Gains from trade:  
The Costa Rican case

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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 (2013) (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 allows for counterfactual exercises in which we compare the current situation with autarky and other average tariff levels. As CRC show, this can be done using different productive structures and competition schemes in the economy. 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 Classification: F10, I30, D57

Abstract

Uno de los retos más interesantes de la literatura económica es la cuantificación de las ganancias del Comercio. Recientemente, Costinot & Rodríguez-Clare (2013) (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. Esto permite realizar ejercicios contrafactuales en los que se compara la situación vigente con autarquía y otros niveles de tarifas promedio. Como CRC muestran, esto se puede hacer considerando 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

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1 Introduction

One of the oldest and most interesting questions in the economic literature is how to quantify the gains from trade. Recent work by Costinot & Rodríguez-Clare (2013) (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.

The results presented in CRC 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. Recent work by Bullón, Mena, Meng, Sanchez, Vargas & Inomata (2015) allowed them to quantify the integration of the country to Global Value Chains (GVCs). 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.

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1 I want to thank Andrés Rodríguez-Clare for the discussions and clarifications.
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 expressions can be summarize how much does real consumption increase when the country opens to trade.
4 This 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 this paper 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 goal of this paper is to present the results of the CRC methodology using this version of the WIOD to compute gains from trade for the Costa Rican economy.

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.

2 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 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 Commission. In Bullón et al. (2015) the authors document how this IOM was embedded into the World Input Output Database. 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 & Rodríguez-Clare (2013) 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. 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.
3 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. 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.

3.1 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 $i = 1, \ldots, n$ countries there is an endowment of a unique domestic good $Q_i$. The preferences take the form

$$C_j = \left( \sum_{i=1}^{n} \psi_{ij}^{\frac{1-\sigma}{\sigma}} C_i^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \quad (3.1)$$

with $C_{ij}$ is the demand for a good exported by country denoted with the first subscript, in this case $i$, to the country denoted with the second subscript, $j$ for this example. The parameters $\psi_{ij} > 0$ are exogenous preference parameters, and $\sigma > 1$ is the elasticity of substitution between the goods. There is a price index associated with the goods consumed in each country $j$:

$$P_j = \left( \sum_{i=1}^{n} \psi_{ij}^{1-\sigma} P_i^{1-\sigma} \right)^{\frac{1-\sigma}{1-\sigma}}. \quad (3.2)$$

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 $\tau_{ij}$ of a good being exported from country $i$ to
country \( j \) are assumed to take an iceberg form:

\[
P_{ij} = \frac{Y_i \tau_{ij}}{Q_i}
\]

(3.3)

where \( Y_i \) is country’s \( i \) income, and \( Q_i \) represents the endowment of the good \( i \). This simple economic environment results in a gravity equation for the trade flows between each pair of countries, \( X_{ij} \), which takes the form\(^5\)

\[
X_{ij} = \frac{(Y_i \tau_{ij})^{-\varepsilon} \chi_{ij} E_j}{\sum_{l=1}^{n} (Y_l \tau_{lj})^{-\varepsilon} \chi_{lj}}
\]

(3.4)

where \( \varepsilon \), is the trade elasticity,

\[
\partial \ln (X_{ij}/X_{jj}) / \partial \ln \tau_{ij} = \varepsilon = \sigma - 1.
\]

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, \( \varepsilon \), and the share of expenditure in domestic goods, \( \lambda_{jj} = \frac{X_{jj}}{E_j} \). Here \( \lambda_{jj} \) is formally defined as the share of expenditure on goods from the same country.

\[
\lambda_{jj} = \frac{X_{jj}}{E_j} = 1 - \sum_{i \neq j} X_{ij} / \sum_{i=1}^{n} X_{ij}.
\]

(3.5)

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 \( \tau \) to \( \tau' \) can be computed simply as:

\[
\hat{C}_j = \hat{\lambda}_j^{-\frac{1}{\varepsilon}}
\]

(3.6)

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

As the authors show, the only requirement to compute the changes in income are the knowledge of the initial expenditure shares \( \lambda_{ij} \), the initial income levels \( Y_i \), and the trade elasticity \( \varepsilon \). Those changes in

\(^5\)Here \( \chi_{ij} \equiv (Q_i / \psi_{ij})^\varepsilon \)

\(^6\)These results abstract from the dynamics involved in the change from one steady state to the other.
income levels can be used to compute the changes in the shares of expenditures for each possible trade partner, \( \lambda_{ij} \) and the changes in real consumption \( \dot{C}_j \).

