, Melitz, and Yeaple, 2003; Helpman, Melitz, and Yeaple, 2004). In this study, the authors used firm-level data of U.S. affiliate sales of 38 different countries in which they concluded that adding heterogeneity in firms led to higher FDI sales relative to export sales.

Theoretical Framework

Consumer and Producer Behavior

Households are assumed to follow a Constant of Elasticity Substitution (CES) functional form with the parameter $\boldsymbol{\sigma}$ for all heterogeneous sectors of the economy. The Armington elasticity of substitution per sector is defined then as $\boldsymbol{\varepsilon} = \frac{\mathbf{1}}{\mathbf{1}-\boldsymbol{\sigma}} > \mathbf{1}$ following Chaney's framework (2008). The demand ***Q(p)*** for any good ***i*** is provided by the exponential demand function [with constant parameter $\boldsymbol{A}$ and price $\boldsymbol{p}$]:

$$Q(p) = Ap^{-\varepsilon} \quad (1)$$

Firms are assumed to be monopolistic profit maximizers. Labor is the unique primary input factor with cost of ***a*** unit-per-output, drawn from a Pareto distribution $\boldsymbol{H(a)}$**,** with a density parameter $\boldsymbol{k} > \mathbf{0}$. Labor productivity $\boldsymbol{\varphi}$ is defined by $\boldsymbol{\varphi} = \mathbf{1}/\boldsymbol{\sigma}$, equivalent to the markup of the product [$\mathbf{1}/\boldsymbol{\sigma}$]. If a firm decides to export, it will face a fixed cost of entry f_X per foreign market ***j*** and a variable transportation cost $\boldsymbol{\tau_{ij}}$. If a firm choose to engage in FDI, then it will have to pay a fixed cost $\boldsymbol{f_I}$, under the condition $f_I > (\tau_{ij})^{\varepsilon-1} f_X > f_D$. The final price sold to the consumer, given the overall demand, is

$$p = \begin{cases} \frac{a}{\sigma} & if\ domestic\ or\ FDI \\ \frac{\tau_{ji}a}{\sigma} & if\ the\ product\ is\ imported\ from\ j \end{cases} \tag{2}$$

Choice for Domestic Sales, Exports, and FDI

Firms are categorized in four groups, depending on their level of productivity $\varphi = 1/a$:

(i) Least productive firms are forced to exit due to lack of positive profits;

(ii) The firms only selling domestically receiving a profit of $\boldsymbol{\pi_D}$;

(iii) Productive firms that sell domestically and can export [paying entry fee $\boldsymbol{f_X}$ and the transportation cost $\boldsymbol{\tau_{ij}}$]. These firms earn a profit of $\boldsymbol{\pi_X}$; and

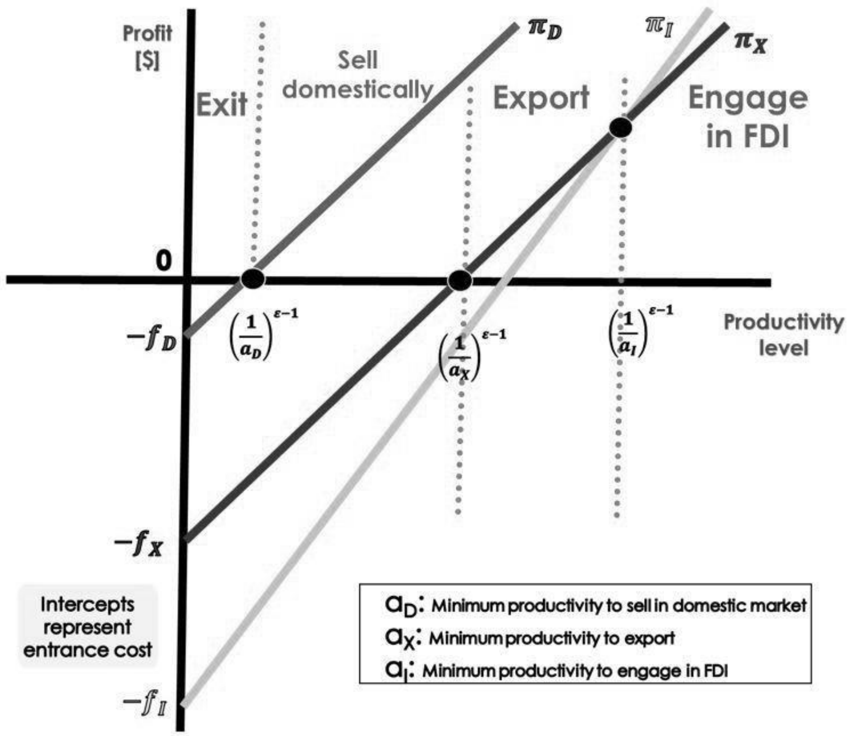
(iv) The most productive firms export and also engage in FDI with a cumulative profit of $\boldsymbol{\pi_I}$**.**

