Central America's Intra and Extra-Regional Trade Potential: 
A Gravity Model Approach to Understanding Regional Integration

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1. **Central American Integration: Gains from Removing Barriers to Trade**

Global competition has intensified the need for efficiency in transport and logistics systems in the delivery chain, from the point of manufacture to delivery to the customer. As tariffs have decreased, transport and logistics costs have become, in many cases, the biggest cost factor in the final price consumers pay. Likewise, efficient and cost-effective transport and logistics services—including efficient physical infrastructure and good intermodal connectivity—are becoming ever more important catalysts for development and deeper regional integration. As evidenced by the experience of the European Union, integration of national infrastructure networks and markets stimulates growth, while the reduced barriers to trade facilitates the gains from structural change, speeding up technology transfer, underwriting market-size effects on R&D spending, and stimulating investment and innovation through reducing transaction costs. By improving the efficiency of connections between demand centers and supply points through improved transport service and infrastructure quality as well as reduced border frictions, connects rural and small producers to new markets, creates employment opportunities for the manufacture of traded goods, and reduces the delivered prices of primary goods—a vital point of urgency for the poor.

The recent signing of the CAFTA-DR trade agreement represents an important step towards regional trade integration in Central America. However, as shown by studies such as Fernandez, Fernandez, et al. (forthcoming), a number of infrastructure and logistics-specific challenges need to be resolved for the region’s countries to be able to fully reap the potential benefits of CAFTA and to integrate not only with each other, but also with the rest of the global economy. As shown by the above study which analyzes of a number of supply chains of exports and imports of agricultural goods in Central America, bottlenecks at the region’s border crossings, mostly attributed to customs delays, as well as to poor road infrastructure present the key burdens for trade between Costa Rica and Nicaragua. Customs costs are particularly relevant for trade in perishable foods: the study finds that customs costs are the most important cost component of the final price of exported tomatoes, at between 10 and 11 percent of the final price of the delivered good. As analyzed by Schwartz et al. (2009), also in other parts of the LAC Region the effect of delays in customs clearance are significant, for instance, resulting in an increase in transport costs by between 4 and 12 percent, while the increase in physical distance—even as much as by 100 percent—raises transport costs only by between 8.5 and 18.7 percent.

Obstacles to increased intraregional trade are posed also by the quality of roads and trucking services that effectively increase the ‘real distance’ that needs to be covered to deliver goods to export markets. For example, in Costa Rica, road quality is identified as one of the three main impediments affecting businesses, with poor road quality causing direct losses from delays in shipments and breakage and theft of 8 to 12 percent of the sales value of exported goods (World Bank, 2006b). For South American countries, the World Bank calculates that a 10-percent reduction in transport costs would increase trade by 3.6 percent in Uruguay, 5.5 percent in Brazil, and 3.3 percent in Argentina (World Bank, 2009). High trucking costs and reliance on road transport, however, are estimated to be particularly detrimental to the trading ability of landlocked countries, with the effect of reducing trade values by about 60 percent compared to coastal countries. As a consequence, as estimated by a the Asian Development Bank (2009), a
10-percent reduction in transport costs in these countries would increase their external trade by as much as 25 percent.

In fact, the above studies and other research on the impact of infrastructure-inefficiency-related costs on the final price of delivered goods reveal that these costs represent a greater barrier to trade than import tariffs and that their impacts become increasingly relevant with the prevalence of free trade agreements such as CAFTA. So, for instance, while, on average, ad valorem tariffs for food imports in the LAC Region between 2005 and 2008 showed a decreasing trend and currently range from 3 to 12 percent of product value, transport and logistics costs, on the other hand—as measured exclusively by the international maritime and road haulage components—still constitute as much as 20 percent of the FOB value of goods. If also accounting for the other costs along the logistics chain, only about ½ of the delivered price of the good is represented by the original farm-gate price.

The studies cited above are useful in providing disaggregated country-specific information on the detailed costs and time requirements involved in cross-border trade, estimating the relative share of each logistics costs component in the price of the delivered goods. At the same time, the micro-level supply-chain approach to trade flow analysis fails to capture some of the overall regional trends and the impact on trade flows of key socioeconomic and spatial variables, including the size of the trading economies and their proximity and adjacency.

Spatial patterns and geographical information play a crucial role in understanding the dynamics of regional integration. When coupled with practical tools such as supply chain analysis and freight flow modeling, spatial-based analysis and spatial representations can serve as a practical tool for informing decisions on public investments, trade and transport regulations and the optimization or prioritization of government resources.

