WORKING PAPER / 2006.05

Challenging the pro-development role of trade agreements when remoteness counts: the Ecuadorian experience

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ABSTRACT

Differences in infrastructure can determine trade opportunities across countries, in a similar manner, unequal infrastructures can also be used to explain trade patterns within countries. The aim of this study is to present evidences that higher levels of trade are related to better infrastructure endowments and that less developed Ecuadorian regions can benefit from improvements on their local infrastructure. An augmented gravity equation is applied in order to determine differences among twelve provinces based on the interaction of variables such as distance to main markets, participation in Trade Preferential Agreements, economic size and border effects.

The analysis of trade and infrastructure at the level of provinces in Ecuador and its link to international trade has not been exploited yet in the literature. This is the first attempt, making use of a detailed regional data set, to unveil the role of disparities among regions within this country, to explain trade patterns.

The main findings of this article confirm the importance of infrastructure development and its improvement as a more effective channel to reduce trade barriers than regional integration agreements, specially for geographically disadvantaged regions within Ecuador. Consequently the poor tend to benefit more from better access to markets and services due to better infrastructure than merely due to commercial openness policies.

The key role of transport costs in international trade needs more attention in order to enhance higher productivity and competitiveness in a framework of a future trade liberalization process. Improving access to services and transport facilities can also help poor regions to increase their market access and job prospects at the same time that new business opportunities are created.

Key Words: Trade, Infrastructure, Regional Integration,Gravity Model, Ecuador
Jel Classification: F15 – O-24 – R12

1. INTRODUCTION

Geography seems to exert an influence over the levels of development and trade, however, it is, in principle, an unchangeable factor. Awareness about remoteness, and the negative or diminishing effects it can exert, at the regional level, on nationwide policies and agreements has been growing recently. Infrastructure development, on the other hand, has been raised as an strategy to reduce transport costs and improve accessibility, therefore facilitating the exchange of goods, services, people and knowledge in general for those areas with adverse location. It is thus a major way of alleviating the consequences of remoteness.

The purpose of this paper is to present empirical evidence in favour of the last point above. The *locus* of the study is Ecuador which, though a small country in South American terms, comprises 22 strongly diversified provinces. Geographical disadvantages have contributed to create big disparities among them, as regards trade and development. According to the last Poverty Assessment performed by the World Bank for the country, poverty is more prevalent in rural areas - particularly in the Andean region - than in urban ones. The incidence of poverty is even higher for landlocked provinces in the Sierra (highlands) and in the Amazon, where the weather, the soil properties and global living conditions are adverse. *(World Bank,2004)*.

We determine, with the aid of enlarged gravity equations, how different the explanatory logic for the trade flows can be at the provincial level. The models of bilateral trade flows use data from 1994 to 2004 and incorporate the use of infrastructure indexes, as well as Andean Community and border dummies. This amounts to consider that – beyond the usual impacts of preferential trade agreements and adjacency - the impact of transport costs over the different provinces trade patterns is determined not only by the distance among trading partners, but also by infrastructure endowments, namely, in our case, the existence of services such as energy, roads and telecommunication networks. This has required the careful calculation of infrastructure indexes, at the provincial and national levels, for the period under study.

The paper is organized as follows. The first section describes briefly the geographical distribution of Ecuadorian provinces and their trade relations, in order to give more elements to support the selection of reporters and partners included in the gravity models. The second section makes a basic assessment of the three infrastructure sectors - Electricity, Telecommunications and Roads – and computes the index. Results are presented and discussed in section 3, while the last section concludes, on the base of the previous interpretations and results.

2. ECUADORIAN PROVINCES – ECONOMIC AND TRADE PROFILE

2.1 Natural regions and political division

Ecuador has a population of 13 million inhabitants (2004) distributed in four natural regions: The Coast, the Highland Andes, the Amazon Rainforest and the Galapagos Archipelago. These four regions are subdivided in 22 provinces which are presented in Figure 1. While the central authorities are concentrated in promoting Free Trade Agreements and the membership of the Andean Community as pro-development mechanisms, the country's poorest provinces and their inhabitants remain sceptical about the benefits of such initiatives.

Export orientation policies during the last ten years have focused mainly on the reduction of tariffs as a result of bilateral or multilateral agreements, considering that access to credit and technical assistance is very low, expensive and/or restricted to exporters with strong lobbying capacity. According to the Central Bank of Ecuador, even though 870 products sold to the United States (US) in 2003 were favoured with the ATPDEA[1], 73.4% of them were concentrated in only four commodities (crude oil, bananas, shrimps and roses) *(Cárate & Fernández, 2004)*.

The major concerns about higher trade openness are faced by provinces with low export capacity, not only due to lack of resources, but most importantly to lack of export oriented infrastructure that could help them to overcome the disadvantages created by their remoteness. Differences in terms of trade flows are huge considering that only two provinces (Guayas and Pichincha) out of twenty two produced 87.7% of the total non-oil exports in 2004, while the five poorest provinces only accounted for 0.6%.

Figure 1 = see page 24

The Coastal region contains 50% of the total country population comprised in five provinces: Esmeraldas, Manabi, Guayas, Los Rios and El Oro, four of them including port facilities. The presence of the biggest port in the city of Guayaquil (the capital of the Guayas province) makes it the centre of the national economic activity and one of the biggest recipients of intraregional migration.

The Andean Highlands covers only a fifth of the surface of the country, but 45.4% of the population of Ecuador lives in the valleys along the Andes Mountains. This region commonly known as "la Sierra" is formed by the provinces of Carchi, Imbabura, Pichincha, Cotopaxi, Tungurahua, Chimborazo, Bolivar, Cañar, Azuay and Loja. Even though all are landlocked, those located in the centre face more difficulties to get access to external markets, due to lack of airport facilities and good roads. The country's capital, Quito, is located in Pichincha, the second biggest exporter of the nation.

[1] The ATPDEA (Andean Trade Promotion and Drug Eradication Act), was signed for the first time in 1991 (initially known as Andean Trade Preferential Act), giving preferential treatment in the US market to exports coming from Ecuador, Peru, Colombia and Bolivia. Special tariffs were granted to 5500 products (8-digits level of the Harmonized System). In 2001, it was extended until December 2006.

The Amazon region covers almost half of the nation's territory but only 4.6% of the population lives in this vast area. It includes the provinces of Sucumbios, Napo, Orellana[2], Pastaza, Morona Santiago and Zamora Chinchipe, concentrating in the three first ones 80% of the oil reserves of the country. Even though 30% of the state budget is financed with the resources extracted from this region, the Amazonian provinces are the poorest and less developed of the country and in 2004 contributed with only 3% to the national GDP.

The Galapagos Islands are located in the Pacific Ocean, some 1000 km off the coast. Barely 19.975 residents live on the archipelago and only the islands of San Cristóbal, Isabela and Santa Cruz are inhabited. Considering the fragile ecosystem of the islands, the level of tourism is controlled by the local authorities although this activity generates almost 80% of its revenues.

2.2 Trade and poverty patterns

The composition of total GDP and exports by provinces, as recorded by the Central Bank, presents important distortions due to the fact that it assigns the contribution of oil production either to provinces where the resources are extracted, in the case of crude oil, or to those where refineries are located, in the case of oil derivatives. On the other hand, exports of petroleum products are registered mainly in the capital, Quito, where the national and foreign companies' headquarters are located. Considering these factors, and to avoid undesired distortions, oil production and its exports are not considered in the present study.

Export activities are mainly concentrated in the coastal and north Andean provinces. The availability of port, airports and medium to good road systems are main characteristics of the biggest exporters. Natural resource endowments, weather conditions and soil properties are also related to the kind of goods traditionally produced and exported by these zones, such as bananas, shrimps, coffee, cocoa, flowers, tropical fruits and tuna fish (entire or processed).

Table 1 contrasts three indicators: non-oil exports volume, non-oil GDP participation and poverty incidence[3] for the 22 provinces, in 2004. Most provinces with higher commercial activity also possess lower rates of poverty incidence. This is the case of Guayas, Pichincha, Azuay and most of the ten biggest exporters. The two important exceptions are Galapagos, whose principal activity is tourism (and therefore the correlation between industrial activity and poverty is low), and Cotopaxi, where the production and export of flowers represents a main activity but unemployment is high, principally among the rural indigenous families who account for 61% of its population.

Table 1 : see page 25

[2] This province was part of the territory of Napo until 1997. In July of 1998 Orellana was declared new province after 11 years of negotiations with the central government in order to gain a higher representation in the state budget.
[3] Poverty incidence is measured using an estimated poverty line of US$1.3 dollars per capita a day of consumption. Detailed information about the methodology used is found in Annex 3 of the 2004 World Bank Ecuador Poverty Assessment.

Deeper incidence of poverty is primarily in the landlocked zones of the Andean region and in the south border province of Loja. Data on poverty in the Amazonian region is not available, but the situation of those provinces in terms of development is certainly fragile. The region as a whole registers the lowest per capita GDP[4].

Concentration is a characteristic of exports, not only from the point of view of items but also from the deep dependency on few big markets. The US, Italy, Colombia and Germany are Ecuador's primary trading partners (2004) when petroleum is not considered in the statistics. In 2004, the US received nearly 42% of Ecuador's exports and provided about 21% of the country total imports, making it the leading import and export partner. Italy, Colombia, Germany, Panama, The Netherlands, Venezuela, Spain and Peru, together, supplied approximately 35% of Ecuadorian imports and were the destinations of 45% of its exports.

