Revista de Ciencias Económicas 37-N°2: julio-diciembre 2019 / 71-90 / ISSN: 0252-9521 / ISSN: 2215-3489

https://revistas.ucr.ac.cr/index.php/economicas

DOI: https://doi.org/10.15517/rce.v37i2.40031

GAINS FROM TRADE: THE COSTA RICAN CASE

GANANCIAS DEL COMERCIO: EL CASO COSTARRICENSE

Alonso Alfaro Ureña[1]

Recibido: 17/12/2018 Aprobado: 29/09/2019

ABSTRACT

One of the oldest and most interesting questions in the economic literature is how to quantify the gains from trade. Recently, Costinot & Rodríguez-Clare (2014) (CRC) developed a methodology that uses the World Input Output Database (WIOD) to compute this value for a list of countries. Costa Rica has never been part of this database given the lack of appropriate data. However, with the publication of a new Input Output Table for Costa Rica, the Foreign Trade Ministry (COMEX) was able to develop a domestic version of the WIOD that includes the country. This paper presents the results of the CRC methodology using this version of the WIOD to compute gains from trade for the Costa Rican economy. Counterfactual exercises that compare the current situation with autarky and other average tariff levels using different productive structures and competition schemes in the economy are also presented. The results can provide valuable information on how much a small open economy like Costa Rica's can benefit from international trade, and what are the differences in the results when compared to similar countries.

KEY WORDS: GAINS FROM TRADE, COSTA RICA, INPUT-OUTPUT.
JEL CLASIFICATION JEL: F10, I30, D57.

RESUMEN

Uno de los retos más interesantes de la literatura económica es la cuantificación de las ganancias del Comercio. Recientemente, Costinot & Rodríguez-Clare (2014) (CRC) desarrollaron una metodología que utiliza la World Input Output Database (WIOD) para calcular este valor para una lista de países. Costa Rica nunca ha sido parte de esta base de datos debido a que no contaba con los datos apropiados. Sin embargo, la publicación de la nueva Matriz Insumo Producto para Costa Rica permitió al Ministerio de Comercio Exterior (COMEX) desarrollar una versión de la WIOD que incluye al país. Este trabajo presenta

1 Banco Central de Costa Rica, Departamento de Investigación Económica, División Económica; Código postal 10058-1000; San José, Costa Rica; alfaroua@bccr.fi.cr
Universidad de Costa Rica, Escuela de Economía; Código postal 11501-2060; San José, Costa Rica.

los resultados de la metodología de CRC utilizando esta versión de la WIOD para calcular las ganancias del comercio para la economía costarricense. Adicionalmente se presentan ejercicios contrafactuales en los que se compara la situación vigente con autarquía y otros niveles de tarifas promedio utilizando diferentes estructuras productivas y esquemas de competencia. Los resultados pueden constituir información valiosa sobre cuánto puede ganar una economía pequeña y abierta como la costarricense gracias al comercio internacional, y en qué se diferencia de otros países en una situación similar.
PALABRAS CLAVE: GANANCIAS DEL COMERCIO, COSTA RICA, INSUMO-PRODUCTO
CLASIFICACIÓN JEL: F10, I30, D57.

I. INTRODUCTION

One of the oldest and most interesting questions in the economic literature is how to quantify the gains from trade[2]. Recent work by Costinot & Rodríguez-Clare (2014) (CRC) described how the results of a wide array of trade models developed in the last two decades can provide parsimonious measures of the gains from trade. Those include, for example, one sector models, multiple sector models, and models with intermediate goods. Different structures for how competition works in those markets are also considered, such as perfect, Bertrand, and monopolistic competition[3].

The results presented in CRC[4] are useful for evaluating the effects of globalization and the differences that arise for different countries depending on the level of integration to the rest of the world. The authors use the World Input Output Database (WIOD) constructed by Dietzenbacher, Los, Stehrer, Timmer & de Vries (2013) for computing the gains from trade. However, this database does not include Costa Rica as an individual country, it is included as part of the "Rest of the World".

For a small, open economy such as Costa Rica it is of particular interest to quantify how much does the country gain from having its economy open to trade with the rest of the world. The two main contributions of this paper are that, first, it updates the results from CRC to the 2011 data, which changed quantitatively after the trade collapse that followed the Great Recession and, second, it computes the gains from trade for Costa Rica using this version of the WIOD.

The results are, in general, consistent with the gains from trade from similar small open economies. The gains from the current situation are above the average of the rest of the world, while increasing dramatically when the assumptions allow for multiple sectors in perfect competition.

II. THE NEW DATABASE

Costa Rica did not update its own Input Output Matrix (IOM) for many decades. Leiva & Vargas (2014) mention that before 2014 there had been only two matrices in the history of the country, one from 1969 (Modelo Insumo-Producto para Costa Rica - 1969: Un ensayo de Economía Inter-industrial), and the 2011 version developed by the Banco Central de Costa Rica (BCCR). There have been other approximations in between, such as the matrix from 1991, which had been the most widely used before the new publication. Even though in February 2016 the newest version of

2 The positive implications of opening to trade have been well established theoretically for decades, see Samuelson (1939).

3 In all of these models simple resulting expressions summarize how much real consumption could increase when the country opens to trade.

4 The work presented in the current paper focuses exclusively on the computation of the gains from trade from the gravity models presented at the beginning of CRC. There are further theoretical and empirical discussions in their work which are not discussed here, but should be of interest of any reader who wants to understand other modeling options, and the discussion of the costs of using parsimonious models such as the ones discussed in this paper. These costs are usually related to the restricting assumptions regarding functional forms that must be used, which may not be a good fit in all dimensions of the data.

the IOM (with data for 2012) was published by BCCR along with a new set of data for the national accounts, this matrix has not been included in a newer version of the WIOD.

The 2011 version which was published in 2014 was constructed using the most recently available information in accordance with the best practices recommended by the United Nations Statistical Commision. In Bullón, Mena, Meng, Sanchez, Vargas & Inomata (2015) the authors document how this IOM was embedded into the World Input Output Database. Their work allowed for the publication of a domestic version of the WIOD that includes Costa Rica as a single country in this database, and not part of the Rest of the World. The authors of Bullón et al. (2015), the Ministry of Foreign Trade (COMEX) and the Central Bank (BCCR) deserve recognition for preparing this database for external use. There is a significant amount of work that can be done thanks to this effort, and the trade and industrial organization literature of Costa Rica can expand much more thanks to this accomplishment.

The Costa Rican 2011 IOM has 76 products, which were aggregated into 35 industries to match the international version. The results shown in this paper are not exactly the same as those presented in Costinot & Rodriguez-Clare (2014) because the version into which the Costa Rican IOM was embedded was the 2011, whereas the authors use the 2008 version. It is also the case that this database shows trade data after the 2008-2009 crisis that caused a collapse of the quantity of international trade in the following years, which affects the magnitude of the gains from trade.

One relevant difference from CRC is that for the calculations presented in this paper, 16 sectors are used for the aggregation levels, instead of the 31 sectors used in the original paper[5]. The reason for this is that the Costa Rican IOM lacks data on some of the sectors, and makes the inversion of the matrices required for the computation impossible without some additional aggregation.