To complement the various supply chain analysis and country-specific economic modeling exercises underway in Central America, the current paper takes a spatial approach to infrastructure integration in Central America, benchmarking the current intra-regional trade performance of the region against the patterns observed in the European Union and, in turn, projecting the potential trade volumes that would take place in a "spatially integrated" Central America. Specifically, the paper attempts to measure the extent to which various physical variables act as obstacles to intra-regional trade. Conversely, it also estimates the maximum potential gains—in terms of increased trade volumes—that could be achieved from raising the level of Central America’s infrastructure integration and efficiency to a level comparable to the European Union, in turn facilitating the achievement of the various gains from trade, including:

- Improved competitiveness and reduction in transaction costs—such as by improving the efficiency of connections between demand centers and supply points through improved quality and allocation of road, railway and port infrastructure and reduced border-crossing times; and
- Poverty reduction and growth, as reduction of physical barriers to trade are expected to not only increase trade flows, but also provide productivity gains, help diversify the range of traded products, expand production capacity, and generate employment and enlarge the market for tradable goods.
For estimating the relative impact of such trade-related variables as the distance between production and consumption centers—measured either in Euclidian terms or adjusted based on such factors as road quality, trucking costs, or customs efficiency—and the absolute incomes of the trading economies, the paper applies the Gravity Model, allowing for an improved understanding of the behavior of the various variables at the regional level and highlighting their linkages, correlations and dynamic over time, simultaneously making it feasible to generate and extract spatial information to explain socioeconomic phenomena.

The Gravity Model of Trade (GMT) - a ‘spatially-conscious’ econometric model - incorporates a geographical perspective to explain socioeconomic dynamics as function of two criteria: mass (i.e., GDP, capital stocks, population, etc.) and distance to gravity centers. The GMT, as other models of this type, attempts to explain trade between two countries by their bilateral connectivity, adjacency, and respective market size, assuming that economic infrastructure and institutional frameworks that are conducive to conducting commerce will expand the intensity of commercial activity, including in the form of cross-border trade.

Since its introduction in the early 1960s, the GMT has become one of the most powerful tools for describing international trade. Several factors explain its success: (i) the intuition behind the GMT is simple yet exhibits high explanatory power; (ii) most of the empirical evidence supports the basic GTM approach; and (iii) academics and researchers (see Anderson, 1979; Bergstrand, 1985; Helpman, 1986; Deardoff, 1995) have developed solid theoretical foundations that prove the validity of the GMT. Lastly, information for estimating GMTs, at least at the country level, is typically reliable and available for several years, allowing for consistent and robust econometric estimations.

Based on the Newton’s Law of Universal Gravitation, the simplest specification of the GTM states that the bilateral trade flows between two or more countries are positively related to the Gross Domestic Product (GDP) of both the exporting and the importing economies and negatively related to the distance between them. While the exporting and importing country GDPs capture the effects of exogenous variables from the supply-side and the demand-side, such as market size effects (Leamer and Stern, 1970), distance provides a good proxy of the transport costs in an impeded trade model (Deardoff, 1995).

According to the GMT, the total export flow $T_{ijt}$ from country $i$ to country $j$ in year $t$ corresponds to

$$T_{ijt} = A \frac{GDP_{it} \cdot GDP_{jt}}{D_{ij}}$$

(1)

where $A$ is a constant of proportionality and transport costs are proxied by distance $D$. 
Usually, gravitational models are estimated through a linear transformation, as it permits to express the relationship between the flows (measured in exports terms) and the regressors (importers’ GDP, exporters’ GDP and distance) in terms of elasticities. However, also augmented versions of the standard GMT have been used – for instance, to better understand the benefits of free trade agreements and free trade zones, including MERCOSUR and the Andean Community (Carrillo and Li, 2002), NAFTA (Montenegro and Soloaga, 2004), the Western Balkan trade zone (World Bank, 2007), the West African Monetary Zone (Balogun, 2008), the Eastern European region (World Bank, 2005), and the Arab Maghreb region (PIIE, 2008). Furthermore, GMT has helped to assess the benefits of trade facilitation measures (World Economic Forum, 2008; World Bank, 2008) and to estimate trade potentials (Benedictis and Vicarelli, 2005).

Often, these augmented versions of the GTM include dummy variables to capture fixed effects at the country-pair level. For example, common language and adjacency (common border) are factors associated with lower costs for doing business (PIIE, 2008), and a vast number of studies have found positive effects on bilateral trade as a result of the adjacency (Helpman, 2005; Benedictis and Vicarelli, 2005; Balogun, 2008; World Economic Forum, 2008; World Bank, 2008; PIIE, 2008).

An interesting result derived using highly disaggregated versions of augmented Gravity Models is that bilateral trade between two countries may often be as low as zero. In fact, the more disaggregated the model and the larger the sample of countries included in the estimations, the greater the chance of having no bilateral trade between two countries. Missing information (i.e. “observations”) caused by absence of bilateral trade may, in turn, introduce a bias in the overall estimations, overestimating the explanatory power of the independent variables (WER, 2008). Methodology for correcting for this selection bias was originally proposed by Heckman (1979),
and has been subsequently modified by Helpman (2005), whereby a two-stage model is applied to the specific case of the determinants of bilateral trade.