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, \( \tau_{ij} \to +\infty \) 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:

\[
G_j = 1 - \lambda_{jj}^{\frac{1}{\sigma}}.
\]

(3.7)

### 3.2 Generalization of the model

CRC discuss how a single gravity equation can tie together many different types of models that are related to different 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 (2000)](#), [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

\[
C_j = \left( \int_{\omega \in \Omega} c_j(\omega)^{\sigma-1/\sigma} d\omega \right)^{\sigma/(\sigma-1)}.
\]

(3.8)

The models also assume balanced trade. In equilibrium a type of good is only imported from one possible origin, so the consumption of goods produced in \( i \) in a destination \( j \) can be summarized as

\[
C_{ij} = \left( \int_{\omega \in \Omega_{ij}} c_j(\omega)^{\sigma-1/\sigma} d\omega \right)^{\sigma/(\sigma-1)}
\]

(3.9)

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

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

8 This is an index of all the prices \( p(\omega) \) of the goods \( \omega \in \Omega_{ij} \) exported from \( i \) to \( j \).
from country \( i \) takes the form

\[
P_{ij} = \left( \int_{\omega \in \Omega_{ij}} p_j(\omega)^{1-\sigma} d\omega \right)^{1-\sigma}.
\]  

(3.10)

In these models the set \( \Omega_{ij} \) is an endogenous variable. Depending on the assumptions of each model 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: change at the intensive margin (change in the price of the goods) or change at the extensive margin, either by the selection of a different set of firms that export from \( i \) to \( j \) or because of a different set of firms producing at the origin \( i \) (entry).

\[
P_{ij} = \tau_{ij} c_p \times \left( \frac{E_j}{c_p} \right)^{\frac{\delta}{1-\sigma}} \times \frac{\tau_{ij} c_p^r}{P_j} \times \left( \frac{R_i}{c_e} \right)^{\frac{\delta}{1-\sigma}} \times \xi_{ij}
\]  

(3.11)

In this environment \( c_p, c_e, c_x \) are variables that relate to variables costs of production, fixed entry costs and fixed exporting costs, respectively. \( E_j \equiv \sum_{i=1}^n X_{ij} \) is the total expenditure of country \( j \), while \( R_i \equiv \sum_{j=1}^n X_{ij} \) is the total sales or revenues for producers from \( i \). Also, \( \xi_{ij} > 0 \) is a function of structural parameters.

The most important parameters for this generalization are \( \delta \) and \( \eta \). 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. The parameter \( \eta \geq 0 \) is related to the extent of heterogeneity across varieties. It is related to the distribution from where the productivities of firms are assumed to take their values. For example, in a monopolistic competition setup with fixed exporting costs like \textbf{Krugman (1980)}, it takes a value of \( \eta = 0 \), where the active firms always export, but it is \( \eta > 0 \) for other models like \textbf{Eaton & Kortum (2002)}, \textbf{Chaney (2008)}, \textbf{Melitz (2003)} and others where there are firms that may decide to stop exporting.

The other parameter, \( \delta \), is active in the model whenever there is monopolistic competition and free entry. 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. Therefore, parameters \( \delta \) and \( \eta \) can be turned on and off, which allows for comparison of the results tied to different assumptions of modeling.
3.3 One sector

In a one sector model where you hold the assumptions that the variable costs of production, fixed entry costs, and fixed exporting costs are all used in the same proportions, \( c_i^p = c_i^m = c_i^e = Y_i \), and trade in goods is balanced, \( R_i = Y_i \), then CRC show that the price equation is

\[
P_{ij} = \tau_{ij} Y_i \left( \frac{E_j}{c_{ij}^x} \right)^{1-\sigma} \frac{\tau_{ij} Y_i}{P_j} \xi_{ij},
\]

and the gravity equation is

\[
X_{ij} = \frac{(Y_i \tau_{ij})^{-\varepsilon} (c_{ij}^x)^{\varepsilon \eta} \chi_{ij}}{\sum_{l=1}^{m} (Y_l \tau_{lj})^{-\varepsilon} (c_{lj}^x)^{\varepsilon \eta} \chi_{lj}} E_j.
\]

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). Even though there are differences in the model, the main contribution of Arkolakis et al. (2012) was to show that the trade elasticity \( \varepsilon \) and the share of expenditure on domestic goods \( \lambda_{ii} \) remain the sufficient statistics for welfare analysis. In this case, the potential gains from trade are the same as in the Armington model. This means that the separation of the intensive and extensive margins does not change the magnitude of the gains from trade.