III. COMPUTING GAINS FROM TRADE

As it was mentioned, the goal of this paper is to apply the same methodology of CRC for the version of the WIOD that includes Costa Rica as a separate country (CRWIOD henceforth), which was developed by COMEX (see Bullón et al., 2015). Even though there is no new theory developed throughout this paper, some basic elements of how the gains from trade are computed in each version will be described explicitly.

I present the main elements that help to understand how the model described works: the preferences, the price index that corresponds to those preferences, the price of each good according to the assumption made regarding the competition of the economy, and the gravity equation that results from the solution of the model. While I give general notions of the relevant elements of each model, the complete description of the derivation can be found in CRC. The discussion of the many caveats that should be considered when analyzing each type of model are also found in that paper.

Armington Model

The simplest multi-country gravity model used in international trade which can match trade patterns across countries is an Armington model, which assumes an endowment economy. This setup can serve as a benchmark for comparison for the rest of the models and assumptions presented in the rest of the paper. In each of the $i = 1,...,n$ countries there is an endowment of a unique domestic good Q_i. The preferences take the form

5 Appendix 2 presents the results in CRC for the 16 sector aggregation.

$$C_j = \left(\sum_{i=1}^{n} \Psi_{ij}^{\frac{1-\sigma}{\sigma}} C_{ij}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{3.1}$$

with C_{ij} is the quantity consumed of a good exported by the country denoted with the first subscript, to the country denoted with the second subscript. In the notation of this paper, *i* is the country of origin of the goods, where they are exported from. In contrast, *j* is the country where goods are received; hence, measures like welfare have to be analyzed in country *j*. The parameters $\psi_{ij} > 0$ are exogenous preference parameters, and $\sigma > 1$ is the elasticity of substitution between the goods. There is a corresponding price index associated to preferences 3.1 with the goods consumed in each destination country *j*:

$$P_j = \left(\sum_{i=1}^{n} \Psi_{ij}^{1-\sigma} P_{ij}^{1-\sigma} \right)^{1/(1-\sigma)} \tag{3.2}$$

where P_{ij} is the price of the good produced in country *i* (also called "good *i*" because it is endowed to that country) exported to country *j*. The trade costs τ_{ij} of a good being exported from country *i* to country j are assumed to take an iceberg form, hence $P_{ij} = \tau_{ij} P_{ii}$. Given that the price index P_{ii} can be expressed as a function of the county i's total income, Y_i, and the endowment Q_i, $P_{ii} = Y_i / Q_i$, we can get the following expression for the price of each good exported from country *i* to country *j*.

$$P_{ij} = \frac{Y_i \tau_{ij}}{Q_i} \tag{3.3}$$

This simple economic environment results in a gravity equation that describes the trade flows between each pair of countries, X_{ij}. This gravity equation relates the preference parameters and ψ, country *j*'s total expenditure $E_j \equiv \sum^{n}_{i=1} X_{ij}$, the countries' total endowment Q_i and income Y_i, and the transport costs. This expression takes the form:

$$X_{ij} = \frac{(Y_i \tau_{ij})^{-\varepsilon} x_{ij}}{\sum_{l=1}^{n} (Y_l \tau_{lj})^{-\varepsilon} x_{lj}} E_j \tag{3.4}$$

where $\chi_{ij} \equiv (Q_i / \psi_{ij})^{\sigma-1}$, and ε is the trade elasticity:

$$\varepsilon \equiv \sigma - 1 = \partial \ln \left(X_{ij} / X_{jj} \right) / \partial \ln \tau_{ij}$$

In general equilibrium, two conditions must hold: $Y_i = E_i$ and $Y_i = \sum^{n}_{i=1} X_{ij}$. Hence, the gravity equation can be written

$$Y_i = \sum_{j=1}^{n} \frac{\left(Y_i \tau_{ij}\right)^{-\varepsilon} x_{ij}}{\sum_{l=1}^{n} \left(Y_l \tau_{lj}\right)^{-\varepsilon} x_{lj}} Y_j \tag{3.5}$$

This system of n equations can be used to compute an equilibrium with n unknowns, which can then in turn be used to compute the levels of expenditure and bilateral trade flows using the budget constraints and the gravity equation 3.4. This system of equations can be used to develop counterfactual welfare exercises, given changes in the trade costs that countries face.

The relevant measure for welfare is real consumption, which can be defined as $C_j \equiv E_j/P_j$. Arkolakis, Costinot & Rodriguez-Clare (2012) show that for a wide variety of trade models it is possible to compute the changes in real consumption when comparing steady state equilibriums[6] from two sufficient statistics, namely the elasticity of imports with respect to the variable trade costs, ε, and the share of expenditure in domestic goods. The variable λ_{jj} is formally defined as the share of expenditure on goods from the same country, $\lambda_{jj} = \frac{X_{jj}}{E_j}$.

$$\lambda_{jj} = \frac{X_{jj}}{E_j} = 1 - \Sigma_{i \neq j} X_{ij} / \Sigma_{i=1}^{n} X_{ij} \tag{3.6}$$

For these types of models, welfare changes are defined as changes in real consumption given a foreign shock. In the case of the Armington model, the welfare consequences of changes in trade costs from τ to τ^0 can be computed simply as:

$$\hat{C}_j = \hat{\lambda}_{jj}^{-\frac{1}{\varepsilon}} \tag{3.7}$$

where, for any variable X, $\hat{X} = \frac{X'}{X}$ denotes a proportional change in any variable between an initial equilibrium, X, and a counterfactual one, X΄.

As a preview of the counterfactual exercises that are performed, the simplest one that can be done is comparing the current situation with autarky. A hypothetical autarky is whenever trade costs for each pair of countries $i \neq j$ approach infinity, $\tau_{ij} \rightarrow +\infty$ and there is no international trade between countries. In that case, the algebra is simpler and the gains from trade, the absolute value of the percentage change in real income associated with moving to autarky, is:

$$G_j = 1 - \lambda_{jj}^{-\frac{1}{\varepsilon}} \tag{3.8}$$

6 These results abstract from the dynamics involved in the change from one steady state to the other.

Generalization of the model

CRC discuss how the gravity equation (3.4) can tie together many different types of models that have very distinct assumptions regarding the market structure: perfect competition, Bertrand competition, and monopolistic competition with either homogeneous firms or firm-level heterogeneity. Those models include, for example, Eaton & Kortum (2002), Bernard, Eaton, Jenson & Kortum (2003), Krugman (1980), Chaney (2008), Arkolakis (2010), Arkolakis, Demidova, Klenow & Rodriguez-Clare (2008) and Eaton, Kortum & Kramarz (2011).

