Trade and free trade agreement formation revisited: 
A trade in value added perspective

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Abstract

Gross bilateral exports can overstate a country’s contribution of value added in trade when imported intermediate inputs are used in their production. The fragmentation of the global value chain makes it hard to disentangle who produces for whom. Value added trade contains this information. Between 1995 and 2007, the ratio of value added exports to gross exports has steadily been declining from 0.74 to 0.66. Can this trend of slicing of the global value chain be explained by trade liberalization? We build a multi-sector gravity model of the Eaton and Kortum (2002) type with inter-sectoral linkages that gives rise to a gravity equation for value added trade flows. We construct a panel database of value added trade for 40 countries and the years 1995-2009 from the World Input-Output database. The data is used to estimate the gravity model’s key parameters. With counterfactual trade liberalization scenarios, we investigate how past FTA formation has shaped the value added of trade and the global value chain.

JEL Classification: F13, F14, F17

Keywords: Structural gravity, trade in value added, free trade agreements

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1 Introduction

The global value chain is increasingly fragmented into production stages across countries. Input trade—or vertical trade—is surging. Intermediate goods are “double-counted” as they cross borders several times embodied in upstream goods. This implies that gross export flows do not accurately measure the value added a country transfers to a trade partner. In a case study, Xing and Detert (2010) document that only about 4% of the value of an iPhone assembled in China and exported to the US is Chinese value added. Linden et al. (2009) come to similar results for the iPod. With macro data, Johnson and Noguera (2012a) estimate that the bilateral trade deficit of the US with China is by about 30-40% smaller when measured in value added. China assembles goods—especially in the electronics industry—with US knowledge/patents and intermediate inputs from Japan and Korea and often adds little value on its own. On the world level, the ratio of exports measured in gross terms to value added terms has dramatically declined.

The fragmentation of the global value chain makes it increasingly hard to track who produces for whom. This in turn makes it difficult to disentangle the effects of trade liberalization on the global value chain. In this paper, we want to address the question how trade liberalization has shaped the global value chain. Value added trade contains information to evaluate this question. Therefore, we use a gravity model that features multiple sectors and input-output linkages to formulate an expression for value added trade. We use the model’s structure to predict how past trade liberalization (e.g. FTA formations) have affected value added trade.

A related strand of literature formulates theories on global value chains. Costinot et al. (2013) develop a model where the production process constitutes of sequentiel stages. A country’s likelihood to make mistakes determines its position in the global value chain: the lower the probability of mistakes the more downstream are the production stages it performs. Antràs and Chor (forthcoming) develop a model with final goods producers
and suppliers and sequential production and investigate how incomplete contractual relationships influence the organization of the global value chain. They also develop measures for an industry’s position in the value chain.

An increasing body of literature documents value added trade flows (see e.g. Johnson and Noguera, 2012a; Baldwin and Lopez-Gonzalez, 2013). (Hummels et al., 2001; Daudin et al., 2011; Johnson and Noguera, 2012a) develop measures of the degree of vertical specialization. Data on the value added of trade between countries also provides a new perspective on revealed comparative advantage (Koopman et al., forthcoming), exchange rates (Bems and Johnson, 2012), business cycle comovements (Giovanni and Levchenko, 2010), the elasticity of trade with respect to tariff cuts (Yi, 2003) or the home bias in trade (Yi, 2010). It also provides an explanation why—during the financial crisis of 2008 and 2009—trade collapsed relatively stronger than GDP (Bems et al., 2011; Bénassy-Quéré et al., 2009).

Johnson and Noguera (2012b) and Johnson and Noguera (2012c) provide first empirical evidence on how the global value chain reacts to changes in trade costs. They study the effects of distance and FTA formation on trade in value added with a gravity equation. However, due to third country effects these estimates have to be interpreted with care. As we show with our model, value added of one country reaches the final consumer in another country via all other countries. Trade liberalization may lead to trade diversion and shock the whole global value chain. Consequently, it requires structural estimation and simulation to evaluate how trade liberalization affects who produces for whom.