Estimations proposed in this study correspond to an augmented version of the GMT that includes both the fixed effect of the adjacency and the two-stages sample selection bias correction suggested by Helpman (2005). Coefficients have been expressed as elasticities and semi-elasticities through the linear transformation:

$$\ln(T_{ijt}) = \beta_0 + \beta_1 \ln(GDP_{it}) + \beta_2 \ln(GDP_{jt}) + \beta_3 \ln(D_{ij}) + \beta_4 Adj_{ij} + \beta_5 \lambda_{ijt} + e_{ijt}$$  \hspace{1cm} (2)

Where $\ln(x)$ denotes the natural logarithm of the variable $(x)$, $Adj$ is a dummy variable that takes value 1 if the country-pair $ij$ shares a common frontier, and $\lambda$ is the non-selection hazard computed in a first-stage as

$$\lambda_{ijt} = \frac{\phi(.)}{\Phi(.)}$$  \hspace{1cm} (3)

where $\phi$ corresponds to the normal density function and $\Phi$ to the standard cumulative normal function.

Equation (2) summarizes most of the academic and empirical work carried out to better understand the determinants and drivers of bilateral trade from the perspective of gravity, while, implicitly, the probabilistic model for estimating the non-selection hazard vector (3) is fitted following the Linder’s hypothesis (1961) which states that the more similar the demand patterns between two countries, the higher the possibilities for bilateral trade between them. The degree of similarity in demand patterns in this specific case is proxied by the absolute difference in the GDP per capita between countries $i$ and $j$ (McPherson et al., 1998).

The current paper applies the above GMT specifications to the Central American region, thus providing valuable clues about the role of markets and distances between them, and the effects of adjacency on trade flows within the region. By disaggregating the exports flows $T_{ijt}$ into three types of goods – Grains, Steel and Steel Products, and Processed Fruits and Vegetables – over a nine-year period from 2000 to 2008, the approach also provides a base for comparing the role of distance and adjacency as well as the effectiveness of domestic and foreign markets in the trade of low versus high value-to-weight goods or in containerized goods versus goods typically transported in bulk.

The selection of the above products groups is also justified by their significant share in the region’s overall exports mix, albeit with some variations across the individual countries. As shown in Figure 2 below, in 2006, Agricultural products (such as Grains) represented anywhere between 21 and 82 percent of the countries’ exports basket, Nicaragua being the most agriculture-dependent exporter, while Manufactures—for instance, Processed Fruits & Vegetables—represented between 8 and 74 percent of exports – in Nicaragua and El Salvador, respectively.
Beyond the pure analysis of trade determinants, the paper also applies the GMT to project the potential trade flow volumes at both the bilateral and the regional level by replicating the behavior of the key variables observed in the European Union (EU15) – a region with a high level of economic and trade integration. This approach allows for an assessment of the relative impact of policy measures aimed at reducing the various non-tariff trade barriers – specifically, those aimed at reducing the real distance between two countries (geographic distance adjusted for additional burdens posed by poor road conditions and high transport costs) and improving efficiency at border crossings.

2. Preliminary results: Part I

The first set of GMT estimations is organized as follows. First, the model is estimated using intraregional bilateral export flow data for the more integrated part of the European Union (EU15) and, second, for the Central America region. Estimations for both regions are first carried out in terms of total exports (measured in US$) and then for a number of disaggregated groups of goods: (i) Grains, including rice, maize, wheat, and barley, in both value (US$) and volume (kg) terms; (ii) Steel and Steel products, including ingots and other primary forms, iron and steel castings, tubes, rods, pipes and fittings, universals, iron and steel bars, rails and railway track construction materials, in both value and volume terms; and (iii) Processed Fruits & Vegetables in both value and volume terms. Estimations were carried out over a nine-year period from 2000 to 2008 using the fixed effects –FE– panel method. In the figures, results are presented at the 10% level of significance.

2.1. Establishing a Benchmark for Central America’s Spatial Integration

The results obtained for the EU15 countries for total intraregional exports (Figure 3) correspond to what is expected according to the intuition underlying the GMT theory: the GDP of both the importing and the exporting countries is significant and positively related to export flows, while
the distance between two economies has a significant and negative impact, whereby an increase in distance by 1 percent reduces the expected exports by 0.93 percent.

**Figure 3**: Model results for EU15 intraregional trade: Total Export Value

![Graph showing EU15 Intra-regional Exports Only](image)

Source: World Bank calculations based on trade flows data from WITS, LCSSD Economics Unit (2010)

Similarly, as expected, adjacency represents opportunities for increasing exports within a highly-integrated region. Expressed as the percentage change in total exports,\(^1\) EU15 countries that share frontiers have 83 percent higher expected bilateral export flows than countries that do not.\(^2\)

Positive and significant effects associated with the adjacency, although of different magnitude, have also been found for other European economic blocks - 56 percent (World Bank, 2005), the Latin America and the Caribbean Region overall - 174 percent (Carrillo and Li, 2002), and in large country-samples covering the rest of the world - 289 percent (World Economic Forum, 2008).

Once the model is disaggregated, the variable capturing the Importers’ GDP loses importance when compared to the Exporters’, especially in Grains and Processed Food. As shown in Figure 1 in Annex 1, on average, an increase in the GDP of the exporting country by 1 percent increases the expected exports from that country by about 1.4 percent (Grains), 1 percent (Steel) and 1.2 percent (Processed Fruits and Vegetables).

