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Logistics in Central America

The Path to Competitiveness

Summary Document

Economics Unit, Sustainable Development Department

Central America Country Management Unit

Latin America and the Caribbean Region

The World Bank

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LATIN AMERICA AND THE CARIBBEAN REGION

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THE PATH TO COMPETITIVENESS

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- Optimal Path Analysis: Darwin Marcelo.
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Contents

Overview

This report is the synthesis of findings from a series of analyses designed to identify transport and logistics bottlenecks that add cost, time and uncertainty to the shipping of products within Central America and between Central America and outside markets. More general assessments of logistics performance often fail to guide policy-makers with specific information on, for example, the underlying causes of high transport costs, or the border activities and infrastructure conditions that generate delays and inefficiencies. Broad indicators do not provide clarity on exactly what poor performance *means* for exporters and producers in the region. Results of the analytical tools described in this summary document provide answers to such questions as: How does poor road quality affect the profit margins of a country's producers? What are the direct security costs for trucking companies? How much time do export processing procedures add to the shipment of goods? How and to what extent does this additional time hurt the competitiveness of key industries? And how fully are the ports of Central America using their existing assets?

From macro to micro, this set of analytical tools derives its conclusions from spatial analysis of regional level data on trade flows, to sector level surveys and diagnostics, down to the movement of individual products. These tools include the following:

- At the aggregate level, a growth model is used to estimate and contrast the elasticity of growth to infrastructure investment at the country level.
- Indices of infrastructure development provide insight into where each country stands relative to its neighbors and to Central America as a whole.
- At the sector level, surveys were developed and administered to explore bottlenecks in port efficiency and trucking services. Benchmarking of ports across the region in terms of their asset utilization was undertaken through Stochastic Frontier Analyses.
- After the consolidation of country-level maps into a unique unified Central American road map, the Optimal Path Analysis illustrates how five friction factors affect total travel times and, in some cases, the least-cost route for cargo on main transport routes to Atlantic ports.
- At the product level, eight supply chain analyses follow agricultural exports from farm gates to ports, identifying product-specific bottlenecks and calculating a structure of logistics expenses.

By no means exhaustive, this report provides a synopsis of these works and integrates their main findings. General conclusions are presented together with supporting evidence from the works' results. Corresponding policy recommendations are then offered, organized into three categories: infrastructure, services, and institutions and regulation. Conclusions and recommendations are based on findings across different levels of analysis, and may serve to guide policy decision-making for relevant trade and transport ministries in Central America, as well as internal audience within the World Bank.

The immediate objective of this report is to help identify the strengths and weaknesses of the logistics structures and services in the countries of Central America. The larger goal is to assist the region's decision-makers to:

- recognize and prioritize their comparative challenges in improving logistics; and
- Improve weaknesses by learning from regional best practices and through regional cooperation.

Following a brief executive summary, conclusions are organized according to their segment or role in the universal supply chain:

(i) from the farm to the distribution center or principal market;
(ii) principal transport corridors and services, including urban areas;
(iii) public sector involvement, including investment levels and export procedures:
(iv) border management; and
(v) port assets and operations.

Executive Summary

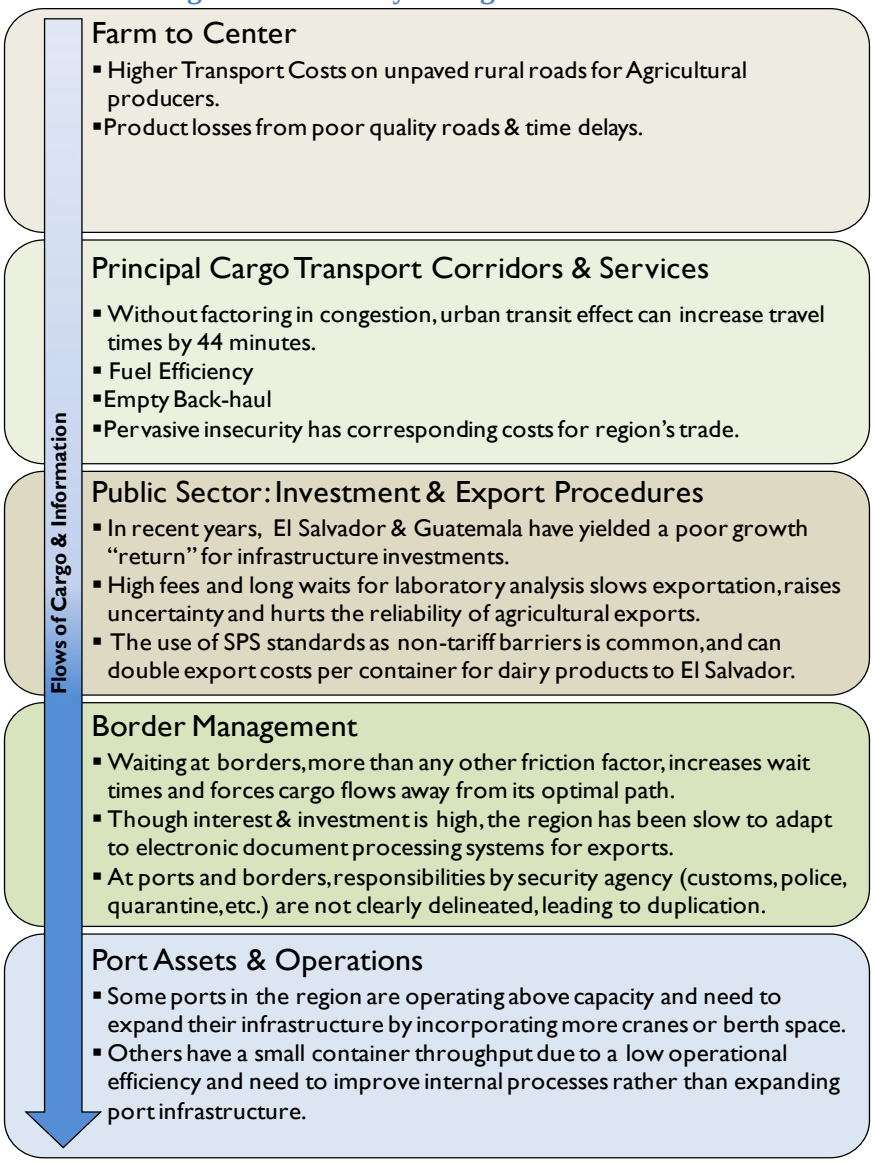
The aggregate effect of logistics bottlenecks can more than double optimum logistics costs for both high and low value goods, depending on the scale of production and the transport route. For beef exports from Nicaragua, total logistics costs also doubled when costs arising from increased transportation time are included, from 11% to about 21% of the wholesale price in the U.S. Logistics costs for large tomato exporters in Costa Rica, including ground transport, handling and custom fees are estimated at around $0.15 per kilogram, while waiting times at the Peñas Blancas border crossing between Costa Rica and Nicaragua double the logistics costs by adding an additional $0.14 per kilogram in hidden costs through losses of this extremely perishable product.

Of the logistics bottlenecks identified in these analyses, this report concludes that poor border management and infrastructure are the greatest causes of delays, inflicting the most detrimental impact on costs, times and timeliness for the region's exporters, particularly for shippers of perishable and time-sensitive goods. Standardized and regular data collection, the application and monitoring of risk management systems, improvement of border infrastructure, and the harmonization of customs and SPS standards should all be priorities for the region's logistics agenda. Another pervasive yet difficult-to-address time-drain on cargo movement is the poor quality of rural roads in the region; small producers, who often have limited access to all-season roads, bear the brunt of this bottleneck in high transport costs and product losses from the farm gate to the distribution center or market.

In many cases, policy and investment decisions that address border wait times and urban congestion would reduce transport times and costs more than improvements to primary and secondary road quality. The Optimal Path analysis shows that exports from countries without direct access to an Atlantic port face wait times that can almost double total time spent in transit. However, relatively low utilization of port assets—twinned with expansion plans that are underway at the Atlantic ports of Honduras and Costa Rica—raise doubts about the need for new Atlantic ports.

Capital cities without easy bypassing routes account for approximately 12 percent of overall transit time, for the two optimal path routes that pass through the urban municipal areas of Guatemala City and Panama City. Depending on the cargo flows and the products that cross frontiers, reducing border wait times by just one hour, or adding a true bypass around capital cities could have a profound effect on transport times, and indirectly on logistics costs.

Figure 1: Summary of Logistics Bottlenecks



In summarizing the country-level comparisons, Panama appears to be a regional benchmark, with important remaining challenges related to urban congestion. Guatemala and Honduras are the most burdened with a range of severe logistics bottlenecks. Despite the reliance on neighbors for Pacific coast gateways, El Salvador and Nicaragua perform slightly better--and appear better endowed with the technical capacity in the public sector--to address logistics challenges. Costa Rica's overall logistics performance appears slightly better than most of the region, especially in terms of the softer aspects, such as technology adoption and SPS standards and procedures. Still, its notoriously poor road infrastructure and slow and inconsistent adaptation of electronic document processing widens the gap with Panama.

Farm to Distribution Center: the First Transport Segment

The poor quality of rural roads means high transport costs particularly for producers of time-sensitive agricultural products such as pineapples, tomatoes, dairy products, cattle and beef. For the tomato export chain, the largest transport cost components correspond to the short freight segment from the farm gate to the consolidation center, and from the distribution center to the final market. For Costa Rican pineapples, transport costs for the short 40 km trip from the farm gate to the packing plant may cost anywhere from $120 to $280, while the long freight from the packing plant to Puerto Limón (220km) costs $600. Factoring in the different vehicle capacities for each transport leg, on a cost per kilo/kilometer basis, the short freight is more than 8 times higher. For cattle in Nicaragua, small producers pay $230 to transport their product a distance of 144 kilometers from their farms to the slaughterhouse, compared to $70 for large producers, because a third of the route is on an unpaved, tertiary road.

Time delays, particularly during the first transport segment can lead to major product losses for producers. For pineapple exports, rough rural roads and lack of cooling facilities also leads to product losses that are 50 percent greater on the short freight journey than on the rest of the journey from the distribution center on to Rotterdam. For cattle from Nicaragua, factoring in the increased distance and cost, expected loss of bodyweight and risk of injury, a small cattle rancher faces logistics costs of $0.32 per kg of body canal weight, as opposed to $0.15 for a larger producer with a farm close to the slaughterhouse in Juigalpa (Figure 2).

Figure 2: Logistics Expenses for Cattle Ranchers in Nicaragua

Logistics Expenses from the Farm Gate to the Slaughterhouse Nicaraguan Beef Export Chain		
Large Producer		**Small Producer**
35 paved km	Distance to Slaughterhouse	144 km, most unpaved
$4/animal	Transport Expenses	$14/animal
Low	Probability of Injury	High
>2.5%	Loss of Carcass Weight in Transit	<5%
About 30 hours	Total Time from Departure to Slaughter	Up to 3.5 days
US$2.84	Farmer's Received Price per kg of Meat on the Canal	US$2.76
US$0.15	**Total Logistics Burden per kg**	**US$0.32**

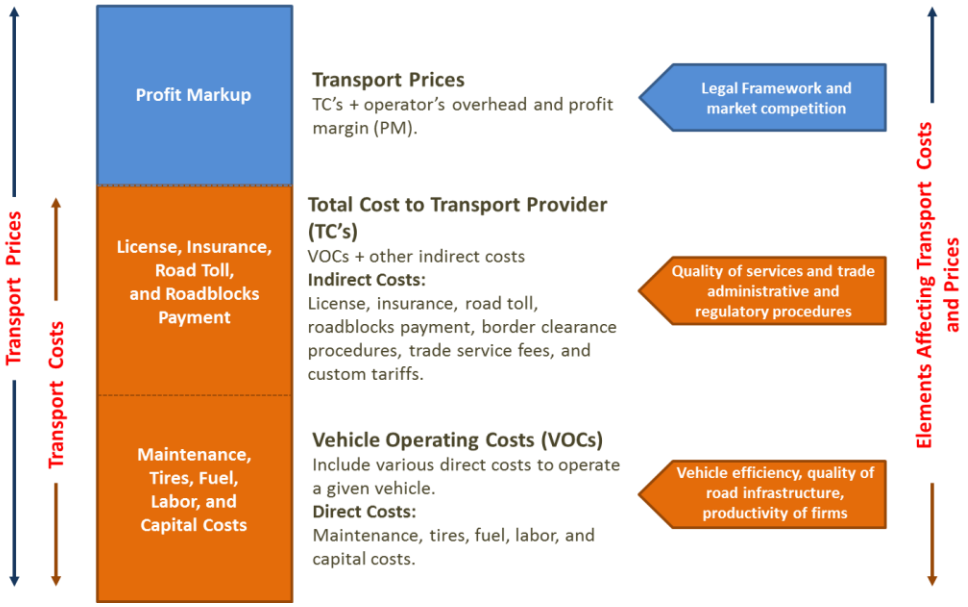
Source: Author's Own Calculations from Survey Responses

Before Honduras' dairy and meat exports leave the processing center, high fees and long waits for laboratory analysis required for the sanitary inspection certificate can slow delivery times and increase costs for exporters. In the case of beef, exporters reported a minimum of 5 days, an average of 8 days, and a maximum of 15 days to perform this process, from taking the sample to receiving the results. The costs for beef tests in Honduras are about a third higher than those of Costa Rica ($625), and 85 percent greater than those for Nicaragua ($540). Dairy test fees in Honduras are double than those in the other two countries. For small lots of dairy (less than one 42,000lb container), these costs represent 36 percent of total costs to export (see Annex 3 for detailed laboratory costs).