In all of those models the assumption regarding preferences is a Constant Elasticity of Substitution (CES) function over the consumption of a continuum of goods or varieties $\omega \in \Omega$ for a representative consumer in each country:

$$C_j = \left(\int_{\omega \in \Omega} c_j(\omega)^{\sigma-1/\sigma} \, d\omega \right)^{\sigma/(\sigma-1)} \tag{3.9}$$

The models also assume balanced trade[7]. In equilibrium a variety is only imported from one possible origin, so the consumption of goods produced in i in a destination j can be summarized as

$$C_{ij} = \left(\int_{\omega \in \Omega ij} c_j(\omega)^{\sigma-1/\sigma} \, d\omega \right)^{\sigma/(\sigma-1)} \tag{3.10}$$

where $\Omega_{ij} \in \Omega$ is the set of goods that country *j* buys from country *i*, and the preferences are defined over the continuum of goods Ω. The corresponding price index takes the same form as Equation (3.2), and ψij=1 is usually assumed for symmetry purposes[8]. Hence, the price[9] in country *j* of the goods imported from country *i* takes the form

$$P_{ij} = \left(\int_{\omega \in \Omega ij} p_j(\omega)^{1-\sigma} \, d\omega \right)^{1-\sigma} \tag{3.11}$$

In these models the set Ω_{ij} is an endogenous variable, firms choose to produce and export from each country to a particular destination depending on the profitability given market and competition assumptions of each model. Hence, it is possible that some firms want to quit exporting to some destinations or producing at all. The changes in the price index of the goods that are traded between a pair of countries reflect three different elements:

1. Change at the intensive margin (change in the price of the goods): depending on the trade costs or the costs of production in each origin, prices at the destination can vary.
2. Change at the extensive margin by the selection of a different set of firms that export from i to j. For example, different specifications of the generalized model could include fixed costs for exporting, or different competition setups in the market that causes entry or exit of firms at that particular destination.
3. Change at the extensive margin because of a different set of firms producing at the origin i (entry). Different specifications of the generalized model could include fixed costs for producing, and different competition setups in the production location that could cause the entry or exit of firms to produce at that origin.

7 CRC show that allowing for trade deficits or surpluses increases the potential gains from trade.

8 Although it may seem contradictory to assume a $\psi ij = 1$ in a generalization of the model, the increase in notation does not provide an additional insight of how the models work.

9 This is an index of all the prices *p(ω)* of the goods $\omega \in \Omega_{ij}$ exported from *i* to *j*.

Those specificities are summarized in equiation 3.12.

$$P_{ij} = \underbrace{\tau_{ij} c_i^p}_{\text{Intensive margin}} \times \left(\underbrace{\left(\frac{E_j}{c_{ij}^x} \right)^{\frac{\delta}{1-\sigma}} \frac{\tau_{ij} c_i^p}{P_j}}_{\text{Extensive margin: seletion}} \right)^{\eta} \times \underbrace{\left(\frac{R_i}{c_i^e} \right)^{\frac{\delta}{1-\sigma}}}_{\text{Extensive margin: entry}} \times \xi_{ij} \qquad (3.12)$$

In this environment c^p_i, c^e_i, c^x_{ij} are variables that, respectively, relate to variable costs of production (c^p_i), fixed entry costs (c^e_i), and fixed exporting costs (c^x_{ij}), and their specific form depends on the assumption of each model. Here, $E_j \equiv \sum^n_{i=1} X_{ij}$ is the total expenditure of country *j*, in goods that come from i=1:n possible origins while $R_i \equiv \sum^n_{j=1} X_{ij}$ are the total sales or revenues for producers in i from $j=1:n$ destinations for their goods. Also, $\xi_{ij} > 0$ is a function of structural parameters.

Note, for example, that for equation 3.3 in the Armington model, $c^p_i = Y$, given that the income of the representative consumer Y_i, is the only variable cost of production, and the endowment is only the labor of that representative consumer.

The most important parameters for this generalization are δ and η. The first one is a dummy variable that takes a value of one with monopolistic competition with free entry. It takes a value of zero with perfect or Bertrand competition. Models with monopolistic competition gained relevance with Krugman (1980). In those models, firms produce the goods or varieties with a technology that has economies of scale[10]. This allows firms to charge a price higher than the cost of production (a markup), but competition among goods or varieties forces profits of firms to be driven to zero.

If this parameter is active in the model with monopolistic competition and there is also free entry, the last term of the expression 3.12 is now active. In those cases, a higher profitability of entry (low entry costs) in the domestic market, , causes an increase in exporting varieties to all countries, which lowers the price of those varieties everywhere.

Both in models with monopolistic competition and in models with perfect or Bertrand competition, there could be heterogeneity that causes the selection of firms that may export to different locations. The parameter $\eta \geq 0$ is related to the extent of heterogeneity across varieties. The exact value that this parameter takes is related to heterogeneity in the selection of firms that may or may not export. For example, in a monopolistic competition setup with fixed exporting costs like Krugman (1980), it takes a value of $\eta = 0$. In this particular model, all the firms are identical in terms of the production function, and there is a fixed cost of exporting, all active firms always export.

Other assumptions relating to market and competition could cause selection of firms, hence $\eta > 0$, for models with perfect competition like Eaton & Kortum (2002), Bertrand competition like Bernard et al. (2003), monopolistic competition like Chaney (2008), Melitz (2003) and others where there are firms that may decide to stop exporting. In this case, the selection component of the extensive margin in equation 3.12 plays a role. The ratio $\frac{\tau_{ij} c_i^p}{P_j}$ could be high for some firms, such that they are not competitive in the destination country, and decide not to export to that destination. This heterogeneity among firms is determined by the shape of the distribution of productivity draws across varieties. The distribution can be Fréchet (for the perfect and Bertrand competition schemes) or Pareto (for monopolistic competition).

---

10 Both in Krugman (1980) and in Melitz (2003) the economies of scale are introduced by simply having fixed costs of production and a constant marginal cost.

If the model has monopolistic competition as well as heterogeneity across varieties (as is the case in Melitz, 2003), the selection also depends on the size of the destination market. The term $\frac{E_j}{c^x_{ij}}$ compares that size to the fixed costs of exporting to that destination, which could cause firms to exit the exporting market.

Therefore, parameters δ and η can be turned on and off, which allows for comparison of the results tied to different assumptions of modeling. This generalization of trade models can be used to describe different versions relying in very different assumptions, and those setups produce different price and gravity equations that can be used to measures the changes in real consumption given a trade shock, as compared to equation (3.18). The main equations of three versions of those types of models will be presented as follows.