The distance effect, as expected, is negative and significant, with much larger negative impacts on the trade in Grains and in Steel than in Processed Food or in the overall trade model. On average, an increase in distance by 1 percent reduces the total expected bilateral exports by 0.9 percent, while, in the case of the Steel exports, an increase in distance by 1 percent reduces the expected exports in value and volume terms by 1.2 and 1.4 percent, respectively.

The “adjacency effect” on trade is much greater on the separate export flows of Grains, Steel, and Processed Foods than that observed in the overall trade model. In all three cases, "adjacency"

\[\Delta T = \frac{(T|Adj = 1)}{(T|Adj = 0)} - 1 = \frac{exp(\alpha exp(\beta x))}{exp(\alpha)} - 1 = exp(\beta x) - 1\]

\[\text{Expressed as } (exp(adj) - 1).\]

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\(^1\) The discrete change in expected exports correspond to $\Delta T = \frac{(T|Adj = 1)}{(T|Adj = 0)} - 1 = \frac{exp(\alpha exp(\beta x))}{exp(\alpha)} - 1 = exp(\beta x) - 1$

\(^2\) Expressed as $(exp(adj) - 1)$. 
increases the expected exports by over 300 percent,\(^3\) although, in the case of Steel exports expressed in volume terms, that effect is slightly lower (243 percent).

### 2.2. Results for the CA intraregional trade only

Over the period from 2000 to 2008, intraregional trade in Central America has grown significantly, with individual country bilateral exports to the other five countries in the region increasing at a faster rate than exports to the world as a whole. As illustrated in the Figure below, between 2000 and 2008, the total exports of Costa Rica, for instance, increased by 77 percent, with the strong growth rate partially attributed to China becoming a major export partner. In contrast, however, the growth of Costa Rica’s exports to the rest of the Central America region was even more significant – a combined increase of 130 percent. (Annex 3 shows each of the CA country’s extra-regional exports in volume terms).

![Figure 4: Costa Rica’s Exports by Destination, 2000 versus 2008 (US$)](image)

Source: World Bank calculations based on trade flows data from WITS, LCSSD Economics Unit (2010)

According to calculations by SIECA, for the region overall,\(^4\) the share of intraregional exports in the total exports (as measured in FOB US$ terms) has fluctuated between about 26 and 30 percent, reaching the highest share in 2008 and then decreasing slightly in 2009. The Figure below illustrated the overall trend in terms of intraregional versus total Central American exports in 2005-2009.

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\(^3\) aprox. \(\exp(1.4) - 1\)

\(^4\) Calculations exclude Panama
According to the model results produced for the current paper, the size of the domestic markets and the distance between them are the main factors affecting bilateral trade in Central America. Given a 1-percent increase in GDP of the exporting country, it is expected that exports from that country to the rest of the region increase by nearly 1.7 percent. Conversely, a 1-percent average increase in distance between that country and its export partners is associated with reductions in expected exports by 1.6 percent.

Compared to the EU15, in Central America, the ‘gravitational pull’ (proxied by the Importing Countries’ GDP) is relatively low and insignificant. A 1-percent increase in the GDP of the importing country (i.e. the export partner) increases expected exports to that country by 0.5 percent. As illustrated in Figure 6, this effect is approximately one third of that associated with a 1-percent increase in the Exporter’s own GDP.

Surprisingly, the effects of "adjacency" are negative for total exports and mostly insignificant when flows are disaggregated into the three groups and the model corrected for selection bias. Contrary to what was observed in EU15, the estimations show that the expected export flows between two countries sharing borders are 40 percent\(^5\) lower than expected bilateral exports with other countries in the region. This result, in principle counterintuitive, suggests that the Central American common borders serve as "barriers" rather than as "points of encounter and exchange." Possibly, the lack of significance of adjacency can be explained by the current inefficiencies at the border crossings that counterbalance the overall greater opportunities for doing business and trading that are typically enjoyed by countries located directly next to each other.

\(^5\) \(e^{-0.5} - 1\)
It is fair to suppose that the "adjacency effect" varies across the pairs of Central American countries sharing borders. Based on this presumption, a further set of estimations were carried out, separately estimating the effect of each common border on the expected exports while keeping all other coefficients constant.\(^6\) This made it possible to identify the exact borders that currently act as bottlenecks and explain the negative and/or insignificant value of the adjacency variable in the Central America GMT model for bilateral trade.

As shown in the Figure 7, only the adjacency between Costa Rica–Nicaragua does not produce adverse effects on total exports within the region. Conversely, the adjacency between Honduras and Nicaragua is associated with reductions in expected export flows by close to 60 percent. Likewise, the effects of the adjacency between El Salvador and its two neighbors are more negative than the regional average, at – 53 percent and -48 percent for the El Salvador-Guatemala and the El Salvador-Honduras adjacency, respectively.

The disaggregated models show that the GDP of the exporter and the distance tend to have more pronounced impacts on Central American trade flows compared to the EU15 intraregional flows. Especially in the case of Steel and Processed Fruits and Vegetables, a 1-percent increase in the exporter’s GDP is associated with a 2.5-percent increase in the expected exports. The same increase in GDP generates positive effects also on Grains exports - of an increase of 2 percent

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\(^6\) See the Annex for details
and 1.3 percent when models are expressed in values and volume terms, respectively (Figure 2, Annex 1).