Transport Corridors and Trucking Services

Road freight transport from farm gate to final destination has a growing impact on the final cost of goods produced, thus influencing countries' competitiveness. Transport prices can be used to determine the competitiveness of the road freight transport sector, and are determined by the sum of three elements: (1) vehicle operating costs (VOC's); (2) other indirect costs – usually referring to costs to transport provider (TC's) – such as licenses and road tolls; and (3) the operator's profit margin (Figure 3).

Figure 3: Elements Affecting Transport Costs and Prices

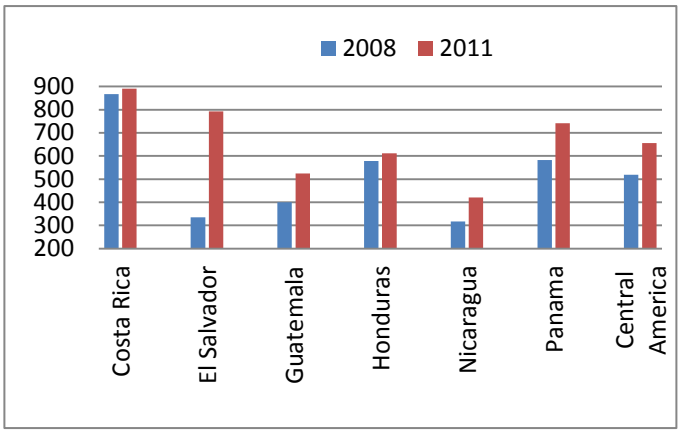


Source: Elaborated from Teravaninthorn and Raballand, 2008 and Hansen and Annovazzi-Jakab, 2008

As a result of increased crime and violence in Central America in recent years, trucking companies have seen a rise in security costs. The direct cost of security measures alone represent about 3 to 4 percent of their total operating costs. This does not include the cost of lost backhaul from the immediate "retreat" of trucks after delivery; the costs of avoiding night transport; the hidden costs of waiting for sufficient numbers of vehicles to form convoys; or, most insidiously, the lost opportunity of sales due to the unwillingness of purchasing firms and agents to work in dangerous countries. In terms of direct measures, trucking companies have attempted to adapt to the new security threats by implementing a number of techniques to secure cargo, such as by using enhanced vehicle tracking devices, hiring additional security guards on premises, and providing armed escorts to trucks. Consequently, average security costs over the past three years have increased by around 25 percent, and are likely to increase further along with growing security issues (Figure 4).

Figure 4: Annual Direct Security Costs in 2008 and 2011 (US$ dollars)

From 2008 to 2011, security costs have increased throughout the region. The highest increase took place in El Salvador, where costs increased from US$335 per vehicle in 2008 to US$790 in 2011 (a 130% increase). In Guatemala, costs increased by 32%, while in Panama security costs increased by 27%. Overall, the region as a whole experienced an average increase in security costs of 25% for this time period.



Source: World Bank Central America Trucking Survey

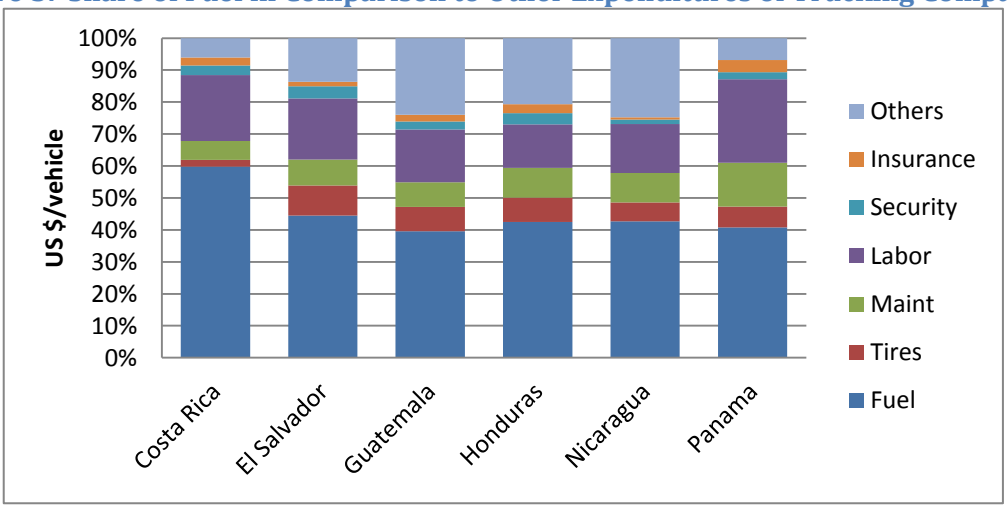
According to most truckers in the region, growing security costs are a significant obstacle to service provision.[1] In Nicaragua, on the other hand, truckers experienced the lowest security costs in the region and over 60 percent reported that security costs are not an obstacle to service provision. This is likely due to Nicaragua having some of the lowest crime rates in Central America.

Furthermore, evidence suggests that pervasive insecurity in Central America has corresponding costs for the region's trade and competitiveness. For instance, high-value meat and coffee exports must pay for a security patrol or armed guard to accompany containers in transit, particularly for vehicles traveling in or through Honduras. For small and large coffee exporters surveyed, the price of this security service ranged from $250 to $368 dollars per trip from production zone to port, equal to a third of overall transport costs, or half of ground transport service costs.

The survey also revealed that fuel costs are considerable for trucking companies, representing between 40 to 60 percent of total variable costs, compared to around 20 percent in the U.S. and Canada (Figure 5). In Nicaragua, the sector's operating costs has soared by rising diesel prices, while Costa Rica has the most expensive fuel in the region, with prices exceeding US$1 per liter[2].

[1] In Guatemala, for example, 100 percent of the survey respondents reported that security costs are an obstacle to service provision.
[2] The price of fuel in Nicaragua is approximately 9 percent more expensive than the average for Central America.

Figure 5: Share of Fuel in Comparison to Other Expenditures of Trucking Companies



Source: World Bank Central America Trucking Survey

Despite the high share of fuel prices as a percentage of total variable costs, measures related to fuel efficiency have yet to be deployed by most trucking firms in the region. The survey found that only 34 percent of companies claimed to be engaged in fuel efficiency practices. In addition, there are notable differences among countries in this regard. While around 30 percent of companies in El Salvador and Guatemala claim to be using tire and wheel technologies (such as aluminum rims, automatic tire inflation, external signal, booster, and low rolling resistance tires) to improve truck's fuel efficiency, the figure in Nicaragua is only 6 percent.

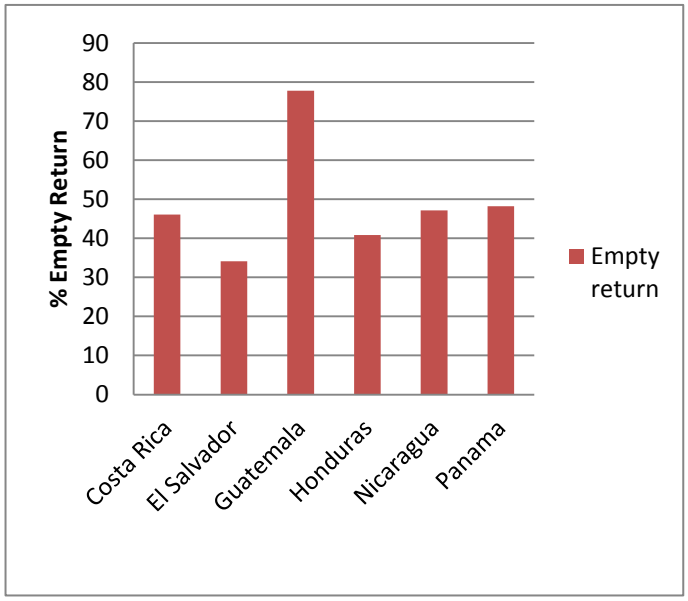
Given the large share of fuel prices as a percentage of total transportation costs, promoting fuel efficiency in the region, perhaps through private-public initiatives, can significantly reduce transportation costs as well as CO2 emissions. Furthermore, it appears that the required investment for truck companies if they would deploy fuel efficient technologies is not an obstacle. A World Bank study estimates that the one-time cost per vehicle to increase fuel efficiency is USD$3,200, while the annual benefits are $2,800. This translates into truckers having a positive return to investment after only 1.1 years.

A large share of cargo trips in the region return with empty backhauls, resulting in prices for one leg of the trip that cover the costs of empty return trips. In general, about 60 percent of the cargo is allocated through direct contracts with shippers and cargo owners, while independent agencies' deliver 30 percent of the cargo. The main reason for empty returns appears to be the lack of opportunities for most truckers to obtain cargo for return trip due to the lack of coordination mechanisms that match supply and demand. In addition, truckers point out to long waiting time at border crossings as a discouraging factor when considering to fill their return trip. Thus it appears that empty backhauls is a combination of both market and government inefficiencies.

Backhaul practices are pivotal in explaining differences in prices, as truck companies compensate for their expenses of the empty backhaul by charging higher prices in the first leg of the trip. Empty backhauls are particularly high in Guatemala, where 77 percent of truck trips are returning empty.

Empty backhauls affect firms of all sizes. In Costa Rica, El Salvador, Guatemala and Panama, large firms present the highest empty backhaul percentage; while in Nicaragua and Honduras, it is small firms that suffer most from this imbalance of trade.

Figure 6: Regional Comparison of Empty Backhauls



Source: World Bank Central America Trucking Survey

Without accounting for urban congestion, speed reductions in the municipals of Central America's capital cities are a primary factor in slowing cargo movement. For example, all goods traveling to an Atlantic port from the western production regions of Guatemala must pass through Guatemala City, which does not have a good bypass. For the optimal route from Chimaltenango, urban transit speeds add approximately 30 minutes, equivalent to 11.4 percent of total transit time. Similarly, goods traveling from Boquete must cross the Panama Canal using the Bridge of the Americas. Slow transit speeds going through Panama City add 44 minutes, equivalent to 12.3 percent of overall travel time – the highest urban transit effect in the region.

Figure 7: Transport & Security Costs for Honduras Coffee Exports

Organic Coffee	#1		#2**		#3**	
Kilometers to Puerto Cortés	276		200		300	
Ground Transport: Cooperative to Puerto Cortés*	$ 578.40	61%	$ 536.00	67%	$ 736.84	67%
Security: Cooperative to Puerto Cortés	$ 368.40	39%	$ 263.16	33%	$ 368.42	33%
Total	$ 946.80		$ 799.16		$1,105.26	

**Includes 2 ground transport legs: 1) Cooperative to San Pedro Sula 14 ft. container with 294 quintales 2) S.P.S. to Puerto Cortés in a 20 ft. container with 420 100lb quintals. To compare costs, a per quintal cost for the 1st leg was estimated and then applied to a total of 420, rather than 294. This method is close but imperfect, because coffee weight changes after drying.*

***Assuming one 20 ft. container shipment with 420 100lb quintals.*

Crossing the Line: Border-related Bottlenecks

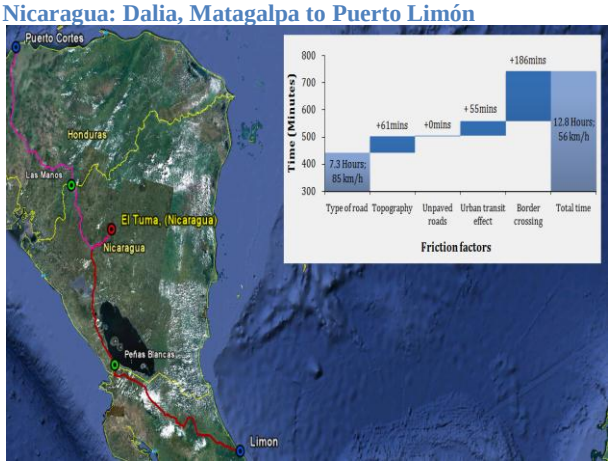
Border crossings are inherently complex, involving constant interplay between physical infrastructure, logistics services needs and government agencies procedures. A range of actors, including drivers, customs brokers, health inspectors and police officers, have both competing and complementary responsibilities that require concerted coordination in order for goods and passengers to travel quickly and safely across country lines. Effects of border bottlenecks include additional costs for exporters including fuel costs to maintain containers refrigerated, waiting time costs for truck drivers, and costs associated with inventory management, delayed distribution, and reduced shelf time of the product.

Delays at the border can be attributed to a long list of service and infrastructure factors, including the following: (i) lack of technical skills and corruption of customs agents and personnel; (ii) poor or nonexistent risk management systems, leading to duplicate inspections or 80 to 100% cargo inspection rates; (iii) limited coordination of multiple border protection agencies; (iv) underuse or erratic functioning of electronic information management systems; and (v) poor spatial layout, making it difficult to select and isolate trucks for inspection.

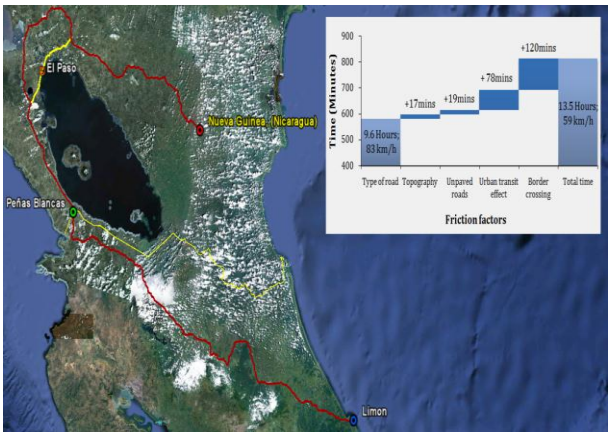
More than any other studied friction factor, border crossings often add time and distort optimal cargo flows in the region. Of the primary friction factors analyzed in the optimal path analysis, border crossings introduced the greatest delays into travel times, and, in two cases, distorted the flow of cargo towards a different port, or along a different route. For example, the two Nicaragua routes studied show that border crossings increases the total travel time by 120 minutes from Nueva Guinea and 186 minutes from Matagalpa to Puerto Limón, equivalent to approximately 50 percent and 30 percent of respective travel times (Figure 8). For the Matagalpa route, long delays at border crossings with Honduras (4 hours crossing time instead of 2 hours at border crossing with Costa Rica) actually change the flow of cargo away from what would otherwise be the shortest and fastest route through Puerto Cortés in Honduras; instead, the optimal route is 67 km longer, and travels down through Costa Rica to Puerto Limón.

