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An Economic and Trade Comparison of Two Alternatives for the Port of Guayaquil: Constructing a Deep Sea Terminal in Posorja vs Keep Running the Actual Port of Guayaquil

By

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Abstract

The Port of Guayaquil (PoG) has faced problems of dredging during the last 10 years due to sediment accumulation in the Canal of Access to the Port and a lack of maintenance and dredging works. The opening of the new locks in the Panama Canal with a capacity for bigger vessels to pass through have raised a big concern in the West Coast Ports of Latin-America about the possibility of expecting bigger vessels in the region – for which some ports are equipped and others not. The Port of Guayaquil is not sufficiently equipped. The Government of Ecuador has therefore proposed two alternative solutions to this problem. First - building a New Deep Sea Terminal (DST) in Posorja with 3.000.000 TEUs capacity that would replace the Actual Port of Guayaquil. Or – second - keep the Port of Guayaquil as it is now with 3.1000.000 TEUs capacity, but investing in dredging works to improve the draught and the quality of the sailing through the Canal.

This thesis employs a Cost Effectiveness Analysis (CEA) and the Global Simulation (GSIM) model as methodological components to look at this issue. The CEA is used to compare the 'Business As Usual' (BAU) scenario of doing nothing at all with the first proposed policy: building a DST at Posorja. The comparison of the BAU scenario with the second proposed policy, dredging the existing Canal, is outside the scope of this research, because it is picked up in another thesis in parallel to this work. The GSIM model is used to add to the analysis the international economic impact of the deepening of the Panama Canal and asymmetric impact on Ecuador in terms of welfare, output, trade and prices. We define two scenarios to simulate the international economic impact of enlarging the Panama Canal: one scenario is where the Panama Canal is enlarged and Ecuador does nothing. The second scenario is where the Panama Canal is enlarged and Ecuador builds the DST at Posorja at the same time.

The CEA finds that the Net Present Cost generated from the DST scenario is USD 7,137 milion while the Net Present Revenue is USD 2,893 million. These costs are 246% higher than the BAU in the first 15 years, and not only during the period of construction. The difference in extra costs generated from the DST are 3.04 times in 2016 to 7.23 times in 2030. This shows a high level of costs for this project over time, while the costs from the BAU do not have much variation over the years. In addition, we found that taking into consideration only the benefits of both projects, the first 29 years there are no net benefits from the DST only from the BAU. And if we compare the costs of both projects during the first 30 years, the costs from the DST always remain higher because the extra cost from the inland transportation is much higher than the benefit received from the savings on ocean transport.

The GSIM analysis sheds more light on the trade and economic welfare impacts. We find that in both Scenarios (with and without building the DST at Posorja), Ecuador gains. Ecuador, however, gains much more in case the DST at Posorja is built. Trade for Ecuador increases more when the DST in Posorja is built: the DST effect is clearly

only positive for Ecuador, not for its regional trade partners. We also see that the effects of enlarging the Panama Canal have a much larger impact than building the DST at Posorja. When we look at national income effects, in case the Panama Canal is enlarged, but the DST at Posorja not built (scenario 1), Ecuadorian welfare goes up by Euro 276 million. When the DST at Posorja is built in addition, Ecuadorian welfare is expected to go up by Euro 502 million. These are significant amounts, albeit lower than for its regional competitors because the size of trade flows for Ecuador are smaller. When we look at output effects, it is clear, first, that the enlargement of the Panama Canal has a positive effect on Ecuador's output (+0.4%), but also on almost all other regions in the world, except for the EU, Mexico and Panama itself. A production gain of 0.4% is more than the average, when compared to all other regions in the world. When – at the same time – however, Ecuador builds the DST at Posorja, trade costs for Ecuador drop further (in addition to the Panama Canal costs drop), which will have no to a marginal impact on other countries. However, Ecuadorian production is expected to go up from the aforementioned 0.4% to 1.0%. That is a significant production impact.

We conclude that even though at the end the benefits from the DST at Posorja become evident, still the domestic price on the inland rates is so high that building the DST at Posorja is not worth is: making such a big investment, that would take years including new highways and the Terminal, is unwarranted given the cargo transport costs over there are too high. Based on these conclusions our recommendation to the Government of Ecuador that is more convenient in economic terms to keep operating with the Port of Guayaquil as now and transport the cargos via Feeders to other transshipment ports in the regions where the bigger vessels can call. That option would end up being more competitive even for the trade costs.

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List of Abbreviations

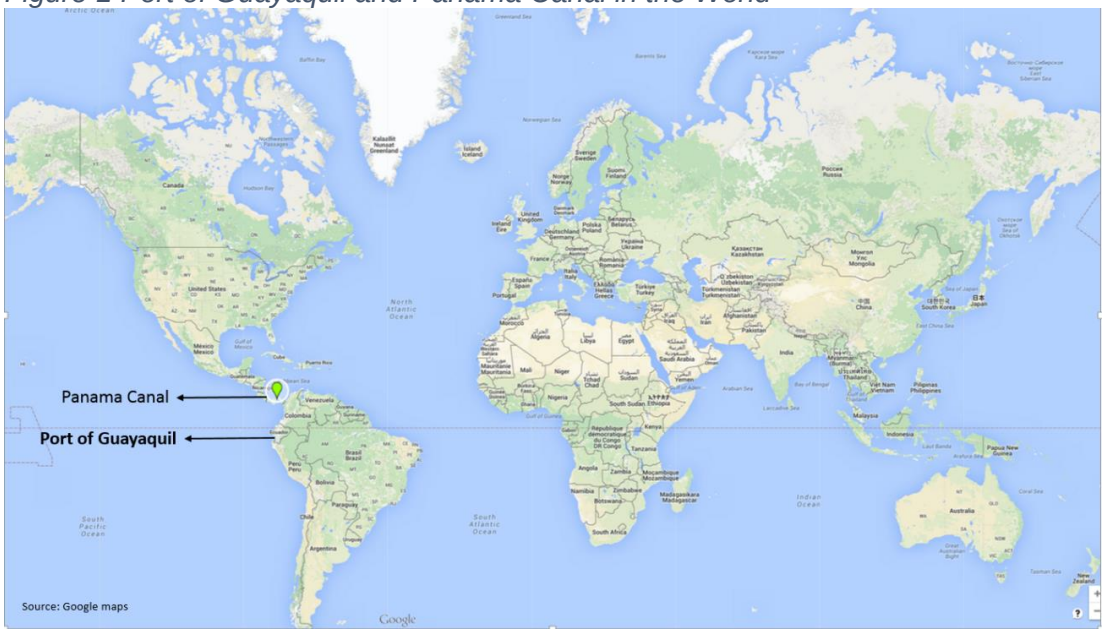
POG:	Port of Guayaquil
CEA:	Cost-Effectiveness Analysis
GSIM:	Global Simulation Model
GDP:	Gross Domestic Product
BAU:	Business as Usual
DST:	Deep Sea Terminal
IMF:	International Monetary Fund
US:	United States
EU:	European Union
ROW:	Rest of the world
CAN:	Community Andean Nations
FDI:	Foreign Direct Investment
CEPAL:	Comisión Económica para América Latina y el Caribe
SAWC:	South America West Coast
MSC:	Mediterranean Shipping Company
ICTSI:	Company of International Container Terminal Services Inc
TPG:	Terminal Portuaria de Guayaquil
VAN:	Net Actual Value
UNCTAD:	United Nations Conference on Trade and Development
COMTRADE:	United Nations Commodity Trade Statistics Database
THC:	Terminal Handling Charge
TEUs:	Twenty-foot equivalent unit

Chapter 1 Introduction

1.1 Context

Since 2009 the future of the Port of Guayaquil (POG) has been heavily debated in Ecuador, driven by economic and political interests. Guayaquil is the Main Port of Ecuador located in the Province of Guayas. It mainly focuses on container handling and it is responsible for approximately 90% of the non-petroleum imports and exports of the country, while the other Ports of Manta, Esmeraldas and Puerto Bolivar together handle 10% of the cargo. The most important export commodities of the country after oil are bananas, shrimps and cocoa beans which are mainly produced in the Province of Guayas: 30.64% of bananas exports, 61% of shrimps and 35% of cocoa beans. Regarding the total imports of the country, 57% of the cargo have Guayaquil as a final destination and while second place is taken by Quito with 26% of the imports (Newspaper El Universo, 2013).

Figure 1 Port of Guayaquil and Panama Canal in the World

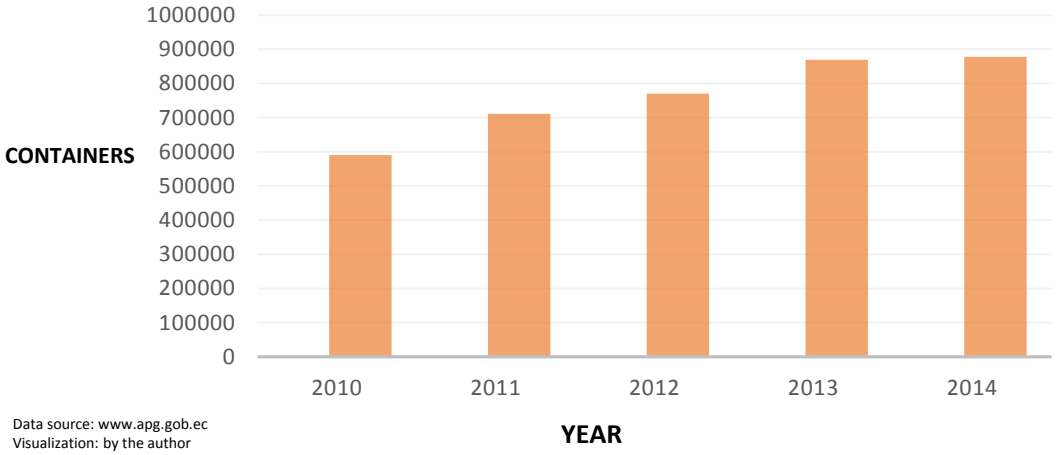


Due to problems regarding the depth of the access to POG and in order to be prepared for the opening of the new Locks in the Panama Canal, there are some potential choices that Ecuador has to make. If not, Ecuador may miss out regionally. The problem for Ecuador is that the draught of POG is not very deep – not compared to competitor ports regionally, and not for vessels that may – in the future – make use of the enlarged Panama Canal. So Ecuador needs to act pro-actively if it does not want to lose out. More concretely, the actual conditions do not allow Post-Panamax and bigger vessels to call at the port. When looking at the options that Ecuador most likely has, it is possible to distinguish two of them. The first option is that policy makers could choose for building a Deep Sea Terminal in Posorja that would work as part of

the POG but would provide for a deep-sea port. The second option is to dredge the POG (permanently) and make adjustments to the current POG. Clearly there are economic and political interests involved. Looking deeper into these two options, it is important to find out what option is most attractive for Ecuador taking into account its actual possibilities and economic interests.

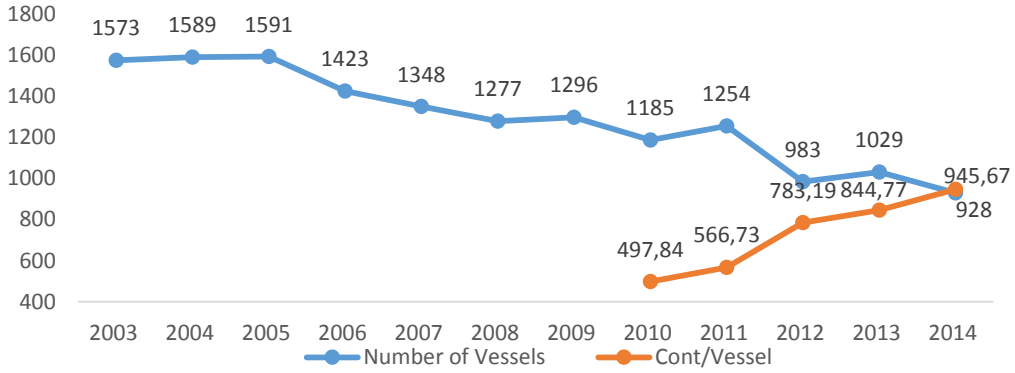
Below chart shows the traffic of international vessels calling at the Port of Guayaquil, from 2003 to 2014, we can see that during those years there had been a decrease on the number of vessels. On the other hand we can notice that the average of containers per vessel had decreased in almost 50% over the last five years since 2010, which is the latest data that was possible to collect from the Port Authority. If we analyze these two data and compare them we can deduce that there could be an inverse relationship between those variables, we can attribute this to an increase of the size of vessels coming into the Port.

Figure 2 Total number of Containers arriving to POG



Data source: www.apg.gob.ec
Visualization: by the author

Figure 3 Vessels arrived at Port Authority of Guayaquil and Average containers per vessel



Data source: www.apg.gob.ec
Visualization: by the author

According to the statistics of the Port Authority of Guayaquil for the period from 2007 to 2012, there is a trend of containerization of the cargos: with respect to imports. The

degree of containerization increased from 70% to 90% and for exports this increase was from 58% to 88% (Port Authority of Guayaquil, 2007-2012).

Although this is a public project that will be decided by the government, it also involves the private sector with the entry of a new Leasing Company that will build, operate and run the new Deep Sea Terminal. One of the main objectives is to safeguard the welfare of the country as a whole taking into account the possible negative effects that the implementation and running of the new project could bring to all the parties involved. This also needs to be researched further.

1.2 Research Objectives

This thesis aims to look at the first option that suggests building a Deep Sea Terminal at Posorja. This thesis will focus on the expected costs and benefits – doing a Cost Effectiveness Analysis (CEA) and a Global Simulation. As part of that GSIM Model, this thesis will also look at what the potential economic impact of this investment could be in terms of welfare for Ecuador, output, trade, and prices (on the benefit side).

We will examine potential costs and benefits and try to give a value to them – including looking at future potential costs and revenues. We will then examine different models to look at potential economic impact of such a Deep Sea Terminal in terms of welfare, GDP, trade and prices.

The CEA will help us to measure and determine if the monetary and non-monetary benefits will overcome all the costs related to the investment generated from the building and running of the prosed new Deep Sea Terminal in Posorja. If the CEA gives a positive result, meaning that the discounted benefits in general are higher, then we will be able to conclude that this scenario is a better option for the country than to do nothing, not only in monetary terms but also in broader economic terms.

We use the Global Simulation (GSIM) model to add to the analysis the international economic impact of the deepening of the Panama Canal and asymmetric impact on Ecuador in terms of welfare, output, trade and prices.

1.3 Research Question

The aim of this study is to determine whether one scenario, the scenario to build a new Deep Sea Terminal in Posorja, to deal with the actual problem of the limited draught of the POG, is a net beneficial one in terms of economic outcomes by employing a Cost-Effectiveness Analysis (CEA) and also assessing the impact of the Panama Canal in Ecuador in terms of national welfare and revenue effect by the application of the GSIM Model. This thesis does not aim to look at the option of dredging the canal to the existing POG – this topic falls outside the scope of the present analysis. Our research question will therefore be:

What are the economic and trade effects for Ecuador of building a Deep Sea Terminal at Posorja compared to keeping the Port of Guayaquil as it is today (Business As Usual scenario) as a response to the Panama Canal expansion?

In order to answer this research question, we ask ourselves the following sub-research questions (in brackets the chapter where we will answer these sub-research questions:

- What is the position of Ecuador and POG within the regional competitors? (Chapter 2)
- What are the effects of the Panama Canal expansion in terms of trade flows, vessel size and expected transportation costs? (Chapter 2)
- Are the benefits from building a DST higher than the cost? And higher than the benefits of the BAU? (Chapter 4)
- What is the global effect of the Panama Canal expansion? (Chapter 4)
- Is there a real gain for Ecuador in terms of trade effects, welfare and output effects if the DST is built? (Chapter 4)
- What is the best option for Ecuador to face the Panama Canal expansion? (Chapter 5)

1.4 Structure of the thesis

In order to answer the main research question and the sub-questions, this thesis is structured as follows.

In Chapter two, we present the contextual picture that matters for this research in three parts. First, we look at the competitive position of Ecuador compared to other countries in the region. Second we describe the competitive position of the POG compared to regional competitor ports (including a comparative overview of POG infrastructure). And third, we estimate the effects of the Panama Canal expansion on trade flows, composition, vessel size and container transportation costs. Chapter three covers the methodological approach taken in this thesis: what are the best methods to carry out a counterfactual analysis in terms of monetary and non-monetary costs and benefits compared to a 'business-as-usual' (BAU) baseline? How do these methods work in detail and what are their data requirements? We describe a Cost-Effectiveness Analysis and the GSIM (Global Simulation Analysis) model for our analysis. In Chapter four we present the results of the Cost-Effectiveness Analysis (CEA) and the GSIM model. Chapter five concludes, provides policy recommendations and suggests areas for further research.

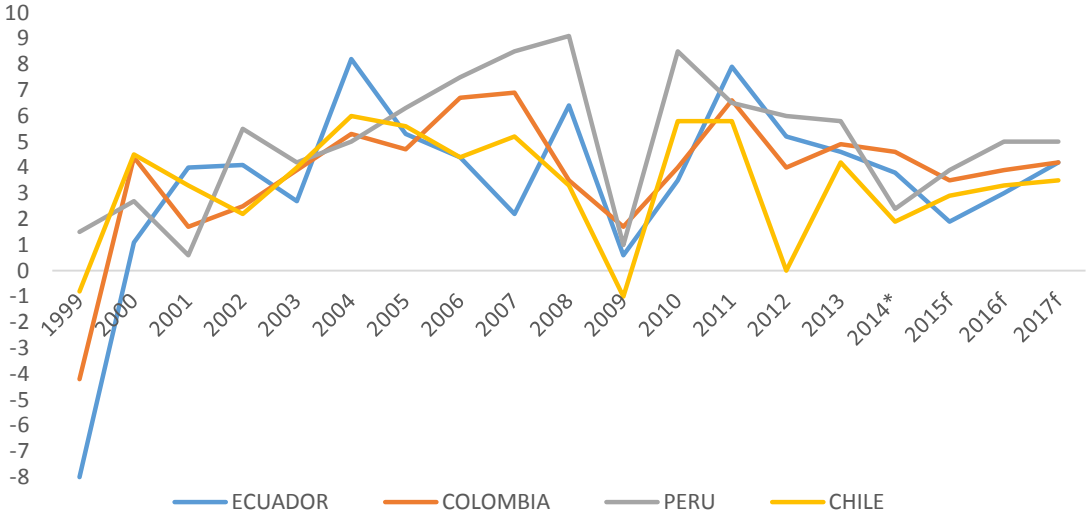
Chapter 2 Contextual environment in Ecuador

In Chapter two, we analyse the context. This contextual analysis consists of three parts: the competitive position of Ecuador compared to other countries in the region, the competitive position of the POG compared to regional competitor ports (including a comparative overview of POG infrastructure), and an estimation of the effects of the Panama Canal expansion on trade flows, composition, vessel size and container transportation costs.

2.1 Competitive position of Ecuador vis-à-vis regional competitors

In the Figure below, we can see the GDP growth of Ecuador and the countries in the same region along the West Coast of South America, the biggest growth is from Peru, followed by Colombia, Ecuador and at the end by Chile.