Our paper is related to structural gravity applications. To take into account general equilibrium effects of trade liberalization, this strand of literature resorts to counterfactual policy experiments, typically evolving around effects of trade cost changes on (gross) trade patterns and welfare in general equilibrium. Several studies investigate the effects of abolishing the Canada-US border (see, for example Anderson and van Wincoop, 2003; Bergstrand et al., 2013). Other studies simulate the gains from trade of trade liberalization
(see for example Eaton and Kortum, 2002) or free trade agreement (FTA) formation (Egger et al., 2011; Egger and Larch, 2011) or deal with the role of trade imbalances for welfare (Dekle et al., 2007). However, only Caliendo and Parro (2012) introduce input-output linkages in a multi-sector Eaton and Kortum (2002)-type gravity model. They provide a new method to identify the main model parameter – the dispersion of productivities within sectors – and simulate the welfare effects of tariff cuts in the wake of the North American free trade agreement (NAFTA) formation. Yet, they do not provide an explicit formulation of value added trade. Costinot and Rodríguez-Clare (forthcoming) evaluate the welfare implications of trade liberalization in different formulations of the gravity model (one vs. multi-sector, input-output linkages, homogenous vs. heterogeneous firms etc.). We contribute to the literature by explicitly investigating value added trade and the global value chain.

The paper proceeds as follows. Chapter 2 uses the Caliendo and Parro (2012) gravity model with input-output linkages to derive an expression for value added trade. We show how trade liberalization affects gross exports and value added trade differently. While the trade elasticity is governed by the elasticity of substitution, the effect on bilateral value added trade depends on changes along the entirety of the global value chain. Chapter 3 describes features of our data on bilateral (sectoral) value added trade for 40 countries over the period 1995-2009 and performs gravity estimates. In Chapter 4 we use the sectoral trade elasticities estimated by Caliendo and Parro (2012) to simulate the trade and value added trade effects of counterfactual trade liberalization scenarios. To what extent can past trade liberalization explain the falling VAX ratio, i.e. global production fragmentation? We can also predict effects of FTAs currently under discussion, such as the transatlantic FTA between the US and the EU. Chapter 5 contains concluding remarks.
2 Trade in value added: a gravity model

In this chapter, we use the Caliendo and Parro (2012) multi-sector gravity model with input-output linkages to develop a formulation for bilateral value added trade.

2.1 Consumption and production

There are $N$ countries indexed by $i, n$ and $J$ sectors indexed by $j, k$. The representative consumer’s utility over final goods consumption $C_n^j$ follows Cobb-Douglas preferences, with $\alpha_n^j$ denoting sectoral expenditure shares

$$u(C_n) = \prod_{j=1}^{J} C_n^j \alpha_n^j. \quad (1)$$

Household income $I_n$ comprises wage income and lump-sum tariff rebates. The labor force $L_n$ of a country is mobile across sectors, i.e. $L_n = \sum_{j=1}^{J} L_n^j$, but not between countries.

In each sector $j$, a continuum of goods $\omega_j$ is produced with labor $l_n^j(\omega_j)$ and a composite intermediate input $m_k^j(\omega_j)$ of each source sector $k$ according to the following production function:

$$q_n^j(\omega_j) = x_n^j(\omega_j)^{\theta^j} \left[ l_n^j(\omega_j) \right]^{\beta_n^j} \left[ \prod_{k=1}^{J} m_n^k(\omega_j)^{\gamma_{nk}^j} \right]^{(1-\beta_n^j)}, \quad (2)$$

where $\beta_n^j \geq 0$ is the value added share in sector $j$ in country $n$ and $\gamma_{nk}^j$ denotes the cost share of source sector $k$ in sector $j$’s intermediate costs, with $\sum_{k=1}^{J} \gamma_{nk}^j = 1$. It implies sectors are interrelated because sector $j$ uses sector $k$’s output as intermediate input, and vice versa. $x_n^j(\omega_j)$ is the inverse efficiency of good $\omega_j$ in sector $j$ and country $n$. $\theta^j$ describes the dispersion of efficiencies in a sector $j$. A higher $\theta^j$ implies higher dispersion of productivities across goods $\omega_j$. The dual cost $c_n^j$ of an input bundle depends on a country’s wage rate $w_n$ and the price of the composite intermediate goods $k$ country $n$.
has to pay

\[ c^j_n = \gamma^j_n \, w_n \, \beta^j_n \left[ \prod_{k=1}^{J} p^k_n \, \kappa^j_n \right]^{(1-\beta^j_n)}, \]  

(3)

where \( \gamma^j_n \) is a constant. Note that sectoral goods \( \omega^j \) only differ in their efficiency \( x^j_i(\omega^j) \). Consequently, we re-label goods with \( x^j_i \).