Figure 8. Optimal Path: Additional Time by Friction Factor[3]

Nicaragua: Dalia, Matagalpa to Puerto Limón



Nicaragua: Nueva Guinea to Puerto Limón



[3] Quality of roads penalized unpaved primary and secondary roads by increasing the time it takes to cross each 100 meter square. Where the effect is 0, none of the primary and secondary roads along the route are unpaved.

Source: Optimal Path Analysis, Economics Unit, LCSSD World Bank (2012). Border crossing times provided by Apex Logistics [a trucking Services Company from Honduras]. Note that the Border Crossing time from Matagalpa to Puerto Limón (186 minutes) includes the border crossing time (120 minutes) plus the detour (66 minutes) due to the new, longer route (690 km) to Puerto Limón (in red) rather than to Cortez (622 km) in pink. Below is a description of friction factors calculated by the Optimal Path:

- **Type of Road:** Takes into account the time it takes to travel a certain number of kilometers based on the design speed, which is determined by type of road (primary, secondary, and tertiary).
- **Topography:** Takes into account the time it takes to travel a certain number of kilometers based on the topography or terrain slope.
- **Unpaved Roads:** Accounts for additional time added on to the optimal path due to unpaved primary and secondary roads.
- **Urban Transit Effect:** Accounts for the additional time needed to transport cargo through municipal regions of capital cities, where the permitted road speeds never exceed 50 km/hr.
- **Border Crossing:** Accounts for the time it takes, on average, to cross a border.

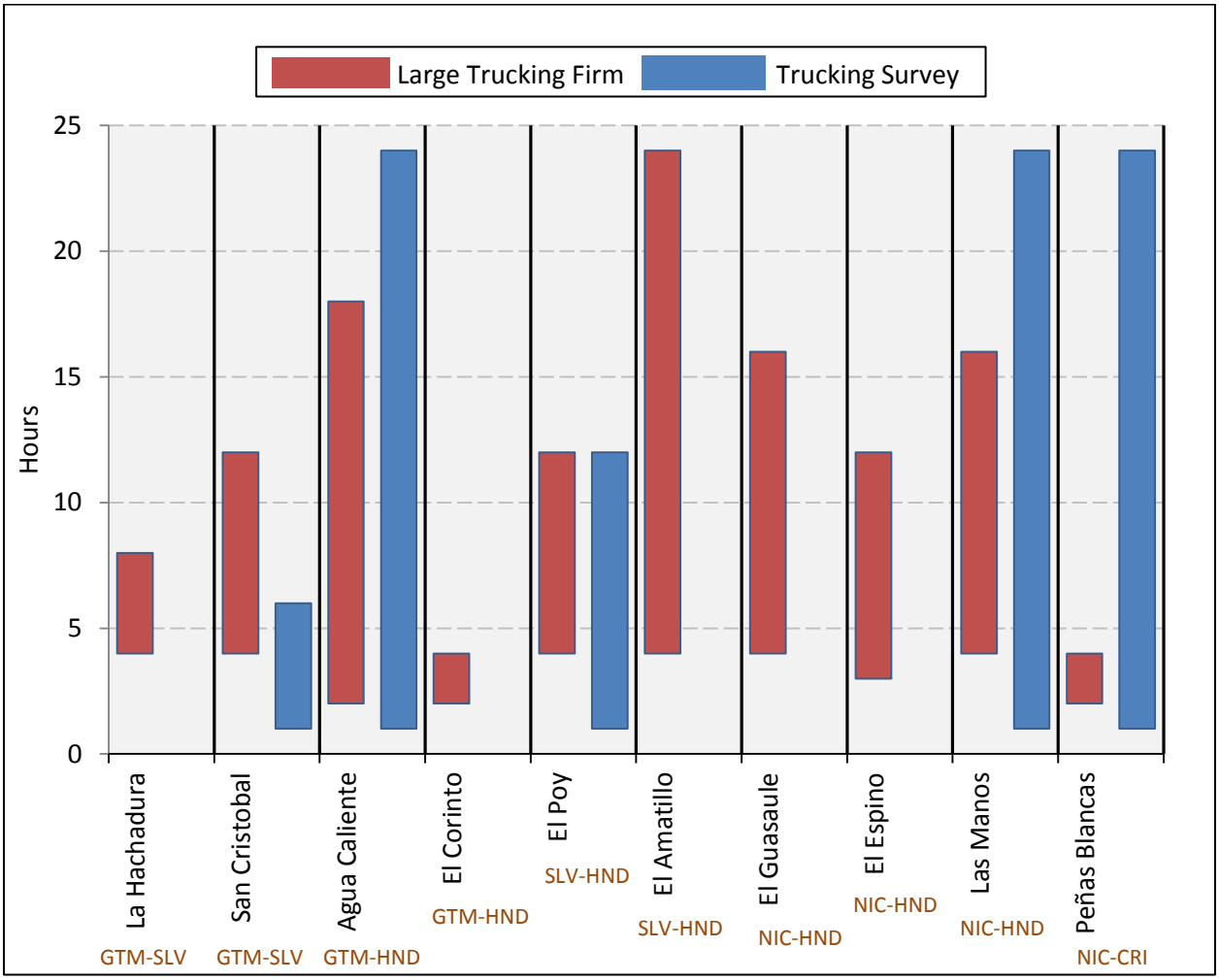
The Optimal Path Analysis does not attempt to measure the real travel time; it only focuses on the specific friction factors indicated. For instance, it does not account for heavy traffic or for stops made by truck drivers to rest and eat. In reality, the time it takes truck drivers to travel from Matagalpa to Puerto Limón is around 44 hours and from Nueva Guinea to Puerto Limón about 55 hours (around 30 and 44 hours longer than the Optimal Path calculation respectively). In addition, the Optimal Path calculates the minimum time it takes to cross a border (based on available data) rather than maximum or average times. Finally, the Optimal Path calculation does not include the transport segment from farms to consolidation or distribution centers, which can add significant time and costs to producers given that roads are typically unpaved and in worse condition, slowing the travel time. Supply Chain Analyses can help shed light on the costs involved with the first segment of transport (from farm to consolidation center). For instance, in the case of the transport of cattle from the farm gate to the slaughterhouse in Nueva Guinea (Nicaragua), farmers have to travel an additional 35 (large producers) to 144 (small producers) kilometers, typically on poor quality roads which can significantly increase transport time expenses.

At the four border crossings studies for these supply chain analyses[4], poor technical capacity, out-dated paper document processing, inconsistencies in the application of export laws, regulations and practices, as well as inadequate infrastructure converge in an environment of insecurity to create a nexus of delays and confusion. According to supply chain interviewees, within the region, border crossings with Honduras produce the longest unexpected delays, with recent recording crossing times reaching up to two days for the El Amatillo border with El Salvador.

There is high variation of border crossing times across Central America, which illustrates that border services are not consistent amongst the different countries in the region. For example, at the border crossings Peñas Blancas (NIN-CRI), Las Manos (NIC-HND) and Agua Caliente (GTM-HND), trucks reported that the time it takes them to cross the border is anywhere between 1 to 24 hours (Figure 9). The high degree of variation of border crossing times can be a result of differences in the application of regulations in the different countries, efficiency of the customs and immigrations authorities, poor border infrastructure, and border congestion. Figure 9 presents recent data of border crossing times across the region. It includes data from two sources: the first source (red bars) is Apex logistics, a large trucking firm based in Honduras that offers freight transport services across the region, while the second source (blue bars) is a World Bank trucking survey, which surveyed trucking firms of different sizes across Central America.

[4]El Amatillo, El Guasaule, Las Manos and Peñas Blancas.

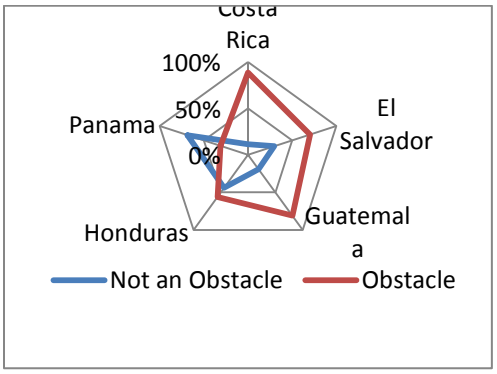
Figure 9: Border Crossing Times (Average Min' and Max' Times), September 2011- March 2012



Sources: Trucking Services Survey, Economics Unit, LCSSD World Bank (2012). The Trucking Survey took place between September 2011 and March 2012. The data is based on 15 to 20 observations per border (of different truck companies of different fleet sizes travelling across the region).
The Large trucking firm is Apex Logistics, a freight (trucking) logistics company based in Honduras. Their data is based on 80 to 100 observations per border crossing between January and March 2012.

In addition, trucking companies throughout the region (with the exception of Panama) report that customs and immigration procedures, and excessive document control are obstacles to efficient service provision.

Figure 10: Perception on Poor Infrastructure at Border Crossing



Source: World Bank Central Trucking Survey

Moreover, all routes have high idle times (or waiting times), frequently reaching more than 40% of total transport time. In routes like San Salvador – San Jose, the Idle time can reach 167 hours representing 69% of the Total Time. Idle times can be explained by issues including: (a) arrival times at the borders, (b) mandatory recovery periods, (c) restrictions on traveling times (i.e. arrival and exit to/from metropolitan areas[5]), and (d) inability to travel late at night due to lack of security.

As a port of exit, some administrative bottlenecks at Puerto Cortés in Honduras are similar to those experiences at the region's borders. Delays are generated by entrance congestion, slow export procedures and poor coordination of border authorities. Normal experiences involve backlogs of paperwork, duplicated procedures and additional costs and fees. There is one SENASA[6] employee to manage, stamp and sign the export permit for every container of agricultural exports.[7] Customs brokers routinely arrive with documentation for 30 to 50 containers at a time, and this signing process can take several hours, or even an entire day.[8]

The misuse of SPS measures as non-tariff barriers was reported throughout the region, primarily for intraregional exports.[9] Research suggests that these SPS measures have negatively impacted intraregional trade volumes, particularly for common exports within the region, such as beef and dairy (Díaz, 2006). Exporters reported that intraregional agricultural exports are arbitrarily expected to adhere to phyto- and zoosanitary standards that are unreasonable and in excess of what is required to export to the U.S. This unnecessarily increases the cost of compliance for exporters, and may complicate firm-level strategies to plan for tightening international trade standards, and particularly new demands for traceability for major beef and dairy importers. Related border wait times, expenses and product losses are primarily a problem for beef and dairy imports into El Salvador from Nicaragua and Honduras, and for beef exports from Nicaragua to Guatemala. According to one Honduran dairy exporter, every time a refrigerated container of dairy products undergoes a duplicate inspection at the El Salvador border, logistics expenses may increase by up to $900, and the time in transit from 2 to 9 days.

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[5] Ciudad de Guatemala and San Jose in Costa Rica have placed restrictions on the times that trucks can enter/exit the city. These restrictions are a result of local efforts to reduce travel times during high congestion peak hours.

[6] In reality, this is an official for the *Servicio de Proteccion Agropecuaria*/Agricultural Protection Service (SEPA). SEPA is a subdivision of SENASA that handles border inspection and quarantine.

[7] This is a requirement for all containers shipped to the United States.

[8] Even without the documentation signed, the container may be loaded and travel on to its destination. However, at the port of destination, the cargo will not be allowed to leave the port until the proper documentation has been received.

[9] SPS measures are taken to ensure that goods entering a country are safe for consumers, and that exported products are free of contaminants and abide by The Codex Alimentarius Commission (the international framework for food safety, operated by the FAO and WHO). SPS procedures include documentation, sampling, testing, and fumigation (and sometimes treatment and/ or quarantine).

The Council of Regional Trade Ministers (COMIECO) receives and handles allegations of discrimination for trade within Central America. Of twenty cases presented to COMIECO from 2003 to 2012, seven were related to dairy exports, and five to beef. Nicaragua registered the highest number of reported cases, while El Salvador was the most frequent respondent. As evidenced by the failure of Honduras to officially report its allegations against El Salvador for measures to impede dairy imports, the list of reported cases does not necessarily reflect the totality of intraregional trade disputes.

Ports, Roads and Logistics Infrastructure Indicators

Infrastructure stock and quality are persistent bottlenecks to attain a sustainable growth path in Central America. In spite of the different levels of development, countries in the region struggle with infrastructure shortcomings. In regard to transport and logistics infrastructure, improvements during the last decade are noticeable, but reducing the gap with respect to more developed nations still requires an additional significant amount of strategic planning and efficient investment.

The Central American region has 12 relatively large container ports on the Atlantic and Pacific coasts. Out of these, four are in Panama, three in Guatemala, two in Costa Rica and only one in each of the remaining countries[10]. Due to the region's strategic location, which has an easy access to the main international maritime routes, and to the significant growth of containerization in recent years, an improvement in operational efficiency and infrastructure has become a priority in face of an increasingly higher demand for maritime shipping and thus port services.