The net profit for any firm ***j*** that engages in any activity is computed as price *p* times the quantity demanded *Q(p)* minus the entry cost:

$$\pi_J = p\left(A_i p^{-\varepsilon}\right) - f_j \tag{3}$$

$$\pi_J = \left(\frac{1}{a}\right)^{\varepsilon-1} A - f_J \tag{4}$$

where *j* = *D* (domestic), *X* (exporting) or *I* (engaging in FDI).



Source: Modified from Helpman, Melitz, and Yeaple (2004)

Figure 1. Profit from Domestic Sales [π_D], Export [π_X] and FDI [π_I].

The profit functions are used to determine these cut-off productivities[1] and classify the firms into one of the four categories. The cut-off productivities are: a_D for domestic firms, a_X for exporters, and a_I for multinational companies investing in other nations. Taking the ratio of the (a_X/a_I), we obtain the following relationship:

(5) $$\left(\frac{a_X}{a_I}\right) = \left[\left(\frac{f_I - f_X}{f_X}\right)\left(\frac{1}{\tau^{\varepsilon-1} - 1}\right)\right]^{\frac{1}{\varepsilon-1}}$$

[1] A more detailed and technical explanations of the theory and techniques used in this study are available from the author upon request.

Therefore, the cutoff productivities are a function of the Armington elasticity of substitution, the fixed costs of exports [$\boldsymbol{f_x}$] and FDI [$\boldsymbol{f_I}$], and the variable transportation costs $\boldsymbol{\tau}$.

New, Modified Version of Elasticity of Trade: Elasticity of Foreign Sales $\boldsymbol{\zeta}$

From the profit function, we can obtain the revenue [R] as price times quantity for an exporter $R_X = \left(\frac{\tau_{ji}a}{\sigma}\right)^{\varepsilon-1} A$ and an investor in FDI: $R_X = \left(\frac{a}{\sigma}\right)^{\varepsilon-1} A$. Aggregating all firms within productivity for a specific sector, we can obtain the total sales (**TS)** in a sector as the revenue from all exporters (called $\boldsymbol{TR_X}$) and from the sales of the multinational companies (called $\boldsymbol{TR_I}$). Note that τ only appears as part of the first component. The elasticity of trade ($\boldsymbol{\zeta}$) proposed by Chaney (2008) can be found:

(6) $$\zeta \equiv -\frac{\partial lnTS}{\partial ln\tau} = (1-\varepsilon)\frac{TR_X}{TS}$$

Thus, this modified elasticity of trade depends on two factors: (1) The Armington elasticity of substitution $\boldsymbol{\varepsilon}$, and (2) the share of exports with respect to total foreign sales, which acts as a corrector to include the FDI sales. If a country does not have FDI sales, then the elasticity of foreign sales would only depend on $\boldsymbol{\varepsilon}$, as suggested by Hummel (1997).

Analysis of Effect of FDI with Respect to Entry Cost, Exports, and Transportation

The relative size from trade with respect to FDI [SXI] helps to understand the patter of multinational companies. This ratio can be calculated as:

(7) $$SXI = \frac{TR_X}{TR_I} = \tau^{1-\varepsilon}\left[\left(\frac{a_X}{a_I}\right)^{k-\varepsilon-1} - 1\right]$$

This can be simplified to obtain the final trade-FDI ratio:

(8) $$SXI = \tau^{1-\varepsilon}\left[\left(\frac{f_I - f_X}{f_X}\frac{1}{\tau^{\varepsilon-1}-1}\right)^{\frac{k}{(\varepsilon-1)}-1} - 1\right]$$

where SXI represents the ratio between aggregate sales in exports by sales from FDI in a determined sector M.