*Figure 4 Real GDP Growth % South America West Coast 1999- 2017**



Data source: World Bank
Visualization: by the author

Despite the international crisis, Peru has been considered as the Latin American miracle, for the important growth on its GDP since 2010, keeping the trend in 2012. The principal axil of its growth are construction, trade and services, plus the monetary and currency policy of the last years. Peru is the second biggest producer of copper and silver and the sixth biggest producer of gold in the world. All this added to an increase in the agricultural sector which predicted a constant sustainable growth (Newspaper El Pais, 2012).

Colombia is considered to be one of the top 14 economies of most international influence and it is the second growing economy in Latin America. Its GDP growth is based on the growth in such sectors as construction, mining and as well as in

industrial sectors. The Government on the other hand had been encouraging the foreign investment (Newspaper Portafolio, 2014).

Chile is known for its stable fiscal and commercial policy helping the country to reduce its exports due to the US and European crisis (Newspaper El Pais, 2012).

The economic growth of Ecuador from 2014-2015 has not been expected due to the fall in oil prices which led to government expenditure cuts and new fiscal policies in order to decrease the imports and to reduce the outflows of capital from the country, imposing new and higher taxes to a wide variety of imported products (International Monetary Found, 2014).

According to the International Monetary Fund (IMF), Latin America economies should strengthen public finances and reform the economic structures in order to manage the world decrease in the prices of raw materials and increasing financing costs that would affect the growth in the region. In case of financially integrated economies, such as Chile, Colombia and Peru it's advisable to calibrate macroeconomic policies, reducing financial vulnerabilities. What concerns raw materials, export countries like Ecuador are expected to experience a drop in the growth in 2015 (International Monetary Fund, 2014).

Figure 5 Evolution of volume of country exports in TONS of the main products

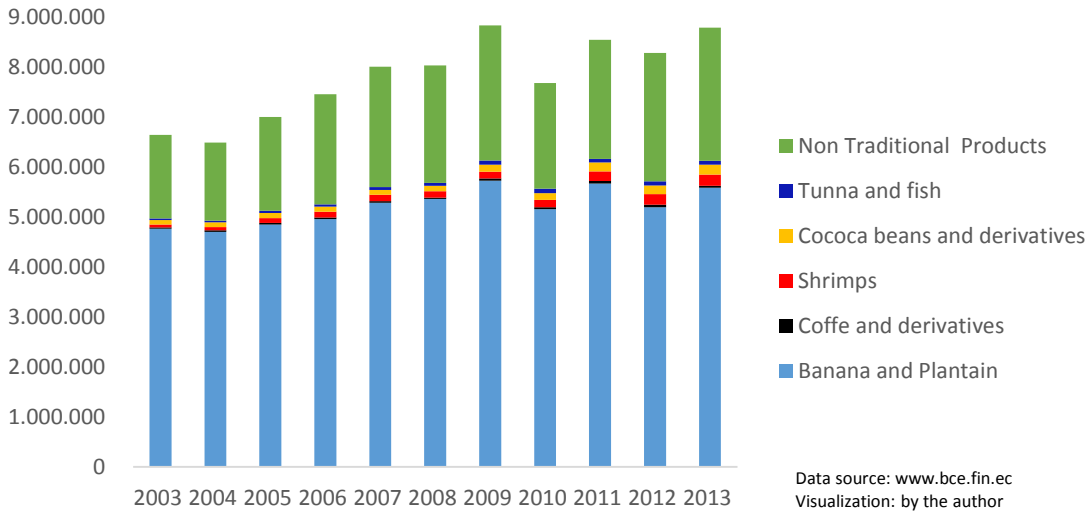


Table 1 Regional Trade

	Main trading partners	**Basic traded products**	**Main traded products**
Ecuador	US 37%, America, European Union 22%, China 9.6%, Mercosur 8%	Oil and agricultural exports 77%, industrial products 23%	Oil, bananas, can tuna, fish, shrimps, flowers, cocoa beans

	Main trading partners	Basic traded products	Main traded products
Colombia	US 36.2%, EU 23.4%, CAN 8.4%, Venezuela 5.7%, Mercosur 5.2%	Mining and oil 60.7%, followed by manufacture products, agricultural, food and beverage	Coffee, crude oil, refine oil, coal , gold, flowers
Peru	US 20%, China 18%, EU 18%	Mineral products 74%, agricultural and fishing 25%	Cooper, gold, zinc, oil gas, minerals, coffee, animal feed
Chile	China 22%, US 17%, EU 16%	Mining and oil 53.3%, manufacture products 27.7% and agricultural products 19%	Cooper, minerals, fresh fruits, salmon, wood paste (cellulose), manufactured wood, drinks and alcoholic drinks, wine, gold

In 2014 Latin America received USD158.803 million of Foreign Direct Investment, 16% less compared to 2013.

The outputs of FDI from the region also decreased by 12% in 2014 the slowdown of the economy and the decrease in the prices of export products reducing the revenues by 16% in the countries of the region, giving a rate of return of 5%. In the case of SAWC countries like Colombia faced a drop of 10% in the revenues of FDI, Chile -12% and Peru-14%. As a result of this, the percentage of revenue reinvestments decreased. According to CEPAL study, a further drop by 10 per cent is expected on the FDI in the region for 2015, mainly in yields like mining and fuel (CEPAL- United Nations, 2015).

Europe and the U.S are the main sources of FDI in the region. In case of Colombia, 28% of the FDI comes from Latina America and Caribbean countries, 43% from Europe, and 14% from the US. In case of Ecuador, Canada is the bigger fund with 30%, followed by Latin America and Caribbean with 24% and Europe 23%. The countries of the region are looking for foreign investments in activities with positive environmental impacts like: renewable energy, agriculture, tourism, manufacture, etc. According to the experts, a fall of around 10%.in the FDI in the region is expected in 2015 with this expected decrease it is also expected that these economies will experience slow growth (CEPAL- United Nations, 2015).

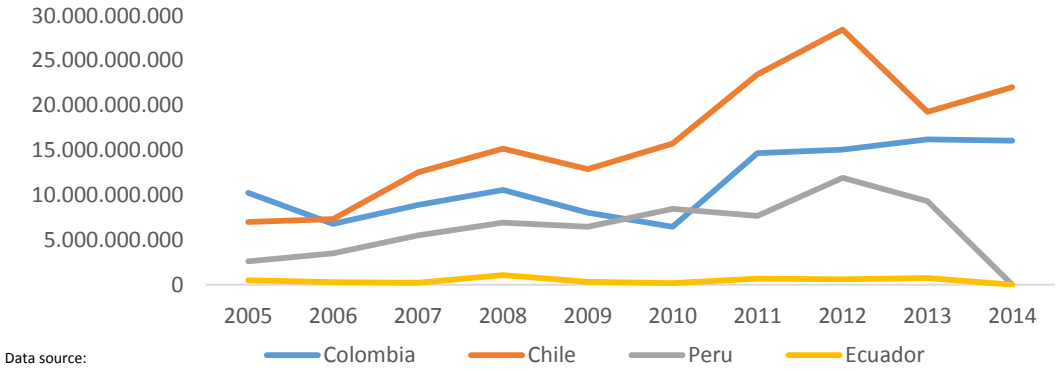
In Ecuador in 2014 23% of FDI came from Europe (mainly Spain, Netherlands and Switzerland), 41% from Canada, and 11% from Latin America and Caribbean, 14% from China and 12% from unknown countries and the rest from the U.S. and other countries in small percentages The total of 68% was directed to natural resources investment, 14% to manufacture and 17% to services (Expansion, 2014)

In 2014 FDI in Ecuador increased by 6%, two thirds of FDI went to natural resources sector, while manufacture sector received only 14% of the flows of capital that year. Service industry fell from 43% to 18%. At this moment the government is trying to attract new FDI for oil explorations in new reserves, which is estimated to increase the income flow for the next 5 years. On the other hand food and beverages are receiving attention from foreign companies. For example, the Mexican Arca Continental which just acquired the lacteal company Tonycorp and Coca-Cola that had announced investments in the upcoming five years.

Ecuador had issued a framework within financial services on international public banking for big infrastructure projects called “Ecuadorian Principles”, an environmental and social management risk system for developing countries that focus on supporting risk responsible decision for new FDI that had been applied by the banks of the region and foreign banks investing in this region (CEPAL United Nations, 2015).

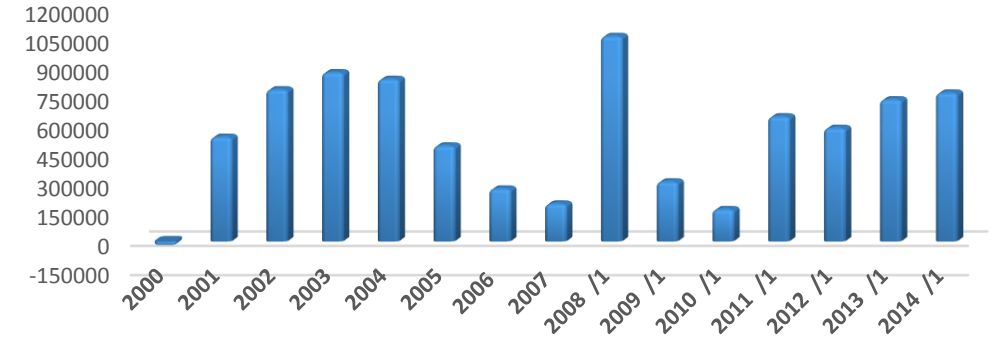
According to the data from World Bank on the FDI, in Ecuador compared to the other economies in SAWC we can see that the last ten years Ecuador got the lowest flows of money from the region. Chile has the highest FDI, followed by Colombia and Peru.

Figure 6 FDI of SAWC of net capital income (USD)



Data source:
datos.bancomundial.org/
Visualization: by the author

Figure 7 Ecuador: Total Foreign Direct Investment



Data source: Central Bank of Ecuador
Visualization: by the author

2.2 Competitive position of the Port of Guayaquil vis-à-vis regional competitors

2.2.1 History of the Port of Guayaquil

In the XVII th century Guayaquil was an important trade and industrial center in the South Pacific. It was built on of the most emblematic shipyards in America due to the variety and quality of the wood employed, the qualified labor force that also brought foreign labor after the conquest of the Spanish and finally the strategic location of the Port Terminal. The reputation of the city as a shipyard was one of the reasons that Guayaquil became a Port.

During 1959-1963 the Port Authority at that time managed the funding for the construction of the Maritime Port ¨Libertador Simon Bolivar¨, through a loan of usd13 millions from the World Bank, which imposed the creation of a Private Port Authority scheme in 1958 (El Universo Newspaper, 2013).

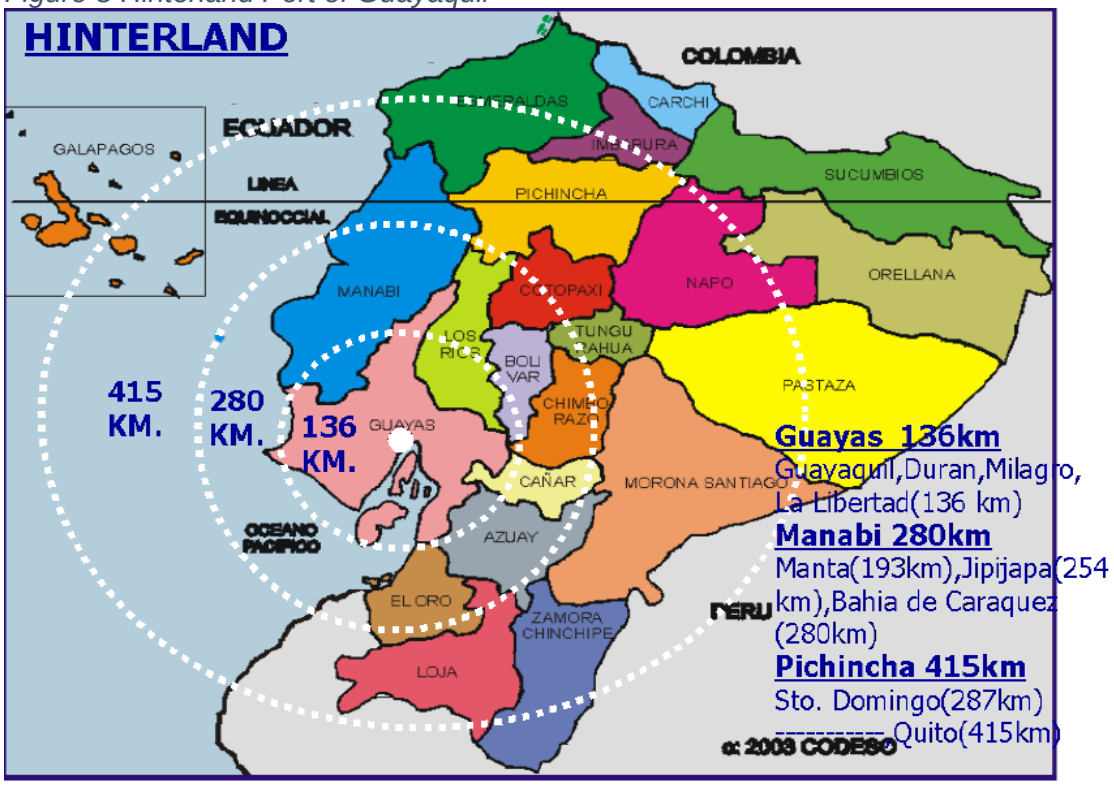
Port of Guayaquil was opened in January 1963 with the aim to develop the national economy at that time. As a result of modernization processes since 1996, the Port Authority decided to move the model to a concession one, allowing private companies to run and manage the Terminals.

2.2.2 Inland Connectivity

The hinterland of the Port of Guayaquil is one of its main strengths since it is located in the city of Guayaquil which has almost 3'000.000 of habitants. The city of Guayaquil concentrates important industries of goods and services, preserved food manufacturers, oil refineries and has a big volume of commercial activities that is expected to continue growing. Due to the previous facts most of the imports stay in Guayaquil and most of the exports come from the Province of Guayas and the neighboring provinces, where it is easy to appreciate agricultural plantations of African palms, bananas, cocoa beans, shrimps, etc. The Capital of the country is Quito, and it is also the second bigger destination of the imports located just 415kms from Guayaquil.

In the economic yield, in case of building a new Terminal in Posorja the distance for the inland connectivity would represent a disadvantage compared to the distances from the actual Terminal. This could lead to the decision of the shippersto change the Port of Loading, for example in the bananas sector where most of the plantations are in the Province of Guayas, Los Rios and El Oro. For this sector there is the possibility to load through the Port of Bolivar in the province of El Oro. This port does not have the same frequency of shipping services but with an increase in the volume the shipping lines it could be able to increase the frequencies and the services over time. One consequence of the increase in the distance from the new Terminal in Posorja would also be an increase in the truck transportation cost which is the only hinterland leg in the country. The transit time would increase as well in this case.

Figure 8 Hinterland Port of Guayaquil



Source: Kevin Lazo, 2008.

Regarding only the bananas exports there is a weekly movement of around 1500 trucks transporting the fruit from Guayas and Los Rios (Association, 2013).

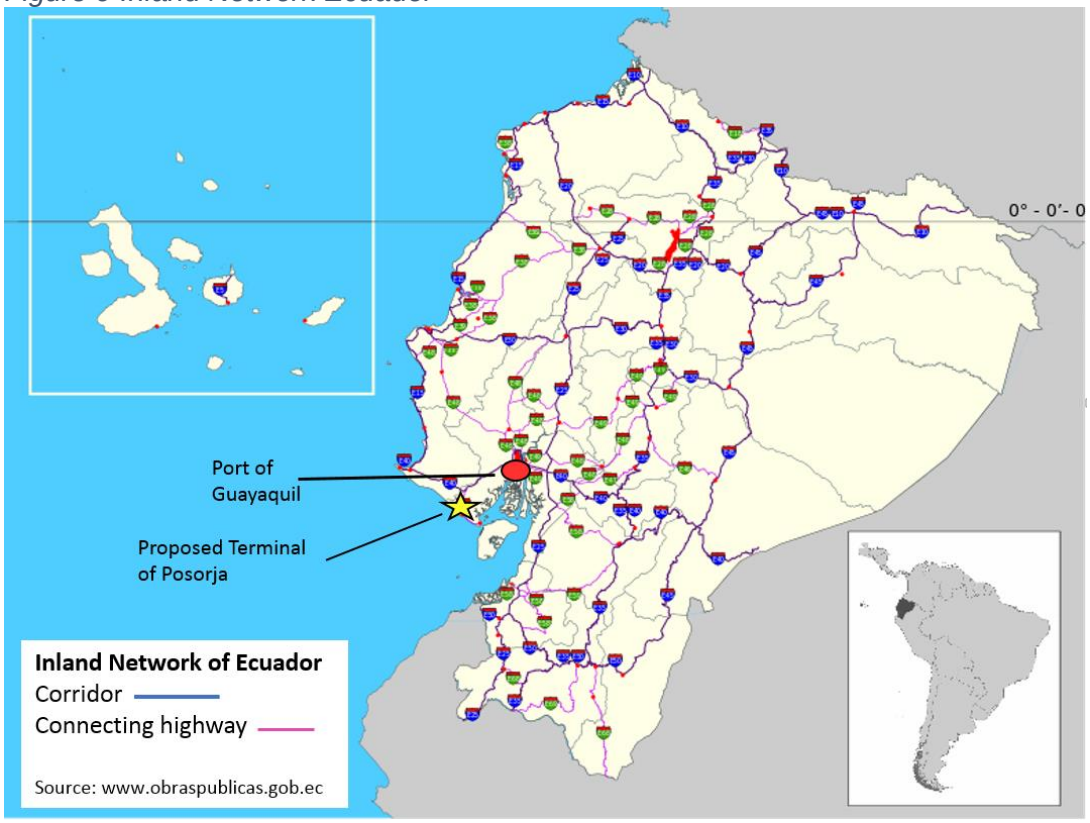
The actual cost for inland cost from the Port of Guayaquil to the factories located within the city for 20 and 40 feet dry containers are around usd180 and usd250 respectively with a path of about 15kms (Zurita, 2015).

The distance to the main origin and destinations provinces of the cargos from the Port of Guayaquil are:

- Guayas 136km: Guayaquil, Duran, Milagro, La Libertad (136 km.)

- Manabí 280km: Manta (193km), Jipijapa (254 km.), Bahía de Caráquez (280km)
- El Oro 280km: Puerto Bolívar (193km)
- Pichincha 415km: Sto. Domingo (287km), Quito (415km)
- Loja 415km: Loja (415km)

Figure 9 Inland Network Ecuador



Source: Own elaboration

In the above figure we can appreciate the corridor and highway network of Ecuador, also the Port of Guayaquil and the location of the proposal new Deep Sea Terminal located in Posorja.

The Port of Guayaquil is highly connected with the main zones of the country. The location of the new Terminal in Posorja is connected by an actual highway infrastructure which was not designed to manage the transit of the amount of trucks expected with the new Terminal. According to the government the construction of a new faster and shorter highway is planned in case of the construction of the new Terminal, but there is still no information about the execution of it.