Let \( \kappa^j_{ni} \) denote trade costs of delivering good \( j \) from country \( i \) to country \( n \). They consist of iceberg trade costs \( d^j_{ni} \geq 1 \), with \( d^j_{nn} = 1 \), and ad-valorem tariffs \( \tau^j_{ni} \geq 0 \) such that \( \kappa^j_{ni} = (1 + \tau^j_{ni})d^j_{ni} \). Perfect competition and constant returns to scale imply that firms charge unit costs

\[ p^j_{ni}(x^j_i) = \kappa^j_{ni} \left[ x^j_i \right]^{\theta^j} c^j_i. \]  

(4)

Label a particular intermediate good with the vector of efficiencies \( x^j = (x^j_1, \ldots, x^j_N) \). Country \( n \) searches across all countries for the supplier with the lowest costs. Consequently, the price \( n \) pays for good \( x^j \) is

\[ p^j_n(x^j) = \min_i \{ p^j_{ni}(x^j_i); i = 1, \ldots, N \}. \]  

(5)

Comparative advantage is introduced by assuming that countries differ in their productivity across sectors. The set of goods a country produces follows an exponential cumulative distribution function. The distribution of productivities is assumed to independent across countries, sectors, and goods. The joint density of \( x^j \) is

\[ \phi^j(x^j) = \left( \prod_{n=1}^{N} \lambda^j_n \right) \exp \left\{ - \sum_{n=1}^{N} \lambda^j_n x^j_n \right\}, \]  

(6)

where \( \lambda^j_n \) shifts the location of the distribution, and thus, measures absolute advantage.

The composite intermediate good \( q^j_n \) in each sector \( j \) is produced with a Dixit-Stiglitz CES technology. Let \( \eta^j \) denote the elasticity of substitution and \( r^j_n(x^j) \) the demand for intermediate good \( x^j \). The sum of costs for all intermediate goods \( x^j \) are minimized
subject to
\[
\left[ \int r_j^n(x^j) \frac{\eta_j^{\nu_j-1}}{\nu_j} \phi_j^i(x^j) dx^j \right]^{\frac{\eta_j}{\nu_j-1}} \geq q_j^n.
\] (7)

As usual, demand for \( x^j \) depends on the variety’s price relative to the sectoral price index
\[
p_i^n = \left[ \int p_i^n(x^j)^{(1-\eta_j)} \phi_j^i(x^j) dx^j \right]^{\frac{1}{1-\eta_j}}:
\]
\[
r^n_j(x^j) = \left( \frac{p_i^n(x^j)}{p_i^n} \right)^{-\eta_j} q_j^n.
\] (8)

Note that \( r^n_j(x^j) \) is the demand for intermediates of \( n \) from the respective lowest cost supplier of \( x^j \). The composite intermediate good \( q^n_j \) is either used to produce intermediate input of each sector \( k \) or to produce the final consumption good.

## 2.2 Gross exports

Solving for the distribution of prices and integrating over the sets of goods where each country \( i \) is the lowest cost supplier to country \( n \), we get the price of the composite intermediate good
\[
p_i^n = \left( \frac{\sum_{i=1}^N \lambda_i^n \left( c_i^j k_{ni}^{j} \right)^{\frac{1}{\nu_j}}}{\sum_{i=1}^N \lambda_i^n \left[ c_i^j k_{ni}^{j} \right]^{\frac{1}{\nu_j}}} \right)^{-\theta_j}.
\] (9)

Prices are correlated across all sectors (via \( c_j^i \)). The strength of the correlation depends on the coefficients of the input-output table \( g_{n,i}^{k,j} \).

Similarly, a country \( n \)’s expenditure share \( \pi_{ni}^j \) for source country \( i \)’s goods in sector \( j \) is
\[
\pi_{ni}^j = \frac{\lambda_i^n \left[ c_i^j k_{ni}^{j} \right]^{\frac{1}{\nu_j}}}{\sum_{i=1}^N \lambda_i^n \left[ c_i^j k_{ni}^{j} \right]^{\frac{1}{\nu_j}}}.
\] (10)

These shares apply to gross exports. Hence, gross exports follow the usual gravity equation. In the following, we provide an expression for value added trade.
2.3 Value added trade

As in Johnson and Noguera (2012a), we need information on bilateral final goods exports, the world input-output table and labor requirements in all countries and sectors to compute value added trade. The value of final consumption in sector $j$ is $C_n^j = \alpha_n^j I_n$.