One sector

Allowing for a more general setup but restricting it to one sector assume, as it is standard in the literature, that the variable costs of production, fixed entry costs, and fixed exporting costs are all used in the same proportions. Recall that in the Armington model $c^p_i = Y_i$ given that the income of the representative consumer is the only variable cost of producing the good exported by country i. For a more general setup where there can be fixed exporting and entry costs, the assumption described implies that $c^p_i = c^x_{ii} = c^e_i = Y_i$, all equal to the income of the representative consumer. Assume also that trade in goods is balanced, $R_i = Y_i$, then CRC show that the price equation (3.12) is simplified to

$$P_{ij} = \tau_{ij} Y_i \left(\left(\frac{E_j}{c^x_{ij}} \right)^{\frac{\delta}{1-\sigma}} \frac{\tau_{ij} Y_i}{P_j} \right)^{1-\sigma} \xi_{ij} \,. \tag{3.13}$$

Under these assumptions, the gravity equation (3.4) is then

$$X_{ij} = \frac{\left(Y_i \tau_{ij}\right)^{-\varepsilon} \left(c^x_{ij}\right)^{-\delta\eta} \chi_{ij}}{\sum_{l=1}^{n} \left(Y_l \tau_{lj}\right)^{-\varepsilon} \left(c^x_{lj}\right)^{-\delta\eta} \chi_{lj}} E_j \,. \tag{3.14}$$

In this case, $\varepsilon = (1+\eta)(\sigma - 1)$, so the interpretation of the trade elasticity is not the same as in the Armington model. Also, $\chi_{ij} \equiv \xi_{ij}^{1-\sigma}$. In this case, the increase of trade costs affects both the price of existing varieties (intensive margin) and the set of those varieties sold from country i to country j (extensive margin). There are scale effects in the selection, meaning that the entry of firms is determined by the size of the destination market, as explained before. Even though there are differences in the model, the main contribution of Arkolakis et al. (2012) was to show that the trade elasticity ε and the share of expenditure on domestic goods λ_{ii} remain the sufficient statistics for welfare analysis. In this case, the potential gains from trade are the same as in the Armington model, as in equation (3.8). This means that the separation of the intensive and extensive margins does not change the magnitude of the gains from trade.

Multiple sectors

Multiple sectors $s = 1,\dots,S$ can be incorporated into this setup by assuming that the preferences are two-tiered. The upper level of the preferences is Cobb-Douglas for S sectors, and takes the form

,
$$C_j = \prod_{s=1}^{S} C_{j,s}^{\beta j,s}, \tag{3.15}$$

with $\beta_{j,s} \geq 0$ exogenous parameters and $\sum_{s=1}^{S} \beta_{j,s}=1$. The second tier is CES preferences that take the following form:

$$C_{j,s} = \left(\int_{\omega \in \Omega ij} c_{j,s}\left(\omega\right)^{(\sigma_s - 1)/\sigma_s} d\omega \right)^{\sigma_s/(\sigma_s - 1)} , \tag{3.16}$$

and $\sigma_s > 1$ is the elasticity of substitution between different varieties, and can be different across sectors. In that case, the price equation has to hold for each sector, and if the assumption that factors of production are used in the same way across all activities in all sectors in a similar way as in the one-sector version of the model[11], and that the trade in goods is balanced, $R_i = Y_i$, the price equation (3.12) can be expressed in the following form

$$P_{ij,s} = \tau_{ij,s} Y_i \left[\left(e_{j,s} \frac{E_j}{c_{ij,s}^x} \right)^{\frac{\delta_s}{1-\sigma_s}} \frac{\tau_{ij,s} Y_i}{P_{j,s}} \right]^{\eta_s} r_{i,s}^{\frac{\delta_s}{1-\sigma_s}} \xi_{ij,s} , \tag{3.17}$$

where $e_{j,s} \equiv E_{j,s}/E_j$ *is* the share of total expenditure in country j allocated to the sector s, and $r_{i,s} \equiv R_{j,s}/R_j$ is the share of total revenues in country i generated from sector s. In this particular case there can be monopolistically competitive sectors that cause scale effects through selection, $\left(e_{j,s} \frac{E_j}{c_{ij,s}^x} \right)^{\frac{\delta_s}{1-\sigma_s}}$ and entry $r_{i,s}^{\frac{\delta_s}{1-\sigma_s}}$. The latter effect was not present in the one sector model because there $r_{i,s} = 1$. Therefore, the size of the sector with respect to the domestic economy can determine the entry of firms thanks to the existence of scale effects arising from the assumed monopolistic competition setup.

Here the gravity equation for each sector takes the form

$${}_{ij,s} = \frac{\left(Y_i \tau_{ij,s}\right)^{-\varepsilon_S} \left(c_{ij}^x\right)^{-\delta_S \eta_S} r_{i,s}^{\delta_S} \chi_{ij,s}}{\sum_{l=1}^{n} \left(Y_l \tau_{lj,s}\right)^{-\varepsilon s} \left(c_{lj,s}^x\right)^{-\delta s \eta s} r_{l,s}^{\delta s} \chi_{lj,s}} e_{j,s} E \tag{3.18}$$

In this case, $\varepsilon s = (1 + \eta s)(\sigma s - 1)$, and $\chi_{ij,s} \equiv \xi_{ij,s}{}^{1-\sigma s}$.

---

11 This means $c^p{}_{i,s} = c^m{}_{ii,s} = c^e{}_{i,s} = Y_i$.

Tradable intermediate goods

Finally, tradable intermediate sectors can also be incorporated by assuming that in each sector the production of good $I_{j,s}$ takes the following form, where production of each variety s is a CES aggregation of production $i_{j,s}$ (ω) over a continuum of goods or varieties $\omega \epsilon \Omega$:

$$I_{j,s} = \left(\int_{\omega \in \Omega} i_{j,s}(\omega)^{\frac{\sigma_s - 1}{\sigma_s}} d\omega \right)^{\frac{\sigma_s}{\sigma_s - 1}} , \tag{3.19}$$

The sector level prices in this model take the form in equation (3.21), and measure both the prices of final consumption goods and production. It is assumed that total expenditure equals total producer revenues, $E_i = R_i$, but the costs of production are allowed to vary across sectors:

$$c_{i,s}^{p} = Y_i^{1-\alpha_{i,s}} \prod_{k=1}^{S} P_{i,k}^{\alpha_{i,ks}} , \tag{3.20}$$

Where $\alpha_{i,ks}$ are exogenous technology parameters that satisfy the condition that $\alpha_{i,s} \equiv \sum^{S}_{k=1} \alpha_{i,ks} \epsilon[0,1]$ Using the same assumption explained with detail before, $c^p_{i,s}= c^x_{ii,s} =c^e_{i,s}=Y_i$. In this case the price and gravity equations take the form

$$P_{ij,s} = \tau_{ij,s} c_{i,s} \left[\left(\frac{e_{j,s}}{v_j} \frac{Y_j}{c_{ij,s}^{x}} \right)^{\frac{\delta_S}{1-\sigma_S}} \frac{\tau_{ij,s} c_{i,s}}{P_{j,s}} \right]^{\eta_S} \left(\frac{r_{i,s}}{v_j} \frac{Y_i}{c_{i,s}} \right)^{\frac{\delta_S}{1-\sigma_S}} \xi_{ij,s} \tag{3.21}$$

and

$$X_{ij,s} = \frac{ \left(\tau_{ij,s} c_{i,s} \right)^{-\varepsilon s} \left(c_{ij,s}^{x} \right)^{-\delta s \eta s} \left(\frac{r_{i,s} Y_i}{v_i c_{i,s}} \right)^{\delta s} \chi_{ij,s} }{ \sum_{l=1}^{n} \left(c_{l,s} \tau_{lj,s} \right)^{-\varepsilon s} \left(c_{lj,s}^{x} \right)^{-\delta s \eta s} \left(\frac{r_{l,s} Y_l}{v_l c_{l,s}} \right)^{\delta s} \chi_{lj,s} } e_{j,s} E_j , \tag{3.22}$$

where $c_{i,s} = c^p_{i,s}$ from equation (3.20), and $v_i \equiv Y_i / R_i$ is the ratio of total income to total revenues in country *i*.