According to an interview to the Logistics Manager of Mediterranean Shipping Company-MSC Ecuador Mr. Renato Zurita, who is in charge of the containers inland logistics in Ecuador, the rates for the inland would increase either with the actual highway or with the new highway expected to be built, because in both cases the distance and transit time will increase. With the actual highway the distance from

Guayaquil-Posorja is around 134 km and a transit time of 2.5 hours. If the new highway is built the distance would be 75km with a transit time of 1.5 hours.
In the next charts we can observe the predicted values according to MSC Ecuador that would be charged in both cases for the New Terminal and the actual rates for the Port of Guayaquil:

Table 2 Expected rates to/from the New Terminal in Posorja

Actual Highway		New expected highway	
Origin/Destination	**Rate USD**	**Origin/Destination**	**Rate USD**
Quito	1370	Quito	1220
Manta	850	Manta	700
Machala	900	Machala	750
Guayaquil	580-650	Guayaquil	450

Table 3 Actual rates to/from Port of Guayaquil

From/to Port of Guayaquil	
Origin/Destination	**Rate USD**
Quito	970
Manta	450
Machala	500
Guayaquil	180-250

2.2.3 Current quality of port infrastructure and state of affairs

2.2.3.1 Current infrastructure of POG

The Port of Guayaquil is located in the Pacific Coast in South America, with a total area of 103.000 square meters. The size of the docks are 180 x 31.5 meters of extension, designed to support Gantry cranes. The walls of the docks can support berthing shocks of 45.000tons (CONTECON Guayaquil, 2015).

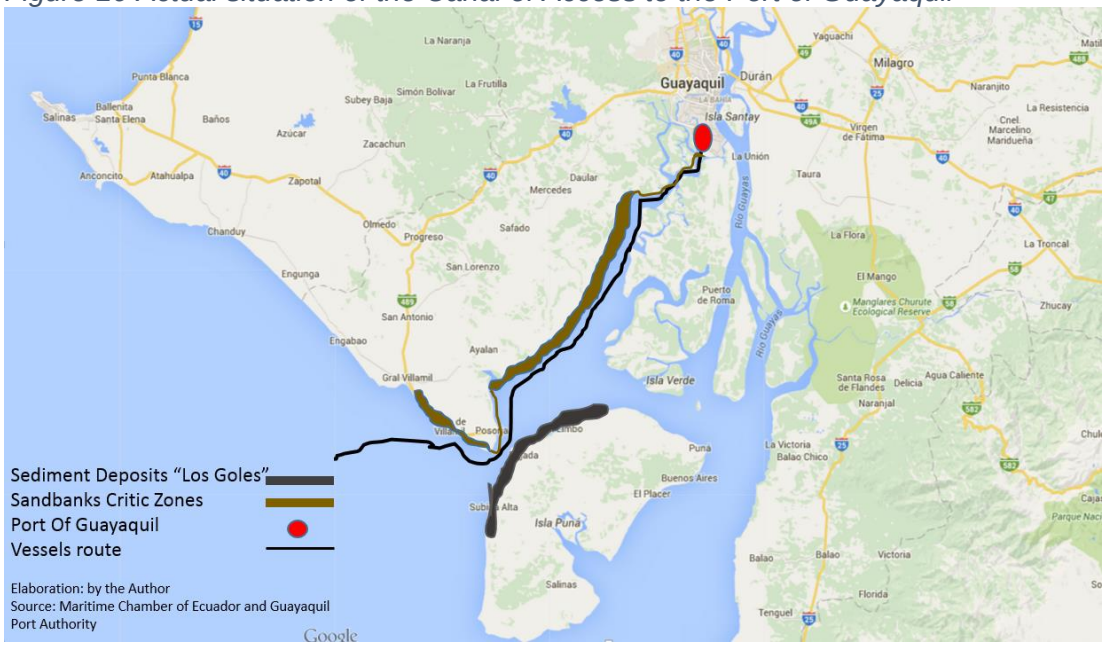
The access to the Terminal from the sea is through a Natural Firth called “Canal del Morro” at the entrance and further called “Estuary Salado”. The access Canal has the following features:

- Length: 51 nautical miles divided between a marine external Canal (10.8 nautical miles) and an interior canal (estuary) of 40.2 nautical miles.
- Width: 122 meters
- Depth: 10.5 meters at high tide and 8.2 at low tide
- Average Breadth of the tide at the entrance: 1.80 meters
- Average Breadth of the tide at the dock: 3.80 meters

The Canal is subject to tidal action, two high and two low tides daily, varying along the canal and also according to the season (Port Authority of Guayaquil, 2015). According to the Port Authority the dredging of “Los Goles” is fundamentally important. The dredging basically involves removing the rocks at the entrance of the Access Canal that does not allow the access of bigger vessels than Panamax loaded at full

capacity. Further in the canal there is also need for a dredge due to critic accumulation of sandbanks zones. The ideal draft requested for the Port is 11 mts at a low tide and 13 mts at high tide, which would allow bigger vessels to call at this Port including also Postpanamax (Port Authority of Guayaquil, 2015).

Figure 10 Actual situation of the Canal of Access to the Port of Guayaquil



The Port is located 10kms from the downtown of the city, its preferential location is the principal incentive for the traffic of the routes to the Far East and the American Continent, especially to the pacific Coast Ports (CONTECON Guayaquil, 2015).

POG has enough infrastructure including docks, loading and unloading cranes, access routes, container yards for storage, electric plug in for reefers containers, customs areas and stuffing and unstuffing yards (Peña, 2013).

2.2.3.2 POG performance

The main trade partners of origin and destination of the cargos handled by the POG are the US, European Union and Latin America. Main exported commodities are bananas, frozen shrimps, plantain, hardwood, cocoa beans, pineapple, tuna, froze fish, etc. and main import commodities include vehicle parts, plastic materials, paper, chemicals products, fertilizers, metals, canned food, etc.

Compared to the previous year, in 2014 POG increased by 14.5% in its volume, thereby, reaching the second place within the Andean Community Nations (CAN), after Buenaventura in Colombia with 15.6% (Andean Community Nations , 2014).

The volume of cargo handled by the Port had been increasing year by year, in 2012 Guayaquil moved in/out 558.416 containers through six container terminals located

at the Port: Contecon, Andipuerto, Inarpi, Fertisa, Naportec and Trinipuerto (Peña, 2013).

2.2.3.3 Terminals within the Port of Guayaquil

The Port of Guayaquil is concessioned by the Company of International Container Terminal Services Inc. (ICTSI), established in the country as Contecon Guayaquil S.A which started its operations in August 2007 for a period of 20 year, being the biggest Terminal in the Port (Port Authority of Guayaquil, 2015).

There are also some private dedicated terminals that also offer container handling services:

- Andipuerto Guayaquil, is a grain bulk and multi-purpose Terminal the tender was issued in 1998, but it is also allowed to handle general cargo and containers (Adinaves Company, 2010).
- Inarpi is a private Terminal, concessioned in 2006, its core services are: storage of containers, storage of LCL cargos and stevedoring (TPG, 2013).
- Fertisa is a multi-purpose Terminal, which has a dock of 300mts and 50.000square meters of yards, allowed to manage imports and exports. It is considered to be the most flexible Terminal, because it's the only one that has a close dock type (Fertisa Terminal, 2015).
- Naportec was opened in 2002, as Terminal Operator, handled by the Company Dole which finished its operations as ship owner and shipping agency to operate as a terminal operator. This terminal provides inland services for dry and reefer containers, storage, loading and unloading, tracking of containers. In reality it operates at Bananapuerto, with an area of 120.000sqmeters (Naportec, 2013).
- Trinipuerto started in 1995, for handling all kinds of bulk and LCL cargos, for vegetables and minerals. It is the oldest Terminal with a dock length of 125mts, able to receive vessels until 2010m of length, with warehouse with storage capacity of 140.000 metric tons (ASOTEP, 2015).

According to the information provided by the Port Authority of Guayaquil in 2012, the total of dock's hours available in general cargo Terminals was 44%, in grain bulk and multi-purpose Terminals 62% and in terminal containers 43%, meaning that there is still a considerable unused capacity in general and container terminals in Guayaquil, so it is still capable to handle an increasing volume of cargos and traffic without any physical extension (Port Authority of Guayaquil, 2015).

2.2.4 An investigation into regional competitors for Ecuador

Nowadays with the globalization all the countries around the world have the need to adapt themselves to the new challenges, like foreign trade, for example. With growing trade between the regions and growing economies like China the shipping industry is in need for innovations in their technologies and ways of operating. In current circumstances, shipping industry needs to strive for transporting higher volumes of cargo at much competitive costs and prices. Due to this the shipping lines had been increasing the sizes of the vessels, but this also brought a new challenge for the Ports in order to adjust their infrastructure and capacity to be able to handle the new

vessels. This worldwide trend encouraged some countries and Port Authorities to invest and be prepared for this new wave of shipping. One of the most important examples in Latin America is Panama with their new locks that are expected to be opened in 2015, this will allow bigger vessels till 15.2 meters of draft to pass through the Panama Canal to the West Coast of South America *(Maritime Chamber of Ecuador, 2013)*.

With the operation of the bigger vessels the Ports have the challenge to increase their draft to approximate 11 meters to be able to call at the Ports. The canal of access to the Port of Guayaquil has a draft of 9.60 meters meaning that it's not possible to receive those vessels. In reality the canal of access only allows vessels with a draft of 8.20 meters at low tide and with a maximum of 9.75 meters. For this reason it is vital for the country and for the port to take new measures.

Within the Latin America and Caribbean Region Ecuador's Port of Guayaquil is ranked as the 8th port out of the 120 ports in the region (2014). Main competitor port in the SAWC region that is ranked higher than the one in Ecuador is the port of Callao in Peru which hold the position number 6. In 2013-2014 the Port of Guayaquil increased the throughout by 7%, reaching the maximum throughout Callao.

Chile which is also located in SAWC, has the highest ranking of its ports. San Antonio holds the place number 12, with a fall in the throughput by 9% from 2013-2014 followed by Valparaiso which holds the position number 14. Colombia in the Pacific Coast is raked 17 with the Port of Buenaventura. The other ports of in the SAWC hold positions after 17 *(CEPAL, 2014)*.

Table 4 Latin America and The Caribbean Container throughput, Ranking 2014

RANKING	PORT	COUNTRY	2012 (TEU)	2013 (TEU)	2014 (TEU)	CHANGE % 2014/2013
1	Balboa	Panamá	3,304,499	3,187,387	3,468,283	9%
2	Colón	Panamá	3,518,669	3,356,060	3,286,736	-2%
3	Santos	Brasil	2,961,426	3,221,348	3,040,231	-6%
4	Manzanillo	México	1,992,176	2,118,186	2,368,741	12%
5	Cartagena	Colombia	2,205,948	1,987,864	2,236,551	13%
6	Callao	Perú	1,817,663	1,856,020	1,992,473	7%
7	Kingston	Jamaica	1,855,425	1,703,949	1,638,113	-4%
8	Guayaquil	Ecuador	1,448,687	1,519,059	1,621,381	7%
9	Buenos Aires	Argentina	1,656,428	1,784,800	1,400,760	-22%
10	Freeport	Bahamas	1,202,000	1,500,000	1,400,000	-7%
11	San Juan	Puerto Rico	1,423,192	1,269,902	1,319,961	4%
12	San Antonio	Chile	1,069,271	1,196,844	1,093,625	-9%
13	Limón-Moin	Costa Rica	1,045,215	1,053,734	1,089,518	3%
14	Valparaíso	Chile	942,647	910,780	1,010,202	11%

15	Lázaro Cárdenas	México	1,242,777	1,051,183	996,654	-5%
16	Caucedo	República Dominicana	1,153,787	1,083,208	915,101	-16%
17	Buenaventura	Colombia	850,385	851,101	855,404	1%

Source: http://www.cepal.org/

According to the historical data of the throughput from the region there is evidence about the slowdown of foreign trade within Latin America and Caribbean terminal during the last years. Since 2011 the growth of this sector was 13.8%, then in 2012 it grew only by 5.8% and finally in 2013 by 1.7%, being the average growth of the region at 1.3%. But in 2014 SAWC Ports faced a recovery of the throughput of the ports from 3.8% in 2013 to 5.3% in 2014, being the leading countries: Colombia with a growth of 7%, Peru 8.7% and Ecuador 7.9% (CEPAL, 2014).

Figure 11 Ports Ranking. The Top 20 in Latin America and the Caribbean in 2014

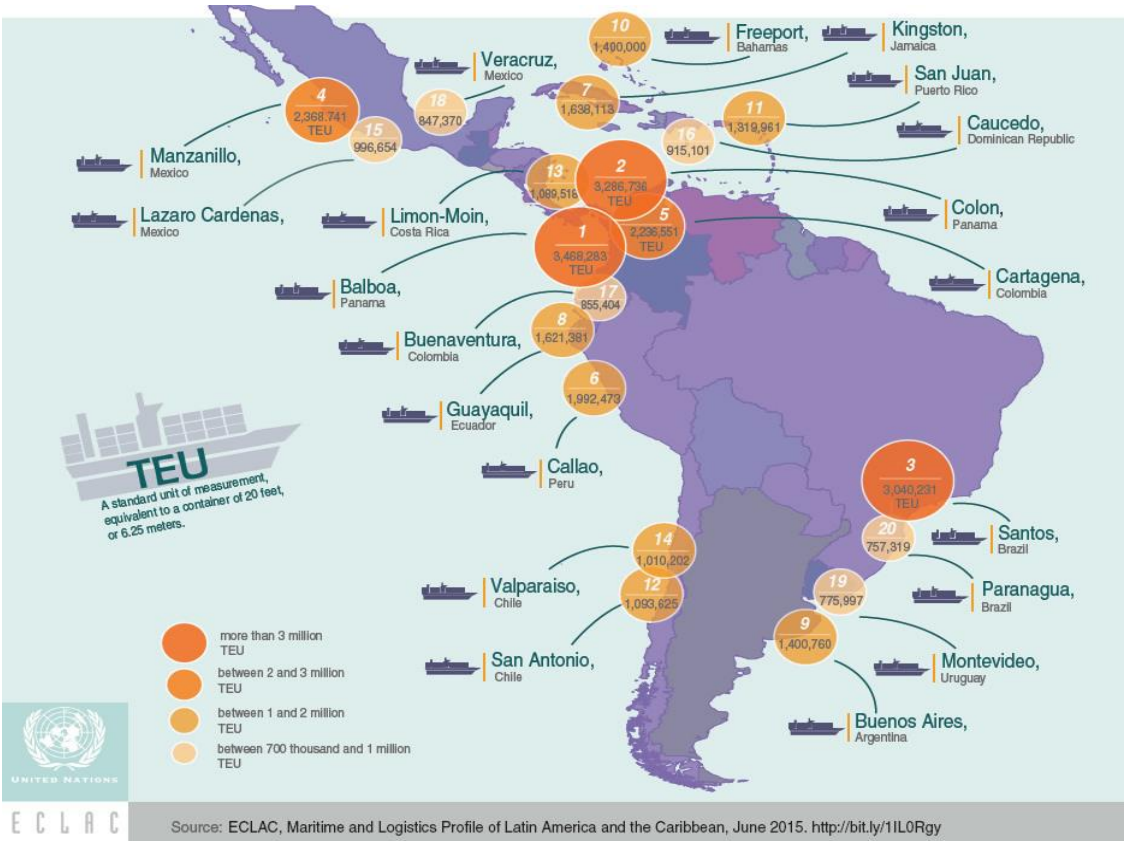
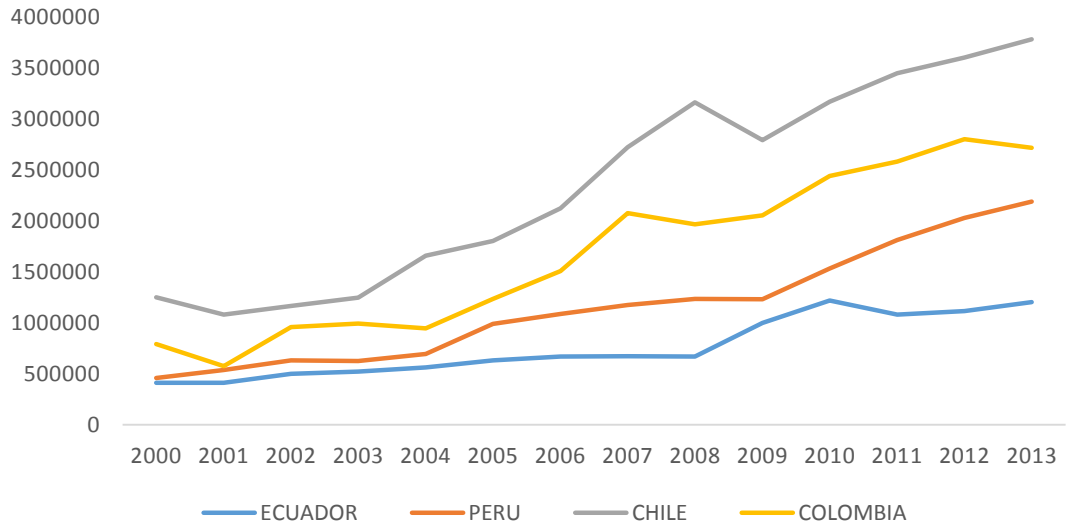


Figure 12 SAWC Maritime Traffic evolution in TEUs 2000-2013



Data source: World Bank
Chart: own elaboration

For this study we had selected the biggest ports per each country in the SAWC according to the raking of ports: in Peru the Port of Callao, in Colombia Buenaventura and in Chile San Antonio.

Regarding the drafts of the mention ports the deepest one in the region is Callao with a depth of 12.5 meters, followed by San Antonio with a depth of 11.58mts, then Buenaventura with 10.7 mts and at last Guayaquil with the lowest depth of 9.75mts (El Universo Newspaper, 2013).

Figure 13 SAWC main competitive Port's drafts

2.2.5 The economic importance of POG for the Ecuadorian economy

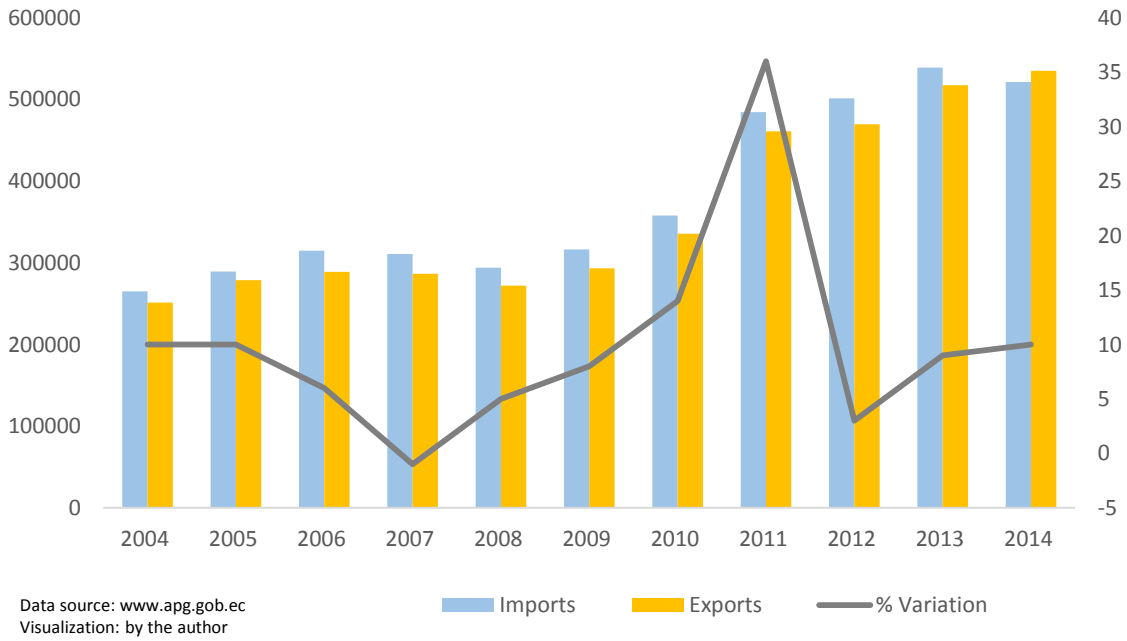
The Port of Guayaquil handles approximately 70% of the total flow of total cargo of the country and 95% of containerized cargos, due to the Hinterland of the Port that is the most important of the country (Maritime Chamber of Ecuador, 2013).