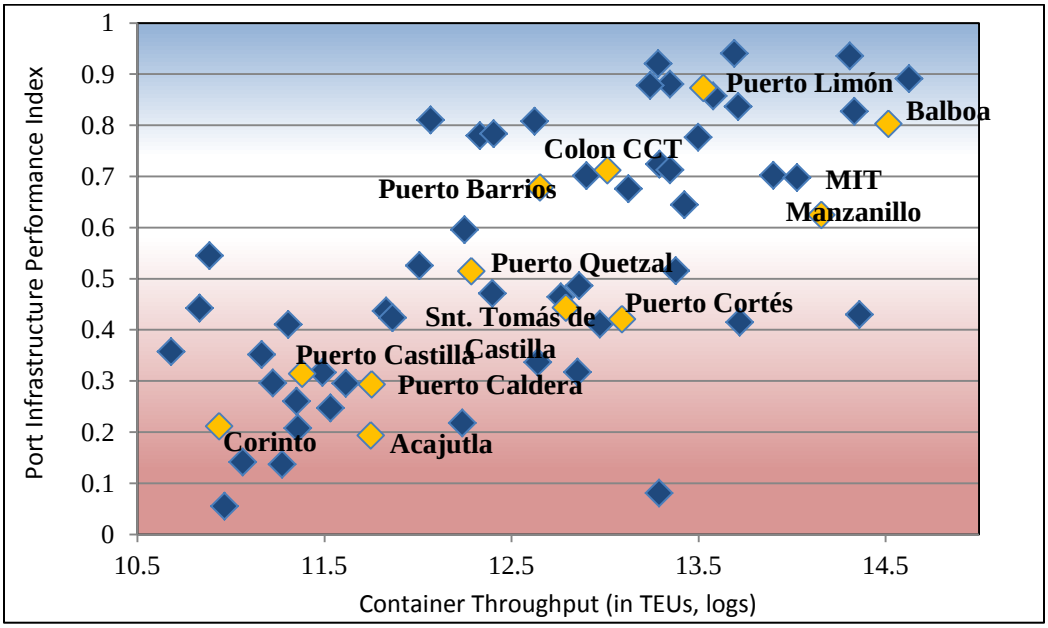
Many of the region's container ports must improve operational efficiency in order to attract larger cargo volumes, while others should consider expanding their infrastructure stock. In Central America, the overall infrastructure performance index resulting from the Stochastic Frontier Analysis (SFA) estimation has increased in recent years, showing that the gap between actual and potential throughput is diminishing. Nevertheless, important differences –and priorities– can be found among the ports in the region. Figure 11 identifies, in the blue area, the ports that will soon reach (or have already reached) their physical capacity, and therefore would need an infrastructure expansion. In turn, the ports in the red area are likely to be underutilizing their stock of assets, and therefore would need to improve their operational efficiency in order to increase throughput.

Ports in the region should have different priorities, such as increasing capacity or improving operational efficiency given their current infrastructure. Of the region's main container ports, the analysis suggests that Puerto Limón-Moin in Costa Rica, in particular, needs to expand its physical capacity either by increasing the number of container cranes or the length of the container berths. And indeed a new container terminal is currently being constructed at Limón-Moin. On the other hand, many principal ports, including Puerto Corinto-NIC, Puerto Acajutla-SLV and Puerto Cortés-HON, according to the results, are underutilizing their present infrastructure endowment and would benefit from improved operational efficiency; in other words, there is room to scale up operations through performance improvements. For Honduras, Puerto Castilla is farther from reaching its potential than Puerto Cortes, but both could take better advantage of their assets in their operations. The same happens with Puerto Caldera-CRI that has a low efficiency index.

[10] Considers ports with an annual throughput over 50,000 TEUS. Those ports are, from the largest to the smallest in 2010, PPC Balboa (PAN), MIT Manzanillo (PAN), Limón (CRI), PPC Cristóbal (PAN), Cortés (HND), Colón CCT (PAN), Santo Tomás de Castilla (GUA), Barrios (Guatemala), Quetzal (GUA), Caldera (CRI), Acajutla (SLV), Corinto (NIC).

Still, these ports may also be in need of infrastructure improvements, particularly with regards to maintenance and rehabilitation or updating of machinery, in addition to improved efficiency. For example, though Puerto Cortés does not fall into the range of ports that are operating at capacity, interviews with port operators, customs brokers and shipping agencies from the SCAs found that the patios and docks at Cortés had been badly damaged by a strong earthquake in 2009, and never repaired.

Figure 11: Results from the SFA: Port Infrastructure Performance



Source: Port Stochastic Frontier Analysis, LCSSD Economics Unit, World Bank (2012)

Ports that fall between the blue and red areas are in an intermediary situation with regards to capacity and operational efficiency. According to the estimations and in terms of physical inputs, Puerto Barrios-GUA, Colon CCT-PAN and MIT Manzanillo-PAN are not in urgent need of improvements in terms of number of cranes or berth space. In turn, Puerto Balboa in Panama appears to be reaching its current potential output due to a steady increase in port demand.

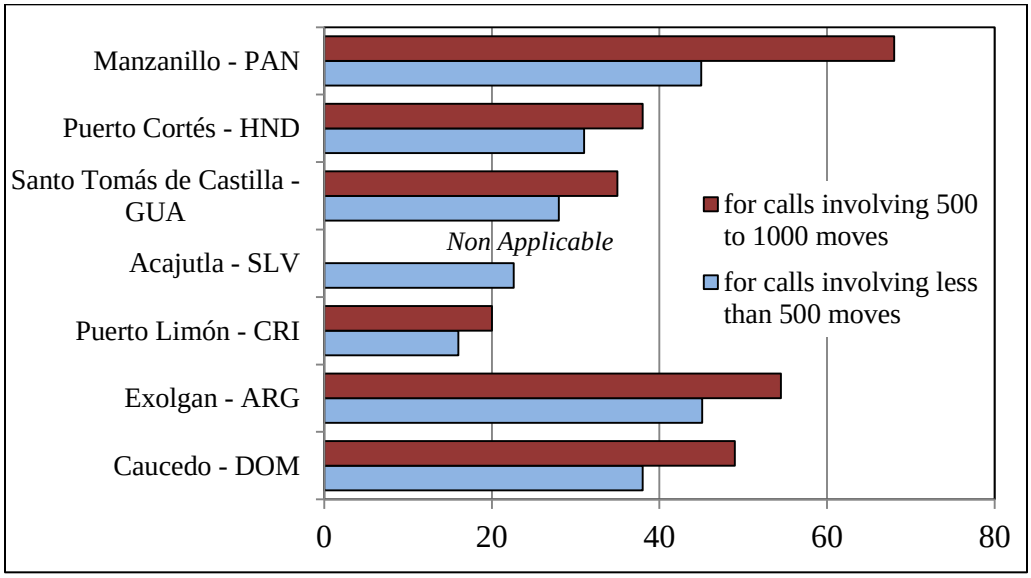
The absence or scarcity of container cranes and other equipment hinders port performance. Results from the SFA show that the gains in productivity from the use of ship-to-shore container cranes are the largest. Excluding Panama, there are only four container cranes in the other five countries combined, thus creating a big dependence on the less efficient ships' gear. Ports Corinto, Acajutla and Limón are known for having limited cranes available, leading to a slower container movement and thus contributing to higher ship delays. Actually, the two latter ports have estimated ship delay times[11] of 5 and 18 hours, respectively, much higher than the region's average, according to Kent (2011).

Alternative metrics of port performance confirm the poor overall performance uncovered in the SFA analysis. Ship productivity based on the number of moves per hour during a vessel's net berth time provides an indication of time efficiency. According to the results, all of Central America's non-

[11] The additional time that ships must wait to come to berth, beyond their scheduled arrival time.

transshipment ports perform poorly compared to two regional benchmarks, Exolgan in Argentina and Caucedo in the Dominican Republic. Puerto Limón has the lowest performance in Central America while Panama's Manzanillo leads in terms of ship productivity (Figure 12). Panama's productivity increases substantially with the number of moves per call, reflecting its efficiency in handling large vessels. Puerto Cortés demonstrates the second best productivity among the sampled ports in region, followed by the ports in Guatemala, El Salvador and Costa Rica. This metric shows that Puerto Limón in Costa Rica is the only one that is not within international acceptable standards of ship productivity, which, according to the SFA analysis, is in part due to the limitations of its infrastructure and equipment.

Figure 12: Ship Productivity (Average Ship Mover per Hour)



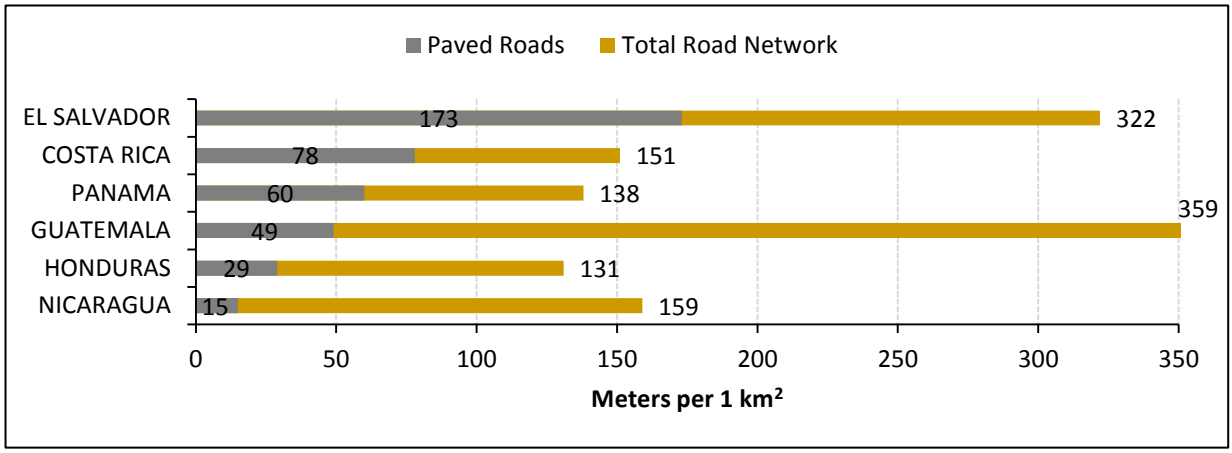
Some also claim that poor technical capacity of port operators is to blame for inefficiency. Fruit and vegetable shippers in Nicaragua, for instance, reported an accident, in which a gantry crane dropped a container, badly damaging cargo and equipment. Delays leading to missed boats are passed on by the shipping companies to the exporters in late charges normally around $125 to $150 per day.

With regards to ground transportation infrastructure, existing studies raise concern about the quality of Central American roads. In the World Competitiveness Index, executives from the six countries in Central America ranked, on average, the quality of roads as inferior to the quality of airports, ports and electricity supply in the region. On a scale from 1 to 7, the region's average score for the quality of roads was only 3.7 in 2011. Comparing with the different infrastructure components assessed in the same survey, the road sector was the poorest ranked in Panama, Guatemala and Honduras. Even so, the lowest overall score in roads was given to Costa Rica. El Salvador had the highest marks, but still below its air transportation or electricity supply assessment. From 2008 to 2011, executive ratings of road quality have slightly increased in Nicaragua and Panama, decreased in Honduras, El Salvador and Guatemala, and fluctuated in Costa Rica.

The density of the road network marks a big difference in infrastructure stock within the region. Considering only paved roads, El Salvador has the densest network in the region, with 173 meters of paved road per km^2, followed by Costa Rica. In these terms, Nicaragua is the region's poorest performer,

by having a paved road density almost 12 times smaller than the region's leader. Nevertheless, after accounting for unpaved roads, there is a surge in Guatemala and Nicaragua. In addition, the data indicates that only 9% of the roads in Nicaragua are paved, 14% in Guatemala and 22% in Honduras. In Panama, Costa Rica and El Salvador these same figures stand between 43-54% (Figure 13).

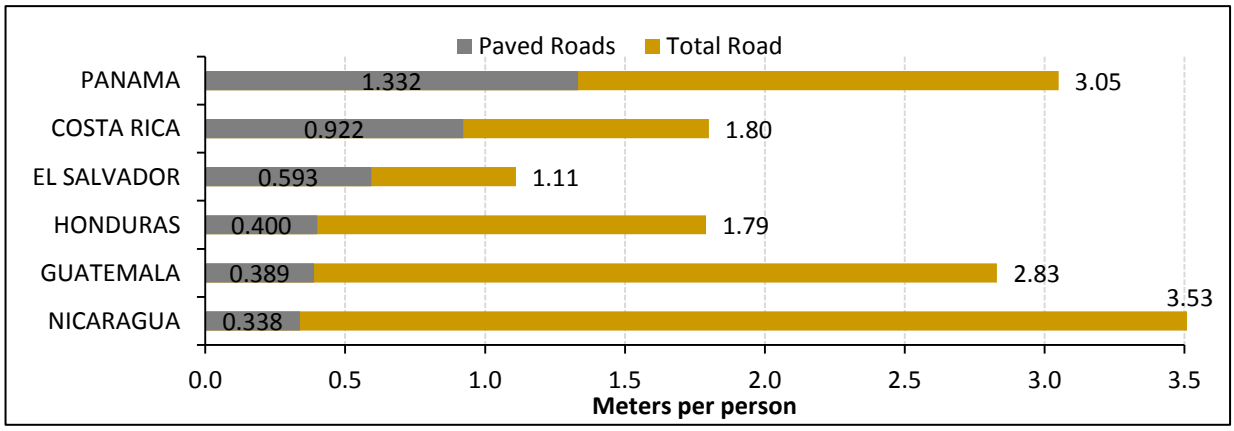
Figure 13: Road Network Density



Source: Authors' calculation based on data from Ministries of Transportation (2009-10 Data)

However, when accounting for population density, it appears that El Salvador has the shortest road network in the region, with 1.1 meters per person. Still, when examining the quality of roads, it has more paved roads per person than Honduras, Guatemala and Nicaragua. Nevertheless, it appears that availability of quality (or paved) roads is very limited throughout the region (Figure 14).