The cost share of labor $l_i^j(x_i^j) = \ell_i^j w_i / c_i^j$ in the production of good $x^j$ in country $i$ follows from Shepard’s lemma

$$ l_i^j(x_i^j) = \frac{\partial c_i^j}{\partial w_i} w_i = \beta_i^j. \quad (11) $$

Similarly, we can derive the cost share of sector $j$ in country $i$ for the composite intermediate $k$

$$ a_i^{k,j} = \frac{\partial c_i^j}{\partial p_i^k} c_i^j = (1 - \beta_i^j) \gamma_i^{k,j}. \quad (12) $$

Using the proportionality assumption, we can derive bilateral input-output coefficients $a_{ni}^{k,j}$ (in value terms) as

$$ \pi_{ni}^{k,j} = \pi_{ni}^{k} a_{ni}^{k,j} = \frac{\lambda_n^k [c_{n}^{k,k_m}]^{\frac{1}{\gamma_k}}}{\sum_{n=1}^{N} \lambda_n^k [c_{n}^{k,k_m}]^{\frac{1}{\gamma_k}}} \gamma_i^{k,j}. \quad (13) $$

Like final goods trade, intermediate inputs trade $X_{ni}^{k,j} = \pi_{ni}^{k,j} \alpha_i^j I_n$ also follows the gravity equation.

We can collect all bilateral input-output coefficients in a world input-output table $A$. Elements $b_{ni}^{k,j}$ of the Leontief inverse of this matrix, i.e. $B = (I - A)^{-1}$, inform about the quantity sector $j$ in country $n$ requires of inputs produced in country $i$ in sector $k$ in order to produce one unit. $B$ takes into account the world-wide fragmentation of the value chain and intermediates trade. Consequently, the value added (in terms of labor content) generated in a sector $k$ that flows to country $n$ from country $i$ is

$$ VA_{ni}^k = \frac{\ell_i^k}{w_i} \sum_{j=1}^{J} b_{ni}^{k,j} C_n^j = \frac{\beta_i^k I_n}{w_i} \sum_{j=1}^{J} \alpha_n^j b_{ni}^{k,j}. \quad (14) $$
Let us further distinguish by exporting sector $j$

$$V A_{ni}^{k,j} = \frac{\beta_k^i}{w_i} \alpha_n^j I_n b_{ni}^{k,j}.$$  \hspace{1cm} (15)

Approximate Leontief coefficients $\tilde{b}_{ni}^{k,j}(m)$ that capture indirect value added flows through third countries up to the $m^{th}$ round can be derived as the finite sum of direct and indirect effects. Using (11), (12) and (10) we obtain

$$\tilde{V} A_{ni}^{k,j} (3) = \alpha_n^j I_n \left( \mathcal{I}[j = k, n = i] \pi_{ni}^k \frac{\beta_k^i}{w_i} + (1 - \beta_n^j) \gamma_{nj}^k \pi_{ni}^k \frac{\beta_k^i}{w_i} \right. \left. + \sum_{k_1=1}^{J} \sum_{i_1=1}^{N} (1 - \beta_n^j) \gamma_{nj}^{k_1,j} \pi_{ni_1}^{k_1} (1 - \beta_{i_1}^{k_1}) \gamma_{i_1i}^{k_1,k_1} \pi_{n_1i_1}^{k_1} \frac{\beta_k^i}{w_i} \right)$$

$$+ \sum_{k_1=1}^{J} \sum_{i_1=1}^{N} \sum_{k_2=1}^{J} \sum_{i_2=1}^{N} (1 - \beta_n^j) \gamma_{nj}^{k_1,j} \pi_{ni_1}^{k_1} (1 - \beta_{i_1}^{k_1}) \gamma_{i_1i}^{k_1,k_2} \pi_{n_1i_1}^{k_1} (1 - \beta_{i_2}^{k_2}) \gamma_{i_2i}^{k_2,k_2} \pi_{n_2i_2}^{k_2} \frac{\beta_k^i}{w_i})$$

$$= \alpha_n^j I_n \frac{\beta_k^i}{w_i} \tilde{b}_{ni}^{k,j} (3)$$

as approximate bilateral value added flow from sector $k$ in $i$ to sector $j$ in $n$ that takes into account all direct and indirect value added flows up to the second transit country, i.e. value added that has traveled through at most two other countries $i_1$ and $i_2$ embodied in composites of any sector $k_1$, $k_2 = 1, ..., J$ before it reaches $n$. The first term inside the parenthesis is the direct value added content of producing an output value of $\alpha_n^j I_n$ for final consumption. Note that this term is zero whenever the source sector and demanding sector or source country and destination country are not identical, i.e. the indicator function takes on a value one only if $j = k$ and $n = i$, and zero otherwise. The second component $(1 - \beta_n^j) \pi_{ni}^k \gamma_{nj}^k \frac{\beta_k^i}{w_i}$ captures value added from $k$ in $i$ that is directly embodied in the composites used by $j$ in $n$. The third component describes $j$’s demand for composites from other sectors $k_1$, that source a share $\pi_{ni_1}^{k_1}$ from country $i_1$, which in turn embodies a share $(1 - \beta_{i_1}^{k_1}) \gamma_{i_1i}^{k_1,k_1} \pi_{n_1i_1}^{k_1}$ of value from the source sector $k$ in country $i$ directly. Furthermore, outputs from sectors $k_1$ embody value of all other sectors $k_2$ in the proportion of $(1 -$
\( \beta_{k_1} \gamma_{i_1}^{k_2, k_1} \), which, again, source a share \( \pi_{i_1 i_2}^{k_2} \) of their components from a third country \( i_2 \), embodying direct value of the source sector \( k \) in \( i \) in the proportion of \((1 - \beta_{i_2}) \gamma_{i_2, i}^{k_2, k_2} \pi_{i_2} \).