The maritime transport is vital for the economy of the country since 90% of trading with the rest of the world is done this way and since the economy of the country is based on 70% foreign trade.

The Port of Guayaquil handles important amounts of cargos, 57% of the imports and 72% of the exports of the country. Most of the export products are originated in the province of Guayas and it surroundings which are still located in the proximity to the Port of Guayaquil. That's why there is an economical agglomeration within this part of the country, considering that the hinterland is the biggest strength of the Port (Maritime Chamber of Ecuador, 2013).

From the next chart we can see that the volume of TEUs on imports and exports in the Port Authority of Guayaquil have increased, meaning that there had been a growth in foreign trade. Maritime traffic does not only consist on the movement of TEUs but also in the number of vessels that arrive to the Port Terminal.

Figure 14 International Container Traffic Evolution in Port Authority of Guayaquil (TEUs)



Data source: www.apg.gob.ec
Visualization: by the author

In reality POG is a big source of employment, there are 2800 people in direct jobs, in addition it also generates 2000 jobs in other sectors, such as insurance companies,

equipment suppliers and 92 unions within the Port. In addition indirect employment is generated in truck transportation, informal trader, food, etcetera (Newspaper El Universo, 2013).
The balance of trade is measured in imports and exports. 70% of the activities in the country are linked to foreign trade.

2.3 Expected impacts of the Panama Canal expansion for trade flows and costs

The expansion in the Panama Canal will allow Post Panamax vessels to sail through the canal from the Atlantic to the Pacific Coast, which is not possible until now. The Canal is fundamental for the trade activities of the world, mainly for the Americas.

According to some studies the expansion of the Panama Canal will lead to an increase in the volume of the cargo that comes to West Coast by 3% annually, with a double effect for 2025. It would be essential to increase the efficiency of the operation of all the ports along cost, due to an increase in the transit of cargo, without increasing the number of vessels, through the application of the principle of economies of scale with bigger ships.

With an increase of the size of the vessels the activities of the Ports will increase, with a need for bigger and additional cranes to handle the volumes, meaning more handling activities on each terminal of the region. There are some ports that have already been investing and preparing their capabilities.

The type of vessels considered for this new route are the Post Panamax vessels, capable to transport from 8.000 to 12.000 TEUS. Basically this increase in ship size is expected to reduce transport costs and to avoid congestion costs on the Ports that are faced nowadays.

The employment of bigger vessels can also mean higher incomes for the Ports in the region, because the handling rates would also increase according to the size. But even though the Canal fee for the vessels will increase, it will still be lower per unit compared to the amount paid today by users. Meaning that both parties would benefit: the terminals and the users.

Based on all factors and changes mentioned above, it would mean a revolution on transport, routes, ports and vessels. (Vergara, 2011).

The West Coast of South America and Central American countries highly depend on the Panama Canal to promote economic and trade growth. In the case of Ecuador, Peru and Chile this dependence is mainly due to the high percentage of their foreign trade that relies on transportation of goods through the Canal. For Ecuador it is very important due to its location on the Pacific Coast, far from it biggest trade partners that are located along the US East Coast and in Europe. For example the maritime

route from Ecuador to Europe through the Canal saves a distance of 5.000 miles, compared to the other route that would be going through the bottom of the continent.

Table 5 Relative importance of the Panama Canal on the international maritime trade of the SAWC Countries

	MARITIME EXPORTS	MARITIME IMPORTS
COUNTRY	**Relative Importance of the Canal**	**Relative Importance of the Canal**
Ecuador	28,10%	72,80%
Chile	31,10%	36,20%
Perú	23,20%	44,70%
Colombia	8,40%	21,70%

Source: Panama Canal Port Authority, Oct 2012

Is difficult to forecast the exact benefits and consequences that the expansion on the Canal will bring for the region, but it is clear that this project will increase the competition between regional ports and the shipping lines.

Table 6 Comparison of the maximum vessel sizes allowed between the old and the new locks of the Panama Canal

	ACTUAL LOCKS	**NEW LOCKS**
LENGTH	294,13mts	366mts
BEAMS	32,31 mts	49mts
DRAFT (tropical river water)	12,04mts	15,2mts
AIR DRAFT (limited by Americas Bridge)	62,5mts	62,5mts

Source: Marina Magazine Chile 02/2011 revistamarina.cl/revistas/2011/2/galvez.pdf

Chapter 3 Methodological approach

In this Chapter we cover our methodological approach. Below we present the Cost-Effectiveness Analysis and – as part of it – the Global Simulation (GSIM) analysis. We explain why we believe these two (integrated) methods would yield the best results given our research question, we look in detail at how the methods work, what data are required, what data we use and what issues we have to solve. We also define the scenarios that are used: the business-as-usual scenario and the 'building the deep sea terminal' scenario.

We look at the cost effectiveness analysis of constructing a new Deep Sea Terminal in Posorja as a response of the Panama Canal expansion and compare that option to the actual Scenario of keeping the Port of Guayaquil as it is now.

We use the GSIM model which was created by Francois and Hall (2003) for assessing the impact of global or regional changes in trade policy. The function of the GSIM is described analytically in chapter 4. Apart from that, this paper is based on secondary quantitative and less qualitative data from previous studies and research.

3.1 Conceptual methodological approach

Our aim is to determine how important is the new Project of the Panama Canal for Ecuador and the development of the trade and economy of the country. For this purpose, we have chosen two approaches either to keep the Port of Guayaquil in the actual location or to build a new Deep Sea Terminal that is able to receive bigger vessels. In order to study these two alternatives we need to determine the costs and benefits of both scenarios to determine what is better for the country.

There are many methods that can be applied in order to analyze the project, and we opted to work with the Cost-Effectiveness analysis of the proposed scenario and the actual scenario because this method allows us to describe and quantify the advantages in social incomes and disadvantages in costs and social expenses of the proposed scenarios. The CEA looks for economic welfare and it also provides proof that the project is financially viable. This method is a tool to evaluate all the effects of both scenarios: financial, economic, social, environmental, etc.

Like all the methods, this methodology has advantages and disadvantages. The main advantage of the CEA is the simplicity to understand in dollar terms the costs and benefits involved in a project. On the other hand those estimations also constitute a disadvantage because they are only estimations that sometimes are not aligned with the realm behavior of the users of proposed projects. The unit of measure can also represent a disadvantage at the moment of quantification of qualitative benefits. On the other hand it is important to be accurate with respect to the calculations of costs and benefits to avoid double counting. Regarding the advantages, apart from the

simplicity, it is also capable to compare two scenarios and provide us with extra information necessary to make a decision on which option is better for the country.

3.2 The Cost-Effectiveness Analysis (CEA) in detail

3.2.1 The CEA approach

The Cost-Effectiveness Analysis approach is helpful to compare economic benefits against costs, the result obtained from deducting the monetary and derived costs over economic and derived benefits is the net effective benefit of the project that will determine if it is feasible or not.

Therefore the goal of CEA is to determine the profitability of the project, including private and social cost and benefits derived. For this purpose it is important to calculate the social or economic Net Actual Value, with the following formula:

(1)

$$VAN_s = -I + \frac{B_1 - C_1}{(1-r)} + \frac{B_2 - C_2}{(1-r)^2} + \cdots \ldots \ldots + \frac{B_T - C_T}{(1-r)^T}$$

Where:

B_i $= social\ benefits\ obtained\ for\ the\ construction\ of\ the\ infrastructure\ in\ i\ period$

$C_i = social\ costs\ obtained\ for\ the\ construction\ of\ the\ infrastructure\ in\ i\ period$

$r = social\ discount\ rate\ to\ update\ future\ cost\ and\ benefits$

In CEA we can identify many yields of impact, regarding the benefits of the project it is important to take into account all the benefits obtained for the society as a whole, including the investor and the rest of direct and indirect stakeholders involved, including the surplus for consumers.

Regarding construction, maintenance and exploitation of the infrastructure, for the CEA we should take into account the opportunity cost of the benefits that would be lost with the actual factors of infrastructure if the project is not realized, including the possible positive and negative externalities caused by the construction of the new Terminal. If we get positive externalities those would be accounted as social benefits as trade cost decrease on the case of transport cost decrease.

To apply the CEA methodology, we follow the following steps:

1. We specify the possible alternatives to the development of the project, in this case these are our two scenarios – 1.the actual situation with the actual conditions of the Port of Guayaquil and 2. The construction of the new Deep Sea Terminal in Posorja.

2. After defining the two scenarios we determine the cost and benefits of the project for the society in a national scope.

3. At the next stage we quantify the costs and benefits. We do it in terms of economic surplus. There could be two options, when markets works well without failure then the surplus is calculated through the demand function of customers. For markets with failure or without proper market mechanisms we should apply stated preferences and revealed preferences through interviews for example. For those goods without a market the quantification of costs and benefits should be measured in unit values of time for the users of the infrastructure, values of time for shipped cargos, values of animals and species, etc.

4. Aggregation of costs and benefits. For the CEA is important to discount the future costs and benefits in relation to the present ones, in order to obtain actual values.

5. Estimation of the Actual Net value. It is estimated by subtracting the actual costs from the actual benefits. In the first scenario we analyze the status quo, it means the actual situation, and if the VAN is positive then the scenario is viable. In case of evaluating more than one scenario, like in this study, if more than one scenario has a positive VAN then the higher VAN is the most viable, or by the other hand if both are negative then the project is not feasible.

6. Suggest policies and recommendations based in the VAN. After establishing the scenario with the positive and highest VAN, and after determining if it is sustainable the best alterative can be choice to assign the economic resources in the best way to maximize the economic efficiency. In a Microeconomic scope the CEA is based in the welfare of the society trying to maximize their utility based on their preferences bundled by available productive resources and technology. The goods that should be produced are the ones most valued by consumers.

3.2.2 CEA Data

The data for this research is mainly focused on port and trade indicators and values. In the case of the Port costs and benefits for the CEA it was gathered for both scenarios, mainly for the scenario DST which is the new one. Another set of data was collected for the GSIM model from international trade data bases certified in order to run the model.

For the CEA some data was quantified in order to be able to compare them with monetary benefits and analysis, both had to be in the same type of measure.

From the surveys and interviews with experts in the area we can mention Mr Renato Zurita who is the operations manager of MSC Ecuador, which is the second biggest containers line in Ecuador and around the world, Mr Jacques Van Hal Port Captain Rotterdam from the shipping line CMA-CGM who has also previously been involved on activities of terminal operations and dredging activities.

Regarding the literature we obtained most of the information from experts as mentioned above and from actual newspapers and publications from entities involved in this area like Port Authorities, World Bank, UNCTAD.

Information regarding the situation in the port of Guayaquil and its needs we have collected from government institutions, such as the Ministry of Transport and Ports, The Municipality of the City of Guayaquil.

3.2.3 Scenario development: costs and benefits (factors)

Ecuador port system is composed of four Ports around the Pacific Coast: Port of Guayaquil, Port of Bolivar, Port of Manta and Port of Esmeraldas. But the main port regarding containers handling is Guayaquil, for this reason our study will be bounded by the container trade.

The Port of Guayaquil had been the most important axis to develop the economy of the city and the country since its construction, but some years ago the Port started to face infrastructure problems due to the depth of the access Canal and the constant need to be dredged. The government proposed two possible alternatives that would be able to solve this issue, those two alternatives are divided into scenario 1 called DST (Deep Sea Terminal) and scenario 2 called BAU (Business as Usual).

The DST Scenario which is the object of study, proposes to maintain the operations in the actual port for Panamax vessels plus to construct a new Deep Sea Terminal in Posorja that is located within the Province of Guayas. This new terminal is expected to work together by the hand with the actual Port of Guayaquil, and is expected to be able to receive Post panama vessels because in this location it is possible to reach a draft of 16mt (El Universo Newspaper, 2013). The idea is to give freedom to the shipping lines to choose where they want to call with their vessels regarding the volume of cargo and the size of the vessels they want to call with and to give freedom to the customers to be able to choose which terminal fits them better. The project of the government is to look for a terminal operator that is able to invest in the construction of the new facilities and to operate under landlord model. Landlord Model is a combination of public and private orientation, where the Port Authority is mainly a regulatory body and landlord, and port operations are executed by private companies. This model is dominant in large and medium sized ports. The Port Authority leases infrastructure to private operating companies (Dooms, 2015).

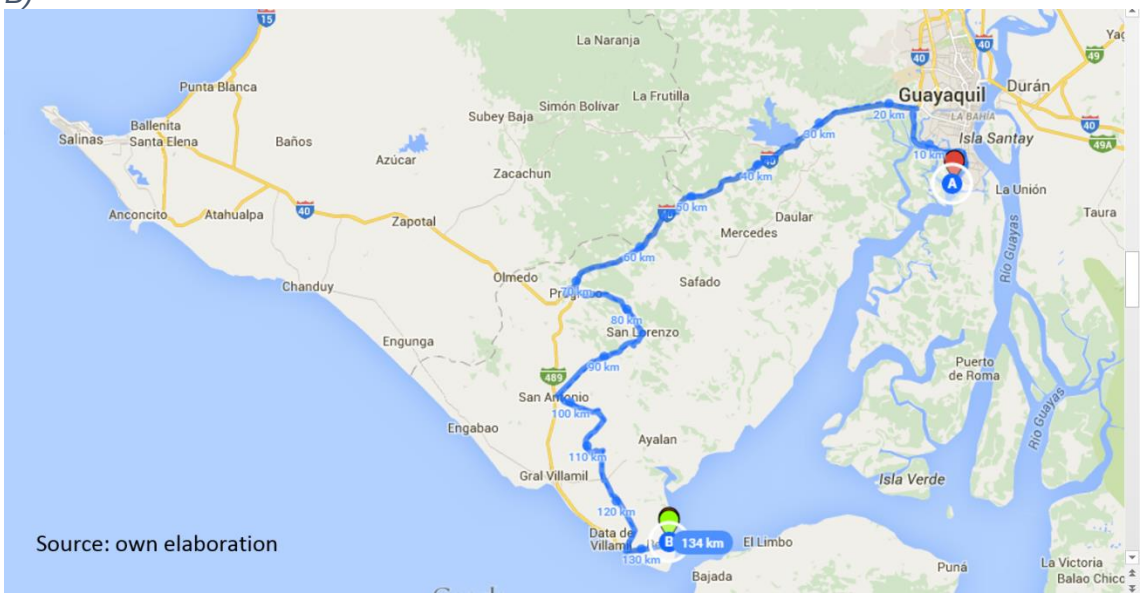
The new Terminal in Posorja would be located 134km from Guayaquil through an existing highway which was not designed to handle the volume of traffic that a Port Terminal may generate. The central government had proposed the construction of a new direct highway to the new location, with a distance of just 75 km from Guayaquil, but it’s not in process yet. Posorja belongs to the rural parish of Guayaquil, meaning that the incomes and profits regarding the Terminal activities will still be for the City of Guayaquil.

With the construction of the new terminal several questions had been raised from all stakeholders regarding the increase in the inland costs for containers, the increase in transit time for inland, safekeeping costs, the mobility of the people that will work with

all the parties involved, the decrease probably in employment rate in the actual POG,etc.

We consider that is optimal to understand the actual Port Infrastructure of the country as described in chapter 3, to comprehend the importance of the proposed scenario. The second Scenario BAU suggests to maintain the Port Of Guayaquil in the same location without taking any action.

Figure 15 Location and Route of the proposed Deep Sea Terminal in Posorja (Point B)



In order to develop de CEA we needed information regarding the costs and benefits of both scenarios, mainly focused in the first scenario that is Building a Deep sea Terminal. To calculate the total costs generated from the DST scenario we looked into the infrastructure and maintenance costs, and operational costs. We got some data from previous research made in the country by the Maritime Chamber and also from professionals from shipping lines, terminal operators and dredging companies specialized in this field.

To calculate the benefits from this scenario we look into the port revenues that are already known because they are similar to the ones generated in reality, and also we looked into the economies derived from economies of size gathered from the previous studies of Ecorys. We also compiled information regarding the economies of size from shipping lines.

Regarding the data of the BAU scenario, we received it from the Port authority of Guayaquil and the Terminal Operator.

For the GSIM Model the data we selected has three sets of data from the United Nation COMTRADE: Total trade Values, Container Trade Values and Banana trade values from Ecuador, the countries in the region, China, EU, US and rest of the world.

The commodity of bananas was chosen because it is the most important Non-Oil product traded by Ecuador.

3.3 The Global Simulation model

As part of our analysis, we also employ the Global Simulation (GSIM) model. This model allows us to give a better idea of the impact of the Panama Canal expansion while taking into account the CEA results. We compare two scenario outcomes to give insight into and get useful results for Ecuadorian policy making. In particular the GSIM model adds to the CEA by looking at the global effects – mostly on trade, but also on the global changes and how they affect Ecuador. As such the GSIM model is a clear addition to the CEA approach.

3.3.1 The GSIM model

The Global Simulation Model (GSIM) has been developed by Francois and Hall (2003). The GSIM Model is a partial equilibrium model widely used for an industry level analysis of trade liberalization. In our case in particular for the analysis of global, regional and unilateral trade policies changes derivate from the Panama Canal Expansion. This model assesses changes in welfare, prices, output and trade flows as a result of tariff removal and/or reduction of production/export subsidies. This includes interaction of multiple market access concessions across various trading partners, exporter gains, consumer surplus (importer) gains, and changes in tariff revenue (Francois & Hall, 2003).

We have applied global prices in order to simplify the model, also applied at a national level. We have also assumed that the imports are imperfect substitutes from different sources. The product heterogeneity comes from the different bilaterally imposed policies (tariffs, etc.). Meaning that the elasticity of substitution depends on the different tariffs applied bilaterally by countries, changing the imports depending on the source.

3.3.1.1 Demand and Supply side

The imports demand from one country to another is a function of industry prices and total expenditure, as per next equation:

(2)

$$M_{(i,v),r} = f\left(P_{(i,v),r}, P_{(i,v),s\,r}, Y_{(i,v)}\right)$$

To define the own and cross-price elasticities, on equation (3) we address imports expenditure at internal prices at a given country in a given region. In equation (3) we combine world and domestic prices of the same good.