The linearized version of this ratio results in the following expression:

$$\ln(SXI) = -k\, ln(\tau) + \left(\frac{k}{(\varepsilon-1)} - 1\right)[lnf_I - lnf_X] \tag{9}$$

There are three insights from this linearized model:

1) $\vartheta = \frac{\partial \ln(SXI)}{\partial \ln(\tau)} = -k < 0$: Export decreases in favor of FDI sales with costlier transportation.

2) $\delta = \frac{\partial \ln(SXI)}{\partial \ln(f_X)} = -\left(\frac{k}{(\varepsilon-1)} - 1\right) < \mathbf{0}$: Rise in entry free for trade decreases exports

3) $\rho = \frac{\partial lnSXI}{\partial lnf_I} = \left(\frac{k}{(\varepsilon-1)} - 1\right) > \mathbf{0}$: Increase in the investment for FDI favors exports sales

Econometric Analysis and Data

Data

Our study focuses on determining the Armington elasticity of substitution of U.S. to foreign countries through exports and engaging in horizontal FDI. Thus, data from U.S. foreign sales were collected for the period of 2001-2007. The data is based on Brainard (1997). We include exports and outward sales from U.S. multinational companies (MNC), also called affiliates, to the most relevant 37 trade partners. Four aggregated sectors are considered: Mining and extraction, light manufacturing, heavy manufacturing, and food (processed and agricultural products).

The sales from U.S. affiliates to foreign countries are collected by BEA. Bilateral exports were obtained at FOB prices from the historical GTAP database from the U.S. to each destination. All sales data collected are represented in millions of dollars. The transportation cost is obtained as the transportation margin (difference between bilateral trade at Free-on-Board and Cost-Insurance-and-Freight prices) of the United States to each of the 37 countries. For the trade entry fee, the proxy variable is the sum of ad valorem tariffs, tariff-rate-quotas, and sectorial tariffs (in millions of dollars).

For an FDI entry cost, there is no direct data. We use two proxies under the following relationship: $f_I = \omega e^{\emptyset_I EXC + \emptyset_2 FDIINDEX}$. EXC is the appreciation in the exchange rate of the host currency with respect to the U.S. dollar. *FDIINDEX* is the FDI restrictiveness index. The score of the FDI index is based on the list provided by the OCED (Kalinova, Palerm, and Thomsen, 2010). Under both proxies, the higher their value, the costlier to engage in FDI. Finally, we also considered the GDP of the host country *j* as a control variable, collected from the International Monetary Fund (and shown in billions of dollars).

Econometric Approach for Analysis of Elasticity of Substitution

Using our theoretical framework, we develop the panel-data equation:

$$(10) \qquad \ln(SXI^{US,j,t}) = \widehat{\mu_0} + \hat{\vartheta}\ln(\tau)^{US,j,t-1} + \widehat{\mu_I} EXC_I{}^{US,j,t-1} + \widehat{\mu_2} FDI_{Index}{}^{j,t-1} + \hat{\delta}\ln(f_x)^{US,j,t-1} + \widehat{\mu_3}\ln(GDP^{j,t-1}) + \widehat{\mu_4}\boldsymbol{T} + \epsilon^{US,j,t}$$

In (10), $SXI^{US,j,t}$ refers to the ratio exports-to-FDI sales from U.S. to country j at year t. We assume that the decisions of investing depend on the expected values of the costs, in which the costs from the immediate previous period may serve as the expectation. The term $\widehat{\mu_m}$ represents the coefficients parameters of the control variables of the study. The term $\hat{\vartheta}$ provides the negative of the k parameter and $\hat{\delta}$ is the estimate of the coefficient of trade entry fee. Both of these coefficients are key to determining the Armington elasticity of substitution using the following relationship taken from the theoretical framework: $\varepsilon = 1 + \frac{\hat{\vartheta}}{\hat{\delta}+1}$

The first three cost variables in (10) represent the proximity-concentration variables proposed by Brainard (1997) and Helpman, Melitz, and Yeaple (2004). An additional dummy variable $\boldsymbol{T}$ which represents years was added into the study as a control variable to capture the effect of time, whereas lnGDP was added to control for country size. Finally, $\epsilon^{US,j,t}$ is the error term which is assumed to be normally distributed.