This makes up the forth component of the expression. The true Leontief coefficients are an infinite sum of those sort of higher round effects.

### 2.4 Value added trade and trade cost changes

In this section, we investigate how changes in trade costs affect value added trade. This helps to guide our empirical estimation. For ease of comparison, we can first derive the partial effect of a change in trade cost on bilateral trade shares

\[
\frac{\partial \chi_{ni}^{k,j}}{\partial \kappa_{ni}^k} = (1 - \beta_{ni}^{j}) \gamma_{ni}^{k,j} \alpha_{ni}^{j} I_{ni} \frac{\partial \pi_{ni}^{k}}{\partial \kappa_{ni}^k}.
\]

(16)

Note that the trade share \( \pi_{ni}^{k} \) depends on \( \kappa_{ni}^k \) directly and indirectly through \( c_{ki}^i \) and \( c_{hi}^h \forall h = 1, ..., N \).

Now, differentiate \( VA_{ni}^{k,j} \) with respect to \( \kappa_{ni}^j \)

\[
\frac{\partial VA_{ni}^{k,j}}{\partial \kappa_{ni}^j} = \alpha_{ni}^{j} I_{ni} \frac{\partial b_{ni}^{k,j}}{\partial \kappa_{ni}^j}.
\]

(17)

Using our third round approximation to the Leontief coefficients we obtain

\[
\frac{\partial VA_{ni}^{k,j}}{\partial \kappa_{ni}^j} \approx \beta_{ni}^{k} \gamma_{ni}^{k,j} \alpha_{ni}^{j} I_{ni} (1 - \beta_{ni}^{j}) \left( \gamma_{ni}^{k} \frac{\partial \pi_{ni}^{k}}{\partial \kappa_{ni}^k} + \sum_{k_1=1}^{J} \sum_{i_1=1}^{N} \sum_{k_2=1}^{J} \sum_{i_2=1}^{N} \gamma_{ni}^{k_1, j} (1 - \beta_{i_1}^{k_1}) \gamma_{i_1}^{k, k_1} (1 - \beta_{i_2}^{k_2}) \frac{\partial (\pi_{ni_1}^{k_1} \pi_{ni_2}^{k_2})}{\partial \kappa_{ni}^k} \right).\]

(18)

The first term captures the direct effect of the trade cost change as in (17). Compared to bilateral trade flows, value added flows are also affected by the reorganization of the entire global value chain. This is reflected in the additional terms and depends on changes in all other bilateral sectoral trade shares. The sign of these terms is ambiguous. Some entries
may be positive, but since we also expect some trade diversion we also expect negative entries.

This finding implies that empirical estimates on the value added trade elasticity depend on which country pairs’ trade costs are reduced. However, we can use the structural model as outlined above to predict changes in value added trade from counterfactual trade liberalization scenarios. For example, we can simulate the effects of a transatlantic free trade agreement between the US and the EU. Taking into account changes along the entirety of the global value chain, to what extent does this FTA formation increase the US to source value added from the EU, and vice versa?