(3)

$$P_{(i,v),r} = \left(1 + t_{(i,v),r}\right)P^*_{i,r} = T_{(i,v),r}\, P^*_{i,r}$$

T =1+ t is the power of the tariff. We will define export supply to world markets as being a function of the world price P* (Francois & Hall, 2003).
By differentiating the first equation, applying the Slutsky decomposition of partial demand, and taking advantage of the zero homogeneity property of Hicksian demand, we can then derive the following (Francois & Hall, 2003):

(4)

$$N_{(i,v),(r,s)} = \theta_{(i,v),s}(E_m + E_s)$$

(5)

$$N_{(i,v),(r,r)} = \theta_{(i,v),r}\, E_m - \sum_s \theta_{(i,v),s}\ E_s = \theta_{(i,v),r}\, E_m - \left(1 - \theta_{(i,v),r}\right) E_s$$

Where $\theta_{(i,v),s}$ is and is and expenditure share, and $E_m v$ is the import composite demand elasticity on the given region.
The function P represents the export supply to the world:*

(6)

$$X_{i,r} = f\ (P^*_{i,r})$$

Differentiating equation (6) we obtain equation (7) with the elasticity of the export support:

(7)

$$\hat{E}_{i,r} = E_{X(i,r)}\hat{P}^*_{i,r}\ , or\ E_{X(i,r)} = \frac{\hat{X}_{i,r}}{\hat{P}^*_{i,r}} > 0$$

3.3.1.2 Global Equilibrium Conditions

Equation (8) is derived from previous equations, adding import markets:

(8)

$$\hat{M}_{i,r} = \sum_v \hat{M}_{(i,v),r} = \sum_v N_{(i,v),(r,r)}\, \hat{P}_{(i,v),r} + \sum_v \sum_{s\ r} N_{(i,v),(r,s)}\, \hat{P}_{(i,v),s} = \sum_v N_{(i,v),(r,r)} \left[P^*_r + \hat{T}_{(i,v),r}\right] + \sum_v \sum_{s\ r} N_{(i,v),(r,s)} \left[\hat{P}^*_s + \hat{T}_{(i,v),s}\right]$$

Equation (9) express global markets clearing conditions for each export variety, this is the core equation:

(9)

$$\widehat{M}_{i,r} = \widehat{X}_{i,r} \rightarrow$$

$$E_{X(i,r)}\widehat{P}^{*}_{i,r} = \sum_{v} N_{(i,v),(r,r)}\,\widehat{P}_{(i,v),r} + \sum_{v}\sum_{s}\sum_{r} N_{(i,v),(r,s)}\,\widehat{P}_{(i,v),s}$$
$$= \sum_{v} N_{(i,v),(r,r)}\left[P^{*}_{r} + \widehat{T}_{(i,v),r}\right] + \sum_{v}\sum_{s}\sum_{r} N_{(i,v),(r,s)}\left[\widehat{P}^{*}_{s} + \widehat{T}_{(i,v),s}\right]$$

3.3.1.3 Welfare and Revenue Effect

After solving equation (12) for world prices, we can use equations (6) and (8) for export and import quantities respectively. We can also derive consumer and producer surplus as measures of welfare effects, involving the trade effects due to the tariffs applied.

We express can calculate from below equation the Producer surplus:

(10)

$$\Delta PS_{(i,r)} = R^{0}{}_{(i,r)} \cdot \hat{P}_{i,r}{}^{*} + \frac{1}{2} \cdot R^{0}{}_{(i,r)} \cdot \hat{P}_{i,r}{}^{*} \cdot \hat{X}_{i,r}$$
$$= \left(R^{0}{}_{(i,r)} \cdot \hat{P}_{i,r}{}^{*}\right) \cdot \left(1 + \frac{E_{X,(i,r)} \cdot \hat{P}_{i,r}{}^{*}}{2}\right)$$

For consumer welfare, we focus on the implicit composite good, assuming an underlying CES aggregator (Francois & Hall, 2003).

(11)

$$Q_{i,v} = A_{v} \cdot \left[\sum_{i=1}^{r} Y_{(i,v),r}\, M^{p}_{(i,v),r}\right]^{1/p}$$

The proportional change in price of Q of the composite good will be:

(12)

$$\hat{P} = \frac{dP}{P} = \sum_{i=1}^{r} \theta_{(i,v),r} \cdot \hat{P}_{(i,v),r} = \sum_{i=1}^{r} \cdot \theta_{(i,v),r} \cdot \left[\left(1 + P^{*}{}_{i,r}\right) \frac{T_{1,(i,v),r}}{T_{0,(i,v),r}}\right]$$

From equation (12) we builds on the following relationship:

(13)

$$\frac{dP_{(i,v),r}}{P_{(i,v),r}} = \frac{\left(P_{(i,v),r}\right)_{1}}{\left(P_{(i,v),r}\right)_{0}} - 1 = \left[\left[\left\{\frac{\left(P^{*}{}_{i,r}\right)_{0} + dP^{*}{}_{i,r}}{\left(P^{*}{}_{i,r}\right)_{0}}\right\} \cdot \frac{T_{1,(i,v),r}}{T_{0,(i,v),r}}\right] - 1\right]$$

Below equation represents the Consumer surplus, which is built from the changed in the area between the demand and the price of a composite good. This combined with the producer surplus and the import tariff revenues provide us an approach to welfare changes (Francois & Hall, 2003).

(14)

$$\Delta CS = \left(\sum_r {R^0}_{(i,v),r} \cdot {T^0}_{(i,v),r}\right) \cdot \left({}^1\!/_2\, E_{M,(i,v)} {\hat{P}_{(i,v)}}^2 \cdot sign\left(\hat{P}_{(i,v)}\right) - \hat{P}_{(i,v)}\right)$$

$$where\ \hat{P}_{(i,v)} = \sum_r \theta_{(i,v),r} {\hat{P}_r}^* + \hat{T}_{(i,v),r}$$

3.3.1.4 Own-and cross- Trade Effects

In previous equations we assumed that world prices are fixed, so price changes are caused by the different tariffs. If we take one country we will have following equation:

(15)

$$\hat{M}_{(i,v),r} = N_{(i,v),(r,r)} \hat{P}_{(i,v),r} + \sum_s \sum_r N_{(i,v),(r,s)} \hat{P}_{(i,v),s}$$

$$= N_{(i,v),(r,r)}\, \hat{T}_{(i,v),r} + \sum_s \sum_r N_{(i,v),(r,s)}\, \hat{T}_{(i,v),s}$$

We can derive two equations from equation (15) as follows:

(16)

$$Own - trade\ effect: \qquad TC_{(i,v),r} = M_{(i,v),r}\ x \left[N_{(i,v),(r,r)} \hat{T}_{(i,v),r}\right]$$

(17)

$$Cross - trade\ effect: \qquad TD_{(i,v),r} = M_{(i,v),r}\ x \sum_s \sum_r N_{(i,v),(r,s)}\, \hat{T}_{(i,v),s}$$

As own-trade we can define the trade generate from tariff reductions of a product and for cross-price the trade changes generated by changes in tariffs on imports from third countries (Francois & Hall, 2003).

This sub-chapter provides us with information necessary to answer the main research question. The model is also explained analytically.

The GSIM Model contains the following inputs:

- Values of the cargo including exports, imports and transshipment value of cargo for specific port pairs and destinations (in dollars).

- Value of the existing tariffs and estimated non-trade barriers (percentage)
- Elasticities on demand, supply side and substitution effect (indexes)

As an output we have the following information from the GSIM model:
- Changes in output for the countries put in the model
- Welfare decomposition describing welfare distribution for consumers and producers after “shock” effects in the model

In order to answer the main research question scenario approach can be used. By running model with initial scenario and scenario after changing input values different results can be compared and the impact can be estimated not only for Ecuador being the main research object but also other countries and regions.

3.3.2 The GSIM Data

The GSIM model needs to run with specific information and based on specific choices. The first choice to make is to decide the country disaggregation that we will use. This disaggregation has to allow us to answer the research question properly. Hence, we have of course singled out Ecuador as the first country. However, In order to see how trade flows to and from Ecuador are affected by changes in the Panama Canal, we must also choose countries or regions that trade heavily with Ecuador – some totally through the Panama Canal (e.g. the EU), some partially through the Panama Canal (e.g. the US), and some not through the Panama Canal at all (e.g. China). This is why we have chosen for the following countries: Ecuador, Chile, Colombia, Peru, Venezuela, Brazil, US, China, EU, Panama, Mexico, Rest of South-America, and Rest of World. In rest of South-America are all countries in South-America not singled out already, and in Rest of World are all the countries that have not been specified separately. This implies that all countries in the world are represented in this model – some singled out, some as part of Rest of World.

Second, several data sources are available containing information about the trade volume values exchanged between regions of the world, for this paper we chose the United Nations Comtrade data base (United Nations, 2015) which allow users to obtain trade information from all the countries in the world by year, commodity traded, trade partners and trade flows. Since the focus of this work is on the changes that follow from the expansion of the Panama Canal for the West Coast region of Latin America, in particular Ecuador, an important part of this work as dedicated to deriving the trade values of the Port of Guayaquil-Ecuador in the most accurate way possible.

Because we focus on container trade (not total trade), we assume that 90% of the global trade is containerized. Thus, we apply the following formula:

(18) Container Trade Value

$$= Total\ trade\ Value_{countries\ XY} * 0.90$$

For the calculation of tariff barriers, we took the data available in the WITS database of tariffs, where we found all tariff rates by commodities. Since the biggest partners are the US and the EU impose the tariffs and terms of trade within most of their trade partners around the world we decided to take them as reference. Also for the main countries of focus: Ecuador as well as Colombia, Peru, Chile and the other countries identified, we also used the WITS database. For ROW, we have used trade weighted WITS tariff data.

The total barrier effect does, however, not only consist of tariff barriers. Differences in regulatory systems, ranging from food safety standards to technical barriers to trade and to costs related to transport form a significant part of global barriers. To calculate the non-tariff barriers we take as source the Ecorys (2009) study: "Non-Tariff Measures in EU-US Trade and Investment - An Economic Analysis" (Berden, 2009). In this thesis we take a trade weighted average of the barriers found – these range from 15% to 50% in some cases. These NTM values were then added up to the tariff rates to get the total (i.e. tariff plus non-tariff measure) levels of barriers. This is the starting situation for the GSIM model.

Finally, the final data input that we need are elasticities. In particular, we need composite demand elasticities for each country/region defined in the model, industry supply elasticities, and substitution elasticities. The composite demand elasticity is composed of domestic demand elasticities and import demand elasticities. Because these were difficult to come by for container trade in total, we took the earlier Francois and Hall (2003) estimates. At the end of this research, we do a sensitivity analysis using different elasticities to demonstrate the degree of sensitivity of the results for these elasticities.

3.3.3 The scenarios

In order to finalize the set-up of the GSIM model, we need to develop the scenario or scenarios. These follow directly from the research question. The GSIM model has to look at the potential effects of the 'doing nothing' scenario for Ecuador given the expansion of the Panama Canal and the potential effects of the 'DST at Posorja' policy response from Ecuador given the expansion of the Panama Canal. Those are the two scenarios for analysis:

Scenario 1	The Panama Canal is expanded and Ecuador does nothing (i.e. faces the limited draught problem of the PoG)
Scenario 2	The Panama Canal is expanded and Ecuador reacts to this expansion by building a Deap Sea Terminal (DST) at Posorja

For proper execution of these scenarios, we have taken the country-country (container) trade flow values and checked for each bilateral trade flow whether it would pass through the Panama Canal, whether it would partially pass through the Panama Canal or whether it would not pass through the Panama Canal at all. This distinction matters because – for example – the expansion of the Panama Canal

would not have a direct impact on a Sino-Ecuador trade flow (since that trade flow simply crosses the Pacific). It could have a partial effect on the US-Ecuadorian trade – not insofar containers are shipped from – for example – Los Angeles to Ecuador, but yes insofar Baltimore – Ecuador trade is concerned. When a partial use of the Panama Canal is possible, we simply assumed that 50% of trade would go through the Panama Canal and 50% not. Finally, for the EU-Ecuador trade flow, it is clear that it (almost) entirely goes through the Panama Canal. As such we assume there to be a full and direct effect on this trade flow of the Panama Canal expansion. Table 7 below illustrates how we have modelled the transport cost reductions that are the consequence of larger vessels being able to pass through the Panama Canal on these bilateral country-pair trade flows. In case of a trade flow that passes for 100% through the (enlarged) Panama Canal, we assumed a maximum reduction of 3% point of non-tariff barriers (i.e. drops in transport costs) if all trade goes through the Panama Canal (e.g. EU-Ecuador) and a drop of 2% points if 50% passes through (e.g. Mexico-Ecuador). Finally we looked at less than 50% going through the Panama Canal (e.g. US – Ecuador) and no trade going through the Panama Canal (i.e. no drop in trade costs). We have also assumed that if – for example – Ecuador-US trade costs would drop by 1% point, then also US-Ecuador trade would drop by 1% point (i.e. the table below is symmetrical over the diagonal)

Table 7 Trade cost reductions following the Panama Canal expansion

	Ecuador	Chile	Colombia	Peru	Venezuela	Brazil	US	China	EU	Panama	Mexico	Rest of SA	Rest of World
Ecuador	0,00	0,00	0,00	0,00	0,02	0,02	0,01	0,00	0,03	0,02	0,02	0,02	0,01
Chile	0,00	0,00	0,00	0,00	0,02	0,02	0,01	0,00	0,03	0,02	0,02	0,02	0,01
Colombia	0,00	0,00	0,00	0,00	0,02	0,02	0,01	0,00	0,03	0,02	0,02	0,02	0,01
Peru	0,00	0,00	0,00	0,00	0,02	0,02	0,01	0,00	0,03	0,02	0,02	0,02	0,01
Venezuela	0,02	0,02	0,02	0,02	0,00	0,00	0,01	0,03	0,00	0,00	0,00	0,02	0,01
Brazil	0,02	0,02	0,02	0,02	0,00	0,00	0,01	0,03	0,00	0,00	0,00	0,02	0,01
US	0,01	0,01	0,01	0,01	0,01	0,01	0,00	0,01	0,00	0,00	0,00	0,02	0,01
China	0,00	0,00	0,00	0,00	0,03	0,03	0,01	0,00	0,00	0,01	0,01	0,02	0,01
EU	0,03	0,03	0,03	0,03	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,01
Panama	0,02	0,02	0,02	0,02	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,02	0,01
Mexico	0,02	0,02	0,02	0,02	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,02	0,01
Rest of SA	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,01
Rest of World	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01

Scenario 2 is the same as Scenario 1, except for the fact that for trade to and from Ecuador, trade costs go down a bit further than in Scenario 1 (green cells) and also in comparison to other countries, because in addition to the Panama Canal expansion, Ecuador opts for building the DST at Posorja. The DST has greater draught and takes less time to reach than the original PoG – hence the additional drop in trade costs. These trade cost reductions we assume to be a little bit bigger between US-Ecuador and EU-Ecuador because those are the routes where largest vessels would be most used and beneficial. These adjustments lead to trade cost reductions as presented in Table 8 below (note: in green the changed cells compared to Table 8 above).

Table 8 Trade cost reductions following the Panama Canal expansion + DST

	Ecuador	Chile	Colombia	Peru	Venezuela	Brazil	US	China	EU	Panama	Mexico	Rest of SA	Rest of World
Ecuador	0,00	0,00	0,00	0,00	0,03	0,03	0,02	0,00	0,04	0,03	0,03	0,03	0,01
Chile	0,00	0,00	0,00	0,00	0,02	0,02	0,01	0,00	0,03	0,02	0,02	0,02	0,01
Colombia	0,00	0,00	0,00	0,00	0,02	0,02	0,01	0,00	0,03	0,02	0,02	0,02	0,01
Peru	0,00	0,00	0,00	0,00	0,02	0,02	0,01	0,00	0,03	0,02	0,02	0,02	0,01
Venezuela	0,03	0,02	0,02	0,02	0,00	0,00	0,01	0,03	0,00	0,00	0,00	0,02	0,01
Brazil	0,03	0,02	0,02	0,02	0,00	0,00	0,01	0,03	0,00	0,00	0,00	0,02	0,01
US	0,02	0,01	0,01	0,01	0,01	0,01	0,00	0,01	0,00	0,00	0,00	0,02	0,01
China	0,00	0,00	0,00	0,00	0,03	0,03	0,01	0,00	0,00	0,01	0,01	0,02	0,01
EU	0,04	0,03	0,03	0,03	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,01
Panama	0,03	0,02	0,02	0,02	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,02	0,01
Mexico	0,03	0,02	0,02	0,02	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,02	0,01
Rest of SA	0,03	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,01
Rest of World	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01

The results of the GSIM scenario runs 1 and 2 will be presented in the next Chapter.

Chapter 4 Results

4.1 Forecasting container flows

The approach followed in order to calculate the GDP and TEUs forecast was taken from the paper Container Throughput Forecast for Africa using elasticity values method provided by Ecorys.

4.2.1 Forecast of the BAU

In order to determine the GDP and TEU growth till 2030 we took the data from the World Bank regarding the historical GDP and TEUs per country. Regarding the forecast growth of GDP until 2030 we used the Real Projected Gross Domestic Product (GDP) and Growth Rates of GDP from USDA (United States Department of Agriculture Economic Research Service).

Table 9 Historical GDP and GDP forecast to 2030

	GDP in USD Billions				**GDP FORECAST in USD Billions**			
Country	**2000**	**2004**	**2008**	**2013**	**2018**	**2022**	**2026**	**2030**
COLOMBIA	122,70	139,98	173,10	212,91	415,58	496,98	589,48	691,65
ECUADOR	32,75	39,42	47,10	58,21	96,77	109,87	123,82	138,95
PERU	60,79	70,52	95,45	124,79	222,09	264,21	312,08	368,61
CHILE	101,25	117,85	141,08	171,77	309,53	370,25	444,61	531,43

After gathering this information for our assessment we calculated the Compound Annual Growth Rate (CAGR) for the GDP and TEUs in intervals 2000-2004, 2004-2008, 2008-2013, 2013-2018, 2018-2022, 2022-2026, 2026-2030 for the countries in the SAWC: Colombia, Ecuador, Peru and Chile with the following formula:

(19) GDP Compound Average Growth Rate

$$GDP - CAGR = \left(\frac{GDP_1}{GDP_0}\right)^{1/n} - 1$$

Where:
GDP_1= Actual GDP from the interval
GDP_2= Previous GDP from the interval
n = number of years within the interval

Table 10 GDP Compound Annual Growth Rate

Countries	2000-2004	2004-2008	2008-2013	2013-2018	2018-2022	2022-2026	2026-2030
COLOMBIA	3,35%	5,45%	4,23%	14,31%	4,57%	4,36%	4,08%
ECUADOR	4,74%	4,55%	4,33%	10,70%	3,22%	3,03%	2,92%
PERU	3,78%	7,86%	5,51%	12,22%	4,44%	4,25%	4,25%
CHILE	3,87%	4,60%	4,01%	12,50%	4,58%	4,68%	4,56%

(20) TEUs Compound Average Growth Rate

$$TEUs - CAGR = \left(\frac{TEUs_1}{TEUs_0}\right)^{1/n} - 1$$

Where:
$TEUs_1$= Actual TEUs from the interval
$TEUs_0$= Previous TEUs from the interval
n = number of years within the interval

Table 11 TEUs Compound Annual Growth Rate

Countries	2000-2004	2004-2008	2008-2013	2013-2018	2018-2022	2022-2026	2026-2030
COLOMBIA	4,58%	20,09%	6,66%	23,08%	7,38%	7,03%	6,57%
ECUADOR	8,05%	4,41%	12,43%	17,26%	5,20%	4,89%	4,72%
PERU	10,85%	15,44%	12,15%	32,84%	11,93%	11,42%	11,42%
CHILE	7,26%	17,52%	3,64%	20,16%	7,39%	7,55%	7,35%

With the GDP and TEUs CAGR from each interval we calculate the elasticity of the growth on TEUs as a result of the growth in the GDP per interval with the next formula:

(21) Growth elasticity of TEUs as a function of the growth in GDP

$$e = \frac{g_{TEU}}{g_{GDP}}$$

Table 12 Elasticities of TEUs growth as a function of GDP growth

Countries	**2000-2004**	**2004-2008**	**2008-2013**
Colombia	1,37	3,68	1,58
Ecuador	1,70	0,97	2,87
Perú	2,87	1,96	2,21
Chile	1,88	3,81	0,91
AVERAGE	**1.95**	**2.60**	**1.89**

With the elasticities per country for each interval we calculated the average of the region SAWC adding all the elasticities and divided them by the number of elasticities. With the average elasticity for the region to look for correlations between the elasticities per country in order to determine which had a correlation between intervals and which did not. In the case of Ecuador, Colombia and Chile there was no correlation between the elasticities within the intervals, we subtract 0.25 in order to equilibrate the elasticity. In the case of Peru the elasticity had a higher degree of correlation, so in this case 0.25 was added to the regional average in order to adjust.