Patterns of exports concentration, by provinces and products (at two and ten HS digits), were determined for the year 2004. We used the Hirschman-Herfindahl index, calculated using the shares of all three-digit products in a country's exports:

$$H_j = \sqrt{\sum \left(\frac{x_i}{x_t} \right)^2} \quad ;$$

where x_i is province *j*'s exports of product *i* (at the three-digit level) and x_t is province *j*'s total exports. The lowest the index the less concentrated are the province's exports.

Table 2 includes the values of the H_j and the number of products at the 10-digit level exported by each province. The share of this number in the total number of goods exported by the country, as well as other simple concentration indicators (in value traded) are also shown.[5]

Table 2 : see page 26

The Coast offers a more limited scope of exportable commodities than "la Sierra" and a high level of specialization on tropical crops and fishing products. Even though specialization is the base of competition, the region relies on the production of commodities with low value added like bananas, coffee and cocoa beans. Only in the case of canned fish, mainly composed by tuna fish and mackerel processing industries, and metallic manufactures a higher value added is generated.

Export oriented activities in the highlands are more related to the manufacturing sector. Textiles, tapestry, hats, sugar and food processed products, vegetable oils, automotive parts and assembling, rubber and plastic articles, synthetic yarns, leather products, carton and paper products and ceramic articles, together with flowers, onions, broccoli and cauliflower are the most successful items produced by the provinces of Imbabura, Carchi, Pichincha, Bolivar and Azuay.

[4] Oil extraction is not included in the calculations, since – as mentioned above - its value is assigned to the Central Government, even though the production facilities are located mainly in this area.

[5] A detailed table, including the main commodities traded by province, their major economic activity and infrastructure facilities are included in Annex 1.

For the majority of the poorest provinces, the extent of their exports is limited to very few products. No more than three items in the case of Chimborazo and only one in the case of Loja, Cotopaxi, Esmeraldas and Cañar, represent at least 80% of the value of the exports generated by these provinces.

A non-stable trade structure is observed in the Eastern region. From 1993 to 1996, fishing products and animal skins appeared as its two most important exportable commodities, but in the following years these exports almost disappeared. From 1997 to 2000, wood exploitation became an important source of exports, but the activity was lightly reduced because of protests against the damages caused to the rainforest ecosystem. The exploitation continues, but the processing of wood is done and registered in other regions. Two industries seem to be blooming in the Amazonian provinces: the extraction of essences and oils from vegetable sources and the farming of tropical and exotic flowers, but their exports are still incipient.

3. INFRASTRUCTURE ENDOWMENTS AND INDEXES

We have addressed three main infrastructure sectors: telecoms, energy and road transportation. Specific facilities, like ports and airports were not taken into account. Beyond quite reduced in number, when their presence might explain some less clear result in section 4, this possibility is highlighted in the text.

3.1. The three main sectors

3.1.1 Telecommunications

In preparing for the privatisation of EMETEL (State Enterprise of Telecommunications) in 1997, two limited liability companies were created, ANDINATEL and PACIFICTEL, giving to the first the assets of the previous EMETEL subsidiary No.1 and to the second the property of the previous subsidiaries No. 2 and 3[6] *(Ramos & Neira, 2004)*. Another two companies are part of the sector, the first one is ETAPA owned by the Municipality of Cuenca (the capital of the Azuay province) and LINKOTEL a company that in 2003 won the concession to operate in a determined zone of the Guayas province.

Although since the partition of EMETEL the telecommunication sector has evolved positively, the country still lies under the average of the Andean Community, in terms of growth of absolute number of fixed lines in operation and phone density *(Ramos & Neira, 2004).* The performance of each company has exerted an important impact on the availability of telecommunication services on the provinces where they operate. The Andean provinces, served by Andinatel, present a higher level of phone density than the provinces served by Pacifictel (mainly located in the Coast).

While the development of fixed telephony has been limited by the availability of resources of the state owned operators, mobile telephony, whose investments have been performed by huge multinationals, has evolved tremendously not only in number of lines sold but also in the scope of services provided (text messages, internet, data transference, rooming, etc.). In 1993, the first two licenses were granted. The first operator, CONECEL, launched services in 1993. The company was eventually acquired by the Mexican Telmex in March 2000. The second operator, OTECEL, started in 1994. After three years, it sold 89% of its shares to the US Bellsouth which, in 2004, put up for sale its assets to the Spanish Telefonica *(World Telecoms, 2000).* A third operator received the concession for mobile services in 2003. The company, TELCSA, is a national consortium formed by the state Andinatel and Pacifictel with Swedtel, a Swedish partner in charge of the administration and operation of the new firm.

The mobile market experienced moderate growth during its first four years, however, since 2000, the mobile network has expanded enormously, considering that in only five years the number of subscribers has increased almost ten times. This spectacular growth has been attributed to the reduction in the

[6] Subsidiary No. 1 comprised operations in the provinces of Esmeraldas, Carchi, Imbabura, Pichincha,Cotopaxi, Tungurahua, Chimborazo, Bolívar, Sucumbíos, Napo and Pastaza. Subsidiaries No. 2 and 3 operated in the following provinces: Manabi, Los Rios, Guayas, El Oro, Galapagos, Canar, Azuay, Loja, Zamora Chinchipe and Morona Santiago.

calling prices, the incorporation of young consumers and the availability of its services in zones or communities without access to fixed telephony.

Values of phone density (fixed or mobile lines per 1000 people) were calculated by the authors using data provided by SUPTEL (Telecommunications Superintendence) on the number of phone lines by company, since 1994, and the distribution of such lines by province. Additionally, data from the engineering department of Otecel, using congestion statistics by provinces, was used to determine the distribution of mobile phones within the country.

The provinces with the higher total phone density (fixed + mobile phone lines) are Pichincha, Guayas, Azuay and Galapagos with figures of 578, 537, 502 and 409, respectively. The three last provinces in the ranking are Bolivar, Morona Santiago and Zamora Chinchipe. The first is located in the poor Andes Central region and the last two belong to the Amazon region.

3.1.2 Electricity

The former state monopoly in charge of the electricity industry was INECEL (National Institute of Electrification). In 1997, its assets were divided and transferred to a new electricity authority, CONELEC (National Council of Electrification). In 2004, thirteen companies generated 75.3 % of total electricity demand; the difference was covered by fourteen distributors with generation capacity, self-producers companies and 11.54% of electricity imports from Colombia *(CONECEL, 2004)*. Only 59% of the locally produced energy is from hydraulic systems, while the rest is produced by thermal generation using gas or oil derivatives. According to the last analysis of the sector performed by the Central Bank of Ecuador, the price of the industrial KW of electricity in 2002 was the highest among the Andean Community countries, with fares 34% and 21% above the Colombian and Peruvian ones, respectively*(Ramos & Neira, 2003*).

Distribution involves 20 companies, 18 of them connected to the national interconnection system (SNI), and two to minor independent systems, one operating in the East and the other in the Galapagos Islands. Only one distributor, EMELEC, which operates in the city of Guayaquil (Province of Guayas), is private, while the rest are state owned.

The distribution companies define two types of consumers: regulated and non-regulated. The general fares determined by the electricity authority apply to the first group, while the second comprises big companies (private or state owned) that negotiate directly their contracts with the generators or distributors. Additionally, regulated consumers are divided into five categories: households, commercial clients, industrial clients, public lighting systems and others[7].

Though the majority of studies about infrastructure consider annual electricity generation normalised by the number of inhabitants to make comparisons across countries, this measure is not valid for our purposes. The gross level of consumption by province seems a better indicator in our case, since higher levels of consumption are related to higher commercial activity or higher income. The allocation of

[7] Special clients, public or private, for whom a different price is calculated: e.g. public rural schools.

energy utilization by province was performed by the authors using electricity consumption by type of purchaser and distribution company taken from the CONELEC annual statistics, from 1994 to 2004. As a province can be served by more than one distributor, we had first to determine, for each distributor, the proportion of its sales by province to allocate the distributors-based figures into consumption figures by province. Electricity purchased by industrial non-regulated clients was then added considering the location of these special consumers.

Annual variation in electricity consumption per capita is highly tied to the country's overall economic situation. After the "El Niño" phenomenon, and during the 1998-2000 banking crisis, the reduction in consumption is clear, but since the improvement of the macroeconomic situation in the post-dollarisation period (after 2001), electricity consumption recovered its positive trend.

Annex 2 includes the evolution over time, by province, of the number of Megawatts/hour of electricity consumed per capita. The provinces of Guayas, Pichincha and Azuay are the biggest electricity consumers while the Amazonian provinces plus the landlocked territories of Bolivar and Loja are among the five lowest in the ranking.

3.1.3 Road transportation

Ecuador is covered by a road network of 43,197 km divided in two main groups, the State Road Network and the Provincial and Cantonal Road Network. The State Road Network (the backbone of the system) comprises 5,609 km of primary roads and 3,876 of secondary ones. The second network made of tertiary roads, plus rural or local ones. Approximately, 13% of the network is paved, 59% consists of gravel and "improved earth" ways and 28% are called "summer roads" because during the rainy season most of them are unusable *(MOP, 2004)*.