Figure 14: Road Density Relative to the Country's Population (Meters of Road per person per 1 km2)



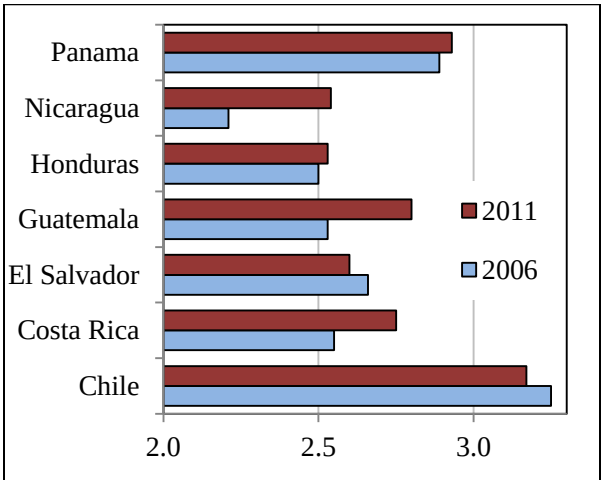
Source: Authors' calculation based on data from Ministries of Transportation (2009-10 Data)

Modest to sizeable improvements have been seen across Central America with regards to logistics performance. The World Bank's Logistics Performance Index, which reflects the perceptions of a country's logistics based on customs efficiency and quality of infrastructure, among other indicators, show that in 2011 Central American countries had overall scores between 2.5 and 3 out of a maximum of 5 points. In 2006, the same indicator ranged between 2.2 to 2.9 in the region. The results show

Panama as the top and Nicaragua as the poorest performer (Figure 15). Over time, the biggest improvements were seen in Nicaragua, Guatemala and Costa Rica. A more modest advance was seen in Panama and Honduras. On the other hand, El Salvador saw a decrease in the logistics performance index over the 5-year period. Using Chile as the region's benchmark, even Panama, which is known for having a good infrastructure for competitiveness, still lags behind.

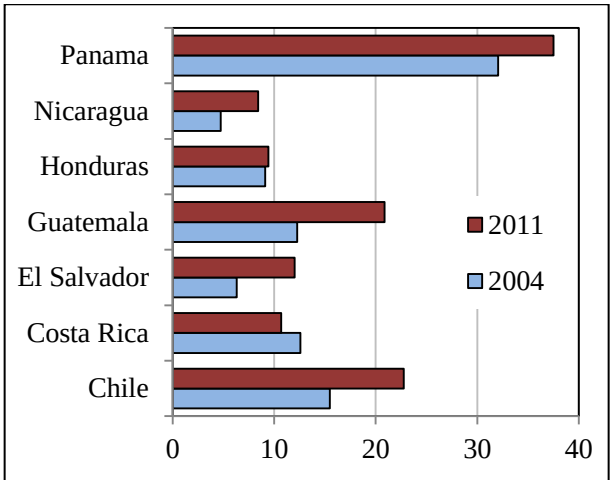
In terms of maritime logistics, Panama is the only highlight in the region. UNCTAD aggregates five different components of the maritime transport sector in the Liner Shipping Connectivity Index[12], capturing how well countries are connected to the global shipping networks (UNCTAD, 2010). Out of 100 points (the score of the world top performer), in 2011, Panama stands out with respect to other countries in the region with 38 points, even outperforming Chile in this index (Figure 16). Taking advantage of the externalities generated by the Panama Canal, the country's maritime services are more developed than in any other country in Latin America. In addition, this index in Panama has averaged a 2.3 percent annual growth between 2004 and 2011. However, the difference in Panama's performance in the LPI vis-à-vis the Liner Shipping Index suggests that the country has not yet fully leveraged its role as a regional transshipment center so as to improve the access of its own goods and service to market. The only country that saw a decrease in the liner shipping index during the same period was Costa Rica. Guatemala, on the other hand, is the country that has had the most significant improvement according to the UNCTAD indicator.

Figure 15: Logistics Performance Index



Source: Trade Logistics and Facilitation, World Bank.
* For Nicaragua, 2009 data is presented instead of 2011, due to the absence of data for 2011.

Figure 16: Liner Shipping Index



Source: UNCTAD

[12] The components of the Liner Shipping Index are: number of ships, their container-carrying capacity, maximum vessel size, number of services, and number of companies that deploy container ships in the ports of a country.

Key Findings & Recommendations

Results from these analyses point to several key priorities for Central America's logistics agenda, which can be divided into three areas: infrastructure, logistics services, and institutions and regulations.[13]

Infrastructure

1) Finding (Road Network): There are large infrastructural deficiencies in the secondary and tertiary road networks across the region, hindering trade and competitiveness. Poor quality of rural roads limits accessibility of farmers to market (above all during the rainy season) and increases transport times and costs, especially for producers of time-sensitive products. Time delays, particularly during the first transport segment from the farm gate to the consolidation center, can also lead to major product losses for producers. In the case of beef exports from Nicaragua to the U.S. (through Puerto Cortés in Honduras), for instance, for the first transport segment alone (transport of cattle from farm to slaughterhouse), poor quality of rural roads significantly reduces driving speeds which increases transportation times, as well as contributes to cattle injuries, deaths, and weight loss.[14] It is estimated that for this segment alone, these costs range from around 4 percent of the wholesale price in the best case scenario (usually for large cattle farms) to 9 percent in the worst case (usually for small cattle farms), directly impacting producer margins.

> **Recommendation:** Increase farmers' access to processing centers and markets by building, improving, and maintaining rural roads in strategic areas, with attention to cost-effective and sustainable alternatives to asphalt.

2) Finding (Logistics Facilities): Limited availability of refrigerated storage facilities, distribution or processing centers by production zones in rural areas delays the time it takes to transport products from farm to processing centers, leading to delays and product loss.[15] In the case of pineapple exports from Costa Rica to Europe, for example, rough rural roads and lack of cooling facilities leads to product losses that are 50 percent greater on the short freight trip in the first transport segment (farm to distribution center), than from the rest of the journey from the distribution center in Costa Rica to the port of Rotterdam in the Netherlands.

> **Recommendation:** Shorten the distance between farms and refrigerated storage facilities, distribution or processing centers by facilitating and providing incentives for the construction of small storage centers in rural production zones.

3) Finding (Ports): Ports in the region can be found in a heterogeneous state of evolution, with most still mired in outdated practices, yet to introduce private terminal operators who bring with them modern practices.[16] The Stochastic Frontier Analysis suggests, for instance, that Puerto Cortés in Honduras is

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[13] Logistics can be described as being composed of infrastructure, logistics services that support this infrastructure, and institutions and regulations that bind infrastructure and logistics services together.

[14] Farmers get paid per weight of the cattle once it arrives at the slaughterhouse.

[15] In addition, the lack of logistics facilities by production zones often means that large trucks have to go all the way to farms in order to pick up load, damaging roads that are not designed for these truck sizes.

[16] Such as electronic tracking of containers, links to global shipping networks, investments in labor-reducing and time-saving gantry cranes, transtainers and other modern cargo handling equipment.

underutilizing its present infrastructure endowment, and could benefit from improved operational efficiency.[17] Apart from low operational efficiencies, some container ports in the region suffer from insufficient infrastructure stock, limiting their operations. Puerto Limón-Moin in Costa Rica, in particular, needs to expand its physical capacity either by increasing the number of container cranes or the length of the container berths. Higher costs due to poor shipping services and inadequate port conditions are passed on to consumers and local producers.

> **Recommendation:** Ports management models throughout the region may be revisited and modernized, encouraging private sector investment and operations. This will help with optimal investments in the improvement of operational efficiency or expansion of infrastructure stock.

4) Finding (City Congestion): The lack of easy bypassing routes around the region's metropolitan areas significantly contributes to transit times and delays. For instance, for the two optimal path routes that pass through the urban municipal areas of Guatemala City and Panama City, the lack of easy bypassing routes account for approximately 12 percent of overall transit time.

> **Recommendation:** Further investigate the effects of the lack of city bypassing routes on transit times and costs, and make plans to construct bypassing routes or ring roads when it is estimated that the negative impact on the local economy from congestion outweighs the estimated construction and maintenance costs.

5) Finding (Extreme Weather): Roads and bridges in countries across the region are highly vulnerable to natural disasters,[18] often getting damaged and thus limit the access of rural areas to markets and create safety concerns, especially during the rainy season. In addition, repairing damaged roads and bridges not properly reinforced to withstand reoccurring natural disasters places a very heavy burden on authorities. For instance, the 1998 Hurricane Mitch caused massive damage to infrastructure across Central America. In Honduras alone, it is claimed to have destroyed over 70 percent of the transport infrastructure in the country. In El Salvador, the World Bank estimates that damages from the 2011 Tropical Depression 12E to the transport infrastructure alone totaled over $223 million.

> **Recommendation:** Consider disasters and the environment in road planning and design, and construct infrastructure that is likely to withstand extreme weather conditions typical in the area. Even in terms of costs, it probably makes more sense to emphasize properly enforced quality roads and bridges rather than volume, as spending a large share of limited resources on fixing damaged transport infrastructure every year is costly and unproductive. To increase effectiveness of limited maintenance resources, it is also imperative that transport authorities and maintenance agencies use appropriate technologies for road construction, such as concrete paving stones (*adoquines*), which is a much cheaper method than asphalt paved roads, as well as requires a much lesser maintenance burden.

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[17] Cortés may also be in need of infrastructure improvements, particularly with regards to maintenance and rehabilitation or updating of machinery. Interviews with port operators, customs brokers and shipping agencies found that the patios and docks at Cortés had been badly damaged by an earthquake in 2009, and never repaired.

[18] Countries in Central America are constantly exposed to a variety of natural disasters including floods, hurricanes, earthquakes, and landslides.

Logistics Services

1) Finding (Border Inspections): Risk management systems are only partially implemented in most border crossings in the region, as demonstrated by low detection rates and high percentage of physical and documentary inspections, often causing considerable delays in the clearance of imports. For instance, the World Bank's Customs Assessment Trade Toolkit (CATT) found that the Costa Rican customs agency has no integral customs risk management, either in manual operating or computerized operating systems,[19] leading to excessive physical inspections and low non-compliance detection.

> **Recommendation**: Complement risk profile systems with additional information to help assure fair selection of inspections, minimize opportunities for corruption and reduce the need for high percentage inspections. In addition, implement preclearance of low-risk perishable products prior to completion of laboratory tests to facilitate the inspection process. Finally, countries that are lagging behind others in the region would benefit from learning from best practices on ways to improve customs processes and other border procedures. For instance, much can be learned from El Salvador's risk management system, which applies selectivity based on automated compliance measurement and risk-assessment and profiling systems to target suspect consignments, minimizing the incidence of physical examinations.

2) Finding (Weigh Stations): Weigh stations in countries across the region are a source of long delays and corruption, increasing transportation costs. In the case of frozen beef exports from Nicaragua, for example, the supply chain analysis discovered that delays at the weight station can add two additional days to the journey to port and result in fines anywhere from $16 (for the first offense) to over $1,000 per container (for a repeat offender). Many interviewees across the region openly reported paying bribes to avoid excessive weight station delays.

> **Recommendation**: Implement a regional Weigh Station Review and Strategy to identify specific reasons for long delays by station and to monetize and ferret out corruption practices at weighs stations across the region. Convene a regional agreement to implement changes according to findings and best practices in the region.

3) Finding (SPS Sampling): High fees and long waiting times exist for laboratory analysis required for the sanitary inspection certificate, often slowing delivery times and increasing costs for exporters.

> **Recommendation**: Study the current process and problems of Sanitary and Phytosanitary (SPS) sample approval, and take measures to increase the efficiency and speed of this process. If needed, expand the number and reach of national laboratories. In addition, develop a regional web-based platform where countries would be required to announce blockades and retention of agricultural products in real-time.

4) Finding (Security Costs): Trucking firms have seen a rise in direct security costs in recent years as a result of measures taken to cope with increased crime and violence rates in Central America. Average security costs in the region over the past three years have increased by around 20 percent, and are likely to increase further along with growing security issues. This negatively impacts the business of trucking firms, as well as increases transportation costs.

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[19] Customs only defines certain risk criteria at the central level and in a general manner, on the basis of value, classification and origin, which at the operative level are insufficient for profiling high-risk operators. There are no operator risk profiles that might identify high-risk operators and support Customs control.

Recommendation: Greater efforts of central and local governments to combat crime and violence would likely reduce security costs and losses due to theft. Further research should be conducted in order to collect specific data to identify where exactly trucking firms suffer most from crime, so governments could make specific efforts in this regard. In addition, governments can learn from best practices in LAC, such as from efforts undertaken in Bogota, Medellin, and Sao Paulo in the last two decades, which have proved successful in reducing their crime rates. [20]

5) Finding (Fuel Costs): Fuel costs are considerable for trucking companies, representing between 40 to 60 percent of total variable costs, a much higher figure in comparison to USA and Canada (between 15 and 22 percent depending on the configuration of the truck). Despite this, measures related to fuel efficiency have yet to be deployed by most trucking firms in the region.

Recommendation: Promote fuel efficiency in the region in an attempt to reduce transportation costs and CO2 emissions, by for instance, (1) implementing mandatory periodical technical inspections to ensure fuel standards are up to par; and by (2) incentivizing trucking firms to implement fuel saving technologies and practices such eco-driving techniques and tire technologies.

6) Finding (Access to Information): Agriculture producers often operate in an information-poor environment, cut off from valuable market trends.

Recommendation: Explore the possibility of facilitating mobile information platforms[21] in an attempt to improve producers' access to market information, which would allow for farm-management adjustments necessary to comply with real-time consumer demand.

Institutions and Regulations

1) Finding (Border Waiting Times): Waiting times vary widely amongst border crossings in the region, between two sides of the same border crossing, and even within a border crossing. This variation demonstrates that border services are not consistent amongst the different countries in the region, adding uncertainty in the logistics process, and thus harming local importers and exporters.[22] For example, in the border crossing El Amatillo, between Honduras and El Salvador, truckers reported spending anywhere between 2 and 24hours to cross both sides of the border.