In all cases, on the other hand, the negative effect of distance on export flows is higher in Central America than in EU15: the elasticity “distance-exports” is in the range from 1.3 percent to 3 percent for all model specifications.

Both costs and time of transportation increase the ‘real’ distance between markets. Yet, from the point of view of the GMT models, geographical distance is a relatively good proxy of the distance between markets, in that it is also assumed to capture the two factors mentioned above. As illustrated in Figure 8, also based on the data provided in the World Bank’s 2010 Logistics Performance Index on the average inland supply chain distances (measured in kilometers) and the associated lead time (expressed in days) in each of the Central American countries, the correlation between the two variables is relatively high – at approximately 0.83 – which is comparable to that calculated for the EU15.7

Figure 8: Correlation between Average Land Supply Chain Distance and the Associated Lead Time in CA

![Figure 8: Correlation between Average Land Supply Chain Distance and the Associated Lead Time in CA](image)


To construct a variable representing the “real” distance between two countries in Central America, the current study calculates the ratio of average time (measured in days) required to complete a land supply chain distance (measured in km) in the Central America region versus the average time required to cover the respective distance in the EU15.8 The ratio obtained – equal to 1.675 – is then used as a factor by which to multiply the bilateral Euclidean distances in Central America to express them in Time Equivalent Terms.

The "adjusted distance" variable in the Gravity Model equation as follows:

\[ y = 3.9875\ln(x) - 6.2647 \]

\[ R^2 = 0.692 \]

Correl = 0.83

7 Similarly, also the calculated correlation between the average land supply chain distance and the associated cost (measured in US$) in Central American countries is relatively high – about 0.81.

8 The calculations are based on the Logistics Performance Index respective values for each country in Central America and EU15.
\[ e^{\ln(T_{ij})} = e^{\beta_0 + \beta_1 \ln(GDP_i) + \beta_2 \ln(GDP_j) + \beta_3 \ln(D_{ij}+1.675) + \beta_4 Adj_{ij} + \beta_5 \lambda_{ij} + e_{ijt}} \tag{4} \]

Whereby the coefficients obtained are later used for projecting each Central American country's intraregional exports potential, using a number of different specifications or "benchmarks."

GMT estimations carried out for this specific paper show that in Central America the effect of distance is much greater than in the EU, which may be due to comparatively greater difficulty of transporting goods using Central American roads and transportation services than those of EU15. The average distance between the Central American cities is 27 percent higher than that among major cities in the EU15, and the average time of exportation takes almost twice as much time: 19.8 days in Central America compared to 10.3 days in EU15. The time difference can at least partially be attributed to the fact that most of the topography in CA is rugged and major cities within the region are at an average altitude of 1,100 meters. Yet, also the excessive paperwork on the bilateral borders and other inefficiencies associated with the transportation of goods in CA may be playing a role in the results. As shown in Figure 9, the efficiency of Customs Administration is still low in some of the region’s countries – estimated at 3 and 3.2 (measured on a scale from 0 to 7, where 7 signifies the highest performance) – in Nicaragua and Honduras, respectively.

In terms of adjacency, the only model specification where the effect is significant and positive is the Grain exports model, whereby the expected bilateral trade between countries sharing a common border is 140 percent higher than between countries not adjacent to each other. When the adjacency effect is disaggregated (Figure 2, Annex 1), the strongest positive impact on trade in Grains can be observed for the Costa Rica–Nicaragua proximity, where Grains exports are expected to be a 400 percent higher than those between not adjacent countries.
As illustrated in Figure 10, although Guatemala, Honduras and El Salvador all share common borders, only the Guatemala-Honduras and the Guatemala-El Salvador adjacencies are expected to generate a positive impact on expected bilateral trade in Grains. In contrast, the adjacency of Honduras to El Salvador (or to Nicaragua) does not have a positive effect on expected bilateral Grains exports, similarly to the adjacency between Costa Rica and Panama.

The above results are consistent with those of a recent Standardized Logistics Survey of eight supply chains of various representative containerized and bulk agricultural goods (see Fernandez et al. forthcoming). Similarly to the results obtained from the GMT-based modeling, the supply chain analyses show that high domestic transportation costs, along with bottlenecks at land border crossings, present the biggest hurdle to both intra-regional trade, such as between Costa Rica and Nicaragua, and, equally so, for extra-regional imports, such as grain shipments from the United States. Supporting the patterns observed in the current Gravity Modeling exercise, the surveyed Central American exporters, too, point to the lack of good quality paved secondary roads, especially for linking farms with cities, which impedes intra-regional commerce notwithstanding the relatively good condition of the major transit arteries. The poor road quality, in turn, causes direct losses from delays in shipments and breakage of 8 to 12 percent of the sales value of exported goods and is seen by a large share of local firms as presenting a severe obstacle to growth.