3 The empirical evidence

3.1 Data

We construct value added trade flows by applying (14). That is we need data on final goods trade flows, a world input-output table and value added coefficients. These data are, e.g., provided in the world input-output database (WIOD). It features data for 40 mainly OECD countries for the years 1995-2009 with a sectoral breakdown at the two digit ISIC level, i.e. 35 industries. It contains information on trade levels for all goods, including the services industries. Note that the WIOD does not have information on bilateral input-output coefficients. These are imputed from national input-output tables with the proportionality assumption. Accordingly, a sector’s usage of a certain intermediate input is split between trade partners according to their respective import share of the intermediate. See Timmer (2012) for an in-depth description of methods and assumptions used to construct the WIOD. Also note that in the model there exists only one production factor. Consequently, value added is equivalent to labor input. In the WIOD database,
Table 1: Summary statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Observations</th>
<th>Mean</th>
<th>Std.Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exports (Mio US-§)</td>
<td>22,230</td>
<td>3,892</td>
<td>13,876</td>
<td>0</td>
<td>428,893</td>
</tr>
<tr>
<td>.. of final goods</td>
<td>22,230</td>
<td>1,547</td>
<td>6,175</td>
<td>0</td>
<td>236,162</td>
</tr>
<tr>
<td>.. of intermediate goods</td>
<td>22,230</td>
<td>2,345</td>
<td>8,089</td>
<td>0</td>
<td>207,139</td>
</tr>
<tr>
<td>Value added exports (Mio US-§)</td>
<td>22,230</td>
<td>2,758</td>
<td>9,911</td>
<td>0.3</td>
<td>323,342</td>
</tr>
<tr>
<td>FTA dummy (0,1)</td>
<td>22,230</td>
<td>.528</td>
<td>.499</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Distance (km)</td>
<td>22,230</td>
<td>4,971</td>
<td>4,459</td>
<td>60</td>
<td>18,550</td>
</tr>
<tr>
<td>Contiguity (0,1)</td>
<td>22,230</td>
<td>.061</td>
<td>.239</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Common language (0,1)</td>
<td>22,230</td>
<td>.062</td>
<td>.241</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Colonial history (0,1)</td>
<td>22,230</td>
<td>.039</td>
<td>.194</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: The table provides summary statistics for dependent and independent variables averaged over the years 1995 to 2009.

the value added coefficient captures labor as well as capital services.\(^3\)

Bilateral distance and dummies for contiguity, common language, and colonial history are obtained from the CEPII distance database. The FTA dummy is constructed from the WTO homepage. GDPs stem from the World Development Indicators (WDI) 2012.

Table 1 provides summary statistics for all variables. The average bilateral export value amounts to about 4,000 US-§. Intermediate goods trade constitutes about two thirds of trade flows. Bilateral value added exports are on average smaller than gross exports. In about 50% of all observations, trade partners are in a FTA. On average, trade partners are 5,000 km apart. 6% of the country pairs share a common border or a common language and 4% share a colonial tie.

Figure 1 shows that the ratio of value added exports to gross exports has been consistently declining over the period 1995 to 2008, with a small surge in 2009—the year of the financial crisis. This implies that vertical trade and production sharing has become more and more important. Gross exports have become less accurate statistics for the value added generation behind the exports. In 2008, about one third of the export value

\(^3\)We also construct the high, medium and low skilled contents of trade.
Note: The figure shows the evolution of world-level exports (dark blue bars) and value added exports (light blue bars) for the period 1995-2009. It also shows the ratio of value added exports to exports (orange line, right scale).

constitutes double counting.

### 3.2 Gravity estimates

Next we estimate a log-linearized cross-sectional gravity equation as given in (10). Importer and exporter fixed effects take into account unobserved country-level heterogeneity. The log of distance and dummies for FTAs, contiguity, common language and colonial history proxy for bilateral trade costs. Column (1) in Table 2 provides the results. As usual, the gravity equation does well in explaining trade flows: about 90% of the variation in exports is explained with our specification. All trade cost proxies enter with the expected sign. The coefficient on bilateral distance is -0.995 and statistically significant at the 1% level. This implies distance hinders exports, with an elasticity of about 1. A common border, a common language and a common colonial history increases exports,
Table 2: Gravities – Cross section 2007

<table>
<thead>
<tr>
<th>Dep. var.: Log of...</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All goods</td>
<td>Final goods</td>
<td>Intermediate goods</td>
<td>Value added exports</td>
</tr>
<tr>
<td>FTA (0,1)</td>
<td>0.314***</td>
<td>0.243**</td>
<td>0.355***</td>
<td>0.143**</td>
</tr>
<tr>
<td></td>
<td>(0.097)</td>
<td>(0.103)</td>
<td>(0.101)</td>
<td>(0.062)</td>
</tr>
<tr>
<td>Ln distance</td>
<td>-0.995***</td>
<td>-0.967***</td>
<td>-1.018***</td>
<td>-0.733***</td>
</tr>
<tr>
<td></td>
<td>(0.054)</td>
<td>(0.057)</td>
<td>(0.055)</td>
<td>(0.037)</td>
</tr>
<tr>
<td>Common language (0,1)</td>
<td>0.359***</td>
<td>0.345***</td>
<td>0.351***</td>
<td>0.267***</td>
</tr>
<tr>
<td></td>
<td>(0.115)</td>
<td>(0.119)</td>
<td>(0.123)</td>
<td>(0.078)</td>
</tr>
<tr>
<td>Colony (0,1)</td>
<td>0.325**</td>
<td>0.312**</td>
<td>0.358**</td>
<td>0.185*</td>
</tr>
<tr>
<td></td>
<td>(0.133)</td>
<td>(0.146)</td>
<td>(0.140)</td>
<td>(0.097)</td>
</tr>
<tr>
<td>Contiguity (0,1)</td>
<td>0.262**</td>
<td>0.277**</td>
<td>0.273**</td>
<td>0.291***</td>
</tr>
<tr>
<td></td>
<td>(0.128)</td>
<td>(0.136)</td>
<td>(0.132)</td>
<td>(0.098)</td>
</tr>
<tr>
<td>Observations</td>
<td>1,482</td>
<td>1,482</td>
<td>1,482</td>
<td>1,482</td>
</tr>
<tr>
<td>Adj-R²</td>
<td>0.890</td>
<td>0.894</td>
<td>0.875</td>
<td>0.951</td>
</tr>
<tr>
<td>F-stat</td>
<td>136.217</td>
<td>143.716</td>
<td>121.105</td>
<td>339.592</td>
</tr>
<tr>
<td>RMSE</td>
<td>0.747</td>
<td>0.763</td>
<td>0.805</td>
<td>0.467</td>
</tr>
</tbody>
</table>