The statistics from the Ministry of Public Works (MOP) about the road length and its distribution by province do not present significant changes every year. Differences in road length appear every three or four years when new ways are finished and included in the national roads balance. Damages and depreciation in the network are not considered in the MOP statistics, therefore it becomes very difficult to determine the annual effects of rainfalls, landslides, floods or quakes on the availability of the roads.

Considering that total roads length has been seriously affected during natural disasters, we decided to determine the volume of ways affected during the "El Niño" phenomenon and reduce it from the original statistics, in order the have a better approximation to reality. By using a report from the Inter American Development Bank about the social and economic effects of the "El Niño" in Ecuador *(Vos, Velasco & De Labastida, 1999)* the length of the roads system was recalculated. These estimates were cross-checked with data in a report of the Ministry of Public Health on the effects of the same phenomenon *(MSP, 1999)*. We concluded that 40% of the total, final damages took place during 1997, while the rest happened in 1998. The same report also helped us to redistribute the losses (in kilometres of roads) among the provinces affected, using data of the provincial distribution of destroyed and affected households during the hurricane.

The total roads network was divided by provinces using the distribution provided by the MOP and normalised by the surface area of each province in order to calculate a roads' infrastructure index by provinces. Amazon provinces present the weakest infrastructure in terms of roads, while those in the Highlands present the highest density of roads. These provinces are all located in the Andean zone, therefore, the extension of roads needed to travel from one place to another across this region is higher than the length needed for the same geodesic distance in the Coast.

3.2 The Infrastructure Index by provinces

The rationale behind the construction of an infrastructure index is to generate a single indicator able to capture the public capital endowment of a certain location. Some authors evaluate separately the effects of single infrastructure indicators on growth, since measures of different infrastructure sectors are generally correlated. This is the case of, e.g., Röller and Waverman (2001), on the impact of telecommunications on economic development, and Fernald (1999) who determined positive effects in productivity due to changes in road infrastructure.

Serven and Calderon (2003b), in order to capture the overall influence of infrastructure endowments on economic growth, built aggregate indexes of quantity and quality of infrastructure capital, taking into account that infrastructure indicators are highly correlated. Following Alesina and Perotti (1996) and Sanchez-Robles (1998), they used principal component analysis (PCA)[8] to summarise in a single index the effects of the indicators from different sectors. In a study about the effects of infrastructure on trade in the Andean Community, Acosta et al. (2004, 2006) calculated an index based on five infrastructure variables: the same used by Limão and Venables (2001) plus kilowatts of electricity generating capacity[9]. The final index was a linear average of the five (normalised) infrastructure variables calculated for each country in their sample.

Inspired by these last studies, and following Sanchez-Robles' (1998) methodology, we also used principal component analysis to obtain an infrastructure index by provinces. Three variables were included: megawatts hour of electricity consumption per capita, main phone lines (fixed + mobile) per 1000 people and kilometres of roads length normalized by the area (square kilometres) of the province. A sample of 242 observations, including the value of every indicator for each of the 22 provinces, for the 1994 to 2004 period, was used to perform the PCA. The two first components explained 89% of the variation in the indicators. All the indicators composed the overall index $I(1)$, chosen as the first principal component. The index gives higher weights for the electricity and telecoms indicators, its value for province i in year t being equal to:

$$I(1)_{it} = 0.6805 * Electcons_{it} + 0.6510 * Phonelines_{it} + 0.3365 * Roads_{it}$$

[8] The aim of PCA is to replace metrical correlated variables by a much smaller number of uncorrelated ones which contain most of the information in the original set, see Bartholomew et al.(2002) and Mardia.
[9] Telephone main lines and kilowatts of electricity were divided by population, while roads, paved roads and railroads were normalised by square kilometres of country area.

where *Electcons* is electricity consumption (in MWh per capita), *Phonelines* is the number of main telephone lines per 1000 people and *Roads* represents the total road length normalised by surface area (in km per square km).

A second infrastructure index was built for the chosen partner countries, using the same methodology and the same infrastructure indicators and time period. For the phone lines indicators, data was obtained from the OECD Fact Book 2006 and BADEINSO, a Social Indicators Database provided by CEPAL-ECLAC (United Nations Economic Commission for Latin America and the Caribbean)[10]. Data for the Electric sector was obtained from the OLADE (Latin American Energy Organization) web page, ECLAC Statistical Yearbook 2004[11] and OECD Fact Book 2006. Since values of roads length were not available for all the years between 1994 and 2004, missing years were estimated using inter-temporal growth rates per country. Only 10% of the data was estimated, the rest was obtained from the OECD Fact Book, the ECLAC Statistical Yearbook 2004, and the North America Transportation Statistics web page.

A sample of 231 observations was used to perform the PCA. The sample included observations of every indicator for each of the 21 partner countries from 1994 to 2004. In this case, 91% of the variation was explained by the two first components. The final index, *I(2)*, has weights similar to those in *I(1),* though more emphasis is given to road transportation:

$$I(2)_{jt} = 0.5738^{*}\ Electcons_{jt} + 0.6283^{*}\ Phonelines_{jt} + 0.5254^{*}\ Roads_{jt}$$

where *j* stands for a partner country.

Table 3 presents a ranking of Ecuadorian provinces and their main commercial partners, in terms of the infrastructure index, for the period 1994-2004. The average of the province's index *I(1),* in 2004, is 147.45, only slightly higher than that of Peru, in the sample of 21 trade partners. However, since the dispersion of the infrastructure stocks by province is very high, the most developed provinces appear over some countries average index.

Pichincha, Guayas and Azuay after 10 years are still the three best endowed territories in terms of infrastructure, with Guayas recently taking the second place due principally to the increase of the mobile phone line density since the entry in 2003 of the third Mobile Phone Operator (TELECSA) whose main operations are based on that province.

Table 3 : see page 27

[10] Available on line at: http://websie.eclac.cl/sisgen/Consulta.asp
[11] Available on line at: http://www.eclac.cl/badestat/anuario_2004/index.htm

4. MODELS AND ESTIMATIONS

Geography and Transport Costs. Impacts of Infrastructure on Trade and Growth

Geography influences economic and social development through several channels. Gallup, Gaviria and Lora (2003) defined four basic elements in which geography exerts an important impact: soil productivity , health conditions, the frequency and intensity of natural disasters and access to markets. In addition, these elements interact with the distribution of the population and the production that at the end is tied also to geographical factors.

Access to the main world markets is a key element for development. The interaction produced between trading partners (especially when a big partner is included) allows them to increase competition, economies of scale and to gain access to new technologies. Given that access to markets is related with the geographical distance and the level of trade barriers existent between them, overcoming those limitations would increase their trade opportunities.

Nowadays when countries and world trade organizations promote elimination of trade barriers, differences in productivity and transport costs become more important to determine commercial partners. The effective rate of protection provided by transport costs is in many cases higher than that provided by tariffs. The World Bank determined that for 168 out of 216 US trading partners in 2001, transport costs outweighed tariff barriers (WTO, 2004). Limão and Venables (2001) showed that transport costs depend on both the countries' geography and their levels of infrastructure. They found that poor infrastructure accounts for 40% of estimated transport costs in the case of coastal countries and up to 60% in the case of landlocked countries. Martinez-Zarzosa & Suarez-Burguet (2005), for the case of Latin American imports coming from the European Union, concluded that higher distance and poor importer's infrastructure notably increase transport costs and that economies of scale, proxied by trade volume, are also relevant in explaining the variation of transport costs.

While the cost of moving goods is tied to the distance between importers and exporters, progresses on transport and trade related infrastructure may reduce the effect of distance in international trade, Limão and Venables (2001).

Serven and Calderon (2003a) determined that a main portion of the per capita output gap that opened between Latin America and East Asia over the 80's and 90's can be explained by the slowdown in Latin America's infrastructure accumulation during that time. Rozas and Sanchez (2004), at the Economic Commission for Latin America and Caribbean, concluded that infrastructure investments contribute to output growth and have an impact on four main aspects of the economic development: the costs structure of the firms, the productivity of factors, the access and connectivity between markets and the general wellbeing of the population.

Infrastructure in a broader sense is not only related to trade facilitation and transportation but also has an impact on school attendance and use of computers at schools. Access to safe water and appropriate

sanitation reduces the vulnerability of the poor to infectious diseases that decrease their working capabilities, their job opportunities and income prospects.

Considering the important contribution of the literature to link the positive effects of infrastructure development and growth across countries, our study attempts to demonstrate that such effects can be replicated at the level of regions within a country. Infrastructure therefore could be an important element to reduce gaps between regions in terms of trade and development

4.2 Gravity model specification

The economic gravity model, firstly proposed by Tinbergen (1962) and Linnemann (1966), provided consistent specifications on the determinants of trade flows based on the interaction forces between two partners. Gravity models estimate the flow of international trade between a pair of countries as being proportional to their economic "mass" (income) and inversely proportional to the distance between them. Other variables – usually dummies - have been added to the model (Aitken, 1973; Braga, Safadi and Yeats 1994) to, for instance, address the effect of a Preference Trade Agreement (PTA) or measure the impact of intra regional trade on trade-creation and trade-diversion (Soloaga &Winters,2001).