3.4 Multiple sectors

Multiple sectors \( s = 1, \ldots, S \) can be incorporated into this setup by assuming that the preferences are two-tiered. The upper level of the preferences is Cobb-Douglas in the form

\[
C_j = \Pi_{s=1}^{S} C_{j,s}^{\beta_j,s},
\]

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:

\[
C_{j,s} = \left( \int_{\omega \in \Omega} c_{j,s}(\omega)^{\sigma_s-1/\sigma_s} d\omega \right)^{\sigma_s/(\sigma_s-1)},
\]
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 is balanced, $R_i = Y_i$, the price equation can be expressed in the following form

$$P_{ij,s} = \tau_{ij,s} Y_i \left[ \left( e_{j,s} \frac{E_j}{c_{ij,s}} \right)^{\frac{\delta_s}{\sigma_s}} \frac{\tau_{ij,s} Y_i}{P_j} \right]^\eta_s \frac{\delta_s}{\sigma_s} \xi_{ij,s},$$

(3.16)

where $e_{j,s} \equiv \frac{E_j}{E_j}$ is the share of total expenditure in country $j$ allocated to the sector $s$, and $r_{i,s} \equiv \frac{R_{j,s}}{R_j}$ is the share of total revenues in country $i$ generated from sector $s$. In this case there can be monopolistically competitive sectors that cause scale effects through selection and entry. The latter effect was not present in the one sector model because there $r_{i,s} = 1$.

Here the gravity equation for each sector takes the form

$$X_{ij,s} = \frac{(Y_j \tau_{ij,s})^{-\varepsilon_s} \left(c_{ij,s}^p\right)^{-\delta \eta_s} \chi_{ij,s}}{\sum_{l=1}^n (Y_l \tau_{lj,s})^{-\varepsilon_s} \left(c_{lj,s}^p\right)^{-\delta \eta_s} \chi_{lj,s}} e_{j,s} E_j.$$

(3.17)

3.5 Tradable intermediate goods

Finally, tradable intermediate sectors can also be incorporated by assuming that in each sector the production takes the form

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

(3.18)

Here, total expenditure equals total producer revenues, $E_i = R_i$, but the costs of production are allowed to vary across sectors:

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

(3.19)

where $\alpha_{i,k,s}$ are exogenous technology parameters that satisfy the condition that $\alpha_{i,s} = \sum \alpha_{i,k,s}$. In this case $c_{i,s}^m = c_{i,s}^e = Y_i$. 

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8 This means $c_{i,s}^m = c_{i,s}^e = c_{i,s}^e = Y_i$. 

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case the price and gravity equations take the form

\[ P_{ij,s} = \tau_{ij,s}c_{i,s} \left[ \left( \frac{Y_j}{v_j} \right) \tau_{ij,s} c_{i,s} \left( \frac{Y_j}{v_j} \right) \right]^{\frac{\delta_s}{1-\delta_s}} \eta_s \left( \frac{R_i}{R_i} \right)^{\delta_s} \xi_{ij,s}, \]  

(3.20)

and

\[ X_{ij,s} = \frac{\left( \tau_{ij,s} c_{i,s} \right)^{-\varepsilon} \left( c_{x,ij,s} \right)^{-\delta_s \eta_s} \left( \frac{R_i}{R_i} \right) \delta_s \chi_{ij,s}}{\sum_{l=1}^{n} \left( c_{l,s} \tau_{lj,s} \right)^{-\varepsilon} \left( c_{x,lj,s} \right)^{-\delta_s \eta_s} \left( \frac{R_l}{R_l} \right) \delta_s \chi_{lj,s}} \eta_s \varepsilon \xi_{ij,s}, \]  

(3.21)

where \( c_{i,s} = c_{i,s}^p \), \( v_i \equiv Y_i/R_i \) is the ratio of total income to total revenues in country \( i \).