Table 13 Average Elasticities per country 2013-2030

Countries	**2013-2030**
COLOMBIA	1,61
ECUADOR	1,61
PERU	2,69
CHILE	1,61

After the elasticities per country was possible to calculate the Forecast of TEUs in millions for 2018, 2022, 2026 and 2030 with the following formula:

(22) TEUs Forecast for SAWC 2018-2030

$$TEUs\ Forecast = last\ data\ of\ TEUs + (1 - Elastificity\ of\ eacht\ country * CAGR - GDP\ per\ coumtry)^{n}$$

Table 14 TEUs data to 2013 + Forecast to 2030

	TEUs in millions				**FORECAST in millions of Teus**			
Country	**2000**	**2004**	**2008**	**2013**	**2018**	**2022**	**2026**	**2030**
COLOMBIA	791588	946945	1969316	2718138	7676875	10204764	13391432	17275859
ECUADOR	414104	564515	670831	1205294	2671583	3272100	3960752	4762571
PERU	460631	695577	1235326	2191594	9066570	14228626	21930702	33801976
CHILE	1253131	1658672	3164137	3784386	9478103	12604067	16863475	22398032

After calculating the forecast of the total throughput of Ecuador including all the Ports as explained previously, we then calculate the throughput of Port of Guayaquil with the information obtained from the Maritime Chamber of Guayaquil which states that 95% of the national container throughput is handled by this Port (Maritime Chamber of Ecuador, 2013).

Table 15 FORECAST in Millions of TEUs for the Port of Guayaquil
(95% of National throughput)

2018	2022	2026	2030
2.538.004	3.108.495	3.762.714	4.524.442

In reality the Port of Guayaquil has an install capacity of 1'300.000 TEUs on its concession Terminal Contecon, while all the private Terminals can handle 1'800.000 altogether according to Fernand Donoso, former president of the Guayaquil Port Authority (Newspaper El Telegrafo, 2013). According to our forecast of TEUs the actual capacity of Port of Guayaquil, will only be able to fulfill the need of the volume till 2022, after this year there will be a shortage of capacity, that would bring congestion in the Port, increase on waiting times and time at Port as well, and as a consequence lead to an increase on operation costs for the vessels which in the end are translated to consumers of shipping transport services. This will increase the cost per TEU making more expensive the trade cost for the country. According to the experts the actual port of Guayaquil still has space to grow and increase its capacity with an investment on more docks and storage areas, in addition to the imperative dredging of the channel of access.

4.2.2 Forecast of the DST

According to the project proposed by the Company Alinport that is one of the optioned in getting the rights of concession and construction of the New Terminal, initially it was expected to have three phases within 10 years reaching a capacity of 1'600.000 TEUs at the end of the 10th year (Port Company Valparaiso, Chile, 2007). The new proposal according to the Ministry of Transport and National Infrastructure is based on the study carried out by the Company Ineco from Spain in the Strategic Mobility Plan for Ecuador and is expected to reach 3'000.000 TEUs capacity till the year 15 (Newspaper El Mercurio, 2015).

There is no specific source that contains the final version of the project and construction description, since there are three international companies including Alinport trying to take part of this new project. Alinport is a foreign company composed of five shareholders: APM Terminal, Comercio International del Atun, Delea Finance S.A., Pacific Port International and Servicio y Trafico de Contenedores from Panama (Newspaper Expreso, 2015).

In order to calculate the Forecast for the New Terminal in Posorja as initial year we set 2018, since the study for the concession of this Port indicates that the first phase

will be done within three years, the second within 5 years, the third within 10 and the final within 15 years (Port Company Valparaiso, Chile, 2007).

Table 16 Estimated Capacity Forecast for the New Terminal in Posorja in Millions of TEUs

2018	2020	2026	2030
730.000	1.110.000	1.600.000	3.000.000

In order to resume and compare the expected throughput for Port of Guayaquil and the expected throughput for the New Terminal in Posorja we have adjusted the years to the intervals in the forecast of Port of Guayaquil. In the case of the New Terminal in Posorja the expected throughput is the installed capacity of the port per phase and in the case of the actual Port of Guayaquil (capacity of 1'300.000 TEUs on its concession Terminal Contecon plus the private Terminals together capacity 1'800.000) have a total capacity of 3'100.000 TEUs per year. So even though the forecast showed higher volumes we have to adapt them to the installed capacities.

Table 17 Expected throughput for both scenarios constraint by their installed capacities in TEUs

Year	Scenario 1- BAU	Scenario 2- DST
2018	2.538.004	730.000
2022	3.100.000	1.110.000
2026	3.100.000	1.600.000
2030	3.100.000	3.000.000
2035	3.100.000	3.000.000
2040	3.100.000	3.000.000

4. 3 The cost side of the CEA

For the DST scenario we have considered all the approximate costs derived by the new Terminal outside of Guayaquil including: the land, the docks, storage areas construction, additional trucking fees that would be charged for the users due to the longer distances, costs and investments in basic services, road infrastructure, etc. Those costs haven been calculated over a period of 25 years, for this reason our CEA is developed based on this amount of time.

There is no need for major investment dredging because the natural depth of are where the new terminalis proposed is already 15 meters.

On below chart we have summarized all the possible charges generated based on 25 years calculation that is the period that is supposed to take the Port Authority to recover the investment.

Table 18 DST direct and indirect costs for 25 years

	Costs in UDS Millions
Docks	USD540
Area (Dynamic Capacity)	USD38
Area (reserve)	USD32
Over cost of inland trucking rates, New Highway, infrastructure, operational costs	USD4933
Total Costs for 25 years	**USD5543**

Source: Maritime Chamber of Guayaquil, 2013

*Values in USD Millions

Regarding the Costs of the BAU the only additional cost expected would be the dredging plus the maintenance that has been calculated by several studied as follows:

Table 19 BAU costs for 25 years

Dredging and maintenance cost on 25 years of the Canal	**USD1,000**

Source: Maritime Chamber of Guayaquil, 2013

*Values in USD Millions

4.4 The benefit side of the CEA

The benefits that we can predict are the ones generated by the economies of size of the ships that would decrease the trade cost for the country, meaning that the ocean freight should decrease as the price per slot drop.

According to Drewry the economies of scale in terms of savings on price per slot depend also on the price of the bunker, when oil price is high for example we can notice a difference of 40 points between an 8.000 TEU vessel and an 18.000 TEU vessel (Drewry, 2015).

Table 20 Ship employment for South America Trade Route

		2004	2014	Variation 2004-2014
EUROPE	No. Vessels	194	565	291%
	Max Vessel Cap TEUs	2816	3.716	132%
	Annualised Cap TEUs	546.758	2.098.281	384%
NORTH AMERCIA	No. Vessels	354	311	88%
	Max Vessel Cap TEUs	2816	3.732	133%
	Annualised Cap TEUs	1.056.789	2.678.671	253%
ASIA	No. Vessels	487	448	92%
	Max Vessel Cap TEUs	2375	6.417	270%
	Annualised Cap TEUs	1.156.789	3.855.620	333%

Data Source: The Drewry Annual Container Market Review and Forecast for 2004/05 & 2014; Chart and calculations: Own Elaboration

With the information collected from the Drew report of 2004 and 2014 for the Ship employment for South American trade we made the calculation for the number of vessels employed for each trade: Europe, North America and Asia, then we calculated average the maximum vessels size (capacity) per trade employed at mentioned years and finally the annualized capacity of TEUs per trade. With the results from 2004 and 2014 we calculated the percentage variation in that from 2004-2014 are 10 years and from 2014-2030 there are 16 months but we took the lowest scenario assuming that the increase will be the same taking into account economic problems in South America for the last years regarding the decrease in oil price and the expected El Nino phenomenon for 2016.

From above results we can see that from 2004-2014 the number of vessels increased on all trades mainly in the Europe trade, due to a growth in trade between the regions. Also the size of the vessels increased - reaching vessels of 8.608 TEUs vessels in trade with North America and Asia. With the forecast there is evidence to say that the size of the vessels will continue growing.

Table 21 Economies of Ship Size

COSTS/YEARS	2000 TEUs	3000 TEUs	4500	8500	15000	19000
Capital Cost at 5% depreciation and 4% interest (per day)	$ 20.242	$ 28.941	$ 32.157	$ 21.945	$ 32.203	$ 37.726
Estimated consumption of fuel (per day)	$ 22.395	$ 33.948	$ 63.369	$ 103.738	$ 175.794	$ 87.897
Operating Cost (per day)	$ 5.751	$ 7.153	$ 7.431	$ 9.521	$ 12.762	$ 14.479
TOTAL COSTS PER DAY	**$ 48.388**	**$ 70.042**	**$ 102.957**	**$ 135.204**	**$ 220.759**	**$ 140.102**
SLOT COST PER DAY	**$ 24**	**$ 23**	**$ 23**	**$ 16**	**$ 15**	**$ 7**

Data Sources: International Transport Forum, The Impact of Mega-Ships, Case-Specific Policy Analyis (OECD/ITF) 2015 http://www.internationaltransportforum.org/pub/pdf/15CSPA_Mega-Ships.pdf
Ship Size Revolution and Potential New Opportunities 2011
http://globalmaritimehub.com/custom/domain_2/extra_files/attach_233.pdf
CMA-CGM Head Office Marceilla
Elaboration and Calculations: by the author

We are going to focus our analysis on the costs and benefits between the vessels of 4.500TEUS that are actually calling at POG and 8.500TEU vessels that are expected to pass through the new locks in the Panama Canal. As the operational cost from Panamax Vessels to Post Panamax Vessels will decrease by 30% the assumption is that the ocean rates will also drop on the same amount.

Another benefit expected is the increase in Port Revenues through the rise on the quantity of handlings of the Terminal as more units will be transported on every vessel. In the actual Terminal the handling charge from ship to gate is USD166/box.

The Port revenues for the scenario 1 will remain the same from 2022 because at that year it reaches its full capacity so there is no possibility to increase rather than expanding the Port which is not for the part of this study. On the other hand in the scenario 2 the port revenues remain the same from year 2030 when it reaches its full capacity.

Table 22 Forecast of Port Revenues for both scenarios in USD Millions

Year	Scenario 1- BAU	Scenario 2- DST	Scenario 1- BAU	Scenario 2- DST
2018	2.538.004,00	730.000,00	$ 406.080.640,00	$ 116.800.000,00
2022	3.100.000,00	1.110.000,00	$ 496.000.000,00	$ 177.600.000,00
2026	3.100.000,00	1.600.000,00	$ 496.000.000,00	$ 256.000.000,00
2030	3.100.000,00	3.000.000,00	$ 496.000.000,00	$ 480.000.000,00

There are also other benefits that are difficult to measure, such a decrease in congestion on actual Port Area due to the new highway in the case a new Terminal is

built, decrease of pollution due to more efficient engine systems on bigger vessels, but we are not going to take them into account for this study due to their complexity.

4.5 Cost effectiveness analysis of the economic comparison: New Deep Sea Terminal and Business as Usual

First we calculated for the scenario of the New Deep Sea Terminal (DST) the cost and benefits of the project.

- The infrastructure and construction costs involved: the new docks, storage facilities, dynamic areas, a new high way for heavy transit to the zone, cranes, equipment needed. These costs were taken from a study by the Maritime Chamber of Guayaquil, about the costs of building a new Deep Sea Terminal in Posorja.

- The expected overprice in inland rates due to the distance from main origin/destination of the cargos to the new Terminal location. For this point there were two possibilities, to calculate the overprices with the actual highway, which is not adequate for heavy transit of tricks and only has two lines, or to calculate it with a new highway which is fundamental due to a faster and better route for the cargos. We have decided to base our calculations on the scenario with a new highway. The expected rates to the new terminal have been collected from the Inland Manager of MSC Ecuador. The routes that have been chosen for this calculations are the main provinces in terms of exports and imports share from the total national cargo: Guayaquil, El Oro, Los Rios and Pichincha.

  The Guayas province with the capital of Guayaquil exports 30.6% of the national bananas exports, 62% of shrimp exports and 35% of cocoa beans national exports. From the imports of the country, 57% stayed in the province of Guayas.

  From Los Rios 32.53% of the bananas are exported and 25% of the national exports. From El Oro Province 27.63% of the national bananas exports are generated and 22% of national shrimp's exports. In terms of imports Pichincha province with its capital Quito, is the second most important imports destination with 26% of national imports.

  Because the commodities mentioned above substitute the most important commodities in terms of exports, we have considered that above routes are the most significant to be taken to calculate the over prices of the inland rates.

  We have made previously a forecast of containers for the country for the coming years, but we have not used the forecast values for all the years because there's not enough capacity in the Terminal to accommodate all the containers.

  In the first two years of the project no handling of containers is expected, because it is the period of construction of the docks and part of the facilities. On the third year it

is expected to start handling operations of the capacity constraint by the advance in the construction and infrastructure with a same amount of 730.00 TEUs until the seventh year where the capacity will increase to 1.100.000 TEUS, and in the fifteen year when the maximum installed capacity is reached. In order to calculate the over value we determined the share per province from the total of imports and exports, and then each percentage of cargo was multiplied by the total of TEUs and then multiplied by the trucking rate. We made the same operation for the actual inland rates and for the rates to the New Terminal and then we subtracted one result from the other.

(23) Inland Cost per Year

$$= \big((\text{TEUs} * 0{,}1) * \text{Quito rate}\big) + \big((\text{TEUs} * 0{,}19) * \text{Manta rate}\big) + \ ((\text{TEUs} * 0{,}15) * \text{Machala Rate}) + ((\text{TEUs} * 0{,}57) * 450\ \text{Guayas rate})$$

- The third considered cost is the operational cost of running a new port, based on the number of TEUs that will be handled taking into consideration the forecast made in the chapter before constraint by the capacity of the port and the construction of all the facilities. Those costs has been taken from the same study from the maritime chamber regarding the construction of the new Terminal, where an operational cost including labor was estimated to be EUR 74.83 per TEU. For the Benefits of the project we choose the port revenues and the benefits in transport costs.

- Port revenues: to calculate the Port revenues we multiplied the number of TEUs expected to be handled each year times the terminal handling per TEU. We assumed that the THC at the new Terminal will be the same as the one in Port of Guayaquil USD160/Box, because a higher charge would make the Terminal loose competitiveness among the old one.

- Benefits in transport cost: in order to calculate this value, first we calculated the market share per main trade partner and we obtained that Europe is responsible for 24% of the TEUs movement, North America 31% and Asia 45%.

  On the other hand we obtained an average from the last 5 years from ocean rates in the involved traffics: Guayaquil-Europe-Guayaquil, Guayaquil-North America-Guayaquil and Guayaquil-Asia – Guayaquil. The average was calculated from the last 5 years rates from each route for dry cargo, from the Shipping Line CMA-CGM.

  With this average rate per route we calculated and with the help of below formula we got the relationship between rates and increase in the ship size. As we have discussed previously in this research the main goal of a New Deep Sea Terminal is to receive bigger vessels that would be able to pass through the Panama Canal. The expectation is an increase from 4.000 TEUs vessels to 8.000 TEUs vessels.
  With the formula we got the approximate ocean rate with the project.

(24) Sea freight target year

$$= Sea\ freight\ base\ year * \left(\frac{Ship\ size\ target\ year}{Ship\ size\ base\ year}\right)^{-0,3}$$

Source: Dr SImme Veldman

After obtaining previous information we calculated the inland amount per trade first with the base year sea freights per trade and the with the target year sea freight previously calculated. After obtaining the amounts per trade with actual employed vessels and with bigger vessels, we subtract both values and we got one result per trade per year. After this step we add the results from the three trades per year and we obtain the total benefits per year, as detailed formula presented below.

(25) Ocean rates benefits

$$\left(Base\ year\ Ocean\ rate_{Europe} *\ TEUs\ per\ year_{\ Europe}\right) - \left(Target\ year\ Ocean\ rate_{Europe} *\ TEUs\ per\ year_{\ Europe}\ \right)$$

After calculating the cost and benefits for the DST, we calculated for the Business as Usual (BAU). From the cost side we did not consider any infrastructure or construction cost because the infrastructure is already there, we did not consider any overprice on inland rates because actually the trucking rates are cheaper than the expected rates for the new project. Instead we took into account the dredging and maintenance of the canal of access to the Port and the operational costs. For this scenario we have adjusted the forecast of containers to the maximum install capacity of the Port, that's why from 2022 onwards the number of TEUs remain on 3.100.000 TEUs per year.

- Dredging and maintenance costs: these costs were obtained in the study of the Maritime Chamber of Guayaquil about the Future of the Port of Guayaquil. It's a high value that should be paid within the years in order to maintain proper sailing conditions for the ships. But this is not going to increase the draft of the Port.

- Operational costs: we have calculated from an average operations costs per TEU taken from the Port of Barcelona in Spain that has a similar capacity in TEUs to Port of Guayaquil.

From the benefits side we only took into account the Port Revenues because in this scenario there is no Benefits in Ocean Transport. In the same way as in the previous scenario we multiplied the THC USD160/Box times the number of expected TEUs per year.

With the cost and benefits calculated from both scenarios we compared both costs and found that the costs generated from the DST scenario are higher within the next 15 years than the BAU, not only during the period of construction. The difference in

extra costs generated from the DST are from 3.04 times in 2016 to 7.23 times in 2030. Showing the high increase on the costs for this project, while the costs from the BAU do not have much variation over the years.

We can conclude that even though at the end the benefits from the DST start to be noted, the overpricing of the inland rates is still too high. Therefore, it is not worth to make a big investment that would take years including new highways and the Terminal when the cost of transporting the cargo over there is too high. In economic terms, it is more beneficial to keep operating with the Port of Guayaquil as it does now and transport the cargos via Feeders to other transshipment ports in the regions where the bigger vessels can call. That option would end up being more competitive even for the trade costs.

After making the whole calculation of the costs and benefits our outcome was negative in all the years except the first year. Revealing that the scenario of the DST is not viable in both aspects. Based on the explanations presented above we can conclude that regarding costs the DST is not viable because the costs are way too high.

But then what are the macro-economic effects of enlarging the Panama Canal with- and without the DST Terminal – effects that we need to combine with the – narrower, domestic – CEA results.