Commonly, in the gravity equations, geographical distance has been considered as a good proxy for transportation costs. Distance relates to the time elapsed during shipment but also to synchronization and communication costs. Cultural distance, an important element in business, is also related to physical distance (Soloaga &Winters,2001). Limão and Venables (2001) and Acosta et al. (2006) included distance and infrastructure indexes, or distance modified by the level of infrastructure in their models to capture the effects of these variables on the predicted volume of imports.

Following the criteria in the literature, we included in the basic gravity equation different variables related to characteristics of the reporter region and used as dependent variable the value of exports, since information about imports by provinces were not available. Considering the relative low weight of some provinces on the Ecuadorian non-oil exportable supply, and the dispersion of their trading partners, 10 of them were dropped from the gravitational model. They were the six Amazonian provinces, Galapagos and three of the poorest Andean provinces, Loja, Cañar and Bolivar. Actually, not enough data was available for these three last provinces, as their exports are very low or do not exhibiting a continuous pattern, while trading partners vary wildly across time.

On the other hand, 21 common trading partners were chosen under the criteria of grouping more than 70% of the exports of each province to these destinations[12]. At the national level, these partners received 89.8% of the country sales in 2004 and between 70% to 98% of each province exports.

The first equation, estimated using a data set of 252 bilateral trade observations for eleven years (1994 to 2004), was composed as follows:

[12] The partners included are: Germany, Argentina, Belgium, Bolivia, Brazil, Canada, Chile, Colombia, Spain, USA, France, The Netherlands, Italy, Japan, Mexico, Panama, Peru, United Kingdom, Dominican Republic, Switzerland and Venezuela.

$$ln\ X_{ij} = \beta 0 + \beta 1\ lnY_iY_j + \beta 2\sqrt{D_{ij}} + \beta 3 ln\ Infra1_i + \beta 4 ACP + \beta 5 Border + e_{ij} \quad (4.1)$$

where X_{ij} is the value of province i (reporters) exports to country j (partners); Y_iY_j is the multiplicative nominal GDP from both economies as a proxy for size; D_{ij} is the physical distance from the economic centre of province i to that of country j; $I(1)_i$ is the value of the infrastructure index of the reporter; ACP is a dummy variable equal to 1 when the partner is a member of the Andean Community and zero otherwise; and Border is another dummy to measure the impact of adjacency, taking the value of 1 when province i and country j share a common border. Shocks e_{ij} are supposed normally distributed.
Data on exports by provinces and trading partners was developed by the authors, using information provided by the Central Bank of Ecuador; export values are in US dollars at current prices. GDP (in current dollars) for the partner countries was obtained from the United Nations National Accounts Main Aggregates Database[13], while for the reporting provinces was calculated using data from the Central Bank. Infrastructure observations come from the first infrastructure index, *I(1)*, described in the previous section. Finally, (great circle) distances in kilometres between the economic centre of the reporting territories and partners' capital cities were determined using the Meridian World Data web page[14] .
The series of the combined GDP, exports and infrastructure indexes were normalised using a natural logarithm transformation while, for distance, the square root transformation was applied. In order to avoid the log transformation of zero exports, a one was added to all original values.

[13] http://unstats.un.org/unsd/snaama/dnllist.asp
[14] http://www.meridianworlddata.com/Distance-Calculation-Demo.asp?guid=46C675B5-826E-4F2A-9CE2-DA032EE20A3D

4.2.1 Infrastructure at national level – empirical results

OLS estimations were carried out, for each year, for model (4.1). The R^2 reported by the regressions are between 0.335 and 0.442, confirming the ability of the gravity model to explain bilateral trade of the Ecuadorian provinces with their international commercial partners. Table 4 presents the evolution of the coefficients found for each year.

Table 4: see page 28

Contrary to what observed in many studies using gravity models, the combined GDP of the two trading partners is not the most important variable explaining trade, even though its coefficients remain positive and statistically significant. This suggests that the orientation of a province to export is more related to other factors than merely income. In this case infrastructure seems to be a more powerful determinant of the exporting capacity[15].

The coefficients of the Infrastructure variable are positive and statistically significant during the whole period under study. Their evolution is presented in Figure 2. In order to determine whether the differences between the coefficients of the combined GDP and those of the Infrastructure Index were statistically significant, we performed a test of equality of coefficients, with a null of identity between B_3 and B_1. The results confirmed the significant prevalence of infrastructure over income for the majority of the years analysed, with the exception of the 1995, 1999 and 2000 years, when the null could not be rejected.

Graph 2: see page 24

The lower growth rate of exports during 1996 (8%), compared with the increase of the overall infrastructure index (17%), explains the fall in the infrastructure coefficient for that year. The deterioration of the transport network and the reduction of electricity consumption due to "El Niño" produced a small reduction in the coefficient of the infrastructure variable between 1997 and 1998.

Moreover, the 1999 financial crisis and the ensuing dollarisation process in 2000 reduced the country's total exports and, at the same time, increased the operation costs of local electricity generation. Both effects reduced the potential of infrastructure in explaining provincial exports during that period, until the exports recovery in 2003 and the entry of the new mobile phone operator during the same year.

The distance coefficient is negative and its values evolve through the time in opposition to those of the infrastructure index (distance "increases" when infrastructure "decreases" and vice versa) in the majority of cases. This confirms the predicted reduction of transport costs by improvements in physical infrastructure.

[15] Improving the infrastructure index in 10% for one of the richest provinces of the country, e.g. Pichincha, would increase its exports in 2.5%, while the effect of the same policy over the poorest province, Cotopaxi, would mean an export growth rate of 22.5%. In terms of distance the same policy is equivalent to reduce 22 Km with its trade partners for the first case, and 99 km for the second one.

The variable ACP, set up to determine the effect due to the Andean Community, remains non significant for almost all years except 1996 when exports to the Andean countries raised as a result of the implementation of the CET (common external tariff) by Colombia, Ecuador, Venezuela and Bolivia. This result contrasts with previous studies where the effect of the Andean Regional Integration agreements are positive and significant, when Ecuador is included as a reporter. It unveils the weakness of the agreement to generate trade for the majority of the provinces which did not have previous commercial relations with the other members. On the other hand, since oil exports are not included, and a large portion of them goes to neighbours like Peru and Venezuela, our reduced flows diminish even more the impact of the Andean Community trade which, recorded at the country level, is important.

Another important consideration to explain the lack of power of the Andean Pact in determining exports is that, after the dollarisation, some sectors reduced their participation in the region. This is the case of the automotive industry whose production was primarily exported to Venezuela and, since 2001, reduced its sales from U$ 83,211 to U$ 1,547 in 2004.

The dummy for adjacency (Border) demonstrated that neighbour territories tend to trade more between them. The positive values of the coefficients show the importance of adjacency in trade flows, due to lower transport costs related to short distances. The presence of non significant coefficients (at the 95% level) during some years is related to the fact that not all provinces neighbour to Colombia and Peru were included (such as Loja and Amazon provinces due to lack of exports data). Notwithstanding, the significant values from 2001 to 2003 are related to a positive trend observed in exports towards Colombia and Peru, and to the sales of the excess of rice production to the former, during that period.

4.2.2 Infrastructure at provincial Level – empirical results

Once the importance of infrastructure as an explanatory variable has been determined, we look in this subsection at its differentiated impact at the level of provinces, to determine a pattern within the country. Provinces with low income levels should be able to increase their access to markets once they experiment improvements in their physical infrastructure. For this purpose, we used the same model (4.1) and corresponding data but with two differences. First, the data set was disaggregated by province, pooling the 11 years analysed, for each regression. The second change is a modification of the infrastructure variable, now combining the two infrastructure indexes of both reporting province and partner country.
The specification of the equation becomes the following:

$$ln\, X_{ij} = \beta o + \beta 1\, lnY_i Y_j + \beta 2 \sqrt{D_{ij}} + \beta 3\, ln\, InfraComb_{ij} + \beta 4 ACP + \beta 5 Border + e_{ij} \qquad (4.2)$$

where $InfraComb_{ij} = I(1)_i + I(2)_j$ represents the combined infrastructure index, equal to the addition of both province *i* and partner *j* indexes; the remaining variables keep the same notation as in the previous section.

OLS estimates were computed for every province dataset including 231 observations each one; results are presented in Table 5.

Table 5: see page 29

Contrary to the previous results, the coefficients have different connotations for each province, but also show similarities according to some basic characteristics. We divided the 12 analysed provinces into three main categories:

a first group, named *"High Economic Activity"*, including provinces with the highest indicators for exports and GDP per capita and where poverty incidence is low;
another group containing the two *"Border Provinces"* in the sample, El Oro and Carchi, that share borders with Peru and Colombia, respectively;
a last group, with *"Medium to Low Economic Activity and Medium to High Poverty Incidence"* provinces, where the two central Andean landlocked provinces are included. Members of this group includes provinces may show high level of exports diversification, such as Tungurahua, as well as very high concentration, such as Chimborazo, Cotopaxi and Esmeraldas.

For the *"High Economic Activity"* group, the coefficients of the combined GDP measure are positive and significant in all cases and slightly higher than the infrastructure one, except for Manabi and Guayas where infrastructure was not significant. The four provinces in this group represent nearly 95% of the country's total non-oil exports and generate 68% of the national GDP; therefore, their income as well as the size of their partners are big enough to generate new and continuous business opportunities.