Recommendation: Investigate the reasons behind time variations and waiting times amongst border crossings in the region. Take measures to harmonize customs systems regionally, and ensure that they interface seamlessly with quarantine and sanitary inspection systems (country-level).

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[20] For instance, it appears that approaches that include both crime control and prevention interventions are most successful in yielding reductions in crime and violence. Tough-on-crime approaches alone, such as the *mano dura* policies of much of Central America in the 1980s focused primarily on arrests as the key indicator of success, and have been criticized for generating the opposite of the intended effects.

[21] Through mobile platforms, farmers receive text messages from governments or other organizations with information that could help improve the productivity of their land and access to potential buyers.

[22] Variation of border crossing times can be a result of differences in the application of regulations in the different countries, efficiency of the customs and immigrations authorities, poor border infrastructure, and border congestion.

2) Finding (SPS Procedures): SPS procedures are often very burdensome for importers and exporters throughout the region. According to Honduran dairy exporters, for instance, every time a refrigerated container of dairy products undergoes a duplicate inspection at the El Salvador border, logistics expenses may increase by up to $900, and the time in transit from 2 to 9 days. It has even been suggested that SPS measures are deliberately used by countries as non-tariff barriers to trade.

> **Recommendation**: As part of regional initiatives to improve trade, integration and competitiveness, proactively address the use of SPS measures as non-tariff barriers to trade.

3) Finding: A relatively high rate of empty backhauls exists throughout the region, resulting in inefficiencies and higher prices for importers and exporters.[23] Empty returns are particularly high in Guatemala, where around 77 percent of trips are reported to return empty.

> **Recommendation:** (1) Develop an explicit agreement for the reciprocity of backhaul for cross-border trucking, including to and from export processing free trade Zones; (2) Further investigate ways to promote coordination mechanisms that match supply and demand for trucking services; and (3) Reduce wait times at border crossing (a reason mentioned by truckers for discouraging them from looking for return cargo).

4) Finding: The trucking industries in the region appear to be in an infant stage of development, not well structured or regulated. This leads to a high level of fragmentation and informality, with a high percentage of small one-man companies (*hombre camiónes)*, as seen in Nicaragua for example. Even when regulations do exist, they are often not enforced. The costs of an unregulated trucking industry are indirect and take time to manifest themselves, but they are significant. Although transport regulations such as weight restrictions and truck quality and safety may increase transport costs, the lack of regulations and/ or enforcement leads to overloading problems, product losses, and safety issues (e.g., driver fatigue, unsafe vehicles, improperly licensed drivers).

> **Recommendation**: Strengthen trucking regulations and enforcements, and try to coordinate them regionally to facilitate the logistics process. Better weight controls, inspections and standards for truck safety will reduce costly losses from damage. In addition, learn from best practices from other regions.

5) Finding: Excluding Panama, countries in the region are not getting the full value of their roads; average speeds are below the designed speed for highways (especially in Guatemala, Honduras, and Costa Rica).[24] This is usually not a road quality issue but rather a right of way issue.

> **Recommendation:** An "average speed against design speed" assessment will help countries understand the poor returns they are receiving on road infrastructure investments. In addition, enforce the right of way and land use alongside of main corridors throughout the region.

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[23] Trucking firms delivering cargo to a foreign country are not allowed to pick up cargo at that country and deliver it locally, and they are often not permitted to pick up cargo from foreign free trade zones. Trucking firms also complain of a problem to find backhaul cargo due to lack of contacts, as well as claim to be discouraged from long waits time at borders (returning empty would allow them to pass through the border crossing faster).

[24] From the trucking survey, it is estimated that speed utilization in Guatemala is 67 percent, in Honduras it is 78 percent, and in Costa Rica it is 81 percent.

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Annex I. Tools and Methodologies

Supply Chain Analysis

The SCA methodology[25] is a survey-based tool used to pinpoint transport and logistics bottlenecks that hinder access to markets and/or reduce firms' competitiveness. The analysis follows a selected product from the farm gate to its destination, identifying where logistics inefficiencies increase logistics expenses, travel times, and uncertainty. Logistics bottlenecks negatively impact producer/exporter margins, in the case of exports, and consumer prices, in the case of imports.. SCAs quantify and monetize the effects of identified bottlenecks for individual producers, providing policy-makers a snap shot of where in the supply chain bottlenecks exist, as well as the extent of their impact. Logistics bottlenecks revealed in this SCA may include:

- insufficient capacity or stock of road, rail and/or port infrastructure;
- poor management, operations or maintenance of that infrastructure;
- non-competitive freight handling, trucking, shipping and warehousing services; and
- border congestion along with customs and phytosanitary inspections increase costs and delays.

Within an abundant body of analytical tools related to the movement of goods, this methodology is a product-level assessment with a singular focus on infrastructure and logistics. Wider-ranging studies, such as Trade and Transport Facilitation Assessments (TTFAs), are conducted at the country level and consider the institutions and corresponding regulations that govern the movement of goods; they often include SCAs as one component of a more holistic assessment (World Bank, 2010). Sectoral diagnoses of, for example, domestic trucking services or the shipping industry, can identify a range of inefficiencies related to a particular step along the chain. Freight-flow simulations, among other types of spatial modeling exercises, can identify bottlenecks in the movement of cargo, but are unable to quantify the cost-impact on producers or address the unique challenges that these bottlenecks pose to different types of cargo. Because the SCA is a micro-level tool, complementary analyses are necessary to show the degree to which product-specific points of friction are structural and symptomatic.

This SCA methodology must not be confused with a value chain analysis, which is also product-based, but attempts to identify inefficiencies in the production of a good, from the usage of inputs to product positioning in the final retail market. Value chain analyses offer a more general perspective of a particular industry or agricultural sector, and may complement supply chains, but ultimately do not provide the same kind of detailed analysis of constraints to product movement that are integral to an SCA. Other supply chain methodologies differ in their focus on price transmission, the role of intermediaries, or customs services and documentation, which often pay a great deal of attention to the movement of information through the chain (see Kunaka, 2010; Zuñiga-Arias, 2007).

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[25] The unique methodology used to conduct the SCAs in this report was developed expressly for this purpose by the Economics Unit of the Sustainable Development Department for the Latin America and Caribbean Region of the World Bank. It has appeared in other World Bank publications, including: 1) Fernandez, R., Flores Gomez, S., Estrazulas de Sauza, F., & Vega, H. (2011). Report 6. Supply Chain Analyses of Exports & Imports of Agricultural Products: Case Studies of Costa Rica, Honduras and Nicaragua. In J. H. Lopez, & R. Shankar, *Getting the Most out of Free Trade Agreements in Central America* (pp. 151-181). Washington D.C.: The World Bank and 2) Arias, D., & De Franco, M. D. (2011). *Integrating Central American and International Food Markets: An Analysis of Food Price Transmission in Honduras and Nicaragua.* Washington D.C.: World Bank.

The SCA case studies presented in this study were chosen for their relevance in Central American trade and the representativeness of their route. Destinations that require the use of a principal Atlantic port were favored because Puerto Cortés in Honduras and Puerto Limón in Costa Rica traditionally handle the highest volumes of trade in the region, when Panama's ports are excluded.[26] The three Honduras supply chains (beef, dairy & organic coffee) were conducted as part of an IFC project designed to address administrative constraints that diminish the competitiveness of agricultural exports. The case studies chosen for this analysis include the following:

Exports beyond Central America

- Pineapple exports from Costa Rica to Europe
- Frozen ground beef exports from Nicaragua to the U.S. (Small & Large Producer)
- Fresh Beef exports from Honduras to the U.S.
- Organic coffee exports from Honduras to Germany
- Snow peas exports from Guatemala to the U.S.

Exports within Central America

- Tomatoes from Costa Rica to Nicaragua (Small & Large Exporter)
- Dairy from Honduras to El Salvador

The time sensitivity of perishable agricultural goods means that bottlenecks in the logistics system have a clear and measurable impact on the quality and quantity of goods delivered.[27] For Costa Rican tomatoes and Nicaraguan beef, a product-specific calculation for time value was made to estimate the impact of delays on overall logistics costs.

Freight Flows from an Optimal Path Analysis Perspective

The Optimal Path Analysis (OPA) is one of the main outputs that can be derived from the family of algorithms known as Accumulated Cost Surface Methods (ACS) implemented by the Geographic Information System (GIS). Given a friction surface, the OPA calculates the least-effort path or the most-efficient route to connect a point of origin to a destination. The friction surface corresponds to a pixilated representation of space –a raster dataset– that assigns to each pixel of space information on the effort required to cross it from side to side. The friction surface assigns to each cell the cumulative effort to the origin. The optimal route is one that, among all the possible ways to reach a destination, demands the least possible effort. The effort can be measured in terms of times or costs. For more on the methodology, please see Annex II.

In the case of Central America, a unified digital map of the road network was generated based on information provided by the ministries of transport of the region. This digital map contains information on the functional type –primary, secondary or tertiary– and the surface condition –paved, unpaved– for all roads within the region.

[26] Comisión Centroamericana de Transporte Marítimo (2008).

[27] Time to trade imposes a number of additional costs on exporters which vary in character and degree according to the product. For non-perishable, time-insensitive products, delays often result in increased logistics expenses for labor, fuel, and storage, as well as fees or fines for delays or demurrage.

The effort required to move across the map is increased or attenuated due to numerous factors that may be quantifiable and spatially linked to each pixel. The analysis considers the following friction factors: (i) terrain slope; (ii) type of road[28], as defined by the design speed and the magnitude of daily traffic flows; (iii) the quality of the road, assuming that unpaved primary and secondary roads have the same speed limitations as tertiary roads; (iv) the urban transit effect, which slows cargo trucks down to no more than 50 km/hrs[29]; and lastly (v) wait times to cross borders, which average around 3 hours, but can reach 18 to 24 hours in extreme cases, at particularly problematic borders[30].

For each of five friction factors, a friction surface containing pixel-level information on the terrain inclination was calculated based on the Digital Elevation Map (DEM) of Central America[31] (Figure 17). Since the resolution of this DEM corresponds to a minimum pixel size of 100 square meters, all additional calculations were performed at this level of detail. After all the layers of information associated with the friction have been generated, each of them was gradually superimposed on the previous one. First, the layers containing information on slopes and type of roads were combined to generate a base-scenario to calculate the optimal paths for cargo transportation based solely on design speeds. Then, the quality of roads layer was added to this base-scenario to produce a new set of optimal routes and times. Later, additional layers of paths and times were produced to account for the urban transit effect and the waiting time at border crossings. In the best case scenario, on a primary paved road on level ground outside the urban area, it takes 4 seconds to cross a pixel implying an average speed of 90 km/h. In the worst case, a truck has to wait several hours at a border post (more than 6000 seconds).

[28] The Annual Average Daily Traffic (AADT) for primary roads, which are meant to connect major cities, trade centers and municipalities with more than 50 thousand inhabitants ,can exceed 1,000 vehicles a day, while secondary roads and are designed to reach an AADT around 250 vehicles a day. Finally, tertiary roads provide access to remote areas and channel the agricultural production from the farm gate to the distribution centers and local markets. These roads serve small towns and have an AADT lower than 50 vehicles a day (Navarro, 2008).

[29] Does not account for urban congestion.

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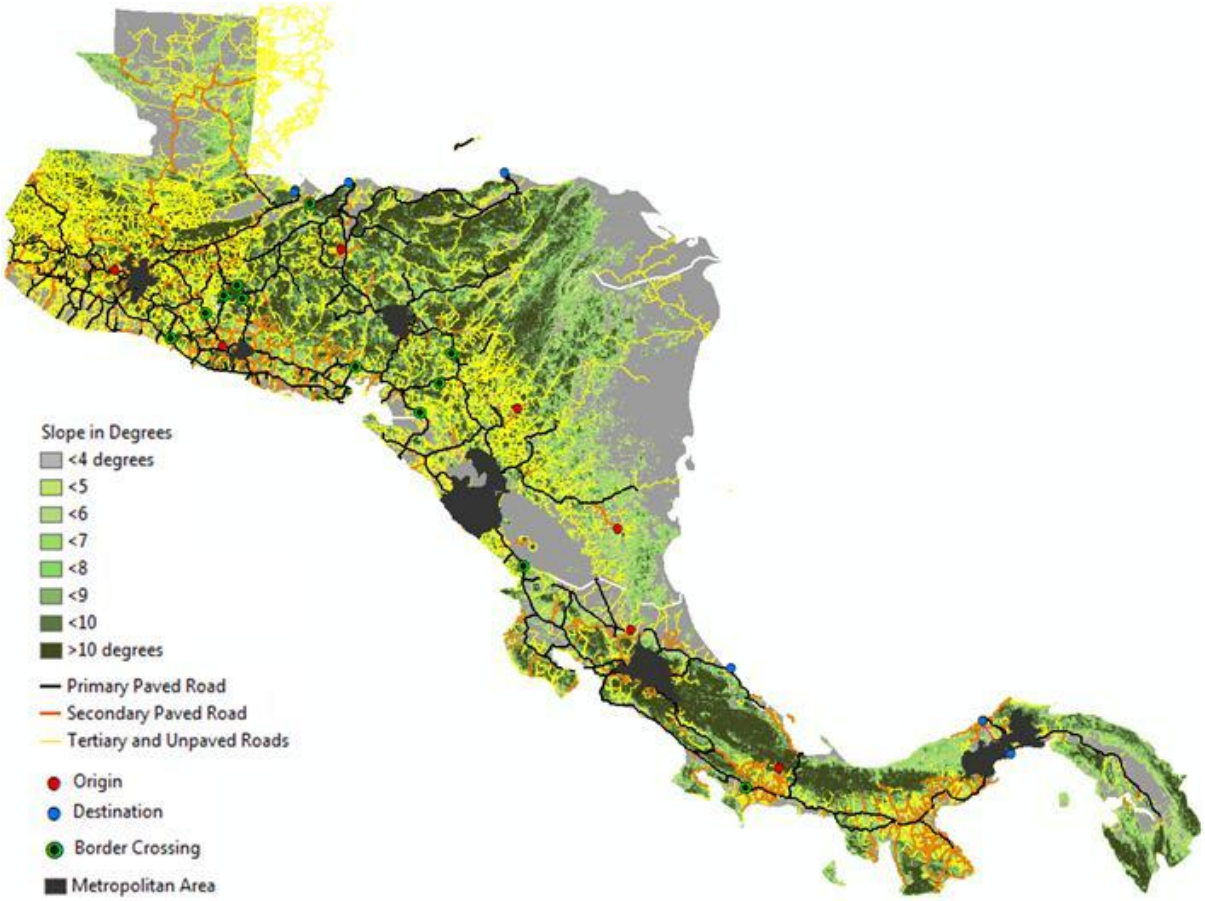
Figure 17: Five Friction Factors of the Optimal Path



Points of origin and destinations were defined to identify least-cost paths to the freight flow in Central America, taking into account three factors: (i) time sensitivity; (ii) heavy reliance on trucking for cargo transport in Central America; (iii) the significance of Atlantic side ports, since nearly two thirds of agricultural exports are destined for markets in Europe, the USA and Canada (see Figure 5). In total, seven agricultural zones (origins) were selected - two zones in Nicaragua and one zone in each of the other countries of the region. In turn, six ports were chosen as destinations; the five most important ports on the Atlantic side of the region, and one –the most accessible by road from the rest of the region– located on the Panama Canal.