The overall policy implications of the above estimations are similar to those identified in the recent supply chain analyses cited above that focus on both intra-regional trade within Central America and on the key challenges faced by producers conducting cross-border trade with countries outside the region. As highlighted previously, these include the need for improvements at the region’s border crossings to enable the individual countries to take advantage of being adjacent to one another, as well as the importance of investments and policies aimed at reducing the ‘economic’—that is, the cost- and time-equivalent—overland distance between production and consumption centers within the region.

3. Preliminary results: Part 2

The second set of GMT estimations is organized as follows. First, the model is estimated using bilateral export flow data for each of the EU15 countries to each of the 27 current European Union Member States as well as to the United States. Second, the same set of estimations are carried out using data on bilateral export flows within the Central America region as well as for each of the CA country’s exports to the U.S. and the EU27. Estimations for both regions are first carried out in terms of total exports (US$) and then separately for: (i) Grains, including rice,
maize, wheat, and barley, in both value (US$) and volume (kg) terms; (ii) Steel and Steel products, including ingots and other primary forms, iron and steel castings, tubes, rods, pipes and fittings, universals, iron and steel bars, rails and railway track construction materials, in both value and volume terms; and (iii) Processed Fruits & Vegetables in both value and volume terms.

Estimations were carried out over a nine-year period from 2000 to 2008 using the fixed effects – FE – panel method. In the figures, results are presented at the 10% level of significance.

3.1. Establishing a benchmark for Central America’s extra-regional trade behavior

In the second set of estimations, the paper first looks at the patterns of trade between EU15 and the other twelve EU economies as well as the United States to then compare these with trade patterns observed in Central America’s trade with EU27 and the U.S. The results indicate that also for the “expanded EU sample” the effect of the independent variables is still as predicted by the theory underlying the GMT; however, distance gains importance when the models also include bilateral trade between each of the EU15 countries and the rest of the EU and with the US, while the effect of adjacency is comparatively weaker.

Figure 11: Model results for EU15+EU12/US bilateral trade: Total Exports Value

First, the effect of the adjacency on Processed Food and on total exports is about 20 percent lower, although still positive and significant, than in the model restricted to the EU15 group. For exports of both Grains and Steel, this effect is 30 and even 50 percent lower, respectively. On average, adjacency is expected to lead to bilateral exports 70 percent above those expected in the absence of adjacency (see Figure 3 in Annex 1).

Second, it is expected that, given a 1 percent increase in the distance, total bilateral exports as well as Grain exports decrease by 1.3 percent (when exports are expressed in value terms) and by slightly above 1.5 percent when measured in volume terms. Meanwhile, the same increase in distance reduces Steel exports by up to 2 percent (when measured in value terms) and Processed Food exports by about 1 percent when flows are expressed in either value or volume terms.
3.2. Results for the CA regional trade including the U.S. and the EU27

When estimations include CA country trade with the EU and the U.S., the total exports model for Central America follows the behavior predicted by the GMT theory. In particular, under this data specification, adjacency becomes a driver of bilateral trade: countries sharing common frontiers have a level of expected total bilateral exports of about 22 percent above and their bilateral Grain exports of more than 90 percent above countries that are not adjacent to one another.

It should be noted that trade from CA to U.S. and especially EU27 involves the transportation of goods toward the ports on the Atlantic coast. For countries, such as El Salvador and Nicaragua, with no ports located on the Atlantic coast, bilateral trade with the two external regions necessarily implies to transit through their neighboring Central American countries: in the case of El Salvador, through Guatemala to reach the Santo Tomas de Castilla port and through Honduras to arrive to Puerto Cortez, and in the case of Nicaragua, through Costa Rica toward Puerto Limón.

![Figure 12](image)

**Figure 12:** Model results for Central America intraregional trade (including trade with the U.S. and EU27)

Source: World Bank calculations based on trade flows data from WITS, LCSSD Economics Unit (2010)

Finally, estimations show that the effect of distance on both total and disaggregates exports tends to be lower when the data sample also includes trade toward EU27 and the US (both when exports are expressed in value and volume terms). For instance, while in the restricted CA intraregional model a 1% increase in distance between two trade partners, on average, leads to a decrease in the expected bilateral Processed Food exports by about 2.7% (in volume terms), the same increase in distance in the expanded sample decreases the expected exports by only 1% (see Figure 4, Annex 1).

Although bilateral trade from the CA countries to the U.S. and the EU is mainly by sea and air, exports within CA are basically by land through the Pacific corridor. Given that the negative effect of distance is greater in the restricted intraregional model of trade, the estimations are probably suggesting that the "economic distance" between the markets is much higher when trading is done by land. For example, the inefficiencies in land transportation of goods may explain the higher negative effect exerted by the distance on exports within CA.
At the same time, the quality of road transportation in Central America is a key factor affecting also the facility of the region’s external trade, in particular, to the extent that it encourages or impedes the movement of export goods from production centers to ports and of imported goods from ports to consumption centers inland. The above observation is also supported by the results of recent supply chain analyses focusing specifically on corn imports from the U.S. into Nicaragua, showing that transport costs incurred domestically in Central America represent a higher share of the final price of the good (in this case, 30 percent) than the U.S. transport, ocean transport, and other logistics costs combined (18 percent).