The higher effect of the economic size over the infrastructure endowments is probably related to the condition that information about other logistic and transportation services, such as ports and airports, were not included in our index. For the provinces in this group, the presence of the two main country ports (Guayaquil in Guayas and Manta Port in Manabi) as well as of international and local airports is fundamental for their prevalence as commercial corridors.

Additionally, the non significant infrastructure coefficient in the case of Manabi is also due to the fact that it ranks very low (15 out of 21) on this measure, though having important exports. What the infrastructure index is not explaining here is the fact that even though roads are relatively poor in this province, the type of commodities produced and exported (frozen and processed tuna fish, shrimps, palm oil, coffee, and other fish residuals) rely more on the port an airport facilities available in the region than on the endowments included on the index. As for the case of Guayas, the absence of partners only important for this province but not included in the sample, as Switzerland, may have contributed to the non significance of the coefficient.

The dummy variable that measures the effect of the Andean Pact, with positive and significant coefficients in the group, clearly reveals which provinces have benefited most from the trade openness policies. Producing more that 80% of the national non-oil exports, the provinces on this group concentrate the majority of industrial and agricultural exporters that supply the Andean region[16]. The establishment of the CET increased the level of protection within the agreement for several local industries, increasing their share in the regional market.

[16] Exports by province towards CAN members, as part of total CAN exports, are included in Annex 3.

In the "Border Provinces" group, the most remarkable characteristic is the positive and predominant values for the dummy Border, compared to those for Economic Size (also positive and significant). While Economic Size remains higher for El Oro than for Carchi, demonstrating the lowest income of the second province and its partners, the opposite happens with adjacency. The last is not only due to the fact that Carchi effectively trades more, in volume, with Colombia than El Oro with Peru, but also since wages are lower in the northern provinces of Peru than in the Southern provinces of Colombia. As a result, purchasing power is lower in the south, reducing the opportunities of exporting more from El Oro to Peru.

While the Andean Pact dummy remains not significant for the Border Provinces, the distance coefficient for El Oro presents an unexpected sign. Contrary to the theory that countries tend to commerce more with nearby economies where they can minimize the transport costs, the type of commodities sold by this province supports the opposite. The two main commodities produced and sold by this province that represent 63.5% of its exports are shrimps and processed tropical fruits whose major markets are in the United States of America, Italy, The Netherlands and Japan with low presence in South America or other closer destinations.

The last group deserves special attention, since the most remarkable aspect on it is the positive, high and significant value of the infrastructure coefficient in all provinces within this category. Moreover the coefficient of the infrastructure measure is even higher for the poorest provinces where Economic Size play a weaker role in boosting the export opportunities while higher investment in export oriented services has a bigger potential to overcome the adverse trading conditions prevalent in these territories.

The value of the Andean Pact coefficient was not significant for four out of six provinces included in this group, precisely for those among the poorest provinces in this classification. This uncovers the weak role of Free Trade Agreements in improving commercial opportunities for the poor regions where productivity is low and production and distribution costs are high. Moreover, the general effect of the tariff dismantling has resulted in reduced consumption of local production in these provinces increasing inequality together with internal and external migration.

Meanwhile, only two provinces within this group, Los Rios and Tungurahua, present a positive, high and significant ACP coefficient. The impact of the agreement was positive for them since previously their industries were complementary towards those existing in Colombia and Peru, both country members of the Andean Pact.

Traditional industries in Tungurahua such as leather and textile manufactures increased their sales of raw materials to the blooming clothing and shoes industry in Colombia, since the common external tariff (CET) applied for the Andean countries diverted imports from Asian partners. Los Rios also benefited from the Agreement since excess of rice production is exclusively exported to Colombia, and other products such as Cocoa and steel manufactures take advantage of of the CET implementation.

5. CONCLUSIONS

While countries and the World Trade Organization promote the elimination of trade barriers, differences in productivity and transport costs become more important to determine commercial partners since for the majority of the Middle and Low income countries the level of protection provided by transport costs is higher than the tariffs faced by their exports.

Previous studies on trade and infrastructure within the Andean Community *(Acosta, et al, 2004)* revealed that even though in general the Pact was positive at boosting trade in the region, its effect is stronger once infrastructure endowments of the members and partners are considered on the model.

Therefore, if the integration process is to be improved by better availability of trade related services, our main objective has been to replicate those effects within a single country, Ecuador in this case, and to determine which provinces can be more favoured by changes in their infrastructure endowments.

Two gravity models were analysed in this study. The first model examined the effect of infrastructure stocks on trade flows at a national level, including data from twelve provinces during eleven years. The second model studied, at the level of provinces, the impact of two main variables as determinants of exports, such as combined infrastructure level and membership at the Andean Pact.

The first gravity model highlighted important differences. Notwithstanding other studies pointing up at the size of the trading economies as the most relevant trade determinant, the empirical evidence for the case of Ecuador confirms that the level of infrastructure weights heavier when explaining the exporting capability of its regions. While the size of an economy can not be easily modified by short-term policies, access to international markets can be reached only at the expense of more competitive production and distribution systems.

The previous finding supports the fact that for a country like Ecuador with high dependency on non processed agricultural exports, where international prices tend to decrease over time, transport costs are a huge determinant of trade opportunities.

The evolution of the infrastructure index variable also determined how trade can be affected when infrastructure deteriorates due to natural disasters like in the case of "El Niño" phenomenon. Episodes like "El Niño" but at a lower scale occur every year in the Coast of the country but statistics on damages to the road network are not available as well as the losses caused to the production during every serious rainy season. The lack of information hides the effects that bad quality of infrastructure causes to the production and therefore delays the decisions that the authorities should take in that field.

When the level of disparities observed among Ecuadorian regions is incorporated into the model less uniformed results emerged. For poorest provinces within the country infrastructure popped out as a crucial factor in explaining exports and at the same time showing the lowest (or not significant) score for the trade preferential agreement variable, unveiling the limited impact of trade policies , in isolation, as effective remedy to reduce poverty and the key role of infrastructure as a development catalyst element.

On the other hand the highest commercial centres are those who gain more from trade liberalisation agreements. The Andean Pact seems to be playing a relevant and positive role only for few provinces, 70% of them belonging to the richest country regions. Consequently it s not surprising that the biggest pressures in favour of the signature of the Free Trade Agreement with the Unites States of America come out from the Chambers of Commerce and Industry of these provinces, while the least privileged regions of the country , more likely to bear risks than glamorous opportunities, are opposed to the FTA negotiations.

The novelty of the study, including data from different provinces, shows clearly the importance of considering disparities among regions when dealing with policy implications issues. Moreover in a country like Ecuador, where differences in terms of income, infrastructure services, education and trade are high, openness, in the absence of complementary policy measures, is likely to increase inequality rather than reducing it.

The challenge for the government, under the framework of the negotiations of a future trade liberalisation agreement with the United States of America, implies a keen assessment of priorities, giving more emphasis to policies that can benefit the poor who are not able to take advantage of tariff reduction policies and which, contrary to expectations, are likely to be harmed by them.

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Figure 1: Ecuador Administrative Division