There are two versions of the model. The full "modified" version which is presented above, and the "basic" version which does not include GDP nor exchange rate. We use these two models to verify the robustness of the results. Each model is estimated through three different methods for robustness: (1) cross-sectional ordinary least square [OLS], (2) fixed effects [FE] model which captures the variation across nations, and (3) random effects model [RE], assuming that the error has a random component for each nation at a given sector. All regressions were unrestricted to test empirically the signs of the coefficients.

Results and Discussion

Results for each of the four aggregate sectors are presented in Tables 1 to 4. The first three columns show the results from the basic model, the last three columns display the outcomes for the full model.

Table 1. Results for the Mining and Extraction Aggregate Sector.

Dependent variable: Ratio Exports-FDI sales	OLS Basic model	RE Basic model	FE Basic model	OLS modified version	RE modified version	FE modified version
Intercept	-978.25	-1010.16**		-960.42	-929.89**	
	-630.51	-403.19		-605.28	-418.71	
ln(transportation margin)	-2.47***	-1.61***	-1.37	-3.87***	-2.15**	-1.44
	-0.9	-0.98	-1.08	-0.89	-0.98	-1.1
ln(tariff)	-0.52***	-0.29	-0.25	-0.69***	-0.34***	-0.25**
	-0.12	-0.11	-0.12	-0.11	-0.11	-0.12
ln(FDI index)	4.8	3.33	-6.01	-0.35	1.5	-3.84
	(2.82)”	-5.62	-12.76	-2.82	-5.1	-13.2
ln(GDP of country j)				3.17***	2.22**	1.11
				-0.58	-0.92	-1.63
Δ Exchange Rate (Currency j / USD)				5.08	1.3	0.44
				-3.1	-2.32	-2.44
Time	0.49	0.51**	0.49**	0.46	0.45**	0.47**
	-0.31	-0.2	-0.2	-0.3	-0.21	-0.21
Elasticity (ε)	**2.69**	**2.25**	**2.09**	**3.29**	**2.6**	**2.15**

Significant codes: 0 *** 0.01 ** 0.05 * 0.1.

For all aggregate sectors, the coefficient of the transportation cost is negative, which following Helpman, Melitz, and Yeaple (2004), is consistent with theoretical expectations. This negative sign means that an increase in transportation cost would discourage the U.S. to export, inclining the U.S. to engage in FDI. This coefficient was significant in the four sectors under OLS and RE modeling.

Table 2. Results for the Food Sector (Processing and Agricultural).

Dependent variable: Ratio Exports-FDI sales	OLS Basic model	RE basic model	FE basic model	OLS modified	RE modified	FE modified
Intercept	-1381.41*	-1871.21**		-1286.32**	-1371.38**	
	-780.69	-687.83		-792.98	-697.97	
ln(transportation margin)	-2.08***	-1.87**	-1.05	-1.79***	-1.58*	-1.01
	-0.55	-0.76	-1.5	-0.68	-0.94	-1.6
ln(tariff)	-0.4	-0.28	-0.18	-0.28	-0.2	-0.15
	-0.32	-0.32	-0.36	-0.34	-0.34	-0.36
ln(FDI index)	6.42	4.31	-7.45	6.94	4.89	-10.69
	-5.5	-8.1	-28.82	-5.52	-8.28	-32.57
ln(GDP of country j)				-0.77	-0.84	-0.94
				-1	-1.4	-3.16
Δ Exchange Rate (Currency j / USD)				-3.62	-2.76	-1.9
				-4.13	-3.86	-4.22
Time	0.69*	0.70**	0.7	0.65	0.67*	0.67
	-0.39	-0.34	-0.35	-0.4	-0.35	-0.35
Elasticity (ε)	**2.49**	**2.46**	**1.89**	**2.4**	**2.32**	**1.88**

Significant codes: 0 *** 0.01 ** 0.05 * 0.1.

Table 3. Results for the Heavy Manufacture Aggregate Sector.