All of the versions of the model presented in this section can be used to compute counterfactual exercises using different assumptions. The range of values for the gains from trade can then be used as a quantitative reference for the possible gains from trade for each country, and are useful to compare the differences among countries in different versions.

IV. COUNTERFACTUAL EXERCISES

Data

The CRWIOD used in the estimations of this paper are from Bullón et al., 2015. This database updates the database originally used in CRC from the year 2008 to the year 2011, and adds the observations for Costa Rica as an individual country instead of aggregating them as part of the "Rest of the World". Hence, there are 35 regions used, 34 of which are the individual countries for which results are presented, while the rest are aggregated in the same way as before. Appendix 1 describes how sectors are aggregated and the elasticity used for each one (from Caliendo and Parro, 2012)[12].

This aggregation is coarser than the main specification in CRC due to limitations imposed by the aggregation of the data for Costa Rica. This aggregation allows for correct empirical estimation by reducing the number of observations that have zero value. However, Appendix 2 shows the original results from CRC but using the 16 sector aggregation used in this paper. This table shows that the quantitative results are almost identical to the disaggregation in 31 sectors.

For each country and sector, the computation of trade flows, final demand, and intermediate purchases is required to use as inputs for the gains from trade and counterfactual exercises. The exact same procedure described in the Online Appendix of CRC[13] was followed to construct these variables with the CRWIOD.

Gains from trade

All the versions of the model presented in Section 3 can be used to compute gains from trade using the CRWIOD in a similar way as in the Armington model. For the Armington model we had a measure that quantifies the changes in real consumption with respect to a change in the trade variables that in turn affect the share of expenditure in domestic goods:

$$\hat{C}_j = \hat{\lambda}_{jj}^{-\frac{1}{\varepsilon}}, \tag{4.1}$$

The simplest counterfactual exercise that can be performed is to compute the changes in real income with respect to autarky. This measurement gives an insight of how much a country gains from engaging in international trade. In this case, the measure G_j quantifies the absolute value of the percentage change in real income that would be associated with moving to autarky. For the cases with only one sector,

$$G_j = 1 - \lambda_{jj}^{\frac{1}{\varepsilon}}, \tag{4.2}$$

12 The elasticities of substitution for each sector have been calibrated in the paper by Caliendo and Parro, 2012 using their novel methodology that allowed them to estimate sectoral trade elasticities consistent with any trade model that delivers a multiplicative gravity equation, and have become standard in the literature. There are only four elasticities from Caliendo and Parro, 2012 that are not used in this paper because data is aggregated in other categories, which correspond to Medical, Office, Communication and Other goods. For Services a value of 5 is used, which is the standard in the literature, see Anderson & van Wincoop (2004).

13 Available at https://economics.mit.edu/files/9215

Given that $\lambda_{jj} = \frac{X_{jj}}{E_j} = 1 - \left(\sum_{i \neq j} X_{ij} / \sum_{i=1}^{n} X_{ij}\right)$, the numerator in the expression is simply total imports by country *j*, while the denominator is total expenditure by country *j*.

The results presented in this paper provide a novel contribution to the literature for two reasons. First, it updates the results from CRC from 2008 to 2011. Alessandria, Kaboski & Midrigan (2010), among others, discuss the magnitude of the trade collapse that occurred around the year 2009, which results in lower gains from trade for all countries and all possible specifications. The average gains from trade computed by CRC were 4.4%, and these are 3.8% with the CRWIOD for 2011. Table 1 presents the results for the one sector models in column 2. These numbers use the number that CRC[14] use for the elasticity in their baseline scenario $\varepsilon = 5$. Eaton & Kortum (2002) find estimates from $\varepsilon = 3.60$ to $\varepsilon = 12.86$, and their preferred estimate is $\varepsilon = 8.28$. The aggregate elasticity can result in different magnitudes for the gains from trade, especially when considering the sectoral elasticity as in Caliendo & Parro (2012). CRC discuss the sensitivity issues regarding this parameter.

The second contribution to the literature is the use of this new database to compute the gains for Costa Rica, a result that was impossible to obtain when the country was aggregated as part of the "Rest of the World" data (the countries not included in the database). Since Costa Rica is very open to international trade, the estimated gains are relatively large. These gains are above the average of the other countries and larger also than the countries aggregated as part of the "Rest of the World". The estimated gains of 5,0% are larger than those of other Latin American countries such as Mexico (3.2%), Brazil (1.3%) and almost all other developed countries. The gains are, however, smaller than other countries such as Ireland (8.3%), Belgium (6.6%) and Czech Republic (5.5%).

It is possible to obtain expressions equivalent to the latter for each version of the model presented in Section III. When multiple sectors are considered, the changes in real consumption that are associated with a trade shock are now

$$G_j = 1 - \prod_{s=1}^{S} \left(\lambda_{jj,s} \left(\frac{e_{j,s}}{r_{j,s}} \right)^{\delta s} \right)^{\frac{\beta_{j,s}}{\varepsilon_s}}, \tag{4.3}$$

The scale effects in the models that use monopolistic competition (δ_s=1) cause a difference in the gains from trade compared with models with perfect competition.

These gains from trade are on average larger than the ones computed for one sector models, such as the ones presented in Arkolakis et al. (2012). Here, the scale effects play a role but the selection effects do not. To estimate the gains from trade, the data from the original WIOD tables (see Dietzenbacher et al, 2013) is used to compute the measures $\lambda_{jj,s}$, $e_{j,s}$, $\beta_{j,s}$ and rj,s. Sector level trade elasticities ε_s are those from Caliendo & Parro (2012) for the sectors included in manufacturing and agriculture, while for the sectors included in services, the assumption of $\varepsilon = 5$ is kept. As mentioned before, for sectoral computation using the CRWIOD we need to use 16 sectors instead of the 31 used in CRC because of how aggregated is the data included for Costa Rica.

Table 1 shows in columns 3 and 4 the results for the different assumptions of competition schemes. Costa Rica is one of the countries in which the gains in perfect competition are much larger than the gains computed under the assumption of monopolistic competition, which occurs also in countries like Ireland. On the opposite side, countries like Mexico and Brazil have larger gains under the monopolistic competition assumption.

14 Further discussion can be found in Anderson & van Wincoop (2004).

This result depends on the comparative advantage of each country in the sectors that have strong scale effects. The data from CRWIOD describes which sectors are most important in each country, while the parameters of the model describe which sectors have the strongest scale effects. If for a given country $\frac{e_{j,s}}{r_{j,s}}$ is negatively correlated with $\frac{\delta_s}{\varepsilon_s}$, this country has comparative advantage in sectors with strong scale effects. Hence, this country would have larger gains under the monopolistic competition assumption.

The opposite is true for countries like Costa Rica, in which specialization occurs in sectors that do not have large scale effects and therefore the gains are smaller. The different results with various assumptions reveal potential challenges for the Costa Rican economy. The lack of specialization in the sectors that have large scale effects could reflect a misallocation problem, where resources are devoted to firms and sectors that lack scalability. Alfaro Ureña and Vindas (2019) and OECD (2018) document how the sectoral allocation of resources has hindered productivity growth in Costa Rica in recent years.