Graph 2

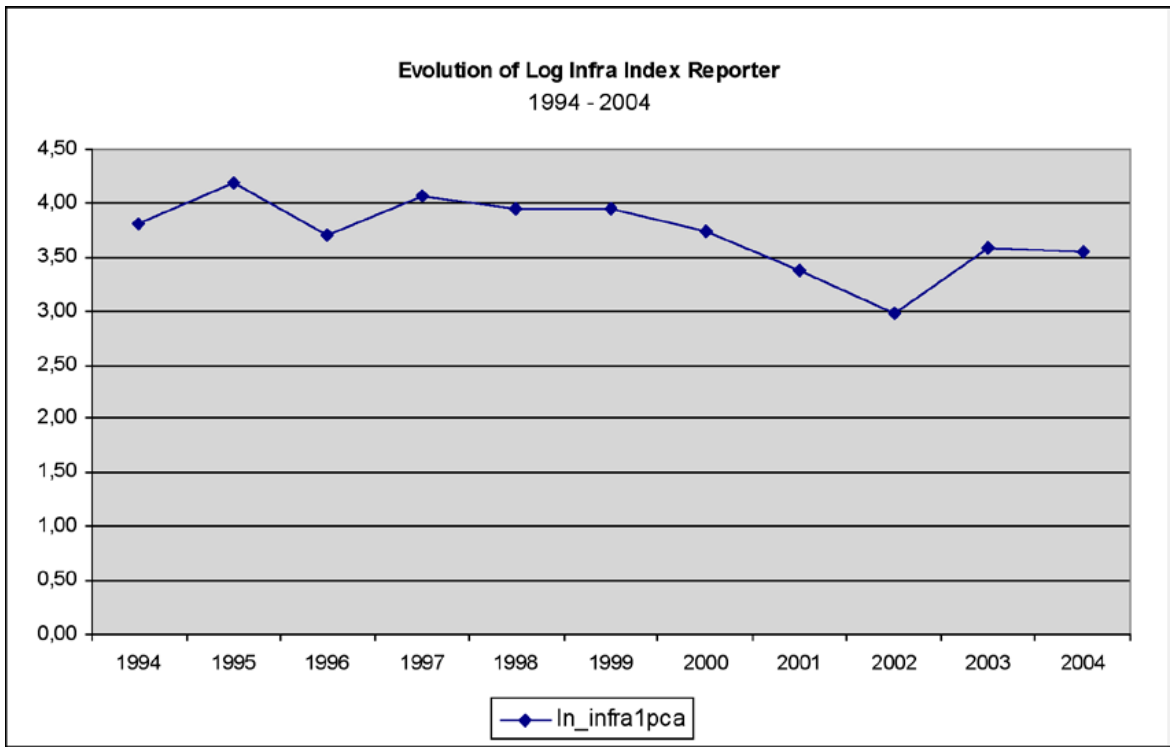

Table 1

Exports, GDP and Poverty Incidence by Province

2004

Province	*Region*	*Share over total Exports*	*Ranking Main Exporters*	*Share over total GDP*	*Ranking GDP*	*Poverty incidence*	*Ranking Lower poverty Incidence*
Guayas	Coast	0.57	1	0.30	1	0.40	4
Pichincha	Andean	0.31	2	0.25	2	0.30	2
Manabi	Coast	0.07	3	0.08	3	0.52	7
Azuay	Andean	0.02	4	0.05	4	0.48	5
Tungurahua	Andean	0.01	5	0.04	7	0.52	8
Los Rios	Coast	0.01	6	0.05	5	0.52	9
Cotopaxi	Central Andean	0.01	7	0.03	9	0.67	15
Carchi	Andean	0.01	8	0.01	13	0.56	10
Imbabura	Andean	0.00	9	0.02	10	0.57	11
El Oro	Coast	0.00	10	0.04	6	0.40	3
Esmeraldas	Coast	0.00	11	0.03	8	0.50	6
Chimborazo	Central Andean	0.00	12	0.02	11	0.62	14
Loja	South Andes	0.00	13	0.02	12	0.61	13
Sucumbios	Amazon	0.00	14	0.01	19	nd	nd
Canar	Central Andean	0.00	15	0.01	14	0.59	12
Morona Santiago	Amazon	0.00	16	0.01	17	nd	nd
Bolivar	Central Andean	0.00	17	0.01	16	0.68	16
Zamora Chinchipe	Amazon	0.00	18	0.00	20	nd	nd
Pastaza	Amazon	0.00	19	0.01	18	nd	nd
Galapagos	Galapagos	0.00	20	0.01	15	0.19	1
Napo	Amazon	0.00	21	0.00	21	nd	nd
Orellana	Amazon	0.00	22	0.00	22	nd	nd

nd = no data available

Source: Exports and GDP obtained from the Central Bank of Ecuador. Poverty incidence taken from the World Bank Poverty Assesment of 2004

Table 2

Exports Concentration Indicators by Province

2004

Province	*Region*	*Products Traded (10 digit level)*	*% over National Prod. Traded*	*# Prod. 80% Exp.*	*# Prod. 90% Exp.*	*H-H Concentr. Index*
Imbabura	Andean	294	12.5	24	44	0.29
Pichincha	Andean	1697	71.9	29	68	0.35
Carchi	Andean	135	5.7	14	24	0.35
Bolivar	Central Andean	48	2.0	9	15	0.41
Azuay	Andean	290	12.3	8	15	0.43
Los Rios	Coast	152	6.4	7	18	0.48
El Oro	Coast	30	1.3	3	6	0.53
Guayas	Coast	1270	53.8	13	31	0.53
Chimborazo	Central Andean	47	2.0	3	4	0.59
Tungurahua	Andean	99	4.2	5	10	0.60
Manabi	Coast	149	6.3	5	9	0.67
Pastaza	Amazon	10	0.4	2	2	0.74
Loja	South Andes	14	0.6	1	2	0.75
Morona Santiago	Amazon	7	0.3	3	4	0.83
Sucumbios	Amazon	4	0.2	1	1	0.91
Cotopaxi	Central Andean	25	1.1	1	1	0.97
Esmeraldas	Coast	13	0.6	1	1	0.97
Canar	Central Andean	8	0.3	1	1	1.00
Galapagos	Galapagos	1	0.0	1	1	1
Zamora Chinchipe	Amazon	1	0.0	1	1	1
Total Country		**2360**				

Source: Authors

Table 3

Infrastructure Index Ranking of Ecuadorian Provinces and Main Trading Partners

1994 vs 2004

1994			*2004*		
State or Province	***InfraIndex***	***Ranking***	***State or Province***	***InfraIndex***	***Ranking***
Switzerland	433,94	1	UK	999,41	1
USA	424,88	2	Switzerland	985,64	2
Canada	423,75	3	Italy	972,25	3
France	358,23	4	Germany	962,71	4
Japan	357,96	5	Netherlands	880,78	5
UK	355,63	6	Belgium	844,57	6
Germany	343,51	7	Spain	833,77	7
Netherlands	338,66	8	France	821,57	8
Italy	297,63	9	USA	776,20	9
Belgium	296,95	10	Japan	745,02	10
Spain	244,98	11	Canada	688,77	11
Argentina	94,74	12	Chile	503,71	12
Venezuela	79,41	13	**Pichincha**	**377,00**	**13**
Chile	77,38	14	Brazil	370,10	14
Panama	70,66	15	Argentina	365,03	15
Pichincha	**68,64**	**16**	**Guayas**	**350,54**	**16**
Mexico	61,34	17	Mexico	343,12	17
Colombia	60,31	18	**Azuay**	**327,33**	**18**
Azuay	**55,12**	**19**	Venezuela	284,53	19
Brazil	53,48	20	Colombia	268,69	20
Guayas	**48,67**	**21**	Dominican Rep.	249,59	21
Dominican Rep.	47,22	22	Panama	244,69	22
Imbabura	32,23	23	Canar	230,61	23
Tungurahua	30,89	24	El Oro	225,02	24
Pastaza	28,57	25	Tungurahua	220,54	25
El Oro	27,17	26	Cotopaxi	194,05	26
Loja	25,74	27	Pastaza	189,78	27
Carchi	25,00	28	Sucumbios	170,66	28
Canar	24,96	29	Bolivia	169,47	29
Peru	22,53	30	Imbabura	161,64	30
Cotopaxi	22,10	31	Manabi	157,09	31
Chimborazo	21,68	32	Chimborazo	151,67	32
Bolivia	21,59	33	Peru	140,49	33
Morona Santiago	18,15	34	Napo	136,86	34
Esmeraldas	17,89	35	Esmeraldas	129,72	35
Manabi	17,67	36	Orellana	115,08	36
Los Rios	15,96	37	Loja	105,05	37
Napo	14,41	38	Carchi	91,77	38
Bolivar	13,11	39	Los Rios	65,80	39
Zamora Chinchipe	12,26	40	Bolivar	63,08	40
Sucumbios	10,96	41	Morona Santiago	39,58	41
Orellana	0,00	42	Zamora Chinchipe	27,50	42

Source: Authors

Table 4

OLS / GRAVITY MODEL ESTIMATES

Sample of 12 Ecuadorian Provinces and 21 Partner countries - Infrastructure Reporter Province

Independent Variables	Years										
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Ln YiYj	2.005	1.953	2.177	1.921	1.942	1.67	1.615	1.746	2.02	1.891	1.832
	(12.03)***	(11.83)***	(12.11)***	(11.05)***	(11.44)***	(10.22)***	(10.18)***	(9.42)***	(11.16)***	(11.32)***	(10.71)***
Sqt_Distance	-0.091	-0.09	-0.069	-0.075	-0.079	-0.074	-0.072	-0.075	-0.081	-0.075	-0.083
	(-5.35)***	(-5.38)***	(-3.77)***	(-4.31)***	(-4.52)***	(-4.34)***	(-4.27)***	(-4.03)***	(-4.53)***	(-4.47)***	(-4.92)***
Lninf1re	3.813	4.183	3.705	4.075	3.94	3.95	3.739	3.382	2.982	3.578	3.546
	(6.10)***	(6.62)***	(5.11)***	(6.00)***	(5.78)***	(6.19)***	(5.79)***	(4.75)***	(4.08)***	(5.05)***	(5.27)***
ACP	1.562	1.021	3.437	1.728	0.959	1.39	1.531	1.177	1.724	1.388	0.7
	(1.55)	(1.01)	(3.10)***	(1.56)	(0.87)	(1.32)	(1.49)	(1.08)	(1.57)	(1.22)	(0.64)
Border	-0.25	-0.657	4.09	0.239	4.21	-0.072	-0.453	4.94	5.082	5.757	2.595
	(-0.06)	(-0.16)	(2.31)**	(0.05)	(2.08)**	(-0.02)	(-0.10)	(2.63)***	(2.64)***	(2.75)***	(0.90)
Constant	-91.07	-90.21	-102.3	-91.22	-91.86	-79.27	-76.32	-81.99	-94.41	-92.38	-89.62
	(-13.42)***	(-13.40)***	(-14.44)***	(-12.87)***	(-13.21)***	(-11.50)***	(-11.30)***	(-11.03)***	(-12.93)***	(-13.11)***	(-12.85)***
Observations	252	253	253	253	253	253	253	253	253	253	252
R-squared	0.42	0.43	0.44	0.39	0.4	0.36	0.34	0.34	0.38	0.39	0.39