Dependent variable: Ratio Exports-FDI sales	OLS Basic model	RE basic model	FE basic model	OLS modified version	RE modified version	FE modified version
Intercept	-336.90*	-336.13**		-310.85*	-312.57**	
	-175.5	-156.74		-176.79	-158.21	
ln(transportation margin)	-0.49***	-0.48**	-0.53	-0.36*	-0.38	-0.57
	-0.14	-0.2	-0.45	-0.21	-0.29	-0.5
ln(tariff)	-0.21**	-0.18	-0.08	-0.17*	-0.14	-0.07
	-0.08	-0.11	-0.17	-0.1	-0.12	-0.17
ln(FDI index)	1.02	0.39	-5.26	1.13	0.51	-5.94
	-2.16	-3.09	-8.23	-2.18	-3.16	-8.88
ln(GDP of country j)				-0.22	-0.21	-0.2
				-0.27	-0.36	-0.74
Δ Exchange Rate (Currency j / USD)				-0.94	-0.87	-0.87
				-0.91	-0.86	-0.96
Time	0.17*	0.17**	0.168**	0.16*	0.16**	0.16**
	-0.09	-0.08	-0.08	-0.09	-0.08	-0.08
Elasticity (ε)	**1.4**	**1.41**	**1.49**	**1.31**	**1.33**	**1.53**

Significant codes: 0 *** 0.01 ** 0.05 * 0.1.

Table 4. Results for the Light Manufacture Aggregate Sector.

Dependent variable: Ratio Exports-FDI sales	OLS Basic model	RE basic model	FE basic model	OLS modified version	RE modified version	FE modified version
Intercept	-729.53**	-734.17***		-729.53**	-482.41*	
	-319.34	-264.44		-324.93	-277.76	
ln(transportation margin)	-0.98***	-0.89**	-0.48	-0.03	-0.18	-0.22
	-0.24	-0.37	-0.88	-0.45	-0.58	-0.89
ln(tariff)	-0.02	-0.09	-0.32	0.2	0.09	-0.48
	-0.12	-0.19	-0.39	-0.16	-0.22	-0.38
ln(FDI index)	2.46	2.52	4.7	-1.3	-1.91	-12.55
	-3.88	-6.15	-13.61	-4.06	-6.39	-14.61
ln(GDP of country j)				-1.44**	-1.70**	-3.25***
				-0.59	-0.75	-1.23
Δ Exchange Rate (Currency j / USD)				2.43	2.1	1.59
				-1.64	-1.46	1.58
Time	0.37**	0.37***	0.37***	0.26	0.25*	0.21
	-0.16	-0.13	-0.13	-0.16	-1.37	-0.14
Elasticity (ε)	**1.96**	**1.81**	**1.36**	**1.04**	**1.2**	**1.15**

Significant codes: 0 *** 0.01 ** 0.05 * 0.1.

The trade entry cost is negative and significant for both manufacturing sectors (heavy manufacturing and mining-and-extraction). This result suggests that for the manufacturing sector, increasing trade costs such as tariffs will decrease manufacturing sales in exports and increase foreign investment, decreasing the ratio of exports-to-FDI. The proxy of FDI shows a positive sign overall under the basic model, whereas the appreciation of exchange rate is also positive under the full model. Both indices show that higher FDI entry costs (exchange rate and riskier FDI) will motivate increases in exports. However, both indices did not provide statistical significance in the model, considering that both are indices.

The time effect is overall significant which is consistent through the years. This result is likely to happen because the new trade agreements that the U.S. has been negotiating with several countries in recent years favored FDI over trade.

GDP has important effects on two aggregate sectors. For the mining industry, there is a motivation for exporting more products (such as gold, silver, and other metals) if the GDP of the host country is higher (equivalent to a higher power of purchase). For the light manufacturing sector, a high GDP in the host country would discourage exports of products such as textiles and wood and, instead, motivate horizontal FDI.

Table 5 shows the results for the Armington elasticity of substitution for all four sectors using the basic and modified versions of the model. The values from both versions are similar for the four sectors. As Table 5 displays, the mining and construction sector has an elasticity on average of 2.5; the range of this value goes from 2.09 and 3.29, depending on the type of model. The food sector, on average, has an elasticity of 2.24, with a range of 1.89 and 2.49. The heavy manufacturing sector, on average, has an elasticity is 1.41 with a range between 1.31 and 1.53. Finally, the light manufacturing sector, on average, has an elasticity of 1.42 with a range between of 1.04 and 1.96. Overall, the value for the Armington elasticity ranges from 1.41 to 2.51. These values are relatively low because of the inclusion of FDI, which is consistent with our theoretical framework.

Table 5. Results of the Armington Elasticity of Substitution for the Four Aggregate Sectors.