Table 23 Cost Effectiveness Analysis of both Scenarios

USD MILLIONS

DEEP SEA TERMINAL	Present value	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total Costs	7.137	539	614	681	785	821	852	921	964	1.006	1.050	1.133	1.236	1.285	1.337	1496
Total Benefits	2.893	-	-	295	295	295	295	449	449	449	449	648	648	648	648	1214
CBA= Benefits - Costs	-4.244	-539	-614	-385	-489	-526	-556	-472	-514	-557	-601	-486	-588	-638	-689	-281

BAU	Present value															
Total Costs	1.690,71	144,71	162,78	183,97	191,46	199,33	207,62	216,33	224,96	234,00	243,49	253,44	263,51	274,05	285,09	296,65
Total Benefits	4.062,44	310,90	364,55	427,45	449,68	473,06	497,66	523,54	549,14	576,00	604,17	633,72	663,61	694,91	727,69	762,01
CBA= Benefits - Costs	**2.371,73**	**166,18**	**201,76**	**243,48**	**258,22**	**273,73**	**290,04**	**307,20**	**324,18**	**342,00**	**360,68**	**380,28**	**400,10**	**420,86**	**442,59**	**465,36**

BENEFITS BOTH PROJECTS	Present value															
DST	2.893	-	-	295	295	295	295	449	449	449	449	648	648	648	648	1.214
BAU	4.062	311	365	427	450	473	498	524	549	576	604	634	664	695	728	762
BENEFITS= DST - BAU	(1.169)	(311)	(365)	(132)	(154)	(178)	(202)	(74)	(100)	(127)	(155)	14	(16)	(47)	(80)	452

4.6 Global Simulation results

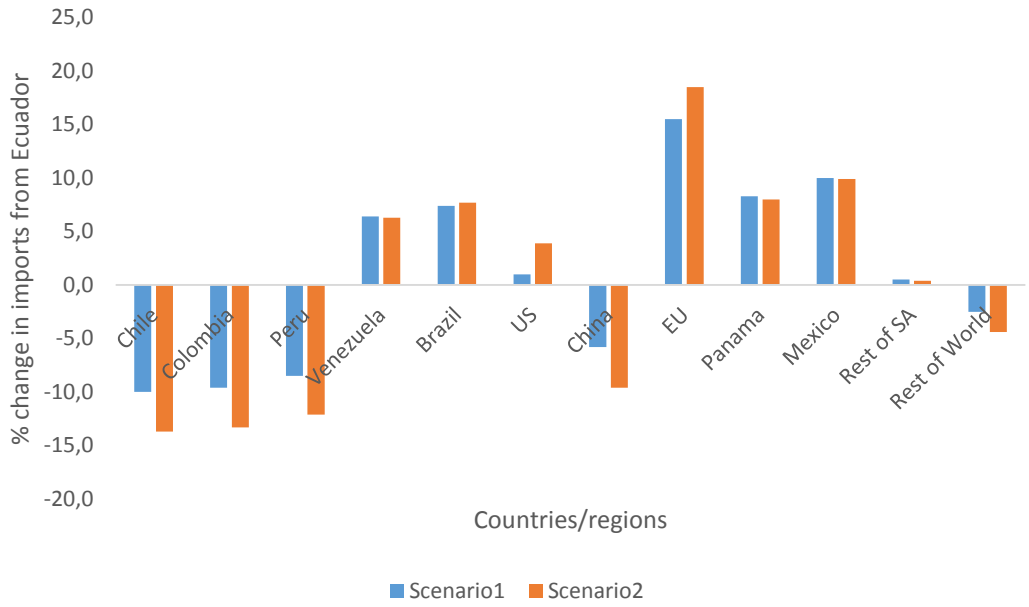
As explained before, the macro-economic effects of expansion of the Panama Canal will have an impact on the west-coast of Latin-America – especially Colombia, Peru, Ecuador and Chile. We look at two scenarios: the first to investigate the expansion of the Panama Canal without Ecuador building the DST; the second to investigate the effects of the expansion of the Panama Canal with Ecuador building the DST. The results of the GSIM analysis are presented below, starting with the national income effects, followed by the trade effects, the output effects and price effects for Ecuador and neighboring countries.

4.6.1 Trade effects

We expect the expansion of the Panama Canal to affect positively those trade flows that make use of the Canal (as they will experience a relative cost decline because larger vessels can now sail the Canal) and negatively affect those trade flows that do not make use of the Panama Canal. This is indeed also what we find. There is much to report about trade flows, but since this thesis is about Ecuador, we focus on the trade effects for Ecuador. In Figure 16 we see that trade between countries on the West-coast of Latin-America decreases because trade between these countries does not make use of the Panama Canal. We also see that trade between these countries decreases further when Ecuador opts to build the DST at Posorja (Scenario 2). What this implies is that trade shifts more to Ecuador and thus away from its direct regional competitors when Ecuador builds the DST at Posorja. What we also see is that trade with some countries increases in both scenarios 1 and 2: Venezuelan, Brazilian, US, EU, Panamanian and Mexican exports to Ecuador increase – and for the US and EU even more so when Ecuador builds the DST at Posorja. For Ecuador – in absolute terms – trade with the EU and US matters most, so these two percentage changes drive the total trade value results.

Figure 16 Percentage changes in exports of trade partners to Ecuador

Figure 17 Percentage changes in imports of trade partners from Ecuador



When we look at Ecuadorian imports from the main trading partners – as depicted in Figure 17, we see a very similar picture as with exports: imports from regional trading partners (not using the Panama Canal) decreases, while imports from the US and EU – those that use the Panama Canal – increase significantly.

Combining Figure 16 with Figure 17, we can conclude that the Panama Canal expansion clearly benefits Ecuadorian trade with those trade partners that make use of the Panama Canal. We also conclude that building the DST at Posorja further strengthens this effect.

Overall, when comparing scenario 1 and 2, we also conclude that the Panama Canal expansion has a much larger impact on Ecuadorian trade flows than building the DST at Posorja. This we see when comparing the percentage changes in exports and imports (in the above figures) for scenario 1 with the difference between scenario 1 and 2 for those exports and imports (i.e. the additional percentage changes because of building the DST at Posorja) – this was a result that we expected. Moreover, we see that the relative importance of building the DST at Posorja is most important for the regional competitors.

4.6.2 National income effects

Table 20 below shows the welfare effects for the two scenarios. In scenario 1 (Panama Canal expansion only), we see a total welfare (consumer plus producer surplus) gain of Euro 276 million for Ecuador because of the expansion of the Panama Canal. That is much less than its direct competitors, Chile (+ Euro 930 mln), Colombia (+ Euro 855 mln) and Peru (+ Euro 455 mln). Especialy Ecuadorian producer surplus is significantly lower. The largest gains accrue to Rest of World (+ Euro 34 bn), China (+ Euro 10 bn) and the US (+ Euro 9.4 bn). The relatively lower gains for Ecuador have mainly to do with the fact that the Ecuadorian trade flows are smaller, and

because trade cost drops are limited by the limited draught of the Port of Guayaquil. When we look at scenario 2 – expansion of the Panama Canal and – at the same time – building the DST at Posorja – we see that the welfare effects for Ecuador are much more positive. From a total gain of Euro 276 million in scenario 1, when the DST is built, gains for Ecuador increase to Euro 502 million. This is due to the relative increase in attractiveness of Ecuador because of the DST (i.e. the increased draught).

Table 24 Welfare effects of Panama Canal expansion + DST Posorja

Country	**Scenario 1: PC only**			**Scenario 2: PC + DST Posorja**		
	Producer Surplus	**Consumer Surplus**	**Total Welfare**	**Producer Surplus**	**Consumer Surplus**	**Total Welfare**
	(1)	(2)	**(3)**	(4)	(5)	**(6)**
Ecuador	68,8	206,7	**275,5**	158,6	343,3	**501,9**
Chile	252,0	678,2	**930,2**	250,0	667,4	**917,5**
Colombia	259,0	595,9	**854,9**	253,6	592,5	**846,2**
Peru	150,1	305,3	**455,4**	147,7	2985	**446,2**
Venezuela	26,7	347,1	**373,8**	26,2	347,6	**373,7**
Brazil	714,6	1961,8	**2676,4**	713,0	1964,3	**2677,3**
US	307,0	9062,0	**9369,0**	320,9	9144,1	**9465,0**
China	1697,5	8320,2	**10017,7**	1668,4	8341,3	**1009,7**
EU	-1045,5	4880,0	**3834,5**	-1056,6	4920,8	**3864,2**
Panama	-0,7	554,5	**553,8**	-0,7	556,8	**556,1**
Mexico	-517,0	614,8	**97,8**	-522,2	615,1	**92,9**
Rest of SA	504,9	1476,0	**1980,9**	504,4	1476,9	**1981,3**
ROW	2910,6	31223,8	**34134,4**	2832,5	31306,3	**34138,8**

This relative gain comes at the expense of welfare in other countries. In Table 21, we show the percentage changes in welfare due to building the DST as well as the related absolute welfare changes. Clearly – as said above – welfare for Ecuador increases significantly (by 82 percent and Euro 226.3 mln). Chile (-1.4 percent), Colombia (-1.0 percent), and Peru (-2.0 percent) see small decreases in welfare due to divergences to Ecuador. The US and EU see welfare gains that mainly link to more trade with Ecuador. The largest loser in relative terms is Mexico with a welfare decrease of 5.0 percent. Finally we note that in total, global welfare gains are positive (+ Euro 316.4 mln) as a result of building the DST.

Table 25 Percentage and absolute value changes between the two scenarios

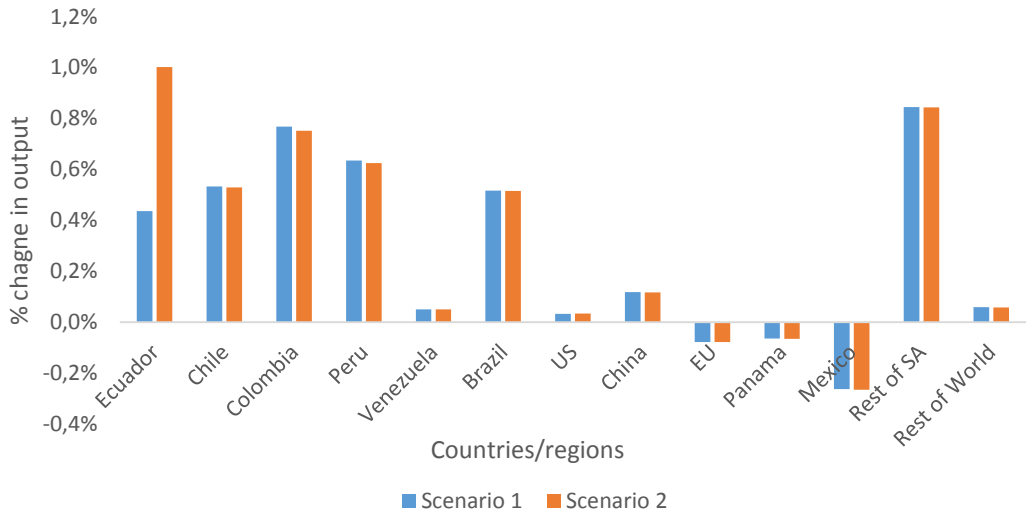
Country	**% Change in welfare**	**Absolute value change in welfare**
Ecuador	82.1	226.3
Chile	-1.4	-12.7
Colombia	-1.0	-8.7
Peru	-2.0	-9.2
Venezuela	0.0	-0.1
Brazil	0.0	0.9
US	1.0	96.0

Country	% Change in welfare	Absolute value change in welfare
China	-0.1	-8.0
EU	0.8	29.8
Panama	0.4	2.4
Mexico	-5.0	-4.9
Rest of SA	0.0	0.4
ROW	0.0	4.3
TOTAL		**316.4**

4.6.3 Output effects

The output effects that we find using the GSIM model are interesting to report. We see that – in the Panama Canal expansion scenario, Scenario 1 – the countries on the West coast of Latin America see their output levels increase. This also is the case for Brazil and the rest of South-America. Reporting percentage changes, the gains in output for the US and China do not seem large, though they are when covered in absolute terms. The EU, Panama and Mexico will see their output levels decline. This is due to the fact that more production will shift to those gaining, and because the relative cost decline of the Panama Canal expansion is a lower percentage of total transport costs for the EU than for other countries. What is most striking in the below Figure 22, however, is what happens to Ecuador. We see that Ecuador is expected to gain less (in percentage terms) than its direct regional competitors, Chile, Colombia and Peru, in Scenario 1 (where Ecuador does not build the DST at Posorja). However, if the Panama Canal expansion is flanked by enabling domestic policy in the form of building the DST at Posorja – allowing Ecuador to benefit from larger draughts of vessels passing the enlarged Panama Canal – the county is expected to more than double its output gains from just over 0.4 percent to around 1.0 percent.

Table 26 Percentage changes in output for Scenarios 1 and 2



4.6.4 Conclusions GSIM analysis

From the GSIM analysis an interesting overall picture emerges. First of all, the expansion of the Panama Canal will have a global impact on trade, welfare and output. Countries that trade with each other through the Panama Canal are expected to gain, while those that do not are expected to relatively lose out.

The second main finding relates to the research question and Ecuador: given the Panama Canal expansion (exogenous to Ecuadorian domestic policy making), it is clear that the 'do nothing' scenario for Ecuador (Scenario 1) leads to less positive effects than if Ecuador will build the DST at Posorja. In terms of welfare, we see increases in total welfare of around 80 percent – at the expense of other regional and global trade partners, while output in Ecuador is set to go up from 0.4 percent to 1.0 percent. Also trade increases significantly for Ecuador.

Chapter 5 Conclusions

The big concern in the region regarding the expansion of the Panama Canal is complemented by the difficult position of the Port of Guayaquil which needs to increase its competitiveness due to draught problems. This situation raised the idea to conduct a research about the possibilities to solve the problem taking into account the actual situation in the country.

The purpose of this research was to determine **What are the economic and trade effects for Ecuador of building a Deep Sea Terminal at Posorja compared to keeping the Port of Guayaquil as it is today (Business As Usual scenario) as a response to the Panama Canal expansion?**

Ecuador and its main competitors in the region Peru, Colombia and Chile basically trade similar products: agricultural products, oil, fisheries and mining products.

The Port of Guayaquil has a strategic position due to its hinterland which is its major strength. It is located in Guayaquil, the biggest city which concentrates the majority of the industries and commercial activities of the country, which is also the destination of most of the imports. Guayaquil belongs to the province of Guayas, most of the export are generated from this province as well as the neighboring provinces of El Oro and Los Rios. The distance from the city center to the Port is approximately 15kms, with well-connected corridors to the whole country that avoids congestion problems and facilitates cheaper inland rates.

The weak point of the Port is the canal of access which needs a removal of the rocks at the entrance of the Canal and an expensive dredging of the canal due to critic accumulation of sandbank zones. This limits the draught of the Port to 9.75 mts at high tide making it the least deep port in the region. Its competitive ports in the West Coast have higher draughts: Callao in Peru is 12.5mts, San Antonio in Chile - 11.58mts and Buenaventura in Colombia - 10.7mts.

Although Port of Guayaquil has its limitations, it still has a high performance rate. According to Cepal, it is ranked as #8 Port out of 120 Latin American and Caribbean Ports in terms of throughput handled, infrastructure installed capacity and service, while Calla is ranked 6, San Antonio - 14 and Buenaventura - 17.

For this study we applied two methodological approaches: The Cost Effectiveness Analysis (CEA) and the Global Simulation Analysis.

In CEA we identified many yields of impact, regarding the benefits and costs of the project in economic terms and for the society as a whole. When we speak about society benefits we include the surplus for consumers, as the decrease on maritime transport cost which is translated as trade cost decrease. Regarding the cost we did not take into account only construction and investment costs, but also derived costs

from the New DST as the overprice on the inland rates, that was translated as an increase on trade costs and a deficit on consumer surplus. All the values were brought to a Net Present Value to further apply a social discount rate to get the opportunity cost of the capital invested in the new Terminal.

The GSIM model on the other hand was run with the bilateral trade matrix at world prices in ad valorem form, with the two scenarios proposed that yield to trade liberalization. Trade liberalization effects were estimated in terms of changes in welfare, producer and consumer surplus, trade flows, tariff revenues and prices. The GSIM model generated new prices that clears the markets and yields to new trade values and welfare effects.

From the CEA with the cost and benefits calculated from both scenarios we compared both costs and we found that the costs generated from the DST scenario are higher within the next 15 years than the costs of BAU, not only during the period of construction. The difference in extra costs generated from the DST are 3.04 times in 2016 to 7.23 times in 2030. This demonstrates a high increase of the costs for this project, while the costs from the BAU do not change much over the years. Our outcome was negative in all the years except the first year. Revealing that the scenario of the DST is not viable because even though there is a benefit generated on trade costs due to decrease on maritime transport costs derived from the Economies of Scales on Ships, it is not high enough to justify the high prices on inland rates to the new DST.

We can conclude that even though at the end the benefits from the DST start to be noted the overprice on the inland rates is too high, is not worth to make a big investment that would take years including new highways and the terminal when the cost of transporting the cargo over there is too high.

Our findings based on the analysis with the help of the GSIM Model were that all the countries with cargo flows passing through the Panama Canal are positively affected by the expansion.

The regional trade between Ecuador and its competitors decrease at an important rate in both scenarios as the Panama Canal is not used. The trade flows increase with both US and EU, Brazil, Venezuela and Panama for Ecuador and even more with the DST.

We can conclude that clearly the Panama Canal expansion benefits Ecuadorian trade with the trade partners that use the Panama Canal and building the DST at Posorja further strengthens this effect. When comparing scenario 1 and 2, we also conclude that the Panama Canal expansion has a much larger impact on Ecuadorian trade flows than building the DST at Posorja. We see that the relative importance of building the DST at Posorja is more important for the regional competitors.

The expansion of the Panama Canal will have a global impact on trade, welfare and output. Countries that trade with each other through the Panama Canal are expected to gain, while those that do not are expected to relatively lose out.

Do nothing' scenario for Ecuador (Scenario 1) leads to less positive effects than if Ecuador builds the DST at Posorja. In terms of welfare, we see increases in total welfare of around 80 percent – at the expense of other regional and global trade partners, while output in Ecuador is set to go up from 0.4 percent to 1.0 percent. Also trade increases significantly for Ecuador.

Table 27 Results of the CEA and GSIM analysis

	CEA analysis: no DST	CEA analysis: DST
	GSIM analysis: no DST	GSIM analysis
Quantitative CEA results	2.372 USD MILLIONS	-4.244 USD MILLIONS
Quantitative GSIM results	275,5 USD MILLIONS	501,9 USD MILLIONS
TOTAL results	**2.647.5 USD MILLIONS**	-3.142.1 USD MILLIONS

Based on the analysis and the findings presented above, our recommendation to the policy makers is to keep the operation of the Port of Guayaquil as it is being operated at the moment as it is the most profitable option in economic terms. Even though a new Deep Sea Terminal would bring new opportunities in terms of output, trade flows and economic effect, the cost of it is higher than the benefits. At this point the opportunity cost is not worth it. It's better to maintain the actual Port doing dredging and cleaning works on the Canal of access in order to keep a low trade cost. In case bigger vessels arrive to the region the cargos to/from Ecuador should be transported via Feeder to other closer Ports where the big vessels can be called. Stakeholders would think that transporting trough transshipment ports would increase the transport cost but at the end the pressure from customers would push the transport rates closer to other Ports that able to receive bigger vessels. In case transport prices increase due to the transshipment, the increase would be lower than the over price paid for the inland to a new Terminal.