4 Counterfactual exercises

4.1 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:

\[ \hat{C}_j = \lambda_{j,j}^{-\frac{1}{2}}. \]  

(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,

\[ G_j = 1 - \lambda_{j,j}^{\frac{1}{2}}. \]  

(4.2)

Given that \( \lambda_{j,j} \equiv X_{jj}/E_j = 1 - \left( \sum_{i \neq j} X_{ij} / \sum_{i=1}^{n} X_{ij} \right) \), 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 valuable information 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 is resulting 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 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, specially when considering the sectoral elasticity as in Caliendo & Parro (2012). CRC discuss the sensitivity issues regarding this parameter.

The second advantage of using this new database is that we can obtain measures for Costa Rica, which was impossible before when the country was included in the Rest of the World data. Since Costa Rica is very open to international trade, the estimated gains are relatively large. These gains are above the average of the rest of the world and larger also than the rest of the world (the countries not included in the database). 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 the previous section. When multiple sectors are considered,

\[
G_j = 1 - \Pi_{s=1}^{S} \left( \lambda_{j,j,s} \left( \frac{e_{j,s}}{r_{j,s}} \delta_s \right)^{\beta_{j,s}/\varepsilon_s} \right). \tag{4.3}
\]

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 WIOD is used to compute the measures \( \lambda_{j,j,s}, e_{j,s}, \beta_{j,s} \) and \( r_{j,s} \). Sector level trade elasticities \( \varepsilon_s \) 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 I mentioned before, for sectoral computation using the CRWIOD we need to use 16 sectors instead of the 31 used in CRC because of how well disaggregated 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 cases in which the gains in perfect competition are much larger than the ones 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. This result depends on the comparative advantage of each country in the sectors that have

\(^{10}\)Further discussion can be found in Anderson & van Wincoop (2004).
strong scale effects. If this is the case, a country that opens to trade can specialize in sectors with large scale effects. The opposite is true for countries like Costa Rica, in which specialization occurs in sectors that do not have large scale effects.

When multiple sectors are included in the model the gains from trade increase dramatically. For the Costa Rican case, they do so five times with respect to the benchmark case. The increase is significant in part due to the Cobb-Douglas preferences assumed for the sectors. However, the increase is greater in countries for which the market structure means that closing the possibility to trade may increase the prices for some goods significantly, which is particularly sensitive with the Cobb-Douglas assumption.

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

$$G_j = 1 - \Pi_{s,k=1}^S \left( \lambda_{jj,k} \left( \frac{e_{j,k}}{b_{j,k}} \right)^{\eta_s} \frac{r_{j,k}}{b_{j,k}} \right)^{-\delta_k} \beta_{j,s} \tilde{\alpha}_{j,sk} / \varepsilon_k,$$

where $b_{j,k} \equiv v_j (\sum_{l=1}^S \beta_{j,l} \alpha_{j,kl})$ and $\tilde{\alpha}_{j,sk}$ is the elasticity of the price index in sector $s$ with respect to changes in the price index in sector $k$. The same 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 $\alpha_{j,ks} = \sum_i X_{ij,js} / R_{j,s}^{11}$.

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 that the price of intermediates used in production decreases in this scenario.

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. Again, this is the case for countries with comparative disadvantage in the sectors with strong scale effects which are amplified in this setup.

---

11 However, for monopolistic competition, an additional assumption by Balistreri, Hillberry & Rutherford (2011) explained in CRC must be made to obtain these measures. Otherwise, computation would be impossible.
Table 1: Gains from trade as percentages of income