Assessment of Infrastructure Stock and Quality

In order to provide an overview of current infrastructure levels, this component presents a brief compendium of stock and quality indicators in Central American countries, analyzing and comparing country-level aggregate data. This assessment takes into account not only the large infrastructure gap with respect to the best international standards, but also considering the contrasts within the region, which are equally significant. The infrastructure components related to transport and logistics assessed are: roads, ports, and trade logistics performance.

Port Asset Performance Analysis

Regarding port asset performance, a Stochastic Frontier Analysis (SFA) of ports was carried out to provide a comparative picture among ports in the region. This analysis allows the ranking of port performance based on the utilization of their infrastructure-superstructure. Moreover, this analysis determines the distance of each port to its output capacity.

In the SFA model specification, the stock of assets of each port is considered as inputs and container throughput as output. Output data for the 73 ports evaluated came from the Containerization Yearbook for the years 1999-2009. The inputs considered were the area of the container terminals, length of container berths, number of ship-to-shore gantry cranes and number of mobile and quay cranes. Using these assets, the SFA model calculates a corresponding infrastructure performance index (on a scale of 0 to 1), that shows the port's distance to its potential. The econometric estimations controlled for the boost originated from transshipment in ports in which this type of movement prevails, as well as for the use of ship cranes by ports with insufficient crane infrastructure. This methodology distinguishes the ports that can improve performance through more efficient operations with those that should consider expanding their infrastructure in order to meet increasing demand.

Trucking Services Survey

A comprehensive analysis of the trucking industry in the six countries of Central America was carried out, with a survey being the main tool for information gathering . The sample was selected based on a comprehensive data set of trucking services in each country, provided by the main trucking associations in the region. The questionnaire was divided into eleven sections including: control information, general information, characteristics of vehicle fleet, transport service characteristics, market pricing, employment, regulations and technologies, and constraints to service provision. The sample is representative of both the formal sector, defined as formal firms with five or more vehicles in their fleet, and the informal sector, defined as operators with less than five trucks, firms with less than five employees and owner-operators. Serving as data gathering tool that helps identify bottlenecks affecting the transport of goods in the region, the trucking survey also allows for an in-depth micro-level analysis of determinants of transport costs and prices, and firm behavior.

Over 250 trucking firms in Central America were interviewed for this survey. Jointly, they operate over 3,400 vehicles that transport goods across borders or to and from ports of entry or exit in more than 260 routes in the region. This is the first survey of this type conducted in Latin America and the Caribbean that enables cross-country and cross-region comparisons.

Hierarchical Growth Model for Infrastructure Investment

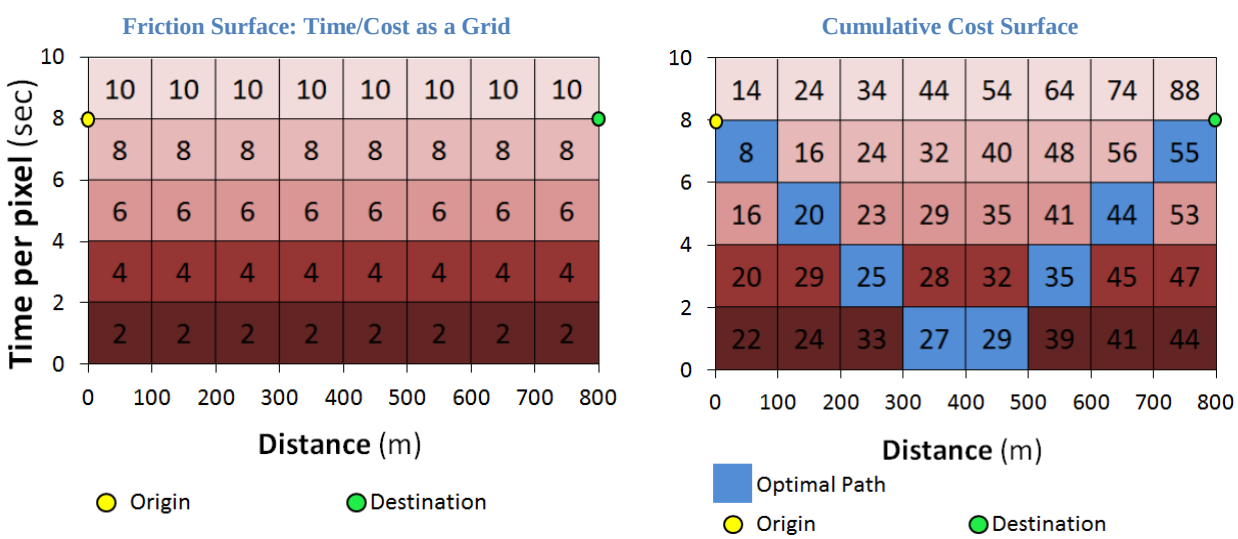
This analytical component is premised on a simple hypothesis that not every dollar of infrastructure investment is equal. Put simply, one million dollars towards transport infrastructure may go farther in Panama than in Honduras, and farther in Honduras than Guatemala. Existing empirical literature on infrastructure development appears to have an unbalanced focus on generating a target investment level as a percentage of GDP, either globally or regionally, without taking into account wide variations in each country's ability to turn that investment into growth. Country governments do not always act as

“social welfare maximizing planners”, and even when they do, productive investments must be planned for, constructed and operated successfully to have the maximum impact on growth (Pritchett, 1996). This analysis studies the variation in growth returns from infrastructure investment. First, infrastructure investments in transport, including ports, airports, roads, electricity, telecommunications and water and sanitation are combined in a unique dataset of public and private investment commitments over the period 2000 to 2010. Next, a hierarchical linear model estimates country-specific elasticities of GDP growth to infrastructure investment. The numeric elasticity for each country represents a percentage point increase over current GDP that can be generated from a 1 percentage increase over current levels of infrastructure investment. For further detail of the dataset and methodology see Annex II.
The result of this study, referred to as the “infrastructure investment bottleneck”, is understood as the aggregate effect of inefficiencies on the growth returns from infrastructure investment - in other words, how much a diverse basket of disadvantages can diminish the impact of each dollar of infrastructure investment on GDP growth. Inefficiencies can be divided into three categories as they relate to: i) planning at the national, sector and project levels; ii) management of financial resources; and iii) project execution. As these inefficiencies delay employment generation, diminish the number or quality of jobs created, or reduce the operating efficiency of otherwise productive investments, they impact the ability of each infrastructure investment to spur short-term growth at the country level.

Annex II. Optimal Path Methodology, Route Selection, Time & Distance Details

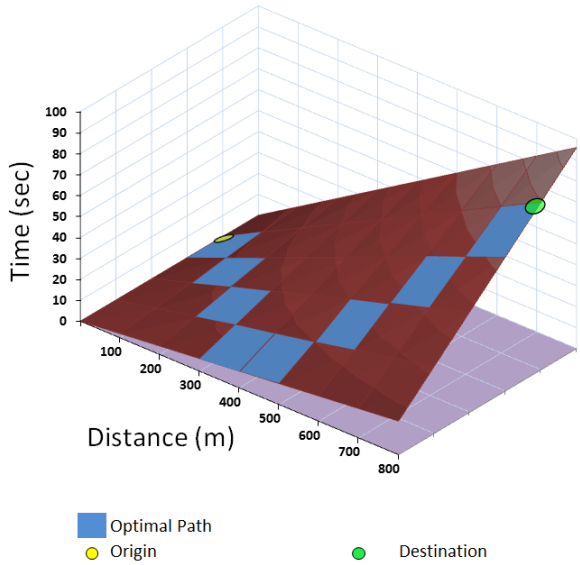
Explanation of Friction Surfaces

The time (proxy of the effort) it takes to pass through a 100 square meters pixel from side to side varies in a range between 2 and 10 seconds depending on several factors. The time to travel 800 meters following a straight line from the origin (O) to destination (D) is 64 seconds, that is equivalent to an average travel speed of 45km/h.



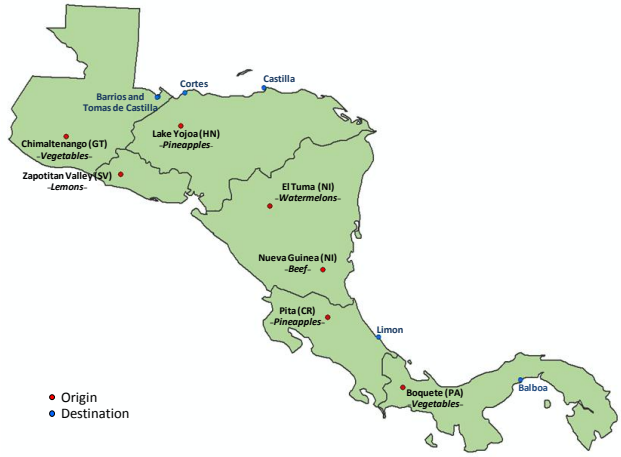
As shown above, a straight line is not always the most efficient way to connect two points in space. Following the optimal path (in blue, Figure 3) the travel time can be reduced to 55 seconds[32]. This optimal route implies a 14% reduction in total effort and an increase in the average speed up to 69 km/h, even though the total distance traveled has increased by 31percent.

Figure 2. 3D Friction Surface: Time/Cost as a Grid



The most efficient way to climb up to the point of destination is by avoiding the steepest terrain, traversing the areas of least resistance. Even though the length of the optimal path is 249 meters longer than the straight line connecting the origin to the destination, the time needed to complete this route is 14% lower. Assuming the slope as the only factor that increases the effort (travel time), the friction surface and the optimal path can be represented three-dimensionally as shown in Figure 2.

Route Selection



Top 2 Perishable Exports to Europe & the U.S. (2009)

Country	Product	Value (1000USD)	Quantity (kgs)
Costa Rica			
	Pineapples	$ 438,065.07	1,097,615,141
	Melons	$ 75,166.63	146,514,243
El Salvador			
	Bell Peppers	$ 2,114.68	1,301,841
	Lemons	$ 696.42	1,259,092
Guatemala			
	Melons & Watermelons	$ 141,442.77	445,548,836
	Peas	$ 39,372.42	38,941,642
Honduras			
	Melons & Watermelons	$ 40,950.03	229,086,578
	Pineapples	$ 23,653.22	47,816,877
Nicaragua			
	Meat of bovine animals,	$ 21,432.78	6,063,856
	Watermelons, fresh	$ 765.60	3,403,935
Panama			
	Watermelons, fresh	$ 43,573.06	78,042,319
	Salmon	$ 66,133.58	24,350,175

*Due to the large scale of most producers, bananas have been omitted.
**Melons and watermelons have been grouped together, because they come from similar production zones.
***Panama: Salmon is exported in only slightly greater quantities than
Source: UNCTAD/WITS Database

1. The time associated to diagonal movements take into account the Pythagorean Theorem.

Time and Cost Details

Boquete (Panama)

	Length	Hours	Change	Speed
Speed design	471.30	5.56		84.8
Topography	471.77	5.80	4.3%	81.3
Unpaved roads	471.77	5.98	3.0%	78.9
Urban transit effect	471.77	6.71	12.3%	70.3

Pita (Costa Rica)

	Length	Hours	Change	Speed
Speed Design	190.28	2.46		77.3
Quality of Roads	190.28	2.46	0.1%	77.2
Urban transit effect	190.28	2.58	4.8%	73.7

Chimaltenango (Guatemala)

	Length	Hours	Change	Speed
Speed Design	332.74	3.88		85.7
Topography	333.47	4.35	12.2%	76.6
Unpaved roads	338.17	4.42	1.6%	76.5
Urban transit effect	338.17	4.93	11.4%	68.6

Yojoa (Honduras)

	Length	Hours	Change	Speed
Speed Design	116.04	1.53		75.8
Unpaved roads	116.04	1.53	0.0%	75.8

Zapotitan (El Salvador)

	Length	Hours	Change	Speed
Design Speed	327.54	3.83		85.6
Topography	328.61	4.30	12.4%	76.4
Unpaved roads	335.08	4.37	1.7%	76.6
Border Crossing	335.08	8.38	91.5%	40.0

Nueva Guinea (Nicaragua)

	Length	Hours	Change	Speed
Speed Design	802.09	9.65		83.1
Topography	742.25	9.93	2.9%	74.7
Unpaved roads	802.78	10.25	3.2%	78.3
Urban transit effect	802.78	11.54	12.6%	69.5
Border Crossing	802.78	13.54	32.1%	59.3

Dalia (Nicaragua)

	Length	Hours	Change	Speed
Speed Design	621.27	7.34		84.7
Topography	622.40	8.36	13.9%	74.4
Unpaved roads	622.40	8.36	0.0%	74.4
Urban transit effect	622.40	9.28	10.9%	67.1
Border Crossing	689.56	12.37	47.9%	55.7

Annex III. Hierarchical Linear Growth Model: Methodological Note

Public Sector Data

Public sector investment figures represent approved, rather than executed expenses[33].