Robust t statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5

OLS / GRAVITY MODEL ESTIMATES BY PROVINCES

IMPACT OF INFRASTRUCTURE OVER EXPORTS BY PROVINCES - COMBINED INFRASTRUCTURE INDEX

Independent Variables	High. Econ Activity Provinces				Border Provinces		Medium to High Poverty Incidence and Medium to Low Economic Activity Prov.					
	Azuay	Guayas	Pichincha	Manabi	El Oro	Carchi	Los Rios	Imbabura	Chimborazo	Esmeraldas	Tungurahua	Cotopaxi
Ln YiYj	0.734	0.763	0.669	1.069	1.403	0.586	0.994	0.527	1.078	1.283	1.364	0.489
	(10.93)***	(9.48)***	(9.39)***	(6.58)***	(5.22)***	(2.17)**	(3.92)***	(4.17)***	(4.75)***	(6.12)***	(6.15)***	(2.23)**
Sqt_Distance	-0.069	-0.012	-0.055	-0.045	0.056	-0.023	-0.066	-0.04	-0.143	-0.047	-0.109	-0.112
	(-14.73)***	(-2.06)**	(-14.72)***	(-5.08)***	(2.64)***	(-1.10)	(-3.70)***	(-4.51)***	(-8.49)***	(-2.46)**	(-6.46)***	(-6.09)***
Lninf1co	0.633	0.066	0.447	-0.069	0.044	-0.381	0.982	1.359	1.496	2.119	2.121	4.951
	(3.36)***	(0.35)	(2.19)**	(-0.18)	(0.07)	(-0.76)	(1.68)*	(4.29)***	(2.80)***	(3.74)***	(3.53)***	(10.19)***
ACP	1.572	0.701	0.363	1.075	0.576	-0.142	2.818	0.386	0.842	-1.209	4.255	-0.737
	(4.79)***	(2.83)***	(0.88)	(2.68)***	(0.52)	(-0.16)	(3.45)***	(0.61)	(0.78)	(-1.73)*	(4.63)***	(-0.83)
Border	na	na	na	na	9.586	14.41	na	na	na	4.222	na	na
					(9.92)***	(15.09)***				(2.21)**		
Constant	-20.59	-20.07	-15.20	-33.14	-63.02	-20.78	-37.09	-19.24	-44.76	-64.27	-61.10	-36.19
	(-5.65)***	(-6.01)***	(-3.60)***	(-5.32)***	(-5.91)***	(-1.82)*	(-3.79)***	(-3.72)***	(-4.80)***	(-7.94)***	(-7.35)***	(-4.28)***
Observations	231	231	231	231	231	231	231	231	231	231	231	231
R-squared	0.55	0.4	0.4	0.22	0.36	0.39	0.15	0.21	0.26	0.3	0.3	0.37

Robust t statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

ANNEX 1

ECUADORIAN PROVINCES: SUMMARY OF ECONOMIC, TRADE AND INFRASTRUCTURE CONDITIONS

2004

Province	*Region*	*Share of Exports* [1]	*Ranking Exports* [2]	*Share of Total GDP* [3]	*Ranking GDP* [4]	*Poverty Incidence* [5]	*Share Exports to CAN* [6]	*Number of Products 80% Exports* [7]	*Hirshman Concentration Index*	*Main Traded Commodities* [8]	*Main Economic Activities*	*Infrastructure related facilities* [9]
Guayas	Coast	57%	1	30%	1	40,4%	7%	13	0,53	Bananas, fish frozen or processed, canned tuna fish, crude cocoa paste, fish preparations, edible preparations of fruits and vegetables, shrimps, passion fruit extracts, pineaples, sugar and sugar confectionery, tobacco, fish residues for animal feeding, cocoa butter, pharmaceutical products, mangoes, coffee and coffee preparations	Commercial, Import-Export services, banana, shrimps, cocoa, coffee, tuna fish and fish production and processing, food and beberages industries, sugar and tobacco production, poultry and livestock industries, transport and Port services, banking and financial activities, construction services and tourism	One International Passengers and Cargo Airport, two additional local airports, one Maritime Port, three private Sea Ports, one Granel Port, one Oil and Fuels Refinery, two Oil Terminals, three Fuel Terminals - Reservoirs, one Hydroelctric and seven Termoelectric generation plants, two marginal oil fields and one maritime oil and gas extraction facility
Pichincha	Andean	31%	2	25%	2	30,3%	26%	29	0,35	Mineral fuels, oil and waxes, roses, industrial solvents, vehicles, trucks and their parts, gypsophilas (clowers), cultivated hearths of palms, animal and vegetable oils, cocoa and cocoa preparations, ceramic products, candies and other sugar confectioneries, plastics and other polypropylene articles, cocoa butter, textile fibers and yarns, denim manufactures, pharmaceutical products, paper and paper pulp articles,wood planks, cotton yarns and its manufactures	Automotive Industry, cut flowers production, industrial chemical production, vegetable and animal oil industries, sugar confectionery manufacturing, plastic articles production, paper industry, food products, livestock, milk and poultry processing, transport services, Oils & Gas industry related services, infrastructure and construction services, banking and financial activities and tourism	One International Passengers and Cargo Airport, two Fuel Terminals - Reservoirs, one Hydroelctric and four Termoelectric generation plants
Manabi	Coast	7%	3	8%	3	51,8%	13%	5	0,67	Tuna fish canned, prepared and preserved, other prepared and frozen fish, shrimps and other crustaceans, animal and vegetable oil and waxes, vegetable ivory (tagua nuts) manufactures, processed coffee, other fish preparations and 'Panama' type woven hats	Tuna fish and other fish and shrimps processing activities, edible fats and oil manufacturing industries, Panama woven hats production, agriculture, livestock and poultry farms, Port and transport services, paper industry, infrastructure and construcion services and tourism	One Maritime Port, two national airports and one Fuels Terminal-Reservoir
Azuay	Andean	2%	4	5%	4	48,3%	49%	8	0,43	Rubber tyres, Gypsophilas (flowers), Gold and other precious metals jewelry, iron or alumminium stoves, kitchen appliances and boilers, Roses, Ceramic products, 'Panama' type woven hats and headgear, Leather manufactured articles and clothes	Automotive tyre industry, cut flower crops, stoves, ovens and home appliances manufacturing, ceramic industry, woven hats production, jewelry, wooden furniture and leather manufactures	One National Airport, one Fuels Terminal-Reservoir, three Hydroelectric and two Termoelectric generation plants
Tungurahua	Andean	1%	5	4%	7	52,0%	62%	5	0,60	Footwear leather or synthetic, sport shoes, roses, raw hides, skins and leather, cotton apparel and clothing accesories, wooden products and other edible preparations	Textiles, leather, clothing, shoes, food and beberage industries, fruits and vegetables crops and processing, buses and truck bodies manufacture, wood industry and tourism	One Fuels Terminal-Reservoir and two Hydroelectric generation plants
Los Rios	Coast	1%	6	5%	5	52,1%	28%	7	0,48	Crude cocoa paste, preparation of fruits and vegetables, steel and iron flat rolls, wires and related products, wood articles, man-made staple fibers and yarns, iron and steel nails and staples, printed books and notebooks	Livestock, milk and poultry production, rice, cocoa, bananas, fruits, maiz and soya crops, rice processing and steel and iron industry	
Cotopaxi	Central Andean	1%	7	3%	9	66,7%	3%	1	0,97	Roses, carnations and broccoli	Cut flowers production, agriculture, livestock industry and pottery	One national and international cargo airport

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2004

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Carchi	Andean	1%	8	1%	13	55,5%	97%	14	0,35	Oil seeds, Yellow corn, onnions, cultivated fish, animal or vegetable oil and waxes, rice, mandioc, beans, palm oil, fish residuals processed, rice flour, advocados and mangoes	Agriculture, commerce, transport services and production of furniture	One national and international airport and one Land Port of entry
Imbabura	Andean	0,3%	9	2%	10	56,9%	32%	24	0,29	Knitted or crocheted whool clothes or apparel, yellow corn, oil seeds, other animal or vegetable oils or waxes, roses, coffee, articles and clothes of whool or animal fur, palm seeds oil, apparel or clothes from synthetic fibers, mangoes, wood decoration articles, avocadoes, headgear, scarf, veils and similar cotton articles, natural and synthetic yarns,and textile industry equipment	Agriculture, livestock production, textiles processing, whool knitted appareal and clothing industries, leather and wood manufactures, sugar processing, cement production and tourism	
El Oro	Coast	0,3%	10	4%	6	39,6%	3%	3	0,53	Fish frozen processed, shrimps, processed fruits, bananas, precious metals and bambu raw or in panels	Banana production, shrimp farming, fish processing, mining, beberages production and Port services	One local airport, one Maritime Port, one Land Port of entry and one Termoelectric generation plant
Esmeraldas	Coast	0,2%	11	3%	8	50,3%	11%	1	0,97	Cultivated hearts of palms and fish frozen or processed	Agriculture, fishing, vegetable oils and waxes processing, tourism and Crude Oil and fuels refining	One local airport, one Maritime Port, one Oil Port, one Oil and Fuels Refinery, one Fuels Terminal Reservoir and one Termoelectric generation plant
Chimborazo	Central Andean	0,03%	12	2%	11	62,0%	47%	3	0,59	Ceramic products, Quinoa and other cereals, roses and raw hides and skins	Farming, milk industry, cement production, flour processing and whool and fur manufacturing	One Fuels Terminal-Reservoir
Loja	South Andes	0,03%	13	2%	12	60,6%	10%	1	0,75	Coffee, cooking spices, rum and other sugar cane distilled beberages	Sugarcane and coffee production, livestock and milk industries, tourism and cereals milling industry	One national airport and one Land Port of entry, one Fuels Terminal-Reservoir
Sucumbios	Amazon	0,02%	14	1%	19	nd	44%	1	0,91	Palm oil and cultivated hearts of palms	Oil extraction	One local airport, two Oil Refineries, one Fuels Terminal-Reservoir and four Oils extraction fields
Canar	Central Andean	0,01%	15	1%	14	59,2%	9%	1	1,00	Roses, articles of stone, plaster, cement and similars	Cement Production, ceramic manufactures and textiles production	
Morona Santiago	Amazon	0,01%	16	1%	17	nd	22%	3	0,83	Raw hides, skins or leather, aromatic oils and essences, other small machinery	Oil extraction, livestock production and tourism	One Local airport and one oil extraction field
Bolivar	Central Andean	0,01%	17	1%	16	68,1%	0%	9	0,41	Cocoa preparations, sugar confectionery, mushrooms raw or processed, knitted or crocheted whool clothes or apparel, processed whool, leather bags and accessories, brown-cane sugar semi processed, special tapestry	Agricultural, livestock and cheese production, sugarcane manufactures, citrus processing and pottery	
Zamora Chinchipe	Amazon	0,004%	18	0%	20	nd	0%	1	1,00	Precious metals and stones	Mining Industry and lumber exploitation	
Pastaza	Amazon	0,000%	19	1%	18	nd	9%	2	0,74	Wood planks and wooden articles, footwear, headgears and small boats and floating structures	Oil extraction, tea production and lumber exploitation	Four Oil extraction fiels
Galapagos	Galapagos	0,000%	20	1%	15	19,4%	0%	1	1,00	Plywood panels and mouldings and frozen fish and crustaceans	Turism	Two national airports, one shipboats port and one Fuel Terminal - Reservoir