<table>
<thead>
<tr>
<th>Country</th>
<th>Models</th>
<th>One Sector</th>
<th></th>
<th>Multiple sectors</th>
<th></th>
<th>Intermediates</th>
<th></th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Costa Rica</td>
<td>5.0%</td>
<td>23.6%</td>
<td>11.3%</td>
<td>36.1%</td>
<td>22.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUS</td>
<td>2.0%</td>
<td>6.3%</td>
<td>2.6%</td>
<td>11.7%</td>
<td>3.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUT</td>
<td>4.8%</td>
<td>23.1%</td>
<td>23.3%</td>
<td>38.9%</td>
<td>49.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BEL</td>
<td>6.6%</td>
<td>34.0%</td>
<td>33.2%</td>
<td>55.3%</td>
<td>67.8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BRA</td>
<td>1.3%</td>
<td>3.2%</td>
<td>3.0%</td>
<td>5.4%</td>
<td>8.8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAN</td>
<td>3.4%</td>
<td>12.9%</td>
<td>11.7%</td>
<td>22.4%</td>
<td>32.1%</td>
<td></td>
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</tr>
<tr>
<td>CHN</td>
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<td>2.4%</td>
<td>2.4%</td>
<td>6.5%</td>
<td>66.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CZE</td>
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<td>18.9%</td>
<td>31.9%</td>
<td>74.3%</td>
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<tr>
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<td>42.0%</td>
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<tr>
<td>DNK</td>
<td>4.8%</td>
<td>35.8%</td>
<td>30.7%</td>
<td>52.4%</td>
<td>51.1%</td>
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<td></td>
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<tr>
<td>ESP</td>
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<td>6.9%</td>
<td>7.8%</td>
<td>13.6%</td>
<td>23.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIN</td>
<td>3.7%</td>
<td>12.0%</td>
<td>11.6%</td>
<td>20.8%</td>
<td>27.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FRA</td>
<td>2.6%</td>
<td>8.1%</td>
<td>9.3%</td>
<td>14.6%</td>
<td>27.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GBR</td>
<td>3.1%</td>
<td>11.6%</td>
<td>10.6%</td>
<td>20.2%</td>
<td>21.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRC</td>
<td>3.6%</td>
<td>16.4%</td>
<td>4.5%</td>
<td>24.0%</td>
<td>4.2%</td>
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<td></td>
</tr>
<tr>
<td>HUN</td>
<td>7.2%</td>
<td>19.3%</td>
<td>21.3%</td>
<td>38.4%</td>
<td>67.8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IDN</td>
<td>2.2%</td>
<td>4.2%</td>
<td>3.2%</td>
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<td>11.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IND</td>
<td>2.1%</td>
<td>3.4%</td>
<td>3.6%</td>
<td>6.7%</td>
<td>10.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRL</td>
<td>8.3%</td>
<td>20.3%</td>
<td>13.5%</td>
<td>33.5%</td>
<td>26.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ITA</td>
<td>2.5%</td>
<td>7.2%</td>
<td>7.6%</td>
<td>13.2%</td>
<td>18.7%</td>
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<td></td>
</tr>
<tr>
<td>JPN</td>
<td>1.3%</td>
<td>1.3%</td>
<td>2.7%</td>
<td>2.7%</td>
<td>21.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KOR</td>
<td>3.7%</td>
<td>3.8%</td>
<td>8.1%</td>
<td>10.2%</td>
<td>74.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEX</td>
<td>3.2%</td>
<td>10.5%</td>
<td>11.9%</td>
<td>17.5%</td>
<td>27.3%</td>
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<td></td>
</tr>
<tr>
<td>NLD</td>
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<td>25.5%</td>
<td>23.6%</td>
<td>41.5%</td>
<td>46.3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>POL</td>
<td>4.0%</td>
<td>15.1%</td>
<td>17.1%</td>
<td>28.4%</td>
<td>46.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRT</td>
<td>3.7%</td>
<td>17.6%</td>
<td>13.7%</td>
<td>29.0%</td>
<td>26.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROM</td>
<td>3.8%</td>
<td>11.0%</td>
<td>10.9%</td>
<td>19.3%</td>
<td>17.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RUS</td>
<td>2.1%</td>
<td>9.7%</td>
<td>0.7%</td>
<td>16.9%</td>
<td>-3.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SVK</td>
<td>6.5%</td>
<td>18.1%</td>
<td>19.1%</td>
<td>41.2%</td>
<td>79.8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SVN</td>
<td>5.8%</td>
<td>31.3%</td>
<td>32.8%</td>
<td>50.8%</td>
<td>66.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SWE</td>
<td>4.6%</td>
<td>10.9%</td>
<td>12.0%</td>
<td>20.2%</td>
<td>33.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TUR</td>
<td>2.5%</td>
<td>10.6%</td>
<td>10.6%</td>
<td>18.5%</td>
<td>24.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TWN</td>
<td>5.5%</td>
<td>7.5%</td>
<td>8.2%</td>
<td>14.7%</td>
<td>28.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>1.5%</td>
<td>3.3%</td>
<td>3.1%</td>
<td>5.8%</td>
<td>9.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rest of World</td>
<td>3.7%</td>
<td>11.6%</td>
<td>5.3%</td>
<td>21.5%</td>
<td>15.0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>3.8%</td>
<td>13.3%</td>
<td>12.1%</td>
<td>23.2%</td>
<td>33.4%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Computations using the Matlab programs used in Costinot & Rodríguez-Clare (2013). 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.
4.2 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:

\[
\hat{C}_j = \left( \frac{1 - \pi_j}{1 - \pi_j'} \right) \left( \hat{\lambda}_{jj} \right)^{-1/\varepsilon}
\]  

(4.5)

where \( \pi_j = \sum_{i=1}^{n} \frac{t_{ij} + \lambda_{ij}}{1+t_{ij}} \) and \( \pi_j' = \sum_{i=1}^{n} \frac{t'_{ij} + \lambda_{ij}}{1+t_{ij}} \) 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) from a country from unilaterally increasing the tariffs it charges for products entering the country. The potential unilateral gains of a country like Costa Rica of increasing tariffs (assuming that other countries do not retaliate) are larger than the average country, but not as large as those of a country that is even more open to trade as Ireland.

![Figure 1: Gains from a unilateral increase in the tariff](image)

Source: Computations using the Matlab programs used in [Costinot & Rodriguez-Clare, 2013]. 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)

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

Source: Computations using the Matlab programs used in Costinot & Rodriguez-Clare (2013). Data from CRWIOD for 2011. 16 sectors are used. Trade elasticities from Caliendo & Parro (2012).

12 This is the multiple sectors, intermediate goods, heterogeneous firms (Melitz) version. The average loss from the one sector model is 0.4%.
5 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 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 was 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 advantage in the sectors with the highest scale effects. However, this characteristic is not unique to low and middle income economies, as other advanced economies show this characteristic too.

Therefore, the results imply that Costa Rica is in a significantly better situation in terms of real income thanks to its involvement in international trade. However, the advantages of the country may be hindered by where they are located. 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.
References


Appendices

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

Table 3: Description of the 16 sectors used in estimation, and trade elasticity used.

<table>
<thead>
<tr>
<th>Sector’s description</th>
<th>16-sector aggregation</th>
<th>Caliendo-Parro trade elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, Hunting, Forestry and Fishing</td>
<td>1</td>
<td>8.11</td>
</tr>
<tr>
<td>Mining and Quarrying</td>
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<td>15.72</td>
</tr>
<tr>
<td>Food, Beverages and Tobacco</td>
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<td>2.55</td>
</tr>
<tr>
<td>Textiles and Textile Products, Leather, Leather and Footwear</td>
<td>4</td>
<td>5.56</td>
</tr>
<tr>
<td>Wood and Products of Wood and Cork</td>
<td>5</td>
<td>10.83</td>
</tr>
<tr>
<td>Pulp, Paper, Paper, Printing and Publishing</td>
<td>6</td>
<td>9.07</td>
</tr>
<tr>
<td>Coke, Refined Petroleum and Nuclear Fuel</td>
<td>7</td>
<td>51.08</td>
</tr>
<tr>
<td>Chemicals and Chemical Products</td>
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<td>4.75</td>
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<td>Rubber and Plastics</td>
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<td>1.66</td>
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<td>Other Non-Metallic Mineral</td>
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<td>Basic Metals and Fabricated Metal</td>
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<td>1.52</td>
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<td>10.6</td>
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<td>Transport Equipment</td>
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<td>0.37</td>
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<td>5</td>
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<td>Electricity, Gas and Water Supply</td>
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<td>Construction</td>
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<tr>
<td>Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods</td>
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<td>Hotels and Restaurants</td>
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<td>Air Transport</td>
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<td>Transport Activities; Activities of Travel Agencies</td>
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<td>Public Admin and Defence; Compulsory Social Security</td>
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