Note: OLS regression with importer and exporter dummies (not shown) in a cross-section of 2007. Standard errors (in parantheses) are heteroskedasticity-robust. *, ** and *** indicate statistical significance at the 10, 5 and 1% level, respectively.

each by roughly 30%. The FTA dummy enters with a coefficient of 0.314, statistically significant at the 1% level. Formation of a bilateral FTA increases bilateral exports by about 31.4%.

Column (1) focuses on total exports. In columns (2) and (3), we distinguish between final goods and intermediate goods exports, respectively. Results are very similar with one exception. The coefficient on FTAs is 0.243 (p-value of 5%) in the final goods specification and 0.355 (p-value of 1%) in the intermediate goods specification. This implies that FTA formation overproportionally benefits intermediates trade.

In the last column of Table 2, the dependent variable is the log of value added exports. First, note that the gravity specification also fairs well in explaining value added exports. The R² is 0.951. This is somewhat surprising given that the theoretical expression in (14) is not quite a gravity equation. Second, both the coefficients of the FTA dummy and
the coefficient on bilateral distance are smaller in absolute size than the ones obtained in
the export specifications. Johnson and Noguera (2012c,b) report similar findings. The
coefficient on distance is estimated to be -0.733, statistically significant at the 1% level.
Distance matters less for bilateral value added flows. Put differently, value added travels
further. The FTA dummy estimate is 0.143 and statistically significant at the 5% level.
A potential explanation for this sizeably smaller effect is that while FTAs stimulate the
region’s production sharing—as also indicated by the stronger response of intermediate
trade to the FTA dummy—the goods might finally not be consumed in the FTA region.

These observations also hold in panel estimations, see Table 3. We include bilateral
fixed effects to control for unobserved country pair heterogeneity. Consequently, we can
no longer identify the effects of distance and other trade costs that have no time variation.
We include GDP of both importer and exporter, multilateral resistance terms and time
dummies to capture business cycle effects. While the FTA dummy is highly statistically
significant in all export specifications and in the order of magnitude of 17 to 19%, it is
no longer statistically different from zero in the value added export specification. When
two countries form an FTA, this does not lead to more absorption of the respective trade
partners goods.

Does FTA formation have different effects for different types of goods? To investigate
this question, we split the sample into manufacturing, services and agricultural goods
trade. For manufacturing goods, formation of an FTA has similar effects for gross exports
and value added exports, see columns (1) and (2). For services, we do not detect an effect
of FTA formation on gross exports. The respective coefficient is 0.056 and statistically not
different from zero. However, FTAs matter for transferring services value added to trade
partners. If two countries form an FTA, their value added exports increase by about 11%.
Services are not directly exporter, but rather indirectly through manufacturing goods. For
agricultural goods, the FTA coefficient is estimated to be 0.186, but the precision of the
estimate is very low so that it is not statistically significant. As in the case of services,
### Table 3: Gravities – Panel 1995-2009