1: Share of the province in the national non-oil exports of 2004

2: Ranking of the province as exporter 2004

3: Share of the provincial non-oil GDP on the national non-oil GDP 2004

4: Ranking of the province by Income (GDP) 2004

5: Poverty Incidence 2004, measured as a percentage of people leaving under an estimated poverty line of U$1,3 dollars per capita a day

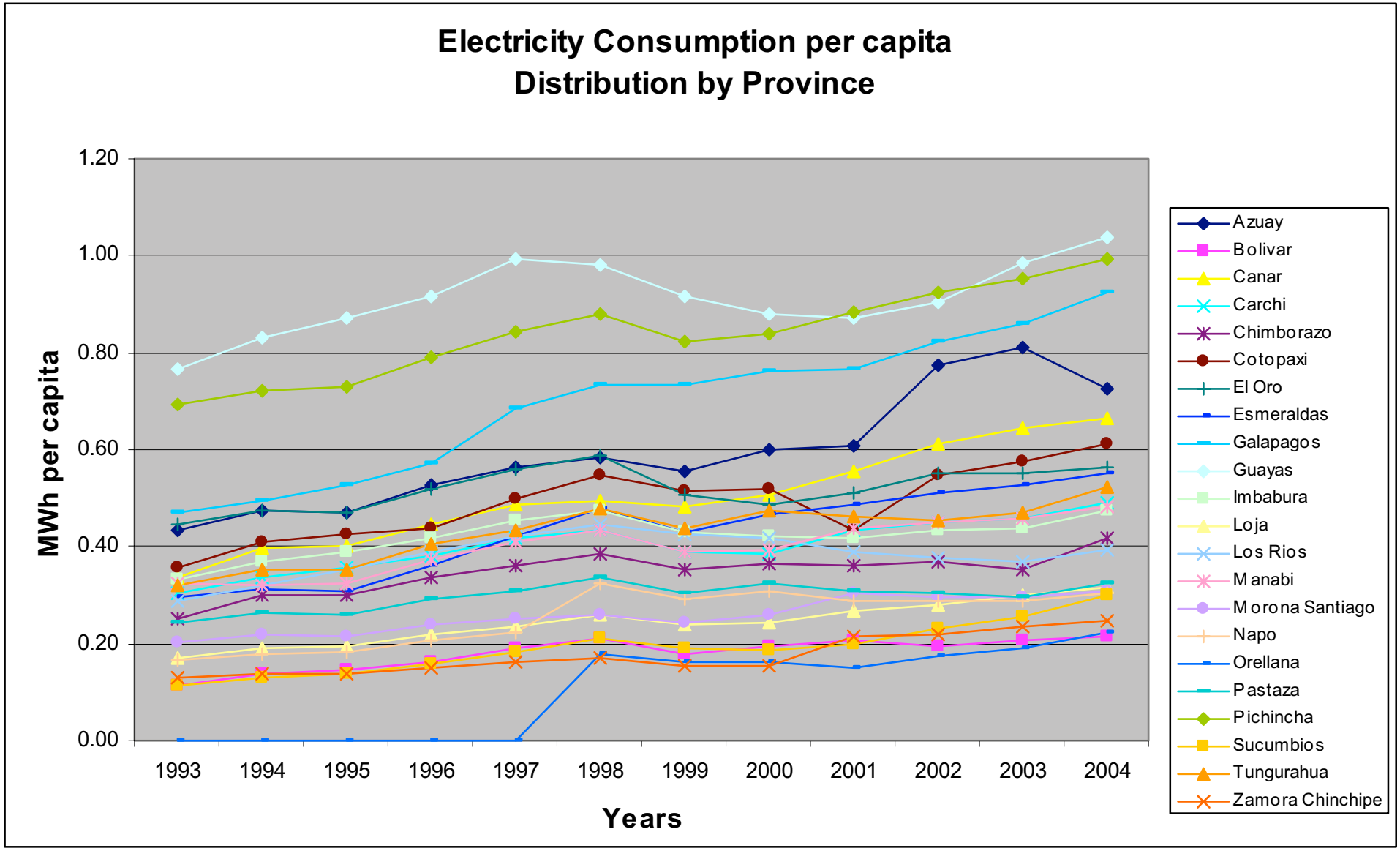
6: Share of sales to the Andean Community (Bolivia, Colombia, Peru and Venezuela) over the total province exports. Average of the last 11 years exports

7: Number of products at HS 10 digit level that represent 80% of the province exports

8: Description of the main export commodities at 10 digit level traded by each province

9: Provinces without information, on this category, have no Energy generation or storage facilities as well as ports or airports. Basic infrastructure is not described separately since this is available for all provinces

Annex 2


Electricity Consumption per capita
Distribution by Province
MWh per capita
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Years
Azuay
Bolivar
Canar
Carchi
Chimborazo
Cotopaxi
El Oro
Esmeraldas
Galapagos
Guayas
Imbabura
Loja
Los Rios
Manabi
Morona Santiago
Napo
Orellana
Pastaza
Pichincha
Sucumbios
Tungurahua
Zamora Chinchipe

ANNEX 3

SHARE OF EXPORTS BY PROVINCE TOWARDS CAN MEMBERS OVER TOTAL CAN TRADE

	Years											
Provinces	***1994***	***1995***	***1996***	***1997***	***1998***	***1999***	***2000***	***2001***	***2002***	***2003***	***2004***	***Average***
Pichincha	43.8%	43.2%	37.4%	42.8%	48.1%	44.8%	49.1%	48.2%	44.5%	43.8%	47.7%	**44.9%**
Guayas	35.1%	33.7%	33.0%	25.7%	28.2%	26.4%	25.5%	24.5%	28.8%	32.4%	28.6%	**29.3%**
Carchi	3.9%	5.1%	9.2%	15.2%	6.3%	6.6%	6.4%	9.5%	8.4%	6.5%	3.0%	**7.3%**
Azuay	3.5%	5.2%	8.0%	7.3%	9.0%	11.3%	8.1%	6.3%	6.1%	4.9%	4.8%	**6.8%**
Manabi	5.9%	7.1%	8.0%	5.6%	5.1%	4.8%	6.7%	6.4%	6.4%	6.5%	10.6%	**6.6%**
Tungurahua	0.7%	0.9%	1.1%	1.2%	1.6%	1.7%	2.5%	2.2%	3.0%	2.6%	3.2%	**1.9%**
Los Rios	3.0%	2.9%	2.2%	1.9%	1.4%	2.0%	1.1%	0.7%	1.3%	0.9%	0.7%	**1.6%**
Imbabura	0.1%	0.1%	0.6%	0.0%	0.0%	0.2%	0.2%	1.6%	0.7%	0.7%	1.1%	**0.5%**
Esmeraldas	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.5%	1.5%	0.0%	**0.2%**
Chimborazo	0.3%	0.5%	0.2%	0.1%	0.2%	0.2%	0.2%	0.1%	0.2%	0.0%	0.0%	**0.2%**
Canar	0.0%	0.0%	0.0%	0.0%	0.0%	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.2%**
El Oro	0.2%	0.0%	0.2%	0.0%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	**0.1%**
Cotpaxi	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Sucumbios	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	**0.0%**
Moma Santiago	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Napo	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	**0.0%**
Loja	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Pastaza	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Bolivar	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**
Zamora Chinchipe	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**

Source: Authors. Data from the Central Bank of Ecuador

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