1) Panama

Roads: Obras Publicas: Construcción y Rehabilitación, Mantenimiento y Rehabilitación, Construcción y Rehabilitación Calles y AV, Construcción y Rehabilitación de Puentes

Ports: Autoridad Marítima Portuaria: Estudios, Avalúos y Diseños, Adquisición de Equipo y Consultorías, Puertos, Recursos Marinos

[33] Executed expenses, either within national accounts or within a fiscal transparency report, tend to provide data at the ministry, agency or, in the most detailed case, the project level; these figures very rarely separate expenditures according to capital formation, human capital formation, and administrative expenses. Put simply, because budgets are more detailed than expenditure reports, the approved budget allows us to get closer to actual infrastructure investments by sector.

Water: Instituto de Acueducto y Alcantarillado Nacionales: Desarrollo de Sistema de Aguas, Desarrollo de Sistemas de Alcantarillados, Inversiones Complementarias

2) Guatemala

Transport, Telecom, Electricity, Water (2000-2006): 2000-2009: Budget of the Ministry of Public Works - Ministerio de Communicaciones, Infraestructura y Vivienda

Water (2007-2010): Approved Budget for Water and Sanitation from Secretaría General de Planificación, 2007-2010 http://snip.segeplan.gob.gt/guest/SNPGPL$MODULO.indice
See Also: Sistema de Contabilidad Integrado (SECOIN), http://www.minfin.gob.gt/index.php?option=com_content&view=article&id=17&Itemid=21

3) Costa Rica

All Sectors (2000-2009): Ministerio de Hacienda, Secretaría Técnica de la Autoridad Presupuestaria, Unidad de Análisis y Seguimiento Fiscal.

4) El Salvador

All Sectors (2000-2009): Ministerio de Hacienda, Dirección de Administración de Inversión Publica

Transporte (2000-2009): Ramo de Obras Públicas, Transporte y de Vivienda y Desarrollo Urbano

Water and Sanitation (2000-2009): Comisión Ejecutiva Hidroeléctrica del Rio Lempa, Administración Nacional de Acueductos y Alcantarillados

Electrical Energy and Telecommunications (2000-2009): Fondo de Inversión Nacional en Electricidad y Telefonía
Ports (2000-2009): Comisión Ejecutiva Portuaria Autónoma

5) Honduras

All Sectors (2000-2009): Secretaria de Finanzas (SEFN), Sub Secretaria de Crédito y Inversión Pública, Dirección General de Inversión Pública, Informes Físicos Financieros: http://www.sefin.gob.hn/portal_prod/data/2010/DGIP/Linea%20de%20Tiempo/Linea%20de%20Tiempo%20-%20DGIP.html

5) Nicaragua

All Sectors (2000-2009): Ministerio de Finanzas, Ministerio de Hacienda y Crédito Público, el Sistema Nacional de Inversiones Públicas, y el Banco Central de Nicaragua

Private Sector Data

Private sector investment data came primarily from two databases: the World Bank's PPI database and the Dealogic Projectware Database. The PPI database is the most comprehensive of its kind available; The Dealogic Projectware Database includes an extensive, though not entirely comprehensive, list of infrastructure projects that have a private financing component, including privately financed public sector projects, entirely private projects, as well as public-private partnerships. Information on private investment in infrastructure from both databases was sorted and merged to avoid duplication.
The PPI database has three primary shortcomings: figures represent infrastructure investment commitments, rather than executed amounts; only investments with both a public and a private component are included; and it is not comprehensive.[34] Total private investment figures are only so good as the regulation of their disclosure. In the case of El Salvador, this study uncovered that private companies involved in electricity generation are not required by law to disclose investment figures to the government
For both private infrastructure investment databases, investments appear as lumpy, one-time sums, concealing any semblance of a trend in private investment. To manage these spikes and dives, lumpy investment commitments were smoothed over time using likely disbursement cycles developed through consultations with industry experts.[35] Additional research on private participation in infrastructure, including consultations with national regulators and government records ensured that this database was as accurate and comprehensive as possible.

Hierarchical Growth Model Methodology

The macroeconomic model used in this study is designed to measure the magnitude of the contribution of infrastructure investment to economic growth at both the regional and country level. First, an OLS model with fixed effects estimates the relationship between infrastructure investment and economic growth. Then, the coefficient associated to infrastructure, understood as the elasticity of economic growth with respect to infrastructure investment, is used to calculate the infrastructure investments required to reach two economic growth scenarios. The estimated models are specified as follows:

$$\mathrm{GDP}_{i,t} = \beta 0 \quad + \beta_1 \mathrm{Inv}_{i,t-1} + \beta_2 \mathrm{Pop}_{i,t} + \mathrm{Xi} \quad \delta + \epsilon_{i,t} \qquad (1)$$

In Equation 1, all variables are in natural logs; GDP is the gross domestic product of the country i at time t, Inv corresponds to the lagged value of total public and private investment in infrastructure; Pop is the total population, X is a set of dummy variables to capture country and year fixed effects. The model was estimated for six Central American countries using information from 2000 to 2009.
Intuitively, the infrastructure investment elasticity of GDP must vary among countries within the region. A random slope effect at the country level was introduced in equation (1) in order to decompose the regional elasticity β_1. As it is shown in equation (2); $\mu 1j$ captures these

[35] We consulted the following World Bank experts for each sector: Eloy Vidal from the Transport, Water Info & Communications Technology Unit at the World Bank for telecommunications investments; Ariel Yepez and David Reinstien from the LAC Energy Unit for energy investments; and Steve Brushett from the Transport Unit for transport projects. Disbursement cycles were calculated using the sector, size and time cycle of the project.

differences at the country level. The expected effect on GDP produced by changes in total infrastructure investment would vary among countries as follows:

$$\beta_1 = \beta + \mu_{1i} \qquad (2)$$

Replacing equation (2) into (1) obtains a hierarchical linear specification where the random coefficient β_1 captures the differences in the average elasticity within the region,1 in terms of each country's capacity to generate growth from infrastructure investment:

$$GDP_{i,t} = \beta_0 + \beta Inv_{i,t-1} + \beta_2 Pop_{i,t} + X_i\delta + \mu_{1j} Inv_{i,t-1} + \epsilon_{i,t} \qquad (3)$$

The hierarchical structure described in equation (3) adds more information on the effects of infrastructure investment than equation (1) if and only if, the random effect at the country level measured by μ_{1j} is statistically different from 0.

The model was found to be a good fit for the relationship, with an r2 value of .99 for the regional average and .90 for the hierarchical specification. The infrastructure investment elasticity of GDP varies among countries (see Annex II), as hypothesized in equation (3). The random slope effect at the country level is statistically significant when a hierarchical structure is introduced.

Annex IV. Laboratory Analysis for Beef & Dairy Exports

Beef Exports	HONDURAS		COSTA RICA		NICAGARUA	
Laboratory Tests	Lempiras	USD	Colones	USD	Cordobas	USD
Prueba de metales pesados (1 muestra)*	L. 4,500.00	$ 236.84	₡12,332.00	$ 24.09	C$ 2,583.36	$ 112.00
Determinacion de Residuos de Hormonas	L. 900.00	$ 47.37	₡62,248.00	$ 121.58	C$ 1,360.88	$ 59.00
Determinacion de Especie Animal	L. 500.00	$ 26.32	₡12,332.00	$ 24.09	C$ 253.72	$ 11.00
Residuous Ivermectina	L. 1,100.00	$ 57.89	₡38,758.00	$ 75.70	C$ 691.97	$ 30.00
Residuous Benzimidazoles	L. 1,000.00	$ 52.63		$ 99.79	C$ 830.37	$ 36.00
Residuous Cloranefenicol	L. 650.00	$ 34.21	₡51,090.00	$ 40.14	C$ 668.91	$ 29.00
Residuous de Antibioticos en Carne	L. 500.00	$ 26.32		$ 16.06	C$ 922.63	$ 40.00
Residuous de Sulfas en Carne	L. 2,300.00	$ 121.05		$ 21.79	C$ 968.76	$ 42.00
Escherichia coli O157:H7	L. 5,360.00	$ 282.11	₡17,317.00	$ 33.82	C$ 922.63	$ 40.00
Coliformes Totales			₡7,047.00	$ 13.76	C$ 230.66	$ 10.00
Clorinados	L. 550.00	$ 28.95	₡9,983.00	$ 19.50	C$ 922.63	$ 40.00
Fosforados			₡38,758.00	$ 75.70	C$ 807.30	$ 35.00
Salmonella	L. 600.00	$ 31.58	₡7,634.00	$ 14.91	C$ 461.31	$ 20.00
Listeria	L. 700.00	$ 36.84	₡9,983.00	$ 19.50	C$ 691.97	$ 30.00
Recuentro total de Bacterias	L. 200.00	$ 10.53	₡12,617.00	$ 24.64		
Humedad					C$ 138.39	$ 6.00
Total	**L. 18,860.00**	**$ 992.63**	**₡320,030.00**	**$ 625.06**	**C$ 12,455.48**	**$ 540.00**

Dairy Exports Laboratory Tests	HONDURAS Lempiras	USD	COSTA RICA Colones	USD	NICAGARUA Cordobas	USD
Plagacuidas Clorianados	L. 600.00	$ 31.58	₡9,983.00	$ 19.50	C$ 922.63	$ 40.00
Plagacuidas Fosforados	L. 1,200.00	$ 63.16	₡38,758.00	$ 75.70	C$ 807.30	$ 35.00
Ivermectinas	L. 1,100.00	$ 57.89	₡11,157.00	$ 21.79	C$ 691.97	$ 30.00
Antibioticos	L. 500.00	$ 26.32	₡12,332.00	$ 24.09	C$ 922.63	$ 40.00
Plomo	L. 900.00	$ 47.37			C$ 645.84	$ 28.00
Cadmio	L. 900.00	$ 47.37	₡12,332.00	$ 24.09	C$ 645.84	$ 28.00
Cobre	L. 900.00	$ 47.37			C$ 345.99	$ 15.00
Hierro	L. 900.00	$ 47.37			C$ 345.99	$ 15.00
Coliformes Totales	L. 240.00	$ 12.63	₡7,047.00	$ 13.76	C$ 230.66	$ 10.00
Echerichia coli	L. 240.00	$ 12.63	₡7,047.00	$ 13.76	C$ 230.66	$ 10.00
Staphylocuccus Aureus	L. 275.00	$ 14.47	₡6,459.00	$ 12.62	C$ 345.99	$ 15.00
Salmonello spp	L. 600.00	$ 31.58	₡7,634.00	$ 14.91	C$ 461.31	$ 20.00
Listeria Monocytogenes	L. 700.00	$ 36.84	₡9,983.00	$ 19.50	C$ 691.97	$ 30.00
Levaduras y Hongos	L. 200.00	$ 10.53	₡6,459.00	$ 12.62	C$ 230.66	$ 10.00
Bacterias	L. 225.00	$ 11.84	₡12,617.00	$ 24.64		
Total	**L. 9,480.00**	**$ 498.95**	**$ 141,808.00**	**$ 276.97**	**C$ 7,519.42**	**$ 326.00**

Notes: Required tests for exportation vary by country, both by name and by content. A rigorous attempt has been made to confirm with officials at each country's national laboratories to ensure the validity of the figures. For Honduras, the laboratory fees listed closely matched those reported by exporters. Where a test was not required, or could not be found in the official list, it has been left blank. The test for heavy metals, refers to a series of tests for cadmium, copper, lead and iron. For dairy exports from Costa Rica, the 4 heavy metal tests appear combined as one test, which costs approximately $24 (see chart).
Sources: 1) Honduras: CENTEX; 2) Costa Rica: LANASEVE; 3) Nicaragua: DGPSA.

Annex V. Suggestions for Further Research

Future analytical work should be conducted in collaboration with logistics operators, transport operators and customs agents that have representative data on transport costs and times within the region. Useful additional analyses would include:

- The port stochastic frontier analysis should be extended to include operational variables, namely vessel and cargo turnaround times, so that an estimate of total port efficiency can be calculated.

- Complementary analyses that project likely shifts in trade patterns in the region could help inform a regional port strategy such as short sea shipping, as well as infrastructure development of strategic interest for the region as a whole.

- For the trucking industry, further analysis of profit margins, determinants of prices and its relation with firms' characteristics can be developed. Broader impacts of fuel efficiency and climate change would also warrant further investigation.

- Further applications and extensions of the Optimal Path tool may include: (i) building a "flatland" baseline to see how workable friction factors (road quality, urban transit, and border waiting) compare with non-workable terrain slopes in terms of their effect on transit times; (ii) collecting data on urban congestion to more accurately capture the effect of urban bottlenecks

on transit times; (iii) calculating the effect of building a road on freight flows; (iv) calculating the effect of paving rural roads; and (v) introducing port efficiency as a friction factor, drawing on port performance analysis.

- Further work is planned to use a Gravity Model of Trade to estimate the value of each transportation hour based on the relationship between time and trade volumes within the region. And then through the Optimal Path tool, studying these effects on a wider selection of trade routes.