When multiple sectors are included in the model the gains from trade increase dramatically. For the Costa Rican case, and considering perfect competition, they do so five times with respect to the benchmark case. The increase occurs in part due to the Cobb-Douglas preferences assumed for the sectors. Given this assumption, gains from trade could increase infinitely if the price of a good becomes significantly large when moving to autarky. This could happen either if the data shows that the good is not produced domestically (because of high production costs) or if the trade elasticity is close to zero, implying that foreign varieties are essential.

Finally, when intermediate sectors are included in the model, the gains from trade can be computed using the formula:

$$G_j = 1 - \prod_{s.k=1}^{S} \left(\lambda_{jj,k} \left(\left(\frac{e_{j,k}}{b_{j,k}} \right)^{\eta s} \frac{r_{j,k}}{b_{j,k}} \right)^{-\delta_k} \right)^{\frac{\beta_{j,s} \tilde{a}_{j,sk}}{\varepsilon_k}} \tag{4.4}$$

Where $\tilde{a}_{j,sk}$ is the elasticity of the price index in sector s with respect to changes in the price index in sector *k*. These elasticities are calculated using an adjustment to the technology parameters $\alpha_{j,sk}$ to account for the reduction of prices through lowering of fixed entry and exporting costs.

Also, $b_{j,k} \equiv \upsilon_j \left(\sum_{l=1}^{S} \beta_{j,l} a_{j,kl} \right)$ summarizes the effect of intermediate goods in the scale effects, for monopolistic competition models, where $a_{j,kl}$ are calculated using the technology parameters $\alpha_{j,sk}$ without the aforementioned adjustment.

The variables $\lambda_{jj,s}$, $e_{j,s}$, $\beta_{j,s}$ and $r_{j,s}$ are computed using CRWIOD, which allows for computing the shares of intermediate purchases $\alpha_{j,ks}=\sum_{\mathrm{i}} X_{\mathrm{ij,js}}/R_{j,s}$ using an additional assumption from Balistreri, Hillberry & Rutherford (2011).

Columns 5 and 6 show the potential gains from trade allowing for intermediates using two possible competition assumptions, perfect competition and monopolistic competition with firm level heterogeneity. The gains are rather large compared to the previous models. This is mainly due to the fact that allowing for trade in intermediates amplifies the gains of engaging in international trade. The welfare effects occur in more than one round given the loop caused by the input-output structure embedded in the model. Hence, a reduction in the price of imported inputs can cause additional productivity gains.

TABLE 1
GAINS FROM TRADE AS PERCENTAGES OF INCOME

Country	One Sector	Models: Multiple sectors		Intermediates	
		Perf. Comp.	Mon. Comp.	Perf. Comp.	Mon.Comp. (Melitz)
1	2	3	4	5	6
Costa Rica	5,00	23,60	11,30	36,10	22,10
AUS	2,00	6,30	2,60	11,70	3,60
AUT	4,80	23,10	23,30	38,90	49,40
BEL	6,60	34,00	33,20	55,30	67,80
BRA	1,30	3,20	3,00	5,40	8,80
CAN	3,40	12,90	11,70	22,40	32,10
CHN	1,50	2,40	2,40	6,50	66,60
CZE	5,50	14,60	18,90	31,90	74,30
DEU	3,80	11,80	15,50	20,40	42,00
DNK	4,80	35,80	30,70	52,40	51,10
ESP	2,50	6,90	7,80	13,60	23,10
FIN	3,70	12,00	11,60	20,80	27,20
FRA	2,60	8,10	9,30	14,60	27,60
GBR	3,10	11,60	10,60	20,20	21,50
GRC	3,60	16,40	4,50	24,00	4,20
HUN	7,20	19,30	21,30	38,40	67,80
IDN	2,20	4,20	3,20	8,90	11,90
IND	2,10	3,40	3,60	6,70	10,50
IRL	8,30	20,30	13,50	33,50	26,50
ITA	2,50	7,20	7,60	13,20	18,70
JPN	1,30	1,30	2,70	2,70	21,90
KOR	3,70	3,80	8,10	10,20	74,30
MEX	3,20	10,50	11,90	17,50	27,30
NLD	5,60	25,50	23,60	41,50	46,30
POL	4,00	15,10	17,10	28,40	46,40
PRT	3,70	17,60	13,70	29,00	26,50
ROM	3,80	11,00	10,90	19,30	17,90
RUS	2,10	9,70	0,70	16,90	-3,50
SVK	6,50	18,10	19,10	41,20	79,80
SVN	5,80	31,30	32,80	50,80	66,70
SWE	4,60	10,90	12,00	20,20	33,50
TUR	2,50	10,60	10,60	18,50	24,10
TWN	5,50	7,50	8,20	14,70	28,20
USA	1,50	3,30	3,10	5,80	9,00
REST OFF WORLD	3,70	11,60	5,30	21,50	15,00
AVERAGE	3,80	13,30	12,10	23,20	33,40

Source: Computations using the Matlab programs used in Costinot & Rodríguez-Clare (2014), available at https://eml.berkeley.edu/~arodeml/. Data from CRWIOD for 2011. 16 sectors are used for computations with more than one sector. Trade elasticities from Caliendo & Parro (2012), detailed in Appendix A.

Costa Rica is, again, one of the countries in which the gains from trade are smaller with the monopolistic competition assumption. This is rather unusual when compared with the rest of the countries, given that on average the gains increase from 23.2% in perfect competition to 33.4% in monopolistic competition with the Melitz assumption (allowing for firm heterogeneity). Again, this means that Costa Rica is a country with comparative disadvantage in the sectors with strong scale effects which would be amplified in this setup due to firms using expanding thanks to the availability of more traded inputs.

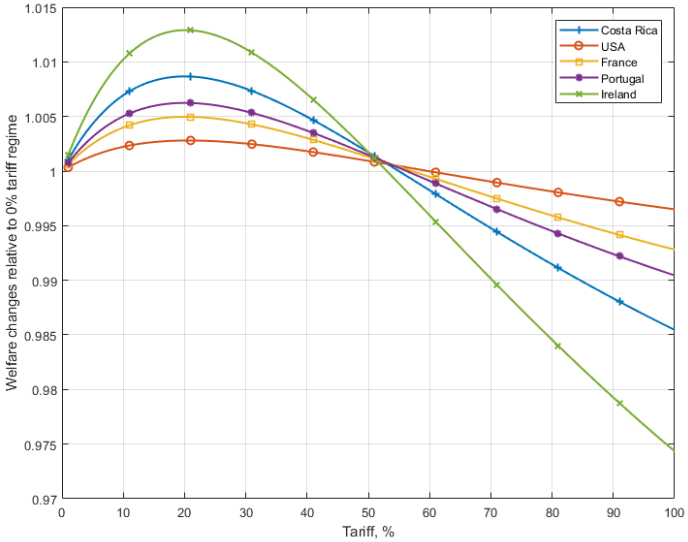
Effects of increases in tariffs

It is possible to perform additional counterfactual exercises in the setup described. CRC show that welfare changes given changes in tariffs in an Armington model can be computed using the following formula:

$$\hat{C}_j = \left(\frac{1-\pi_j}{1-\pi'_j} \right) \hat{\lambda}_{jj}^{-\frac{1}{\varepsilon}}, \tag{4.5}$$

where $\pi_j = \sum_{i=1}^{n} \frac{t_{ij}}{1+t_{ij}} \lambda_{ij}$ and $\pi'_j = \sum_{i=1}^{n} \frac{t'_{ij}}{1+t'_{ij}} \lambda_{ij} \hat{\lambda}_{ij}$ given that $t_{ij}>0$ is the ad-valorem tariff imposed by country *j* on goods imported from *i*. Graph 1 shows the potential gains (or losses) for each country from unilaterally increasing the tariffs it levies to imports. In simple trade models, an increase in tariffs without retaliation causes an improvement in terms of trade and welfare. In models like the ones presented in this paper there are potential unilateral gains of all countries due to the increase in tariff revenues in equilibrium, especially of a small open country like Costa Rica assuming that other countries do not retaliate. The largest gains are those of a country that is even more open to trade as Ireland.