4. Potential intraregional exports in Central America

One of the main benefits of the GTM is that it allows projecting the "potential level" of exports based on a specific set of coefficients. In turn, the ratio between the observed and the potential export flows provides a measure of the closeness— or proximity index— of a specific country or country-pair to its expected exports level expectations frontier. Following Benedictis and Vicarelli (2005), this closeness measure $\chi^p$ can be expressed as:

$$x_{ijt}^p = \frac{e^{x_{ijt}}}{e^{\hat{x}_{ijt}}}$$  (5)

Where $x_{ijt}$ are the observed export flows from the exporter country $i$ to the importer country $j$ and $\hat{x}_{ijt}$ are the expected exports flows generated by the gravity equation. To calculate the potential export flows, four different sets of coefficients were used, resulting in four different scenarios or “proximity indices.”

The first scenario is based on the coefficients for the CA intra-regional trade model (Figure 6). The second one projects the exports flows in CA from the coefficients obtained from the EU15 intra-regional model (Figure 3). The third and the fourth scenarios are based on the same coefficients as those used for the first scenario except for that associated to the variable "adjacency." Namely, to obtain the third scenario, the highest country-pair adjacency coefficient is applied, obtained from the disaggregated GTM for Central America (with results illustrated in Figures 7 and 10), while the fourth scenario applies the adjacency coefficient resulting from the EU15 intra-regional model (Figure 3).

Figure 13 below illustrates the results obtained from the four different scenarios, in this case, comparing Costa Rica with Honduras. In Costa Rica’s case, the observed-to-projected exports are close to the Expectations Frontier (i.e. a ratio equivalent to 1), except for when the country’s currently observed exports are compared to what its exports would be expected to be under the assumption of an “EU15-like” behavior of all the independent trade variables (distance, adjacency, and the GDP of both the exporting and the importing country). In the case of Honduras, on the other hand, the ratio is far from 1 in all of the scenarios, including when the

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9 For Grains (in volume and value terms) and Overall Trade (in value terms) the best country-pair adjacency effect corresponds to the Costa Rica- Nicaragua; for Steel and Processed Fruit & Vegetable exports, even the best “Adjacency Performance” across the country couples is 0.
country’s observed exports are compared to what they would be expected to be assuming an adjacency effect equivalent to the adjacency effect of the best performer in Central America.

**Figure 13:** Closeness of Central America’s total intra-regional exports (in value terms) to the Unconstrained Expectations Frontier

![Graph showing closeness of Central America's exports to the frontier](image)

Source: World Bank calculations based on trade flows data from WITS, LCSSD Economics Unit (2010)

Figure 14, further, shows the closeness of the two countries to the frontier of expected exports in terms of the separate export types. Here, Grains and Steel exports are particularly strong examples of the two countries being at very different levels of “adjacency performance,” whereby, in line with the results illustrated shown in Figure 10, Costa Rica’s is close to the level of the region’s best performer, while Honduras’ is much more distant from the benchmark.

**Figure 14:** Closeness of different types of intra-regional exports flows to the Expectations Frontier: Observed Exports/Projected Exports, where the projection assumes that Costa Rica and Honduras’ Trade Behavior follows Central America’s Best "Adjacency Performance"

![Graph showing closeness of different types of exports](image)

Source: World Bank calculations based on trade flows data from WITS, LCSSD Economics Unit (2010)
Assuming the EU15 intraregional estimations as benchmarks that represent the behavior of a “truly integrated” region, the ratio of observed to potential exports are also calculated separately for each pair of countries in Central America in logarithmic terms by using the coefficients estimated in the first set of regressions. The ratio of observed/projected exports permits to evaluate the closeness of each country to its own exports potential, on average, with respect to the entire Central America region and to a specific commercial partner within the region. The closer the observed/projected ratio is to one, the closer the given country to its export potential.

Results are calculated for: (i) overall exports in value terms; (ii) Grain exports in value terms; (iii) Grain exports in volume terms; (iv) Steel exports in value terms; (v) Steel exports in volume terms; (vi) Processed Fruit & Vegetable (i.e. ‘Food’) exports in value terms; and (vii) Processed Fruit & Vegetable exports in volume terms.

When projecting the potential increase in absolute intra-regional exports under three different scenarios—each of which represents a type of improvement in the region’s “trade performance”—the paper finds that intra-regional trade could be 33-percent higher if the effect of adjacency between each pair of the six Central American countries were to improve to the level of the region’s “best performer.” If, however, the improvement in adjacency performance was to the level of EU15, the potential increase would be as much as 55 percent. On the other hand, intra-regional exports would nearly double if Central America were to become fully “spatially integrated” - i.e., if all of its key infrastructure integration and efficiency indicators were to improve to the level of EU15 (Figure 16). The above projections are constrained in that it is assumed that the share of intra-regional exports in Central America’s combined GDP does not increase by more than 100 percent, given that also in EU15, the share of intra-regional exports in the region’s GDP over the past 30 years has increased by about that much.