Sector	Basic model			Modified model			
	OLS	RE	FE	OLS	RE	FE	Average
Mining and Construction	2.69	2.25	2.09	3.29	2.6	2.15	***2.51***
Food	2.49	2.46	1.89	2.4	2.32	1.88	***2.24***
Heavy Manufacture	1.4	1.41	1.49	1.31	1.33	1.53	***1.41***
Light Manufacture	1.96	1.81	1.36	1.04	1.2	1.15	***1.42***

Armington elasticities reflect the competition between imported and domestic goods in a market. Thus, more precise elasticities allow a better reflection of the economy when evaluating impacts of trade policies. Our new Armington elasticity estimates include the effects of horizontal FDI, which may have spillovers on the domestic labor supply and capital investment. Including the effects of horizontal FDI in the Armington elasticity affects the modeling and the value of the elasticity of trade, providing new insights on the behavior of U.S. firms vis-a-vis the tradeoff between horizontal FDI and exports.

Capturing the effects of horizontal FDI gives us a better understanding of trade and the financial aspects of the economy and, therefore, allows us to address trade policies such as tariffs in a more comprehensive manner. For example, we can provide a more comprehensive explanation on how domestic products can be substituted, not only by exports from foreign economies, but also by the impact of multinational companies through horizontal FDI.

Enhancing our economic understanding of trade is an important matter, especially considering recent changes in trade and investment patterns among important trade partners such as the United States and China. As this article is being written, there is much concern about the “trade war” between the United States and China characterized by dramatic changes in trade policies such as increases in tariffs in several manufacturing and agricultural commodity sectors (Li, He, and Lin, 2018).

The new Armington elasticity estimates obtained from this study can be included in CGE models (depending on the sector) as the elasticity for foreign sales. The insertion of the new elasticity would replace the numerical value of the import-domestic elasticity for manufactured goods, including processed foods. Thus, our elasticity estimates can replace the original Armington elasticity without any further analytical procedures. Our methodology is flexible enough to be able to be repeated in order to obtain the Armington elasticities for other countries (and other sectors), depending on the availability of data to construct the model. The main difficulty in the data collection is the calculation of the trade entry cost and FDI.

In summary, our new elasticity estimates provide a more comprehensive view of an economy that includes the changes in horizontal FDI and its substitution with trade. The new elasticity estimates produce a lower estimate than previously reported in studies due to the fact that domestic products can be substituted not only by trade but also by products made by foreign companies in the host country. Therefore, the effect of a policy shock is expected to be lower when using the CGE model without new Armington elasticity estimates. These results are expected to occur with any new calibration of the Armington elasticity for other regions and sectors.

Conclusion and Final Remarks

The model presented in this paper incorporates FDI in the Armington (trade) elasticity of substitution. Thus, this elasticity captures multinational firms' sales (exporting and engaging in FDI). Our theoretical framework is based on Helpman, Melitz, and Yeaple (2004) which is based on firm heterogeneity.

Our theoretical model extends Hummel's model by incorporating the effects of two factors on the aggregate elasticity of foreign sales with respect to variable trade costs: (1) the elasticity of substitution and, (2) the share of exports relative to total foreign sales. Also, in our model, the ratio between shares of exports and FDI depends on the variable transportation cost, fixed entry cost of trade, FDI entry cost, and the Armington elasticity of substitution. Thus, the model uses standard proximity-concentration trade-off variables, originally proposed by Brainard (2001).

Using data on exports and FDI sales from U.S. affiliates in 37 countries and four aggregate industries (food, mining and extraction, and heavy and light manufacturing) during the period of 2001-2007, our study analyzes and corrects the Armington elasticity of substitution. Every sector was estimated independently with the results showing that the corrected Armington elasticity value is lower than the elasticity obtained in previous studies because of the inclusion of FDI effects. Likewise, our elasticity of substitution estimates which, on average, range between 1.4 and 2.6, show robustness when different estimators are calculated.

Our methodology can be easily used for other regions of the world and other industries depending on the availability of data to construct the model. In terms of policy implications, the new elasticity provides a more comprehensive view of the economy that includes the changes in horizontal FDI and its substitution with trade. Given that our new Armington elasticity of substitution estimates provide a lower value than the original CGE values due to inclusion of FDI, the impacts of a trade policy shock such as change in tariffs is expected to be lower when using a CGE model that incorporates our new elasticity estimates.

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