FIGURE 1
GAINS FROM A UNILATERAL INCREASE IN THE TARIFF



Source: Computations using the Matlab programs used in Costinot & Rodríguez-Clare (2014), available at https://eml.berkeley.edu/~arodeml/. Data from CRWIOD 2011.

This is, however, an exercise that does not take into account the possibility of all countries reacting in a similar manner and simultaneously increasing tariffs. On this issue, Table 3 takes one of the models discussed in Section 3, and shows the effects of a simultaneous increase to a 40% tariff from the current situation. In those cases, the magnitude of the potential losses is similar (in the opposite direction) with the gains from trade when compared to autarky. This exercise must serve as a warning to evaluate potential policy measures by one country. There are potential gains when acting on its own, but the results from Table 3 show that an uncoordinated increase could cause a welfare loss for every single country.

TABLE 2
LOSSES FROM A SIMULTANEOUS 40% TARIFF INCREASE.
MULTIPLE SECTORS, INTERMEDIATE GOODS, HETEROGENEOUS FIRMS (MELITZ)

COUNTRY	GJ %	COUNTRY	GJ	COUNTRY	GJ %
Costa Rica	-5.01%	FRA	-1.59%	POL	-3.05%
AUS	-2.71%	GBR	-3.16%	PRT	-3.54%
AUT	-4.28%	GRC	-3.65%	ROM	-3.58%
BEL	-6.64%	HUN	-6.50%	RUS	-4.26%
BRA	-0.90%	IDN	-1.83%	SVK	-5.74%
CAN	-3.57%	IND	-1.69%	SVN	-4.79%
CHN	-1.23%	IRL	-8.61%	SWE	-3.97%
CZE	-4.82%	ITA	-1.35%	TUR	-1.78%
DEU	-2.34%	JPN	-0.25%	TWN	-4.13%
DNK	-4.54%	KOR	-1.35%	USA	-0.91%
ESP	-1.68%	MEX	-2.22%	RoW	-4.27%
FIN	-3.12%	NLD	-4.62%	Average	-3.4%

Source: Computations using the Matlab programs used in Costinot & Rodríguez-Clare (2014), available at https://eml.berkeley.edu/~arodeml/. Data from CRWIOD for 2011. 16 sectors are used. Trade elastitcities from Caliendo & Parro (2012).

V. CONCLUSIONS

Costa Rica is a small open economy that benefits significantly from being open to trade. The magnitude of these gains and alternative trade policies can have a significant impact in the discussion of alternative paths that a country can take deviating from the current situation. Given that the public policy discussions surrounding these issues sometimes lack technical background, the results provided in this paper are a reasonable starting point.

This paper computes the gains from trade using the methodology proposed by CRC and the new CRWIOD database. The exercise using newer data for the countries that are part of WIOD allows for updated results. The newer results imply lower gains, due in part to the collapse of international trade in the aftermath of the international crisis of 2008-2009. Additionally, for the models with multiple sectors, the gains could be lower when compared to CRC due to the fact that the computations could only be done with fewer sectors.

The CRWIOD database also allows to compute the values for Costa Rica, which is not part of the international version of the database. The results show that Costa Rica is one of the countries that gain the most from trade, and could have significant potential losses when compared to autarky or a simultaneous increase of tariffs around the world. The gains are larger than the average of the world and are closer to those of countries like Ireland than to those of large countries like the United States.

The results also show, as it is expected, that gains from trade are larger whenever the model includes more sectors. However, for the Costa Rican case it is particularly interesting that those gains are smaller in a monopolistic competition setup when compared to assumed perfectly competitive markets. This result hints that the Costa Rican economy has less comparative advantage in the sectors with the highest scale effects. The scale effects are determined by the parameters of the model, using calibrated parameters. The comparative advantage is determined by the data from CRWIOD. However, this characteristic is not unique to low and middle income economies, as other advanced economies show this characteristic too.

Overall, the results imply that Costa Rica has a higher real income thanks to its involvement in international trade. However, the country gains from being involved in trade may be hindered by the specialization shown in the data. The effect in welfare of the scale effects in monopolistic competition models is smaller due to where production is allocated in the country. Further research can be done to analyze how strategic public policies can be pursued to increase the potential gain in sectors with greater scale effects.

VI. REFERENCES

Alessandria, G., Kaboski, J. P., & Midrigan, V. (2010). The Great Trade Collapse of 2008–09: An Inventory Adjustment? *IMF Economic Review, 58*(2), 254–294. https://doi.org/10.1057/imfer.2010.10

Alfaro-Ureña, A., & Vindas-Quesada, A. (2019). Transformación estructural y productividad sectorial en Costa Rica. *Economía y Sociedad*, *24*(55), 53–77. https://doi.org/10.15359/eys.24-55.4

Anderson, J. E., & van Wincoop, E. (2004). Trade Costs. *Journal of Economic Literature, 42*(3), 691–751. https://doi.org/10.1257/0022051042177649

Arkolakis, C. (2010). Market Penetration Costs and the New Consumers Margin in International Trade. *Journal of Political Economy, 118*(6), 1151–1199. https://doi.org/10.1086/657949

Arkolakis, C., Costinot, A., & Rodríguez-Clare, A. (2012). New Trade Models, Same Old Gains? *American Economic Review, 102*(1), 94–130. https://doi.org/10.1257/aer.102.1.94

Arkolakis, C., Demidova, S., Klenow, P., & Rodríguez-Clare, A. (2008). *Endogenous Variety and the Gains from Trade* (No. w13933). https://doi.org/10.3386/w13933

Balistreri, E. J., Hillberry, R. H., & Rutherford, T. F. (2011). Structural estimation and solution of international trade models with heterogeneous firms. *Journal of International Economics, 83*(2), 95–108. https://doi.org/10.1016/j.jinteco.2011.01.001

Bernard, A. B., Eaton, J., Jensen, J. B., & Kortum, S. (2003). Plants and Productivity in International Trade. *American Economic Review, 93*(4), 1268–1290. https://doi.org/10.1257/000282803769206296