Figure 16: Projected Percentage Increase in Overall Intra-Regional Trade in Central America

Source: World Bank calculations based on trade flows data from WITS, LCSSD Economics Unit (2010)

10 The increase resulting from improvements in “Adjacency Performance” under the two scenarios would be as much as 100 percent if also the efficiency of overland transport in Central America—as expressed in Time Equivalent Terms and captured by the variable “Distance”—were improved to the level of EU15.
5. Potential Extra-regional Exports from Central America

When considering not only Central America’s intra-regional exports but also exports to the U.S. and to EU27, the modeling results show the region’s countries as being much closer to the Expectations Frontier than in the case on intra-regional exports only. In fact, due to the behavior of some variables—such as Distance or Adjacency—being much more in accordance with what is expected based on the GMT theory (and with how they perform in the EU15 model), countries such as Costa Rica already now export as much (in value terms) as they would be expected to were they to perform like economies in the benchmark EU15 region.

The closeness of the region to the combined intra- and extra-regional trade Expectations Frontier is partly explained also by the fact that the benchmark coefficients for calculating the potential trade values and volumes are obtained from the expanded EU15 trade model which includes not only each EU15 country’s trade with the rest of EU15, but also with the twelve new Member States and the U.S. As explained previously—and illustrated in Figure 11—the results for the expanded EU sample, as opposed to the expanded Central America example, are further away from what would be expected from a highly-integrated region, especially in terms of the large negative impact of distance on export flows.

**Figure 17:** Closeness of Central America’s intra-regional exports and exports to EU27 and the U.S. (in value terms) to the Expectations Frontier

Source: World Bank calculations based on trade flows data from the WITS, LCSSD Economics Unit (2010)

The projection of potential percentage increase in Central America’s combined intra-regional exports and exports to the U.S. and EU27, similarly, reveals a lower potential for improvement than in the case of intra-regional exports only. Shown in Figure 18, based on the three different scenarios of improvement in export performance, the region as a whole could increase its total export value by between 5 and 29 percent (Figure 18), with improvements in “Adjacency Performance” projected to yield the highest marginal increase.
While in percentage terms the potential increase in the expanded intra- and extra-regional sample is lower than that projected for the intra-regional trade sample only, in absolute terms, the increase would be significant, as illustrated in Figure 19, constituting 53 percent of the current value of exports from Central America to the region itself, the U.S. and EU27.

The potential for growth in export *volumes* of the three separate goods, however, is similar to that observed for intra-regional trade only: based on the results produced by an unrestricted model, Grains exports could increase by at least 50 percent, depending on the degree of improvement in trade—especially Adjacency—performance, while those of Steel and Processed Fruit & Vegetables could grow by at least 45 and 25 percent, respectively.
6. Annexes

Annex 1: Detailed Representation of Results

Figure 1: Model results for the EU15 intraregional trade only

a. When Expressed in Value Terms

b. When Expressed in Volume Terms

Source: World Bank calculations based on trade flows data from the WITS, LCSSD Economics Unit (2010)

Figure 2: Model results for the CA intraregional trade only

a. When Expressed in Value Terms

b. When Expressed in Volume Terms

Source: World Bank calculations based on trade flows data from the WITS, LCSSD Economics Unit (2010)
**Figure 3**: EU15 regional exports and exports to the rest of EU27 and to the U.S.

*a. When Expressed in Value Terms*  
*b. When Expressed in Volume Terms*

Source: World Bank calculations based on trade flows data from the WITS, LCSSD Economics Unit (2010)

**Figure 4**: CA regional exports and exports to EU27 and to the U.S.

*a. When Expressed in Value Terms*  
*b. When Expressed in Volume Terms*

Source: World Bank calculations based on trade flows data from the WITS, LCSSD Economics Unit (2010)
Annex 2: Regression Results

### CA EXCLUDING USA&EU

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<th>GRAIN EXPORTS</th>
<th>VOL. GRAIN EXPORTS</th>
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* p<.1; ** p<.05; *** p<.01

### CA INCLUDING USA&EU

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* p<.1; ** p<.05; *** p<.01
Annex 3: Central America’s Extraregional Containerized Exports Destinations, 2007

Source: World Bank calculations based on trade flows data from the WITS, LCSSD Economics Unit (2010)
Annex 4: Projected Increase in Central America’s Exports under different scenarios

Figure 1: Projected Percentage Increase in Intra-Regional Trade in Central America

a. Grain Exports in Volume Terms

- Assuming Transport Efficiency in CA is improved to EU Level
- Assuming Transport Efficiency in CA remains at current levels

b. Steel Exports in Volume Terms

- Assuming Transport Efficiency in CA is improved to EU Level
- Assuming Transport Efficiency in CA remains at current levels

c. Processed Fruit & Vegetable Exports in Volume Terms

- Assuming Transport Efficiency in CA is improved to EU Level
- Assuming Transport Efficiency in CA remains at current levels

Source: World Bank calculations based on trade flows data from the WITS, LCSSD Economics Unit (2010)
Sources


World Integrated Trade Solutions database.