Based on the findings of this research paper, there are some areas for further research. In our opinion the most relevant would be to study the possibility of expansion of the actual Port of Guayaquil in order to accommodate the excess throughput expected from 2022 derived from our container forecast. Another interesting area that can be researched is the possibility of building a new deep sea terminal in Posorja as a complement of the Port of Guayaquil which will be able to accommodate the excessive throughput expected from 2022.

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Annex 2

Ecuador general overview

Ecuador is located in the North West part of South America in the continent of America, limits in the North with Colombia, in the South and West with Peru and in the west with the Pacific Ocean (Embassy of Ecuador in the Republic of China, 2015). With surface of 256.370 km2 and a density of 62 habitants per Km^2 (Expansion, 2014). The length of the sea Coast is 2237kms (Index Mundi, 2015). The estimated population is 16'290.348 (INEC Instituto Nacional de Estadisticas y Censos, 2015). Ecuador is divided by four regions: Coast, Highlands, Forest and Galapagos Islands. The capital is Quito, located in the Highlands, with a population of 2'551.993 being the second biggest city in terms of population. The most important city of the country is Guayaquil which is located in the Coast, with a population 3'050.728, and with the biggest Port of the country, this situate the city as the economic capital of the country. The third biggest city is Cuenca with 400.000 habitants, then Portoviejo with 257.000 and number five Machala with a population of 250.000 (Embassy of Ecuador in the Republic of China, 2015).

Broader Demographic and Political Context

Ecuador counts with a Democratic system of elections since 1978 (American States Organization, 2007), with three main political powers: The Executive, Legislative and Judicial.

The president is elected through popular election, for a period of 4 years. The actual president Ec. Rafael Correa is on his third consecutive period, being this the last allowed by the actual Constitution. In the popular elections are also elected Congress members and sectional governing. The Congress is composed by 137 members in the actual period from which 99 belong to the President's Party and the other 38 belong to several Parties (National Congress of the Republic of Ecuador, 2015). The Judicial power is elected by the Judicial Council, integrated by 21 Judges for a period of 9 years (Congress of Ecuador , 2008).

Broader Economic Context

Domestic and Regional GDP

Ecuador faced a several crisis that started in 1998 and burst in 1999 unleashed by the extreme dependency on oil exports and the drop of the oil barrel to USD9, massive accumulation of external debt, natural disasters causes by ¨El Nino¨ that hardly affected national production in all agricultural sectors and national infrastructure and the increasingly devaluation of the national currency ¨Sucre¨ (Solimano, 2003). Followed by the bankruptcy of 17 private banks and lost around 6.170 millions of dollars (Newspaper El Telegrafo, 2014) , closing 1999 with an inflation of 60-75%, the highest in Latin America at that time leading to the decision of the Dollarization of the country (CEPAL, 1998). After several changes in the economic structure, new political implementations and due to the increase on Oil Price the economy and social progress of the country had been improving. With an economic growth of approximately 4.5 % on average since 2001 and a decrease of approximately 3% on

inflation per year, in the actuality the country has and inflation of 3.53% in January. Nowadays due to a high capital spending the government is facing a fiscal deficit of 4.7% of GDP, financed mainly by loans from China. Ecuador's public debt is around 24.4% of GDP, among the standards of the region (International Monetary Found, 2014).

Ecuador GDP- Real Growth Rate (%)

Trade

The structure of the economy has not changed significantly the past decades, is still based in oil and agricultural exports of around 77%, with few industrial development of around 23%. As an effort to protect and increase it, the government had develop special politics to encourage and support the export sector, offering international advice and assistance through ProEcuador offices around the world which is a Government Institution focus on helping the development of exports and all the parties involved (ProEcuador- Institute for the Promotion of Exports and Investments, 2014). Mainly the exports are based on oil, banana, can tuna, fish, shrimps, flowers and cocoa beans, and in less quantities industrialized products, oil derivate, etc. (Military Geographical Institute of Ecuador, 2013).

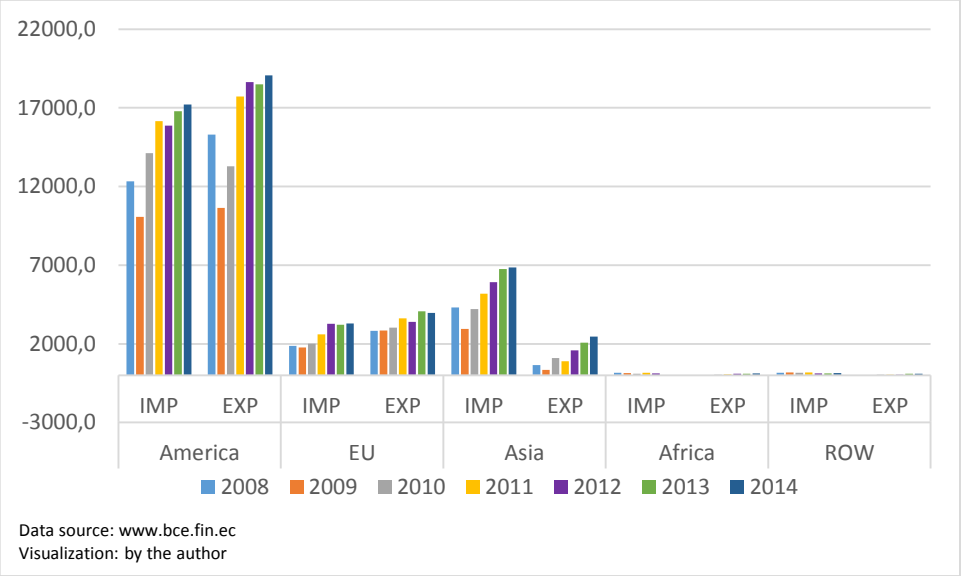
Ecuador main trade partner is US with around 45% of the total exports, due to bilateral agreement signed by both countries ATPDA regarding tariff preferences. The second important market is the rest of America mainly Andean Nation Communities countries, Bolivia, Colombia and Peru, by free common trade agreement. Third the European Union with bilateral agreement signed as well.

It's important for this study to analyze the trade development of the competitor countries in order to understand the context of Ecuador within the region.

In the following charts we can see that the main trade partner region of Ecuador is America, around 65% of the imports comes from this region and about 80% of the exports goes there. The volumes on imports and exports had been increasing with all

the regions during the las seven years. With America and EU Ecuador has a light surplus, but in the case of Asia the imports are higher than exports. There is almost no trade with Africa and the Rest of the World.

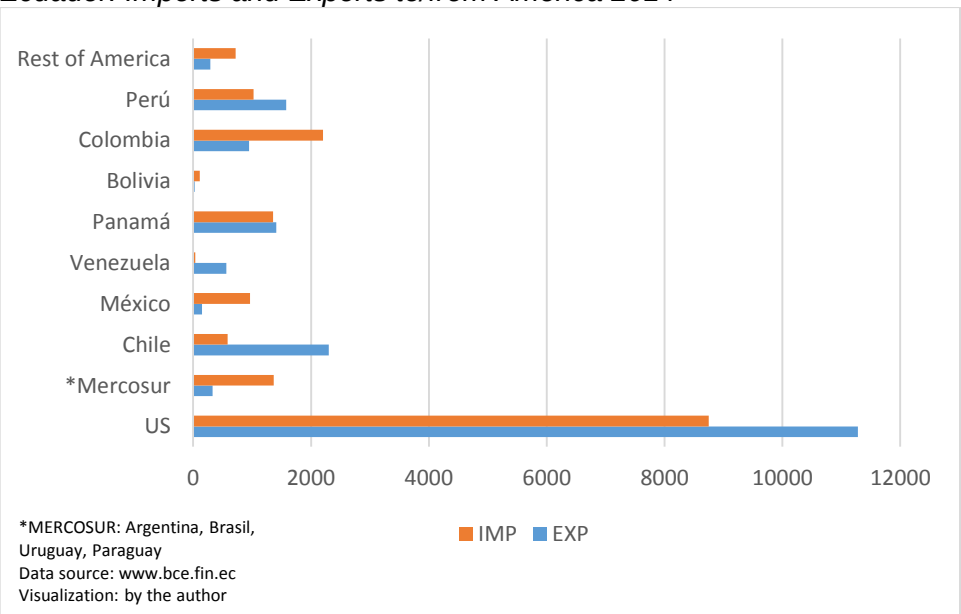
Total Ecuador CIF Imports and FOB exports by trade partners 2008-2013 (Million USD)



Data source: www.bce.fin.ec
Visualization: by the author

Within the American region the most important trade partner by far is US regarding both imports and exports, there followed by Chile with a huge difference, as expressed in Figure 7.

Ecuador: Imports and Exports to/from America 2014



*MERCOSUR: Argentina, Brasil, Uruguay, Paraguay
Data source: www.bce.fin.ec
Visualization: by the author

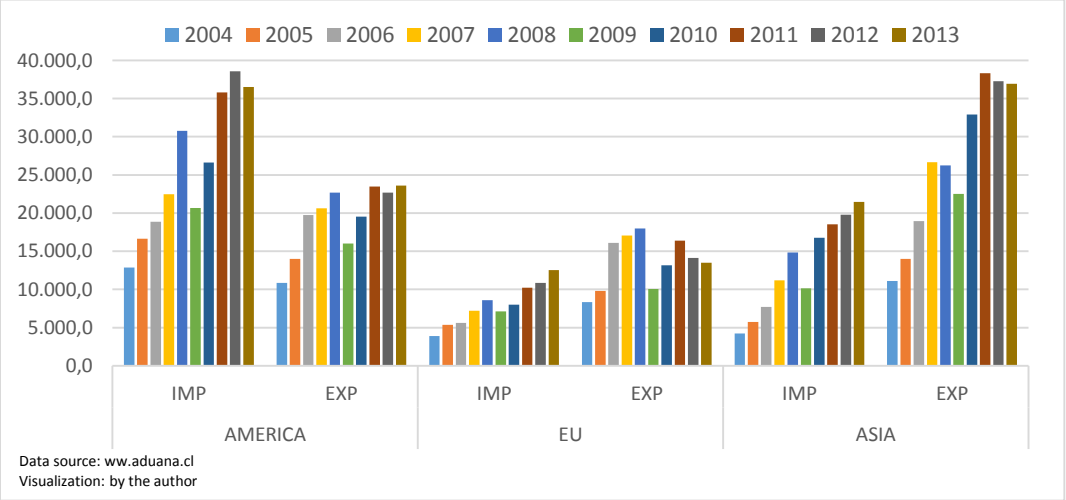
Chile

Chile is one of the biggest export countries in the world, with more than 30 Trade treaties signed, although the crisis in Europe and US the country had managed to handle it. Chile is the biggest exporter of copper in the world.

The exports if the country are based mainly on mining and oil with a share of 53.3% in 2014, followed by manufacture products with a 27.7% and agricultural products with a 19%. (CEPAL, 2014). The principal products within previous categories mentioned are cooper, minerals, fresh fruits, salmon, wood paste (Cellulose), manufactured wood, drinks and alcoholic drinks, wine, gold, etc. (Chile Customs, 2014).

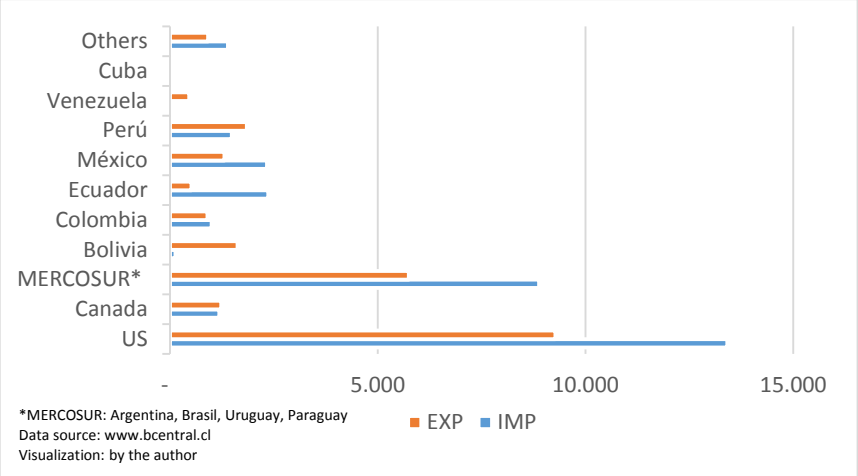
The import groups of products of Chile are mainly intermediary materials with a share of 34.9%, followed by consumption goods 28%, fuels 20.6% and capital goods 16.6%. The principal products within those categories are mineral fuels and oils, machinery and parts, vehicles and parts, electric equipment and parts, plastic and manufacture, iron manufacture (Chile Customs, 2014).

Total Chile CIF Imports and FOB exports by main trade partners 2004-2013 (Million USD)



As America is one of the main trade regions for Chile, in Figure 11 we can see the main trade partner countries, where US is the most important in both imports and exports, followed by Mercosur countries.

Chile: Imports and Exports to/from America 2014



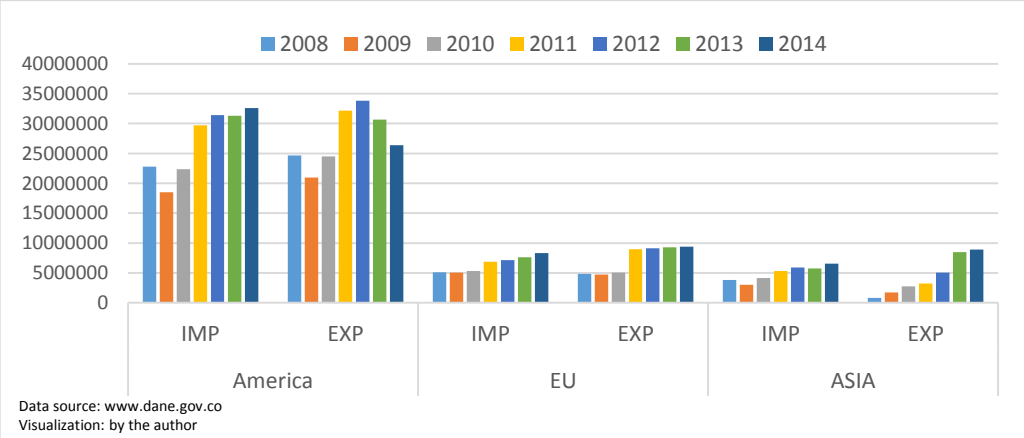
COLOMBIA

The exports of the country are mainly based on mining and oil with a share of 60.7% both, followed by manufacture products and agricultural, food and beverage. By the other hand the most dynamic imports are intermediary materials (33.3%) and capital goods (32.3%) (DANE-National Administrative Department of Statistics, 2015).

Within the region the most relevant partners are Mercosur with 7.2% and CAN with 5.4%. China is a growing market for the country, it exports increased from 5.8% in the first semester of 2010 to 12.4% in the same period on 2014 (CEPAL, 2014).

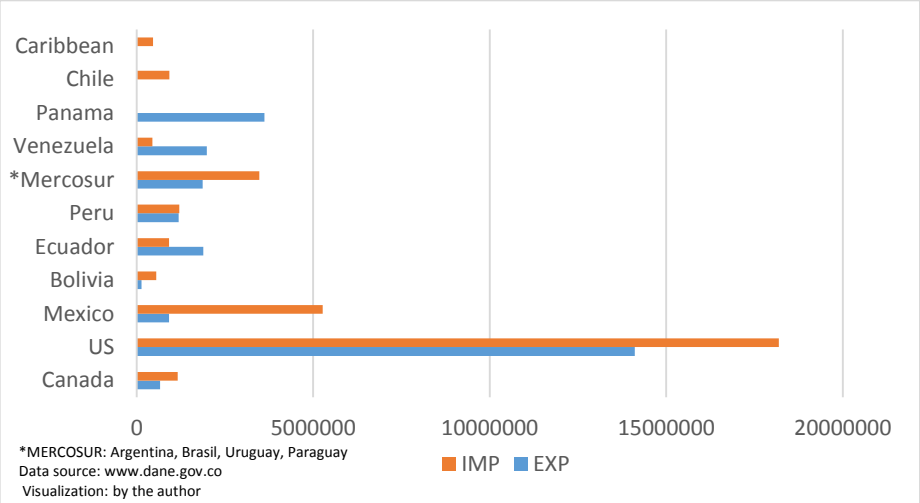
Regarding the imports of the country, US is the main origin followed by Latin America and EU. There is an important difference between the trade with America and the other regions. By the other hand there is a pattern of trade growth with all the regions in the last seven years.

Colombia: Imports and Exports by main trade partner (thousands USD)



From Figure 13 and 14 we can state that 70% of the imports goes to America and almost 50% of the exports to America. There is a reduction of the exports to America in the last seven years and an increase to the EU and Asia.

Colombia: Imports and Exports to/from America 2014

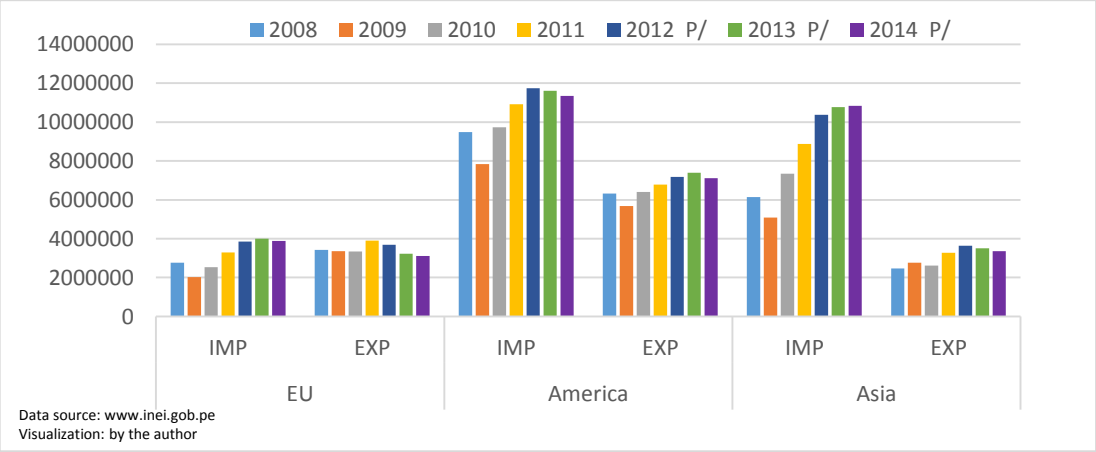


PERU

Peru main trade partners are US, China, Canada and Japan, the exports to those countries but US are mainly primary resources. At first place China, then US with a small difference, the second main trade partner is EU with 14% of share, mainly Germany, Spain and Italy.

The exports are mainly based on traditional goods with a 74% that shows the high dependency on mineral products like copper and gold that represents 74% of the traditional exports. Other sectors as agricultural, fishing and mining had shown decreasing results in the last years. Within the nontraditional exports that represents the 25% of the total, the agricultural sector is still the most important with 31% (National Institute of Statistics and Informatic , 2015).

Peru: Imports and Exports by main trade Partners (thousand USD)



Regarding the imports, the main suppliers of the country are US with 20%, China 19%, Brazil 6%, Ecuador 5% and Mexico 4%. In terms of trade areas EU is still the

second main partner (12%) followed by Mercosur (10%), CAN (9%) and the rest of the world (Superintendencia Nacional de Aduanas y de Administración Tributaria, 2013).

Peru: Imports and Exports to/from America 2014