Bullón, D., Mena, T., Meng, B., Sanchez, N., Vargas, H., & Inomata, S. (2015). *Using the input-output approach to measure participation in GVCs: The case of Costa Rica*. (IDE Discussion paper 529). Retrieved from https://www.ide.go.jp/English/Publish/Download/Dp/529.html

Caliendo, L., & Parro, F. (2012). *Estimates of the Trade and Welfare Effects of NAFTA* (Working Paper No. 18508). https://doi.org/10.3386/w18508

Chaney, T. (2008). Distorted Gravity: The Intensive and Extensive Margins of International Trade. *American Economic Review, 98*(4), 1707–1721. https://doi.org/10.1257/aer.98.4.1707

Costinot, A., & Rodríguez-Clare, A. (2014). Chapter 4 - Trade Theory with Numbers: Quantifying the Consequences of Globalization. In G. Gopinath, E. Helpman, & K. Rogoff (Eds.), *Handbook of International Economics* (pp. 197–261). https://doi.org/10.1016/B978-0-444-54314-1.00004-5

Dietzenbacher, E., Los, B., Stehrer, R., Timmer, M., & de Vries, G. (2013). The Construction Of World Input-Output Tables In The Wiod Project. *Economic Systems Research*, *25*(1), 71–98. https://doi.org/10.1080/09535314.2012.761180

Eaton, J., & Kortum, S. (2002). Technology, Geography, and Trade. *Econometrica, 70*(5), 1741–1779. https://doi.org/10.1111/1468-0262.00352

Eaton, J., Kortum, S., & Kramarz, F. (2011). An Anatomy of International Trade: Evidence From French Firms. *Econometrica, 79*(5), 1453–1498. https://doi.org/10.3982/ECTA8318

Krugman, P. (1980). Scale Economies, Product Differentiation, and the Pattern of Trade. *The American Economic Review, 70*(5), 950–959.

Leiva, C. & Vargas, J. R. (2014). *Estimación del Cambio Estructural por medio de los Modelos de Insumo - Producto para Costa Rica de 1969 y 2011.* (Technical report).

Melitz, M. J. (2003). The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica, 71*(6), 1695–1725. https://doi.org/10.1111/1468-0262.00467

OECD. (2018). *OECD Economic Survey of Costa Rica: Research Findings on Productivity*. https://doi.org/10.1787/9789264298774-en

Samuelson, P. A. (1939). The gains from international trade. *Canadian Journal of Economics, 5*(2), 195–205.

Todos los derechos reservados. Universidad de Costa Rica. Este artículo se encuentra licenciado con Creative Commons Reconocimiento-NoComercial-SinObraDerivada 3.0 Costa Rica. Para mayor información escribir a revista.iice@ucr.ac.cr

APPENDICES

1. Description of the 16 sectors and trade elasticity used in estimation.

SECTOR'S DESCRIPTION	16 – SECTOR AGGREGATION	CALIENDO-PARRO TRADE ELASTICITY
Agriculture, Hunting, Forestry and Fishing	1	8,11
Mining and Quarrying	2	15,72
Food, Beverages and Tobacco	3	2,55
Textiles and Textile Products, Leather, Leather and Footwear	4	5,56
Wood and Products of Wood and Cork	5	10,83
Pulp, Paper, Paper, Printing and Publishing	6	9,07
Coke, Refined Petroleum and Nuclear Fuel	7	51,08
Chemicals and Chemical Products	8	4,75
Rubber and Plastics	9	1,66
Other Non-Metallic Mineral	10	2,76
Basic Metals and Fabricated Metal	11	7,99
Machinery, Nec	12	1,52
Electrical and Optical Equipment	13	10,6
Transport Equipment	14	0,37
Manufacturing, Nec; Recycling	15	5
Electricity, Gas and Water Supply		
Construction		
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel		
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles		
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods		
Hotels and Restaurants		
Inland Transport	16	5
Water Transport		
Air Transport		
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies		
Post and Telecommunications		
Financial Intermediation		
Real Estate Activities		
Renting of machinery and equipment and Other Business Activities		
Education		
Health and Social Work		
Public Admin and Defence; Compulsory Social Security		
Other Community, Social and Personal Services		
Private Households with Employed Persons		

Source: Costinot & Rodríguez-Clare (2013) and Caliendo & Parro (2012).

2. Gains from trade as percentages of income, results for the 16 sector aggregation of Costinot & Rodríguez-Clare (2013).

COUNTRY	MODELS				
	ONE SECTOR	MULTIPLE SECTORS			
		PERF. COMP.	MON. COMP.	INTERMEDIATES	
				PERF. COMP.	MON.COMP. (MELITZ)
1	2	3	4	5	6
AUS	2.32%	8.59%	3.71%	15.72%	6.32%
AUT	5.65%	30.45%	30.70%	50.16%	64.70%
BEL	7.49%	33.09%	32.72%	55.74%	71.50%
BRA	1.50%	3.70%	4.33%	6.45%	12.21%
CAN	3.77%	17.44%	15.39%	29.35%	40.03%
CHN	2.65%	4.23%	4.19%	10.91%	80.64%
CZE	6.00%	17.01%	21.41%	37.73%	86.55%
DEU	4.47%	12.85%	17.81%	22.93%	52.63%
DNK	5.75%	30.94%	25.61%	47.42%	45.73%
ESP	3.10%	9.20%	9.67%	18.03%	29.96%
FIN	4.40%	11.73%	11.17%	20.99%	28.21%
FRA	2.99%	9.58%	11.26%	17.44%	31.35%
GBR	3.23%	12.91%	11.75%	22.19%	23.61%
GRC	4.20%	16.60%	5.06%	25.07%	5.78%
HUN	8.08%	30.07%	31.53%	56.00%	91.18%
IDN	2.90%	5.65%	4.20%	11.63%	16.20%
IND	2.37%	4.64%	4.29%	8.64%	11.64%
IRL	8.04%	25.32%	16.21%	40.08%	29.24%
ITA	2.89%	8.86%	9.40%	16.75%	25.67%
JPN	1.69%	1.53%	3.84%	3.66%	32.19%
KOR	4.30%	4.30%	8.98%	11.87%	69.94%
MEX	3.30%	11.14%	12.10%	18.67%	28.36%
NLD	6.16%	24.64%	23.48%	40.69%	48.00%
POL	4.36%	18.54%	19.85%	35.03%	56.93%
PRT	4.40%	23.92%	20.74%	38.22%	40.09%
ROM	4.46%	17.84%	12.87%	29.48%	20.13%
RUS	2.41%	17.99%	0.91%	30.70%	-7.21%
SVK	7.63%	22.18%	23.62%	51.09%	96.35%
SVN	6.83%	39.74%	39.47%	62.16%	79.91%
SWE	5.06%	13.11%	15.10%	24.59%	45.65%
TUR	2.87%	12.00%	13.31%	21.01%	29.45%
TWN	6.11%	9.62%	9.95%	19.43%	37.72%
USA	1.77%	4.54%	3.88%	8.05%	10.46%
Rest of World	5.23%	15.57%	7.67%	28.51%	21.58%
Average	4.36%	15.57%	14.30%	32.57%	40.08%
Average	3.80%	13.30%	12.10%	23.20%	33.40%