<table>
<thead>
<tr>
<th>Dep. var.: Log of...</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All goods</td>
<td>Final goods</td>
<td>Intermediate goods</td>
<td>Value added exports</td>
</tr>
<tr>
<td>FTA (0,1)</td>
<td>0.166***</td>
<td>0.192***</td>
<td>0.172***</td>
<td>0.048</td>
</tr>
<tr>
<td></td>
<td>(0.058)</td>
<td>(0.063)</td>
<td>(0.063)</td>
<td>(0.038)</td>
</tr>
<tr>
<td>Ln GDPₜₒ</td>
<td>0.714***</td>
<td>0.800***</td>
<td>0.701***</td>
<td>0.736***</td>
</tr>
<tr>
<td></td>
<td>(0.046)</td>
<td>(0.051)</td>
<td>(0.050)</td>
<td>(0.030)</td>
</tr>
<tr>
<td>Ln GDPₜₐ</td>
<td>0.857***</td>
<td>0.999***</td>
<td>0.768***</td>
<td>0.890***</td>
</tr>
<tr>
<td></td>
<td>(0.046)</td>
<td>(0.049)</td>
<td>(0.049)</td>
<td>(0.029)</td>
</tr>
<tr>
<td>Observations</td>
<td>21,998</td>
<td>21,990</td>
<td>21,998</td>
<td>22,004</td>
</tr>
<tr>
<td>No. of countrypair-sectors</td>
<td>1,482</td>
<td>1,482</td>
<td>1,482</td>
<td>1,482</td>
</tr>
<tr>
<td>Within-R²</td>
<td>0.622</td>
<td>0.565</td>
<td>0.600</td>
<td>0.813</td>
</tr>
<tr>
<td>F-stat</td>
<td>319.262</td>
<td>253.846</td>
<td>287.580</td>
<td>710.775</td>
</tr>
<tr>
<td>RMSE</td>
<td>0.422</td>
<td>0.479</td>
<td>0.446</td>
<td>0.251</td>
</tr>
</tbody>
</table>

Note: Bilateral fixed effects regression with multilateral resistance terms a la Baier and Bergstrand (2009) and time dummies in a panel, 1995-2007. Standard errors (in parantheses) are heteroskedasticity-robust and clustered at the country pair level. *, ** and *** indicate statistical significance at the 10, 5 and 1% level, respectively.

FTA formation increases exports of agricultural value added by about 11%.

### 4 How does trade liberalization affect value added trade: Counterfactual experiments

—to be completed—

### 5 Conclusion

—to be completed—
Table 4: Bilateral-sectoral FE with importer-and-time and exporter-and-time effects, 1995-2009

<table>
<thead>
<tr>
<th>Sector: Log of...</th>
<th>(1) Manufacturing Exports</th>
<th>Value added exports</th>
<th>(2) Services Exports</th>
<th>Value added exports</th>
<th>(3) Agriculture Exports</th>
<th>Value added exports</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
</tr>
<tr>
<td>WTO (0,1)</td>
<td>0.274</td>
<td>0.207***</td>
<td>0.013</td>
<td>0.117</td>
<td>-0.191</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td>(0.169)</td>
<td>(0.102)</td>
<td>(0.139)</td>
<td>(0.076)</td>
<td>(0.238)</td>
<td>(0.098)</td>
</tr>
<tr>
<td>EU (0,1)</td>
<td>0.179***</td>
<td>0.246***</td>
<td>0.265***</td>
<td>0.273***</td>
<td>0.588***</td>
<td>0.322***</td>
</tr>
<tr>
<td></td>
<td>(0.056)</td>
<td>(0.033)</td>
<td>(0.070)</td>
<td>(0.036)</td>
<td>(0.090)</td>
<td>(0.036)</td>
</tr>
<tr>
<td>Observations</td>
<td>22,224</td>
<td>22,230</td>
<td>22,131</td>
<td>22,230</td>
<td>22,011</td>
<td>22,230</td>
</tr>
<tr>
<td>No. of clusters</td>
<td>1,482</td>
<td>1,482</td>
<td>1,476</td>
<td>1,482</td>
<td>1,482</td>
<td>1,482</td>
</tr>
<tr>
<td>Within-R²</td>
<td>0.582</td>
<td>0.817</td>
<td>0.589</td>
<td>0.834</td>
<td>0.301</td>
<td>0.723</td>
</tr>
<tr>
<td>F-stat</td>
<td>105.992</td>
<td>241.401</td>
<td>68.798</td>
<td>211.540</td>
<td>28.394</td>
<td>147.015</td>
</tr>
<tr>
<td>RMSE</td>
<td>0.517</td>
<td>0.248</td>
<td>0.555</td>
<td>0.261</td>
<td>0.905</td>
<td>0.313</td>
</tr>
</tbody>
</table>

Note: Bilateral fixed effects regression with importer-and-time and exporter-and-time dummies in a panel, 1995-2009. Standard errors (in parantheses) are heteroskedasticity-robust and clustered at the country pair level. *, ** and *** indicate statistical significance at the 10, 5 and 1% level, respectively.
References


